Illustrated User's Guide – NBC 2015:

Part 9 of Division B, Housing and Small Buildings

Issued by the

Canadian Commission on Building and Fire Codes

National Research Council of Canada

First Edition 2014
Second Edition 2018

ISBN 0-660-24854-7

NR24-28/3-2015E

NRC-CONST-56249

Printed in Canada

First Printing

2 4 6 8 10 9 7 5 3

Aussi disponible en français :

Guide illustré de l'utilisateur – CNB 2015 : Maisons et petits bâtiments (Partie 9 de la division B)
CNRC 56249F
ISBN 0-660-24862-2
NR24-28/3-2015F

Table of Contents

Introduction

The purpose of this Guide is to help Code users understand and apply the provisions in Part 9 of the National Building Code of Canada 2015 (NBC). It is a companion document to NBC Part 9—not a stand-alone document.

This Guide has no legal status and is not intended for formal adoption: its purpose is solely informational. Sketches and diagrams illustrate principles only; other methods of satisfying the requirements may be equally valid. If there are cases where text in the Guide conflicts with a requirement in the NBC, the NBC requirement governs.

Structure

The Guide discusses each Article of NBC Part 9 in turn in Code order through the use of text, illustrations, tables and examples. However, some sections of the Guide cover topics that span multiple Articles.

Each discussion starts with a general statement about the purpose of the Article in question. These general statements are not meant to summarize or paraphrase the content of the "Supplement to the NBC 2015: Intent Statements," which contains detailed statements on the specific intent of each NBC provision and is available online at www.nrc-cnrc.gc.ca/eng/publications/codes_centre/codes_guides.html.

Units of Measurement

Although the NBC only provides measurements in SI units, the Guide, in many cases, also shows corresponding imperial units in parentheses. Surveys indicate that people involved in all aspects of the housing industry still use imperial units, while those involved in the design and construction of small, non-residential buildings rely almost exclusively on SI units.

The SI measurements presented for the spacing of framing members and for the dimensions of products like wood-based panels are soft conversions, not actual conversions, of the actual imperial measurements (see NBC Note A-9.4.2.1.(1)). For example, 300, 400 and 600 mm joist and stud spacings are subdivisions of a floor or wall panel size of 1 200 × 2 400 mm. These SI measurements are soft conversions of the standard imperial 12, 16 and 24 in. spacings, and 4 × 8 ft. panel size, respectively. It is assumed that framing members will be spaced according to the actual metric conversions so that they align with the edges of sheathing materials, which are typically sized using imperial units.

For dimensions that are in effect Code requirements, such as minimum hallway widths, hard conversions of the SI measurements are presented, in which the imperial measurement is rounded up or down as required. The SI measurement is the legal requirement. The imperial measurement, which may be slightly different, is provided for convenience as an approximation of the SI requirement.

A conversion table for imperial equivalents of the most common SI units used in building design and construction is located at the end of the Guide.

Use of Illustrations

The illustrations explain general concepts and principles as well as key features of construction methods and technologies: they are not meant to be used as design or construction drawings. Many drawings focus only on one of many possible solutions. Most drawings highlight key features addressed in the surrounding text and show other construction details in the background. Although efforts have been made to show Code-compliant construction, it is important to note that the illustrations are not to be used as acceptable solutions to Code requirements.

Referenced Standards

The applicable editions of the standards referenced in the Guide are the editions referenced in the NBC 2015, including any updates to those standards published by Codes Canada.

The National Building Code

The Canadian Commission on Building and Fire Codes (CCBFC) develops Canada's five National Model Codes. The National Building, Energy, Farm Building, Fire, and Plumbing Codes are adopted, with or without modifications, and enforced by many provinces and territories. When adopted by a provincial, territorial or municipal authority, the National Model Codes become legal documents and their enforcement is then administered in conformance with the appropriate regulations of that authority.

More information on Canada's Code development system is available at www.nrc-cnrc.gc.ca/eng/solutions/advisory/codes_centre_index.html.

Objective-Based Codes

In the National Model Codes, most provisions in Division B (acceptable solutions) are linked to at least one objective and functional statement found in Division A. These linkages play an important role in allowing these objective-based codes to accommodate innovation. It is expected that the majority of Code users will primarily follow the acceptable solutions given in Division B and that they will consult Division A only in cases where it may serve to clarify the application of Division B's provisions to a particular situation or when they are considering an alternative solution.

The NBC is intended to provide a minimum level of health and safety in buildings. Most NBC provisions address at least one of the Code's five stated objectives, namely:

- safety,
- health,
- accessibility for persons with disabilities,
- fire and structural protection of buildings, and
- environment.

The NBC was published in an objective-based code format for the first time in the 2005 edition. It comprises three Divisions:

- Division A defines the scope of the Code and contains the objectives, the functional statements and the conditions necessary to achieve compliance. Division A cannot be used on its own as a basis for designing and constructing a building or for evaluating a building's compliance with the Code.
- Division B contains acceptable solutions (i.e., technical requirements) deemed to satisfy the objectives and functional statements listed in Division A. The term "acceptable solution" reflects the principle that building codes establish an acceptable level of risk and underlines the fact that a code cannot describe all possible valid design and construction options. Acceptable solutions represent the minimum level of performance that will satisfy the NBC's objectives and that is acceptable to an authority that adopts the NBC into law or regulation. Compliance with the acceptable solutions is deemed to automatically satisfy the linked Division A objectives and functional statements. Alternative solutions can be used in lieu of compliance with the acceptable solutions. However, to do something different from the acceptable solutions described in Division B, a builder, designer or building owner must show that the proposed alternative solution will perform at least as well as the acceptable solution(s) it is replacing. The objectives and functional statements attributed to the acceptable solution(s) identify the areas of performance where this equivalence must be demonstrated.
- Division C contains administrative provisions. Many provinces and territories establish their own administrative provisions upon adopting or adapting the NBC. Having all the administrative provisions in one Division facilitates their customization to suit jurisdictional needs. In the absence of provincial or territorial regulations or municipal bylaws on the administration of the Code, the Administrative Requirements for Use with the National Building Code of Canada 1985 can be used.

Referenced Standards

NBC Part 9 references more than 180 standards published by various standards-writing organizations. Some standards provide detailed installation instructions for materials, equipment or services, others define test methods, while others describe the characteristics of products ranging from elementary building materials to complex systems. Standards vary from simple one- or two-page statements to voluminous codes of practices that rival the NBC in complexity. Code users should always verify that the standard edition they are using is the one currently referenced in the NBC.

Some standards set out different objectives and performance levels from those presented in the NBC, which occasionally results in differences between specific requirements in the NBC and those in the referenced standards. In such cases, the NBC requirements take precedence over those in referenced standards. Requirements from referenced standards are not usually duplicated in the NBC unless there is a valid reason for doing so.

Conformance Assessment

While the NBC generally does not require building products to be certified, a building official may require proof of a product's compliance with standards that are considered to be particularly critical before it is permitted to be used. The official may require the product to be tested and certified by an independent third party, and to be identified with a label or stamp attesting to its certification, even though this may not be required by the NBC. Fire alarm and detection devices, prefabricated chimneys, fire doors, and heating, electrical and plumbing equipment are products for which independent certification and labelling are the most practical means for a building official to ensure compliance with a prescribed standard, since such compliance cannot be determined by visual inspection. This certification and labelling is not required by the NBC—it is simply a convenient administrative arrangement between the building permit applicant and the building official.

In some cases, NBC Part 9 requires products such as structural plywood, oriented strandboard (OSB) and lumber to be identified by a label or stamp. The majority of materials do not carry labels, so the enforcing official (or the purchaser) usually relies on the integrity of the manufacturer. In many cases, manufacturers conform to national standards as a matter of policy, either to protect their public image or to guard against legal challenges from building authorities or from purchasers. Should a failure occur as a result of a non-conforming product, legal steps can be taken to have the situation corrected, and this liability also acts as a deterrent against non-conforming products. In the majority of cases, therefore, self-policing by manufacturers is responsible for compliance to standards where a product is not certified or identified by a label or stamp. In general, all materials, appliances, systems and equipment, including those that are not specifically addressed in the NBC, must be suitable for their intended purpose.

Many manufacturers have their innovative materials, systems and equipment evaluated by the Canadian Construction Materials Centre (CCMC) or other evaluation agencies or testing laboratories to demonstrate their compliance with the Code. CCMC's Registry of Product Evaluations, which describes the products that have been evaluated for Code conformance, is available at www.nrc-cnrc.gc.ca/eng/solutions/advisory/ccmc/registry_product_evaluations.html.

Climatic Information

Climatic information for the design of buildings must be in conformance with values established by the provincial, territorial or municipal authority having jurisdiction. In the absence of such data, refer to the climatic values referenced in NBC Appendix C, which form the basis of the values used by most authorities. NBC Appendix C includes climatic and seismic data for 679 Canadian municipalities. Climatic information, particularly ground snow load data, is needed for the proper application of the requirements in NBC Part 9. For instance, the maximum span for roof framing members depends on the design snow load. The depth of frost penetration, which influences the location of footings, is established on the basis of local experience.

Part 9

The objectives of NBC Part 9 are to provide minimum acceptable levels of health, fire safety and accessibility, as well as of structural safety, structural sufficiency and energy efficiency. NBC Part 9 applies to new buildings and to the demolition, relocation, alteration and change in use of existing buildings. See Guide 9.1., General, for more specific information.

Evolution of NBC Part 9

Before NBC Part 9 existed as a separate part in the NBC, the Canada Mortgage and Housing Corporation (CMHC) issued its own standards for housing. It continued to do so until 1958, when it relinquished this role to the National Research Council of Canada (NRC) and the Associate Committee on the National Building Code (ACNBC), now known as the Canadian Commission on Building and Fire Codes (CCBFC). Until 1958, CMHC Building Standards co-existed with the NBC as separate and distinct requirements, even though there were similarities between the two. Subsequent to ACNBC involvement, the CMHC requirements were melded with those of the NBC, with the resulting requirements reflecting both sets of standards. Many of the detailed specification-type requirements in NBC Part 9 can be traced back to CMHC requirements, which helps to explain the unique style of NBC Part 9.

Soon after the publication of the first edition of the NBC in 1941, it became evident that many municipalities lacked the expertise to enforce its complex requirements. Smaller municipalities were chiefly concerned with small, simple buildings such as houses, and requirements directed at larger, complex buildings had little relevance to them. To accommodate these municipalities, a separate, abridged form of the NBC was published, which was restricted in scope to relatively small buildings and to lower-risk types of occupancies.

The trend in recent editions has been to make NBC Part 9 consistent with the other Parts of the NBC and to replace duplicated requirements with cross-references to similar requirements found elsewhere in the NBC. Requirements affecting only a small portion of the buildings within the scope of NBC Part 9 and intended primarily for larger, complex buildings have been gradually deleted in favour of cross-references. For example, requirements relating to noncombustible construction, firewalls, atria and sprinkler systems are no longer found in NBC Part 9, having been replaced by appropriate references to NBC Part 3.

Since the 2005 edition of the NBC, in which the objective-based approach was introduced, it has become more common to have performance-based requirements alongside the prescriptive, deemed-to-comply requirements.

Organization of NBC Part 9

NBC Part 9 is divided into 37 Sections (see the table below). NBC Sections 9.1. to 9.36. include requirements that correspond to subjects covered in other Parts of the NBC as follows:

- use and egress and fire protection requirements such as those in NBC Part 3;
- building structure requirements that perform a similar role to NBC Part 4;
- environmental separation requirements that serve a similar function to NBC Part 5; and
- building services requirements that are related to NBC Parts 6 and 7.

NBC Section 9.37. contains all the objective-based attributions for each requirement, which facilitate the development and implementation of alternative solutions.

Contents of NBC Part 9

NBC Section	Use and Egress	Fire Protection	Building Structure	Environmental Separation	Building Services
9.1.	General				
9.2.	Definitions				
9.3.		Materials, Systems and Equipment			
9.4.			Structural Requirements		
9.5.	Design of Areas and Spaces				
9.6.				Glass	
9.7.				Windows, Doors and Skylights	
9.8.	Stairs, Ramps, Handrails and Guards				
9.9.	Means of Egress				
9.10.		Fire Protection			
9.11.				Sound Transmission	
9.12.			Excavation		
9.13.				Dampproofing, Waterproofing and Soil Gas Control	
9.14.				Drainage	
9.15.			Footings and Foundations		
9.16.				Floors-on-Ground	
9.17.			Columns		
9.18.				Crawl Spaces	
9.19.				Roof Spaces	
9.20.			Masonry and Insulating Concrete Form Walls Not in Contact with the Ground		
9.21.		Masonry and Concrete Chimneys and Flues			Masonry and Concrete Chimneys and Flues
9.22.		Fireplaces			
9.23.			Wood-Frame Construction		
9.24.			Sheet Steel Stud Wall Framing		
9.25.				Heat Transfer, Air Leakage and Condensation Control	
9.26.				Roofing	
9.27.				Cladding	
9.28.				Stucco	
9.29.		Interior Wall and Ceiling Finishes			
9.30.	Flooring			Flooring	
9.31.					Plumbing Facilities
9.32.					Ventilation
9.33.					Heating and Air-conditioning
9.34.					Electrical Facilities
9.35.			Garages and Carports		
9.36.				Energy Efficiency	
9.37.	Objectives and Functional Statements				

Notable Changes Affecting Part 9 in NBC 2015

Soft Conversions

Note A-9.4.2.1.(1) has been added to clarify that not all metric measurements stated in the NBC are exact conversions of imperial measurements. Both exact and soft conversions are used. For example, exact conversions are given for the dimensions of milled wood products, whereas soft conversions are given for spacings between framing elements. Where soft metric conversions are given, it is assumed that the actual construction will follow common practices based on imperial or metric measurements.

Doors with a “Limited Water” Rating

A section entitled Performance of Doors: Limited Water Ingress Control has been added to NBC Note A-9.7.4.2.(1). This section explains what a door with a “limited water” (LW) rating is and describes the permitted applications of such doors.

Where their tested water penetration resistance does not meet the specific driving rain wind pressure for the building location, LW-rated doors should only be installed in protected locations where they are not exposed to rain, such as under a porch roof or an overhang. What is considered a protected location for a door is dependent on the location of the building. For example, in locations with a high intensity of wind-driven rain, an overhang may not provide adequate protection for LW-rated doors.

Stairs, Handrails and Guards

The following modifications relating to stair terminology have been made to improve clarity:

- A definition of “flight” as a series of steps between landings has been added to NBC Article 1.4.1.2. of Division A.
- A definition of “run” as the horizontal distance between two adjacent tread nosings on a stair has been added to NBC Article 1.4.1.2. of Division A. In contrast, “tread depth” is the horizontal distance between the tread nosing and the riser.
- A definition of “tapered tread” as a non-rectangular tread which can be used in curved flights has been added to NBC Article 1.4.1.2. of Division A. In contrast to treads in winders, which converge on a centre point, tapered treads must have a minimum run at their narrow end.
- The term “angled tread” has been removed.
- Note A-9.8.4.7. explaining the term “spiral stair” has been added.

The following modifications relating to tread dimensions and stair configurations have been made in NBC Subsection 9.8.4. to improve safety and design flexibility:

- The minimum run for rectangular treads in private stairs has been increased.
- The run limits for tapered treads have been revised to align with those for rectangular treads.
- Mixed-run flights are now generally permitted with restrictions on the uniformity of the runs of the treads.
- Spiral stairs are now permitted in certain applications, and have different tread dimension, clear width and clear height requirements from other types of stairs.

The following modifications relating to handrails and guards have been made in NBC Subsections 9.8.7. and 9.8.8. to improve safety and design flexibility:

- The maximum height of handrails has been increased to 1 070 mm (42 in.), which improves design flexibility by allowing the tops of most guards to function as handrails.
- The requirements relating to the continuity of handrails have been revised for clarity and for consistency with an accompanying explanatory Note, international regulations, and current practices.
- Required guards in occupancies other than industrial occupancies that protect a level not more than 4.2 m (13 ft. 9 3/8 in.) above the adjacent level are now exempted from the restrictions on the design of guards to not facilitate climbing.

- Larger openings are now permitted in guards in industrial occupancies other than storage garages for harmonization with Canadian and international regulations.

Protection above Cooktops

Note A-9.10.22. has been modified to clarify that the minimum vertical clearances above cooktops do not apply to microwave ovens or range hoods, as these appliances are already regulated for fire safety. The clearances only apply to combustible framing, finishes and cabinetry.

Apparent Airborne Sound Transmission

NBC Section 9.11. and its accompanying explanatory Notes have been restructured and modified to include a new sound transmission metric, the apparent sound transmission class (ASTC), in addition to the existing sound transmission metric, the sound transmission class (STC).

In previous editions of the NBC, NBC Section 9.11. required that separating assemblies provide a minimum STC rating, which is a laboratory rating of direct sound transmission through the separating assembly. In the NBC 2015, this Section permits separating assemblies to provide a minimum ASTC rating as an alternative to the minimum STC rating. The ASTC rating, which describes both direct sound transmission through the separating assembly and flanking sound transmission through its flanking assemblies, must be determined either by field measurement or by calculation.

The explanatory Notes discuss the STC and ASTC rating systems and flanking sound transmission, which is a major contributor to sound transmission. They also provide options for the design and construction of junctions and flanking surfaces between separating wall and floor/ceiling assemblies, which are intended to reduce flanking sound transmission and improve acoustic performance.

Snow Loads

The snow load values listed in NBC Table C-2 of Appendix C for selected locations in Canada have been updated.

Seismic Loads

The seismic hazard values listed in NBC Table C-3 of Appendix C for selected locations in Canada have been updated.

In previous editions of the NBC, some of the prescriptive solutions in NBC Subsection 9.23. did not apply to buildings in locations where the spectral response acceleration, $S_a(0.2)$, was more than 1.2; consequently such buildings were required to be designed according to NBC Part 4. In the NBC 2015, this Subsection has been modified to include higher performance prescriptive solutions that allow buildings in locations where $S_a(0.2)$ is more than 1.2 but not more than 1.8 to be constructed without being designed according to NBC Part 4. These solutions include features intended to increase the resistance of braced wall bands to lateral loads, such as reduced spacing between anchor bolts, additional fasteners at splices in doubled top plates, perpendicular blocking between wall studs, and thicker sheathing.

Low Permeance Materials

NBC Article 9.25.5.1. has been modified to exempt additional materials from compliance with NBC Article 9.25.5.2. Materials with a water vapour permeance of at least 30 ng/(Pa·s·m^2) (0.5 perm) and a thermal resistance of at least 0.7 (m^2·K)/W (R4), can be used in building locations with less than 6 000 heating degree-days without having to conform to NBC Article 9.25.5.2.

Recent research has shown that assemblies constructed with these materials as exterior insulation generally have less risk of moisture condensation than assemblies constructed with wood-based sheathing materials and without exterior insulation.

Exterior Insulation Finish Systems

NBC Subsection 9.27.13. has been added to provide a prescriptive compliance path for exterior insulation finish systems (EIFSs). In previous editions of the NBC, the only compliance path for EIFSs was through design according to NBC Part 5.

NBC Subsection 9.27.13. references three new ULC standards and requires that an EIFS have a geometrically defined drainage cavity with a minimum cavity depth of 10 mm (3/8 in.) and an open area equal to not less than 13% of the area of the EIFS panel.

Section 9.1. General

Introduction

The application of NBC Part 9 is limited by building size and occupancy (according to NBC Article 1.3.3.3. of Division A). In particular, NBC Part 9 applies to all single, detached, semi-detached, and row houses (as well as to their ancillary garages), whether site-assembled, manufactured or factory-built, that are three storeys or less in building height and that have a building area not exceeding 600 m² (6 458 ft.²).

9.1.1. Application

9.1.1.1. Application

This Article, by reference to NBC Subsection 1.3.3. of Division A, indicates that the application of NBC Part 9 is limited to buildings not exceeding a certain size that are used for certain occupancies. Buildings that are used for other occupancies or that exceed the specified size limits require special fire and structural safety features and are beyond the scope of the simplified requirements in NBC Part 9. Such buildings are regulated by the requirements in other Parts of the NBC. NBC Part 9 must be used in conjunction with NBC Parts 1, 2, 7 and 8, which apply to all buildings regardless of size or occupancy.

Many enforcement officials and designers refer to buildings within the scope of NBC Part 9 as “Part 9 buildings,” while those buildings regulated by other Parts of the NBC are generally referred to as “Part 3 buildings” or sometimes “Part 4 buildings.” However, the latter labels are misleading, since buildings that do not fall within the scope of NBC Part 9 must satisfy the requirements of all other Parts of the NBC, not just those in NBC Part 3 or 4.

NBC Part 9 is not only applicable to the design, construction and occupancy of new buildings, but is also applicable to the reconstruction, demolition, removal, relocation and occupancy of existing buildings (NBC Sentence 1.1.1.1.(1) of Division A). NBC Part 9 is most often applied to existing buildings when an owner plans to rehabilitate a building, change its use, or build an addition, or when an enforcement authority decrees that a building or a class of buildings must be altered for reasons of public safety. The degree to which requirements can be modified for application to an existing building without affecting the intended level of safety requires considerable judgement on the part of the designer and the authority having jurisdiction. New requirements are not intended to be applied retroactively to existing buildings that are not being modified.

Factory-Constructed Buildings

The requirements of NBC Part 9, and the Code in general, apply to both site-built and factory-constructed buildings (NBC Sentence 1.1.1.1.(2)). However, it can often be difficult to determine whether a factory-constructed building complies with these requirements once it has been delivered to its construction site because many of the wall, roof and floor assemblies are closed in, so their components cannot be inspected. CSA A277, “Procedure for Factory Certification of Buildings,” was developed to address this problem with regard to residential, commercial and industrial buildings. This standard describes a procedure whereby an independent certification agency can review the quality control procedures of a factory and make periodic, unannounced inspections of its products.

CSA A277 is not a building code, only a procedure for certifying compliance of factory-constructed components with a building code or other standard. If a factory-constructed building bears the label of an accredited certification agency indicating that compliance with the NBC has been certified using the CSA A277 procedure, the accepting authority will have some assurance that the hidden components do not require re-inspection on site.

On the other hand, standards in the CSA Z240 MH Series, “Manufactured Homes,” do resemble a building code. Most of the individual standards in the series contain requirements regarding many issues also covered by the NBC. Some of these provisions are performance requirements with no quantitative criteria, some simply reference the applicable NBC requirements, and others contain requirements that differ from those in the NBC. Because it would be illogical to have two different sets of requirements for buildings—one set that applies to site-built buildings and one set that applies to factory-constructed buildings—the NBC does not reference these standards. One of the individual standards in the CSA Z240 MH Series deals with special requirements for manufactured homes related to the fact that these house must be moved over roads, which is an issue the NBC does not address. Therefore, labelling that indicates that a factory-constructed house complies with the CSA Z240 MH Series cannot be taken as an indication that the house necessarily complies with the building code in effect for the location where the house will be sited.

The NBC does reference CSA Z240.10.1, “Site Preparation, Foundation, and Anchorage of Manufactured Homes,” which is not actually part of the CSA Z240 MH Series. This standard contains requirements for surface foundations where factory-constructed buildings—not just houses—comply with the deformation resistance test provided in CSA Z240.2.1, “Structural Requirements for Manufactured Homes,” which measures a building’s resistance to damage caused by racking. Unlike conventional site-built buildings, which have little tolerance for foundation movement, factory-constructed buildings are designed to resist deformation while in transit. Buildings that pass the deformation resistance test can be placed on shallow foundations complying with CSA Z240.10.1 (NBC Article 9.15.1.3) and anchored in conformance with the requirements of CSA Z240.10.1 (NBC Article 9.23.6.3.).

Seasonally and Intermittently Occupied Buildings

In Part 9 of the NBC 1990, requirements for double-glazed windows, insulation, air barriers, and vapour barriers in residential buildings intended for use on a continuing basis during the winter months were formally introduced to protect the structure of such buildings from water damage by reducing condensation in walls and ceilings. It is well known that deterioration caused by condensation occurs even when buildings are occupied intermittently during the heating season, such as on weekends or short holidays. Since the NBC 1990 requirements were specific to use during the winter months, it was not necessary to apply these requirements if a building was not used or heated during these periods. In fact, houses were constructed without certain elements or with elements that did not meet the minimum NBC 1990 requirements on the basis of seasonal use only.

The trend has been to prolong the use of summer houses beyond the warmer months and to install appliances previously found only in urban households. This has made it difficult for building officials to determine if a building will only be used during the warm weather months.

In the NBC 1995, this ambiguity was addressed by removing the phrase “intended for use on a continuing basis during the winter months” from the window and insulation sections of NBC Part 9 and adding a reference to “seasonally and intermittently occupied buildings” in NBC Note A-9.1.1.1.(1). As explained in this Note, NBC Part 9 provides some flexibility for situations where exemptions from certain NBC requirements will not compromise the health and safety objectives of the NBC. Table 9.1.-A lists a number of possible exemptions.

Table 9.1.-A
Exemptions from NBC Requirements for Certain Building Conditions

Building Condition	Exemptions
No heating system	No thermal insulation required (NBC Article 9.25.2.1.)(1) No air barrier system required (NBC Article 9.25.3.1.)(2)
No thermal insulation	No vapour barrier required (NBC Article 9.25.4.1.)(3)
No piped water supply	No plumbing fixtures required (NBC Article 9.31.4.1.)
No electrical services	No electrical facilities required (NBC Article 9.34.1.2.) No mechanical ventilation required (NBC Clause 9.32.1.2.(1)(b))(4)
Exposed surfaces of wall and ceilings in a detached building meet flame-spread rating required in NBC Subsection 9.10.17.	No interior finishes required, except where waterproof finishes required(5)

Table 9.1.-A (Continued)

Notes to Table 9.1.A.:

(1) Should a heating system be installed, thermal insulation will then be required.
(2) An air barrier system is required where the building space is conditioned.
(3) Should thermal insulation be installed, a vapour barrier will then be required.
(4) Mechanical ventilation is required where electrical power and a heating system are provided.
(5) Where two units adjoin, additional fire resistance requirements may apply to interior loadbearing walls, floors, and the shared wall (NBC Article 9.10.8.3, and NBC Subsections 9.10.9. and 9.10.11.).

Farm Buildings

Farm buildings that are not residences normally do not have to comply with regular NBC provisions. Farm buildings that have only a few occupants during normal use (not more than one person per 40 m^2 (430 $ft.^2$) of floor area) are covered by the National Farm Building Code of Canada (NBC Sentence 1.1.1.1.(3) of Division A), which permits somewhat lower levels of structural and fire safety than permitted by Part 9.[1]

Occupancy Classification of Buildings

Since NBC Part 9 applies only to buildings used for certain occupancies, one of the first things to establish when applying the NBC to a building is the occupancy classification of the building (see also NBC Subsection 9.10.2.). A building's occupancy classification is important not only for determining whether the building falls within the scope of Part 9, but also for the proper application of many fire protection and egress requirements.

Descriptions of the various occupancies covered by NBC Part 9 (according to NBC Article 1.3.3.3. of Division A) are provided in Table 9.1.-B.

Table 9.1.-B
Occupancies Covered by Part 9 (NBC Article 1.3.3.3. of Division A)

Occupancy	Designation	Description of Use	Examples
Residential	Group C	Sleeping rooms for persons who are not detained involuntarily or who do not need care or treatment	Houses, hotels, dormitories, boarding or lodging houses, motels, apartments, convalescent and children's custodial homes, houses with a secondary suite
Business and personal services	Group D	Transaction of business or for personal or professional services	Banks, barbershops, dental offices, medical offices, offices, tool rental, appliance service
Mercantile	Group E	Display of merchandise or sale of retail goods	Stores, supermarkets, shops
Medium-hazard industrial	Group F, Division 2	Making, repairing or storing goods or materials (combustible content > 50 kg/m^2 or 1 200 MJ/m^2)	Warehouses, workshops, salesrooms, factories, planing mills, repair garages, laboratories, service stations
Low-hazard industrial	Group F, Division 3	Same as above but with low fire load (combustible content ≤ 50 kg/m^2 or 1 200 MJ/m^2)	Creameries, factories, laboratories, storage garages, salesrooms, warehouses, storage rooms, workshops

Buildings are classified according to their major occupancy, which is defined as the principal use of a building. It is not unusual, however, for a building to contain a number of different occupancies that are ancillary or subsidiary to the principal occupancy. A store, for example, is a major occupancy classified as "mercantile" (see Table 9.1.-B). It may have an ancillary office area, which would be classified as "business and personal services," and a storage area, which would be classified as "industrial." These ancillary occupancies do not affect the major occupancy classification of the building.

On the other hand, a building may be classified as having two or more major occupancies if the activities of each are unrelated to the other. For example, a building may consist of a portion intended for office rental space (business and personal services) and a portion rented separately as apartment units (residential).

(1) National Farm Building Code of Canada 1995, NRCC 38732, National Research Council of Canada, Ottawa, 1995.

Because each of these activities is separate from the other, the building must be classified under both major occupancies. If one of the major occupancies were not regulated under NBC Part 9, the entire building would fall outside the scope of NBC Part 9 and be regulated by other Parts of the NBC.

The classification of most small buildings is straightforward, since only one major occupancy is usually involved. In some cases, however, the distinction between a major occupancy and a subsidiary occupancy is not clear cut, and judgement is required. The ramifications for fire safety must be weighed when any judgment of this kind is made. (See Guide 9.10., Fire Protection, for a fuller discussion of fire protection issues.)

Table 9.1.-C lists the occupancies not covered by NBC Part 9.

Table 9.1.-C
Occupancies Not Covered by Part 9

Occupancy	Designation	Description of Use	Examples
Assembly	Group A	Gatherings or meetings of people for functions or events, or for dining and drinking	Theatres, auditoriums, bowling alleys, churches (places of worship), stadiums, dance halls, gymnasiums, pubs, restaurants, schools, swimming pools
Care, treatment or detention	Group B	Housing people for correctional or medical purposes, or housing people with special needs due to age or mental condition	Jails, prisons, hospitals, nursing homes, orphanages, reformatories, residential care facilities
High-hazard industrial	Group F, Division 1	Making, repairing, or storing goods or materials with highly flammable or explosive properties	Feed mills, flour mills, distilleries, spray painting operations, paint plants, chemical plants, grain elevators

Determination of Building Height and Area

Since NBC Part 9 only applies to buildings of three storeys or less in building height having a building area of not more than 600 m^2 (6 458 $ft.^2$), the height and area of a building must be determined to see if it falls within the scope of Part 9. See also Guide 9.10.4., Building Size Determination.

The elevation of grade must first be established since this is the datum from which the building's height is measured. The average ground elevation adjacent to each face of the building is first determined. Grade is then defined as the lowest of these average levels (Figure 9.1.-1).

The determination of a building's height and area is shown in Figure 9.1.-2.

The first storey, by definition, is the uppermost storey having its floor level not more than 2 m (6 ft. 7 in.) above grade (Figure 9.1.-3). Only the first storey and the storeys above it are counted to determine the building's height.

Not all spaces constitute storeys that contribute to building height. For example, roof-top enclosures that are used to enclose service rooms, elevator machinery, or stairs are not counted as storeys (NBC Article 9.10.4.4.). Unfinished attics are also not counted as storeys.

Once the building's height is known, the building's area must also be determined to see if the building is within the scope of Part 9. Building area is defined as the maximum horizontal area of a building above grade. It is measured to the outside surfaces of the exterior walls and, where the building is divided by a firewall, to the centre line of the firewall (Figure 9.1.-4). Although the maximum horizontal area of a building usually occurs on the first storey, it can also occur on the second or third storey in some designs.

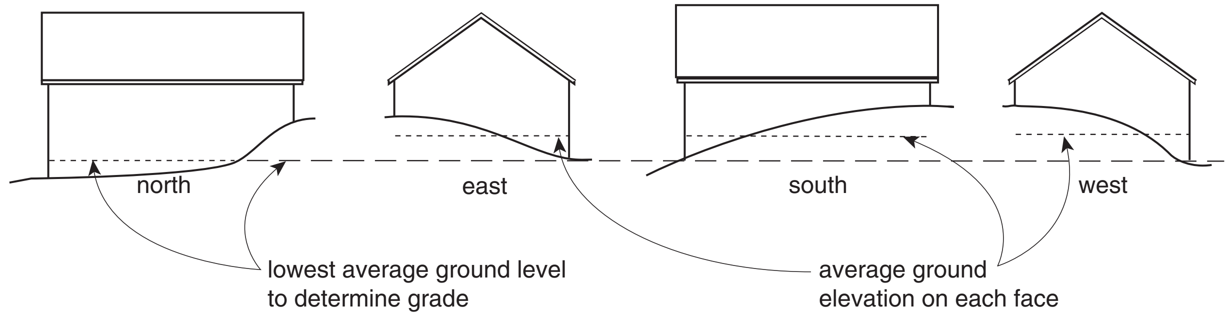


Figure 9.1.-1
Determination of grade

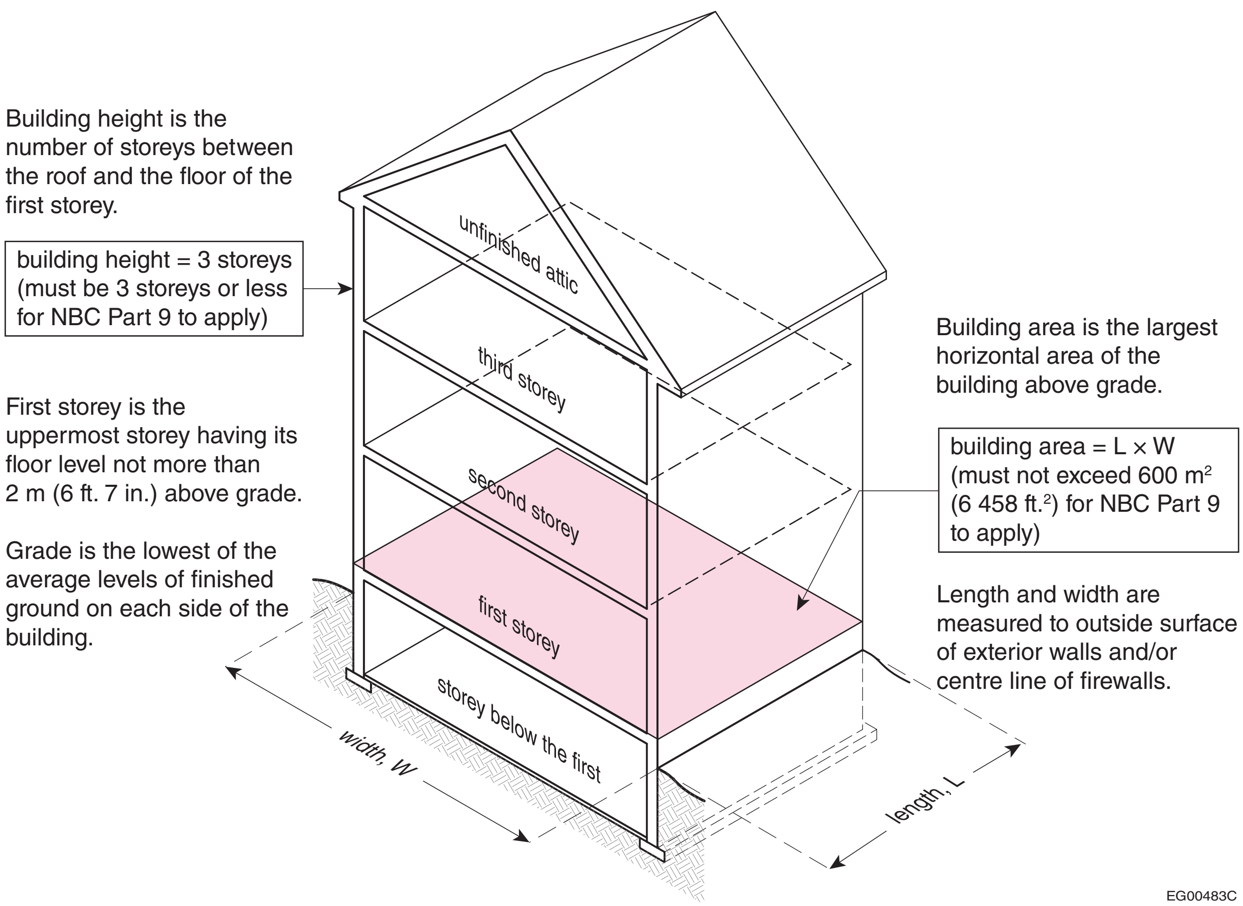


Figure 9.1.-2
Determination of building height and area (NBC Article 1.3.3.3. of Division A)

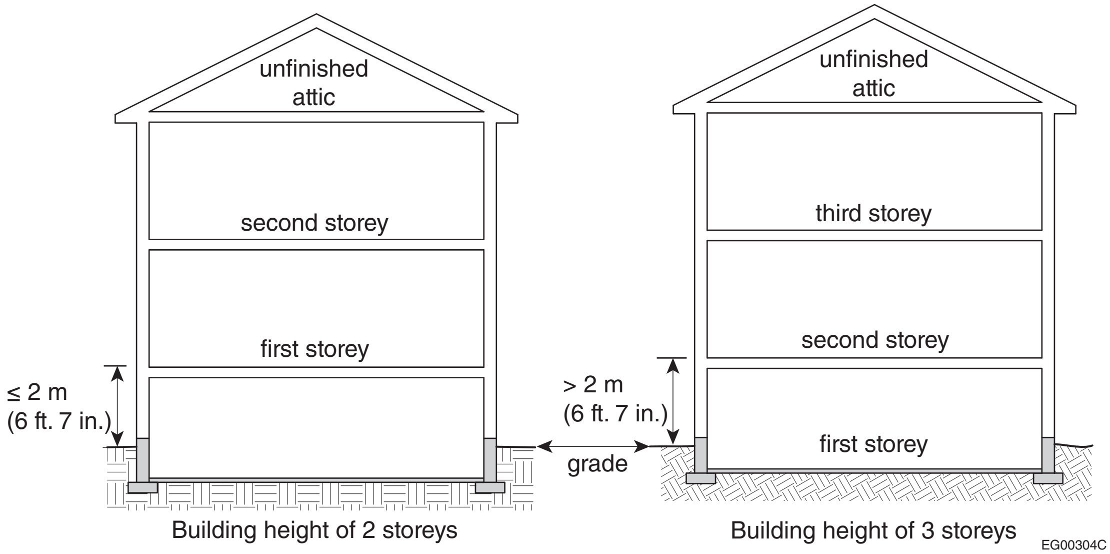


Figure 9.1.-3
Definition of first storey

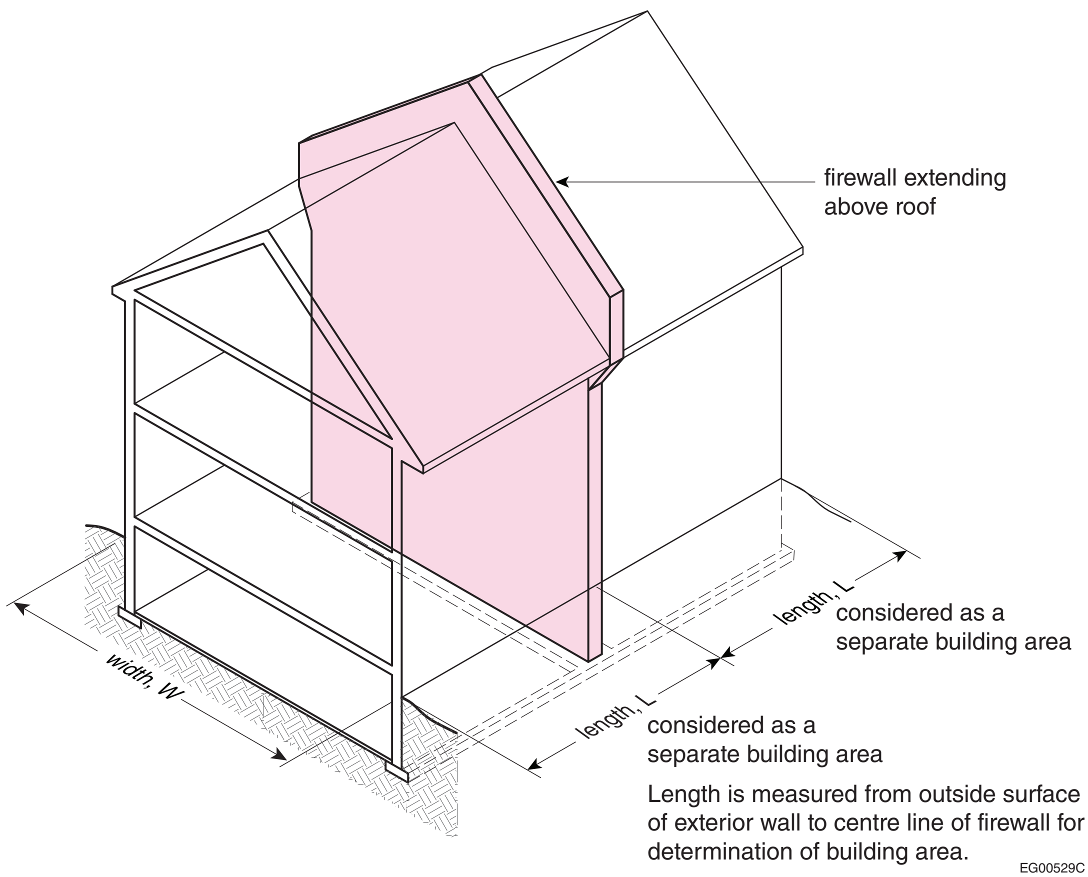


Figure 9.1.-4
Buildings separated by a firewall (NBC Article 1.3.3.4. of Division A)

Buildings Separated by Firewalls

Where a firewall divides a building, each portion of the building is considered as a separate building for the determination of building size (NBC Article 1.3.3.4. of Division A), as shown in Figure 9.1.-4. See NBC Subsections 3.1.10. and 9.10.11. for additional information about firewall construction.

Most walls that separate one property from another are required to be firewalls (walls between semi-detached and row houses are exceptions to this rule). Firewalls are fire separations that have special features to ensure their stability in the event of a fire (NBC Subsection 3.1.10.), so that, should the building on one side of the firewall be destroyed, the firewall and the building on the other side will remain.

Firewalls may be voluntarily used to reduce the building area in order to take advantage of certain fire and structural concessions permitted for smaller buildings. Firewalls are frequently used to create buildings of 600 m^2 (6 458 $ft.^2$) that fall within the scope of NBC Part 9. For example, in some row houses, ordinary fire separations are used between most units, while firewalls are used at 600 m^2 (6 458 $ft.^2$) intervals.

Residential Buildings on Sloping Sites

Where dwelling units in a building are completely separated from other dwelling units by a vertical fire separation having a fire-resistance rating of not less than 1 h, each dwelling unit may be considered as a separate building for the purpose of determining building height, provided that each dwelling unit is not more than four storeys in building height and that the unobstructed path of travel for a firefighter from the street to an entrance of each dwelling unit is not greater than 45 m (147 ft.) (NBC Sentence 1.3.3.4.(2) of Division A). The fire separation has to be complete, extending through all storeys and service spaces from the basement or crawl space (or from the floor assembly immediately above the basement where the basement conforms to NBC Article 3.2.1.2.) up to the underside of the roof deck.

Accordingly, the stepped building on a sloping site shown in Figure 9.1.-5 can be considered as being three storeys in building height instead of six storeys in building height and is, therefore, covered by NBC Part 9. (See also NBC Note A-1.3.3.4.(2) of Division A.)

Mezzanines and Lofts

Mezzanines that are essentially open to view, so that a fire on the mezzanines would be visible from the room below and vice versa, do not have to be counted as a storey if their aggregate area does not exceed 40% of the open area of the room (Figure 9.1.-6) (NBC Sentence 9.10.4.1.(2)).

If, however, the condition for visual communication is not met from above or below the mezzanines, the mezzanines are only permitted to not be counted as a storey if their aggregate area does not exceed 10% of the floor area of the building in which they are located and if the area of each mezzanine does not exceed 10% of the area of the suite in which it is located (Figure 9.1.-7) (NBC Sentence 9.10.4.1.(1)).

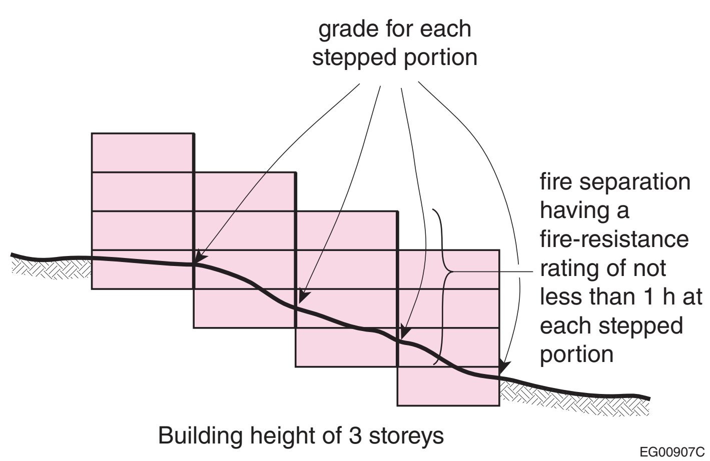


Figure 9.1.-5
Determination of building height on sloping sites (NBC Article 1.3.3.4. of Division A)

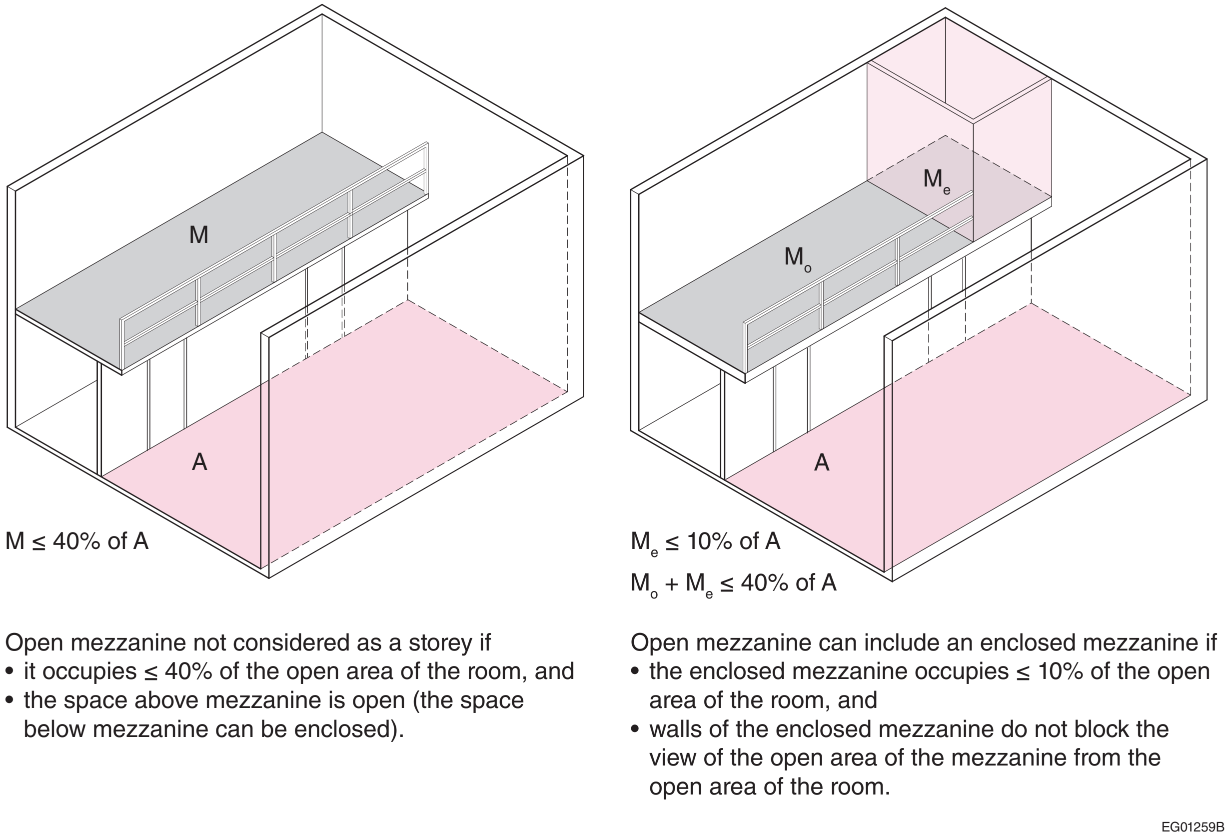


Figure 9.1.-6
Open mezzanines not considered as a storey (NBC Article 9.10.4.1.)

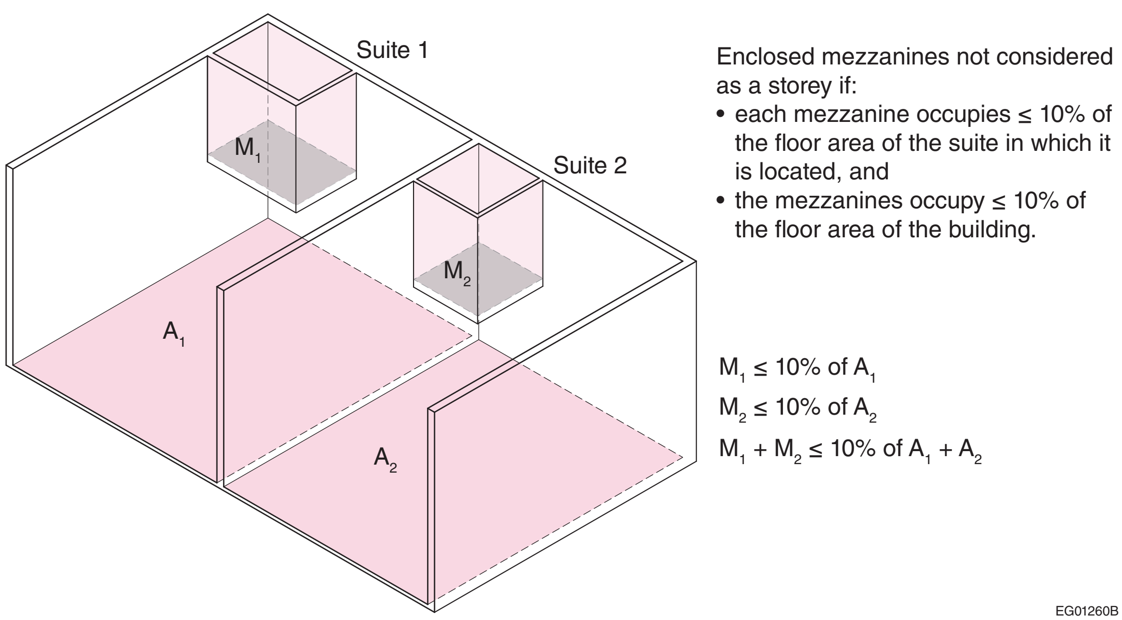


Figure 9.1.-7
Enclosed or visually obscured mezzanines not considered as a storey (NBC Article 9.10.4.1.)

Parking Garage Considered as a Separate Building

Sometimes several buildings are built over a common basement used as a parking garage. For example, in certain housing designs, separate low-rise buildings are built over a common basement parking garage (Figure 9.1.-8).

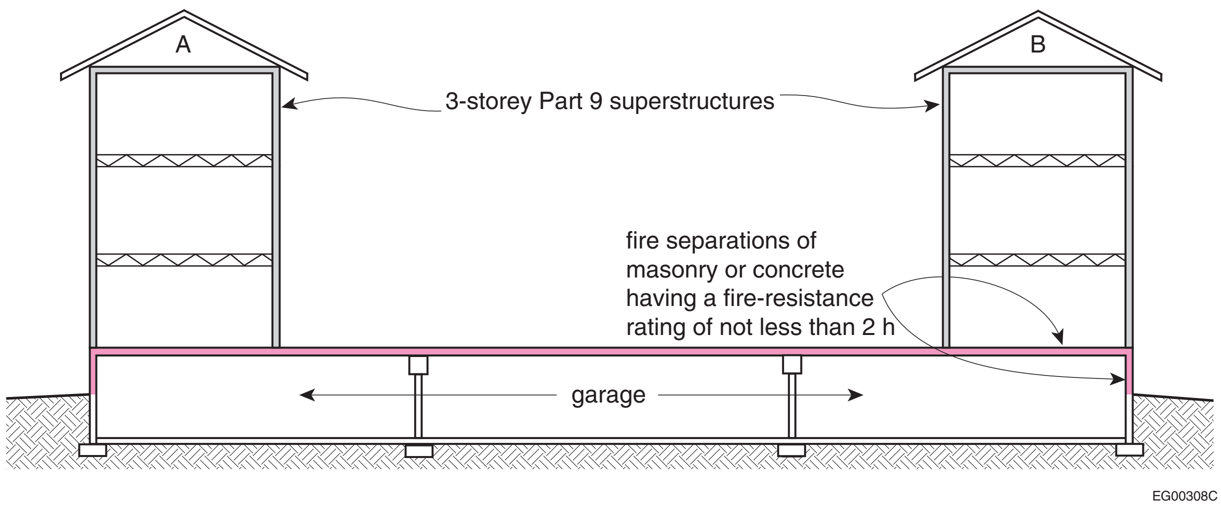


Figure 9.1.-8
Buildings separated from a basement parking garage by a floor slab constructed as a 2 h fire separation (NBC Article 9.10.4.3.)

Ordinarily, such a structure would be considered a single building, and the building area would be the area of the basement parking garage. Because this area tends to be fairly large, the entire building would normally fall outside the scope of NBC Part 9. If, however, the basement parking garage is separated from the buildings above it by a concrete or masonry slab having a fire-resistance rating of at least 2 h, these buildings can be considered separate buildings (NBC Article 9.10.4.3). The separating slab is similar to a firewall in that it creates separate buildings. The walls of the parking garage projecting above the adjoining ground level also have to be constructed as 2 h fire separations. If the parking garage is covered by NBC Part 3, the walls are only permitted to have openings if the requirements of NBC Sentence 3.2.1.2.(2) are met, which are intended to prevent the spread of fire through the openings to the storeys above.

In Figure 9.1.-8, buildings A and B would be considered as separate buildings having their own building areas and would probably fall within the scope of NBC Part 9. The parking garage, however, would probably fall outside of the scope of NBC Part 9 because of its large area.

9.1.2. Limits on Floor Area

9.1.2.1. Floor Area Limits for Secondary Suites

This Article limits the application of NBC Part 9 to secondary suites with a total floor area not more than 80 m² (860 ft.²) or 80% of the total floor area of the other dwelling unit (excluding their common spaces), whichever is smaller.

Section 9.2. Definitions

9.2.1. General

9.2.1.1. Defined Words

Words shown in italics in the NBC have meanings specific to the context of the NBC. Their meanings may differ from the definitions found in dictionaries. These italicized words are defined in NBC Article 1.4.1.2. of Division A.

Some terms in this Guide are defined in the sections in which they appear to help clarify some complicated subjects. In keeping with Code protocol, italics are not used for defined terms in this Guide.

Section 9.3. Materials, Systems and Equipment

Introduction

The materials, systems and equipment commonly used in the construction of buildings are covered by standards prepared by various organizations. These standards are referenced throughout NBC Part 9. NBC Section 9.3. was developed to provide requirements specific to three basic construction materials: concrete, wood and metal. The requirements for these materials apply to succeeding Sections of NBC Part 9 and will not be repeated elsewhere in NBC Part 9 in order to avoid unnecessary repetition. Additional requirements relating to these materials are provided as required in specific Sections of NBC Part 9.

9.3.1. Concrete

This Subsection applies to unreinforced and nominally reinforced concrete. Reinforced concrete must generally conform to the requirements of NBC Part 4. However, for reinforced concrete used in flat insulating concrete form walls not exceeding two storeys in building height that have a maximum floor to floor height of 3 m (9 ft. 10 in.), in buildings of light-frame construction containing only a single dwelling unit, the concrete and reinforcing must either comply with NBC Part 4 or meet the requirements of NBC Clauses 9.3.1.1.(4)(a) and (b).

NBC Part 9 does not have the necessary controls to ensure the adequate performance of reinforced concrete. Reinforced concrete is, therefore, regulated under NBC Part 4, which provides proper design and construction practices.

9.3.1.1. General

This Article references a number of standards and indicates in which circumstances concrete has to conform with the standards, NBC Section 9.3. or NBC Part 4.

9.3.1.2. Cement

This Article references a standard that contains chemical, physical and uniformity requirements for cement.

9.3.1.3. Concrete in Contact with Sulphate Soil

This Article references a standard that addresses the premature deterioration of concrete that is exposed to soils containing sulphate salts.

9.3.1.4. Aggregates

This Article presents requirements for aggregates in concrete. The composition of aggregates for concrete is controlled to avoid the premature deterioration of concrete due to organic materials and alkali salts. The grading of aggregates is also controlled to ensure that concrete is reasonably durable and waterproof and that it does not require an excessive amount of Portland cement.

Well-graded aggregate is necessary for strong, dense concrete. Using insufficient quantities of fine material to fill the voids between coarse aggregate results in weaker concrete with less resistance to the passage of water. On the other hand, if an excess of fine material is used, additional cement paste will be necessary to bind the individual aggregate particles together to obtain concrete of the same strength as concrete made with well-graded aggregate.

The proper placement and vibration of concrete is important to avoid the segregation of aggregates.

9.3.1.5. Water

This Article requires that water of a certain quality be used to ensure that the concrete will have sufficient strength and durability to fulfill its intended functions.

Cement, in combination with water, forms a paste that coats the individual aggregate particles. The aggregate particles become bound together in a solid mass when the cement reacts with the water in a process called hydration. Only a small amount of water is necessary to complete the hydration of the cement. Water in excess of this amount will produce voids in the cement paste when it evaporates, reducing the strength of the concrete. The water/cement ratio, therefore, controls the final strength of the concrete. In designing concrete mixes, a sufficient quantity of water must be used to produce a workable mix that will fill the forms without leaving voids or honeycombs, while maintaining a water/cement ratio that produces the required strength. Only the minimum amount of water needed to achieve workability should be added so as not to compromise the strength of the concrete.

For ready-mix concrete, workability is attained by the ready-mix concrete provider meeting the water/cement ratios set out in CSA A23.1, "Concrete Materials and Methods of Concrete Construction." For site-batched concrete and Class C2 concrete for garage floors, the slump test specified in CSA A23.1 may be used to determine the consistency of the concrete, which is sometimes used as an indicator of its workability. Slump is determined by filling a standard cone-shaped form with concrete and measuring the amount of settlement or slump that the concrete exhibits when the cone is removed.

In most areas, ready-mix concrete is used in preference to site-batched concrete because of its convenience and superior quality control. Adding water to ready-mix concrete on site to facilitate its distribution through the formwork can have several undesirable results, such as reduced strength, increased porosity, increased separation of the aggregate, and increased shrinkage cracking.

If concrete dries before hydration is well advanced, it will be weaker. The longer concrete is kept moist, the greater its final strength. Normally, about seven days of curing is recommended. Removing forms before the concrete has fully set may result in the sagging or deformation of walls. It may also cause inadequate curing, resulting in reduced strength and increased shrinkage cracking. It is important to ensure that concrete has adequately cured before applying any loads, including those resulting from backfilling.

9.3.1.6. Compressive Strength

This Article sets minimum compressive strength values for concrete in certain applications. Compressive strength is used as a measure of concrete quality in terms of strength, durability, and resistance to the penetration of water, vapour and gas.

The minimum compressive strength values required in this Article make no allowance for poor site practices, such as over-watering a mix to increase its workability. Compressive strength is measured by testing in compression small concrete cylinders of 100 or 150 mm (4 or 6 in.) in diameter. These cylinders are prepared when the concrete is placed and are tested after curing (usually for 28 days). Compressive strength is also used as an indicator of resistance to deterioration.

The minimum compressive strength for unreinforced concrete in walls, columns, fireplaces, chimneys, footings, foundation wall, grade beams, and piers is 15 MPa (2 176 psi) and that for unreinforced concrete in floors other than those in garages and carports is 20 MPa (2 900 psi). These values provide reasonable durability for non-severe exposure conditions.

The minimum compressive strength for unreinforced concrete in garage and carport floors, as well as in exterior steps, is 32 MPa (4 641 psi) or 30 MPa (4 351 psi) where indigenous aggregates do not achieve 32 MPa (4 641 psi) with a 0.45 water/cement ratio. These values, which may appear excessive relative to the strength requirements of these applications, are necessary to prevent the premature failure of the concrete under severe exposure conditions. An air entrainment of 5 to 8% is also required for site-batched concrete in these applications to reduce degradation caused by de-icing salts and exposure to freezing temperatures.

9.3.1.7. Concrete Mixes

This Article presents the acceptable water/cement ratios by weight for pre-mixed and site-batched concrete in a number of applications:
(a) 0.70 for walls, columns, fireplaces, chimneys, footings, foundation walls, grade beams, and piers;
(b) 0.65 for floors, other than those in garages and carports; and

(c) 0.45 for garage and carport floors, and exterior steps.

Excess water could lower the concrete strength and cause the aggregate to segregate. It could also affect the durability, drying shrinkage, and permeability of the concrete.

The mix proportions for site-batched concrete are provided in NBC Table 9.3.1.7. For these site-batched concrete mixes, a maximum aggregate size of 1/5 of the distance between the sides of vertical forms or 1/3 of the thickness of flatwork is established to allow concrete to flow around rebars in thin wall sections and to control segregation of the aggregate.

9.3.1.8. Admixtures

This Article references two standards, which describe the acceptable properties for admixtures in a number of applications. The quality and suitability of chemicals added to concrete need to be controlled because the improper use of chemical admixtures can reduce the strength and durability of the concrete.

Plasticizer admixtures can facilitate the placement of concrete without the decrease in strength that can result from the addition of excess water.

An air-entraining agent can be added to concrete to improve its workability. This type of chemical admixture creates minute bubbles in the concrete, making it more fluid. It also increases the concrete's resistance to freeze–thaw cycles and de-icing salts. The quantity of air-entraining agent added must be carefully controlled because an excess of this type of admixture can reduce the strength of the concrete.

9.3.1.9. Cold Weather Requirements

This Article addresses the mixing, placing and curing of concrete at low temperatures. When these steps are performed in cold weather, the temperature of the concrete must be controlled to obtain adequate strength, durability, permeability, and dimensional stability.

The temperature of the concrete must be maintained between 10 and 25°C (50 and 77°F) during mixing and placing when the air temperature is below 5°C (41°F). Concrete can be seriously damaged if it freezes before it sets. If the temperature is too high, concrete may flash-set before it can be properly placed or finished. Frozen material in the mix can reduce the temperature of the concrete and make it more vulnerable to freezing.

The hydration of concrete takes place over a long period of time. Although the initial hardening (also known as "setting") takes place over 48 h or less, depending on the temperature, the chemical reaction of the concrete with released water continues for several months. If freezing takes place before the initial hardening occurs, the strength of the concrete may be seriously reduced. For this reason, the temperature of the concrete must be maintained at not less than 10°C (50°F) for at least 72 h after placing when the air temperature is below 5°C (41°F).

9.3.2. Lumber and Wood Products

This Subsection presents requirements for lumber and wood products used in building construction.

9.3.2.1. Grade Marking

This Article requires that lumber for certain applications be marked with a grade stamp.

The National Lumber Grades Authority (NLGA) issues NLGA 2014, "Standard Grading Rules for Canada." Lumber used for joists, rafters, trusses and beams and for the purposes listed in NBC Table 9.3.2.1. is required to have a grade mark indicating its grade as determined by NLGA 2014.

A grade mark is a user's assurance that lumber has been inspected by a qualified grader who is regularly supervised for grading efficiency. Figure 9.3.-1 shows a typical lumber grade mark and the information it provides.

Each grade mark includes the registered symbol of the accredited agency under whose supervision the grading and marking was done. The grade mark also identifies the mill or grader (usually by number), the grading rule applied, the assigned grade, and the species or species combination. In addition, the grade mark may include indications relating to size and moisture content.

The moisture content indicated on a grade mark reflects the condition of the lumber at the time that it was planed or surfaced (dressed) to its finished size. Lumber is marked “S-DRY” if it was surfaced at a moisture content of 19% or less, and “KD” if it was kiln dried to a moisture content of 19% or less.

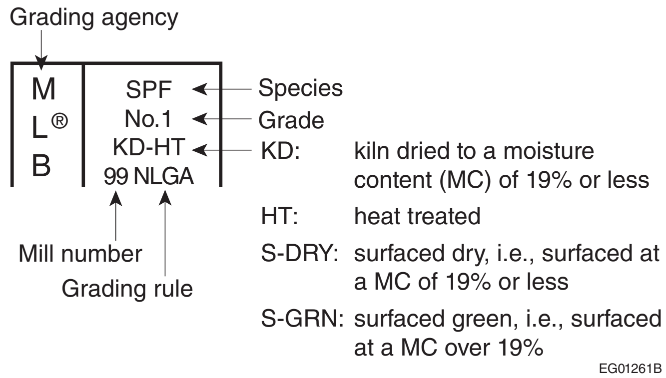


Figure 9.3.-1
Lumber grade mark

Facsimiles of typical grade marks used by lumber associations and grading agencies accredited by the Canadian Lumber Standards Accreditation Board (CLSAB) to grade mark lumber in Canada are provided in NBC Table A-9.3.2.1.(1)-B and in NLGA 2014. Accreditation by the CLSAB applies to the inspection, grading and grade marking of lumber, including mill supervisory services, in accordance with CSA O141, “Softwood Lumber,” and the CLSAB Regulations.

9.3.2.2. Lumber Grades

This Article requires that visually graded lumber, except for joists, rafters, trusses and beams, conform to the minimum lumber grades listed in NBC Table 9.3.2.1.

Lumber is a versatile material with a wide variety of uses, which have specific service requirements. Because it is a natural product made from trees of different species grown in different regions under a variety of conditions, it has a wide range of characteristics. Therefore, comprehensive grading rules have been developed to classify lumber according to its characteristics. The appearance of lumber may be important for some uses, while for other uses its bending or compressive strength may be more important. Grading must take into account the intended service use of the lumber product.

Although some species of lumber are marketed individually, most species are grouped for marketing purposes into the species combinations shown in NBC Table A-9.3.2.1.(1)-A. The maximum allowable spans for joists, rafters and beams of these species combinations are listed in NBC Tables 9.23.4.2.-A to 9.23.4.2.-L.

9.3.2.3. Machine Stress Rated Lumber

This Article requires that machine stress rated (MSR) lumber comply with NBC Subsection 4.3.1.

In Canada, some lumber is graded by machine rather than visually. This MSR lumber is intended to be used for structurally designed elements, such as roof trusses. Since structural design using MSR lumber is not covered in NBC Part 9, NBC Subsection 4.3.1. must be followed.

The control of grading and marking for MSR lumber is similar to that for visually graded lumber. The information provided on grade marks for MSR lumber is also similar to that provided for visually graded lumber, but includes the expression “Machine Rated” or “MSR,” as well as stress and stiffness designations.

9.3.2.4. OSB, Waferboard and Plywood Marking

This Article establishes the information to be indicated on oriented strandboard (OSB), waferboard and plywood used for wall and roof sheathing, and for subflooring. These panel-type wood products must be face stamped so that they can be easily identified after installation.

OSB, waferboard and plywood specified for use in construction are made using waterproof adhesives. OSB has fibres that are principally oriented in the longitudinal direction, making it much stronger in this direction than in the transverse direction. Plywood is also much stronger in the direction of the grain of the surface plies. Waferboard, on the other hand, has randomly oriented fibres, which gives it similar properties in both directions.

Because of their directional properties, OSB and plywood are required by some standards to be marked to show their strongest direction. This marking allows OSB and plywood to be oriented with their strongest direction transverse to the supports when they are used as subflooring or roof sheathing.

9.3.2.5. Moisture Content

This Article limits the permissible moisture content of lumber.

When green lumber dries, no shrinkage takes place until the fibre saturation point is reached (about 30% moisture by weight). As the wood continues to dry, it shrinks almost in direct proportion to moisture loss. Eventually, it reaches a moisture level in equilibrium with that in the surrounding air. In summer, this level is about 8 to 10% moisture content for most regions; in winter, it is about 12 to 14% moisture content.

The maximum moisture content permitted for lumber at the time of installation is 19%. At this moisture level, more than half of the wood's normal shrinkage will have occurred. Additional drying and shrinkage will usually occur before the interior vapour barriers and finishes enclose the wood.

If lumber with a moisture content in excess of 19% is installed, moisture may become trapped between vapour-resisting materials, and the wood may retain excess moisture long enough to allow decay to start.

9.3.2.6. Lumber Dimensions

This Article clarifies that the lumber dimensions referred to in NBC Part 9, including the NBC Span Tables, are actual dimensions determined in conformance with CSA O141, "Softwood Lumber."

When Canada converted to the metric system, it became impractical to use nominal designations for lumber. Precise metric size designations were developed and used where designs were produced in units of the International System of Units (SI). Table 9.3.-A presents the nominal imperial sizes for lumber, the actual dry imperial sizes, and their metric equivalents.

Table 9.3.-A
Imperial and Metric Lumber Sizes

Nominal Size (in.)	Dry Size (in.)	Dry Size (mm)
1 × 2	3/4 × 1 1/2	19 × 38
2 × 3	1 1/2 × 2 1/2	38 × 64
2 × 4	1 1/2 × 3 1/2	38 × 89
2 × 6	1 1/2 × 5 1/2	38 × 140
2 × 8	1 1/2 × 7 1/4	38 × 184
2 × 10	1 1/2 × 9 1/4	38 × 235
2 × 12	1 1/2 × 11 1/4	38 × 286

9.3.2.7. Panel Thickness Tolerances

This Article clarifies that the tolerances for the thicknesses specified in NBC Part 9 for plywood, hardboard, particleboard, OSB and waferboard are those set out in the referenced material standards for these panel-type wood products. If panels of these products are significantly thinner than specified in the NBC, they may not be strong enough to withstand the expected loads. The tolerances contained in the referenced material standards also provide an acceptable uniformity of thickness at joints.

9.3.2.8. Undersized Lumber

This Article allows the use of undersized lumber for joists, rafters, lintels and beams. NLGA 2014, "Standard Grading Rules for Canadian Lumber," permits lumber to be dressed to sizes smaller than standard sizes, provided the grade mark shows the actual dressed size of the lumber. Undersized lumber that is up to 5% smaller than the corresponding Canadian standard size can be used in NBC Part 9 without a special engineering analysis, provided the allowable spans in the NBC Span Tables are reduced by 5%.

9.3.2.9. Termite and Decay Protection

This Article specifies the situations in which wood is required to be pressure-treated to resist termites or decay and indicates how to mark the treated wood.

The NBC permits the placement of wood in contact with or near soil, but in localities where termites are known to occur (Figure 9.3.-2), all structural wood elements less than 450 mm (17 3/4 in.) from the ground need to be pressure-treated with a chemical that is toxic to termites. For structural wood elements 450 mm (17 3/4 in.) or more from the ground, all sides of the supporting elements need to be visible to permit inspection for the presence of termites (Figure 9.3.-3). Where foundations are externally insulated (or otherwise finished) such that the presence of termites could be concealed, a metal or plastic barrier needs to be installed in the supporting assembly to prevent the passage of termites, and all sides of the finished supporting assembly need to be visible to permit inspection.

Figure 9.3.-2
Areas where termites are known to occur

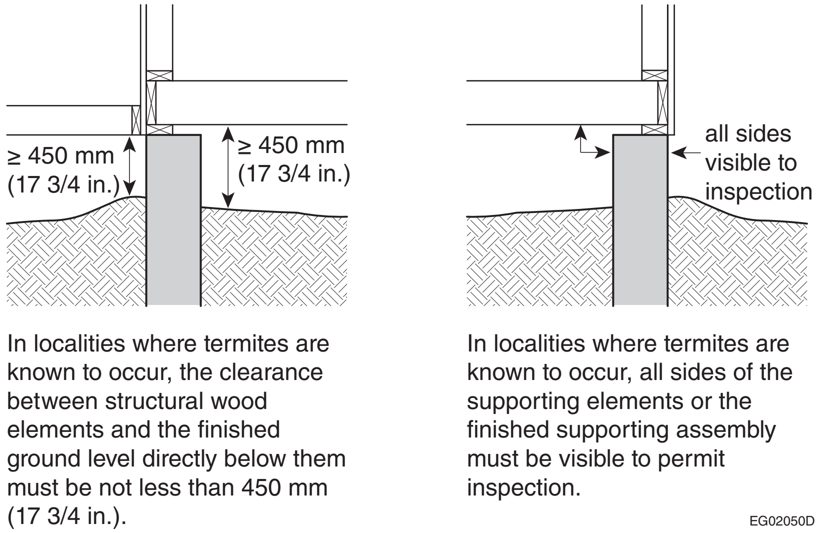


Figure 9.3.-3
Clearance under structural wood elements and visibility of supporting elements to permit inspection in localities where termites are known to occur

Borate is an effective treatment for termite protection, but is subject to leaching from wood exposed to wetting. Therefore, it can only be used for Use Categories 1 and 2. Where wood is protected with an inorganic boron preservative in accordance with Use Category 1 or 2, the wood needs to be protected from wetting during construction and while in service. Where the protected wood is less than 150 mm (6 in.) from the ground, it must be separated from permeable supporting materials by a deterioration-resistant moisture barrier.

There are many above-ground structural wood systems where precipitation is readily trapped or drying is slow, creating conditions conducive to decay: e.g., beams extending beyond roof decks, junctions between deck members, and connections between balcony guards and walls.

Structural wood elements must be pressure-treated with a preservative to resist decay if they are less than 150 mm (6 in.) from the ground (see also NBC Article 9.23.2.2. for decay protection of wood members framing into masonry or concrete at or below ground level) and NBC Article 9.23.2.3. for dampness protection of wood framing members supported on concrete in contact with the ground). Such treatment is also required if the structural wood elements are not protected from exposure to precipitation, the configuration is conducive to moisture accumulation, and the moisture index is greater than 1.00 (mainly in coastal regions).

Structural wood elements in retaining walls and cribbing need to be pressure-treated with a preservative to resist decay if the retaining wall or cribbing is higher than 1.2 m (4 ft.) or supports ground that is critical to the stability of building foundations.

Retaining walls supporting soil are considered to be structural elements of a building if a line drawn from the outer edge of the footing to the bottom of the exposed face of the retaining wall is sloped at an angle of greater than 45° to the horizontal (Figure 9.3.-4). Retaining walls supporting soil may also be considered as structural elements of the building if this line has a lower slope.

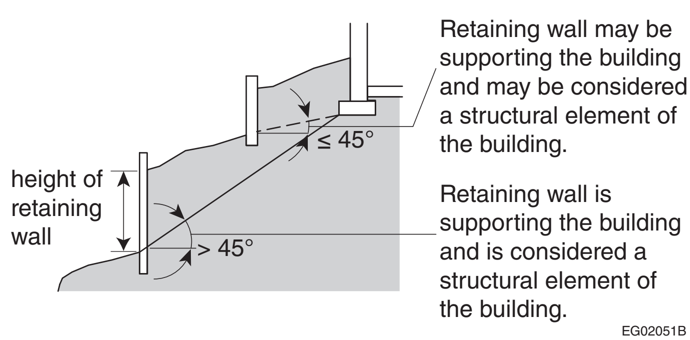


Figure 9.3.-4
Wood retaining walls that require pressure treatment with a preservative

Retaining walls and cribbing that are not critical to the stability of building foundations but are greater than 1.2 m (4 ft.) in height may collapse suddenly and injure persons adjacent to the wall or cribbing if the wood is not adequately protected from decay. The height of the retaining wall or cribbing is measured as the vertical difference between the ground levels on each side of the wall or cribbing.

Wood required to be treated to resist termites or decay needs to be treated in accordance with Use Category 1, 2, 3.2, 4.1 or 4.2, as applicable, in Table 2, Use Categories for Specific Products, Uses and Exposures, of CAN/CSA-O80.1, “Specification of Treated Wood.” The treated wood is required to carry a mark indicating the type of preservative used and the Use Category with which the wood conforms.

The NBC does not include requirements for the control of carpenter ants. Unlike termites, which use wood as a food source, carpenter ants use wood as a refuge. For this reason, pressure treatment of lumber may slow the tunneling of carpenter ants, but will not stop it.

9.3.3. Metal

The general requirements for metal products used in Part 9 buildings are presented in this Subsection. Specific requirements for metal products are addressed throughout NBC Part 9 (e.g., in NBC Section 9.24., which deals with sheet steel stud wall framing).

9.3.3.1. Sheet Metal Thickness

This Article clarifies that the minimum thicknesses for sheet metal specified in NBC Part 9 refer to actual minimum base metal thicknesses. In the case of galvanized steel, the minimum thicknesses include the thickness of the galvanizing coating.

Metal thicknesses have customarily been specified in a variety of ways, depending on the type of metal and its intended use. Several different gauge number systems have been used, each with its own manufacturing tolerance limits. Some metals are also specified in terms of weight per unit area. To simplify the designation of metal thicknesses, NBC Part 9 uses exact minimum metric values that take into account the allowable negative manufacturing tolerances. Except in the case of galvanized steel studs, the minimum thicknesses for galvanized steel specified in NBC Part 9 include the thickness of the galvanizing coating (e.g., zinc coating). For painted sheet metal, the thickness of the paint is not included in the minimum thicknesses.

9.3.3.2. Galvanized Sheet Steel

This Article ensures that sheet steel is provided with adequate resistance against corrosion, so that it can perform its intended function for a reasonable period of time.

Galvanized steel sheets must be coated with zinc or an alloy of 55% aluminum-zinc meeting the requirements of the applicable standard in NBC Sentence 9.3.3.2.(1). Where galvanized sheet steel is intended for use in locations exposed to weather or as a flashing material, it must have a zinc coating not less than the Z275 (G90) coating designation or an aluminum-zinc alloy coating not less than the AZM150 (AZ50) coating designation. This requirement means that the galvanized steel sheet must have a zinc coating of at least 275 g/m^2 (0.9 oz./ft.^{2}) or an aluminum-zinc alloy coating of at least 150 g/m^2 (0.5 oz./ft.^{2}). These values, which correspond to the total amount of coating on both faces of the sheet, are determined under laboratory conditions by measuring the mass of sample specimens before and after the coating is removed by a suitable reagent.

Section 9.4.
Structural Requirements

Introduction

That houses and small buildings have the ability to withstand the loads imposed on them is an important Code requirement. Such buildings must be able to withstand dead loads (their own weight and contents) and live loads due to use and occupancy, as well as wind, snow and seismic loads.

9.4.1. Structural Design Requirements and Application Limitations

9.4.1.1. General

This Article establishes how the structural design of buildings falling within the scope of NBC Part 9 is to be undertaken. The structural members of Part 9 buildings must:

(a) comply with the prescriptive requirements provided in NBC Part 9,
(b) be designed in accordance with accepted good engineering practice, or
(c) be designed in accordance with NBC Part 4 using the loads and limits on deflection and vibration specified in NBC Part 9 or NBC Part 4.

Usually, a combination of approaches is used. For example, even if the snow load calculation on a wood roof truss is based on NBC Subsection 9.4.2., the joints must be designed in accordance with NBC Part 4. In another example, the wall framing may comply with the prescriptive requirements in NBC Subsections 9.23.3., 9.23.10., 9.23.11. and 9.23.12., while the floor framing may be engineered.

Design according to NBC Part 4 or accepted good engineering practice, such as that described in CWC 2014, “Engineering Guide for Wood Frame Construction,” requires engineering expertise. CWC 2014 contains alternative solutions and provides information on the applicability of the prescriptive structural requirements in NBC Part 9 to assist designers and building officials in identifying the appropriate design approach. The need for professional involvement in the structural design of a building, whether in accordance with NBC Part 4, NBC Part 9, or accepted good engineering practice, is defined by provincial and territorial legislation.

In general, the design of floors under NBC Part 9 is limited to those with specified live loads not exceeding 2.4 kPa (50 psf).

Location-specific information for structural design, including snow and wind loads, and seismic spectral response accelerations, is provided in NBC Appendix C. Refer to NBC Subsection 9.23.13. for information on design for lateral loads due to wind and earthquake.

Where structural members and their connections conform to the requirements and limitations of NBC Part 9, structural design is not required. The performance of typical wood-frame structures, in particular, cannot be entirely explained by structural calculations. Many non-structural elements contribute to the strength of a wood-frame building. For example, sheathing, finishes and partitions all help to strengthen the structure. In addition, the loads on the building are shared by the repetitive wood members in a complex manner. The effects of non-structural elements, redundancy and load sharing are difficult to quantify through analysis. However, the numerous wood-frame buildings found throughout Canada and elsewhere represent countless prototypes that have been subject to field-testing over many decades.

The prescriptive structural requirements in NBC Part 9 are generally based on experience with small residential buildings. For this reason, they cannot be applied safely to all buildings within the scope of NBC Part 9. Additional limits are, therefore, specified throughout NBC Part 9 to restrict the application of requirements to the size or type of building for which past experience applies (or, in some cases, for which past calculations apply). When these restrictions are not met, the designer is required to use structural design procedures.

9.4.2. Specified Loads

9.4.2.1. Application

This Article delineates the situations in which the specified snow loads in NBC Subsection 9.4.2. can be used for the structural design of Part 9 buildings.

NBC Subsection 9.4.2. applies to light-frame constructions in which the wall, floor and roof planes are framed with small repetitive structural members, and in which the requirements of NBC Clauses 9.4.2.1.(1)(a) to (f) are met. These requirements place limits on the spacing of the repetitive structural members, the clear spans of these members and supporting structural members, the deflection of structural roof members, the total roof area, and the configuration of the roof. In particular, the repetitive structural members, such as joists, rafters, and trusses, must be spaced at not more than 600 mm (24 in.) on centre (see NBC Note A-9.4.2.1.(1)).

Thus, the simplified specified snow load calculation of NBC Article 9.4.2.2. can be used for structures having a configuration and performance that are typical of traditional wood-frame residential construction.

Because very large buildings may be constructed under Part 9 by using firewalls to break up the building area, it is possible to have Part 9 buildings with very large roofs. The simplified specified snow load calculation must not be used when the total roof area exceeds 4 550 m^2 (48 975 $ft.^2$). Thus, the simplified calculation can be used for typical townhouse constructions, but is not appropriate for much larger constructions, such as commercial or industrial buildings.

The simplified specified snow load calculation also does not apply to the roof configurations described in NBC Clause 9.4.2.1.(1)(f), which seriously exacerbate snow accumulation. This limitation does not pertain to typical projections, such as dormers, or to two-level roofs. Although two-level roofs are generally subject to drift loading, smaller light-frame buildings constructed according to NBC Part 9 have not failed under the drift loads. Rather, this limitation on the application of the simplified calculation pertains to roofs with high parapets or other significant projections, such as elevator penthouses, mechanical rooms or larger equipment, that collect snow and prevent if from blowing off the roof.

9.4.2.2. Specified Snow Loads

This Article provides minimum specified snow loads for use in the design of Part 9 buildings. These snow loads are based on the assumptions that there will be less snow accumulation on roofs with widths not exceeding 4.3 m (14 ft.) than on those with larger widths, and that rain will add to the snow loads. Since bow string, arch and semi-circular roof trusses are sensitive to unbalanced loads (which are not allowed in NBC Part 9), they are required to be designed to meet the more rigorous requirements of NBC Part 4 if their unsupported span exceeds 6 m (20 ft.).

See Guide 9.23.4.2., Spans for Joists, Rafters and Beams, for examples of the calculation of specified snow loads.

Values of the specific weight of snow, γ, measured at a number of weather stations across Canada, ranged from about 1.0 to 4.5 kN/m^3 (6 to 29 lbf/$ft.^3$). An average value of γ for use in design, in lieu of better local data, is 3.0 kN/m^3 (19 lbf/$ft.^3$). In some locations, the specific weight of snow may be considerably greater than 3.0 kN/m^3 (19 lbf/$ft.^3$). In such locations, which include coastal regions, regions where the maximum snow load on the roof is reached only after contributions from many snowstorms, and regions where winter rains are considerable, a value of γ as high as 4.0 kN/m^3 (25 lbf/$ft.^3$) may be appropriate.

9.4.2.3. Platforms Subject to Snow and Occupancy Loads

This Article requires that balconies, decks and other accessible exterior platforms that are subject to both occupancy and snow loads be designed to carry the specified snow load or 1.9 kPa (40 psf), whichever is greater, where the platform (or each segregated area of the platform) serves a single dwelling unit. Where the platform (or each segregated area of the platform) serves more than one dwelling unit or an occupancy other than a residential occupancy, the higher occupancy loads specified in NBC Table 4.1.5.3 will apply.

9.4.2.4. Attics and Roof Spaces

This Article requires that the ceiling joists or the truss bottom chords in residential attic or roof spaces having limited accessibility be designed for a total specified load of not less than 0.35 kPa (7 psf).

In typical residential buildings, the roof is framed with roof trusses and the ceiling is insulated. The trusses are spaced at 600 mm (2 ft.) on centre with web members joining the top and bottom chords. Lateral web bracing is installed perpendicular to the span of the trusses. As a result, there is limited room in the attic or roof space for movement or for the storage of material. Access hatches are generally built to the minimum acceptable dimensions, further limiting the size of material that can be moved into the attic or roof space and leaving only sufficient access space for occasional inspection and maintenance. For these reasons, the ceiling joists or the truss bottom chords must be designed for a minimum total specified load of 0.35 kPa (7 psf), rather than for the typical attic live load.

Also, accessing attic or roof spaces with exposed insulation is not recommended unless protective clothing and a breathing apparatus are worn. Such attic or roof spaces are, therefore, recognized as uninhabitable, and loading can be based on the actual dead load. In emergency situations or for the purpose of inspection, it is possible for a person to access the attic or roof space without over-stressing the trusses or causing damaging deflections.

9.4.3. Deflections

9.4.3.1. Deflections

This Article indicates the deflection limits for structural members.

The maximum deflections for roofs, ceilings, floors, and accessible exterior platforms, such as decks and balconies, are provided in NBC Table 9.4.3.1. A maximum deflection for members supporting plastered ceilings of 1/360 of the span at design load has been a traditional design rule since long before the NBC existed. The purpose of this low deflection limit is to prevent cracks in finished surfaces.

In addition to providing sufficient strength to support expected loads, floors, in particular, are required to have a certain minimum stiffness to prevent excessive deflection and to keep the vibrations from footsteps within acceptable limits. These characteristics are dependent on a number of factors, including the wood species, grade, size and spacing of the floor members, the method of attachment of the subfloor, and the bridging and load sharing between adjacent floor members.

The NBC recognizes the importance of the dynamic behaviour (vibration) of floors to occupants' perception of a floor's acceptability. The spans for floor joists in the NBC Span Tables were determined by a procedure that ensures that they limit floor vibrations, as described in NBC Note A-9.23.4.2.(2).

9.4.4. Foundation Conditions

9.4.4.1. Allowable Bearing Pressure

This Article indicates the maximum allowable bearing pressures for different types of soil. It also requires that footing sizes for shallow foundations be determined in accordance with NBC Section 9.15. or designed in accordance with NBC Section 4.2. using these maximum allowable bearing pressures or the allowable bearing pressures determined from subsurface investigation.

Footings not described in NBC Sentence 9.15.1.1.(1) are required to be designed in conformance with NBC Section 9.4. If, for example, the soil has an allowable bearing pressure of less than 75 kPa (1 500 psf) (e.g., soft clay, or loose sand or gravel), the footings must be designed in accordance with NBC Section 9.4., even for buildings of wood-frame construction.

Soils vary in their ability to support building loads without causing excessive settlement that could lead to building deformation. Footing settlement would have little effect if it occurred uniformly for an entire building. However, some portions of a building are usually more heavily loaded than others and will, therefore, settle more. In addition, the properties of the soil are not usually consistent over an entire building site. Consequently, settlement is not likely to be uniform. Significant differential settlement can lead to foundation cracks and damage to the building's superstructure. For this reason, limits are placed on the allowable bearing pressures for different types of soil.

Sand and gravel can be classified by means of a picket test, in which a 38 × 38 mm (2 × 2 in. nominal) picket with a 45° bevelled end is pushed into the soil by a person of average weight. The sand or gravel is classified as "dense or compact" if the picket does not penetrate more than 200 mm (8 in.) into the soil and as "loose" if the picket penetrates more than 200 mm (8 in.) into the soil.

Clay and silt soils are classified as "stiff" if it is difficult to indent the soil by thumb pressure, as "firm" if the soil can be indented by moderate thumb pressure, and as "soft" if the soil is easily indented by thumb pressure. This indentation test should be carried out on an undisturbed sample, such as on the wall of a test pit.

9.4.4.2. Foundation Capacity in Weaker Soil and Rock

This Article indicates that, where layers of weaker soil or rock exist below the bearing surface, the design capacity of the foundation must not be greater than would cause the weaker soil or rock to be stressed beyond its allowable bearing pressure. If weaker soil or rock underlies the soil supporting the foundation, the weaker soil or rock could be overloaded unless the layer of overlying soil is thick enough to spread the foundation load out over a sufficiently wide area.

Although soil conditions directly beneath the footings may be known, it is also important to know conditions further below the footings. If a weak layer of soil or rock is close to the footing level, the footing pressure may be transferred down to the weak layer, causing the weaker soil of rock to be over-stressed.

Where soil or rock within a distance equal to twice the footing width below the bearing surface has a lower allowable bearing pressure than the soil or rock at the bearing surface, the foundation must be designed to this lower bearing capacity, as illustrated in Figure 9.4.-1.

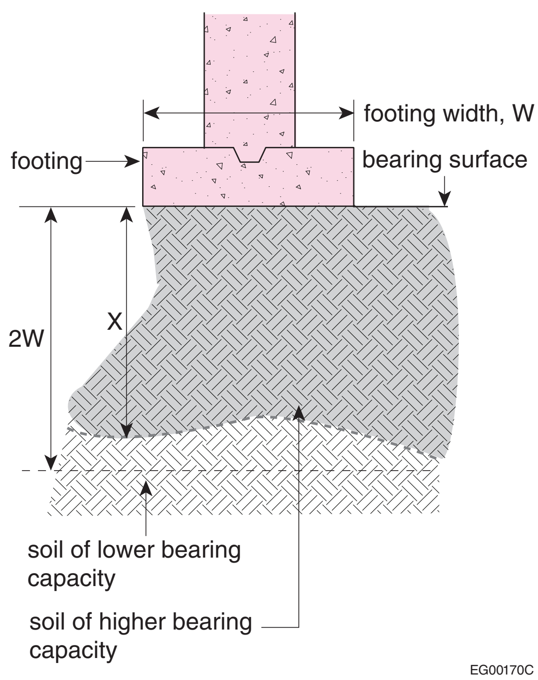


Figure 9.4.-1
Designing a foundation to the lower bearing capacity

NBC Subsection 9.4.4. assumes that the bearing pressure, P, is uniformly distributed over a horizontal plane within a frustum extending downward from the footing at an angle of 60° to the horizontal. In the case of strip footings, the bearing pressure, P_1, at a depth, h, beneath a footing of width, W, can be calculated as follows:

$$P_1 = \frac{PW}{W + 1.15h}$$

In the case of square pad footings, the bearing pressure, P_2, at a depth, h, below a footing of width, W, can be calculated as follows:

$$P_2 = \frac{PW^2}{W^2 + 1.32h^2 + 2.3Wh}$$

Example 1 – Bearing Pressure below Strip Footings

Where a strip footing with a width of 1.0 m exerts a bearing pressure of 200 kPa on the soil on which it rests and is underlain by a soft clay layer at a depth of 0.5 m below the footing, the bearing pressure, P_1, on the clay layer would be calculated as follows:

$$P_1 = \frac{200 \times 1.0}{1.0 + (1.15 \times 0.5)} = 127\,\text{kPa} \quad (2\,652\,\text{psf})$$

Because this pressure exceeds the allowable value of 40 kPa (835 psf) listed in NBC Table 9.4.4.1. for soft clay, the footing design would not be permitted.

As shown in Figure 9.4.-2, the load distribution from a footing to the soil assumed in NBC Sentence 9.4.4.2.(2) differs from the theoretical distribution determined using more precise calculations. A comparison of the two load distributions shows that the assumptions of NBC Sentence 9.4.4.2.(2) are conservative.

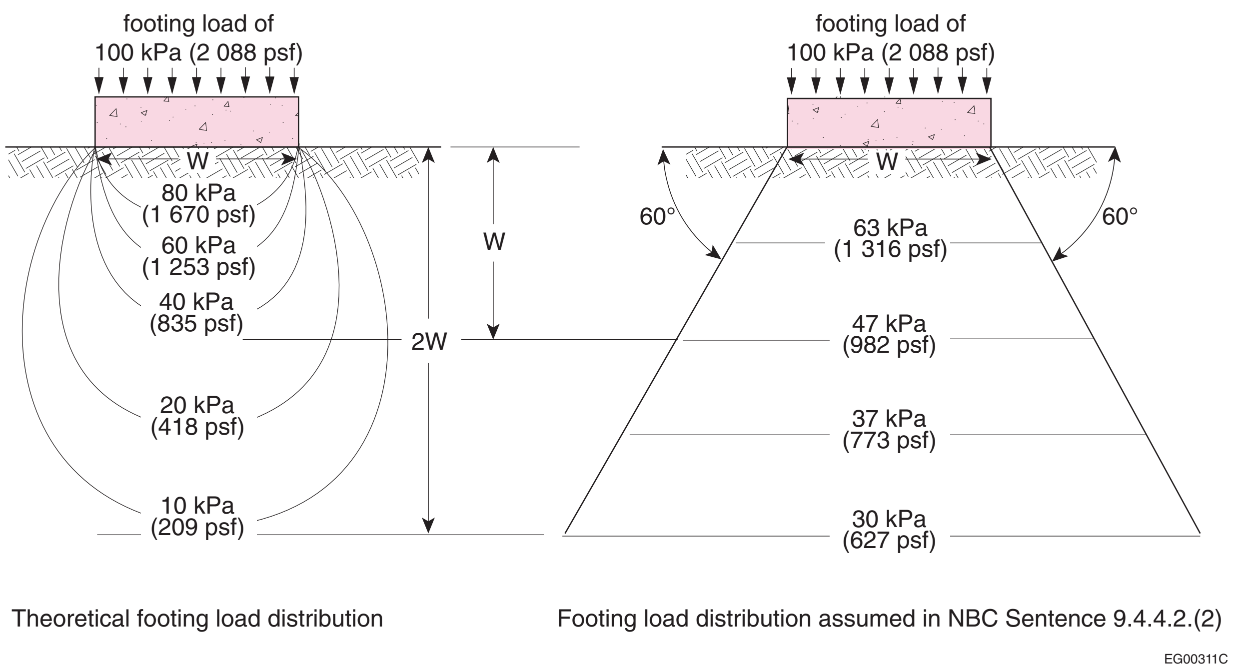


Figure 9.4.-2
Comparison of the theoretical footing load distribution and the footing load distribution assumed in NBC Sentence 9.4.4.2.(2)

Where a foundation wall is located too close to a property line to permit it to be concentrically located on the underlying footing, it must be designed by a competent designer to take into account the effect of the eccentric loading on the underlying soil. Where a new foundation could affect the stability of an existing neighbouring foundation (Figure 9.4.-3), structural analysis is required.

9.4.4.3. High Water Table

This Article indicates that the allowable bearing pressures must be reduced for foundations over high water tables. If the soil at the bearing surface is granular (i.e., gravel, sand or silt), and if the ground water is close to the bottom of the footing (i.e., within a distance equal to the footing width below the bearing surface), then the allowable bearing pressure is 50% of that listed in NBC Table 9.4.4.1.

Free water in granular soil provides lubrication between particles, reducing the soil's load-carrying capacity. Since the foundation load per unit area on soil decreases with depth, this reduction in load-carrying capacity becomes less important at greater depths and can be ignored at a depth equal to the foundation width.

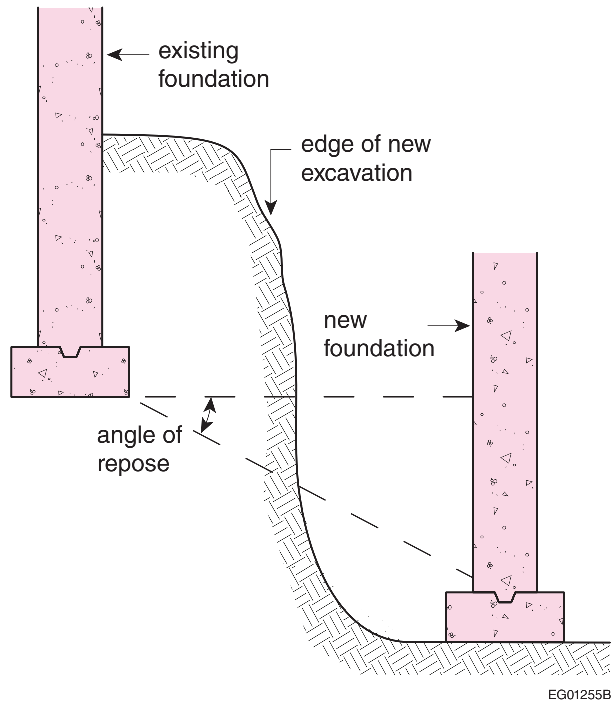


Figure 9.4.-3
New foundation at unsafe distance to existing neighbouring foundation

9.4.4.4. Soil Movement

This Article indicates that, where a foundation is located in an area where there is potential for soil movement due to changes in soil moisture content, freezing, or chemical-microbiological oxidation that could damage a building, measures must be taken to preclude the soil movement or to reduce its effect on the building so that the building will remain stable and its performance will not be adversely affected. See NBC Note A-9.4.4.4.(1) for further information on soil movement.

Expansion and Contraction Due to Moisture

Seasonal variations in climate can cause changes in soil moisture, with the greatest changes occurring during periods of prolonged drought. Particularly wet seasons can increase the volume of the soil under and around the structure to cause heaving of foundations and floors-on-ground or cracking of foundation walls. Particularly dry seasons can decrease the volume of the soil that supports foundations and floors-on-ground, thus causing settling. The changes in soil moisture are greatest at the ground surface level and diminish with depth.

Clay soils are the most prone to expansion and contraction due to moisture. Surface foundations on clay soils can, therefore, be subjected to significant vertical seasonal movement. (For this reason, NBC Table 9.12.2.2. specifies a minimum depth of 1.2 m (4 ft.) for foundations on clay soils.) Clay soils shrink when they lose moisture and swell when they gain moisture, but this process may not be completely reversible in certain types of clay, such as Leda clay. Leda clay (found in the Ottawa and St. Lawrence valleys) and certain prairie clays are particularly sensitive to soil moisture changes.

Trees can also remove soil moisture through their root systems, causing substantial differential footing movement. Deciduous trees, particularly fast-growing varieties such as poplar, should be kept a reasonable distance away from foundations to avoid foundation damage: a minimum distance equal to the anticipated height of the tree has been suggested as a guide.(2)

Frost Heave

Frost heave is probably the most common phenomenon related to freezing soil. Frost heave results when the moisture in frost-susceptible soil (clay and silt) under the footings freezes and expands. This issue is addressed by requirements in NBC Section 9.12. regarding the depth of foundations.

(2) R.F. Legget and C.B. Crawford, Trees and Buildings, Canadian Building Digest 62, Division of Building Research, National Research Council of Canada, Ottawa, 1965.

Ice Lenses

When the moisture in frost-susceptible soils freezes, it forms an ice lens and reduces the vapour pressure in the soil immediately around the lens. The moisture in the ground is then redistributed to rebalance the vapour pressure, providing more moisture in the area of the ice lens. This additional moisture freezes to the lens, and the cycle repeats itself. As the ice lens grows, it exerts pressure in the direction of heat flow. When ice lenses form close to foundations and heat flow is directed towards the foundation—as may be the case with unheated crawl spaces or open concrete block foundations insulated on the interior—the pressure may be sufficient to crack the foundation.

Adfreezing

Ice lenses can adhere to cold foundations. Where heat flow moves essentially upward, parallel to the foundation, the pressure exerted will tend to lift the foundation, which may cause the differential movement or cracking of the foundation. Heat loss through basement foundations of cast-in-place concrete or concrete blocks insulated on the exterior is usually sufficient to prevent adfreezing. However, care must be taken where the foundation does not enclose a heated space or where a foundation of open concrete blocks is insulated on the interior. The installation of semi-rigid glass fibre insulation has demonstrated some effectiveness as a separation layer to absorb the adfreezing forces.

Pyrite

Pyrite is the most common iron disulphide mineral and has been identified in rocks of all types and ages. It is most commonly found in metamorphic and sedimentary rock, especially in coal and shale deposits.

The weathering of pyritic shale is a chemical-microbiological oxidation process that results in volume increases capable of heaving foundations and floors-on-ground. Concentrations of pyrite as low as 0.1% by weight have caused heaving. Weathering can be initiated simply by exposing the pyritic material to air. Thus, building on a soil that contains pyrite at a concentration that will cause damage to the building should be avoided, or measures should be taken to remove or seal the pyritic material. Material containing pyrite should not be used for backfill at foundations or for supporting foundations or floors-on-ground.

Where it is not known if soil or backfill contains pyritic material in a deleterious concentration, an available test can be used to identify its presence and determine its concentration.

9.4.4.5. Retaining Walls

This Article requires that retaining walls be designed to resist the lateral pressure of the material they retain. This requirement applies to all walls that are subjected to lateral loads from retained soil or from another retained material, including foundation walls and walls associated with exterior below-grade entrances. Designing retaining walls to resist the lateral pressure of the retained material ensures that they will not deflect, bulge, lean or tip.

9.4.4.6. Walls Supporting Drained Earth

This Article indicates the lateral pressures to be used for the design of foundation walls supporting drained earth and earth other than drained earth.

Foundation walls for basements must be designed to resist horizontal forces from the soil. This pressure varies for different types of soil and can be significantly affected by the presence of water. The pressure of soil against foundation walls is assumed to increase in direct proportion to depth, in the same manner as the pressure exerted by a liquid increases with depth. Foundations with footing drains are considered to support drained soil only.

The prescriptive solutions in NBC Section 9.15. relating to footings and foundation walls only account for the loads imposed by drained earth. They do not account for surcharges due to saturated soil or due to heavy objects located adjacent to a building. Where such surcharges are expected, the footings and foundation walls must be designed and constructed according to Part 4.

Drained earth is assumed to exert a pressure equivalent to that exerted by a fluid with a density of not less than 480 kg/m^3 (30 lb./ft.^{3}). This value has been shown to be adequate for most soils that are effectively drained to the level of the footing. If the soil is not drained, a static head of water can build up against the foundation wall. The fluid pressure of this surcharge must be taken into account.

Similarly, if the ground supports a significant load due to a heavy object close to the foundation wall, this surcharge load exerts an additional horizontal pressure on the foundation wall. Although significant surcharge loads are not common at housing sites, when they occur, they must be taken into account with the help of a professional.

A foundation wall normally acts as a plate or diaphragm loaded on the outside by soil pressure. This pressure is resisted by the transverse foundation walls and the basement slab. Whether or not the top of the foundation wall is considered to be supported against inward movement depends on the design of the foundation. A full-height foundation wall that extends to the first floor (with an anchored sill plate) is considered to be supported at the top, while a foundation wall that supports a short stud wall (common in split-entry or raised ranch houses) is considered unsupported.

It is common to design foundation walls as vertical beams rather than plates if they are anchored at the top, and as retaining walls if they are unsupported at the top. This approach simplifies the calculations, but leads to more conservative designs.

Figure 9.4.-4 shows the design loads on supported and unsupported foundation walls.

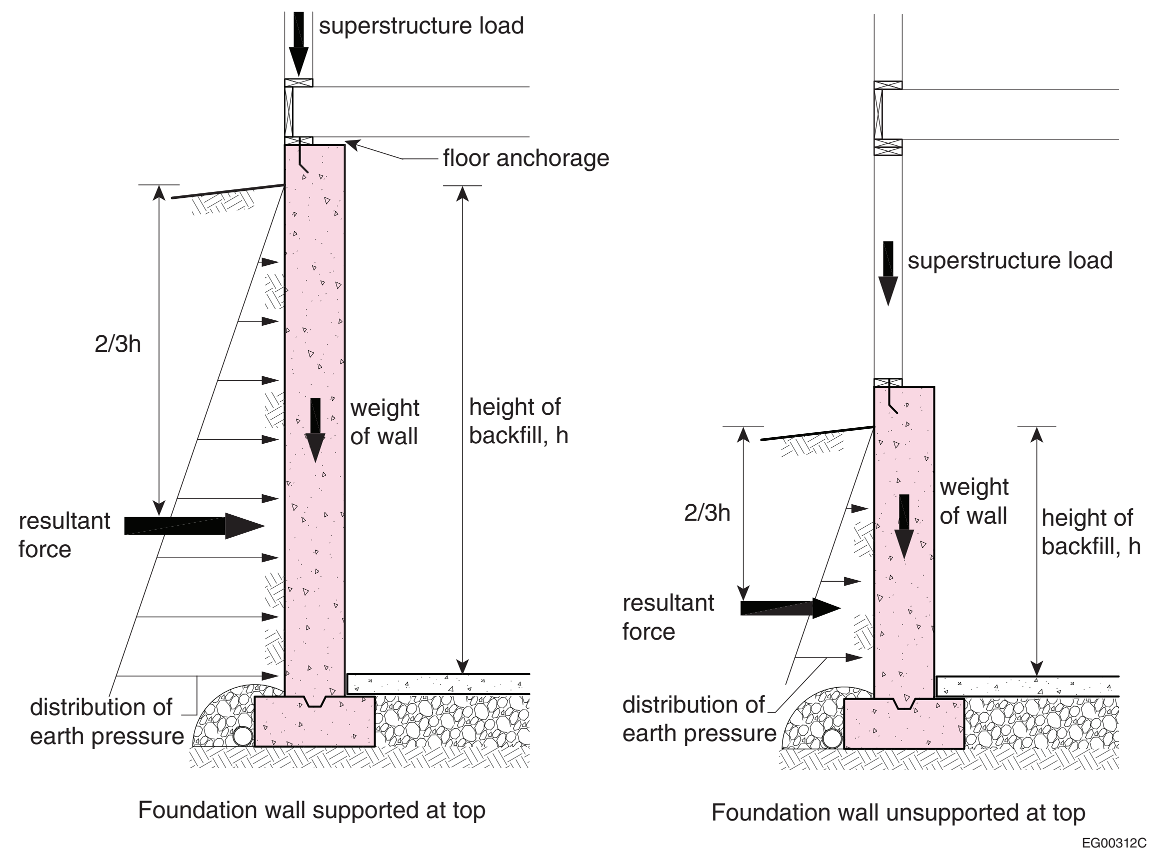


Figure 9.4.-4
Design loads on supported and unsupported foundation walls

Section 9.5. Design of Areas and Spaces

Introduction

This Section provides minimum ceiling heights and hallway widths that allow for safe movement.

At one time, the NBC required minimum sizes for rooms, but this is no longer the case. A review concluded that there was no health or safety justification for specifying the sizes of rooms. For example, sleeping areas in manufactured homes and cottages that are smaller than previously required by the NBC nevertheless provide a healthy and safe space.

It was recognized that minimum room dimensions alone would not ensure livability within a dwelling unit. Room layouts, circulation patterns, and window and door locations significantly affect the usefulness of room spaces, as do the type and size of furniture.

9.5.1. General

9.5.1.1. Method of Measurement

This Article establishes that measurements are made from the finished wall, floor and ceiling surfaces, not from the framing.

9.5.1.2. Combination Rooms

This Article indicates that two or more areas may be considered as a combination room if the opening between the areas occupies at least 3 m^2 (32 $ft.^2$), the approximate area occupied by a set of double doors, or 40% of the area of the wall between the areas, whichever is larger.

If an area draws natural light and natural ventilation from another area, the opening between the two areas must be large enough to effectively provide sufficient light and air. The effectiveness of the transfer of light and air also depends on the size of the transfer opening in relation to the size of the dependent area. The area of the wall separating the two areas is measured on the side of the dependent area without taking offsets in the wall surface into account.

The opening does not necessarily have to be in the form of a doorway. However, if the dependent area is a bedroom, direct passage must be provided between the bedroom and the other area so that the escape window required by NBC Article 9.9.10.1. can fulfill its safety function.

9.5.2. Barrier-Free Design

Barrier-free means that a building and its facilities can be approached, entered and used by persons with physical or sensory disabilities.

9.5.2.1. General

This Article references the requirements of NBC Section 3.8., while noting certain exemptions from these requirements, which, for the most part, relate to residential buildings (see NBC Articles 3.8.2.1. and 9.5.2.3.). Buildings that are not exempted must be designed in accordance with the barrier-free design requirements in NBC Section 3.8, which apply to features such as entrances, parking areas, and washrooms.

9.5.2.2. Protection on Floor Areas with a Barrier-Free Path of Travel

This Article indicates that the requirements of NBC Article 3.3.1.7., which are intended to ensure the safety of persons in wheelchairs in an emergency situation, apply where a barrier-free path of travel is provided to an upper storey in a multi-storey building.

9.5.2.3. Exception for Apartment Buildings

This Article exempts walk-up apartment buildings from the requirements for a barrier-free path of travel in NBC Section 3.8. where the difference in elevation between the entry level and the floor level at every dwelling unit exceeds 600 mm (2 ft.). The purpose of this 600 mm (2 ft.) limit is to discourage the use of unnecessary risers to circumvent accessibility requirements. Other walk-up apartment buildings need to have barrier-free access only at their entrance level.

9.5.3. Ceiling Heights

Minimum ceiling heights are intended to provide reasonable headroom clearances for most people, both to prevent injury and to provide a psychologically acceptable spaciousness within rooms. Minimum ceiling heights are also intended to allow sufficient air circulation within rooms.

9.5.3.1. Ceiling Heights of Rooms or Spaces

This Article provides minimum ceiling and clear heights for different rooms and spaces in residential occupancies (Figure 9.5.-1). NBC Article 9.9.3.4. provides minimum clear heights for means of egress and exits, which are intended to facilitate movement within, into and out of buildings.

A minimum ceiling height of 2.1 m (6 ft. 11 in.) is considered acceptable for living areas, such as living rooms, dining rooms, kitchens, hallways, bathrooms and bedrooms. Because enough height to stand is not necessarily needed over the entire floor area of bathrooms, water-closet rooms, and laundry areas, the minimum ceiling height must only be provided over an area of 2.2 m^2 (24 $ft.^2$) in these spaces.

A lower clear height is permitted in unfinished basements, since relatively little time is spent there. A minimum clear height of 2.0 m (6 ft. 7 in.) is required under beams in unfinished basements, including basement storage and laundry areas, and in basement areas normally used for passage.

The minimum ceiling height in secondary suites is 1.95 m (6 ft. 5 in.), except under beams and ducts where a minimum ceiling height of 1.85 m (6 ft. 3/4 in.) is permitted.

9.5.3.2. Mezzanines

This Article indicates that the minimum ceiling height above and below mezzanine floors in occupancies other than residential occupancies is 2.1 m (6 ft. 11 in.).

9.5.3.3. Storage Garages

This Article indicates that the minimum clear height for storage garages is 2 m (6 ft. 7 in.).

	Room or Space	Minimum Ceiling or Clear Height	Minimum Area Over Which Minimum Height Must Be Provided(1)
Residential occupancies other than secondary suites	Living room or space	2.1 m (6 ft. 11 in.)	Area of the space or 10.0 m^2 (108 $ft.^2$), whichever is less
	Dining room or space	2.1 m (6 ft. 11 in.)	Area of the space or 5.2 m^2 (56 $ft.^2$), whichever is less
	Kitchen or kitchen space	2.1 m (6 ft. 11 in.)	Area of the space or 3.2 m^2 (35 $ft.^2$), whichever is less
	Master bedroom or bedroom space	2.1 m (6 ft. 11 in.)	Area of the space or 4.9 m^2 (53 $ft.^2$), whichever is less
	Other bedroom or sleeping space	2.1 m (6 ft. 11 in.)	Area of the space or 3.5 m^2 (38 $ft.^2$), whichever is less
	Unfinished basement including laundry area therein	2.0 m (6 ft. 7 in.) clear	Area under beams and in any location that would normally be used for passage
	Passage, hall or main entrance vestibule	2.1 m (6 ft. 11 in.)	Area of the space
	Bathroom, water-closet room or laundry area above grade; habitable room or space not specifically mentioned above	2.1 m (6 ft. 11. in.)	Area of the space or 2.2 m^2 (24 $ft.^2$), whichever is less
Storage garages	Storage garage	2 m (6 ft. 7 in.)	Area of the space
Secondary suites	Secondary suite	1.95 m (6 ft. 5 in.)	Area of the space
	Secondary suite under beams and ducting	1.85 m (6 ft. 3/4 in.) clear	Area under beams and ducting

EG00552C

Figure 9.5.-1
Minimum ceiling and clear heights for rooms and spaces in residential occupancies

Note to Figure 9.5.-1:
(1) Area of the space must be measured at floor level.

9.5.4. Hallways

9.5.4.1. Hallway Width

This Article provides the minimum widths for hallways within dwelling units. These minimum hallway widths are intended to facilitate exit from, not access to, buildings.

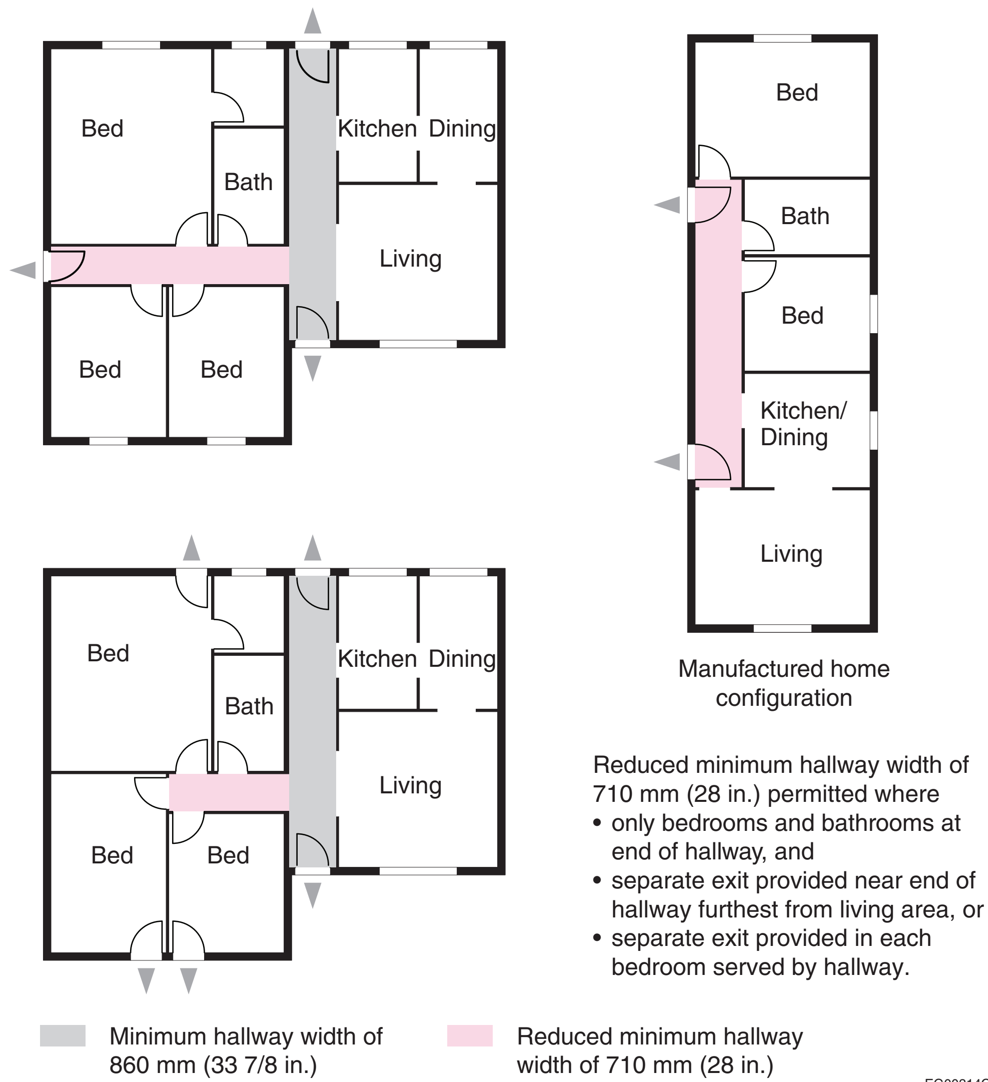


Figure 9.5.-2
Minimum hallway widths within dwelling units

In pre-1995 editions of the NBC, narrow hallways were deemed acceptable in manufactured homes with specific arrangements of bedrooms and bathrooms. Time proved that these arrangements provided a good level of safety. Thus, the minimum hallway widths for manufactured homes were extended to all dwelling units having specific plan configurations.

The minimum unobstructed width of a normal hallway within a dwelling unit is 860 mm (34 in.), but this minimum hallway width is permitted to be reduced to 710 mm (28 in.) when certain requirements are met, as illustrated in Figure 9.5.-2. Hallways narrower than 860 mm (34 in.) must serve only bedrooms or bathrooms at the end of the hallway furthest from the living area, and must have an exit at that end of the hallway or an exit in each bedroom served by the hallway.

9.5.5. Doorway Sizes

9.5.5.1. Doorway Sizes

This Article sets minimum dimensions for doorways within dwelling units and within houses with a secondary suite (including their common spaces), which are intended to ensure that occupants can escape in an emergency. In general, such doorways must be designed to accommodate the door sizes given in NBC Table 9.5.5.1. for swing-type and folding doors.

The minimum width for a doorway depends on its location. Doorways to rooms and spaces where large furniture items or bulky equipment is expected to be moved are required to accommodate a door with a minimum width of 810 mm (31 7/8 in.). Doorways to bedrooms are permitted to be slightly narrower because the limiting dimension of bedroom furniture is usually smaller than that of equipment such as washers, dryers, stoves and furnaces.

The minimum door height of 1 980 mm (78 in.) in NBC Table 9.5.5.1. is 50 mm (2 in.) less than the standard height for doors in CAN/CSA-O132.2 Series, “Wood Flush Doors.” Doorways accommodating this lower minimum door height have been permitted in dwelling units for many years and provide adequate headroom clearance in most cases. While there is an advantage to having increased headroom clearance for taller people, taller doorways are not always feasible in dwelling units designed with the minimum ceiling heights permitted in NBC Subsection 9.5.3. if the doorways are located in loadbearing walls with a lintel above the doorway.

Doorway openings within secondary suites must be designed to accommodate swing-type and folding doors with a minimum height of 1 890 mm (6 ft. 2 in.) where the ceiling height is not less than 1.95 m (6 ft. 5 in.). Although a reduced minimum ceiling height of 1.85 m (6 ft. 3/4 in.) is permitted under beams and ducts in secondary suites (NBC Sentence 9.5.3.1.(3)), doorways are not permitted to be placed in these locations where headroom clearance is already reduced.

9.5.5.2. Doorways to Public Water-Closet Rooms

This Article establishes minimum dimensions for doorways to public washrooms, which provide sufficient clearance for wheelchair passage and sufficient headroom to prevent accidental head contact even when users are not familiar with the building. Their minimum height is 2.03 m (6 ft. 8 in.), and their minimum width is 810 mm (2 ft. 8 in.)

9.5.5.3. Doorways to Rooms with a Bathtub, Shower or Water Closet

This Article indicates that, where one or more rooms containing a bathtub, shower or water closer are served by a hallway of not less than 860 mm (34 in.) wide, at least one doorway providing access to each type of fixture must accommodate a door not less than 760 mm (30 in.) wide, in order to allow wheelchair passage. While this doorway width is considered adequate for dwelling units, it is not considered sufficient for public washrooms, which are required to have doorways at least 50 mm (2 in.) wider. Where the fixtures are distributed between two adjoining rooms, both rooms need to have a doorway that accommodates a door not less than 760 mm (30 in.) wide.

Section 9.6.
Glass

Introduction

In its exterior applications, glass admits natural light into occupied spaces, while limiting heat loss and noise intrusion. In its interior applications, glass serves as a divider between spaces and as a barrier to fire and smoke. The degree to which glass limits the transfer of smoke, air, and water vapour depends less on the glass itself than on how the glass is installed and sealed to its supporting elements, such as window frames and doors. Principally, this Section addresses the structural and fire safety of glass, as well as the safe use of glass.

9.6.1. General

9.6.1.1. Application

This Article specifies the building elements containing glass to which the requirements of NBC Section 9.6. apply.

The requirements in NBC Section 9.6. apply to the design, installation and protection of glass in these building elements. The requirements that apply to glass in manufactured windows, doors and skylights are provided in the standards referenced in NBC Subsection 9.7.4. The requirements that apply to the design, construction, installation, thermal performance, and resistance to forced entry of site-built exterior windows, doors, and skylights are provided in NBC Subsection 9.7.5.

9.6.1.2. Material Standards for Glass

This Article references standards for the material properties of different types of glass. There are several types of glass, some of which have special characteristics, such as wire reinforcing, shatter resistance, and heat absorption. Glass material standards are also referenced in AAMA/WDMA/CSA 101/I.S.2/A440, “NAFS – North American Fenestration Standard/Specification for Windows, Doors, and Skylights” (Harmonized Standard).

Mirrored glass doors in a means of egress can be mistaken for open doorways, leading to accidents. Therefore, the use of mirrored glass doors is limited to clothes closets, which do not form part of an egress route. Such doors are required to conform to CAN/CGSB-82.6-M, “Doors, Mirrored Glass, Sliding or Folding, Wardrobe.” See NBC Note 9.6.1.2.(2) for more information on mirrored glass doors.

9.6.1.3. Structural Sufficiency of Glass

This Article provides requirements that are intended to ensure that glass in doors and windows will safely resist wind and impact loads.

In general, glass in doors and windows must be designed in conformance with CAN/CGSB-12.20-M, “Structural Design of Glass for Buildings,” or ASTM E 1300, “Determining Load Resistance of Glass in Buildings,” as per NBC Article 4.3.6.1. However, if the building that windows serve meets the criteria in NBC Sentence 9.6.1.3.(2)., the glass for the windows must be designed in conformance with NBC Tables 9.6.1.3.-A to 9.6.1.3.-F. Glass for doors must be designed in conformance with NBC Table 9.6.1.3.-G.

Different types of glass have different strength characteristics. Tempered glass, for example, is much stronger than annealed glass of the same thickness. On the other hand, though wired glass and laminated glass are less hazardous when broken, these types of glass are considerably weaker than annealed glass of the same thickness.

Glass of the same type can also exhibit a wide range of breaking strengths. Glazing practices, the rate of loading, natural aging, and defects, such as scratches, can have significant effects on the strength of glass.

Because of the variability in glass strength, it would be uneconomical to set size limits for glass that would completely eliminate all failures. The purpose of establishing maximum glass areas is to limit the probability of failure to an acceptable level.

Glass in Windows

Maximum allowable sizes for different types of glass in windows are provided in NBC Tables 9.6.1.3.-A to 9.6.1.3.-F, which are based on CAN/CGSB-12.20-M, "Structural Design of Glass for Buildings," and the wind load provisions in NBC Article 4.1.7.3. The maximum glass area values given in these tables are intended to be equal to or smaller than those that would be determined using the standard and wind load provisions directly to design for each individual case.

NBC Tables 9.6.1.3.-A to 9.6.1.3.-F apply to 1-in-50 hourly wind pressures of less than 0.55 kPa (11.5 psf), less than 0.75 kPa (15.7 psf), and less than 1.00 kPa (20.9 psf), respectively. Hourly wind pressures for various locations in Canada are provided in NBC Table C-2 in Appendix C. NBC Tables 9.6.1.3.-A to 9.6.1.3.-C apply to windows in buildings with a height from grade to the uppermost roof of 12 m (40 ft.) or less that are located in a built-up area, not less than 120 m (394 ft.) away from the boundary between this area and open terrain. NBC Tables 9.6.1.3.-D to 9.6.1.3.-F apply to windows in buildings in open terrain. These tables cannot be used for buildings in exceptionally exposed locations, such as hilltops.

Glass in Doors

Although glass in windows is subject to breakage caused by accidental human impacts, the severity of such impacts is usually not as great as it is in the case of doors. While the ability to withstand wind forces is the main strength design consideration for window glass, glass in doors needs to be able to resist jarring and impact loads. The ability of glass to resist loads exerted on it depends on its strength characteristics, its thickness and its dimensions. Maximum areas for individual panes of glass in doors are provided in NBC Table 9.6.1.3.-G.

9.6.1.4. Types of Glass and Protection of Glass

This Article sets out the types of glass to be used for certain applications and, in some cases, requires protection of the glass. The requirements for glass sidelights and glass panels in doors are intended to ensure that the glass has sufficient strength to resist accidental impacts in normal use and to withstand the anticipated forces, in order to reduce the risk of injury.

The use of ordinary (annealed) glass in doors has been responsible for many serious accidents, some of which have been fatal. As a result, requirements for safety glass (tempered glass, wired glass, and laminated glass) in doors are included both in the NBC and in the Glass Doors and Enclosures Regulations under the Canada Consumer Product Safety Act. The requirements in the Regulations, while similar to those in the NBC, apply only to glass in doors and enclosures for domestic use, specifically exterior doors, storm doors, and bathtub and shower enclosures. The Act, which is administered federally, prohibits the importation, sale and advertising of products that do not meet the requirements in the Regulations.

Glass in Sidelights, Storm Doors, and Sliding Doors

Glass sidelights that are wider than 500 mm (20 in.) and that could be mistaken for doors, glass in storm doors, and glass in sliding doors within or at an entrance to a dwelling unit and in public areas must be tempered or laminated safety glass or wired glass complying with the standards reference in NBC Sentence 9.6.1.4.(1).

Glass in Swinging Doors

Glass in swinging entrance doors to dwelling units and in public areas that does not exceed 0.5 m^2 (5.4 $ft.^2$) in area is not required to be safety glass. Nor is glass in such doors that does not extend to less than 900 mm (3 ft.) from the bottom of the door. Thus, in swinging entrance doors, ordinary glass can be used for smaller individual panes, such as in French doors, or for larger panes that are more than 900 mm (3 ft.) above the bottom of the door. These exemptions do not apply to storm doors, which are usually subject to more abuse.

Transparent Panels and Sliding Glass Partitions

In general, transparent panels that could be mistaken as a means of egress need to be protected by barriers or railings. The existence of clear glass panels may not be obvious to those unfamiliar with a building. People have walked into glass panels and have been seriously injured as a result. To prevent such injuries, barriers or railings are required, both to alert occupants to the existence of the glass panel and to prevent accidental contact. However, sliding glass partitions that separate a public corridor from an adjacent occupancy and that are open during normal working hours need only be marked so that their existence and position is clear.

Glass or Transparent Doors

Although safety glass improves the safety of glass doors in public areas, such doors can still cause accidents if it is difficult to determine whether they are in a closed position. Therefore, to reduce the risk of people walking into them, glass or transparent doors accessible to the public must be equipped with appropriate hardware, push bars, or other permanent fixtures that make the existence and position of the doors readily apparent.

Glass for Shower and Bathtub Enclosures

The purpose of prohibiting the use of glass other than safety glass for shower and bathtub enclosures is to minimize the risk of injury to users as a result of accidental impact. This prohibition is important to remember when fabricating custom enclosures.

Section 9.7. Windows, Doors and Skylights

Introduction

Windows, doors and skylights perform a multitude of functions in a building. They provide environmental separation (resistance to water entry, thermal resistance, and airtightness), resistance to wind loads, stability under operational loads, and resistance to forced entry. This Section addresses the performance and installation of windows, doors and skylights, both manufactured and site-built.

NBC Section 9.7. is based to a large extent on AAMA/WDMA/CSA 101/I.S.2/A440, "NAFS – North American Fenestration Standard/Specification for Windows, Doors, and Skylights" (Harmonized Standard). The Harmonized Standard assesses the performance of windows, doors and skylights with respect to their resistance to wind, water penetration, and air leakage. The performance can then be compared against the load requirements for climates in specific geographic locations. While the Harmonized Standard contains some Canada-specific test criteria, NBC Section 9.7. also references CSA A440S1, "Canadian Supplement to AAMA/WDMA/CSA 101/I.S.2/A440, NAFS – North American Fenestration Standard/Specification for Windows, Doors, and Skylights" (Canadian Supplement), which contains additional Canada-specific requirements, such as requirements addressing snow loads and requirements relating to performance designators.

9.7.1. General

9.7.1.1. Application

This Article establishes that NBC Section 9.7. applies to windows, doors and skylights in buildings. The term "door" in this Section includes glazing in doors and sidelights for doors; the term "skylight" refers to unit skylights, roof windows, and tubular daylighting devices.

Section 9.7. addresses the performance of windows, doors and skylights with respect to structural loads, operation, air leakage, water penetration, heat transfer, and resistance to forced entry. It also addresses the installation of windows, doors and skylights.

9.7.2. Required Windows, Doors and Skylights

9.7.2.1. Entrance Doors

This Article requires that a door be provided at each entrance to a dwelling unit. The NBC requirements for entrance doors are often more stringent than those for interior doors.

Entrance doors without transparent glazing in the door or a sidelight must be equipped with a door viewer to allow occupants to view visitors without opening the door.

The NBC requirements for the provision of doors are minimal. The NBC only requires the provision of doors at the entrances to a dwelling unit, including those from the exterior and those from common corridors and stairways. Because market forces normally mandate doors for other rooms, such as bathrooms, the NBC does not need to require the provision of such doors.

9.7.2.2. Other Requirements for Windows, Doors and Skylights

This Article lists a number of additional requirements for windows, doors and skylights that are presented elsewhere in NBC Part 9, such as requirements pertaining to fire safety, use and egress, ventilation, and fall protection.

Table 9.7.-A
Other Requirements for Windows, Doors and Skylights

NBC Reference	Requirement
NBC Section 9.5., Design of Areas and Spaces	Minimum sizes of doorways and doors within a barrier-free path of travel
NBC Subsection 9.8.8.1., Required Guards	Protection of window and door openings to protect persons from falling through them
NBC Section 9.9., Means of Egress	Properties of windows and doors within exits
NBC Subsection 9.9.10., Egress from Bedrooms	Windows and doors installed to provide the required means of egress from bedrooms
NBC Subsection 9.10.12., Prevention of Fire Spread at Exterior Walls and between Storeys	Location and protection of windows, doors and skylights in order to control the spread of fire
NBC Article 9.10.13.15., Doors between Garages and Dwelling Units	Doors between dwelling units and attached garages
NBC Article 9.10.17.1., Flame-Spread Rating of Interior Surfaces	Surface flame-spread rating for doors and skylights
NBC Subsection 9.10.20., Firefighting	Windows and doors installed to provide the required access to a building for firefighting purposes
NBC Article 9.32.2.2., Non-Heating-System Natural Ventilation	Windows and skylights installed to provide required non-heating season ventilation
NBC Section 9.36., Energy Efficiency	Energy efficiency requirements for windows, doors and skylights

The NBC once stipulated a minimum window area per room. This requirement was removed because it was considered to relate to psychological well-being and, therefore, fell outside the purview of the NBC. In any case, natural lighting is an important feature of good design, and market forces will demand windows of a certain size in most rooms.

Openable windows are used for natural ventilation and may serve as an escape route in a fire emergency. Windows, however, can also be a hazard. They are less effective than solid walls at preventing the spread of fire from one building to another or from one compartment to another. Should a window break, the glass can be a hazard. People can fall from windows and injure themselves, and objects can fall from windows and injure people below. Windows, therefore, have a significant impact on health and safety.

Some windows may be installed in such a manner that they could be mistaken for exterior doors. Some doors, such as sliding patio doors and French doors, may be installed to act as large windows. If there is a substantial difference in elevation on either side of the door opening, an accidental fall from one level to another could be serious. The requirements for doors used as windows are provided in NBC Article 9.8.8.1.

NBC Subsection 9.9.10. specifies the requirements for windows serving as a means of egress from bedrooms, including those below ground level.

The compliance of windows, doors and skylights with the energy efficiency requirements in NBC Section 9.36. can be demonstrated with maximum overall thermal transmittance values (U-values) or minimum Energy Ratings (only for windows and doors).

9.7.3. Performance of Windows, Doors and Skylights

9.7.3.1. General Performance Expectations

This Article establishes the performance expectations for fenestration components installed in housing and small buildings. It lists the general performance requirements for windows, doors and skylights that separate conditioned spaces from other conditioned spaces, from unconditioned spaces, or from the exterior.

The performance requirements of resisting water entry, resisting wind loads, and resisting the ingress of insects and vermin are typical for any building envelope component separating conditioned space from unconditioned space or the exterior. Windows, doors and skylights (and their components) have the additional performance requirements of controlling air leakage, resisting forced entry, where required, and being easily operated when not intended to be fixed. Skylights (and their components) are also required to resist snow loads (Figure 9.7.-1).

Windows, doors and skylights (and their components) separating interior suites from the remainder of the building are not required to resist water entry or wind loads (Figure 9.7.-1).

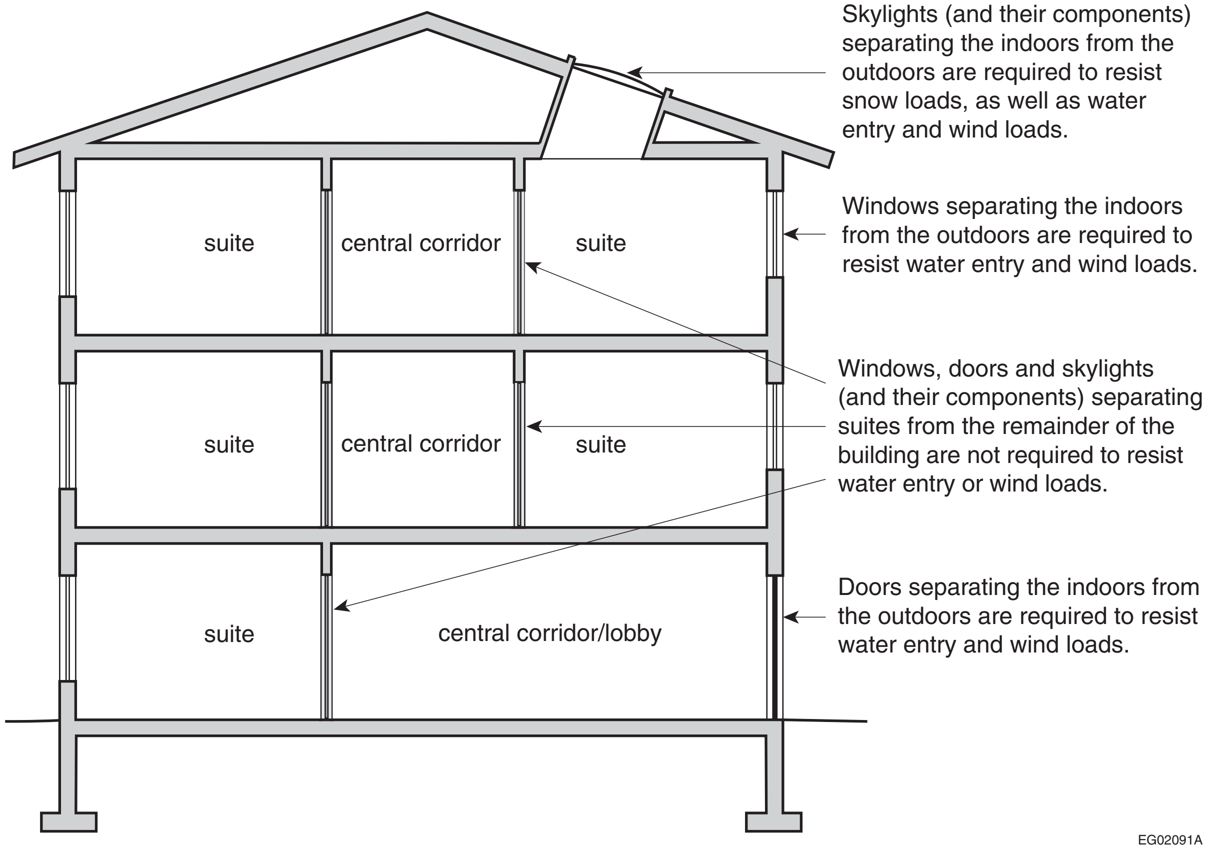


Figure 9.7.-1
Performance requirements for windows, doors and skylights

For manufactured windows, doors and skylights that fall within the scope of the Harmonized Standard and the Canadian Supplement, compliance with the general performance requirements of this Article can be achieved by meeting the requirements of NBC Subsection 9.7.4. For site-built and field-assembled fenestration components that are not covered in the scope of the Harmonized Standard, compliance with each of the general performance requirements has to be demonstrated to the authority having jurisdiction, and the requirements for resistance to forced entry in NBC Subsection 9.7.5. must be met. The installation of both site-built and manufactured fenestration components needs to comply with NBC Subsection 9.7.6.

An alternative compliance route for both manufactured and site-built fenestration components is to design and construct these components according to NBC Part 5.

9.7.3.2. Heat Transfer Performance

This Article establishes the heat transfer performance expectations for windows, doors and skylights (and their components) separating conditioned space from unconditioned space or the exterior, namely, minimizing surface condensation on the warm side of the fenestration component and ensuring comfortable conditions for occupants of the conditioned space.

In pre-2010 editions of the NBC, double glazing was required in exterior windows, doors and sidelights to prevent excessive condensation on these fenestration components in winter, except where a storm door or sash was present. Double-glazed windows and doors have since become standard, and the requirement for double-glazing has been replaced with the requirement of NBC Sentence 9.7.3.3.(3) that exterior windows and doors with or without a storm door or sash have a maximum U-value or a minimum temperature index in accordance with NBC Table 9.7.3.3.

The prevention of absolutely all condensation on the glass of windows, doors and skylights is impossible to achieve and is not necessary. It is, however, necessary that the amount and frequency of condensation be minimized to prevent deterioration and mould. Conditions that allow glass surfaces to dry must be present.

9.7.3.3. Thermal Characteristics of Windows, Doors and Skylights

This Article indicates the required thermal characteristics for windows, doors and skylights (and their components) separating conditioned space from unconditioned space or the exterior. Such windows, doors and skylights that meet the requirements of this Article are deemed to comply with the heat transfer performance requirements of NBC Article 9.7.3.2.

The maximum U-values and the minimum temperature indices for windows, doors and skylights intended for use in normal moisture conditions are provided in NBC Table 9.7.3.3. The U-value of a fenestration component does not take into account all aspects of construction that will have an impact on condensation resistance for the component, such as the component–wall interface (installation), the location of the component in the assembly, and the interior relative humidity. However, the U-value has become recognized as a basic indicator of the thermal performance of fenestration components. The temperature index is a standardized indicator of condensation resistance, which is provided as an alternative to the U-value, but which is not as readily available for most products.

Windows, doors and skylights intended for use where the interior space will have a high moisture content (e.g., swimming pools, greenhouses, laundromats, and facilities housing continuously operating hot tubs or saunas) need to be designed in conformance with NBC Section 5.3. because the thermal characteristics of the fenestration component alone will not be sufficient to minimize condensation. Additional design considerations may have to be taken into account to prevent the premature deterioration of the building envelope in such applications.

Reducing Heat Loss through Windows and Glazed Doors

Heat loss through windows and glazed doors occurs in a number of ways:

- through the glazing by conduction, convection and radiation,
- through the glazing frame by conduction,
- by air leakage around the glazing, between the sashes and frame, and at junctions between sliding elements, and
- by air leakage around the glazing frame.

The first three types of heat loss depend on the characteristics of the glazing design and manufacture. The last can be reduced through proper installation. Using triple glazing to increase the number of still air spaces will increase the glazing's effective thermal resistance. Applying a thin, metallic, low-emissivity coating over the glazing will also improve its heat loss performance.

It should be noted that, in most cases, low-emissivity films will also reduce the amount of light that is transmitted through the window, although this reduction is not very obvious to occupants. Filling a sealed glazing unit with an inert gas, such as argon or krypton, can further improve a window's resistance to heat loss.

Minimizing Condensation on Windows

Thermal bridging at the window sash and frame often contributes to a cooling of the edges of the glazing. During cold periods, condensation may appear around glazing edges, which is normal and probably not a cause for concern. However, continual wetting or dripping, or constant full window condensation may cause the degradation of adjacent components.

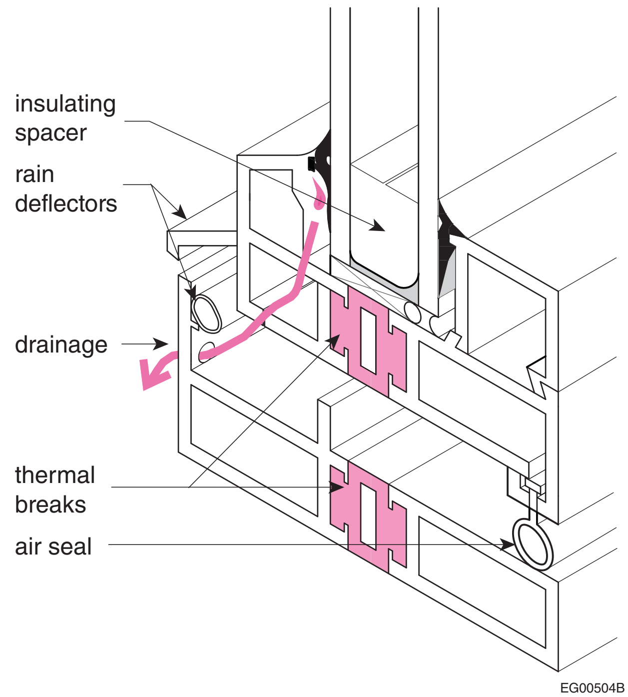


Figure 9.7.-2
Thermal breaks in windows

Various types of glass may be used for windows, including annealed glass, sheet glass, tinted glass, clear glass, coated glass, tempered glass, wire-reinforced glass, and laminated glass. The glass material standards referenced in NBC Article 9.6.1.2. regulate the quality of glass. The referenced material standard for insulating glass units regulates their ability to maintain an effective seal between the panes of glass to ensure that condensation will not occur between the panes in cold weather and mar their clarity.

To minimize condensation, it is important to identify the causes of condensation, such as high interior relative humidity, cool interior temperature, and poor air circulation at the window surface (e.g., due to the use of heavy drapes). These conditions are difficult to assess at the time of construction.

Heat loss by conduction through a window frame can be reduced by using a low-conductivity material, such as wood, or an insulated profile for the frame, such as vinyl or fibreglass, and/or by ensuring that metal sashes and frames incorporate a thermal break, as shown in Figure 9.7.-2.

Heat loss also occurs where spacers are in contact with each layer of glazing. Using spacers made of an insulating material, such as plastic, silicone, or glass fibre, rather than aluminum, will reduce heat loss and help to minimize condensation around the edge of the glazing.

Mounting windows closer to the inside of a wall can further reduce the risk of condensation because in this configuration the exterior window surface is somewhat sheltered from being cooled by wind and the interior window surface is more effectively heated by the room air currents, as shown in Figure 9.7.-3.

Where a removable multiple glazing panel (RMGP) is installed on the inside of a window, care should be taken to hermetically seal the RMGP against the leakage of moisture-laden air from the interior into the cavity on the exterior of the RMGP, because the moisture transported by the air could lead to significant condensation on the interior surface of the outside glazing.

Condensation resistance can be determined by establishing temperature index (I) values using the physical test procedure given in CSA A440.2, "Fenestration Energy Performance," which is referenced in NBC Table 9.7.3.3. Computer simulation tools can also be used to estimate the relative condensation resistance of windows, but these methods employ different expressions of performance known as condensation resistance (CR) factors. I and CR values are not interchangeable.

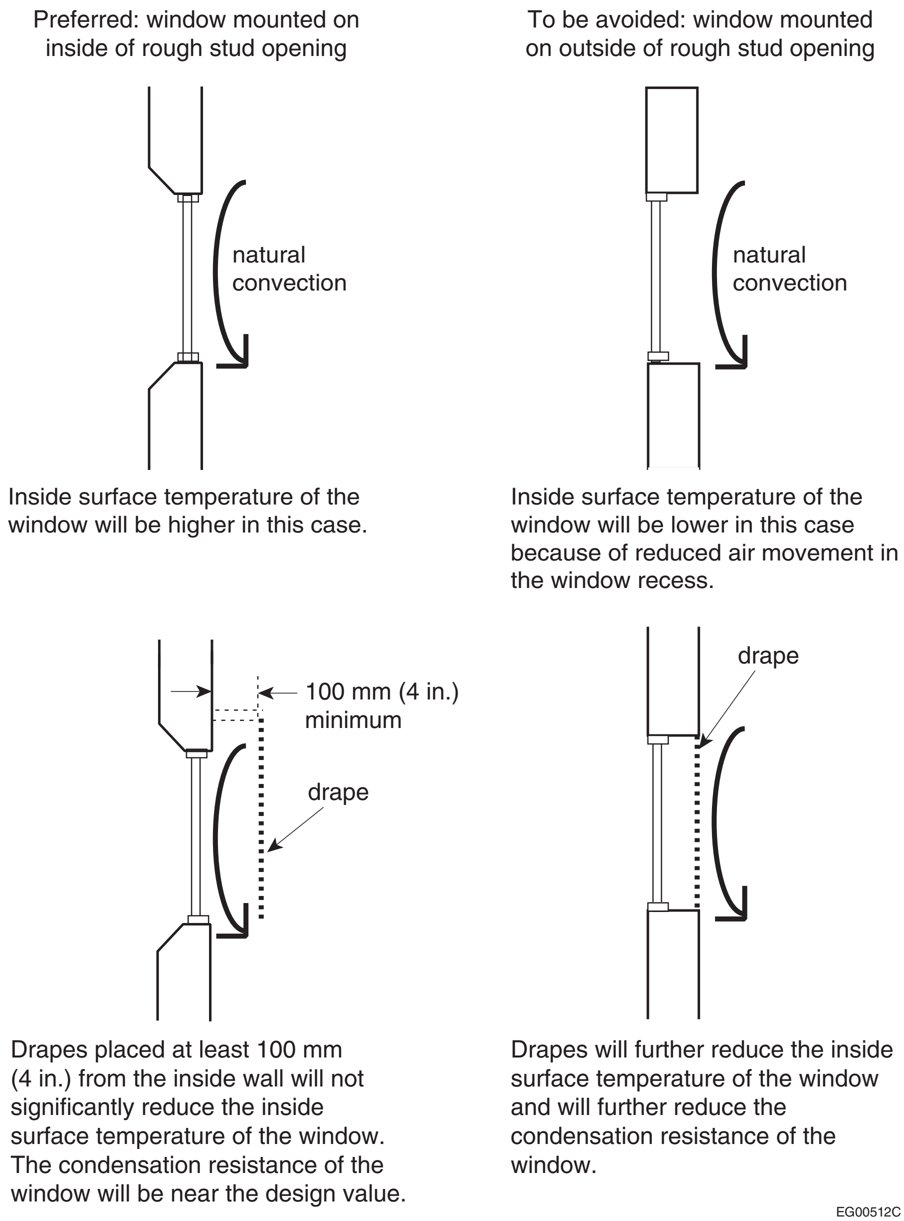


Figure 9.7.-3
Mounting windows to minimize condensation

9.7.4. Manufactured Windows, Doors and Skylights

9.7.4.1. Application

This Article indicates that NBC Subsection 9.7.4. applies to manufactured and pre-assembled windows, doors and skylights covered in the scope of the Harmonized Standard.

The Harmonized Standard does not apply to some fenestration products, such as curtain walls, window walls, and garage doors for vehicle access. However, it references a number of standards that apply to excluded products. Compliance with these standards, which are referenced for information only, is not required by the NBC.

9.7.4.2. General

This Article describes the compliance path for manufactured and pre-assembled windows, doors and skylights covered in the scope of the Harmonized Standard. It requires that these fenestration components comply with the Harmonized Standard, the Canadian Supplement, and the remainder of NBC Subsection 9.7.4. It also requires that manufactured and pre-assembled windows, doors and skylights be installed in accordance with NBC Subsection 9.7.6.

Product Designator

The Harmonized Standard requires that each tested fenestration product be labelled with a performance designator (the label may be non-permanent). The performance designator is a descriptor of the product's performance and can be found in the product literature. The Canadian Supplement requires both a primary and a secondary performance designator. For a fenestration product to carry a label in Canada, it must meet all of the applicable requirements of both the Harmonized Standard and the Canadian Supplement, including the forced entry requirements.

The primary performance designator indicates a certain performance rating, and by itself indicates compliance with the Harmonized Standard. An example is provided in Table 9.7.-B.

Table 9.7.-B
Example of a Primary Designator for a Window

Primary Designator	
Class R — PG1200: Size tested 760 × 1 250 mm — Casement	
Term	Description
Class R	Indicates the performance class (R is the minimum class and the only one required in Canada)
PG 1200	Indicates the performance grade (tested and passed at a design pressure of 1 200 Pa)
Size tested 760 × 1 250 mm	Indicates the maximum size of the tested products (larger products may not meet the performance grade)
Casement	Indicates the product type according to the description in the Harmonized Standard

The secondary designator indicates additional performance ratings for the product, including:
- positive design pressure, where applicable,
- negative design pressure, where applicable,
- water penetration test pressure, and
- Canadian air infiltration and exfiltration levels.

The Canadian Supplement contains a checklist for selecting performance ratings for windows, doors, and skylights.

9.7.4.3. Performance Requirements

This Article describes the procedure for selecting performance grades for windows, doors and skylights and requires that these fenestration components comply with the selected performance grades when tested in accordance with the Harmonized Standard. It also requires that exterior wood doors conform to a material standard and be labelled with certain information.

Compliance with the Harmonized Standard

The Harmonized Standard includes a classification system that rates a fenestration product according to its airtightness, watertightness, and wind load resistance. The ratings achieved by each product are marked on the product to indicate the level of performance that can be expected. The NBC references the Harmonized Standard and the Canadian Supplement to help specifiers, manufacturers, and general users identify fenestration products appropriate for a particular building, on the basis of its geographic location and height.

Specifiers and builders need to ensure that fenestration products are suited to the climates in which they will be used. They must do so by determining the design pressure for a given location using the Canadian Supplement, and by selecting windows with a performance grade that meets or exceeds the design pressure on the basis of the manufacturers' information.

While the NBC does not address the energy efficiency of windows, doors and skylights, Natural Resources Canada's (NRCan) ENERGY STAR program rates fenestration products according to their energy performance.

Water Penetration Resistance

For the various performance grades listed in the Harmonized Standard, the corresponding water penetration resistance test pressures are a percentage of the design pressure. For R-class products, the water penetration resistance test pressure is 15% of the design pressure. The design pressure and the water penetration resistance test pressure are reported on a secondary designator, which is required by the Canadian Supplement to be affixed to the window.

In Canada, driving rain wind pressure (DRWP) values have been determined for the locations listed in NBC Appendix C. To achieve equivalent levels of water penetration resistance for all locations, the Canadian Supplement includes a provision for calculating a specified DRWP for a building location given its exposure. In some cases, the specified DRWP is greater than 15% of the design pressure, and in other cases, it is less than 15% of the design pressure.

To comply with the NBC, a fenestration product must be able to resist the structural, air and water penetration loads at the building site. Reliance on a percentage of the design pressure as a measure of water penetration resistance in the selection of an acceptable fenestration product will not always be adequate. The specified DRWP should be used instead for all products covered in the scope of the Harmonized Standard.

Uniform Load Structural Test

The Harmonized Standard requires that fenestration products be tested at a uniform load structural test pressure equal to 150% of the design pressure for wind (specified wind load) and that skylights and roof windows be tested at a uniform load structural test pressure equal to 200% of the design pressure for snow (specified snow load).

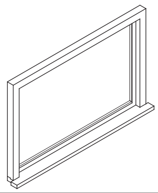
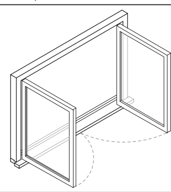
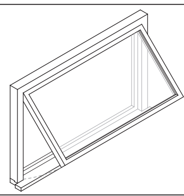
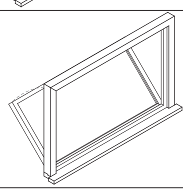
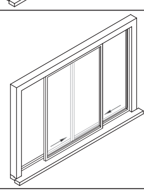
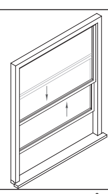
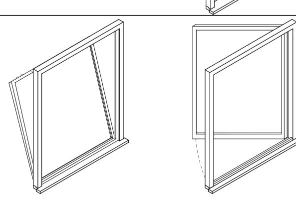
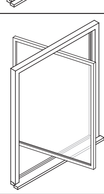
In the NBC, a factor of 1.4, rather than 1.5, is applied to wind loads, and a factor of 1.5, rather than 2.0, is applied to snow loads. Although incorporating these lower load factors into the NBC requirements for fenestration would better reflect the acceptable minimum performance levels, this has not been done because of the benefits of Canada–US harmonization and because differentiating between products that meet the Canadian and US requirements would complicate the work of manufacturers, designers, specifiers and regulatory officials.

Airtightness

The Harmonized Standard requires that fenestration products be tested for air infiltration and exfiltration, but only requires that pass/fail results be reported. The Canadian Supplement, however, requires a minimum rating of A2, which corresponds to a maximum air leakage of 1.5 L/(s·m^2) (0.30 cfm/ft.^{2}), for all operable windows, doors and skylights. (The A rating scale used in the Canadian Supplement is very similar to that used in CAN/CSA-A440-00, "Windows," which was referenced in pre-2010 editions of the NBC.) Fixed windows, doors and skylights are required to have a maximum air leakage of 0.2 L/(s·m^2) (0.04 cfm/ft.^{2}).

Window Types

A great number of windows types are available from various manufacturers and suppliers, some of which are illustrated in Figure 9.7.-4.

Window Type		Description
	Fixed	consists of a frame and a stationary sash can be used in conjunction with operable window units
	Casement	has one or two operating sashes, which usually swing outward; two operating sashes may close on one another or on a vertical mullion able to direct incoming ventilation
	Awning	consists of a frame and an operating sash that is hinged at the top and that swings outward
	Hopper	consists of a frame and an operating sash that is hinged at the bottom and that swings inward
	Sliding	has two sashes, of which one slides horizontally (maximum 50% ventilation), or three sashes, of which the outer two slide horizontally (maximum 66% ventilation)
	Double-hung	has two operating sashes that move vertically and that are held in a desired position by friction fit against the window frame or by a balancing device single-hung windows are similar, but one of the sashes is fixed
	European tilt/swing	has hardware allowing the operating sash to swing inward from the top or from the side
	Pivoting	similar to casement windows, but top and bottom pivots are used instead of side hinges screening not possible

EG00494C

Figure 9.7.-4
Window types

Many windows have been tested, and their test data is readily available. CCMC publishes a Registry of Product Evaluations that includes Evaluation Listings for windows. In addition, CSA Group, the Quality Auditing Institute, and Intertek Testing Services have voluntary certification programs for windows. This information can be used when selecting windows.

Exterior doors

Exterior doors are subjected to much more rigorous exposure conditions than interior doors. Exterior doors have to withstand numerous wetting cycles, as well as extreme temperatures. Doors made with non-waterproof adhesives fail prematurely when exposed to the weather. Hollow-core wood doors, even if constructed with waterproof adhesives, may warp in extreme winter conditions and cease to be an effective barrier against the weather.

Exterior doors are commonly made of wood, insulated steel, or glass (e.g., sliding glass doors). Regardless of the material they are made of, exterior doors have to comply with the performance levels specified in the Harmonized Standard.

Because of past experiences with inferior products, and because of the absence of material specifications for wood doors in the Harmonized Standard, NBC Sentence 9.7.4.3.(4) requires that exterior wood doors be provided with a stamp or label indicating the name of the manufacturer, that they are designed for exterior use, and that they conform to CAN/CSA-O132.2 Series, “Wood Flush Doors.”

9.7.5. Site-built Windows, Doors and Skylights

9.7.5.1. Application and Compliance

This Article contains requirements for site-built windows, doors and skylights that separate conditioned space from unconditioned space or the exterior but are not covered in the scope of the Harmonized Standard. These fenestration components must meet the requirements of the remainder of Subsection 9.7.5. or Subsection 9.7.4. and Subsection 9.7.6. or must be designed and constructed according to NBC Part 5. Glass for site-built windows, doors and skylights needs to comply with NBC Section 9.6.

Site-built windows, doors and skylights must meet the same general performance requirements as manufactured products (NBC Subsection 9.7.3.). The compliance of site-built doors, which are much more common than site-built windows and skylights, with these performance requirements is usually limited to an on-site inspection.

9.7.5.2. Resistance to Forced Entry for Doors

This Article establishes prescriptive measures to provide site-built swinging doors with a basic resistance to forced entry. Similar measures for manufactured and pre-assembled windows, doors and skylights are contained in the Harmonized Standard.

The requirements of this Article apply to swing-type entrance doors to dwelling units, swing-type doors between dwelling units and attached garages (or other ancillary spaces), and swing-type doors that provide access from a storage garage to a dwelling unit. They apply to such swing-type doors in all types of dwelling units within the scope of NBC Part 9, including houses and apartments. They do not apply to sliding doors or to overhead garage doors.

The requirements of this Article are not intended to make a house burglar-proof. Rather, they are aimed at stopping the inexperienced thief responsible for the majority of forced entries. It is impossible to go beyond this degree of security without increasing costs significantly. This security level is consistent with that applied in testing the resistance to forced entry of manufactured doors in the Harmonized Standard.

Security measures aimed at resisting forced entry must not hinder escape in the event of a fire. All egress doors from dwelling units have to be openable from the inside without the use of keys or complicated procedures (NBC Article 9.9.6.7.). There is simply no time to look for misplaced keys or to manipulate complicated release mechanisms under fire conditions.

Doors that conform to a security level of at least Grade 10 as described in the Annex to ASTM F 476, "Security of Swinging Door Assemblies," are not required to comply with the requirements in NBC Sentences 9.7.5.2.(3) to (7). The Annex describes four security levels, with acceptance criteria, which are suitable for different types of buildings located in areas with different crime rates. Grade 10 is the minimum security level.

Glazing in Doors and Sidelights

One method of forced entry is to break glass in doors and sidelights to gain access to door hardware and then unlock the door from the inside. Although insulated annealed glass provides increased resistance to forced entry relative to single-glazed annealed glass, the highest resistance to forced entry is provided by laminated glass. Tempered glass, while stronger than laminated glass against static loads, is prone to shattering under high, concentrated impact loads. However, neither of these types of glass is required by the NBC.

Laminated glass is more expensive than annealed glass and must be used in greater thicknesses. Figure 9.7.-5 shows an insulated sidelight made of one pane of laminated glass and one pane of annealed glass. This use of one pane of laminated glass rather than two reduces the cost of the sidelight.

Although not required, consideration should be given to using laminated glazing in doors described in NBC Sentence 9.7.5.2.(1) and their sidelights, in windows located within 900 mm (36 in.) of locks in such doors, and in basement windows.

ULC-S332, "Burglary Resisting Glazing Material," provides a test procedure to evaluate the resistance of glazing to attacks by thieves. While this test procedure is principally intended for plate glass show windows, it may also be of value for residential purposes.

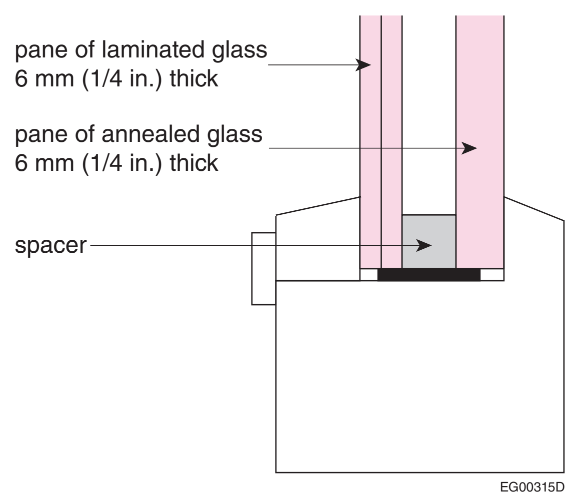


Figure 9.7.-5
Insulated sidelight made of laminated glass and annealed glass

Wood Doors

To reduce their risk of being broken on impact, doors should be of substantial construction. Wood doors must be solid core or stile-and-rail type, and must be at least 45 mm (1 3/4 in.) thick. Panel sections of stile-and-rail doors can be thinner (not less than 19 mm (3/4 in.) thick), provided they do not make up more than half of the door area (Figure 9.7.-6).

Locks

Door locks should be reasonably secure against amateur lock pickers. The swinging doors described in NBC Sentence 9.7.5.2.(1) must be provided with a deadbolt lock with a cylinder having no less than 5 pins and a bolt throw of not less than 25 mm (1 in.), protected with a solid or hardened free-turning ring or bevelled cylinder housing (Figure 9.7.-6).

Since the traditional latch that holds a door closed has a bevelled face to allow the latch to retract automatically when the door closes against it, the latch can also be retracted by the use of a credit card or similar device shoved against the bevelled surface between the door and frame. In contrast, a deadbolt mechanism is not bevelled and has no automatic spring action. It is operated by a key, thumb turn or lever, and is held positively when in the locked position.

The inactive leaf in double doors in locations specified in NBC Sentence 9.7.5.2.(1) must be secured with heavy-duty bolts, top and bottom, having an engagement not less than 15 mm (5/8 in.) (Figure 9.7.-6).

Hinges

All outward-swinging doors described in NBC Sentence 9.7.5.2.(1), except storm doors and screen doors, must be provided with hinges or pins that prevent the doors from being removed when they are in the closed position. One method of satisfying this requirement is to use non-removable pin hinges. Another method is to modify standard hinges by screw fastening a metal pin in a screw hole in one half of each of the top and bottom hinges. When the door is closed, the projecting portion of the pin engages in the corresponding screw hole in the other half of the hinge so that, even if the hinge pin is taken out, the door cannot be removed.

Hinges for wood doors described in NBC Sentence 9.7.5.2.(1) must be securely fastened to the wood doors with wood screws that are at least 25 mm (1 in.) long, and to the wood frames with at least two wood screws penetrating not less than 30 mm (1 3/16 in.) into solid wood (see Figure 9.7.-6). The purpose of this requirement is to prevent the door from being dislodged from the jamb as a result of impact forces. The requirement is not intended to prohibit the use of other types of hinges that are specially designed to provide equal or greater resistance to forced entry.

Hinges for metal doors described in NBC Sentence 9.7.5.2.(1) must be securely fastened to the metal doors and frames with machine screws not smaller than No. 10 and not less than 10 mm (3/8 in.) long.

Strikeplates and Blocking

Strikeplates for deadbolts of doors described in NBC Sentence 9.7.5.2.(1) must be fastened to wood frames with wood screws penetrating not less than 30 mm (1 3/16 in.) into solid wood. Such strikeplates must be fastened to metal frames with machine screws not smaller than No. 8 and not less than 10 mm (3/8 in.) long.

One method of forced entry is to spread the door jambs apart using a jacking device, thus releasing the latch or bolt from the strike plate. To resist this, the space between the jambs of doors described in NBC Sentence 9.7.5.2.(1) and the structural (rough) framing is required to be blocked at the lock height on both sides of the door. Blocking is normally accomplished by using wedges to set the door frame into the rough opening. In addition, the bolt throw of such doors is required to be at least 25 mm (1 in.), making dislodgment of the bolt more difficult (see Figure 9.7.-6).

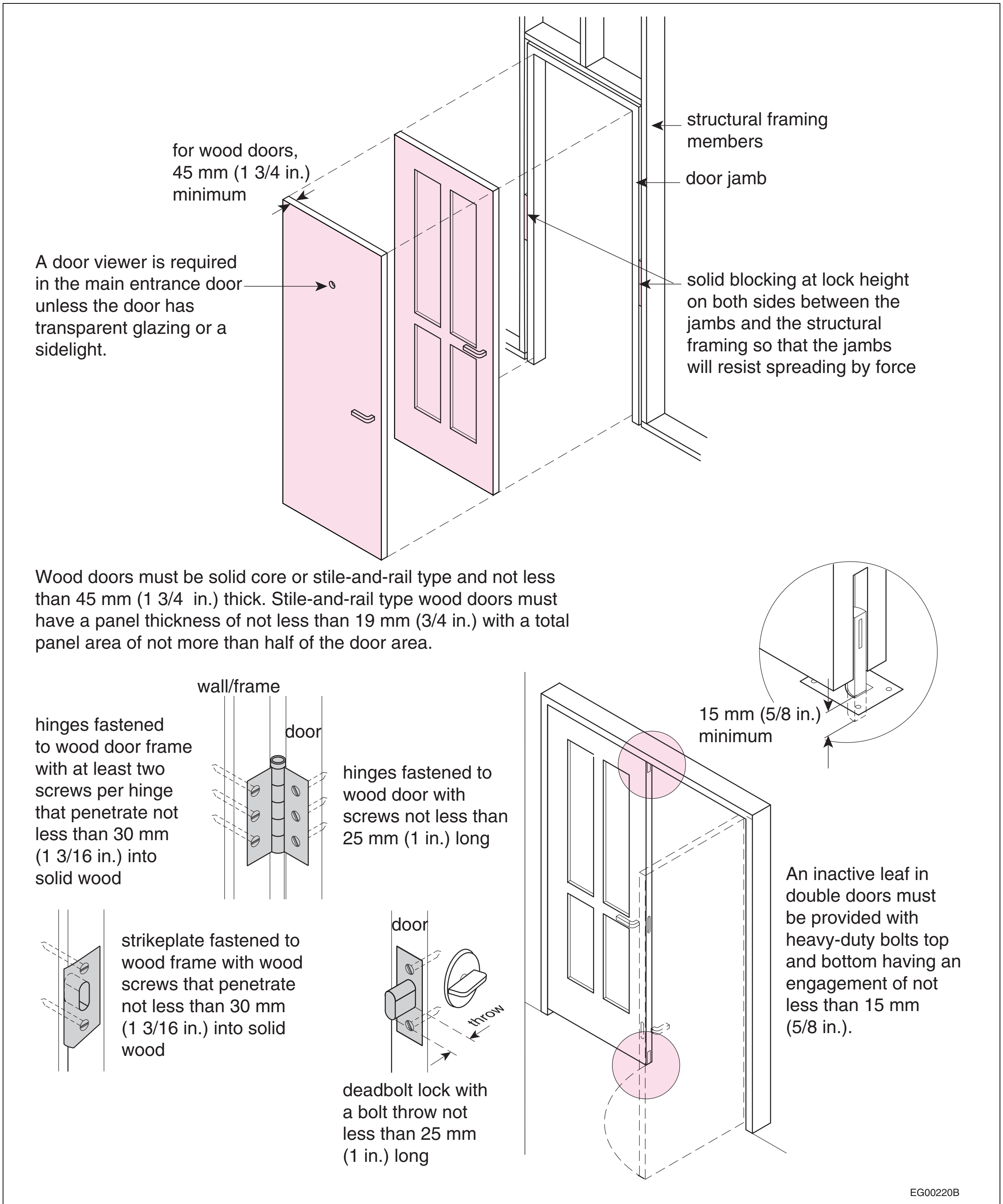


Figure 9.7.-6
Resistance to forced entry for swinging doors and double doors in locations specified in NBC Sentence 9.7.5.2.(1) (NBC Articles 9.7.2.1. and 9.7.5.2.)

9.7.5.3. Resistance to Forced Entry for Windows

This Article establishes prescriptive measures to provide site-built windows near ground level with a basic resistance to forced entry.

While the Harmonized Standard requires manufactured windows to be tested for resistance to forced entry and the Canadian Supplement provides additional guidance on their resistance to forced entry requirements, these standards do not provide any criteria for site-built products.

Many burglaries result from forced entry through windows, particularly those near ground level. For this reason, windows in dwelling units must meet the requirements for resistance to forced entry in Clause 5.3.5 of the Harmonized Standard if they are located within 2 m (6 ft. 7 in.) of adjacent ground level. This requirement does not apply to windows that serve spaces other than the interior of a dwelling unit, such as garages, sun rooms and greenhouses, provided that the connections between these spaces and the dwelling unit are secure. Nor does this requirement apply to windows located at higher elevations near certain building features, such as balconies and canopy roofs, that allow for easy access to the windows. Consideration should be given to specifying break-in-resistant windows in such locations.

One method that is often used to improve the resistance of windows to forced entry is the installation of metal security bars. However, while many such installations are effective in increasing resistance to forced entry, they may reduce or eliminate the usefulness of the window as a means of egress if they are not easily openable. In order to comply with NBC Article 9.9.10.1., a security bar system installed over an egress window must be easy to open from the inside.

9.7.6. Installation

9.7.6.1. Installation of Windows, Doors and Skylights

This Article, in keeping with the standard it references, ensures that windows, doors and skylights are installed in a manner that maintains the integrity of the building envelope. The requirements apply to both manufactured and site-built fenestration components.

The interface between a fenestration component and the rest of the building envelope is a potential location for air and water intrusion. Windows, doors and skylights need to be properly installed and sealed so that the principal planes of protection against air leakage and water ingress are continuous throughout the building envelope.

The installation of windows, doors and skylights must conform to CAN/CSA-A440.4, “Window, Door and Skylight Installation,” except that shims that are used to position and support windows, doors and skylights are permitted to be made of treated plywood. Protection from precipitation for walls and roofs incorporating these fenestration components, and the interfaces of walls and roofs with these fenestration components must conform to NBC Section 9.27.

The installation of manufactured and pre-assembled windows, doors and skylights, and the field assembly of manufactured window and door combinations must also conform to the manufacturer’s instructions.

Skylight curbs are normally necessary to prevent snow and rain from penetrating to the interior of the building. To prevent leaks, it is most important to take care in detailing flashing (see NBC Section 9.26.).

9.7.6.2. Sealants, Trim and Flashing

This Article is concerned with the prevention of water entry and air leakage around windows, doors and skylights. In particular, small openings around window, door and skylight frames can be a significant source of air leakage.

It is important that sealants and caulking be durable and compatible with the materials being sealed. Sealing compounds used to seal the glass component of an insulating glazing unit (e.g., a factory-sealed double-glazed unit) to the sash component must be compatible with the sealing compound used to edge seal the glass component. Sealants must be applied between window frames or trim and the exterior cladding or masonry as described in NBC Subsection 9.27.4.

Windows are normally installed in an opening that is 25 mm (1 in.) larger than the frame to allow them to be correctly levelled and squared using shims or wedges. Heat loss through the shim space can be minimized by insulating and sealing this space.

A complete seal around a window frame is essential. For example, Figures 9.7.-7 and 9.7.-8 show the air sealing of windows to polyethylene and airtight drywall air barriers, respectively.

The type of window used can affect the amount of air leakage and the subsequent heat loss. In general, windows with compression seals can be made to provide greater airtightness than those with sliding seals, although both types of windows must meet the same air leakage requirements. Figure 9.7.-9 illustrates the differences between compression seals and sliding seals.

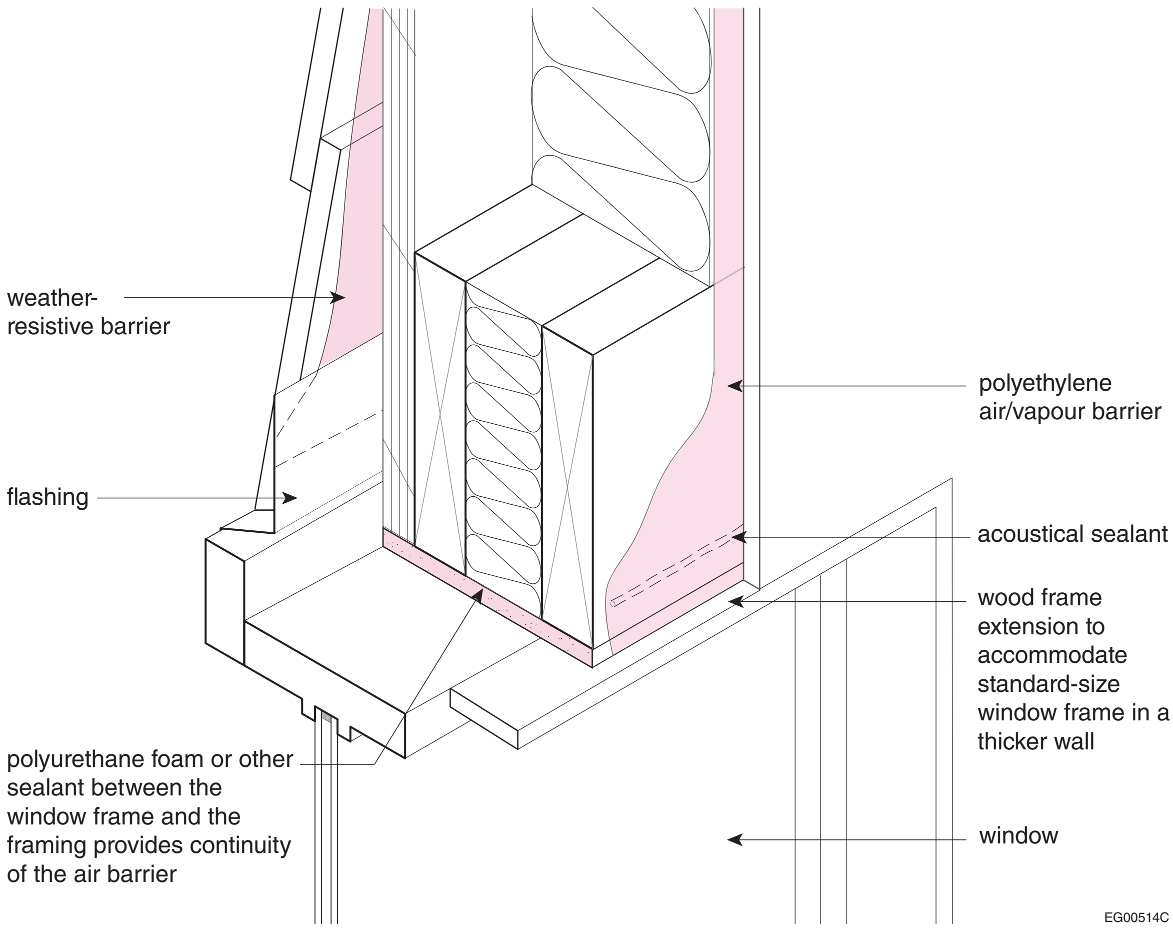


Figure 9.7.-7
Sealing a window to a polyethylene air barrier

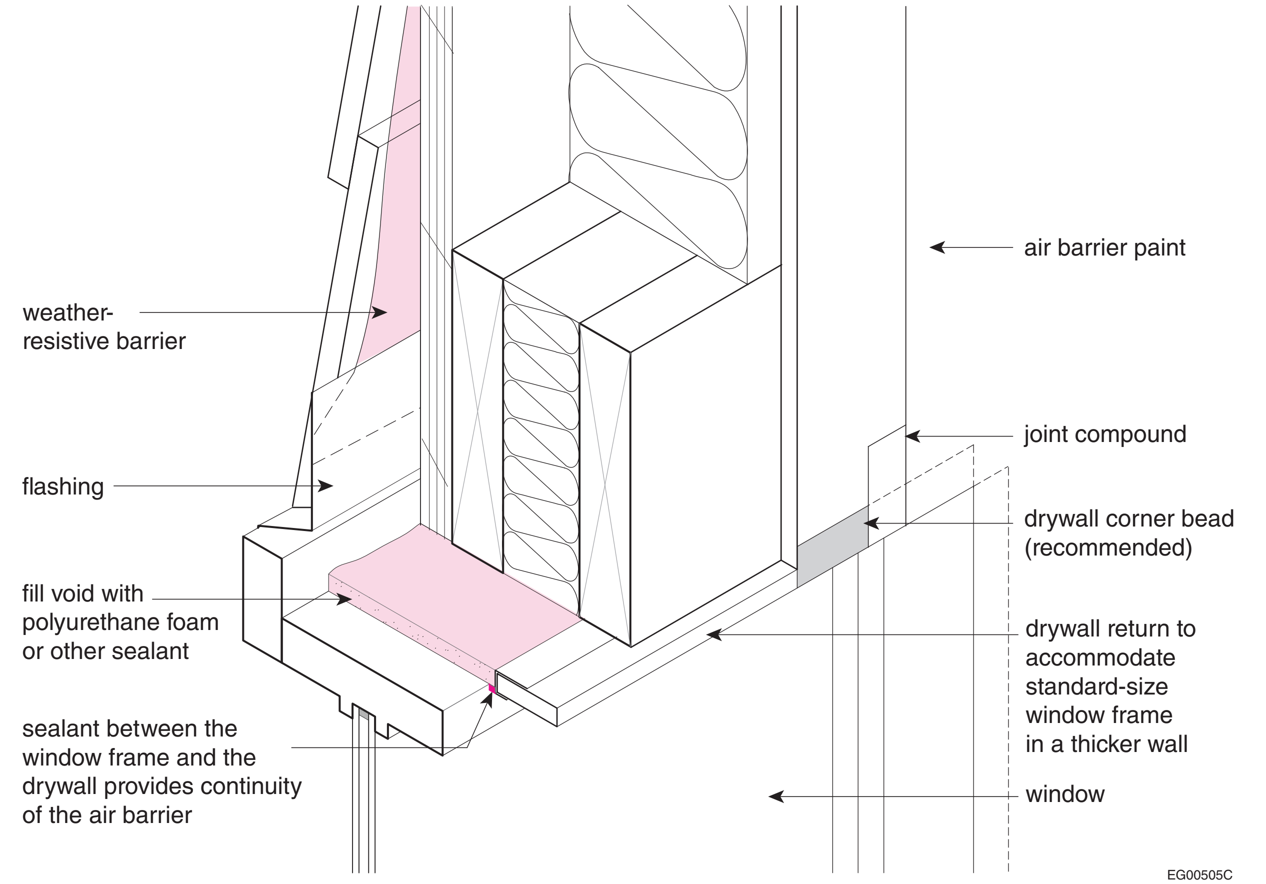


Figure 9.7.-8
Sealing a window to an airtight drywall air barrier

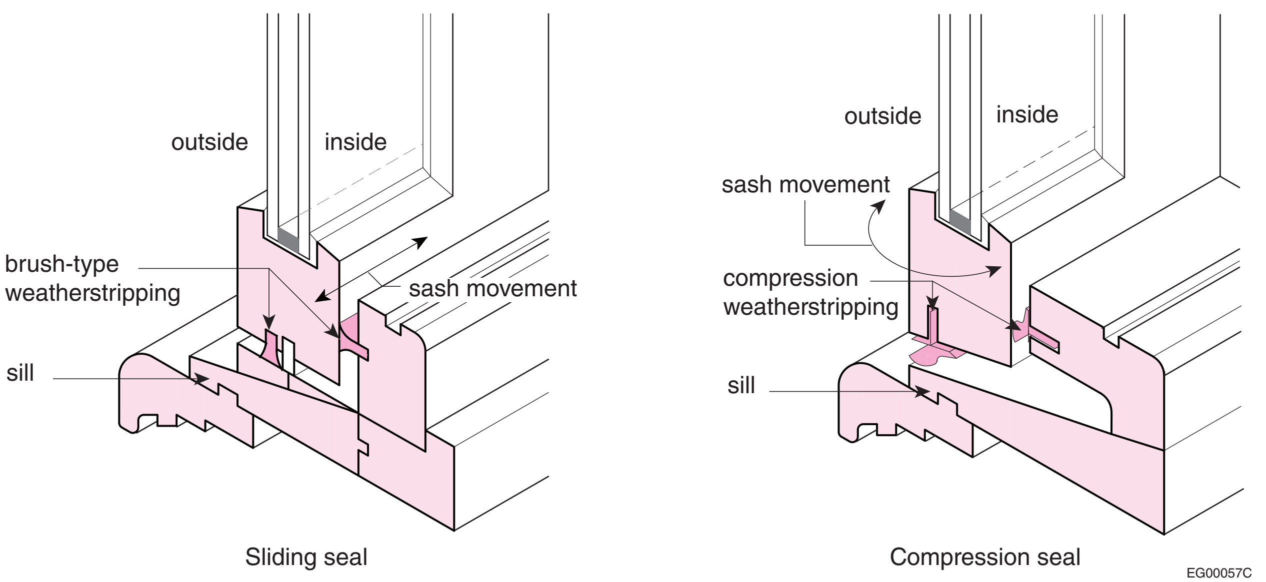


Figure 9.7.-9
Window seals

Section 9.8. Stairs, Ramps, Handrails and Guards

Introduction

The requirements for stairs, ramps, handrails and guards in this Section are derived from ergonomic studies and from practices found to provide reasonable safety and convenience.

The requirements in this Section deal with acceptable dimensions and configurations of stairs, ramps, handrails and guards. Other requirements for stairs and ramps are found in NBC Sections 3.8., 9.9. and 9.10., as well as in NBC Subsection 9.34.2. Requirements for escalators and moving walkways are covered in NBC Part 3.

9.8.1. Application

9.8.1.1. General

This Article indicates that NBC Section 9.8. applies to the design and construction of interior and exterior stairs, steps, ramps, handrails and guards.

9.8.1.2. Stairs, Ramps, Landings, Handrails and Guards in Garages

This Article clarifies that where stairs, ramps, landings, handrails or guards are installed in garages that serve a single dwelling unit or a house with a secondary suite (including their common spaces), the garage is considered to be part of the dwelling unit, and the requirements for stairs, ramps, landings, handrails and guards within dwelling units apply.

In this Guide and in NBC Section 9.8., the qualifier “private” is used to describe exterior and interior stairs and ramps that serve:

- single dwelling units,
- houses with secondary suites (including their common spaces), or
- garages for single dwelling units or houses with secondary suites (including their common spaces).

The qualifier “service” is used to describe stairs and ramps that serve service rooms or spaces. The qualifier “public” is used to refer to stairs and ramps not described as “private” or “service.”

9.8.1.3. Exit Stairs, Ramps and Landings

This Article clarifies that, where a stair, ramp or landing forms part of an exit, the appropriate requirements in NBC Sections 9.9. and 9.10. also apply.

9.8.1.4. Escalators and Moving Walkways

This Article indicates that escalators and moving walkways must conform to the relevant requirements in Part 3. These devices are not covered in NBC Part 9 because of their limited use in Part 9 buildings.

9.8.2. Stair Dimensions

9.8.2.1. Stair Width

This Article indicates minimum allowable widths for stairs. The minimum width for spiral stairs is given in NBC Article 9.8.4.7.

The minimum widths for public stairs are intended to allow ascending and descending users to pass one another without difficulty. The minimum widths for private stairs are intended to permit the movement of furniture and occupants. These stairs are permitted to be narrower than public stairs because they are less frequently used for simultaneous ascending and descending.

Since stairs must accommodate the movement of people as well as furniture, both of these functions must be considered in establishing minimum stair widths. Because stairs can take up valuable floor space that could be employed for more profitable uses, the tendency is to keep stair widths to a minimum. Experience has shown that 860 mm (34 in.) is the smallest acceptable width for most stairs in dwelling units, while 900 mm (3 ft.) is the smallest acceptable width for public stairs in residential buildings. In buildings of other than residential occupancy, the occupant load served by public stairs must also be considered in establishing the minimum stair width.

A minimum clear width of 660 mm (2 ft. 2 in.) is permitted for spiral stairs in all Part 9 buildings (NBC Clause 9.8.4.7.(1)(b)). Spiral stairs are permitted to be used as the only means of egress where they serve no more than 3 persons and as secondary stairs where they serve more than 3 persons. They are not permitted to be used as an exit.

The required minimum stair widths are summarized in Table 9.8.-A.

Table 9.8.-A
Minimum Stair Widths (NBC Articles 9.8.2.1. and 9.8.4.7.)

Location of Stair	Stair Type	Minimum Stair Width or Clear Width
Single dwelling units and houses with secondary suites (including their common spaces)	Exit	860 mm (2 ft. 10 in.)
Single dwelling units	At least one stair between each floor level	860 mm (2 ft. 10 in.)
	Exterior	860 mm (2 ft. 10 in.)
Buildings of residential occupancy	Required exit	900 mm (3 ft.)
	Public	900 mm (3 ft.)
Buildings of other than residential occupancy	Required exit	900 mm (3 ft.) or 8 mm (1/4 in.) per person,(1) whichever is greater
	Public	900 mm (3 ft.) or 8 mm (1/4 in.) per person,(1) whichever is greater
All Part 9 buildings	Spiral	660 mm (2 ft. 2 in.) clear(2)

Notes to Table 9.8.A.:
(1) The occupant load is determined from NBC Table 3.1.17.1.
(2) This value is the minimum clear width measured between the handrails.

9.8.2.2. Height over Stairs

This Article indicates minimum clear heights over stairs. The minimum clear height over spiral stairs is given in NBC Article 9.8.4.7.

These clear heights are intended to provide sufficient headroom clearance to prevent a reasonably tall adult from making accidental head contact with the ceiling or other objects at that height (e.g., light fixtures, sprinklers heads, or piping). The lower minimum clear height for stairs in dwelling units is rationalized on the basis of greater occupant familiarity.

The clear height requirements for stairs are illustrated in Figure 9.8.-1.

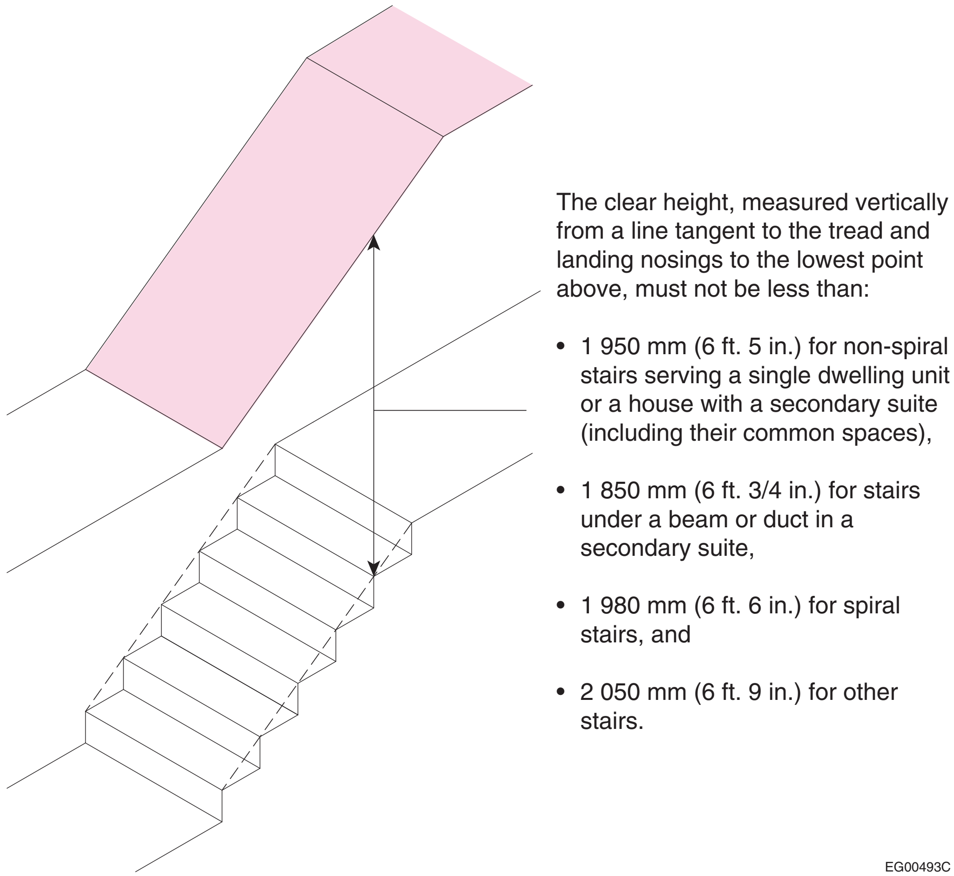


Figure 9.8.-1
Clear height over stairs (NBC Articles 9.8.2.2. and 9.8.4.7.)

9.8.3. Stair Configurations

9.8.3.1. Permitted Configurations

This Article indicates the types of stair configurations that are permitted in Part 9 buildings. Straight flights, curved flights, and spiral stairs are permitted in all Part 9 buildings. In addition, flights with winders and rectangular treads and flights with a mix of tapered and rectangular treads are allowed within dwelling units and houses with a secondary suite (including their common spaces).

Where tapered treads are used in a flight of stairs, they must all turn in the same direction. Where both tapered treads and rectangular treads are used in a flight of stairs, all the treads must generally have a uniform run (NBC Article 9.8.4.5.).

Winders are used to change the direction of a flight without the use of a landing. Although winders are considered to increase the likelihood of missteps, allowing their use in dwelling units and houses with a secondary suite (including their common spaces) is rationalized on the basis of occupant familiarity. Only one set of winders is permitted between floor levels. See Guide 9.8.4.6., Winders, for more information on winder configurations.

If curved flights are used in an exit, they must comply with Sentence NBC 3.4.6.9.(2). Spiral stairs are not permitted to serve as an exit and are only permitted as the lone means of egress where they serve not more than three persons

9.8.3.2. Minimum Number of Risers

This Article indicates the minimum number of risers for interior flights of stairs. In locations other than dwelling units, interior flights must have at least three risers. In dwelling units, there is no minimum number of risers for interior flights because occupants are assumed to be aware of stair locations.

9.8.3.3. Maximum Height of Stairs

This Article establishes a maximum vertical height of 3.7 m (12 ft. 2 in.) for flights of stairs. This maximum height limits the distance between two successive stair landings to reduce the apprehension of stair users during descent and thereby increase traffic flow. This maximum height may also reduce the number of injuries from accidental falls.

9.8.4. Step Dimensions

The NBC distinguishes four types of stair treads: rectangular treads, which are used in straight-run flights; tapered treads, which are used in curved flights; winder treads, which are used to change the direction of flights in dwelling units and houses with a secondary suite (including their common spaces); and spiral stair treads.

The ease of use of a flight of stairs depends on the dimensions of the individual steps. If the risers are too high, people will find the stairs difficult to use. If the risers are too low, they will interfere with the user's natural gait. If the treads are too narrow, users will be forced to walk diagonally on the treads. If they are too wide (a much less common problem), users will have to take two short steps on each tread, which interferes with their natural gait and slows pedestrian traffic.

Since stairways use space that would otherwise be used for other purposes, there is often a desire to construct steeper stairs. However, safety and ease of use must take precedence over space considerations.

9.8.4.1. Dimensions for Risers

This Article establishes minimum and maximum rises for private and public stairs, which are provided in NBC Table 9.8.4.1. The maximum rise for spiral stairs is given in NBC Article 9.8.4.7.

The rise of a step is measured as the vertical nosing-to-nosing distance.

The maximum rise limits the amount of effort required for each step, allowing stair use without excessive exertion. The minimum rise ensures a reasonable speed of travel (the smaller the rise, the more steps must be taken). Steeper stairs are permitted in dwelling units and houses with a secondary suite (including their common spaces) because it is assumed that occupants are familiar with their own dwelling unit. Service stairs are exempted from the requirements of this Article on the basis that they are not frequently used.

The dimensional requirements for steps with rectangular treads in private and public stairs are summarized in Figure 9.8.-2.

9.8.4.2. Dimensions for Rectangular Treads

This Article sets limits on the run and tread depth of rectangular treads in private and public stairs. The maximum and minimum runs for such treads are provided in NBC Table 9.8.4.2.

The limits on the run, together with those on the rise, control the steepness of stairs, which is also a factor in accidents. The minimum run, which is equal to the minimum tread depth, is intended to provide sufficient room to accommodate the length of a foot. Insufficient tread depth causes users to walk sideways to get sufficient foot support, increasing the risk of missteps. The maximum run, on the other hand, is intended to prevent users from having to take more than a single stride between steps, which would decrease the speed of travel. The maximum tread depth is intended to prevent excessive nosing projection.

The dimensional requirements for steps with rectangular treads in private and public stairs are summarized in Figure 9.8.-2.

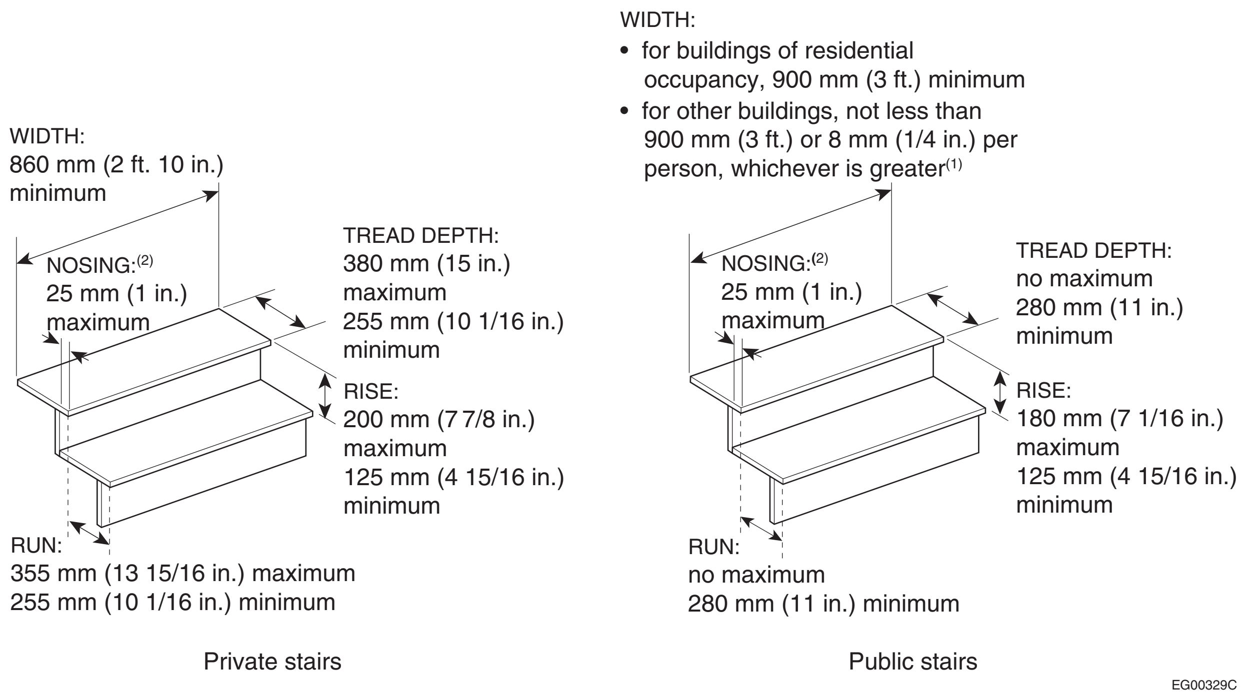


Figure 9.8.-2
Dimensions for steps with rectangular treads in public and private stairs (NBC Articles 9.8.2.1., 9.8.4.1. and 9.8.4.2.)

Notes to Figure 9.8.-2:
(1) The occupant load is determined from NBC Table 3.1.17.1.
(2) The top of the nosing must have a rounded or bevelled edge as specified in NBC Article 9.8.4.8.

9.8.4.3. Dimensions of Tapered Treads

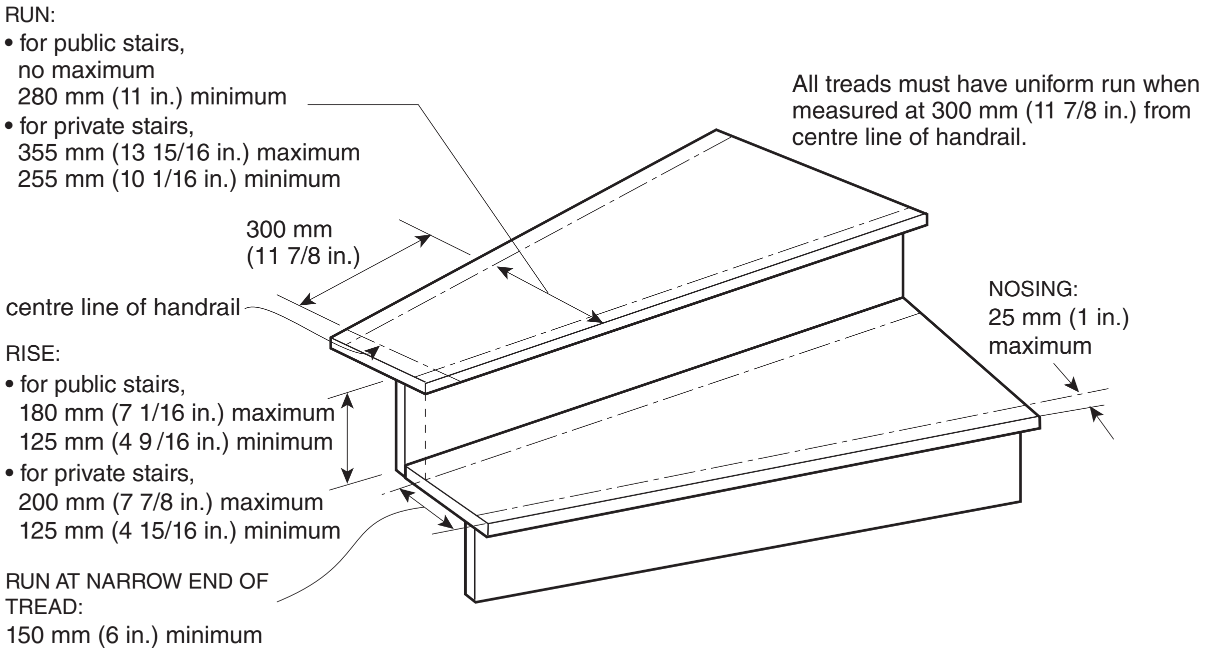
This Article sets limits on the dimensions of tapered treads, which are found in curved stairs.

The run limits for rectangular treads in NBC Table 9.8.4.2. also apply to tapered treads when measured at a point 300 mm (11 7/8 in.) from the centre line of the handrail at the narrow end of the tread.

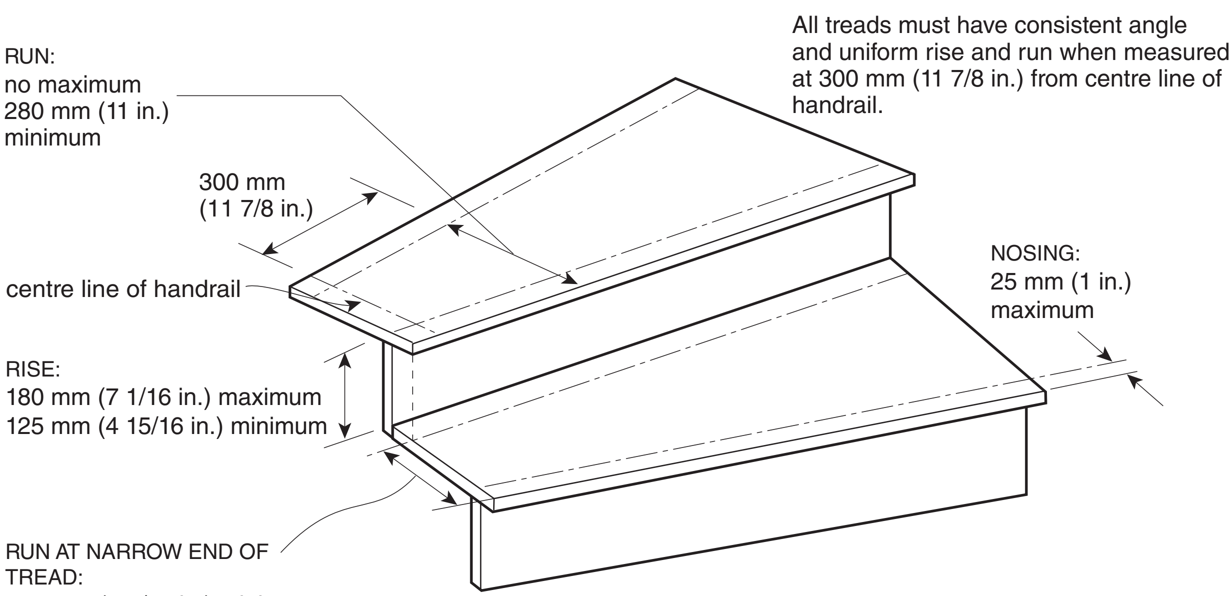
Tapered treads in required exit stairs must comply with the requirements of NBC Article 3.4.6.9. A larger minimum run is permitted for tapered treads in required exit stairs than for tapered treads in private stairs in other locations.

The dimensional requirements for steps with tapered treads in required exit stairs and in other stairs are shown in Figure 9.8.-3.

Tapered treads that converge at the inside of the turn are only permitted if they comply with the requirements for winders in NBC Article 9.8.4.6. or with the requirements for spiral stairs in NBC Article 9.8.4.7. If they do not comply with these requirements, tapered treads that converge to a very small run (or a zero run) are considered unsafe.



Tapered treads not in required exit stairs



Tapered treads in required exit stairs(1)

EG00323D

Figure 9.8.-3
Dimensions for steps with tapered treads in required exit stairs and in other stairs (other than spiral stairs and winders) (NBC Articles 3.4.6.9., 9.8.4.1., 9.8.4.3. and 9.8.4.4.)

Note to Figure 9.8.-3:
(1) Tapered treads in required exit stairs must comply with the requirements of NBC Article 3.4.6.9.

9.8.4.4. Uniformity and Tolerances for Risers, Runs and Treads

This Article requires that steps be uniform within certain limits. Uniformity in step rise and run is necessary to reduce the risk of trips and missteps. Users anticipate such uniformity when ascending or descending stairs, and any significant deviation can lead to tripping.

In any flight of stairs, the risers must be of uniform height, with a maximum tolerance of 5 mm (3/16 in.) between adjacent treads or landings and 10 mm (3/8 in.) between the tallest and shortest risers in the flight. In addition, the treads must have a uniform run with a maximum tolerance of 5 mm (3/16 in.) between adjacent treads and 10 mm (3/8 in.) between the deepest and shallowest treads in the flight. For tapered treads, these run tolerances apply to the run measured at a point 300 mm (11 7/8 in.) from the centre line of the handrail at the narrow end of the tread.

9.8.4.5. Uniformity of Runs in Flights with Mixed Treads within Dwelling Units

This Article sets out requirements for the uniformity of runs in flights with mixed treads in dwelling units. Where a flight of stairs consists of sets of tapered treads and rectangular treads, a large difference between the runs of the two sets of treads could lead to missteps and falls. Therefore, the rectangular and tapered treads, with the exception of tapered treads located at the bottom of the flight, must have a uniform run (Figure 9.8.-4). Where tapered treads are located at the bottom of a flight, their run can exceed that of the rectangular treads above. However, within each set of tapered or rectangular treads, the run must be uniform, as specified by the NBC Article 9.8.4.4.

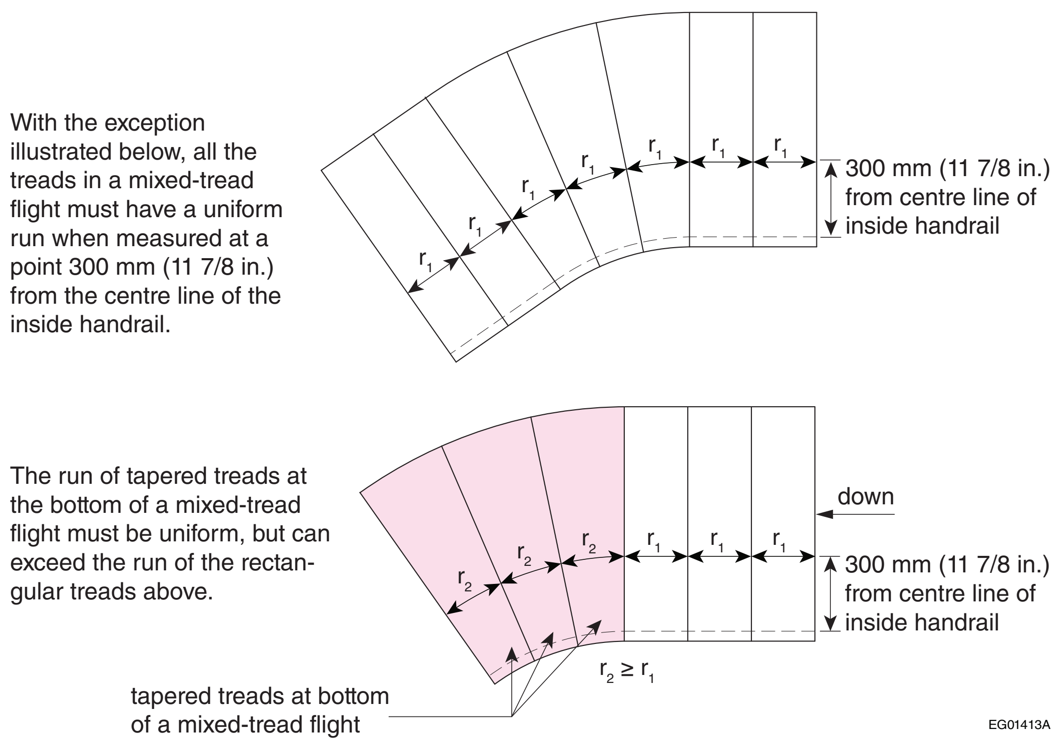


Figure 9.8.-4
Uniformity of runs in flights with tapered treads (other than winders) and rectangular treads within dwelling units and houses with a secondary suite (including their common spaces)

9.8.4.6. Winders

This Article establishes requirements for winders, which can only be used in dwelling units to allow stairs to change direction. Winders can be used instead of landings to reduce the amount of space required for stair turns. Although winders are considered to increase the risk of missteps, permitting their use in dwelling units is rationalized on the basis of occupant familiarity.

Winder treads have a triangular shape with a turn angle of 30° or 45°; other turn angles are not permitted. The specified turn angles are intended to standardize the traditional dimensions of winder treads. Up to three winders of the same turn angle can be used to change the direction of travel from a minimum of 30° to a maximum of 90°, as shown in Figure 9.8.-5.

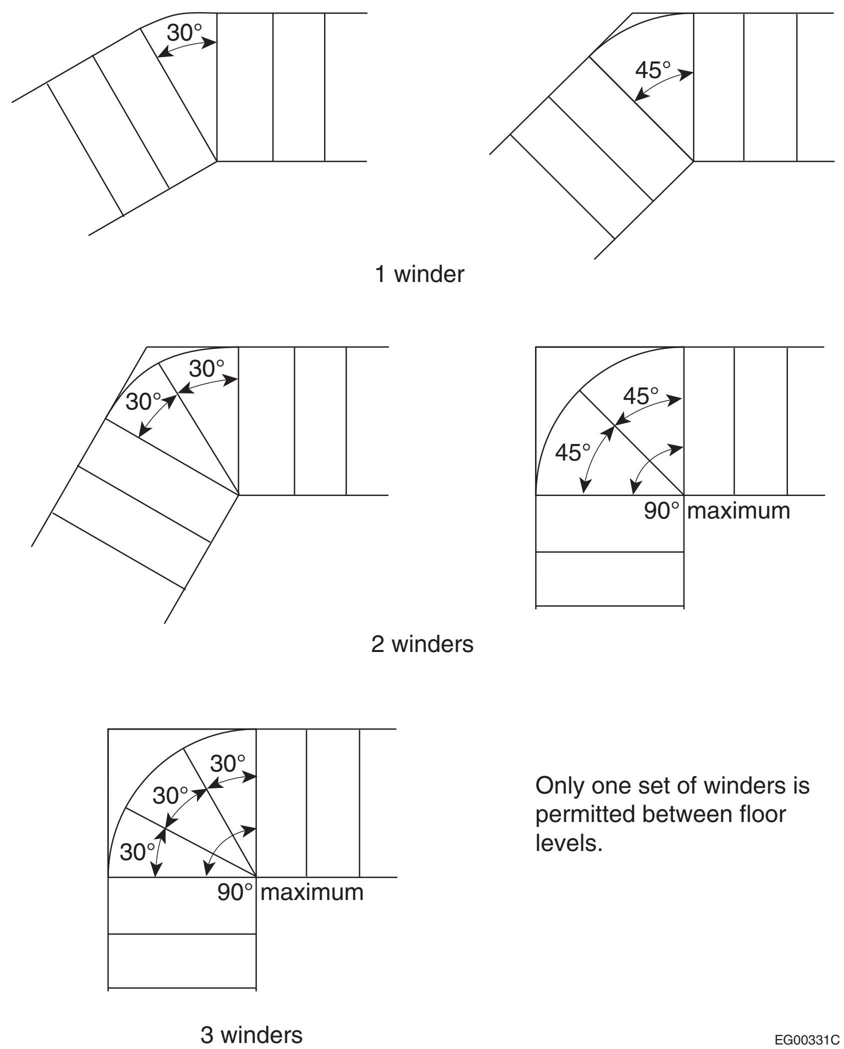


Figure 9.8.-5
Only acceptable winder configurations (NBC Articles 9.8.3.1. and 9.8.4.6.)

According to NBC Sentence 9.8.3.1.(3), only one set of winders is permitted between floor levels. This provision is intended to keep the use of winders to a minimum in order to reduce the risk of missteps.

9.8.4.7. Spiral Stairs

This Article sets out requirements for spiral stairs.

Spiral stairs are permitted to serve as secondary stairs in all Part 9 buildings, but are only permitted to be used as the only means of egress where they serve not more than three persons. Spiral stairs are not permitted to serve as exit stairs.

Although spiral stairs save space, they may increase the risk of missteps. Spiral stairs that are used in applications other than those permitted in this Article or that do not comply with the dimensions required in this Article are considered unsafe.

9.8.4.8. Tread Nosings

This Article requires that stair tread nosings have a rounded or bevelled edge and establishes minimum and maximum extensions for this edge. The purpose of the maximum extension is to reduce the risk of missteps due to slipping at the leading edge. The maximum extension is also intended to ensure that the depth of the horizontal surface of the tread is not reduced excessively by the nosing, but remains sufficient to support a person's foot.

A rounded or bevelled edge on tread nosings will make the tread more visible through light modeling. However, a rounded or bevelled edge that is too wide will increase the risk of foot slippage. For these reasons, the top of stair tread nosings are required to have a rounded or bevelled edge extending not less than 6 mm (1/4 in.) and not more than 14 mm (9/16 in.) measured horizontally from the front of the nosing (Figure 9.8.-6). If resilient material is used to cover the nosing of a stair tread, the minimum extension of the rounded or bevelled edge is permitted to be reduced to 3 mm (1/8 in.).

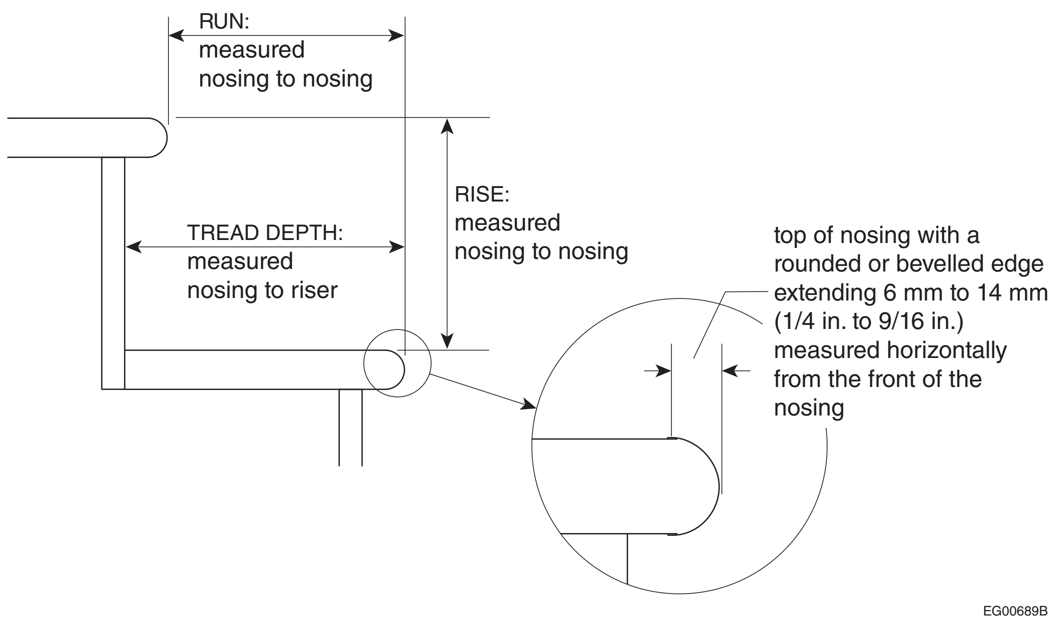


Figure 9.8.-6
Step dimensions and their measurement

9.8.5. Ramps

9.8.5.1. Application

This Article clarifies that NBC Subsection 9.8.5. applies to pedestrian ramps that are not in a barrier-free path of travel. This Subsection provides for ramps that allow pedestrians to access and egress from buildings without excessive effort or undue risk of slipping.

Ramps in a barrier-free path of travel must conform to the requirements in NBC Article 3.8.3.5., as shown in Figure 9.8.-7

Detached houses, semi-detached houses, houses with a secondary suite, duplexes, triplexes, townhouses, row houses, and boarding houses are exempted from the requirements for barrier-free access in NBC Section 3.8., as are apartment buildings without elevators, except for the entrance level where the difference in elevation between it and any dwelling unit entrance is 600 mm (2 ft.) or less (NBC Article 3.8.2.1. and NBC Sentence 9.5.2.3.(2)).

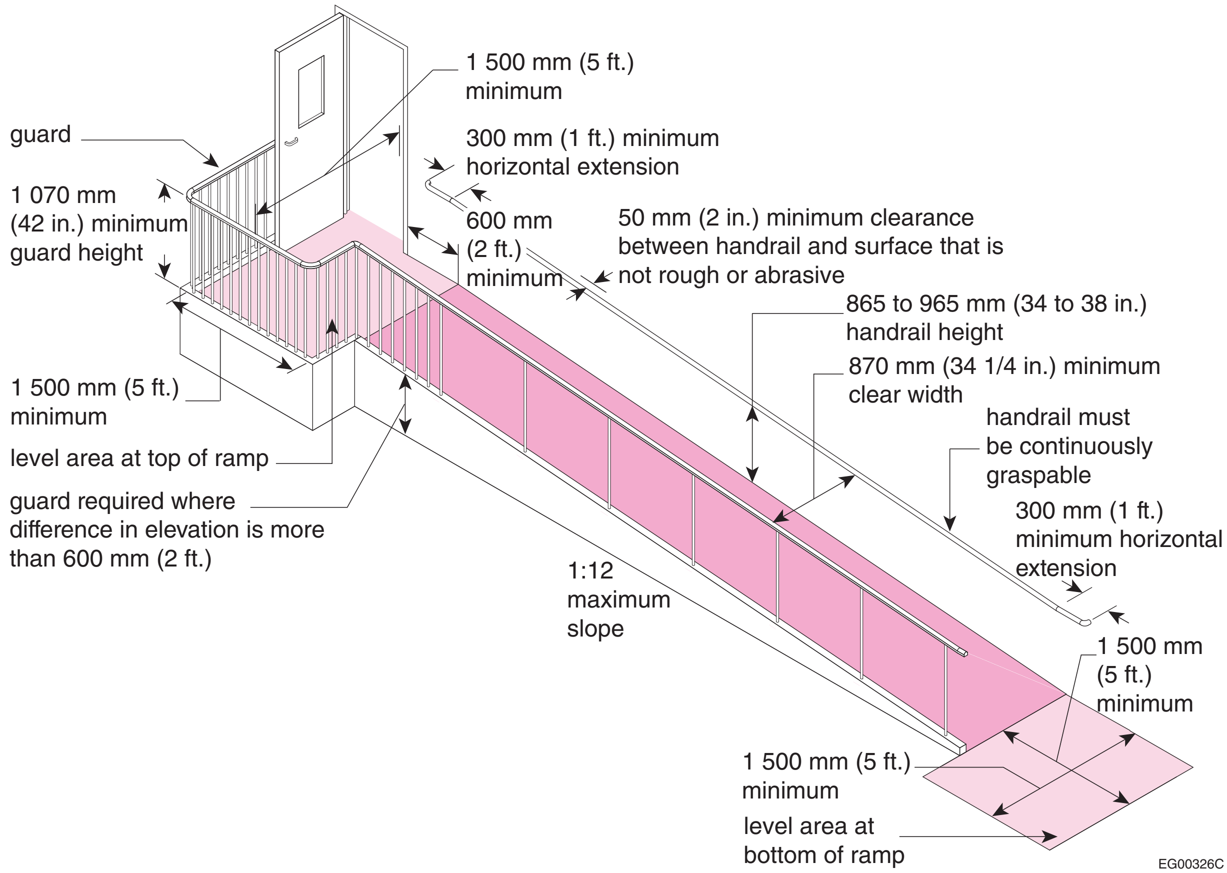


Figure 9.8.-7
Requirements for ramps in a barrier-free path of travel (NBC Article 3.8.3.5.)

9.8.5.2. Ramp Width

This Article establishes minimum widths for pedestrian ramps.

The minimum width for public pedestrian ramps is intended to allow ascending and descending users to pass one another without difficulty. The minimum width for private pedestrian ramps is intended to permit the movement of furniture, as well as occupants. Private pedestrian ramps are permitted to be narrower than public ones because they are rarely used in both directions simultaneously.

The minimum widths for ramps are summarized in Table 9.8.-B.

The requirements for pedestrian ramps are summarized in Figure 9.8.-8.

Table 9.8.-B
Minimum Ramp Widths (NBC Articles 3.8.3.5. and 9.8.5.2.)

Location of Ramp	Ramp Type	Minimum Ramp Width or Clear Width, mm (in.)
Not in a barrier-free path of travel	Private	860 (34)
	Public	1 100 (43 1/4)
In a barrier-free path of travel	All	870 (34 1/4) clear(1)

Notes to Table 9.8.B.:
(1) This value is the minimum clear width measured between any horizontal protrusions such as handrails (NBC Clause 3.8.3.5.(1)(a)).

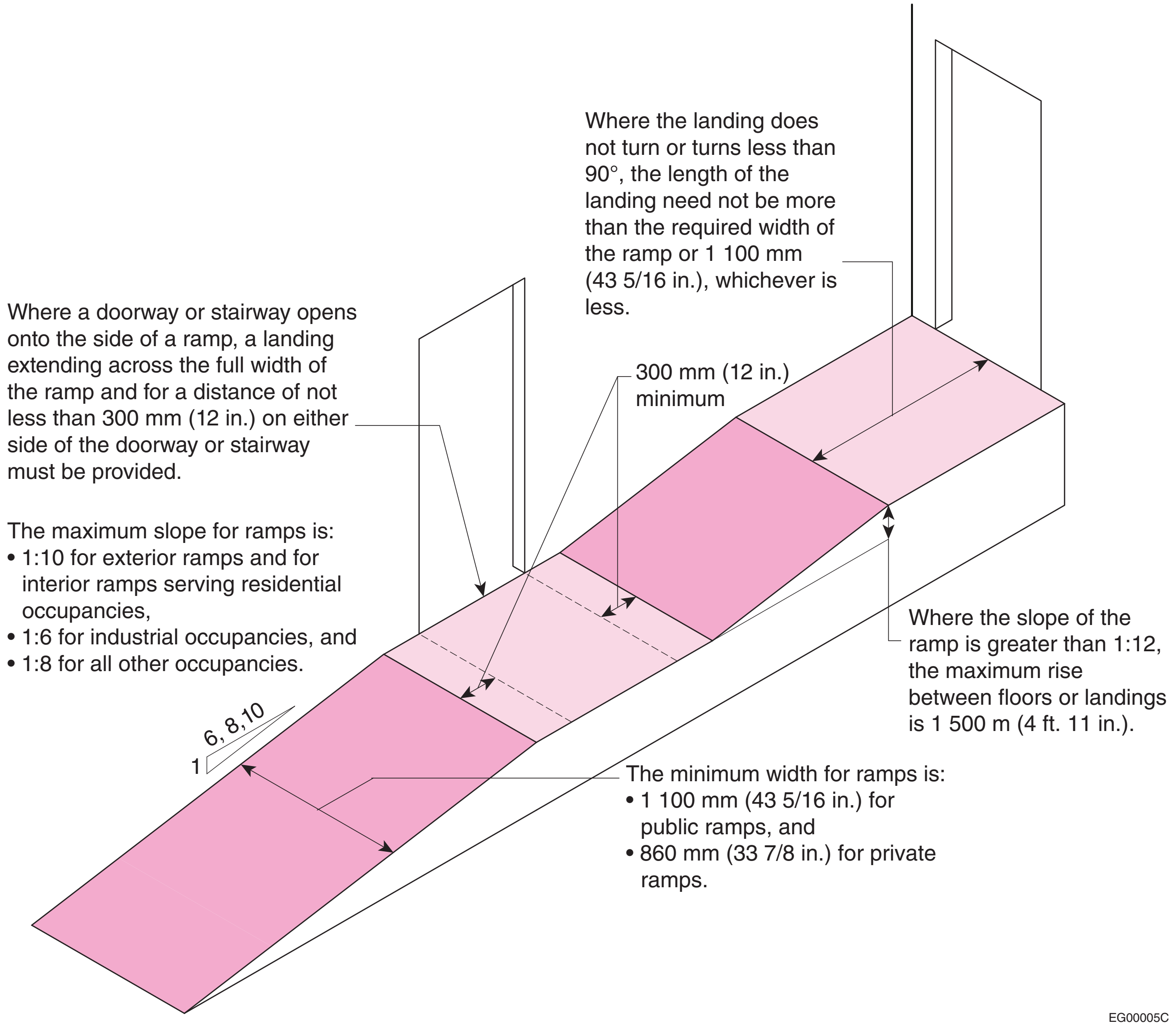


Figure 9.8.-8
Requirements for pedestrian ramps not in a barrier-free path of travel (NBC Articles 9.8.5.2., 9.8.5.4., 9.8.5.5., 9.8.6.2. and 9.8.6.3.)

9.8.5.3. Height over Ramps

This Article establishes minimum clear heights over pedestrian ramps, which are intended to provide sufficient headroom clearance to prevent a reasonably tall adult from making accidental head contact with the ceiling or other objects at that height.

The minimum clear height over private pedestrian ramps is 1 950 mm (6 ft. 7 in.). For public pedestrian ramps, the minimum clear height is 2 050 mm (6 ft. 9 in.).

9.8.5.4. Ramp Slope

This Article indicates the maximum slopes permitted for pedestrian ramps in several applications. The slope must allow pedestrians to ascend and descend ramps without excessive effort or undue risk of slipping. The maximum slope for interior pedestrian ramps serving residential occupancies and for exterior pedestrian ramps is 1:10 (Figure 9.8.-8).

The maximum slope for ramps in a barrier-free path of travel is 1:12 (NBC Clause 3.8.3.5.(1)(b)), which ensures that persons in wheelchairs can ascend and descend the ramps without undue effort or inconvenience (Figure 9.8.-7).

9.8.5.5. Maximum Rise

This Article specifies a maximum rise between floors or landings for pedestrian ramps with a slope greater than 1:12, which ensures that pedestrians will be able to negotiate such ramps safely and without undue effort.

9.8.6. Landings

Landings provide stair and ramp users with a level area on which to pause, change direction, or access the stair or ramp.

9.8.6.1. Application

This Article states that NBC Subsection 9.8.6. applies only to landings that are not part of a barrier-free path of travel and that landings for ramps in a barrier-free path of travel must conform to the requirements of NBC Article 3.8.3.5. It also requires that finished floors and ground surfaces with a slope not exceeding 1:50 at the top and bottom of stairs and ramps be considered as landings.

9.8.6.2. Required Landings

This Article indicates where landings are required. In general, landings must be used to provide occupants with a level area at the top and bottom of ramps and flights of stairs, where a doorway opens onto a stair or ramp, where a ramp opens onto a stair, and where a stair opens onto a ramp. They can also be used to make changes in direction or to break a long stair or ramp into shorter runs. Excessively long stairs and ramps are psychologically intimidating and physically tiring, and can be a cause of serious falls.

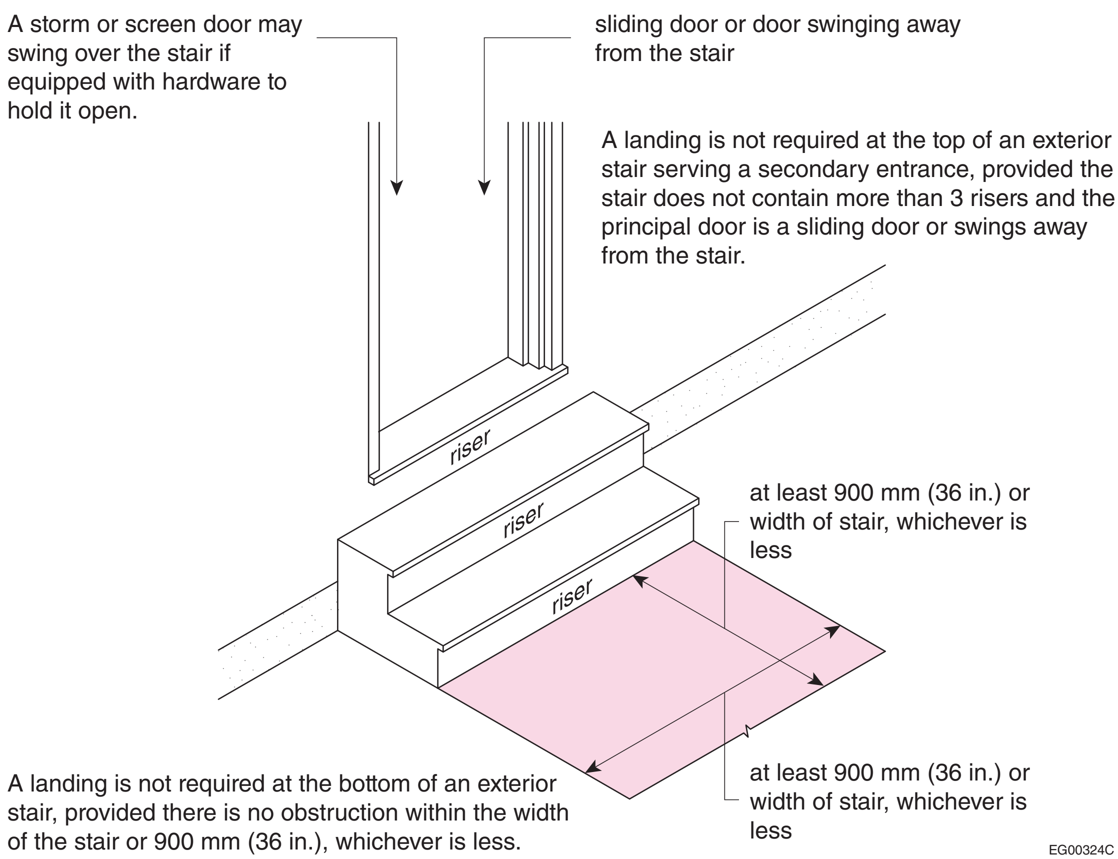


Figure 9.8.-9
Requirements for landings in exterior stairs serving a secondary entrance to a single dwelling unit or a house with a secondary suite

Where a door at the top of a stair within a dwelling unit swings away from the stair, no landing is required between the doorway and stair. A landing may be omitted at the top of an exterior stair serving a secondary entrance to a single dwelling unit or a house with a secondary suite, provided the stair contains no more than three risers and the principal door to the entrance is a sliding door or swings away from the stair (Figure 9.8.-9).

9.8.6.3. Dimensions of Landings

This Article establishes minimum dimensions for landings, and addresses the various situations that have an impact on the minimum dimensions, such as doors opening onto landings, and stairs with different widths ending on the same landing. These minimum dimensions are intended to provide enough room to accommodate door swing and to allow safe passage.

A landing should provide sufficient room for a person to stand while opening or closing a door. The general rule is that the landing should be as wide and as long as the width of the stair or ramp that it serves. Beyond a certain length, there is little to be gained from further increases in length. A landing in a public stair or pedestrian ramp that does not turn or turns less than 90° need not be longer than the required width of the stair or ramp or 1 100 mm (3 ft. 7 in.), whichever is less. A landing in a private stair or pedestrian ramp that does not turn or turns less than 90° need not be longer than the required width of the stair or ramp (typically, 860 mm (34 in.)).

Figure 9.8.-10 illustrates how to measure the length of a landing that turns by less than 90°.

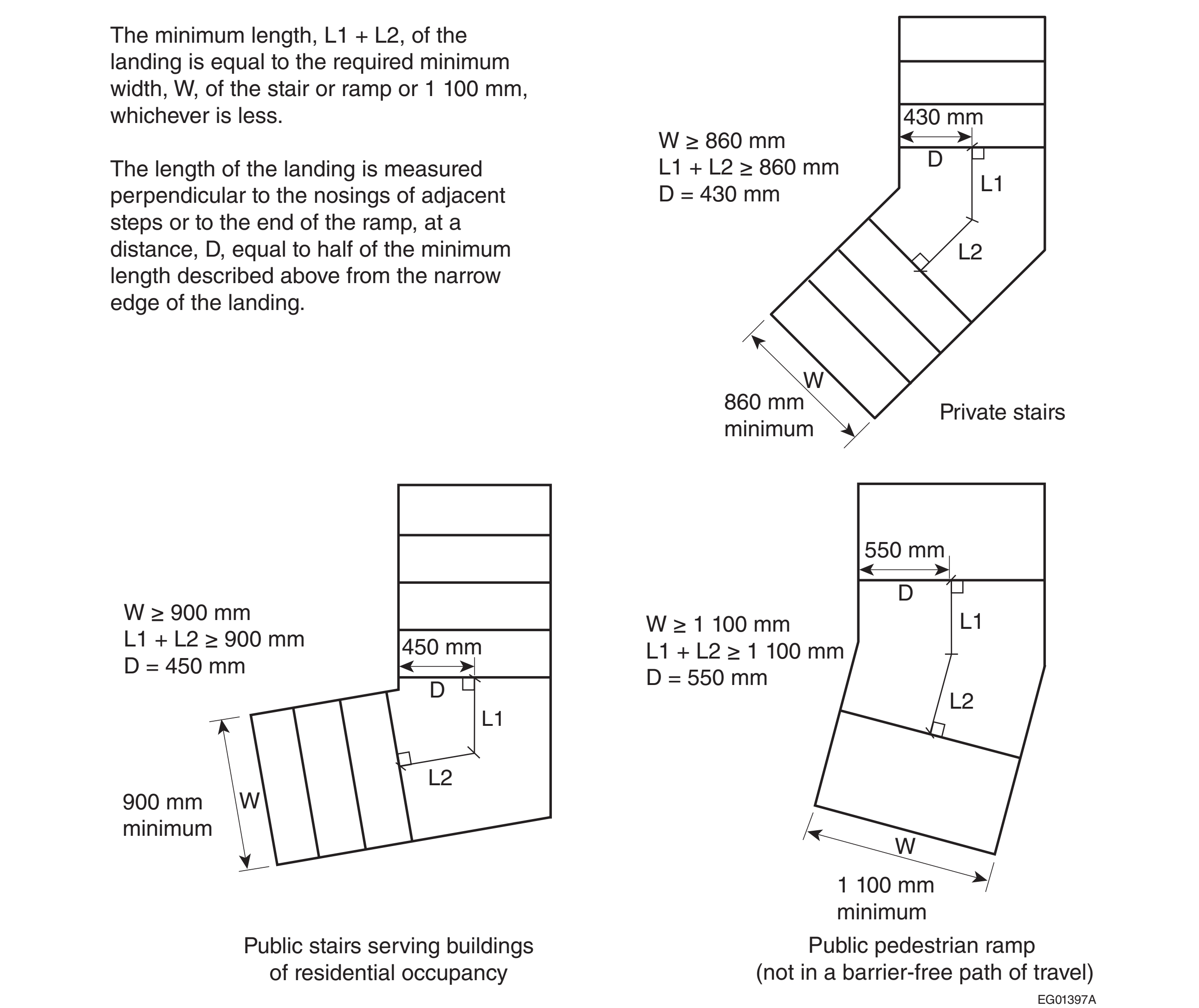


Figure 9.8.-10
Dimensions of landings turning less than 90° (NBC Articles 9.8.2.1., 9.8.5.2. and 9.8.6.3.)

Where a doorway or stairway opens onto the side of a pedestrian ramp, the landing must extend for a distance of not less than 300 mm (12 in.) on either side of the doorway or stairway, except on a side abutting an end wall (Figure 9.8.-8).

For stairs, the maximum vertical distance between landings is 3.7 m (12 ft. 2 in.) (NBC Article 9.8.3.3.). For pedestrian ramps with a slope greater than 1:12, this distance is 1.5 m (4 ft. 11 in.) (NBC Article 9.8.5.5.).

Figure 9.8.-11 illustrates the requirements for landings in stairs.

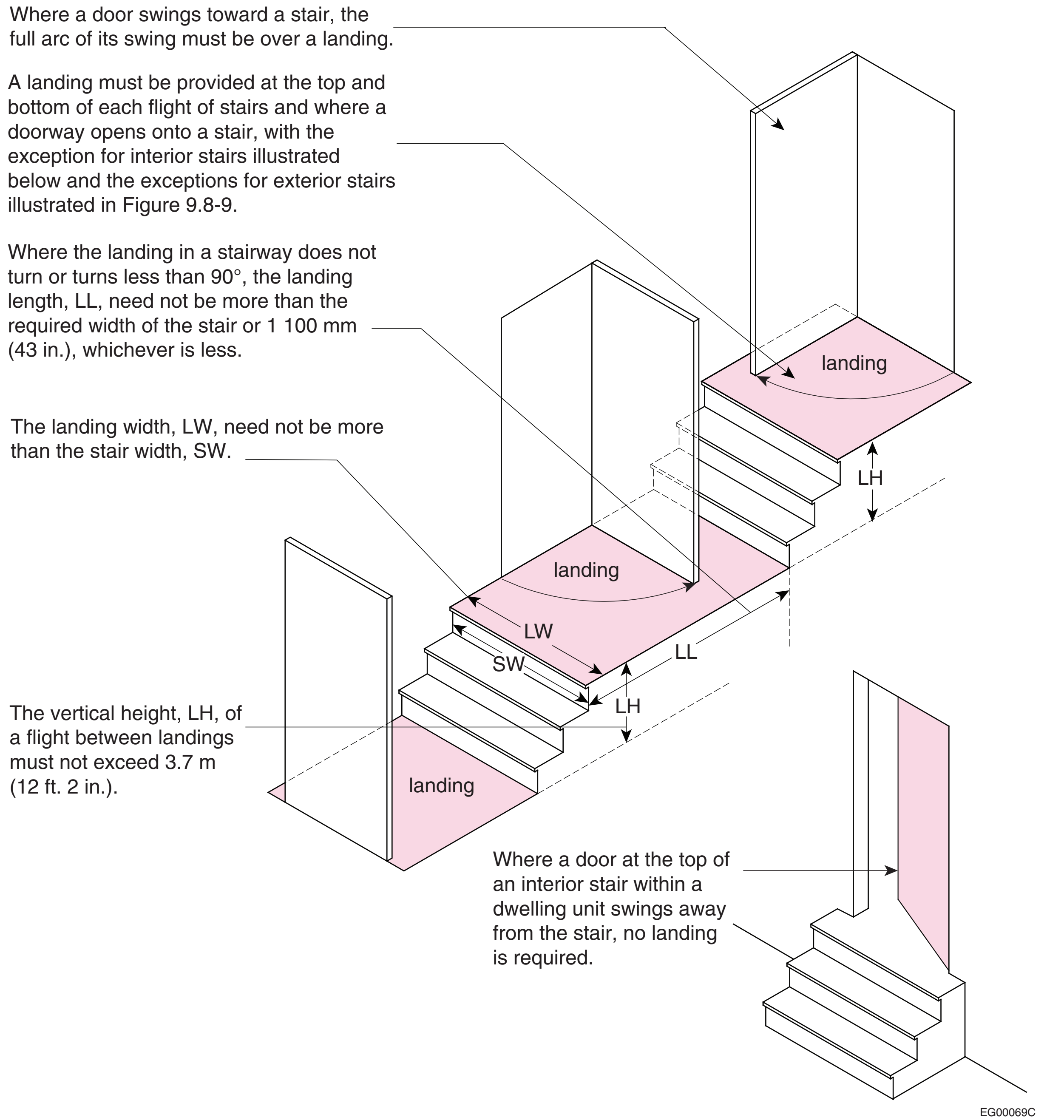


Figure 9.8.-11
Requirements for landings in stairs (NBC Articles 9.8.3.3., 9.8.6.2. and 9.8.6.3.)

9.8.6.4. Height over Landings

This Article establishes minimum clear heights over landings, which are intended to provide sufficient headroom clearance to prevent a reasonably tall adult from making accidental head contact with the ceiling or other objects at that height. The minimum clear height over landings serving a single dwelling unit or a house with a secondary suite (including their common spaces) is 1 950 mm (6 ft. 5 in.). For landings serving other occupancies, the minimum clear height is 2 050 mm (6 ft. 9 in.).

9.8.7. Handrails

Handrails are intended to reduce the risk of falling on stairs and ramps. They must be located so that they can be reached by users at any position on the stair or ramp.

9.8.7.1. Required Handrails

This Article indicates where handrails are required and states some exceptions to these requirements. Handrails on stairs and ramps provide additional support for the physically impaired and guidance for the sight-impaired. They have a different purpose than guards and guardrails, which are primarily intended to prevent people from falling off the side of a stair or ramp.

The handrail requirements for stairs and ramps are set out in NBC Table 9.8.7.1. and in NBC Sentences 9.8.7.1.(2), (3) and (4). For stairs serving a single dwelling unit or a house with a secondary suite, a handrail is required on one side of any interior stair with more than two risers and any exterior stair with more than three risers. Stairs not serving a single dwelling unit or a house with a secondary suite must have at least one handrail, regardless of the number of risers. If such stairs are curved or have a width of 1 100 mm (3 ft. 7 in.) or more, handrails are required on both sides of the stair.

Except for stairs with winders, where a flight of stairs within a dwelling unit consists of tapered treads, or a mix of tapered and rectangular treads, one handrail must be installed along the narrow end of the treads. This handrail is intended to guide occupants to walk where the steps are more uniform in run. If a handrail were installed along only the wide end of the treads, the risk of missteps would be greater since the occupants would be guided to walk where the run varies from step to step.

Figure 9.8.-12 shows the handrail requirements for stairs serving dwelling units and houses with a secondary suite (including their common spaces).

Except where a stair or ramp serves not more than two dwelling units, handrails must be located not more than 750 mm (29 1/2 in.) from the natural path of travel on the stair or ramp.

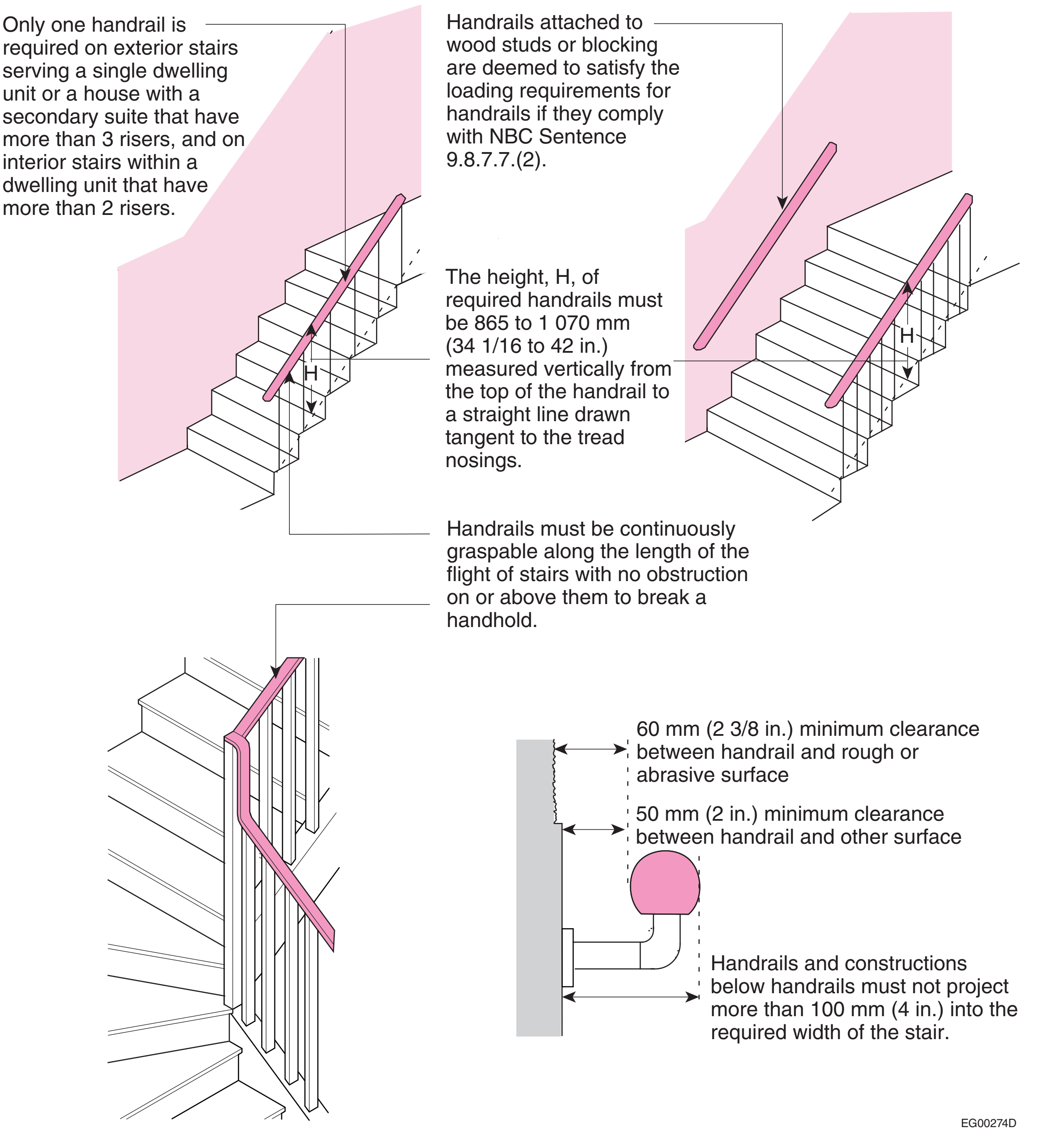
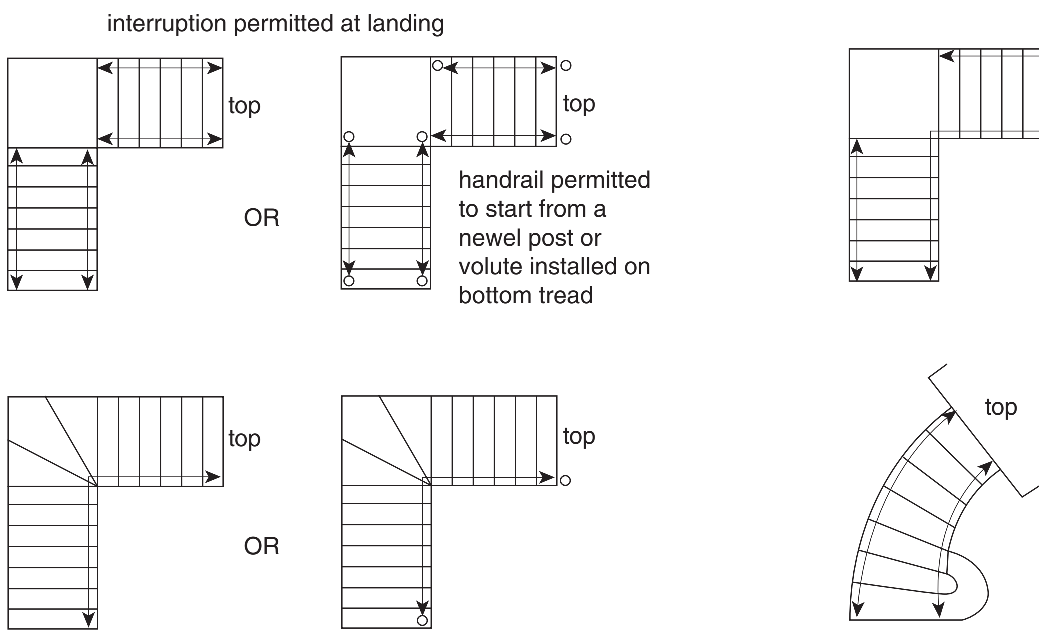


Figure 9.8.-12
Handrail requirements for stairs serving dwelling units and houses with a secondary suite (including their common spaces) (NBC Articles 9.8.7.1, 9.8.7.2., 9.8.7.4., 9.8.7.5. and 9.8.7.6.)

9.8.7.2. Continuity of Handrails

This Article indicates where handrails must be continuous and where they can be interrupted. Continuous handrails provide directional cues for sight-impaired persons and reduce the risk of falls for persons with mobility impairment who rely on handrails for support. The guidance and support provided by handrails is particularly important at the beginning and end of ramps and flights of stairs, and at changes in direction, such as at landings and winders.

For stairs and ramps serving a single dwelling unit or a house with a secondary suite (including their common spaces), handrails must be continuously graspable throughout the length of ramps and flights of stairs, from the bottom riser to the top riser, but are permitted to start from a newel post or volute installed on the bottom tread (Figure 9.8.-13). For other stairs and ramps, at least one required handrail must be continuous throughout the length of the stair or ramp, including at landings except where interrupted by doorways.



Stairs serving a single dwelling unit or a house with a secondary suite (including their common spaces):
required handrails continuous throughout length of flight from bottom riser to top riser

Stairs not serving a single dwelling unit or a house with a secondary suite (including their common spaces):
at least one required handrail continuous throughout length of stair, including at landings except where interrupted by doorways

↔ minimum extent of handrail where handrail is required(1)

○ newel post

EG02057D

Figure 9.8.-13
Continuity of handrails on stairs

Note to Figure 9.8.-13:
(1) See NBC Article 9.8.7.1. for the number of handrails required.

9.8.7.3. Termination of Handrails

This Article indicates that handrails need to terminate in a manner that will not obstruct pedestrian travel or create a hazard. This requirement is intended to reduce the risk of injury to users, particularly those with sight impairment.

Handrails for stairs and ramps serving a single dwelling unit or a house with a secondary suite (including their common spaces) are not required to extend beyond the top and bottom of the stair or ramp. For all other stairs and ramps, at least one handrail is required to extend horizontally not less than 300 mm (12 in.) beyond the top and bottom of each flight or ramp (Figure 9.8.-14). This horizontal extension, which allows the handrail to be grasped while the user is on the landing where there is less risk of falling, is for the benefit of persons with a physical disability or who rely on a cane or crutches for mobility.

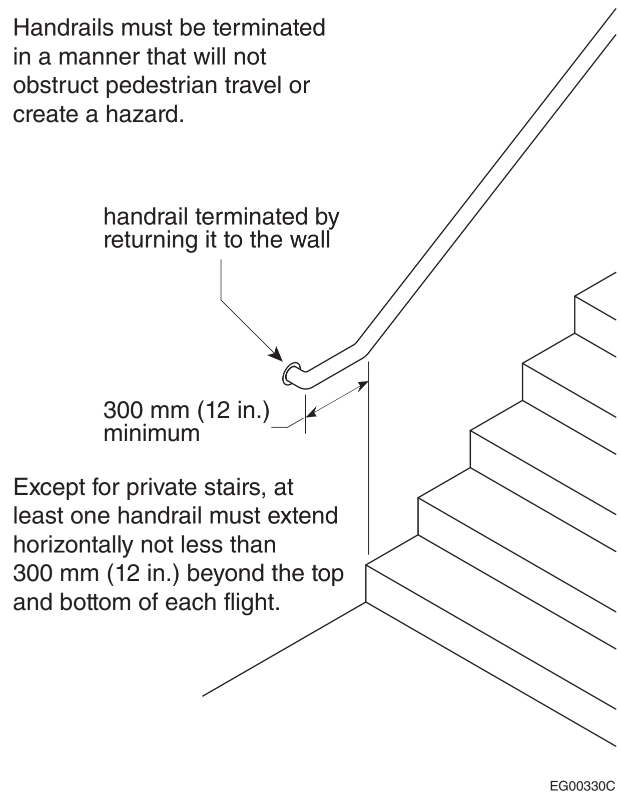


Figure 9.8.-14
Handrail termination for stairs not serving a single dwelling unit or a house with a secondary suite (including their common spaces)

9.8.7.4. Height of Handrails

This Article indicates the required height range for handrails, which ensures that they can be easily grasped by most adult users, and how to measure handrail height.

There is no single optimum handrail height because the optimum height depends on the height of the user. For required handrails, the range of heights permitted is 865 to 1 070 mm (34 to 42 in.), where the handrail height is measured vertically from the top of the handrail to a line drawn tangent to the tread nosings of a stair served by the handrail, or to the surface of a ramp, floor or landing served by the handrail. This height range is intended to satisfy the needs of most adults. Where many of the users are children, a second handrail is sometimes voluntarily installed at a lower height than the required handrail.

Handrails can be located at the top of guards of 1 070 mm (42 in.) or less in height, which allows smooth handrail transition between surfaces that are protected by guards and those that are not.

9.8.7.5. Ergonomic Design

This Article requires that handrails be constructed so as to be continually graspable along their entire length and clear of obstruction that would break a handhold. A minimum clearance of 50 mm (2 in.) is required between the handrail and the surface behind it, which generally allows sufficient room for fingers to encircle the handrail without touching the wall. This minimum handrail clearance is increased to 60 mm (2 3/8 in.) where the surface behind the handrail is rough or abrasive.

9.8.7.6. Projections into Stairs and Ramps

This Article limits the projection of handrails and constructions below handrails to not more than 100 mm (4 in.) into the required width of a stair or ramp so that they do not impede traffic flow.

9.8.7.7. Design and Attachment of Handrails

This Article indicates the loading requirements for handrails, both interior and exterior. Since handrails help to support the weight of the stair or ramp user, they have to be securely supported at appropriate intervals.

Where wood framing is used, handrails serving private stairs are deemed to comply with the loading requirements if they are securely attached to wood studs or blocking at intervals of not more than 1.2 m (4 ft.) apart measured on the horizontal plane. Not less than 2 No. 8 wood screws penetrating not less than 32 mm (1 1/4 in.) into solid wood must be used at each attachment point for proper anchorage. These requirements are intended to reduce the risk of handrails being dislodged by stair users relying on them for support and, by limiting the spacing of attachment points, to reduce the flexing of handrails.

9.8.8. Guards

Guards are required in order to reduce the risk of accidental falls from one level to another where the difference in elevation between the two levels is sufficient to cause significant injury.

9.8.8.1. Required Guards

This Article indicates where guards are required and addresses a number of specific situations related to the protection of doors, windows and glazing. Guards are intended to prevent people from falling from one level to an adjacent level. Generally, guards are required for the open sides of stairs, ramps, landings, balconies, porches, decks, mezzanines, galleries and raised walkways where there is a difference in elevation of more than 600 mm (24 in.) between the walking surface and the adjacent surface or where the adjacent surface within 1.2 m (4 ft.) of the walking surface has a slope of more than 1:2 (Figure 9.8.-15).

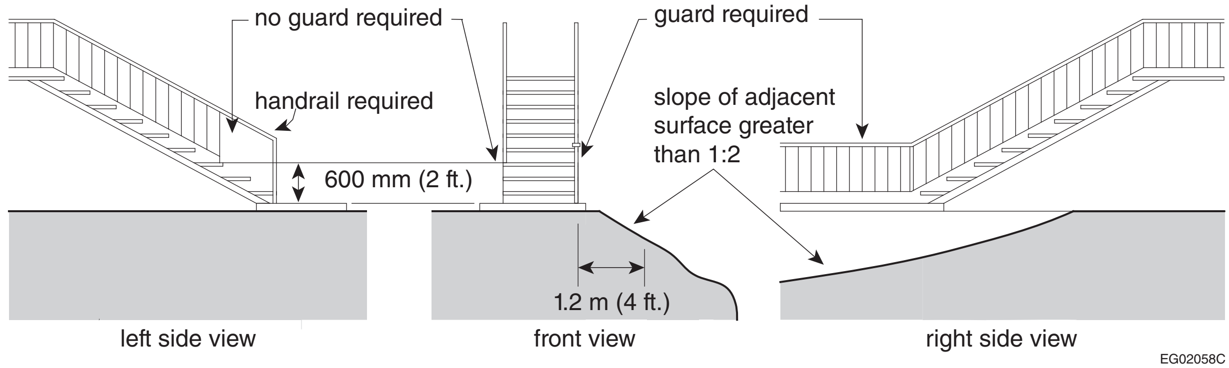


Figure 9.8.-15
Guards for exterior walking surfaces

In buildings of residential occupancy, some doors, such as sliding patio doors or French doors, may be installed to act as large windows when in the closed position. Where the finished floor on one side of the door is more than 600 mm (24 in.) above the floor or other constructed surface or ground level on the other side of the door, the door must have a guard or a mechanism to restrict the clear unobstructed opening of the door to not more than 100 mm (4 in.) (Figure 9.8.-16).

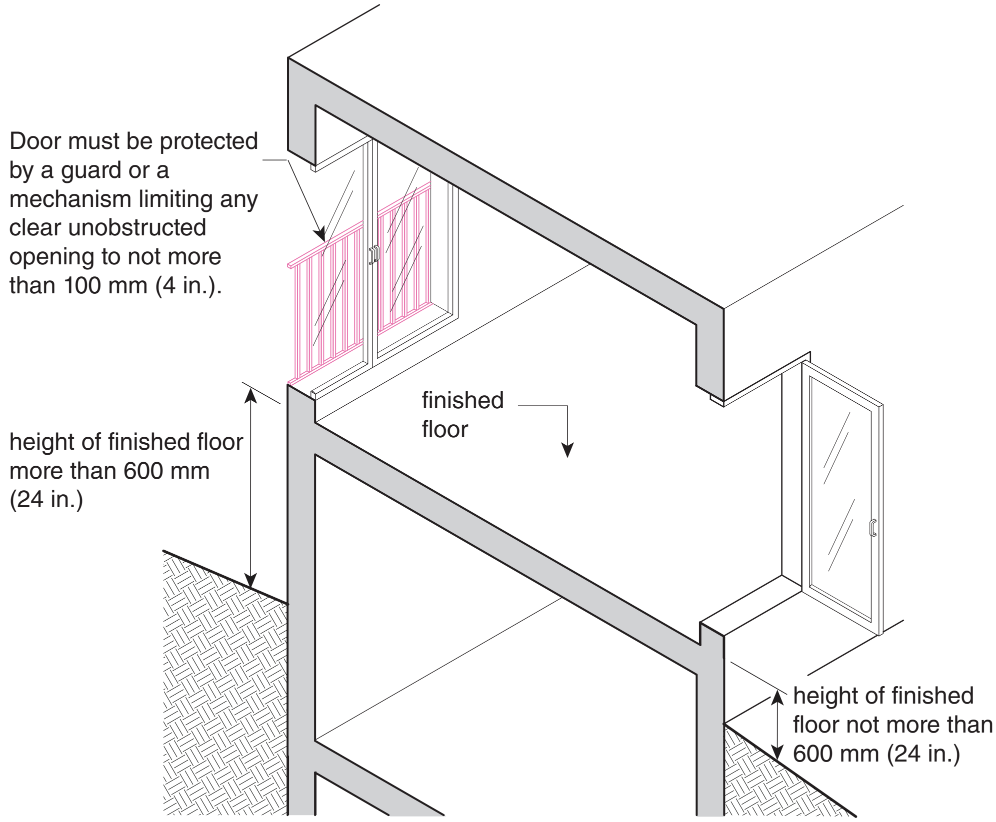


Figure 9.8.-16
Protection of doors used as windows in buildings of residential occupancy

Openable windows in a building of residential occupancy need to be protected by a guard or by a mechanism capable of limiting the unobstructed opening to not more than 100 mm (4 in.) measured either vertically or horizontally, where the other dimension is greater than 380 mm (15 in.) (Figure 9.8.-17). Windows that are unlatched but cannot be opened further simply by leaning on them, such as casement windows operated with a mechanical crank, are considered to comply with this requirement. This requirement does not apply if:

- the window sill is located more than 450 mm (17 3/4 in.) above the finished floor, or the finished floor in the room or space where the window is located is less than 1 800 mm (5 ft. 11 in.) above the floor or ground on the other side of the window,
- the only opening greater than 100 × 380 mm (4 × 15 in.) is a horizontal opening at the top of the window, or
- the window serves a house with a secondary suite, or serves a dwelling unit that is not located above another suite (because where occupants have direct access from their dwelling unit to the ground, the risk of accidents is much reduced).

Except in dwelling units, glazing installed over stairs, ramps and landings that extends to less than 1 070 mm (3 ft. 6 in.) above the surface of the stair treads, ramp, or landing needs to be protected by guards or needs to be non-openable and designed to withstand the specified lateral loads for balcony guards in NBC Article 4.1.5.14. In dwelling units, glazing installed over stairs, ramps and landings that extends to less than 900 mm (3 ft.) above the surface of the stair treads, ramp, or landing needs to be protected in the same manner. In buildings of residential occupancy, glazing that extends to less than 1 m (3 ft. 3 in.) from the floor in public areas above the second storey also needs to be protected in the same manner.

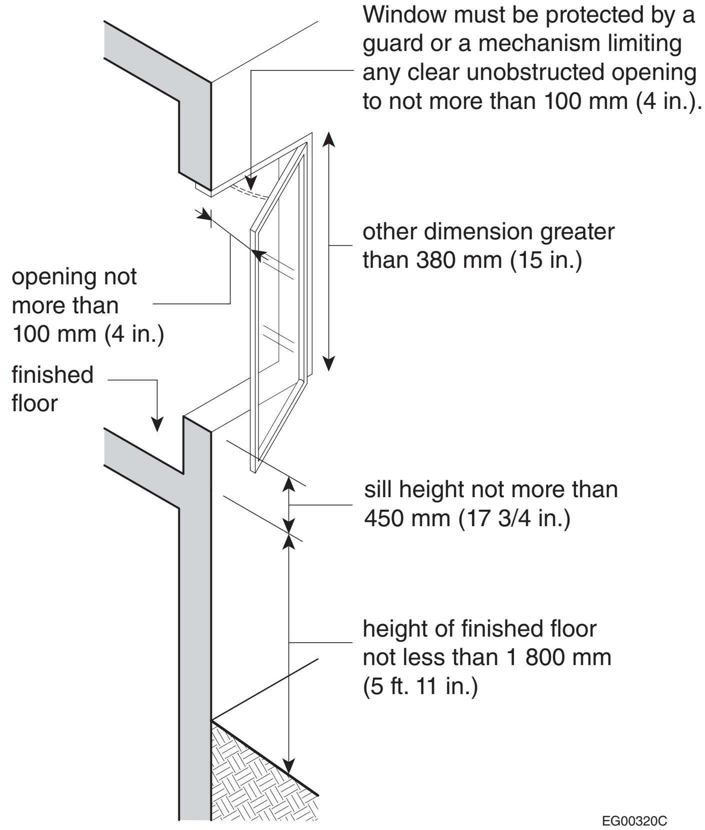


Figure 9.8.-17
Protection of openable windows in buildings of residential occupancy other than dwelling units not located above another suite and houses with a secondary suite

9.8.8.2. Loads on Guards

This Article requires that guards, with some exceptions, be designed to resist the specified loads provided in NBC Table 9.8.8.2.

For guards within dwelling units and houses with a secondary suite (including their common spaces) and for exterior guards serving not more than 2 dwelling units, NBC Table 9.8.8.2. need not apply where the guard construction used has been demonstrated to provide effective performance.

9.8.8.3. Height of Guards

The purpose of a minimum guard height is to ensure that guards are high enough to help prevent accidental falls over the guard. The height of a guard should be close to the waist height of an average person so that jostling or pushing under crowded conditions will not result in accidental falls over the guard.

The lower minimum height for guards serving dwelling units and houses with a secondary suite (including their common spaces), with the exception of exterior guards protecting walking surfaces above a certain height, is rationalized on the basis of occupant familiarity.

In other occupancies, guards protecting level surfaces, such as balconies and landings, are required to be higher than those serving stairs other than required exit stairs. However, the specified minimum height for guards serving stairs, which is measured vertically from the top of the handrail to a line drawn through the tread nosings, corresponds to an effective height in relation to a stair user that is comparable to the specified minimum height for guards serving level surfaces.

Table 9.8.-C summarizes the minimum heights for guards. Where a handrail is required, the top of the guard can be used as the handrail if it is at the proper height. According to NBC Sentence 9.8.7.4.(2), required handrails must be 865 to 1 070 mm (34 to 42 in.) high.

Table 9.8.-C
Minimum Guard Heights

Surface Protected by Guard	Minimum Guard Height, mm (in.)	
	Where Guard Serves a Single Dwelling Unit or a House with a Secondary Suite (Including Their Common Spaces)	Where Guard Does Not Serve a Single Dwelling Unit or a House with a Secondary Suite (Including Their Common Spaces)
Stair other than required exit stair	900 (36)	900 (36)
Exterior walking surface more than 1.8 m (5 ft. 11 in.) above finished ground level (e.g., balcony)	1 070 (42)	1 070 (42)
Required exit stair, ramp, landing, or other surface not specifically mentioned above	900 (36)	1 070 (42)

Figure 9.8.-18 shows the requirements for interior guards in dwelling units and houses with a secondary suite (including their common spaces).

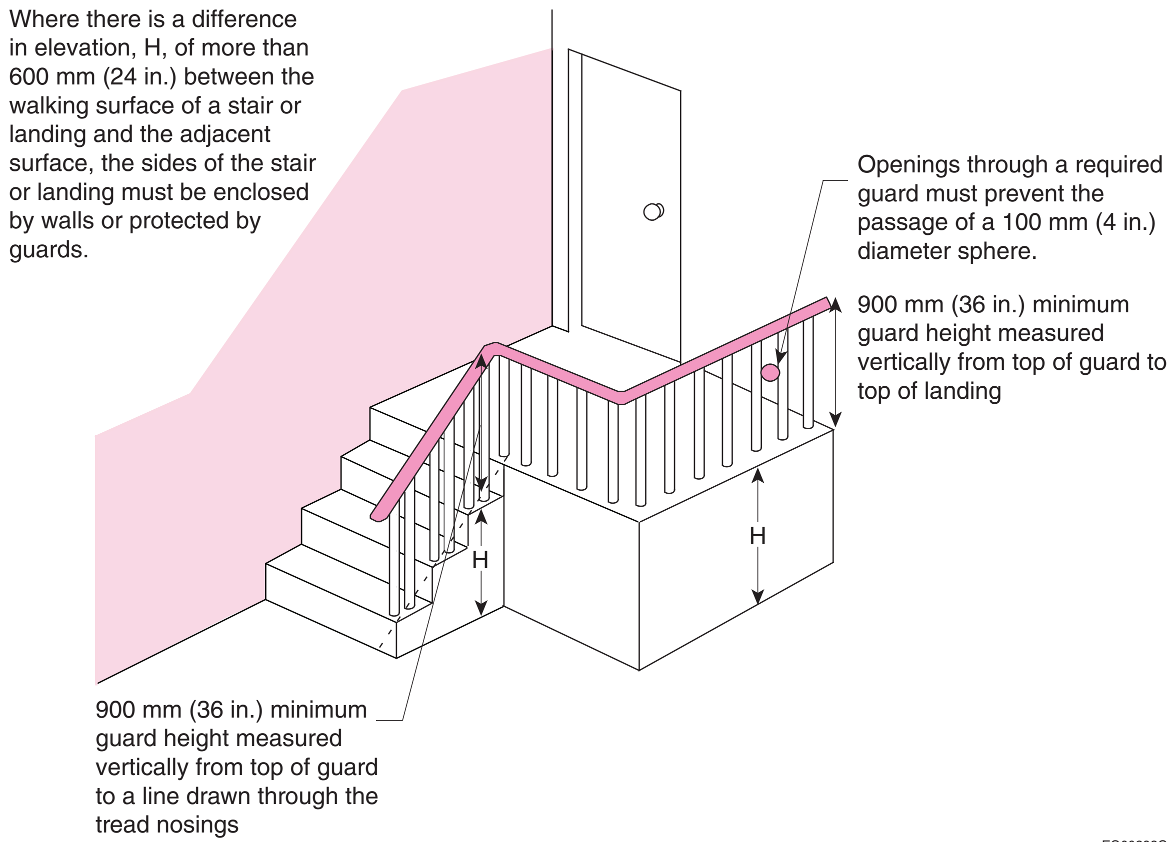


Figure 9.8.-18
Requirements for interior guards in dwelling units and houses with a secondary suite (including their common spaces) (NBC Articles 9.8.8.1., 9.8.8.3. and 9.8.8.5.)

Exterior guards around walking surfaces like porches, decks, landings and balconies are normally required to be at least 1 070 mm (42 in.) high. However, if they serve a single dwelling unit or a house with a secondary suite (including their common spaces) and the walking surface is not more than 1 800 mm (5 ft. 11 in.) above the finished ground level, the minimum guard height is reduced to 900 mm (3 ft.). This reduction is justified by the reduced potential for serious injury in the event of a fall. Figure 9.8.-19 shows the requirements for exterior guards serving dwelling units and houses with a secondary suite (including their common spaces).

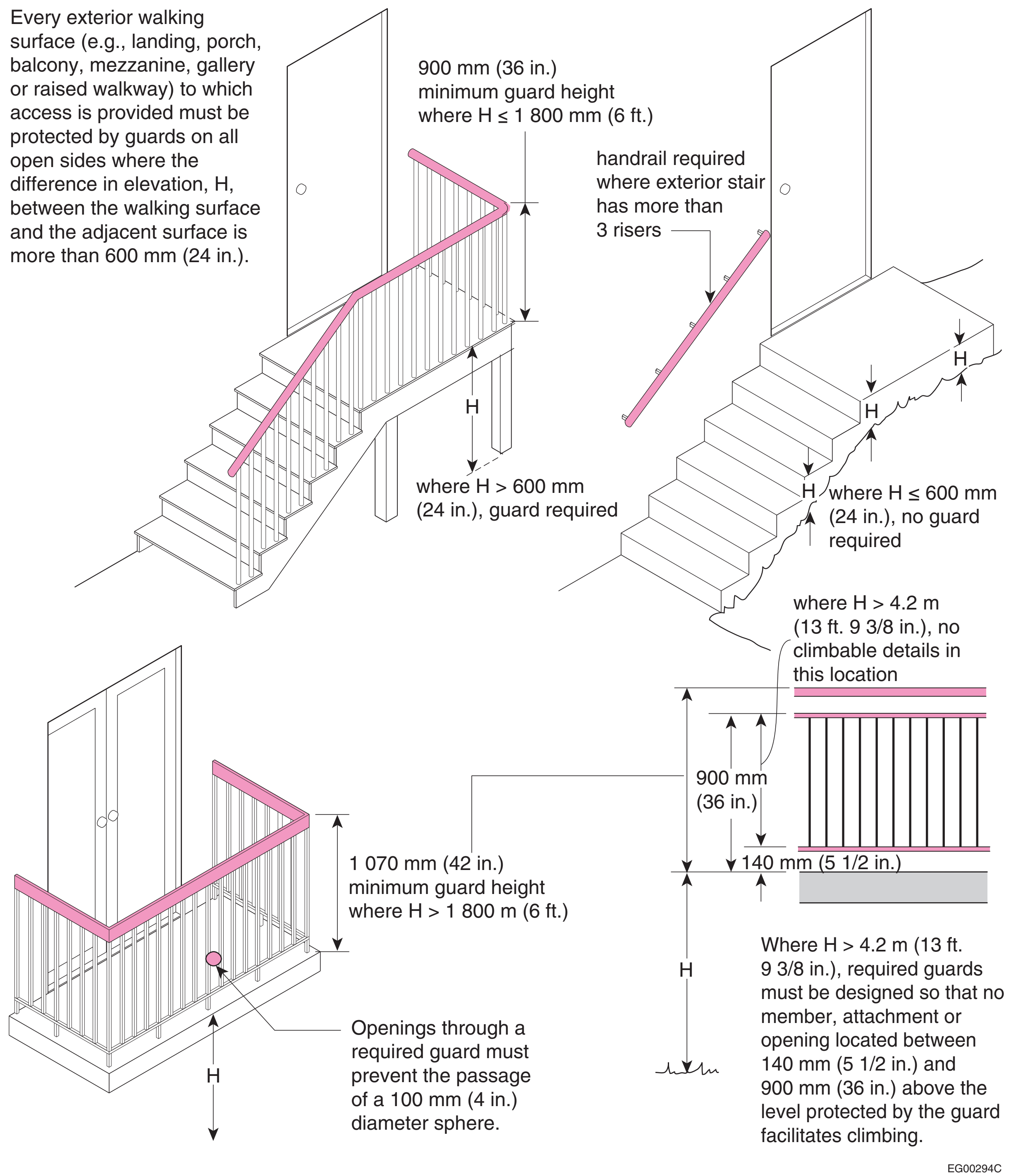


Figure 9.8.-19
Exterior guards serving dwelling units and houses with a secondary suite (including their common spaces) (NBC Articles 9.8.8.1., 9.8.8.3., 9.8.8.5. and 9.8.8.6.)

9.8.8.4. Guards for Floors and Ramps in Garages

This Article addresses the guard requirements for floors and ramps in garages other than those serving a single dwelling unit (which are covered in NBC Section 9.35.).

Where such floors and ramps are 600 mm (24 in.) or more above the adjacent ground or floor level, openings in floors and perimeters of floors and ramps without exterior walls must be provided with a curb and a guard. The curb, which must be continuous and not less than 140 mm (5 1/2 in.) in height, is intended to provide a positive stop for vehicles. The guard, which must be not less than 1 070 mm (42 in.) in height, is intended to prevent pedestrians from falling from one level to another.

9.8.8.5. Openings in Guards

This Article limits the size of openings in guards.

In general, openings in guards must prevent the passage of a spherical object having a diameter of 100 mm (4 in.) in order to prevent small children from crawling through them.

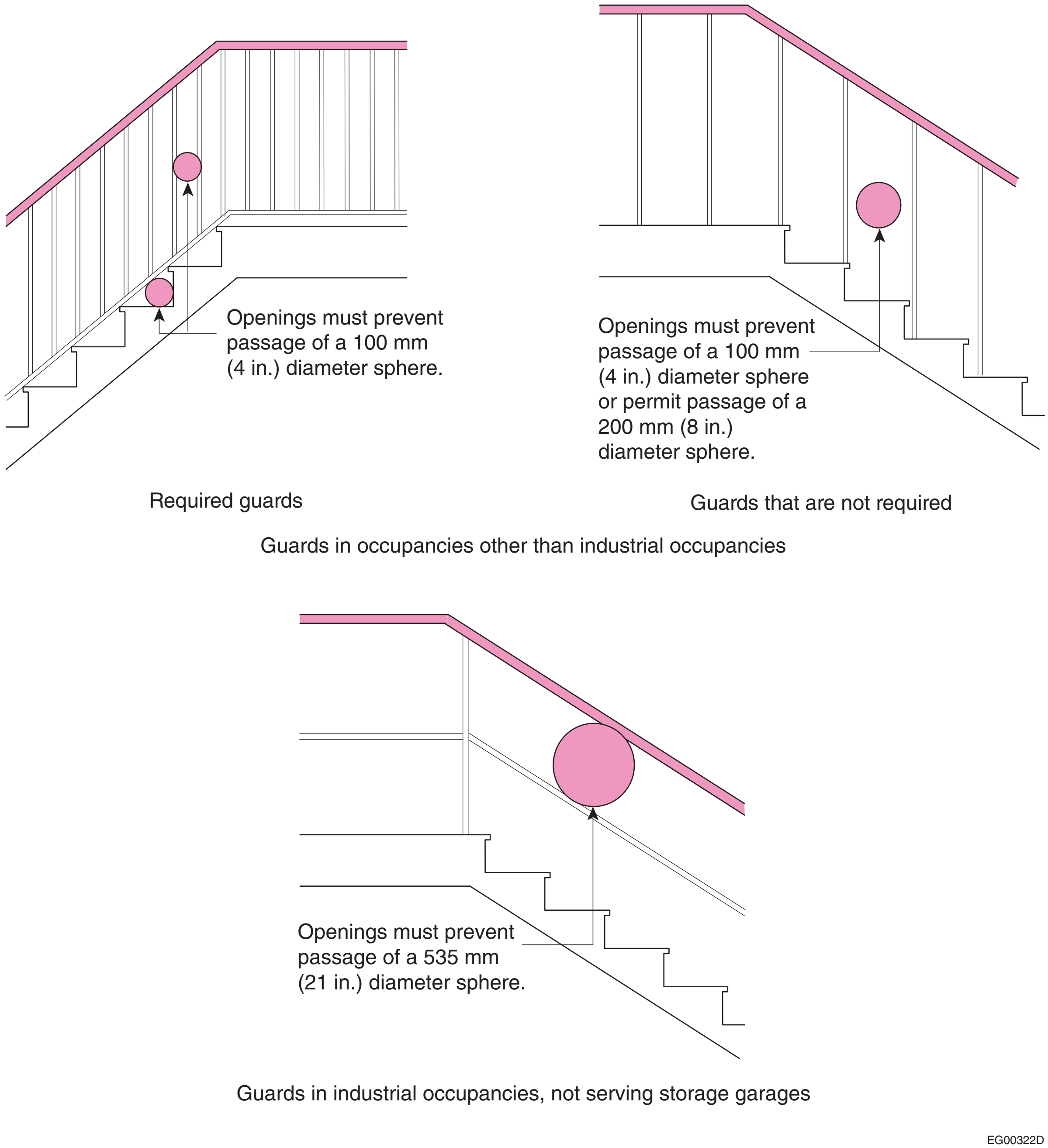


Figure 9.8.-20
Requirements for openings in guards

In industrial occupancies, larger openings are allowed in guards, except where they serve storage garages, because small children are not likely to be present in such occupancies. The guards in such occupancies are permitted to consist of a top railing and one or more horizontal intermediate rails spaced such that the size of the openings through the guard prevents the passage of a spherical object having a diameter of 535 mm (21 in.). This limit on the size of the openings is intended to reduce the risk of an adult falling through the guard.

In other occupancies, the size range of openings in non-required guards is limited to prevent children from getting their head stuck in the openings.

The requirements for openings in guards are shown in Figure 9.8.-20.

9.8.8.6. Design of Guards to Not Facilitate Climbing

This Article requires that guards that protect a level located more than 4.2 m (13 ft. 9 3/8 in.) above the adjacent level, except for those in industrial occupancies, be designed so that no member, attachment or opening located between 140 and 900 mm (5 1/2 and 36 in.) above the level protected by the guard facilitates climbing (Figure 9.8.-19). Such guards must not be constructed with decorative features that young children could use as a foothold.

Some configurations of members, attachments or openings may be part of a guard design and still comply with NBC Sentence 9.8.8.6.(1). Figures 9.8.-20 to 9.8.-23 present a few examples of designs that are considered to not facilitate climbing.

Protrusions that are greater than 450 mm (18 in.) apart horizontally or vertically are considered sufficiently far apart to reduce the likelihood that young children will be able to get a handhold or foothold on the protrusions and climb the guard (Figure 9.8.-21).

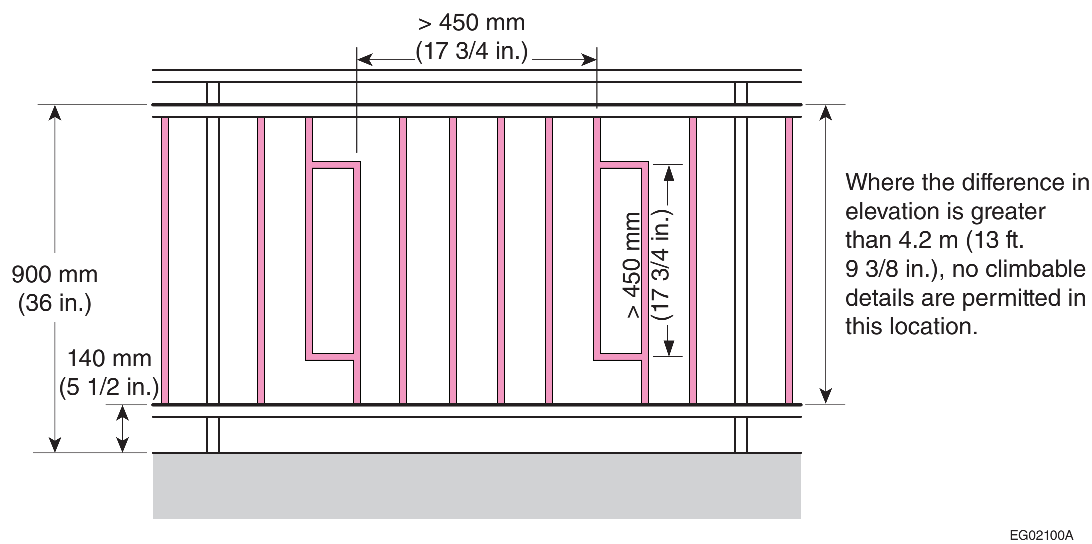


Figure 9.8.-21
Example of minimum horizontal and vertical clearances between protrusions in guards

Protrusions that present a horizontal offset of 15 mm (5/8 in.) or less are considered to not provide sufficient foot purchase to facilitate climbing (Figure 9.8.-22).

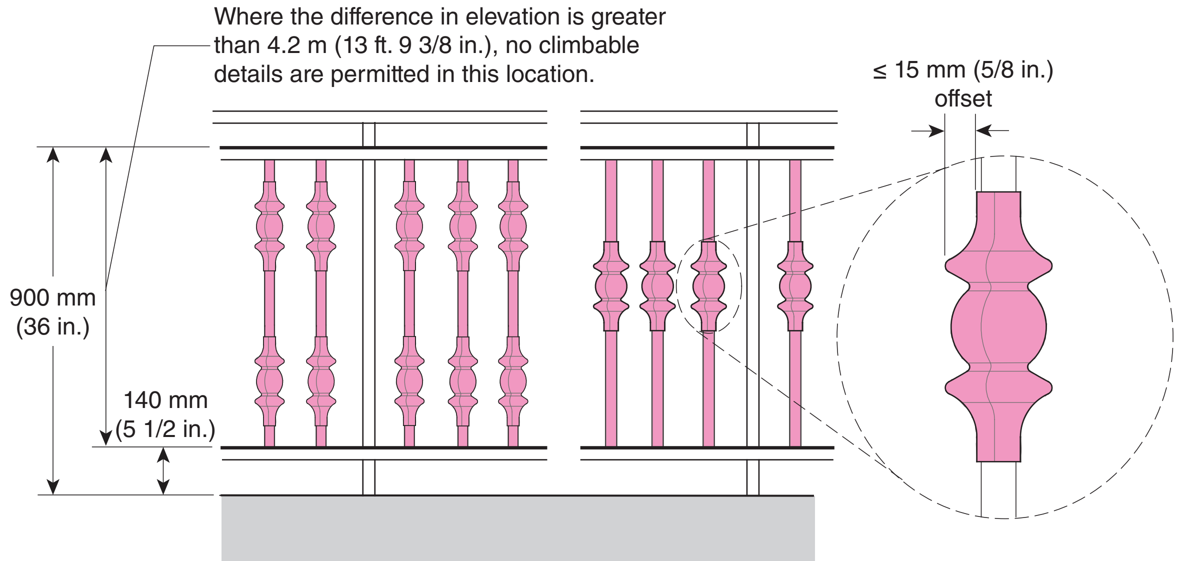


Figure 9.8.-22
Example of maximum horizontal offset of protrusions in guards

A guard incorporating spaces that are not more than 45 mm (1 3/4 in.) wide by 20 mm (3/4 in.) high is considered to not facilitate climbing because the spaces are too small to provide a foothold (Figure 9.8.-23).

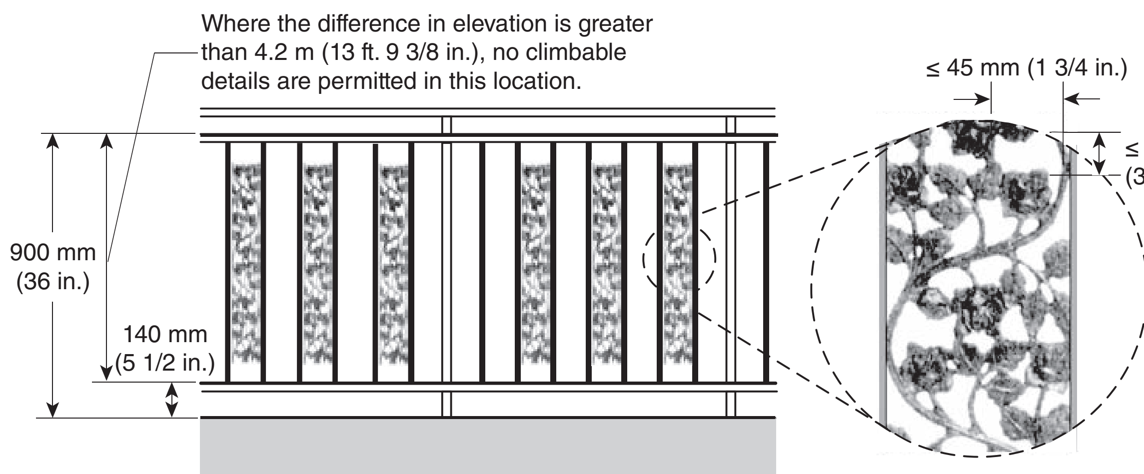


Figure 9.8.-23
Example of a guard with spaces that are not more than 45 mm (1 3/4 in.) wide and 20 mm (3/4 in.) high

Protrusions that present more than a 2:1 slope on the offset are considered to not facilitate climbing because such a slope is considered too steep to provide adequate footing (Figure 9.8.-24).

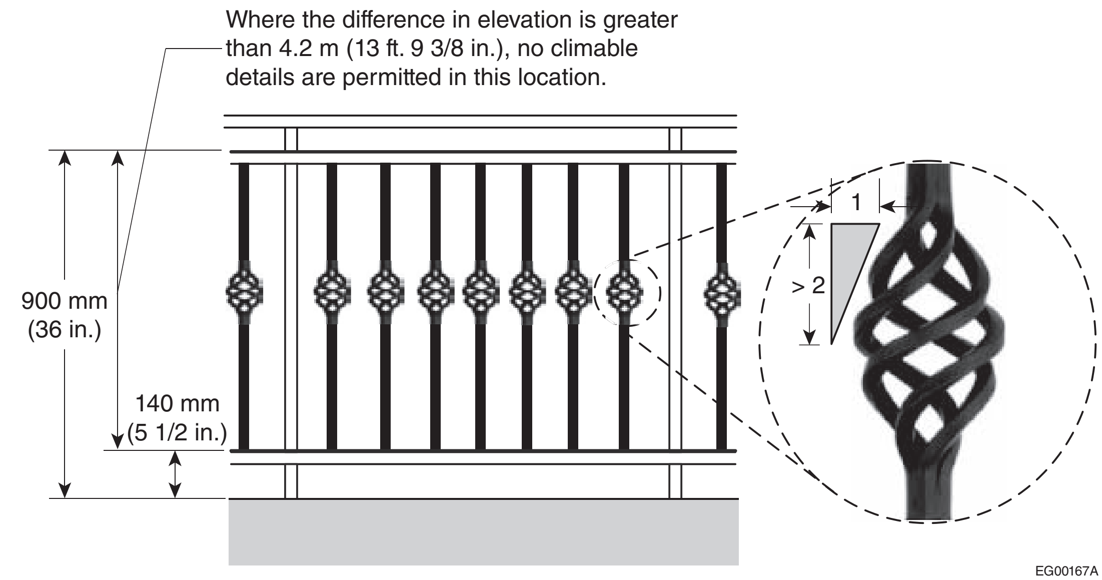


Figure 9.8.-24
Example of guard protrusions with a slope greater than 2:1

9.8.8.7. Glass in Guards

This Article requires that laminated or tempered safety glass or wired glass be used in guards because such glass is not prone to accidental breakage. The glass used in guards must conform to one of the safety standards referenced in this Article to reduce the risk of injury to occupants falling against the glass. The glass should also be adequately restrained so that it does not dislodge from the top or bottom rail.

9.8.9. Construction

Stairs within dwelling units are usually not subject to engineering analyses. Their design has evolved over the years through trade practices. The stair construction requirements in NBC Subsection 9.8.9. apply to normal residential stairs that may be found in dwelling units and Part 9 apartment buildings. They are also adequate for stairs in other occupancies, provided that they are subject to similar loads. Where unusual loads are expected or where stairs are made of steel or reinforced concrete, the design procedures in NBC Part 4 apply.

9.8.9.1. Loads on Stairs and Ramps

This Article indicates the specified loads that stairs and ramps have to be capable of supporting. Except as specified in NBC Articles 9.8.9.4. and 9.8.9.5., stairs and ramps serving a single dwelling unit or a house with a secondary suite (including their common spaces) need to be designed to support a specified load of 1.9 kPa (40 psf), and all other stairs and ramps need to be designed to support a specified load of 4.8 kPa (100 psf).

9.8.9.2. Exterior Concrete Stairs

This Article establishes the support required for exterior concrete stairs. Larger concrete stairs need to have adequate structural support to reduce the risk of uneven movement or settlement caused by changes in soil moisture content or frost. Because of their weight, misalignment or settlement is more difficult to correct for these stairs than for smaller concrete stairs or wooden stairs.

Exterior concrete stairs with more than two risers and two treads are required to be supported on a foundation of unit masonry or concrete walls or piers not less than 150 mm (6 in.) in cross-section, or cantilevered from the main foundation wall, as shown in Figure 9.8.-25. The stair shown in Figure 9.8.-9, for example, would be exempted from this requirement because the concrete portion has only two risers and two treads.

The depth below ground level for foundations for exterior concrete stairs must conform to the requirements in NBC Section 9.12. Because pier-type foundations can heave if the soil freezes to the sides of the piers, excavations for piers should be backfilled with drained granular material to reduce this risk (although this is not a requirement).

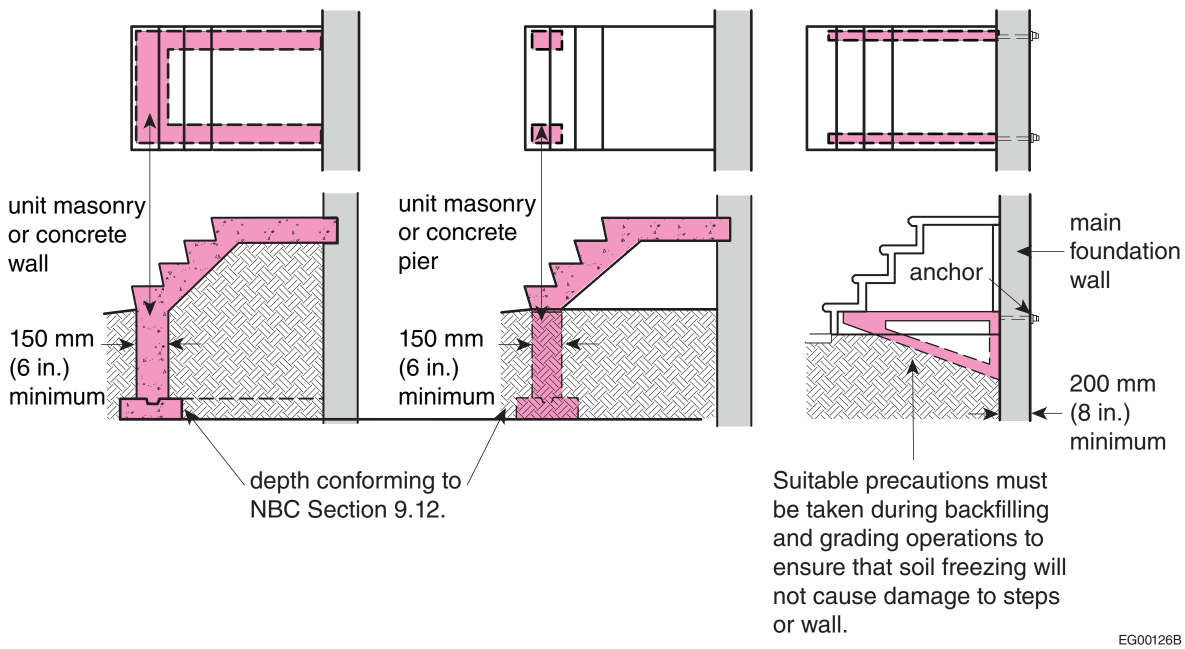


Figure 9.8.-25
Support for exterior concrete stairs with more than two risers and two treads (NBC Articles 9.8.9.2., 9.8.10.2. and 9.8.10.3.)

9.8.9.3. Exterior Wood Steps

This Article requires that wood steps not be in direct contact with the ground unless they are suitably treated with a wood preservative. This treatment ensures that exterior wood steps do not undergo premature decay so that they remain safe and strong enough to resist the expected loads.

9.8.9.4. Wooden Stair Stringers

This Article addresses wooden stair stringers, which provide the structural strength for the support of loads on stairs. The requirements of this Article are intended to prevent excessive springiness of stair treads. Lower structural requirements are permitted in dwelling units because of the lower loads and the limited number of occupants.

The minimum thickness for wooden stair stringers depends on whether they are supported along their length. Unsupported stringers, which are typical in unfinished basements, must be thicker than supported stringers. Stringers must be thick enough to receive the dado for the tread, if this is the method of tread support.

Stringers supporting stairs serving a single dwelling unit or a house with a secondary suite (including their common spaces) must be spaced at not more than 900 mm (36 in.) on centre where risers do not support the front portion of the treads, and at not more than 1 200 mm (47 in.) on centre where risers do support the front portion of the treads. For all other stairs, stringers must be spaced at not more than 600 mm (24 in.) on centre. The larger stringer spacings for dwelling units and houses with a secondary suite are permitted because of the lower loads and the limited number of occupants.

Figure 9.8.-26 illustrates the construction requirements for wood stairs serving single dwelling units and houses with a secondary suite (including their common spaces).

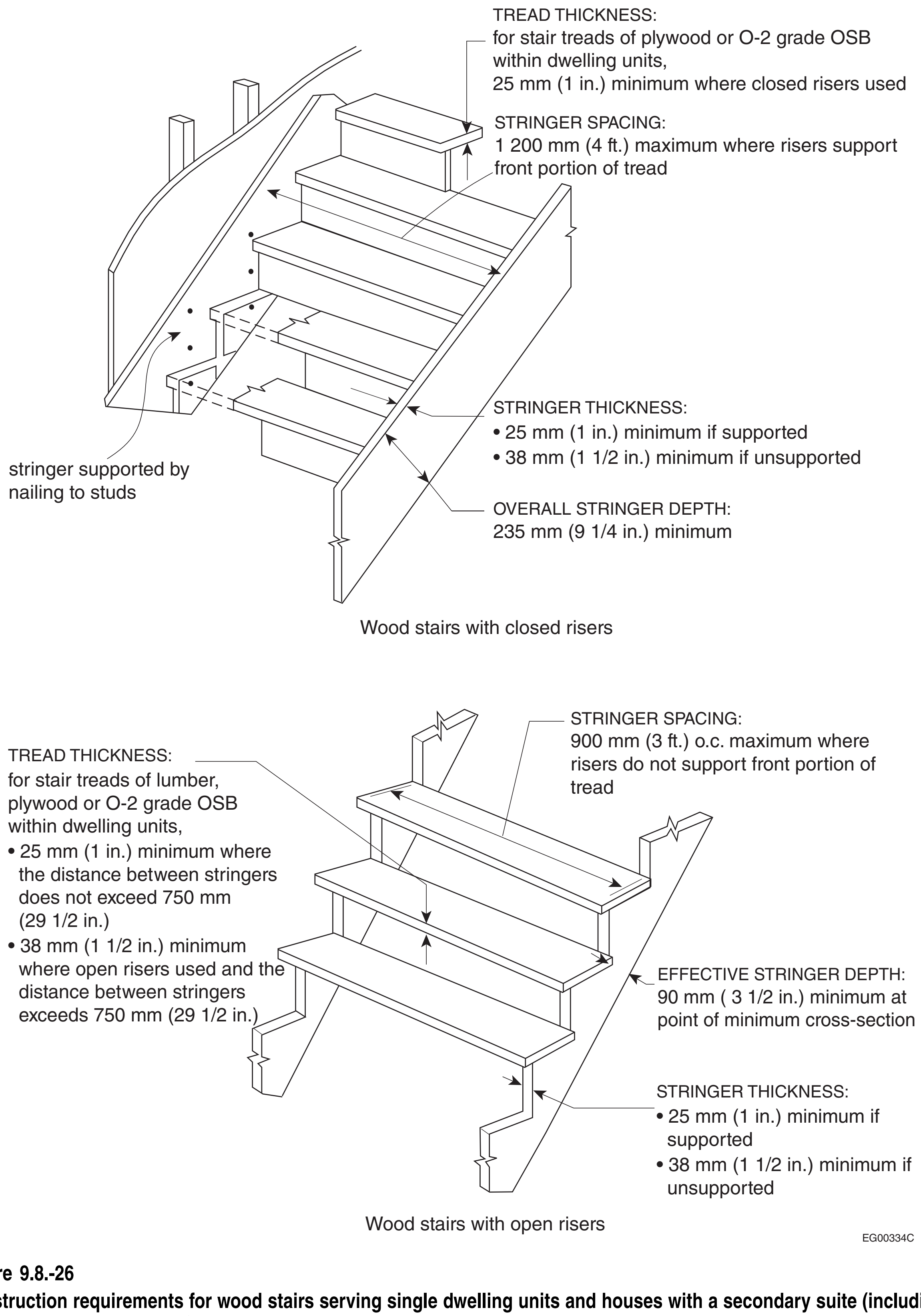


Figure 9.8.-26
Construction requirements for wood stairs serving single dwelling units and houses with a secondary suite (including their common spaces) (NBC Articles 9.8.9.4. and 9.8.9.5.)

Stairs with open risers are more difficult to use than those with closed risers because users are more likely to catch their feet on the underside of the treads as they ascend the stairs.

9.8.9.5. Treads

This Article establishes minimum thicknesses for stair treads of lumber, plywood or O-2 grade OSB within dwelling units and indicates the required orientation of such treads when they are not continuously supported by risers. Treads for stairs with open risers where the distance between stringers exceeds 750 mm (29 1/2 in.) are required to be thicker than those for other stairs.

9.8.9.6. Finish for Treads and Landings

This Article requires that the finish for treads and landings of interior stairs in dwelling units consist of hardwood, vertical grain softwood, resilient flooring or other material providing equivalent performance because such materials provide a safe and reasonably durable wearing surface. Stairs to unfinished basements are exempted from this requirement because they are not subject to as much use and their appearance is not as important.

Treads and landings of stairs and ramps, other than those within dwelling units and houses with a secondary suite (including their common spaces), are required to have a slip-resistant finish or to be provided with slip-resistant strips that extend not more than 1 mm (1/32 in.) above the surface. This requirement is intended to reduce the risk of injury by preventing slipping without causing tripping on slip-resistant strips.

9.8.10. Cantilevered Precast Concrete Steps

9.8.10.1. Design

This Article requires that exterior concrete steps and their anchorage system that are cantilevered from a foundation wall be designed and installed to support the anticipated loads.

9.8.10.2. Anchorage

This Article ensures that cantilevered concrete steps are anchored to a foundation wall having sufficient strength to resist the bending forces due to the weight of the steps and the anticipated loads on the steps. The foundation wall must be of solid concrete at least 200 mm (8 in.) thick.

9.8.10.3. Prevention of Damage Due to Frost

This Article addresses the protection of cantilevered steps from damage due to frost heave.

To prevent such damage, suitable precautions must be taken during backfilling and grading. For example, placing granular backfill beneath the steps will reduce the likelihood of frost heave. The steps should also be supported from the main foundation wall in a manner that will permit them to move upward without breaking the step or damaging the foundation.

Section 9.9.
Means of Egress

Introduction

With the exception of structural adequacy, no safety feature required for buildings is considered to be more important than the provision for safe egress in emergency situations.

Means of egress are intended to allow occupants to safely exit a building in an emergency. Egress facilities should be wide enough to allow pedestrian traffic to flow unimpeded and should be designed so that occupants are protected while exiting and can quickly reach an area of safety. Escape routes need to be clearly designated and must not house any activity or item that could hamper evacuation or create a fire hazard.

Under normal conditions, means of egress are intended to allow people to access the building and to permit the safe movement of furniture and other items.

Figure 9.9.-1 illustrates and names the principal elements of a means of egress.

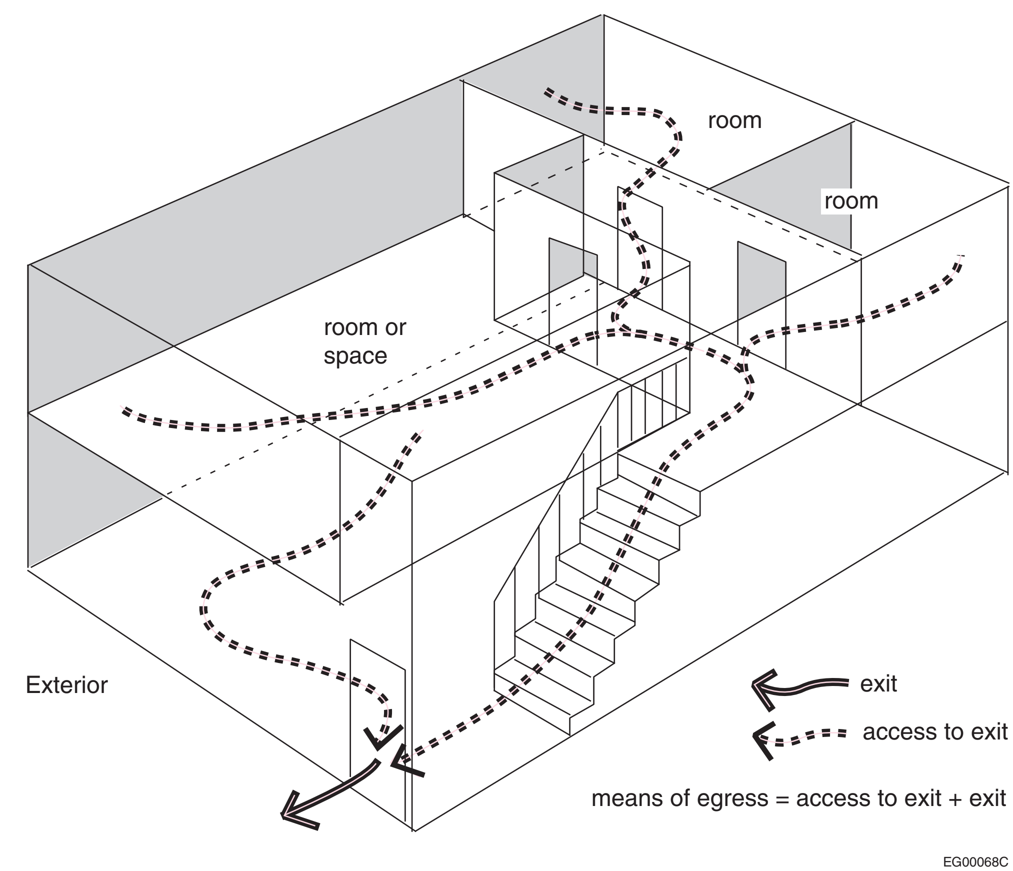


Figure 9.9.-1
Principal elements of a means of egress

A means of egress has two distinct components:
(1) an access to an exit, and
(2) an exit.

The access to an exit originates at any occupied location in a floor area and terminates at the exit door through which occupants leave the floor area. The access to an exit is the total path of travel from the occupied location to the exit door, including any intervening rooms or spaces.

The exit begins at the door through which occupants leave the floor area and ends at an exit door that provides access to a separate building, an open public thoroughfare, or an exterior open space protected from fire exposure from the building and having access to an open public thoroughfare. The exit may include enclosed stairways, ramps and passageways. For example, in a multi-level building, the exit may include the door into an exit stairway, the exit stairway, the door out of the stairway, and the exit door to a place of safety outside the building (or in another building). In a simple single-storey building, the exit may consist of only the exterior door, without any other intervening exit facilities. A stair within a dwelling unit is not considered to be part of an exit, but as part of an access to an exit.

The exit portion of a building (such as an enclosed exit stairway) is intended to protect the occupants as they evacuate the building. Once in the exit, it must not be necessary for the occupants to re-enter a floor area to escape from the building.

NBC Section 9.9. is an abridged version of the egress requirements in NBC Part 3. While NBC Section 9.9. contains many of the same egress requirements as NBC Part 3, requirements in NBC Section 9.9. relating to certain building features that occur less frequently in Part 9 buildings cross-reference provisions in NBC Part 3, instead of repeating the provisions.

Many of the egress requirements in NBC Section 9.9. do not apply to single dwelling units or houses with a secondary suite.

9.9.1. General

9.9.1.1. Application

This Article states that stairways, handrails and guards in a means of egress must comply with NBC Section 9.8. as well as with NBC Section 9.9.

9.9.1.2. Fire Protection

This Article indicates that means of egress must comply with the fire-spread, fire-resistance and fire-protection ratings in NBC Section 9.10. as well as with the fire protection requirements in NBC Subsection 9.9.4.

9.9.1.3. Occupant Load

This Article indicates how to determine the occupant load because some requirements for means of egress depend on occupant load.

The occupant load for dwelling units is determined by counting two persons for each bedroom or sleeping area. For other occupancies, the occupant load of a floor area (or part thereof) is taken as the number of persons for which it is designed, but not less than that determined from NBC Table 3.1.17.1., which contains a long list of occupant load factors for various types of occupancy.

9.9.2. Types and Purpose of Exits

9.9.2.1. Types of Exits

This Article lists the building features that can be used as an exit. It also refers to requirements in NBC Part 3 for certain types of exits.

Fire escapes are required to be designed and installed in conformance with NBC Subsection 3.4.7. and are only permitted to be used as exits on existing buildings, where it may not be practical to upgrade to an egress system with proper exits.

Horizontal exits are required to conform to NBC Sentence 3.4.1.6.(1) and NBC Article 3.4.6.10. This type of exit leads from one building to another (e.g., a door through a firewall, or a bridge or walkway joining two buildings).

9.9.2.2. Purpose of Exits

This Article clarifies that exits must not be designed for any purpose other than for exiting, except that an exit is also permitted to serve as an access to a floor area. They are intended to be kept free of all occupancies, equipment and obstructions that could interfere with traffic flow.

9.9.2.3. Elevators, Slide Escapes and Windows as Means of Egress

This Article states that elevators, slide escapes and windows are not to be considered part of a required means of egress. These facilities are regarded as unreliable or potentially dangerous in a fire emergency.

9.9.2.4. Principal Entrances

This Article requires that at least one door at every principal entrance to a building providing access from the exterior at ground level be designed in accordance with the requirements for exits. Doors serving single dwelling units and houses with a secondary suite (including their common spaces) are exempted from this requirement.

9.9.3. Dimensions of Means of Egress

Egress facilities must not only allow for rapid evacuation in a fire or any other emergency situation, they must also be functional in the everyday use of buildings. To be reasonably functional, doors, stairways, ramps and corridors must have certain basic minimum dimensions. This is to permit two-way pedestrian traffic and the occasional movement of furniture and equipment.

9.9.3.1. Application

This Article indicates that NBC Subsection 9.9.3., which establishes the dimensional requirements relevant to means of egress, applies to every means of egress except

- exits that serve a single dwelling unit or a house with a secondary suite (including their common spaces), and
- access to exits within dwelling units and within houses with a secondary suite (including their common spaces).

These exemptions are permitted because of the low occupant load of dwelling units and houses with a secondary suite and the familiarity of occupants with their dwelling.

9.9.3.2. Exit Width

This Article establishes a minimum width for exit facilities (e.g., stairs and ramps) other than doors and corridors, which permits pedestrian traffic to flow with sufficient room to allow limited passing. The exemption for doors is rationalized on the basis that the obstructions created by doorways do not significantly slow traffic flow. Corridors are exempted because they are required to have a larger minimum width (NBC Article 9.9.3.3.).

In larger buildings regulated by NBC Part 3, the number of occupants served by an exit facility must be taken into consideration in determining its minimum width (NBC Article 3.4.3.2.), but this is not necessary for buildings covered by NBC Part 9 because the occupant loads and travel distances are smaller. The minimum widths for exit facilities specified in NBC Part 9 are considered sufficient to permit the rapid evacuation of the building occupants.

9.9.3.3. Width of Corridors

This Article establishes a minimum width of 1.1 m (3 ft. 7 in.) for public corridors, corridors used by the public, and exit corridors, which is intended to facilitate two-way pedestrian traffic flow in corridors.

9.9.3.4. Clear Height

This Article establishes minimum clear heights for exits and access to exits, which are intended to reduce the risk of accidental head contact by reasonably tall adults. Except for stairways, doorways and storage garages, the minimum clear height in exits and access to exits is 2.1 m (6 ft. 11 in.); for storage garages, it is 2 m (6 ft. 7 in.).

The minimum clear heights for stairs, ramps, landings and doorways in exits and access to exits must be determined in accordance with NBC Articles 9.8.2.2., 9.8.5.3., 9.8.6.4. and 9.9.6.2., respectively.

9.9.4. Fire Protection of Exits

9.9.4.1. Application

This Article establishes where fire protection for exits is required. Private dwelling unit exits are exempt from most of the requirements because of both their low occupant load and occupant familiarity with the dwelling unit.

9.9.4.2. Fire Separations for Exits

The requirements in this Article address the need to separate exits from the remainder of floor areas. The requirements deal with the protection of exits from fire and smoke for a sufficient time to allow complete building evacuation, and the reduction of the risk of fire spread from floor to floor via the exit stairs before a fire is contained by firefighters. Exterior exit passageways with 50% or more of their exterior sides open to the outside air and served by an exit stair at each end are exempted on the basis that, should a fire occur and block the passage, the passage will not become smoke logged, and people will be able to go away from the fire to another exit stair. Certain lobbies are also exempt.

Since the exit system is intended to provide a temporary refuge for the escaping occupants, it must be separated from the other parts of the building by construction that will resist the effects of fire until the occupants escape. Because of their critical locations, such separations allow fewer penetrations for services than typical fire separations. Ducts and combustible piping, for example, are not permitted to penetrate the separation. Only penetrations by piping for standpipes and sprinkler systems, electrical wiring, noncombustible conduits and noncombustible piping are permitted to service the exit.

Where two exits share a common wall, the separation between them becomes even more critical because, if it fails, both exits would become unusable. The wall between them, therefore, is required to be smoke-tight and have no openings for doors or building services that would damage the continuity of the separation.

The fire separation required between an exit stairway and the adjacent floor space is the same as that required for the floor above the exit, except as described in NBC Article 9.9.4.7. for exits serving single two-storey suites of Group D (business and personal services) or E (mercantile) occupancy. If there is no floor above (i.e., the top storey), the rating is then required to be the same as for the floor below, as determined in NBC Subsection 9.10.8. (but not less than 45 min). This effectively means that the fire separation required between an exit and the adjacent floor space is 45 min for all top storeys.

Where an exit is located in a house with a secondary suite (including their common spaces), the exit needs to be protected by a continuous, smoke-tight barrier of not less than 12.7 mm (1/2 in.) thick gypsum board installed on both sides of the walls separating the exit from the remainder of the building, and on the underside of the floor-ceiling framing separating the exit from the remainder of the building.

Example 2 – Required Fire-Resistance Rating for a Wall between a Parking Garage and an Exit Stairway

A three-storey apartment building with single-level suites contains a 12-car basement parking garage, and all levels are served by an exit stairway. The parking garage is intended to serve only the building tenants and is, therefore, not considered to be a separate major occupancy.

According to NBC Article 9.9.4.2., the wall between the garage and the stairway must have the same fire-resistance rating as the floor assembly above it. According to NBC Article 9.10.9.16., the minimum fire-resistance rating for the floor assembly is 1.5 h.

9.9.4.3. Wired Glass or Glass Block

This Article provides the requirements for the properties and size of wired glass and glass block that are used to reduce the risk of heat radiation from a fire on a floor area that can make an exit stairway unsafe for evacuation if the exit is not shielded by a fire-resisting vestibule.

Glass block or wired glass can withstand the effects of fire long enough to permit its use as a closure. Large glass areas, however, can expose the exit user to radiation from fire in the adjacent floor area. For this reason, the area of glass in the doors of an exit (and any adjacent sidelight) must be limited, unless the exit door is protected by an enclosed corridor or vestibule separated from the floor area by fire separations having not less than a 45 min fire-resistance rating (Figure 9.9.-2).

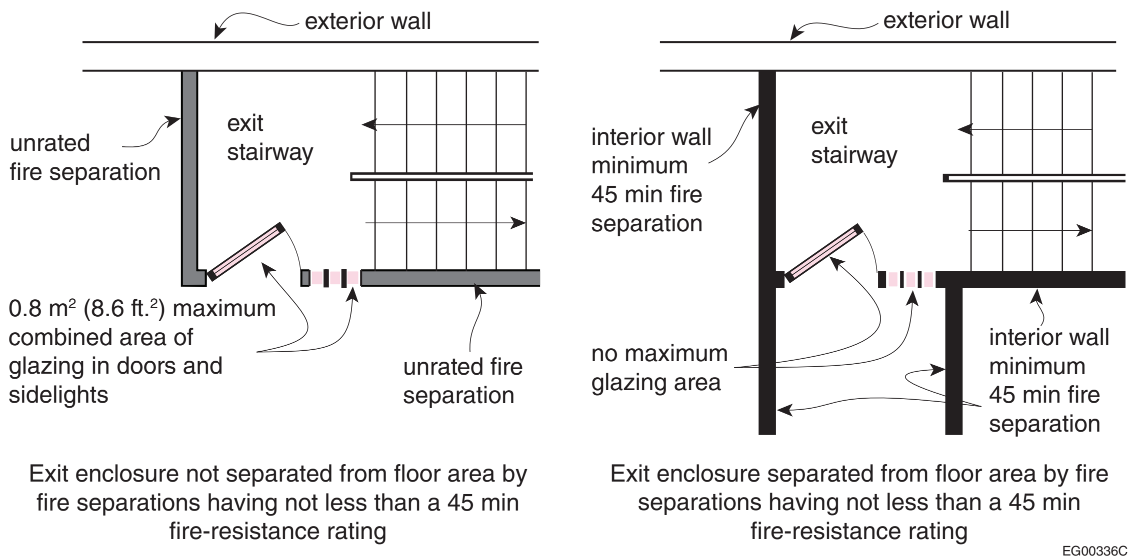


Figure 9.9.-2
Allowable area of wired glass in exit doors and wired glass or glass block in sidelights

9.9.4.4. Openings Near Unenclosed Exit Stairs and Ramps

This Article specifies where unprotected openings in exterior walls have to be protected to reduce the risk of fire breaking out through a window and interfering with evacuation from an exterior exit stairway or ramp as a result of excessive heat radiation.

Exterior unenclosed stairs or ramps are also vulnerable to exposure to fire from openings such as windows. Openings located close enough to be an exposure hazard must be protected with wired glass or glass block (Figure 9.9.-3) if the exterior stairs or ramps are the only means of escape.

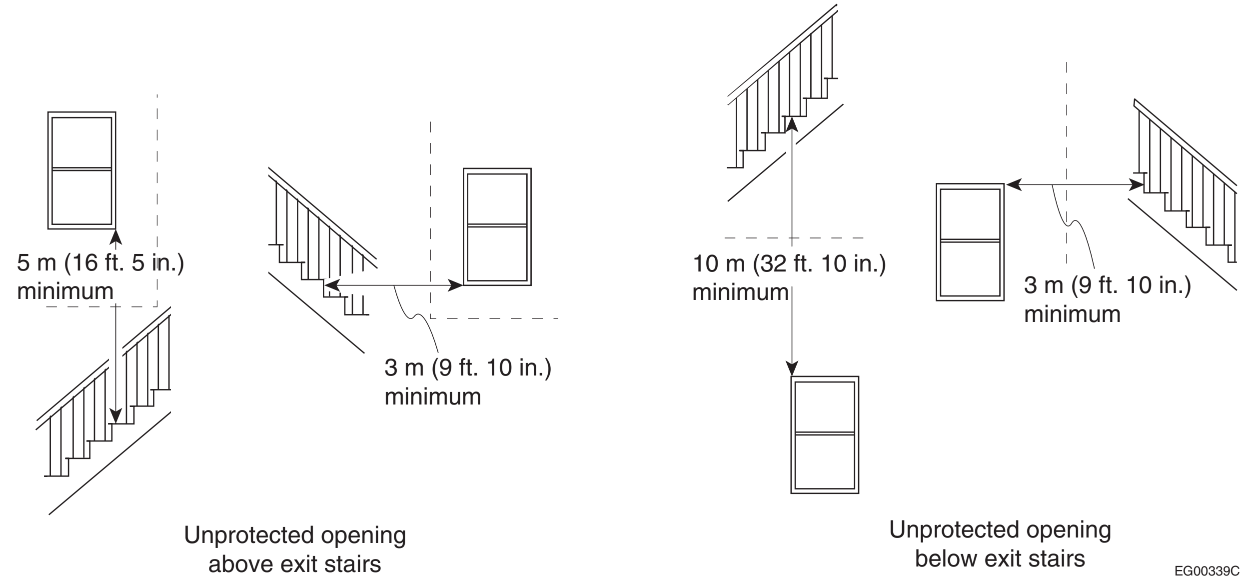


Figure 9.9.-3
Allowable proximity to openings not protected with wired glass or glass block in unenclosed exterior exit stairs and ramps

Note to Figure 9.9.-3:
(1) Dashed lines indicate boundaries between fire compartments or between dwelling units in a house with a secondary suite.

9.9.4.5. Openings in Exterior Walls of Exits

This Article specifies where any opening has to be protected to reduce the risk of fire breaking out through a window in one fire compartment and exposing the window openings in an exit stairway to sufficient heat to break ordinary glass, rendering the exit unsafe.

Windows in the exterior wall of an enclosed exit can be exposed to fire from windows in an exterior wall of another part of the building. Windows in the same plane as the exit windows are not considered to be an exposure hazard. Windows at an angle of less than 135° located within 3 m (9 ft. 10 in.) horizontally and less than 2 m (6 ft. 7 in.) vertically to each other are considered a hazard (NBC Article 9.10.12.3.). For this reason, either openings in exterior walls of an exit or openings in adjacent exterior walls of the building must be protected with wired glass or glass block (Figure 9.9.-4).

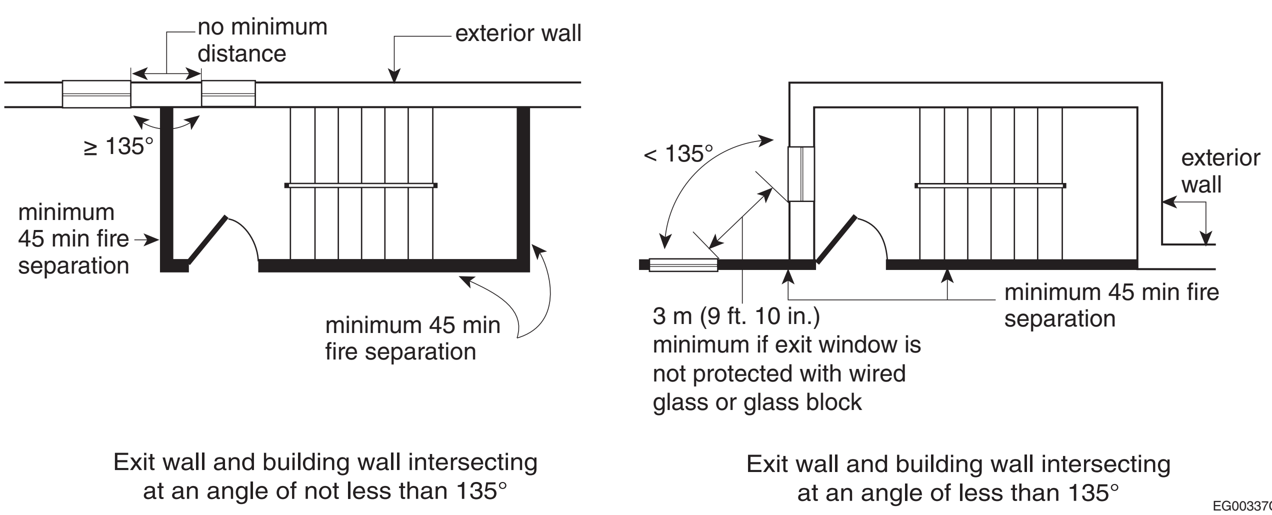


Figure 9.9.-4
Protection of openings in exterior walls of exits

9.9.4.6. Openings Near Exit Doors

This Article specifies where unprotected openings have to be protected when located near exit doors to reduce the risk of a fire breaking out through a window and exposing an exit door to heat, making it unsafe as an exit.

Exterior exit doors can be exposed to fire from unprotected windows in other parts of the building, which may interfere with the evacuation of the occupants in the event of a fire. Unless the exposing windows are kept at a substantial distance away and at a reasonable angle of exposure, they should be protected with wired glass or glass block (Figure 9.9.-5).

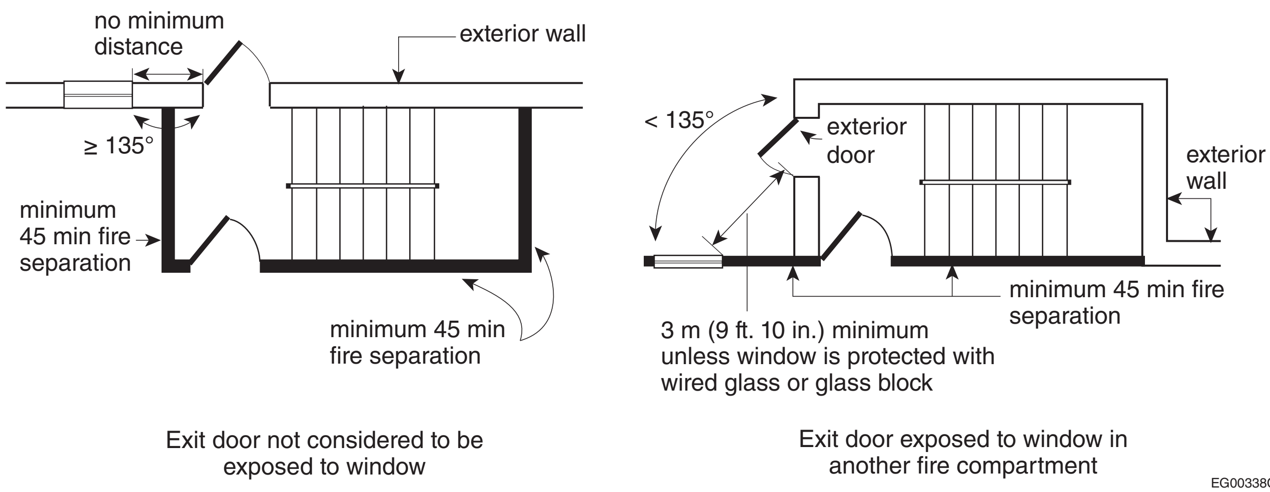


Figure 9.9.-5
Protection of openings near exit doors

9.9.4.7. Stairways in 2 Storey, Group D or E Buildings

This Article allows open stairways between a two-storey mercantile or business suite by providing compensating restrictions to reduce the risks associated with not enclosing the stair. If the listed conditions are met, the stairways serving the second storey of Group D (business and personal services) or Group E (mercantile) buildings are not required to be constructed as exit stairs.

9.9.5. Obstructions and Hazards in Means of Egress

9.9.5.1. Application

This Article describes the scope and application of NBC Subsection 9.9.5., which deals with obstructions and hazards within the means of egress. It exempts dwelling units and their private means of egress from the requirements because of both their low occupant load and occupant familiarity with the building.

9.9.5.2. Occupancies in Corridors

This Article deals with occupancies in corridors and requires that they not encroach on space intended to provide access to an exit, nor that they slow the rate of evacuation.

Corridors are used to direct an orderly flow of pedestrian traffic to the exits. Unlike exits, which are not permitted to be used for any purpose other than for access and egress, corridors may be designed to include seating areas, concession stands or other such facilities. While such occupancies may increase the risk of fire in corridors, they also add to the convenient use of a building. Occupancies in corridors are permitted, but they must not encroach on the required corridor width. Fuel-fired appliances are not permitted in corridors because of the particular fire hazard they present.

9.9.5.3. Obstructions in Public Corridors

This Article deals with facilitating traffic flow to an exit by prohibiting obstructions in the normal path of travel used by the public unless compensating alternative routes are available in a fire emergency to circumvent such obstructions.

Sight-impaired people need to be considered in corridor design. Obstructions that project into egress corridors not only interfere with normal traffic flow, but can also be a special hazard to the blind and sight-impaired. This is particularly important if the obstruction is located so that it cannot be detected with the normal sweep of a cane. For example, if an obstruction does not extend down to within 680 mm (26 3/4 in.) of the floor, it cannot be located by the cane as normally used. The extent to which obstructions can project into a corridor is therefore limited, as shown in Figure 9.9.-6. Obstructions are not permitted to encroach on the required egress width if they are located within 1 980 mm (78 in.) of the floor.

9.9.5.4. Obstructions in Exits

This Article restricts projections into required exits and points to exceptions for doors (as described in NBC Subsection 9.9.6.), as well as for projections into stairs and ramps (as described in NBC Article 9.8.7.6.).

9.9.5.5. Obstructions in Means of Egress

This Article describes what can and cannot be installed within a means of egress in order to ensure that traffic flows easily towards exits. It prohibits obstructions in the normal path of travel used by the public.

Turnstiles restrict traffic flow to exits. Alternate egress routes adjacent to turnstiles are required to permit unrestricted flow to the exits in an emergency. The practice of using closely spaced posts to prevent the removal of shopping carts from stores can also impede traffic flow, particularly if some of the customers use wheelchairs or are on crutches. Spacing such obstructions closer than is needed for wheelchair passage (750 mm (30 in.)) is not permitted unless an alternate egress route is provided.

Counter gates such as those used in post offices are generally not permitted to obstruct a means of egress unless alternative unobstructed openings through the counter are provided. Counter gates are permitted in a required means of egress that serves office and mercantile uses, provided that the space is not accessible to the public, since specialized knowledge to open the gate and reach an exit would be required.

9.9.5.6. Mirrors or Draperies

This Article prohibits the use of mirrors and draperies in or adjacent to exits as that may cause pedestrians to be confused about the exit location or path of egress.

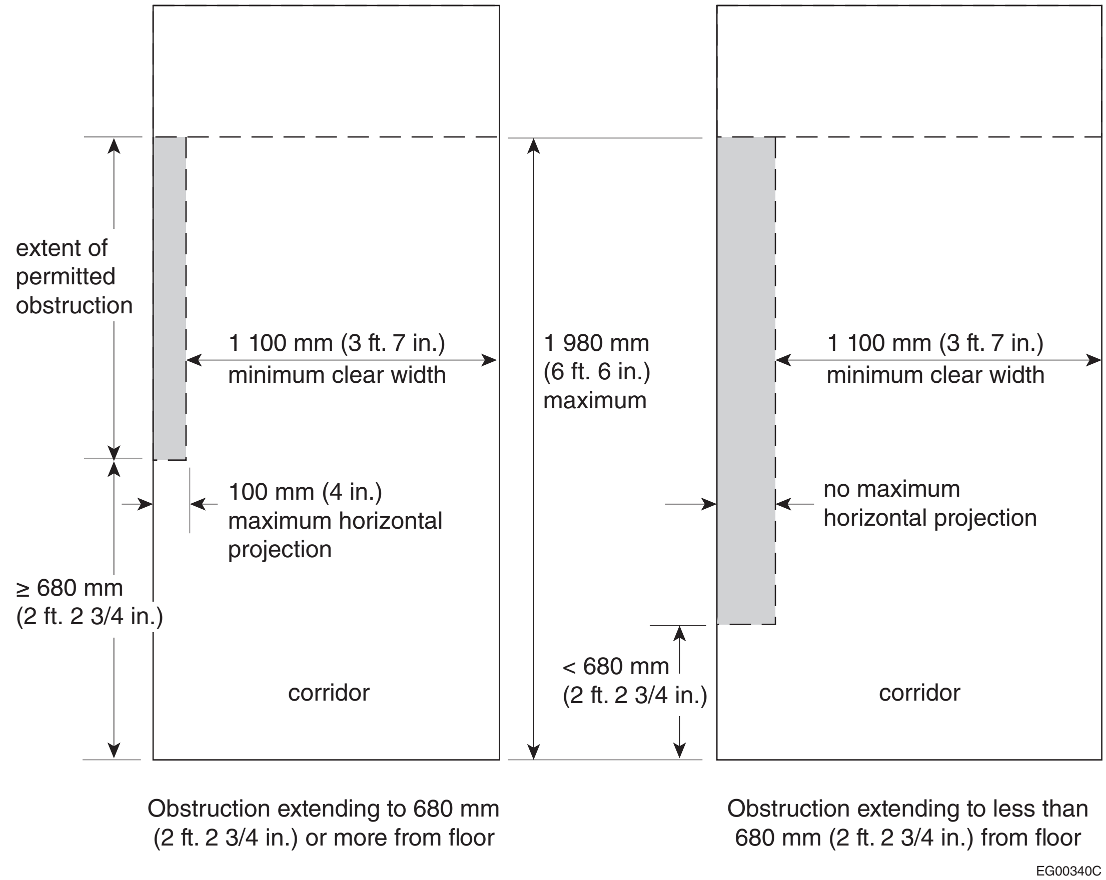


Figure 9.9.-6
Allowable horizontal projection of obstructions in public corridors

9.9.5.7. Fuel-Fired Appliances

This Article prohibits potential fire hazards being placed in exits or access to exits, such as a corridor, that could interfere with evacuation. Specifically, it prohibits the use of fuel-fired appliances in exits or corridors that serve as access to those exits.

9.9.5.8. Service Rooms

This Article intends to avoid rendering an exit inaccessible as a result of an explosion in a service room below it. The requirement limits the boiler size that is allowed in service rooms located under exits to an operating pressure below 100 kPa (2 089 psf).

9.9.5.9. Ancillary Rooms

This Article restricts the types of rooms that can have direct access to an exit in order to reduce the risk of exits being exposed to fires from adjacent rooms.

Except in houses with a secondary suite, ancillary rooms such as storage rooms, washrooms, toilet rooms, laundry rooms and service rooms are not permitted to open directly into an exit. However, indirect access from such rooms to an exit through a corridor or vestibule is permitted.

9.9.6. Doors in a Means of Egress

9.9.6.1. Obstructions by Doors

This Article limits the encroachment a door can have on a means of egress. Since small localized projections into the path of travel do not appear to significantly impede traffic flow, they are permitted within certain limits to allow for the thickness of the door jambs and the thickness of the door in the open position. When doors swing into exit corridors, they can cause accidents if they swing into the path of travel. When doors swing over a stair landing, sufficient space must be provided to allow persons using the stair to get around the opened door so that traffic flow will not be unduly restricted. An exemption for single dwelling units and houses with a secondary suite from most of the requirements is permitted because of both their low occupant load and occupant familiarity with the space.

Under no circumstances should doors offer a significant impediment to escape from a building, or unduly hamper the use of the building by physically disabled people. Certain restrictions are therefore placed on the design of doors and doorways to achieve these objectives.

Obstructions that are created by doors must be limited for all exit doors, doors that open into or are located within a public corridor, or any other facility that provides access to an exit from a suite.

Doors opening onto a landing should not interfere with the traffic flow on the stairs. While this does not affect stairs within dwelling units, it must be taken into consideration for all other stairs. Figure 9.9.-7 illustrates the clearance required for landings in relation to doors.

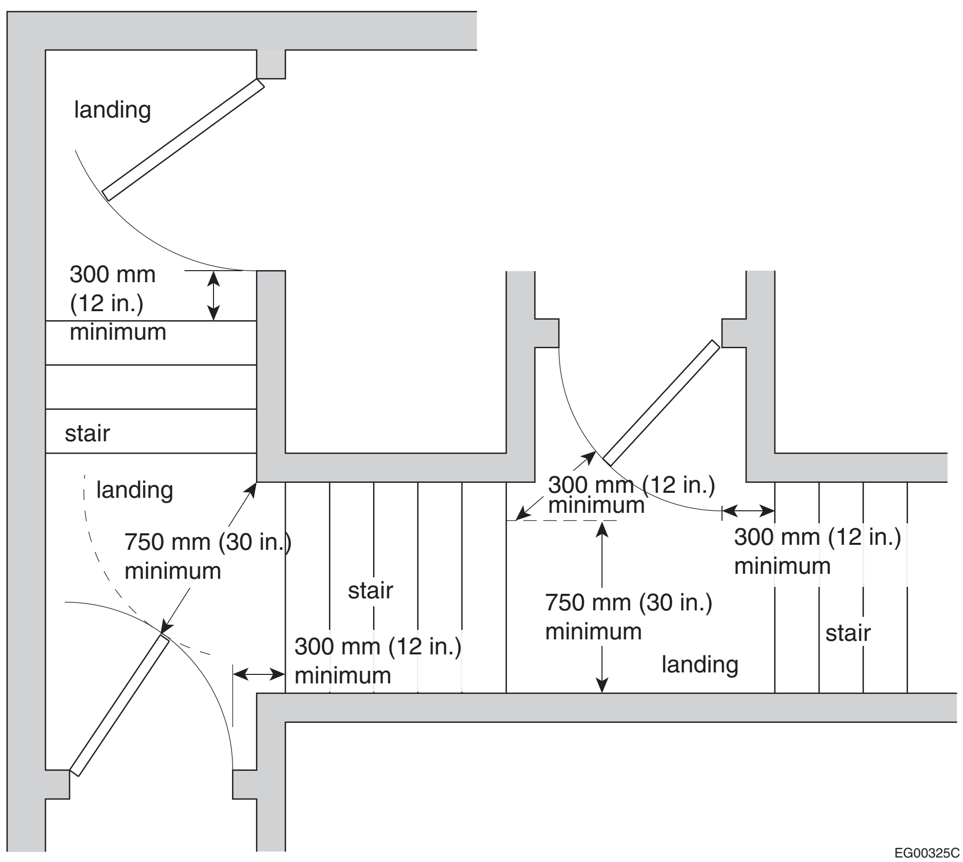


Figure 9.9.-7
Doors opening onto a landing in a means of egress (not serving a single dwelling unit or a house with a secondary suite)

Exit doors in the open position encroach on the clear width provided by the doorway. This encroachment is normally slightly more than the thickness of the door. The clear width of the doorway may therefore be reduced from the required width to allow this, as shown in Figure 9.9.-8. This localized width reduction has little perceptible effect on pedestrian traffic flow.

9.9.6.2. Clear Opening Height at Doorways

This Article intends to minimize injuries from accidental head contact with door closers or other devices. It assumes a reasonably tall adult. The Article also provides for exit doors of sufficient size to facilitate the passage of pedestrians, furniture and equipment, without accidental head contact with the top of the door frame.

Doorways serving single dwellings units or houses with a secondary suite do not need to meet the limitations on clear height at doorways.

9.9.6.3. Clear Opening Width at Doorways

This Article indicates the clear opening features of exit doors to ensure they will allow free passage of pedestrian traffic.

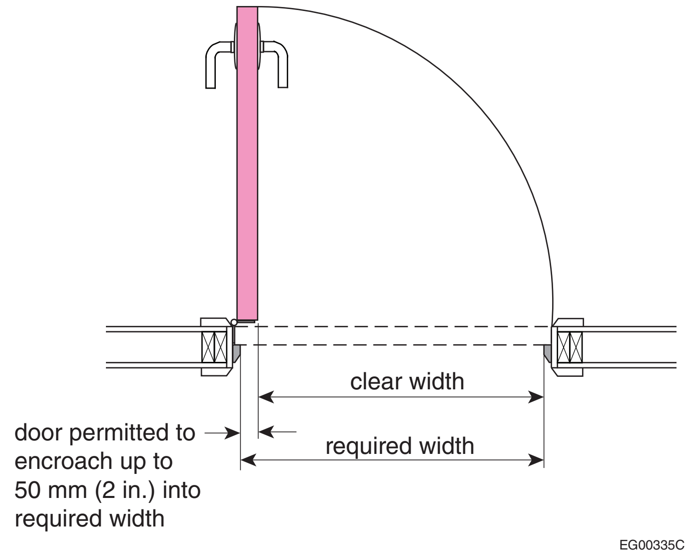


Figure 9.9.-8
Permitted reduction in exit width at doorways

Obstructions that result from reduced widths at doors and their swing areas at exit doors and at doors that open into or are located in public corridors or other facilities that provide access to exit from another suite must be limited. This is done by limiting the allowed decrease in required exit width and ensuring that landings have adequate area to account for a door swing. These requirements are waived for doors serving a single dwelling unit or a house with a secondary suite.

For other occupancies, doors must be wide enough to allow passage without a person having to twist sideways. Therefore, if a single door leaf is used in an opening, it must be somewhat larger than the width of an average person in order to provide reasonable clearance. This basic minimum door leaf size (810 mm (31 7/8 in.) can be reduced to 610 mm (24 in.) if two doors are provided, on the presumption that in an emergency, both doors can be operated. However, an 800 mm (31 1/2 in.) clear width is specified for wheelchairs in NBC Section 3.8., so this would be the overriding consideration if the door were in a barrier-free path of travel (NBC Article 9.5.2.2.).

Doorways serving single dwellings units or houses with a secondary suite are exempted from the limitations on clear widths at exit doors but need to comply with NBC Article 9.5.5.1.

9.9.6.4. Door Action

This Article requires design features for revolving doors and sliding doors to keep them from obstructing pedestrian traffic in order to facilitate evacuation. It also lists a number of exemptions, such as accessory buildings, storage garages or storage suites of less than 20 m² (215 ft.²) gross area and that are only one storey high, as well as doors that open directly to the exterior at ground level.

Using sliding doors in a means of egress and as exit doors is permitted provided they are designed to break open as swing doors under pressure, and that they carry a label indicating that feature. Revolving glass doors in a means of egress must meet the specific requirements of NBC Part 3.

Required exit doors for dwelling units must be swing type, but are permitted to swing either inward or outward.

9.9.6.5. Direction of Door Swing

This Article requires doors to swing away from potential crowd pressure caused by people trying to escape in order to facilitate traffic flow at critical points in a means of egress.

Exit doors must swing in the direction of travel to the exterior, except for doors serving a single dwelling unit or a house with a secondary suite. This makes their operation predictable and allows them to be opened away from crowded areas during evacuation. The exemption for door swing for houses is allowed on the basis of both low occupant load and greater occupant familiarity.

Where a door that provides access to exit from a suite serves a large number of persons (more than 60), it must swing on the vertical axis in the direction of travel to the exit (Figure 9.9.-9).

Where a corridor with exits at both ends is subdivided by a pair of doors, the doors must swing in both directions or must swing in opposite directions, with the door on the right-hand side swinging in the direction of exit travel.

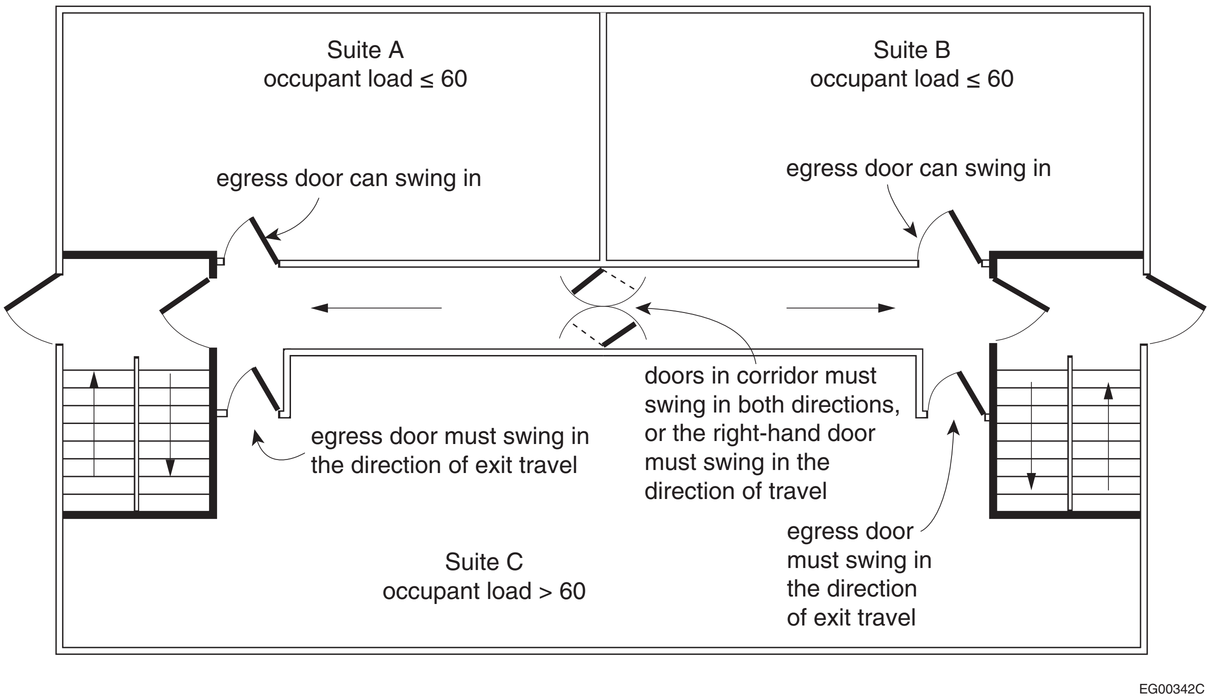


Figure 9.9.-9
Direction of door swing in means of egress and exits

9.9.6.6. Nearness of Doors to Stairs

This Article intends to minimize undue interference with traffic flow on stairs caused by doors that open into stairways, by allowing sufficient space for people to file past the door when it is opened. A second purpose is to facilitate exit flow by allowing exit doors to swing out over a single step in locations where snow or ice may keep the door from opening.

The distance between a stair riser and the leading edge of a door during its swing must be at least 300 mm (12 in.) (see Figure 9.9.-7). This distance can be less for doors serving a single dwelling unit or a house with a secondary suite.

Since one-riser and two-riser stairs can be difficult to perceive, such steps are generally not permitted adjacent to doors. When a step is necessary to provide clearance for snow accumulations, however, a single riser up to 150 mm (6 in.) high is permitted.

9.9.6.7. Door Latching, Locking and Opening Mechanisms

This Article requires that principal entrance doors, exit doors and doors to suites, including exterior doors of dwelling units, and other doors in an access to exit be openable from the inside or in travelling to an exit without the need for keys, special devices or specialized knowledge of the door-opening mechanism, unless they are controlled by electromagnetic locking mechanisms in accordance with NBC Sentence 3.4.6.16.(4). This requirement is intended to prevent occupants from being trapped in a building on fire if the key or opening device for a door forming part of an exit system is mislaid or if the door-opening mechanism is too complicated to be opened quickly by someone in a panicked state.

Doors in a means of egress must be provided with door release hardware that is operable with one hand and must be openable with not more than one releasing operation. Doors serving a single dwelling unit or a house with a secondary suite and doors to accessory buildings or to garages serving a single dwelling unit are exempted from these requirements.

In occupancies such as banks and stores, it may be necessary that some doors be not readily openable for security reasons. Electromagnetic locks can be used to hold such doors closed until they are released upon actuation of a manually operated switch, actuation of a fire alarm system, application of a force of not more than 90 N (20 lbf), or loss of power.

Except in hotels and motels, automatic locking is prohibited for doors equipped with an automatic self-closing device that open onto a public corridor providing access to exit from suites. This prohibition is intended to prevent people from being accidentally locked in suites and cut off from the access to exit. The exemption for hotels and motels is intended to reduce the risk of burglary when doors are accidentally left unlocked.

9.9.6.8. Effort Required to Open

This Article regulates the maximum force that is required to open exit doors, in order to allow most ambulatory people to open a door by applying reasonable force to the knob or handle side of the door.

Automatic door closers can make the opening of doors more difficult if those closures are designed with a powerful return action. This can be a problem for both young and weak people, and is especially problematic for those on crutches or in wheelchairs. Except for doors serving single dwelling units or houses with a secondary suite, the maximum opening force for exit doors is therefore limited to 90 N (20 lbf). If the door is located in a barrier-free egress path, an even lower opening force is mandated (38 N (8.5 lbf)) for exterior doors, and 22 N (5 lbf) for interior doors).

9.9.7. Access to Exits

This Subsection contains requirements intended to facilitate escape from a suite by having more than one path of travel from the suite egress door(s) to a place of safety should one path become untenable in a fire.

9.9.7.1. Egress from Roof Area, Podiums, Terraces, Platforms and Contained Open Spaces

This Article ensures that egress is provided from all areas of a building that are not enclosed, in addition to the area inside a building. It also requires that more than one exit be provided where the occupant load on a roof or platform is greater than 60 persons.

9.9.7.2. Means of Egress from Suites

This Article describes options of escape routes from a suite by having more than one path of travel from the suite egress door(s) to a place of safety should one path become untenable in a fire.

Where a floor area is divided into suites served by a common corridor (a public corridor) or an exterior passageway, the occupants must normally have a choice of two escape routes to different exits when they reach the corridor or passageway (see Figure 9.9.-9, Guide 9.9.6.5., Direction of Door Swing).

9.9.7.3. Dead-End Corridors

This Article restricts the use of dead-end corridors.

Where a corridor does not provide a choice of direction from a suite to separate places of safety (i.e., a dead-end corridor), the additional risk to occupants served by the dead-end is considered to be acceptable if it is relatively short. For this reason, dead-end corridors are limited in length to 6 m (20 ft.). This limit does not apply to corridors within suites, nor does it apply if the dead end portion serves dwelling units that have a second and separate means of egress.

9.9.7.4. Number and Spacing of Egress Doors

This Article sets maximum areas and travel distances for rooms, suites and mezzanines with a single means of egress in order to provide sufficient exit capacity and options for the design capacity of the space.

Although having only a single egress door to serve a room or space violates the general principle of having two ways to escape from that space, the increase in safety as a result of a second egress door is considered to be marginal if the space is very small. In the event of fire, the entire space would be untenable almost immediately, irrespective of whether one or two egress doors served the space. The occupant load of any floor area needs to be calculated to determine the size and number of exits. Usually, two exit doors will suffice. NBC Table 3.1.17.1. provides minimum occupant load limit calculations for specific types of uses.

As the size of the room or space increases, the number of people at risk by virtue of a single egress door increases. The risk of not being able to reach the egress door is also assumed to increase as the travel distance to the door increases. At some stage, the assumed risk is considered to justify a second door being required, provided the doors are located so they are unlikely to be involved in a fire at the same time. Except for dwelling units that are assumed to have low occupant loads, and which have traditionally been permitted to have single egress doors, at least two egress doors are required when the area of a room or suite or the distance from any point in the room or suite exceeds the values in NBC Table 9.9.7.4.

The risk for each type of occupancy varies. Residential occupancies such as hotels and motels with facilities for sleeping are considered to be a greater risk than other occupancies where people are awake when the building is in use. Mercantile occupancies may have a higher occupant load than business and personal service occupancies, putting more people at risk in a given area. The activities in industrial occupancies may create greater fire risks than those in other occupancies, even though the occupant load may be lower. For these reasons, limits for the maximum size of rooms or suites for which a single egress is permitted, as well as the maximum travel distance to it, have been established depending on the nature of the occupancy.

9.9.7.5. Independent Access to Exit

This Article intends to ensure a safe means of emergency egress by prohibiting any escape route that depends on the activities or desires of the occupants of another suite and lead through areas that may be unsafe.

9.9.7.6. Travel Distance within Rooms and Suites

This Article establishes safe escape routes from a room or suite in the event of a fire by limiting the distance (and hence the time) required to reach an egress door from that space.

9.9.8. Exits from Floor Areas

9.9.8.1. Measurement of Travel Distance

This Article establishes how travel distances to exits are measured, and provides some relaxations and alternative compliance options for well-protected areas, sprinklered buildings, and wide hallways.

Generally, travel distance to an exit is measured from the most remote part of the floor area, the same as it is for rooms or suites (Figure 9.9.-10).

If a room or suite is separated from the corridor by partitions that provide a reasonable degree of fire protection (45 min), it is assumed that the occupants in that room or suite will be protected from external fires until they reach the egress door from that fire compartment. The travel distance can therefore be assumed to start from the egress door of the room or suite, and be measured to the nearest exit (Figure 9.9.-10).

If the building is sprinklered, the main threat to occupant escape will be from smoke. In sprinklered buildings, therefore, the travel distance to exits can be measured to the room or suite entrance of an enclosing fire separation that is not required to have a fire-resistance rating.

Travel distance to an exit can also be measured from the egress door of a room or suite having no fire separation between it and the corridor, if the floor area is sprinklered and the corridor is sufficiently wide (9 m (30 ft.)) and high (4 m (13 ft.)) to provide an adequate reservoir for smoke above head level. This is intended to allow for adequate escape time in the event of fire before the corridor becomes untenable. Such shopping-mall-type corridors, however, usually fall within the size limits of NBC Part 3 rather than NBC Part 9.

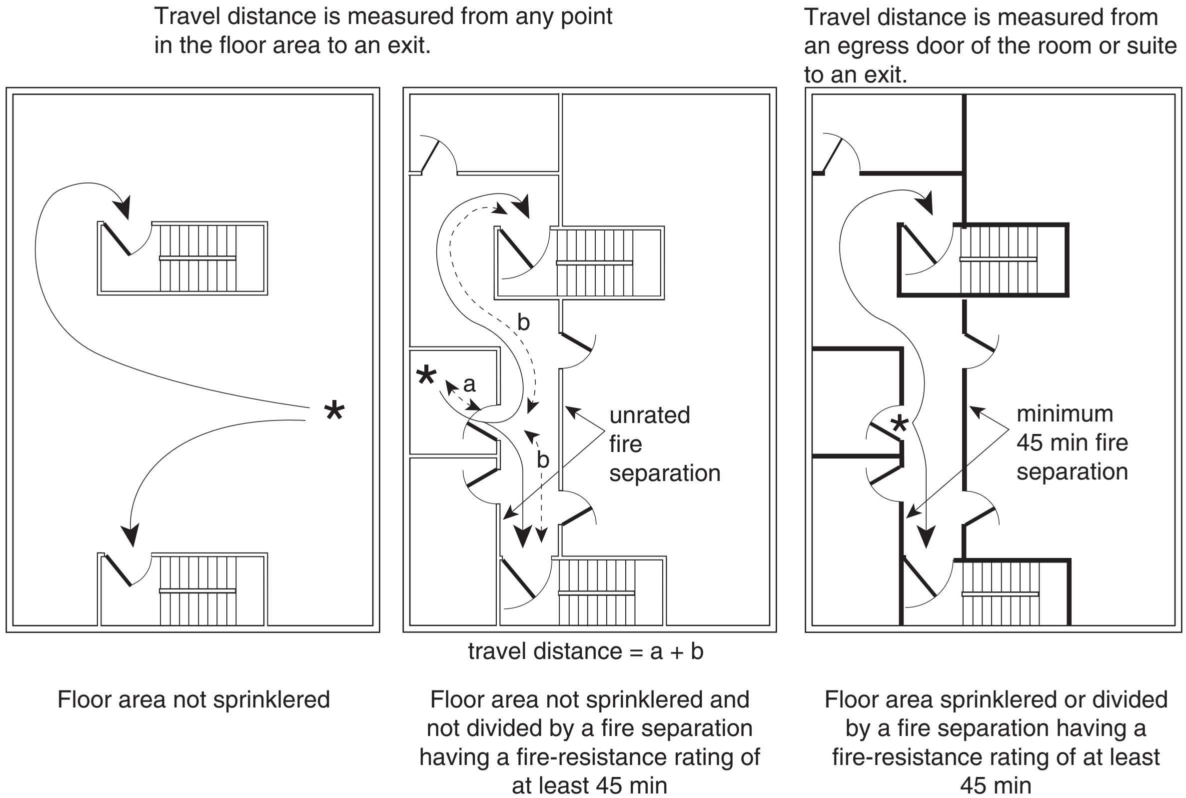


Figure 9.9.-10
Travel distance to an exit

9.9.8.2. Number of Required Exits

This Article establishes the number of exits required to evacuate people quickly and safely, and limits the allowable travel distances and time to reach a place of safety given the building's occupancy classification. It is assumed that one exit may become untenable as a result of fire or smoke, making an alternative escape route necessary.

The size and occupancy restrictions placed on single exits from floor areas make the use of single exits the exception rather than the rule. Generally, at least two exits are provided for buildings within the scope of NBC Part 9. In long buildings, however, even two exits may not be adequate if the travel distance to reach the nearest one is excessive. In business and personal services occupancies (Group D), the travel distance (40 m (131 ft.)) is allowed to be greater than for other occupancies (30 m (98 ft.)) because of the lower perceived risk. Since sprinklers reduce the potential severity of a fire, their use permits even greater travel distance (45 m (148 ft.)) to an exit.

The principle of separate escape routes required in relation to rooms and suites also applies to exits from a floor level provided certain conditions are met. In fact, the maximum floor areas that can be served by a single exit and the maximum travel distance to the exit are the same as those allowed for a single egress from rooms and suites. Single exits, however, can only be used in one-storey and two-storey buildings, and only if the total occupant load served by the facility (from all floor levels) is 60 or less.

When two or more exits are provided, each must be independent of the other so that, should one become involved in a fire, it would not affect the others. In order to preserve the principle of having a choice of escape routes, the exits have to be spaced as far apart as possible or be otherwise separated to reduce the chance of both becoming inaccessible at the same time. NBC Article 3.4.2.3. has specific requirements for the distance between such exits (generally one half the maximum diagonal dimension of the floor area), but it is considered impractical to impose such requirements in the small buildings governed by NBC Part 9.

Where an exit stair terminates at an interior location, it generally has an exit corridor from the stair to the exterior. This exit corridor is subject to all of the requirements for exit stairs, including fire separations, surface flame-spread limits and occupancy prohibition.

9.9.8.3. Contribution of Each Exit

This Article ensures that if any one exit is untenable, at least half of the total required exit capacity will still be available for escape.

9.9.8.4. Location of Exits

This Article intends to ensure that a sufficient distance between exits is provided to make it unlikely that both exits will become inaccessible at the same time.

9.9.8.5. Exiting through a Lobby

This Article establishes conditions under which an exit route can run through a lobby near grade level, by placing restrictions on the lobby's design and construction, and by limiting the occupancies adjacent to it.

Traditionally, small hotels have been allowed to use the entrance lobby rather than an exit corridor as part of the required exit system. This practice has apparently caused no serious problems, and in recent times it has been extended to all occupancies. Although the entrance lobby does not have to meet the same high standards as are required for exit corridors, a number of restrictions are imposed to ensure that occupant safety is not compromised. This is the only case where occupants using an exit are obliged to re-enter a floor area before reaching a place of safety outside the building. Passenger elevators are permitted to open into a lobby provided the doors are designed to remain closed except while loading or unloading passengers.

9.9.8.6. Mezzanine Means of Egress

This Article establishes the conditions under which means of egress has to be provided to a mezzanine level the same way it would be provided for any floor area. It establishes limits based on the occupant load and size of the mezzanine level, as well as the distance to the next exit.

9.9.9. Egress from Dwelling Units

9.9.9.1. Travel Limit to Exits or Egress Doors

This Article describes the acceptable egress facilities in a dwelling unit in the event of a fire. It also sets the limits of the vertical travel required to reach an egress level and permits an increase of the travel distance where a unit cannot be exposed to fire from a lower unit.

Many household activities are a potential fire risk, and the age and mobility of family members can vary widely. These factors, together with the need for dwelling units to provide sleeping accommodations, make them a marked risk to life safety. Dwelling units also differ from other typical suites in that they are commonly designed to occupy two or more levels. This, along with the other risk factors, is taken into account in regulating egress.

The travel distance can be exceeded in detached, semi-detached and row houses (where a dwelling unit is not located above or below another dwelling unit) if the storey is served by a balcony that can provide a temporary refuge, or by an openable window located close enough to the ground to allow the occupant to escape without serious injury. This effectively permits houses up to three storeys in building height to have a single egress door if they have a balcony or an escape window on the top floor.

Dwelling units have to be designed so that it is not necessary to travel up or down more than one storey to reach a level served by an exit doorway within 1.5 m (5 ft.) of ground level. An exception is made if a floor level is served by an exterior balcony or escape window. This window must be operable, with a sill height of 1 m (3 ft. 3 in.) or less and within 7 m (23 ft.) above ground level. It must also be at least 1 m (3 ft. 3 in.) high, and 0.55 m (22 in.) wide.

In effect, a single exit door within 1.5 m (5 ft.) of the ground is permitted for most one-storey and two-storey dwelling units, and for three-storey dwelling units if the top storey has an exterior balcony or escape window. In dwelling units with a narrow hallway (less than 860 mm (34 in.)) that serves the bedroom and bathroom area, such as in certain manufactured home designs, a second exit doorway is required at the end furthest from the living area.

Many dwelling units, particularly in multi-family buildings, have single egress doors, and most multi-storey units have single access stairs to different floor levels. This is considered to be an acceptable risk provided that the travel distance within the dwelling to the egress door does not exceed one storey. If the egress door is not an exterior door within 1.5 m (4 ft. 11 in.) of the ground, it must open into a corridor, enclosed stairway or exterior passageway. If these facilities are shared with other units, the occupants must be given a choice of two exits, or a separate egress facility must be provided for the units.

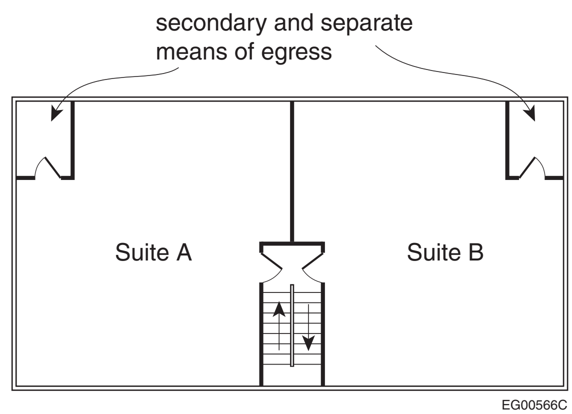


Figure 9.9.-11
Dwelling units opening directly into a shared exit

If the egress from a dwelling is into a dead-end corridor longer than 6 m (19 ft. 8 in.) (NBC Article 9.9.7.3.), a separate means of egress is also required from the unit to give the occupants a second escape route. Similarly, if a dwelling opens directly onto an exit stairway shared by other units (Figure 9.9.-11), a second means of egress is required from the unit, unless the exterior passageway or balcony common to the units is less than 1.5 m (4 ft. 11 in.) above grade when served by a single exit stairway.

Figure 9.9.-12 illustrates the NBC exit requirements for dwelling units with more than one storey.

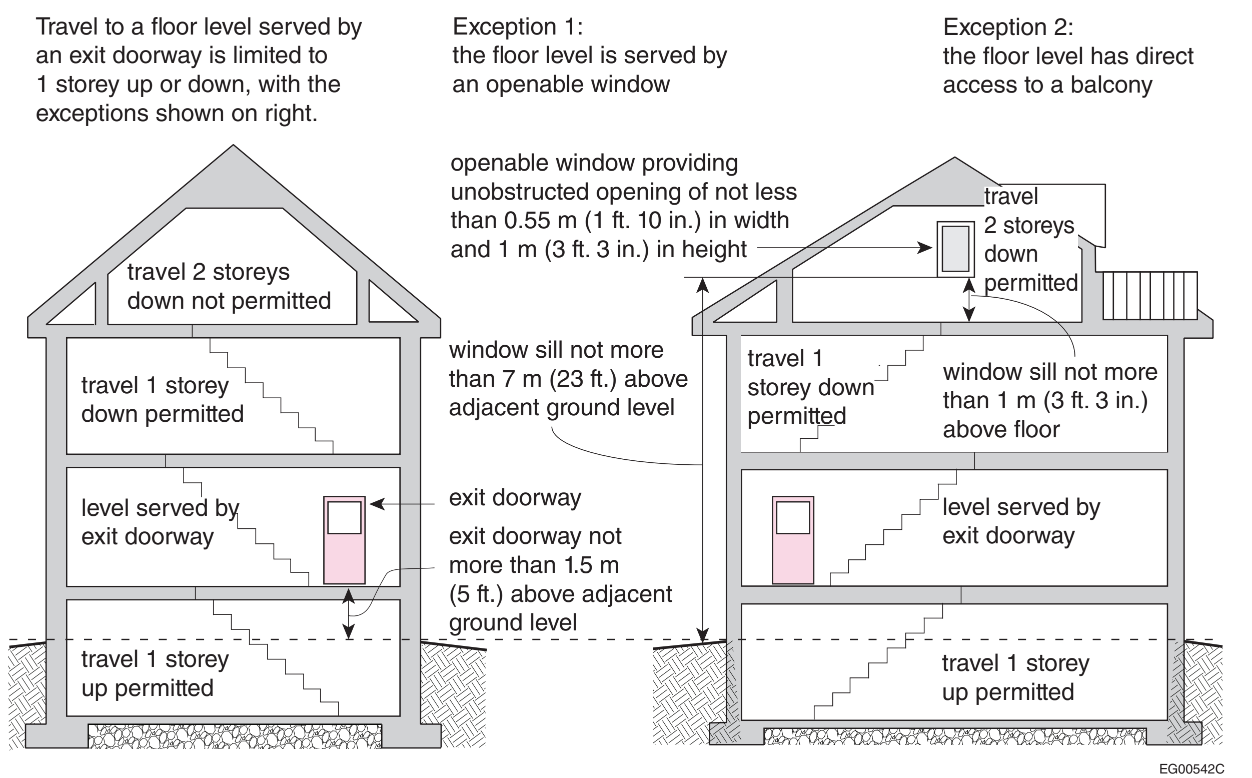


Figure 9.9.-12
Travel limits to exits or egress doors for dwelling units with more than one storey

9.9.9.2. Two Separate Exits

This Article facilitates escape from a dwelling unit with shared egress facilities by ensuring that should one exit be untenable, a second and separate exit will be available for escape.

Houses and dwelling units in houses with a secondary suite are not required to have two separate exits from a door exiting into a public corridor or exterior passageway.

9.9.9.3. Shared Egress Facilities

This Article establishes which shared egress facilities trigger the need for a dwelling unit to have a second and separate means of egress. This ensures that should one exit be untenable, a second and separate means of egress will be available for escape.

A dwelling unit above another unit can have its own private egress stairway designed so that it is an integral part of the upper unit. This would permit a single exit from the upper unit. Such a stairway, however, would have to be separated from the lower dwelling unit by the same level of fire separation as required between the units.

Requirements for a second exit from a corridor that serves as a means of egress for more than one dwelling unit is waived for dwelling units in houses with a secondary suite.

In a house with a secondary suite, where a dwelling unit is located above another dwelling unit, the upper unit of the house shall be provided with a second and a separate egress only when the egress door from that unit opens onto an exterior passageway that is located at a distance of more than 1.5 m (5 ft.) above adjacent ground level, is served by only one exit stairway or ramp, and has a floor assembly with limited fire-resistance rating.

9.9.10. Egress from Bedrooms

9.9.10.1. Egress Windows or Doors for Bedrooms

This Article presents the emergency escape requirements from bedrooms should a fire prevent escape by normal egress routes. Although bedroom windows are not considered to be ordinary escape routes, many occupants have been saved by using them in an emergency.

Unless a dwelling unit is sprinklered, or a bedroom has a doorway to the exterior, every bedroom or combination bedroom must be provided with at least one outside window or exterior door that can be opened from the inside without the use of tools to provide an emergency means of escape or rescue from bedrooms. These windows must have an unobstructed open portion having a minimum area of 0.35 m² (3.8 ft.²) with no dimension less than 380 mm (15 in.) (Figure 9.9.-13). For sliding windows, the minimum dimension applies to the openable portion of the window.

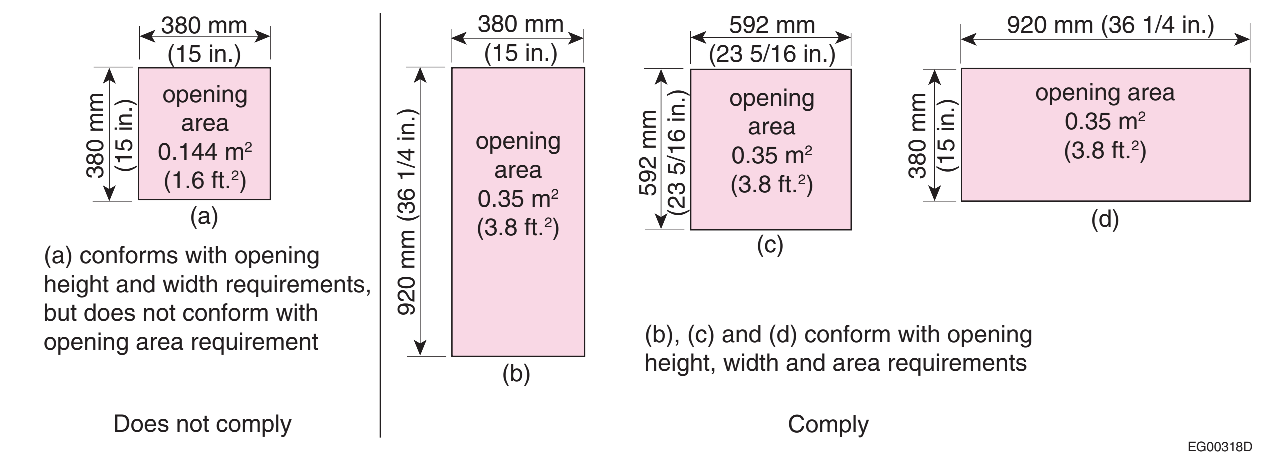


Figure 9.9.-13
Compliance of egress windows for bedrooms with NBC Clause 9.9.10.1.(2)(a)

The escape path must not go through nor open onto another room, floor or space. Bedroom windows required to serve as emergency means of escape or rescue need to remain open during an emergency without the need for support to maintain the open position.

Where a bedroom is located in a basement, an escape window or door must be located in the bedroom. It is not sufficient to rely on egress through other basement space to another escape window or door.

It is recommended that window sills intended for emergency exit be no more than 1.5 m (5 ft.) above the floor. Where this is difficult to provide (such as with basement bedroom windows), access to the windows can be improved through means such as built-in furniture beneath the window.

In some instances, windows located on the second or third floor of a dwelling are required to be larger than the minimum size specified for bedrooms. This is to permit rescue by firefighters where vertical travel distance to an exit for the occupant is excessive. There is no exemption for houses with a secondary suite.

Additional Requirements for Egress from Windows in a Window Well

Where a window well that is required to serve for escape or rescue is covered with a protective enclosure, the enclosure needs to be openable from the inside without the use of tools, keys or special knowledge.

Where an escape window opens into a window well, it must have a clearance of at least 760 mm (30 in.) in front of the window. Once the 760 mm (30 in.) is provided, no additional clearance is required for windows with sliders, casements or inward-opening awnings. However, additional clearance is required for outward-opening awning windows to provide the required 760 mm (30 in.) beyond the outer edge of the sash as shown in Figure 9.9.-14.

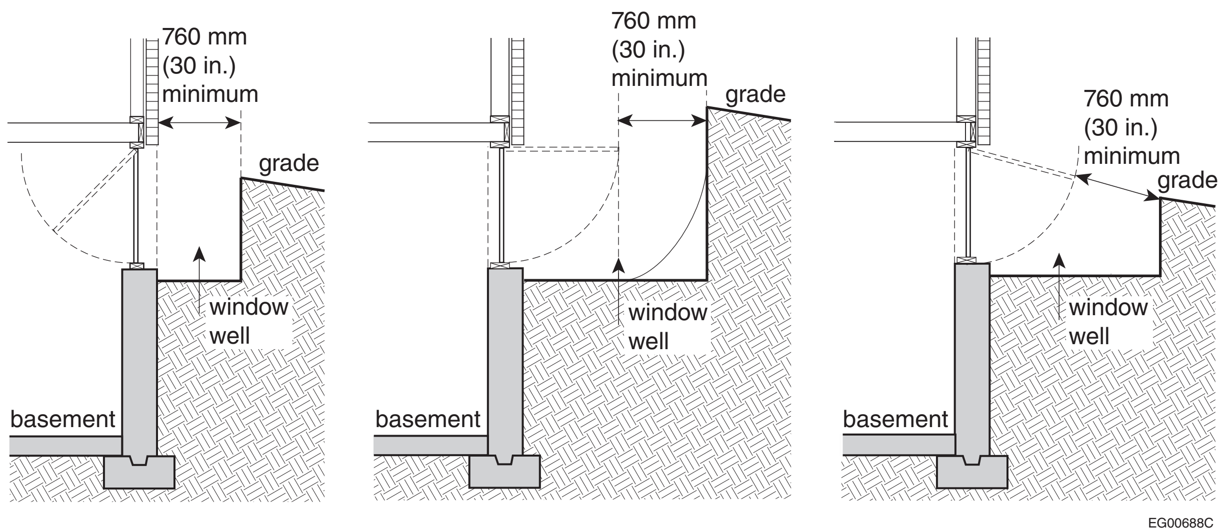


Figure 9.9.-14
Minimum clearance for egress windows for bedrooms opening into a window well

9.9.11. Signs

9.9.11.1. Application

This Article establishes where exit signage is required.

The requirements for exit signage apply to all exits except those serving not more than one dwelling unit or a house with a secondary suite.

9.9.11.2. Visibility of Exits

This Article requires that exits be located so as to be clearly visible or that their locations be clearly indicated by signage where they are not obvious to the occupants.

Within a single dwelling unit or a house with a secondary suite, locating exits is not a problem because of the occupants' familiarity with the building. In locations where occupants are less familiar with the building, however, confusion can occur under emergency conditions unless the egress route is clearly marked. A clearly marked egress route is especially critical in locations providing sleeping accommodations, such as hotels, motels and apartment buildings. Dead-end corridors and complicated egress routes can add to the confusion and should be avoided.

In small buildings in which the corridor arrangement is relatively simple and without dead ends, the direction of egress may be obvious to the occupants, or every egress direction may lead to an exit. Signs indicating the locations of exits are not necessary in such situations.

Where an exterior exit door is located such that it could be obstructed by parked vehicles or storage, a visible sign or a physical barrier prohibiting such obstructions must be installed on the exterior side of the door. This requirement is intended to prevent objects like parked vehicles or dumpsters from being placed adjacent to the door where they could impede the evacuation of the building in an emergency.

9.9.11.3. Exit Signs

This Article sets the requirements for exit signs over doors intended as escape routes in the event of a fire. Every exit door in a building that is three storeys in building height or has an occupant load greater than 150 is required to have an exit sign above or adjacent to the door. In small buildings with a limited number of persons, the exit locations are sufficiently obvious that exit signs over doors are not necessary.

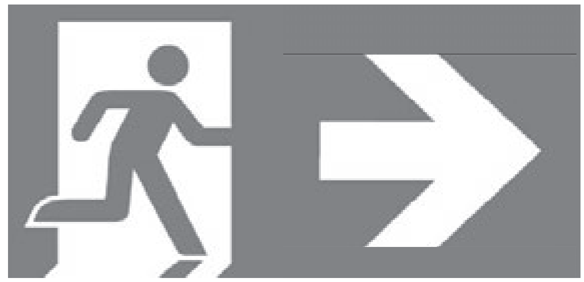


Figure 9.9.-15
Example of a standardized exit sign

To be effective, exit signs have to be obvious in the direction of egress. Although these are normally illuminated internally, external lighting is also permitted. Exit signs are internationally recognized symbols. The colours and lettering are easily understandable without having to be read. (Figure 9.9.-15).

The purpose of exit sign illumination is to facilitate escape in the event of a fire by keeping the power to the circuit that illuminates the exit signs from being interrupted unnecessarily as a result of power demands or servicing that is unrelated to the exit illumination.

9.9.11.4. Signs for Stairs and Ramps at Exit Level

This Article requires that it be clearly indicated where ramps or stairways that do not lead to an exit may be mistaken as an exit route. In some building designs it may not be obvious that a stairway to a basement does not lead to an exit, and additional signage is necessary to avoid confusion.

When three-storey buildings have stairs to the basement, people could walk past the exterior exit door in a fire and be trapped in the basement. Signs are therefore required, in both directions, to indicate the correct direction of exit route.

9.9.11.5. Floor Numbering

This Article establishes standardized floor numbering to help occupants easily identify the storey on which they are located.

Each floor is to be numbered so that it can be identified by occupants, including blind or visually impaired persons. The number is to be placed beside the exit door on the stair side and the numbers are to be raised so that the floor number can be discerned without reading. To be effective, it must provide maximum colour contrast.

9.9.12. Lighting

The lighting ordinarily provided in corridors and stairs for their everyday use is usually more than adequate to meet the requirements of this Section. This does not ensure future safety, however, since bulbs may not be replaced or lower wattage bulbs may be substituted. These risks can only be attenuated through a periodic inspection of the occupied building.

9.9.12.1. Application

This Article establishes where lighting is required on escape routes. Exit lighting is required for all exits except those serving not more than one dwelling unit or a house with a secondary suite.

9.9.12.2. Required Lighting in Egress Facilities

This Article establishes the minimum lighting levels for egress facilities to help escape in the event of a fire, and to avoid accidents in the everyday use of egress facilities.

9.9.12.3. Emergency Lighting

This Article establishes where emergency lighting has to be provided, how it must be powered, and how it must be actuated. It also sets the minimum light intensity values for exit signs.

These requirements intend to facilitate escape in the event of a fire if the normal electrical supply is interrupted, by providing an alternative means for illuminating principal escape routes. Power failure, whether caused by fire or natural events, can seriously impede egress and access to exits. While this is particularly critical in multi-family residential buildings because of nighttime occupancy, emergency lighting is now considered necessary for critical escape paths in all occupancies.

In a floor area divided into separate rooms or suites, these escape paths include the public corridors as well as the exit stairways. In open floor plans, they also include the principal pedestrian routes to exits such as major aisles in stores or open offices. However, they do not include individual dwellings. The most common means of providing emergency lighting in small buildings is by self-contained, battery-operated units that are kept continuously charged by the regular electrical supply. Such lighting must be automatically actuated when power fails, and have sufficient power to light the egress routes for long enough to ensure the safe egress of the occupants (30 min).

Section 9.10. Fire Protection

Introduction

The objectives of fire safety measures are to reduce the risk that a person in or adjacent to a building will be injured due to a fire and to minimize the potential damage to the building where a fire originates and to adjacent buildings. While compliance with Code requirements can reduce the likelihood of fires, it cannot prevent them. Most fire safety requirements, therefore, have components of both life safety and property protection, although the amount of emphasis placed on each of these components varies.

General Principles

Fire Safety Features

The fire safety features in this Section can be broadly divided into six principal categories:

(1) Protecting the structural members to reduce the risk of premature collapse of a building, in order to give the occupants time to escape, and to allow firefighters a chance to extinguish the fire before the damage becomes too extensive. This is commonly referred to as structural fire protection (e.g., NBC Subsections 9.10.3. and 9.10.6.);

(2) Dividing the building into fire compartments (compartmentation), both to retard the spread of fires beyond their area of origin and to delay the onset of untenable conditions in other areas of the building during fire emergencies (e.g., NBC Subsections 9.10.8. and 9.10.9.);

(3) Controlling the rate of fire spread within a compartment by limiting the flame-spread properties of the lining materials. This allows additional time to evacuate the building and reduces the extent of fire involvement prior to the commencement of firefighting (e.g., NBC Subsections 9.10.12. and 9.10.13.);

(4) Controlling the spread of fire from one building to another by regulating the construction of the exterior walls and the openings in them relative to their distance from other buildings (e.g., NBC Subsections 9.10.14. and 9.10.15.);

(5) Providing an early warning of fire through automatic detection and alarm systems to give occupants a chance to escape while the fire is in its early stages (e.g., NBC Subsections 9.10.18. and 9.10.19.); and

(6) Providing access to the building for both firefighters and their equipment to reduce any delays in rescue and firefighting (e.g., NBC Subsection 9.10.20.).

Compartmentation

Compartmentation is the practice of dividing a building into fire compartments, either to confine fires to their areas of origin or to prevent them from reaching areas that must be kept tenable in a fire emergency. In NBC Part 9, compartmentation encompasses the requirements contained in the following Subsections:

- 9.10.9., Fire Separations and Smoke-tight Barriers between Rooms and Spaces within Buildings,
- 9.10.10., Service Rooms,
- 9.10.11., Firewalls,
- 9.10.12., Prevention of Fire Spread at Exterior Walls and between Storeys, and
- 9.10.13., Doors, Dampers and Other Closures in Fire Separations.

The construction of floors as rated fire separations, and the separation of major occupancies with higher occupant risks is the first major step in compartmentation.

Openings through most floor assemblies are required to be protected by shafts or other means to ensure that fire does not spread from floor to floor, unless other compensating measures are taken. These measures are described in NBC Subsection 3.2.8. For example, openings through floors might be necessary in an industrial building for conveyor belts or other equipment needed for manufacturing. In some uses, such as in parking garages, it is obviously impractical to create effective separations at each floor level. The use of escalators and moving walkways also presents difficulties in achieving effective fire separations at each floor level.

In apartment buildings with multi-level dwelling units, floors within the units do not have to be constructed as fire separations. If fire separations were required, stairs within the units would have to be protected with rated shafts and have self-closing doors at the top and bottom of each flight. Since dwelling units are relatively small and are required to be separated from other units, the interconnection of storeys within units is considered an acceptable risk (NBC Article 9.10.9.4.).

Although assemblies required to have a fire-resistance rating are generally required to be supported from below by members with a similar rating (NBC Article 9.10.8.3.), this does not apply to service rooms on the basis that the collapse of such rooms and spaces, which are not normally occupied, do not pose a hazard to persons. Since these compartments are intended to contain fire at the place of origin, and not to protect the contents from fires originating elsewhere, the floor construction is not required to be supported from below by members with a similar fire resistance (NBC Article 9.10.10.2.).

In other locations, the prime objective may not be to contain a hazard, but to protect the space from fires originating elsewhere. Public corridors and exit stairways, for instance, are required to be isolated by fire separations to prevent the entry of fire so that they will remain tenable while the building is being evacuated. This type of fire compartmentation has the objective of protecting the means of egress from a fire originating outside the space, as opposed to restricting fire spread from within the compartment. This is important to keep in mind when considering the wall and ceiling construction of the compartment.

Table 9.10.-A
Minimum Fire-Resistance Ratings for Fire Separations in Various Locations (NBC Subsections 9.10.9. and 9.10.10.)

Location	Minimum Fire-Resistance Rating of Fire Separation
Private residential parking garages	—
Parking garages for up to five cars	1 h
Parking garages for more than five cars	1.5 h
Repair garages	2 h
Individual residential suites (one level)	45 min
Individual residential suites (two or more levels)	1 h
Incinerator rooms	2 h
Fuel-fired furnace and boiler rooms	1 h(1)
Rooms for temporary storage of combustible refuse	1 h(2)
Public storage rooms in residential occupancies	1 h(2)
Other service rooms	1 h(3)
Public corridors	45 min(4)
Exits	45 min(5)

Notes to Table 9.10.A.:

(1) No fire separation is required if the equipment serves only one room or suite, or a building up to 400 m^2 (4 300 $ft.^2$) in building area and up to two storeys in height, if the equipment is designed to be unprotected. No fire separation is required if the equipment serves a house with a secondary suite and the equipment is located in a service room where the walls and floor between the service rooms and dwelling units are protected by a continuous smoke-tight barrier consisting of at least 12.7 mm (1/2 in.) gypsum board.

(2) Can be reduced to 45 min if the floor assembly is permitted to have a minimum fire-resistance rating of 45 min or if the storage room is sprinklered.

(3) No fire separation is required if the equipment creates no hazard or if the floor area is sprinklered.

(4) No fire separation is required in non-residential occupancies if the floor area is sprinklered.

(5) Must not be less than that required for the floor above the fire separation.

Dwelling units and most suites of other occupancy classifications are also required to be isolated as fire compartments. The objective is both to contain fire to its area of origin and to protect the space from fire occurring elsewhere. Because of their relatively low fire risks, suites of Group D (business and personal services) occupancy are not required to be fire separated. If a building is sprinklered, suites in Group E (mercantile) occupancies are also exempted, provided that the suites are served by public corridors more than 5 m (16 ft.) wide (NBC Articles 9.10.9.13. and 3.3.1.4.).

When dwelling units have more than one storey open to each other (including the basement), the resulting fire load is greater than that for single-level units. The fire resistance around multi-level units, therefore, is required to be greater than that for single-level units.

Experience has shown that some locations and activities in buildings are known to be more hazardous than others. They are therefore required to be separated from the remainder of the building by fire separations. Certain industrial uses, such as vehicle repair or parking, are considered to be sufficiently hazardous to be isolated by fire separations. Public storage areas in apartment buildings, incinerator rooms, furnace rooms, boiler rooms, garbage rooms, transformer rooms, and most other service rooms have a higher incidence of fires than other areas. They are also required to be isolated by fire compartments.

A summary of the minimum fire-resistance ratings for fire separations in various locations is provided in Table 9.10.-A.

9.10.1. Definitions and Application

9.10.1.1. Sloped Roofs

This Article defines at what angle a sloped roof is to be considered a wall in terms of its exposure to and from another building. The fire hazard posed when one building exposes another to heat radiation depends on the intensity of the radiation. This in turn depends on the angle that one surface makes with another, and with the maximum radiation occurring when the surfaces are parallel.

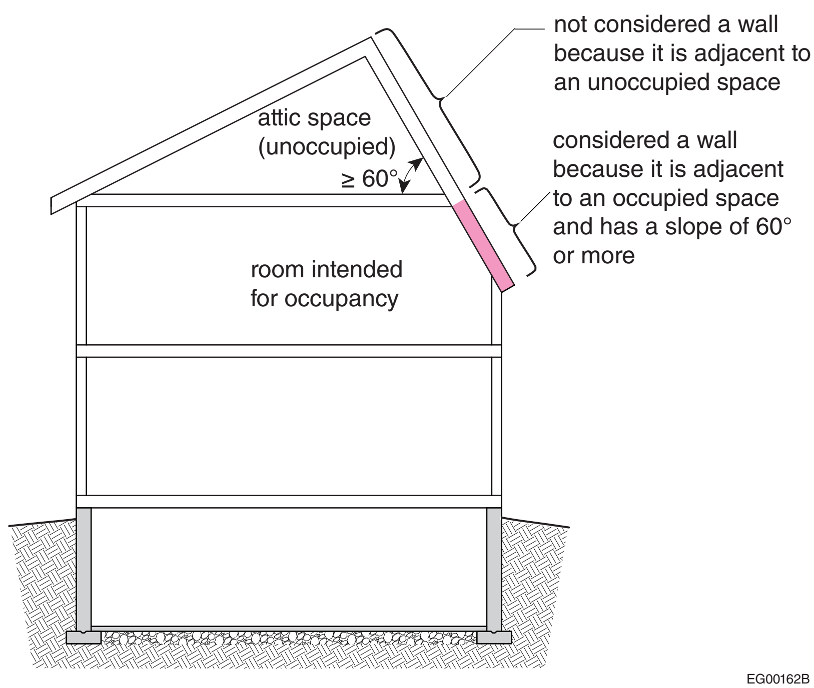


Figure 9.10.-1
Sloped roof considered as a wall

The steeper a roof, the greater the potential radiation to an opposing wall, with the maximum occurring when the roof surface approaches a vertical position. At an angle of 60° or more to the horizontal, the potential radiation hazard is considered to be sufficient for the roof surface to be considered as a wall for the purpose of establishing spatial separation, and determining the construction of the roof assembly (Figure 9.10.-1).

A roof with a slope of less than 60° to the horizontal is considered a roof, even if it is adjacent to a room or space intended for occupancy.

9.10.1.2. Testing of Integrated Fire Protection and Life Safety Systems

This Article states that, where life safety and fire protection systems and systems with fire protection and life safety functions are integrated with each other, they must be tested as a whole in accordance with CAN/ULC-S1001, "Integrated Systems Testing of Fire Protection and Life Safety Systems," to verify that they have been properly integrated.

Life safety and fire protection systems are often installed by more than one tradesperson. For example, one tradesperson may install a door hold-open device whose actuation depends on a fire alarm system installed by another tradesperson. All required life safety and fire protection systems must be tested during the integrated systems testing of the building to ensure the proper operation and integration of the systems.

9.10.1.3. Items under Part 3 Jurisdiction

This Article indicates those aspects of fire protection that are covered under NBC Part 3. NBC Section 9.10. is an abridgment of the requirements therein. The requirements are not as extensive as are those in NBC Part 3, due to the size and occupancy limits of NBC Part 9.

A number of design features regulated in other Parts of the NBC are not commonly used in Part 9 buildings. These are cross-referenced, rather than duplicated in NBC Part 9. NBC Part 3, for example, regulates fire protection requirements for commercial cooking equipment and roof-mounted, fuel-fired equipment. In the event that these are used in Part 9 buildings, the requirements in NBC Part 3 are referenced.

Similarly, other requirements included in NBC Part 3 are generally not associated with the prescriptive type of requirements that apply to buildings covered in NBC Part 9 and are also only referenced. These include requirements for:
- tents and air-supported structures,
- transformer vaults,
- walkways between buildings,
- elevators and escalators,
- rooms or spaces intended for hazardous or explosive materials,
- fuel dispensing,
- service shafts and chutes,
- sprinkler and standpipe systems,
- fire alarm and detection equipment,
- noncombustible construction,
- firewalls,
- fire dampers, and
- fire pumps.

Building occupancies regulated in NBC Part 9 are based on major occupancy classifications as discussed in Guide 9.1.1., Application. They can have subsidiary occupancies that differ from the principal occupancies. Where a subsidiary occupancy is used for assembly or high-hazard industrial uses—occupancies not covered in NBC Part 9—that subsidiary occupancy is regulated in NBC Part 3 (NBC Subsections 3.3.2. and 3.3.5.) even though the major occupancy falls within the scope of NBC Part 9.

Buildings incorporating more than one level of basement, or that have a basement area in excess of 600 m^2 (6 450 $ft.^2$), require special safety features not covered in NBC Part 9. These are also cross-referenced to NBC Part 3 (NBC Article 3.2.2.15. and NBC Subsection 3.2.1.).

The fire protection requirements in NBC Section 9.10. have only limited application to detached houses. NBC users interested only in detached houses should note the specific requirements summarized in Table 9.10.-B.

Table 9.10.-B
Fire Protection Requirements for Detached Houses

Subject	NBC Reference
Fire resistance of exterior walls (for houses within 1.2 m (3 ft. 11 in.) of property line)	9.10.1.1., Sloped Roofs; 9.10.3.1., Fire-Resistance and Fire-Protection Ratings; 9.10.3.3., Fire Exposure; 9.10.15.4., Glazed Openings in Exposing Building Face; and 9.10.15.5., Construction of Exposing Building Face of Houses
Surface flame spread on walls and ceilings	9.10.3.2., Flame-Spread Ratings; 9.10.17.1., Flame-Spread Rating of Interior Surfaces; 9.10.17.10., Protection of Foamed Plastics; and 9.10.17.11., Walls and Ceilings in Bathrooms
Construction between houses and attached garages	9.10.9.16., Separation of Storage Garages; and 9.10.13.15., Doors between Garages and Dwelling Units
Spatial separations between houses	9.10.15., Spatial Separation Between Houses
Fire blocks in concealed spaces	9.10.16., Fire Blocks
Protection of foam insulation	9.10.17.10., Protection of Foamed Plastics
Smoke alarms	9.10.19., Smoke Alarms
Fire department access	9.10.20.3., Fire Department Access to Buildings

9.10.1.4. Items Under Part 6 Jurisdiction

This Article indicates those aspects of fire protection that are covered under NBC Part 6.

Commercial cooking equipment can generate large quantities of grease and smoke that must be ventilated to the exterior, usually by means of duct work. Such equipment can also be a source of accidental fires that can spread into the duct work to ignite grease deposits. The purpose of NBC Article 6.2.2.7. is, in the first place, to indicate that special provisions are needed to reduce potential hazards by means of appropriate design procedures; and second, to reduce the risk of damage to the building or adjacent property as a result of fire or explosion in a rooftop fuel-fired appliance.

9.10.2. Occupancy Classification

The risk to life and property in a building is dependent on the activities of the occupants. An occupancy classification system is used to group various activities together into similar risk groups for the purposes of simplifying the application of NBC requirements.

9.10.2.1. Occupancy Classification

This Article sets out the NBC Part 9 occupancy classifications. Also, see Guide 9.1.1.1., Application.

The term “major occupancy” designates the principal use of a building (or portion of a building), and includes subsidiary occupancies that complement the principal occupancy.

Buildings in which the occupants are at the same general level of risk are placed in the same major occupancy group. However, the effect of having different major occupancy classifications on the structural fire-protection levels for buildings that fall under NBC Part 9 is much less apparent than for those that fall under NBC Part 3, due to their limited building size and less critical occupancies.

Classifying a building according to its major occupancy is also used to broadly categorize its fire load potential (“fire load” designates the weight of combustible content per unit of floor area). This provides one of the significant parameters used in establishing the level of structural fire protection required. While fire loads can vary widely within an occupancy group, major occupancy designations provide an approximate means for establishing fire load divisions.

Every building that might qualify for design under NBC Part 9 is classified according to its major occupancy described in NBC Table 9.10.2.1. See Table 9.1.-B for further description of the parameters for design under NBC Part 9.

9.10.2.2. Custodial and Convalescent Homes

This Article defines the occupant limit for designing custodial and convalescent homes under NBC Part 9. Convalescent homes and children's convalescent homes would normally be classified under Group B, Division 3, which must conform to the requirements of NBC Part 3.

Smaller facilities where the occupants are ambulatory and live as a single housekeeping unit, and where there are sleeping accommodations for not more than 10 persons, can be constructed as residential occupancies under NBC Part 9. Where the number of occupants is very limited, the activities within the home resemble the type of activities that would be carried out in a dwelling unit in a residential occupancy, and the occupants would be subject to a risk similar to that of a family in a dwelling unit.

9.10.2.3. Major Occupancies above Other Major Occupancies

This Article establishes the fire protection requirements for buildings where major occupancies are located above other major occupancies. These requirements are intended to provide sufficient structural stability under fire conditions to permit total evacuation, and to give firefighters a chance to extinguish a fire before a building is destroyed. Since both evacuation time and the difficulty in firefighting increase with storey height, the fire-resistance rating must take into account the total building height, and not the height of each major occupancy component.

If a building contains more than one major occupancy located above another, the structural fire protection requirements for each major occupancy are the same as if the entire building contained that occupancy. The floor-ceiling construction separating different major occupancies is governed by the occupancy below, since the floor is assumed to be exposed from that direction (NBC Article 9.10.8.3.).

Example 3 – Calculating the Minimum Fire-Resistance Ratings Required for Loadbearing Assemblies in a Three-Storey Building Containing Group D and E Major Occupancies

The top storey of a three-storey combustible building is classified as a Group D (business and personal services) major occupancy, and the bottom storeys are classified as a Group E (mercantile) major occupancy (Figure A). Find the minimum fire-resistance ratings required for the loadbearing building assemblies.

1. The minimum fire-resistance rating for the roof is the same as that required for the roof of a three-storey building of Group D major occupancy (NBC Article 9.10.2.3.), 45 min (NBC Table 9.10.8.1.).
2. The loadbearing walls of the third storey are required to have the same minimum fire-resistance rating as the roof they support (NBC Article 9.10.8.3.), 45 min.
3. The minimum fire-resistance rating for the floor assemblies on the second and third storeys is the same as that required the floor assemblies of a three-storey building of Group E major occupancy (NBC Article 9.10.2.3.), 45 min (NBC Table 9.10.8.1.).
4. The loadbearing walls of the first and second storeys are required to have the same minimum fire-resistance rating as the floor assemblies they support (NBC Article 9.10.8.3.), 45 min.

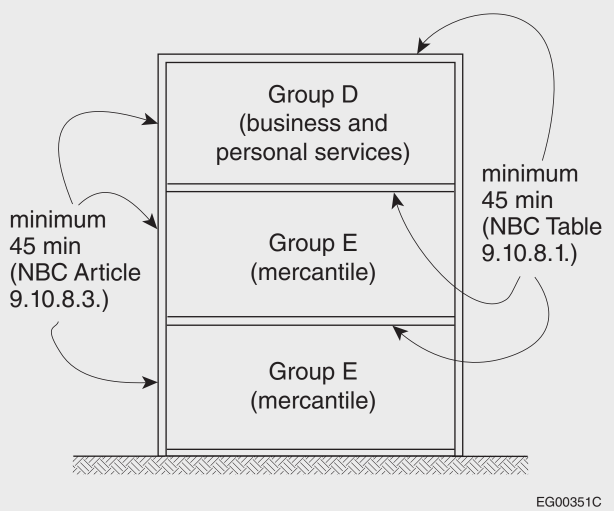


Figure A
Minimum fire-resistance ratings in a three-storey building containing Group D and E major occupancies

9.10.2.4. Buildings Containing More than One Major Occupancy

This Article establishes the fire protection requirements for buildings with more than one major occupancy.

If different major occupancies are located on the same storey, the level of structural fire protection for that storey is determined on the basis of the more restrictive one, again assuming that the entire building is of that occupancy. A major occupancy that constitutes less than 10% of the floor area can be ignored, unless it is classified under the category of medium-hazard industrial. It is important to know that certain uses, due to their inherent fire risk either external or internal to the use, are required to be compartmented. Residential suites (NBC Article 9.10.9.14.), storage garages (NBC Article 9.10.9.16.) and repair garages (NBC Article 9.10.9.17.) are examples of occupancies that must be compartmented.

9.10.3. Ratings

9.10.3.1. Fire-Resistance and Fire-Protection Ratings

This Article references three methods for assigning a fire-resistance rating to a building assembly so that it will withstand the effects of fire for its rating period.

A number of tests have been developed to evaluate the performance of various building elements under fire conditions. The tests attempt to duplicate the conditions in real building fires. Walls are tested in a vertical position with fire exposure on one side. Floors and roofs are tested in a horizontal position with fire exposure from below. Columns are tested in a vertical position with fire exposure on all sides. All tests use the same temperatures, which are designed to mimic a rapidly developing fire.

On the basis of such tests, assemblies have been assigned fire-resistance ratings, which are usually expressed in hours or minutes. For a given rating, an assembly must be able to support its design load for the designated period, and the temperature on the unexposed side must not rise to a level that would ignite the combustible materials that may be in contact with it. The latter condition does not apply to columns.

To reduce the expense of testing generic construction systems, procedures for calculating fire resistance have been developed. These procedures are based on the analysis of hundreds of commercial tests, and are contained in NBC Appendix D. Results of these tests or extrapolations are provided in NBC Tables 9.10.3.1.-A and 9.10.3.1.-B, which list the fire-resistance ratings and sound transmission class (STC) ratings of numerous common wall, floor and roof assemblies.

Information about Tables 9.10.3.1.-A and 9.10.3.1.-B

While a large number of the assemblies listed were tested, the fire-resistance and STC ratings for others were extrapolated from the results of tests conducted on similar assemblies. Where there was enough confidence relative to the fire performance of an assembly, the fire-resistance ratings were assigned relative to the commonly used minimum ratings of 30 min, 45 min and 1 h, including a designation of "< 30 min" for assemblies that do not meet the minimum 30 min rating.

Where there was not enough comparative information on an assembly to assign to it a rating with confidence, its value in the tables has been left blank, indicating that its rating remains to be assessed through another means. Future work is planned to develop much of this additional information.

The tables are provided only for the convenience of NBC users and do not limit the number of assemblies permitted to those in the tables. Assemblies that are not listed or not given a rating in these tables are equally acceptable provided their fire-resistance and STC ratings can be demonstrated to meet the requirements either on the basis of tests referred to in NBC Article 9.10.3.1. and NBC Subsection 9.11.1. or by using the data in NBC Appendix D.

It should be noted that NBC Tables 9.10.3.1.-A and 9.10.3.1.-B are not based on the same assumptions as those used in Appendix D. Assemblies in NBC Tables 9.10.3.1.-A and 9.10.3.1.-B are described through their generic descriptions and variants, and include details given in the notes to the tables. Assumptions for Appendix D include different construction details that must be followed rigorously for the calculated ratings to be expected. These are two different methods of choosing assemblies that meet required fire ratings.

Similarly, the fact that an assembly is listed in these tables does not mean it automatically complies with NBC requirements. For example, a wall between a secondary suite and the primary dwelling unit of a house is required to have an STC rating of 43. Assembly S2b in Table 9.10.3.1.-A would meet this requirement. The same wall assembly would not comply with requirements for walls between two dwelling units that are not in a secondary suite, because this wall assembly requires a minimum STC rating of 50.

In addition, testing agencies such as Underwriters Laboratories of Canada (ULC) and Warnock Hersey publish lists of proprietary assemblies they have tested.

9.10.3.2. Flame-Spread Ratings

This Article provides two different acceptable methods to establish the fire spread on the surfaces of various building materials.

Flame-spread ratings are used to regulate the selection of interior wall and ceiling finishes to prevent the rapid spread of fire. See NBC Subsection 9.10.17.

9.10.3.3. Fire Exposure

This Article establishes the direction from which the rating of an assembly needs to reach the required value. In fires, horizontal assemblies can be exposed to much hotter temperatures on their bottom surfaces than on their top surfaces, because hot gases rise and are replaced at floor level by cooler air. Exterior walls can be exposed to much higher temperatures on their inside surface in the event of internal fire than those affecting their outside surface in the event of a fire in an adjacent building. Interior walls, on the other hand, can be exposed to equally severe temperatures from either direction and are therefore rated accordingly.

Exterior walls that are close enough to the property line to require them to be fire-rated must be rated for fires originating on the inside of the building. Interior walls are generally symmetrical, so that the fire-resistance rating will be the same, regardless of the side exposed to the fire. Exterior walls are generally not symmetrical, however, and may have a different rating depending on the side exposed to the fire. For NBC purposes, it is assumed that the exterior walls will only be exposed to fire from inside the building.

Floors and roofs are tested with fire exposure from below because fire spreads upward. The derived rating represents their resistance from that direction.

9.10.3.4. Suspended Ceiling Membranes

This Article is intended to prevent the premature failure of a suspended ceiling as a result of fire. The buoyancy of hot gases can lift unsecured ceiling panels that are intended to shield the structural members, thereby reducing the time they can withstand fire. Hold-down clips are required to minimize uplift.

9.10.4. Building Size Determination

Building size determination is an essential step towards determining whether a building can be designed under NBC Part 9. See Determination of Building Size in Guide 9.1.1.1., Application.

9.10.4.1. Mezzanines not Considered as Storeys

Mezzanines are attractive because they allow for a flexibility of design and can provide more value for the user. They can do this without increasing building height, so that the building is subject to less onerous requirements. However, mezzanines can also increase the risk to occupants because they can increase the travel distance to exits, they may delay the discovery of a fire, and they may subject occupants on the mezzanine to increased smoke hazards.

NBC Article 9.10.4.1. defines how mezzanines are taken into account in the determination of building size. Any intermediate floor level within a storey has the potential to increase the occupant load and the total fire load. Therefore, it can affect the safety of occupants.

Evacuation and firefighting operations are hampered as the number of storeys increases. This is due to the fire load on each floor level, and the fact that evacuation requires more time for vertical travel than for horizontal travel. Also, the occupants on one level are not aware of the conditions on another level. For these reasons, safety provisions are generally more stringent as the number of storeys increases. The additional fire and occupant loads for very small mezzanines are not large enough to be considered as additional storeys.

An enclosed mezzanine is not considered a storey if the area of the mezzanine does not exceed 10% of the area of the suite in which it is located, and if the aggregate area of all the mezzanines occupies less than 10% of the floor area of the buildings in which they are located.

Similarly, open mezzanines that are constructed so that it is possible to see what is happening above and below the mezzanine floors can be somewhat larger without being considered storeys. The aggregate area of all open mezzanines shall occupy not more than 40% of the floor area of the storey or the room (excluding stair and service shafts) where they are located, and the floor space above and below the mezzanine shall be open except for obstructions that are not more than 1 070 mm (42 in.) in height (see Figures 9.1.-6 and 9.1.-7).

The allowable 40% area of the mezzanine is based on the area of the open portion of the room, excluding the enclosed areas below the mezzanine.

Though mezzanines that can take up to 40% of the floor area are required to be open, some enclosed spaces are permitted; however, that space is limited to no more than 10% of the area of the room in which the mezzanine is located, and the walls must not block the view of the space below from the open portion. This means that it should be located along a full height wall at the back or sides of the open mezzanine (see Figures 9.1.-6 and 9.1.-7).

Although in some cases the space above a mezzanine can be excluded from the calculation of building height, any intermediate floor level within a storey that has storeys above effectively adds to the height of the uppermost storey and therefore has an effect on the safety of occupants in the uppermost storey.

The occupant load within the reference storey also increases in proportion to the area of a mezzanine. Mezzanines increase the occupant load and the fire load of the storey of which they are part, except in a residential occupancy if the mezzanine is not used for sleeping. For the purpose of determining occupant load, the areas of mezzanines that are not considered as storeys are added to the floor area of the storey on which they are located (Figure 9.10.-2). An increase in occupancy load has direct implications on the direction of door swing from suites, on the number of required exits from one-storey and two-storey buildings, on the required exit signs and on the installation of fire alarms.

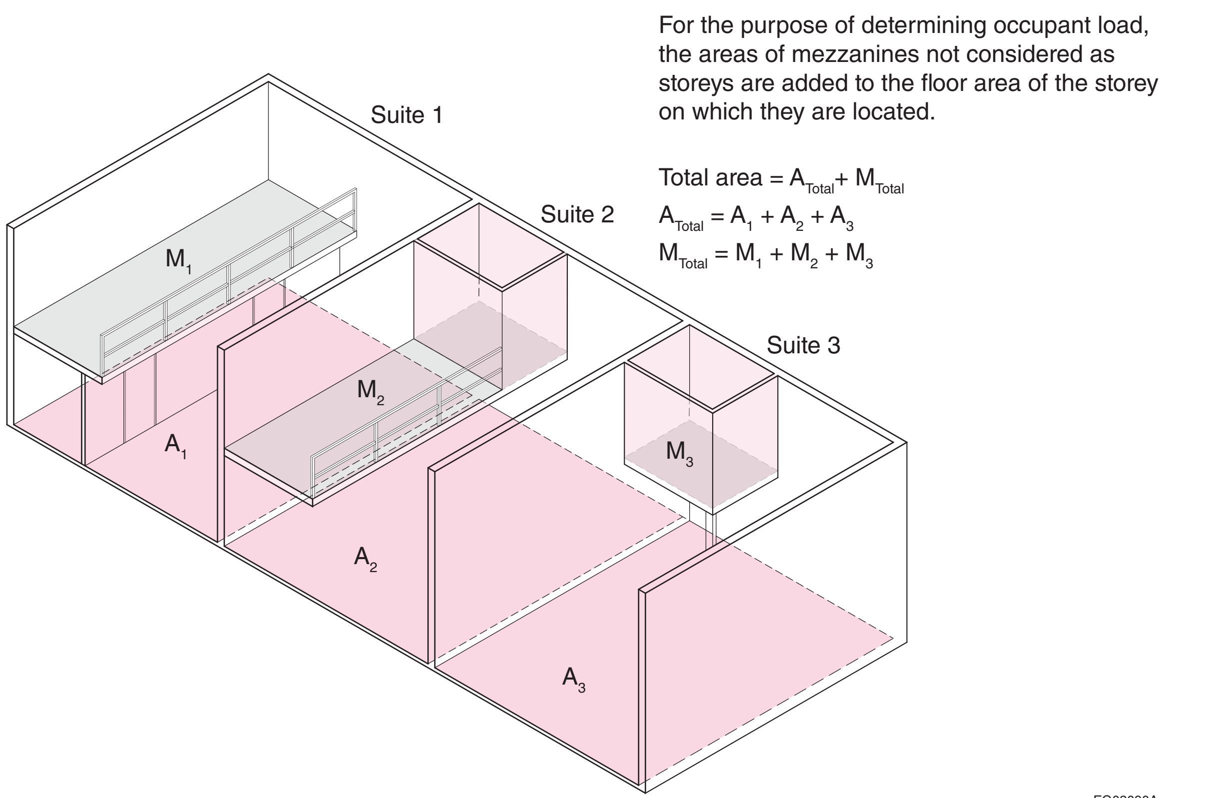


Figure 9.10.-2
Floor area for the purpose of determining occupant load, which includes the area of mezzanines not considered as storeys

9.10.4.2. More than One Level of Mezzanine

This Article defines how mezzanines are taken into account in the determination of building height when one mezzanine is above another. If mezzanines occupy more than one level, the vertical travel distance of the upper level(s) is increased, thereby increasing the time required for evacuation.

For this reason, each level of a mezzanine that is partly or wholly superimposed above the first level of a mezzanine needs to be considered as a storey when calculating the building height regardless of the area of the mezzanine (see Guide 9.1.1.1., Application, for further information on building size determination).

9.10.4.3. Basement Storage Garages

This Article describes the conditions under which a basement can be considered a separate building. If a basement parking garage is separated from the building above it, so that a complete burnout of the garage portion will have little effect on the rest of the building, then the buildings on either side of the separation may be considered as separate buildings, in much the same way as a firewall creates separate buildings. To keep fire from travelling around the edge of the horizontal separation, the enclosing walls of the garage above ground level must be constructed with the same degree of separation as that of the slab ceiling above the garage (see Figure 9.1.-8).

9.10.4.4. Roof-Top Enclosures

This Article describes the conditions under which roof-top enclosures are not considered an additional storey. The roof-top enclosures used for the protection of equipment and that allow access to a roof have no occupants, except for occasional visits by service personnel. In addition, the areas protected by such enclosures usually have very little fire load that would have an effect on the remainder of the building should a fire occur. Therefore, such structures are not considered to add to the height of a building.

9.10.5. Permitted Openings in Wall and Ceiling Membranes

NBC Subsection 9.10.5. addresses the penetrations through a single membrane of a fire-rated assembly. NBC Article 9.10.9.6. provides the requirements related to penetrations into or through fire separations, whether or not they are rated.

9.10.5.1. Permitted Openings in Wall and Ceiling Membranes

This Article indicates where and in what configuration openings are permitted in wall and ceiling membranes. If a wall or a floor depends on a membrane to achieve a certain fire rating, any opening through the membrane will allow hot gases to enter the concealed space and possibly cause a premature failure of the separation in the event of a fire.

A membrane, which is part of an assembly that is required to have a fire-resistance rating, should not be pierced by openings unless the assembly‘s performance has been tested and rated for given openings. An exception is provided for tightly fitted electrical and other service outlet boxes.

Ceiling openings are critical since their exposure in fire is more severe (due to the buoyancy of the hot combustion gases). Unless the rating for an assembly is based on tests in which the actual openings were incorporated in the test specimen, the openings in ceiling membranes should be restricted as shown in Figure 9.10.-3. NBC Appendix D contains rules for limiting such openings where the rating for the assembly is 1 h or less.

9.10.6. Construction Types

The NBC deals with three principal types of construction: combustible, which has little inherent fire resistance unless protected; heavy timber construction, which, although combustible, has a degree of resistance to structural failure when exposed to fire owing to the substantial dimensions required of its members; and, noncombustible construction. Even noncombustible construction may require protection to prevent its collapse when exposed to fire, because structural steel or reinforcing steel has its load carrying capacity reduced at elevated temperatures. The primary difference between combustible and noncombustible construction is that noncombustible materials do not burn, nor do they contribute fuel to a fire. Thus, a basic noncombustible structural frame, if adequately protected from the thermal effects of a fire, should remain in place throughout a fire and offer some degree of safety to occupants and firefighters. However, the combustible components permitted in noncombustible construction do burn and contribute fuel to a fire.

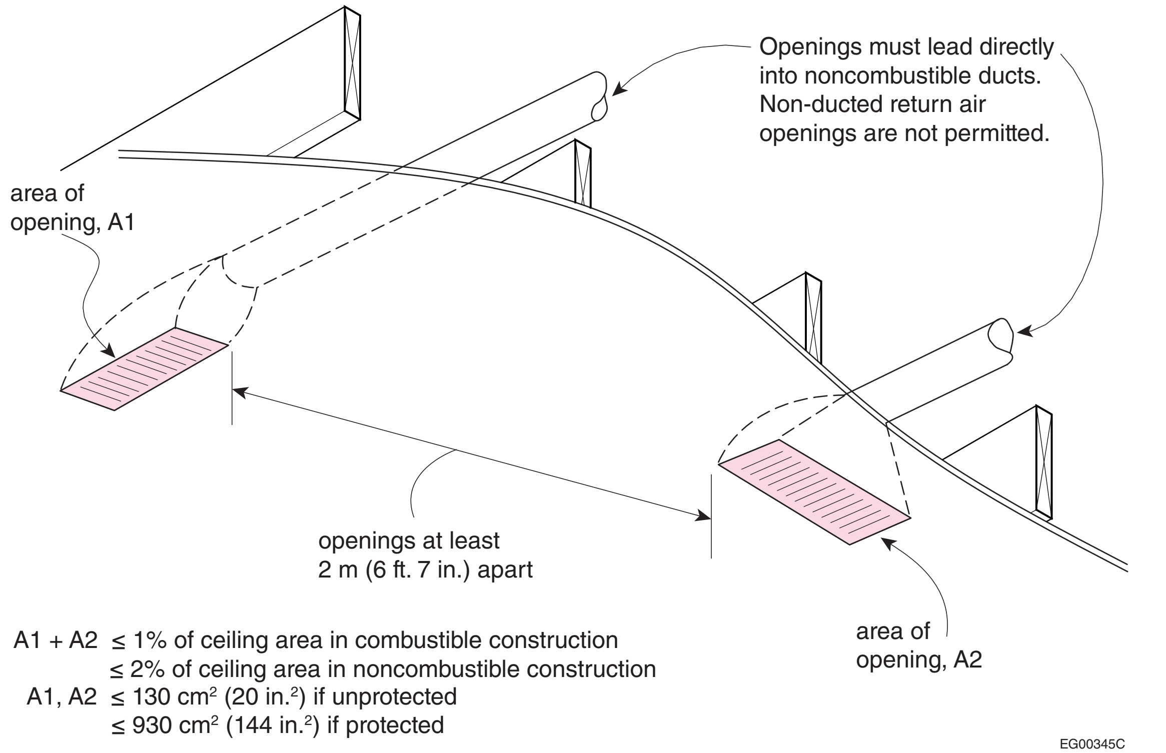


Figure 9.10.-3
Opening limits into ceiling membranes with a fire-resistance rating

9.10.6.1. Combustible Elements in Noncombustible Construction

This Article indicates where combustible elements can be used in noncombustible construction. Although the NBC recognizes several types of construction in establishing the maximum height and area limits for buildings or occupancies, the basic division is between combustible and noncombustible construction. Combustible construction refers to the type of construction that does not meet the requirements for noncombustible construction. Noncombustible construction refers to the type of construction in which a degree of fire safety is attained by the use of noncombustible materials for structural members and other building assemblies.

The term "noncombustible," applied to a material, means that the material will pass the test for non-combustibility as defined in CAN/ULC-S114, "Test for Determination of Non-Combustibility in Building Materials." This standard constitutes a test, which a material either passes or fails, but this result does not constitute the sole criterion for judging the acceptability of a building material. Other criteria may include the melting point temperature and the ability to remain in place when exposed to fire.

Noncombustible construction is used to reduce the probability of fire spreading within a storey during the time required to achieve occupant safety, or for emergency responders to perform their duties. Although certain combustible elements, such as finishing material and other items not directly involved in the load carrying systems, are permitted for practical reasons, they are limited in quantity and in many cases their rate of consumption in fire is controlled by restricting their flame-spread rating. The purpose is to reduce the extent of damage that can occur before firefighting can be undertaken. While generally limited to buildings beyond the scope of NBC Part 9, noncombustible construction is required for critical elements such as firewalls and exterior walls that are close to a property line.

Combustible elements used in construction that is required to be noncombustible must conform to NBC Subsection 3.1.5.

Noncombustible construction generally requires professional design, and is also regulated in NBC Part 3 (NBC Subsection 3.1.5.) and NBC Part 4 (NBC Subsections 4.3.2. to 4.3.6.). Essentially, noncombustible construction consists of noncombustible loadbearing members with limitations placed on the quantities and flame-spread characteristics of combustible materials that may be used with these members. Noncombustible construction may or may not be required to have a fire-resistance rating. This depends on the size and occupancy of the building. Buildings covered by NBC Part 9 are not required to be of noncombustible construction by virtue of their small size and limited occupancy classifications. Where a building is built close to the property line, however, the exterior wall may be required to be of noncombustible construction. Except between unstacked row housing, walls located on property lines are required to be firewalls. (Firewalls are walls of masonry or concrete construction that must conform to NBC Subsection 3.1.10., referenced from NBC Article 9.10.11.3.)

The most common combustible construction uses 38 mm thick (1 1/2 in. nominal) framing members spaced 400 to 600 mm (16 to 24 in.) apart, protected, where necessary, with gypsum board or lath and plaster membranes (once used extensively and still acceptable) to achieve the required fire resistance. In some cases, other materials such as plywood are used where the finish may be subject to rough handling, such as in moveable buildings.

9.10.6.2. Heavy Timber Construction

This Article establishes the conditions, as set out in NBC Article 3.1.4.7., under which this type of construction is considered to have a 45 min fire-resistance rating. This is achieved by establishing the minimum sizes for columns and beams, as well as the minimum thicknesses for floor and roof components.

Heavy timber construction is another form of combustible construction, and is considered to have certain advantages over traditional wood-frame construction in terms of fire performance. The structural members are much larger in cross-section, making them more fire resistant and less likely to ignite.

Furthermore, heavy timber construction does not have as many concealed spaces that can make a fire difficult to detect. Based on performance, heavy timber construction is assumed to have a fire-resistance rating of 45 min, although it actually varies depending on the member size and the jointing details. This type of construction requires professional design, and is regulated under NBC Part 3 (NBC Article 3.1.4.6.) and NBC Part 4 (NBC Subsection 4.3.1.).

9.10.7. Steel Members

9.10.7.1. Protection of Steel Members

This Article indicates that steel members used in construction required to have a fire-resistance rating must be protected to enable them to have a required fire-resistance rating. Structural steel loses strength at higher temperatures. To maintain its strength in fire conditions it must be protected by other materials such as gypsum, concrete or masonry.

There are, however, some exceptions to this rule, which are given in NBC Article 3.2.2.3. Some steel members such as short-span lintels and steel members for stairways that are not part of the structural frame of a building are exempt from these requirements.

9.10.8. Fire Resistance and Combustibility in Relation to Occupancy, Height and Supported Elements

The requirements that pertain to a building's resistance to premature collapse in a fire are sometimes referred to as structural fire protection measures. These affect the entire building and are not to be confused with requirements to establish fire compartments. Structural fire protection requirements specify the types of construction permitted, as well as the level of fire resistance required.

9.10.8.1. Fire-Resistance Ratings for Floors and Roofs

This Article contains the requirements for the structural stability of floor and roof assemblies to allow sufficient time for occupants to escape in the event of a fire, and to permit firefighting to commence before excessive fire damage occurs.

The fire-resistance ratings are listed in NBC Table 9.10.8.1. The risk of a roof collapsing in a fire is generally considered to be less critical than that of a floor. Unoccupied roofs of combustible construction are not required to have a fire-resistance rating; however, where a roof or portion of a roof supports an occupancy, that portion must be constructed as a fire separation and have a minimum 45 min fire-resistance rating.

9.10.8.2. Fire-Resistance Ratings in Sprinklered Buildings

Sprinkler systems have proven to be effective in detecting and suppressing fires in their early stages. Thus, they permit more time for occupants to evacuate, and give firefighters added opportunity to extinguish a growing fire with less risk of roof collapse.

This Article indicates the conditions under which fire-resistance ratings for roof assemblies, which are provided in NBC Table 9.10.8.1., may be waived in buildings with sprinkler systems that are electrically supervised, and where the operation of the sprinkler system is transmitted to the fire department.

9.10.8.3. Fire-Resistance Ratings for Walls, Columns and Arches

This Article indicates the conditions under which walls, loadbearing columns and arches are required to have a fire-resistance rating. Floors and roofs are rated assuming that fire exposure from below is the most critical condition. Unless the supporting structures have at least the same fire-resistance rating, the assembly may collapse before its required rating period has been reached.

Where a floor or a roof is required to have a fire-resistance rating, the walls, columns and beams that support that floor or roof are required to have at least the same rating as the floor assembly. This ensures that, should a fire originate in the storey below, the supports for the floor will survive as long as the floor itself.

In the case of a separation between a secondary suite and the main dwelling unit, the fire separation requirement is waived because it is too onerous, and the risk is comparatively low. In this case, a smoke-tight barrier is required, which means that the separating elements (light-frame walls, columns, arches, and beams, including loadbearing steel elements) that support floors between units in a house with a secondary suite (including their common spaces) need to be protected by gypsum board at least 12.7 mm (1/2 in.) thick. This includes loadbearing steel elements, but not heavy timber elements, masonry or concrete construction.

9.10.8.4. Support of Noncombustible Construction

This Article ensures that the fire resistance of noncombustible construction is not compromised by fire that originates in constructions below them. In cases where noncombustible construction and a fire-resistance rating are required, those constructions must be supported by noncombustible construction.

9.10.8.5. Service Rooms

This Article waives the requirement that an assembly immediately below a service room be fire-resistance rated, because service room compartments are intended to contain fires to their place of origin. They do not need to be protected from fire originating elsewhere. The floor construction is, therefore, not required to be supported from below by members with a similar fire resistance.

9.10.8.6. Mezzanines

This Article requires that mezzanines required to be counted as storeys in NBC Articles 9.10.4.1. and 9.10.4.2. have a minimum fire-resistance rating as set out for “Floors Except Floors over Crawl Spaces” in NBC Table 9.10.8.1.

Mezzanines of combustible construction are generally required to have the same minimum fire-resistance rating as that required for other floor assemblies, 45 min (Figure 9.10.-4). However, no minimum fire-resistance rating is required for mezzanines not required to be counted as storeys in non-residential buildings of two storeys or less in height.

9.10.8.7. Roofs Supporting an Occupancy

This Article requires that roofs supporting an occupancy have a fire-resistance rating that conforms to the specifications set out in NBC Table 9.10.8.1.

Some flat roofs are designed to support an occupancy, and must therefore remain intact for sufficient time to permit evacuation. Roofs with no occupancy, however, have no such need. (See NBC Articles 9.10.4.4. and 9.10.8.1.)

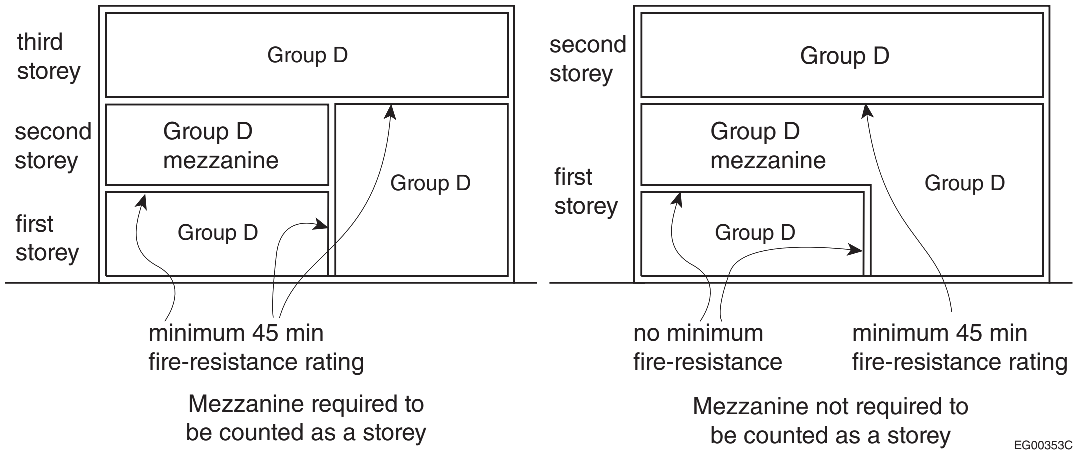


Figure 9.10.-4
Minimum fire-resistance ratings for mezzanines (NBC Articles 9.10.8.1., 9.10.8.6. and 9.10.12.1.)

9.10.8.8. Floors of Exterior Passageways

This Article ensures that exit passageways remain intact for sufficient time to permit complete evacuation by having a floor assembly with a fire-resistance rating of at least 45 min, or be of noncombustible construction.

A fire-resistance rating is not required for the floors of exterior passageways serving:
- a house with a secondary suite, or
- a single dwelling unit where no suite is located above or below the dwelling unit (see also NBC Sentence 9.9.9.3.(2)).

However, if one suite is located above another in a house with a secondary suite, a second means of egress is required from the upper suite if egress relies on a passageway that does not have a floor with a at least a 45 min fire-resistance rating (NBC Article 9.9.9.3.).

9.10.8.9. Crawl Spaces

This Article clarifies the conditions under which a floor over a crawl space is required to have a fire-resistance rating.

Although combustible floor systems are generally required to have a 45 min fire-resistance rating, those over crawl spaces may not (see NBC Table 9.10.8.1.), because the risk of a fire originating in unoccupied spaces is considered to be too remote to justify such a requirement. Should a crawl space be intended for occupancy, be high enough to encourage occupancy (more than 1.8 m (5 ft. 11 in.)), or contain flue pipes or other potential fire sources, the floor above it would have to have the same level of protection as other floors.

9.10.8.10. Application to Houses

This Article clarifies the applicability of NBC Table 9.10.8.1. to dwelling units and houses with a secondary suite.

The fire-resistance rating requirements for floors and roofs that are provided in NBC Table 9.10.8.1. do not apply to:
- a dwelling unit that has no other dwelling unit above or below it,
- a house with a secondary suite, where the floor framing is protected on the underside by a continuous, smoke-tight barrier of not less than 12.7 mm (1/2 in.) thick gypsum board, or
- a dwelling unit that is not above or below another major occupancy.

Detached, semi-detached and row housing are not required to have structural fire protection, although certain assemblies may require a fire-resistance rating for other purposes. These exceptions are discussed in Guide 9.10., Introduction, under the heading Compartmentation, and Guide 9.10.14., Introduction, under the heading General Information for Spatial Separation.

9.10.8.11. Part 3 as an Alternative

This Article states that the fire-resistance ratings for structural elements may be designed in accordance with NBC Part 3 instead of NBC Subsection 9.10.8.

9.10.9. Fire Separations and Smoke-tight Barriers between Rooms and Spaces within Buildings

Fire separation is defined as a construction assembly that acts as a barrier against the spread of fire with materials that will deter the passage of smoke and hot gases for a specified period of time (NBC Section 1.4. of Division A). By providing a physical barrier against fire spread, fire separations can create fire compartments, both to contain fire hazards, and to keep certain areas tenable in the event of fire (see Guide 9.10., Introduction, under the heading Compartmentation). Fire separations may or may not have fire ratings, and they can be constructed with combustible materials.

While the concept of a fire separation is simple, many complicating factors can interfere with the effectiveness of fire separations. Access through them must be provided by doorways, stairways, elevators and escalators. Ducts, piping and wiring must be installed to make buildings functional. All of these operations can create openings or damage the integrity of fire separations. This necessitates requirements to limit the degree to which the separation can be compromised, or to outline the steps that must be taken to reduce the effect of any opening through the separation. Every opening or gap in a fire separation needs to be protected with a closure (a special device or mechanism which blocks an opening, such as a door, wired glass or a rolling shutter), or be fire blocked with fire-resistant materials.

Although fire separations are normally required to have a fire-resistance rating, there are a few instances where a rating is not required. Even though a fire separation does not always have to have a fire-resistance rating, it always needs to act as a barrier to the spread of smoke and fire until some response is initiated. For example, if the fire-resistance rating of a fire separation is waived due to the presence of an automatic sprinkler system, the fire separation still needs to be constructed so that it will remain in place and act as a barrier against the spread of smoke for a period of time until the sprinklers have actuated and controlled the fire.

Another example is the case of noncombustible floor assemblies that do not need to be protected or rated when used in certain small buildings. They are considered to have enough inherent or nominal resistance to fire to ensure the safety of occupants where evacuation can take place quickly. In this case, life safety can be achieved without having to provide additional protection for the floor assemblies.

It should also be noted that a fire separation is not necessarily a firewall (NBC Subsection 9.10.11.).

9.10.9.1. Application

This Article explains that NBC Subsection 9.10.9. applies to:
(a) fire separations required between rooms and spaces in buildings, and
(b) smoke-tight barriers required in houses with a secondary suite (including common spaces).

The requirements for separating the suites of houses with a secondary suite were developed to strike a balance between safety, compliance and cost. One of the trade-offs was the acceptance of a smoke-tight barrier between dwelling units in lieu of a fire separation.

9.10.9.2. Continuous Barrier

This Article requires that fire separations and smoke-tight barriers be continuous in order to contain a hazard or keep egress routes tenable, as well as restrict the passage of smoke and fire for a reasonable time. There are some exceptions. For example, where a wall has an opening that is protected by a closure, that wall is exempted from the requirement for continuity. All other wall or floor assemblies that are required to have a fire separation rating are also required to provide a continuous barrier against the spread of fire. This Article clarifies that the continuity of the fire separation or smoke tight-barrier also needs to be maintained where floor, ceiling, roof or exterior wall fire separations or smoke-tight barrier abut.

It is very important that there is a complete seal with a noncombustible material between the top of the wall and the underside of the roof sheathing to prevent the passage of smoke or flame across the fire separation. The same applies to any part of the fire separation.

The continuity of a smoke-tight barrier at junctions must be maintained by filling all openings at the juncture of the assemblies with a material that will ensure the continuity of the smoke-tight barrier at that location.

All gypsum board joints in assemblies that are required to be a fire separation or a smoke-tight barrier must conform to CSA A82.31-M, "Gypsum Board Application," and their penetrations must be sealed to maintain the integrity of the smoke-tight barrier over the entire surface.

9.10.9.3. Openings to be Protected with Closures

This Article indicates how necessary openings in fire separations that are intended to provide access for people or for the installation of services must be protected or otherwise maintain the integrity of the separation.

Except as permitted in NBC Articles 9.10.9.5., 9.10.9.6. and 9.10.9.7., any opening in a required fire separation needs to be protected by closures as set out in NBC Subsection 9.10.13.

Doors in smoke-tight barriers need to be at least 45 mm (1 3/4 in.) thick, solid core wood doors and have a self-closing device. Such doors are deemed to provide at least a 20 min fire-protection rating, which is considered to be an acceptable level of protection for a house with a secondary suite. Unlike the solid core doors for required fire separations, the doors for smoke-tight barriers do not need to be labelled as complying with CAN/ULC-S113, "Wood Core Doors Meeting the Performance Required by CAN/ULC-S104 for Twenty Minute Fire Rated Closure Assemblies."

9.10.9.4. Floor Assemblies

This Article sets out in which cases floor assemblies are required to be constructed as fire separations. Floor assemblies that are required to be fire separations will limit the potential size of a fire by isolating it to the storey of origin, and will restrict the movement of smoke in order to limit the amount of fire damage that occurs before firefighting commences. It will also facilitate the evacuation of occupants from the unaffected storeys.

Where more than one storey is involved in a fire, the fire load on each fire floor will complement the fire load on others, thus increasing the severity of the fire. This not only increases the risk of structural collapse, but also increases the difficulty of evacuating the building and extinguishing the fire. Floors, therefore, are generally required to be constructed as fire separations, although alternative or compensating safety measures described in NBC Subsection 3.2.8. can be used.

There are several significant exceptions to the general requirement for floor separation. Floors in dwelling units and within houses with a secondary suite are not required to be fire separations. Dwelling units and small bi-level suites in Group D (business and personal services) or E (mercantile) occupancies are permitted to have open stairs under certain conditions. Such suites are fairly small, and are fire separated from other suites (NBC Articles 9.9.4.7. and 9.10.9.4.).

Floors above crawl spaces are not required to be a fire separation as long as the ceiling height is not high enough for it to be used as a basement (not more than 1.8 m (5 ft. 10 in.)), used for any occupancy, used as plenum in combustible construction nor used for the passage of flue pipes (NBC Article 9.10.8.9.).

9.10.9.5. Interconnected Floor Spaces

This Article requires that the design of interconnected floor spaces be carried out in accordance with NBC Subsection 3.2.8.

Mezzanines and other openings are often provided to increase the usefulness or attractiveness of a building space, thereby creating interconnected floor spaces.

An interconnected floor space is one in which two or more storeys of a building are open to each other, and the opening is neither enclosed nor protected in the usual manner. Interconnected floor space also occurs in buildings whose floor areas are connected by open stairs and ramps, escalators and conveyors.

When this is done, compensating measures are required to maintain the appropriate levels of safety. Since interconnected floor spaces are more common in larger buildings, such compensating measures are described in NBC Subsection 3.2.8.

9.10.9.6. Penetration of Fire Separations

This Article provides the requirements for penetrations into or through fire separations, whether or not they are rated, while NBC Subsection 9.10.5. addresses penetrations through a single membrane of a fire-rated assembly.

Where an assembly relies on a protective membrane to provide its required fire resistance (such as in typical wood-frame construction), the rating depends on the continuity of the membrane. Where electrical outlet boxes, air diffusers, recessed cabinets or other facilities penetrate the membrane, such openings can reduce the overall fire resistance of the assembly by allowing more heat into the cavity behind the protecting membrane. Limited sized openings, such as those for electrical wall outlets, can be tolerated if they are tightly fitted and do not coincide with openings on the other side of the assembly.

Piping, conduits, ducts, wiring and chimneys that penetrate a fire separation can reduce its effectiveness if they are installed with appreciable gaps that would allow fire to spread across the separation. Such gaps must be fire stopped with fire-resisting material.

Combustible electrical and plumbing services can also decrease the effectiveness of fire separations, and are restricted unless test evidence is provided to show that the rating can be achieved. Generally, only limited amounts of electrical wiring (up to 25 mm (1 in.) in diameter) or standard-size plastic outlet boxes (up to 160 mm^2 (1/4 $in.^2$)) can be used without such test data.

The exceptions for outlet boxes are based on the size, quantity, and concentration of partial depth penetrations that would not significantly affect the fire resistance of an assembly. The exception is not intended to allow large electrical distribution and control boxes to be recessed into an assembly that is required to have a fire-resistance rating unless they were incorporated into the assembly at the time of testing.

9.10.9.7. Combustible Drain, Waste and Vent Piping

The requirements in this Article are intended to ensure the integrity of fire separations by limiting the penetrations of combustible drain, waste and vent piping through them.

Plastic drain, waste and vent piping is uniquely problematic because the piping is open to the atmosphere at the top of the system. In cold weather the system operates under negative pressure to create a chimney-like draft. Should fire occur in a fire compartment where the piping is exposed, it could enter the piping and be sucked across the separation into an adjacent fire compartment.

With few exceptions, therefore, plastic drain, waste and vent piping is not permitted where any part of the system penetrates or is concealed in a fire separation (Figure 9.10.-5). The following uses of such piping, however, are permitted:

- where a noncombustible toilet on a concrete floor slab (not a concrete topping) is served by a plastic drain pipe, and the slab is part of a floor/ceiling assembly that is required to have a fire-resistance rating, the piping can penetrate the assembly, including a ceiling membrane that contributes to the fire-resistance rating,
- on one side of a vertical fire separation, provided it is not within a shaft, and
- on one side of a horizontal fire separation in a building with two dwelling units, one above the other (an up and down duplex).

Plastic drain, waste and vent piping, or combustible water distribution piping can be used in a system penetrating a fire separation when the pipe is surrounded at the point of penetration by a suitably rated fire block system (usually tested to the ULC standard CAN/ULC-S115, “Fire Tests of Fire Stop Systems”). These are devices that expand when exposed to the heat of a fire and squeeze the pipe closed so that flames and smoke can no longer pass through. These devices are not commonly available for wood-frame construction, but there is no technical reason why this approach could not be used.

When plastic water piping penetrates a fire separation, it does not present as serious a risk as drain, waste and vent piping. Since the piping is filled with water, substantial heat is required to cause it to fail, and such failure would be accompanied by the release of water to counter the fire effects. Such piping is therefore unrestricted in sizes up to 30 mm (1 3/16 in.) provided it does not penetrate a horizontal fire separation, and in the case of sprinkler piping, all sizes can be used if the compartments on both sides of the separation are sprinklered.

Combustible piping could be installed above a ceiling with a fire-resistance rating intended to protect a roof structure, without necessitating that the attic have a sprinkler system, provided that the required NFPA standard does not require the sprinklering of this combustible blind space. In most cases, NFPA 13R, “Installation of Sprinkler Systems in Low-Rise Residential Occupancies,” and NFPA 13D, “Installation of

Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes," will not require these spaces to be sprinklered.

Central vacuum systems, such as those used in hotels and motels, pose a particular problem where the piping penetrates a fire separation. Not only is there a potential for fire to be sucked across the separation, but the collecting bin provides a ready-made fuel source. For this reason, the piping system has the same restrictions on fire separation penetration as drain, waste and vent piping. In addition, central vacuum systems cannot serve more than one suite (NBC Article 9.10.9.19.) and must be designed to shut down when the fire alarm is activated (NBC Article 9.10.18.7.).

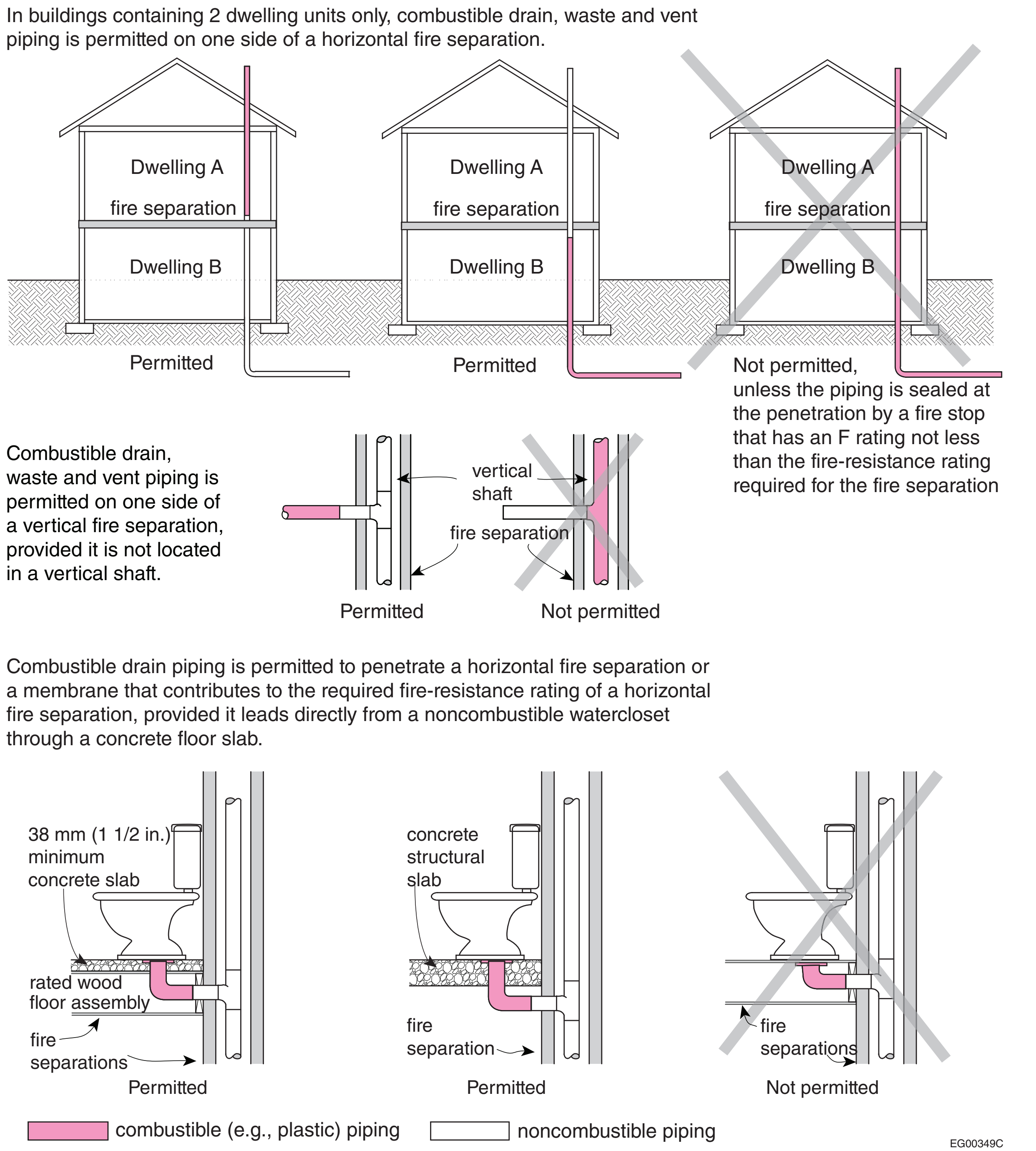


Figure 9.10.-5
Restrictions on the penetration of fire separations by combustible drain, waste and vent piping

9.10.9.8. Collapse of Combustible Construction

This Article ensures that the potential collapse of combustible construction connected to a fire separation will not lead to the collapse of the noncombustible fire separation.

Combustible roof-framing or floor-framing members supported on a masonry or concrete wall can cause an eccentric loading on the wall if the floor should collapse, and could also cause the wall to collapse. Such members are therefore required to be cut or attached with connectors so that they will disengage easily to prevent the failure of the fire separation.

Similarly, a firewall (NBC Subsection 9.10.11.) must be designed to remain standing if the structure on either side of it collapses. Firecuts made on joists framing into such walls are intended to allow the collapse of floor systems without pulling down the wall assembly (Figure 9.10.-6).

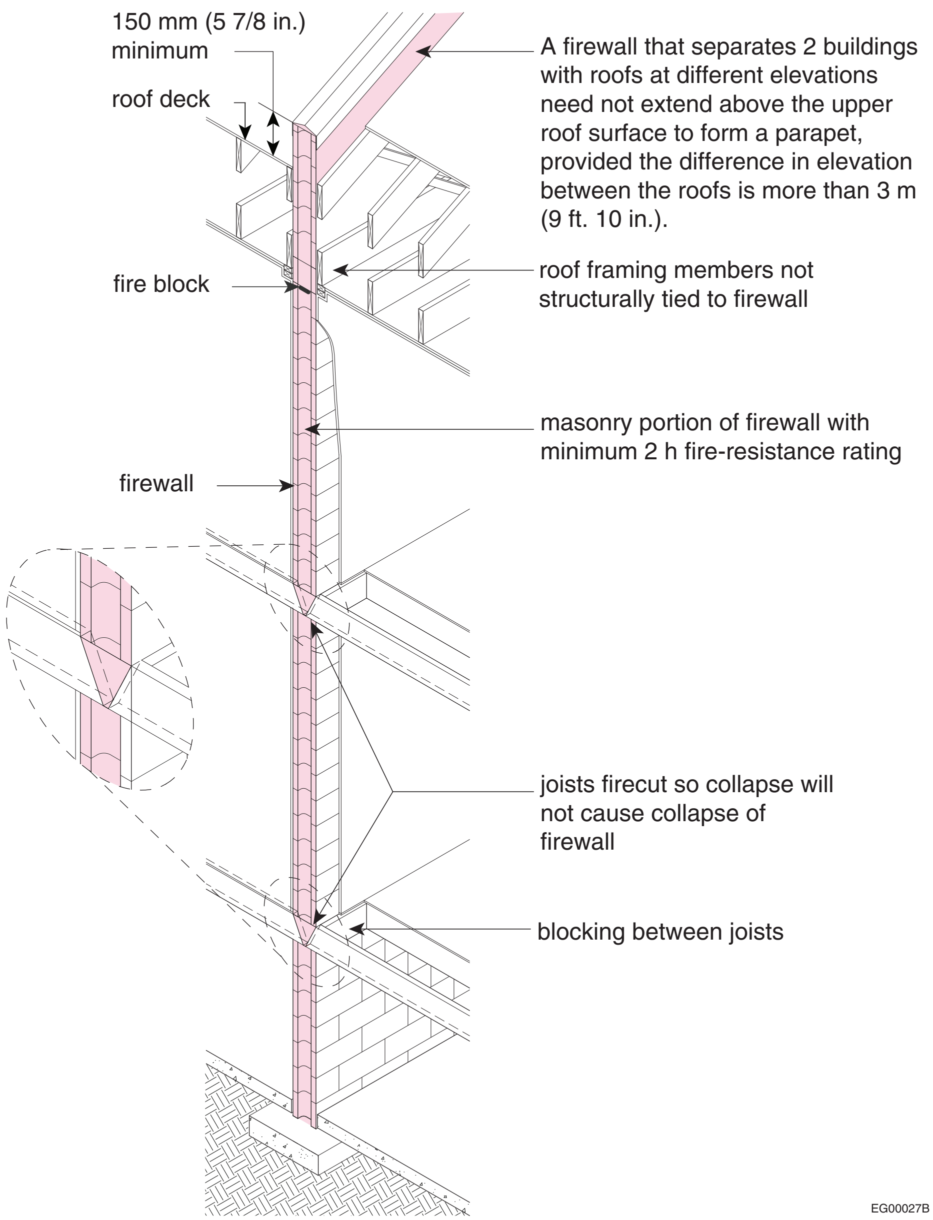


Figure 9.10.-6
Firewall construction

9.10.9.9. Reduction in Thickness of Fire Separation by Beams and Joists

This Article ensures that pockets in a masonry or concrete fire separation for supporting joists and beams do not compromise the integrity of the fire separation.

The thickness of the fire separation must not be reduced to less than needed to maintain the required fire-resistance rating (Figure 9.10.-7).

The remaining concrete or masonry left between the ends of the beams or joists cannot be less than the values for Type S monolithic concrete in NBC Table D-2.1.1. For example, for a monolithic concrete wall required to provide a 1 h fire-resistance rating, the joists would need to be separated with 90 mm (3 1/2 in.) thick concrete. In the case of hollow-core masonry walls, it may be necessary to fill the cores with grout to maintain the fire-resistance rating.

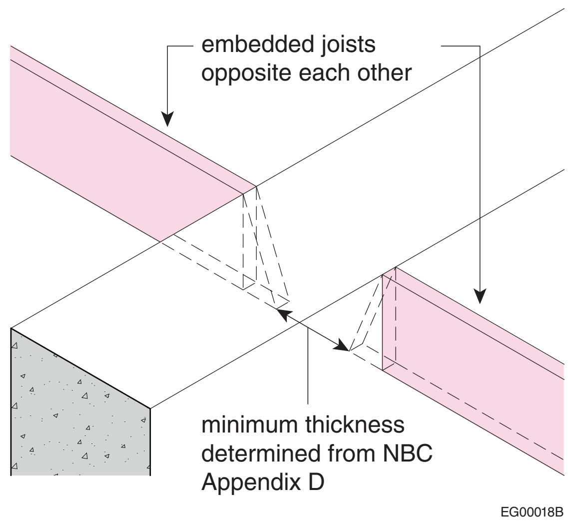


Figure 9.10.-7
Thickness of fire separation at pockets for the support of beams or joists

9.10.9.10. Concealed Spaces above Fire Separations

This Article requires the extension of fire separations into concealed spaces to prevent them from allowing fire to bypass the fire separation below.

The integrity of a fire compartment can be compromised if an attic or other similar space extends across the top of the separation. A fire on one side of the separation or within the concealed space can penetrate the ceiling and enter the adjacent compartment from above. Therefore, fire separations must be continuous through such spaces to complete the compartmentation, or the ceiling membrane on each side of the separation must have sufficient fire resistance to maintain the effectiveness of the compartmentation. Figure 9.10.-8 shows a fire separation that might be used to separate two entities such as an office space and a service space. For separating dwelling units, the fire separation must extend up to the roof.

Where the compartments on either side of the separation are on separate properties, the required fire separation must extend up through the concealed space as required in NBC Subsection 9.10.11., regardless of the ceiling construction. The vertical separations that enclose a shaft are also required to penetrate such concealed spaces.

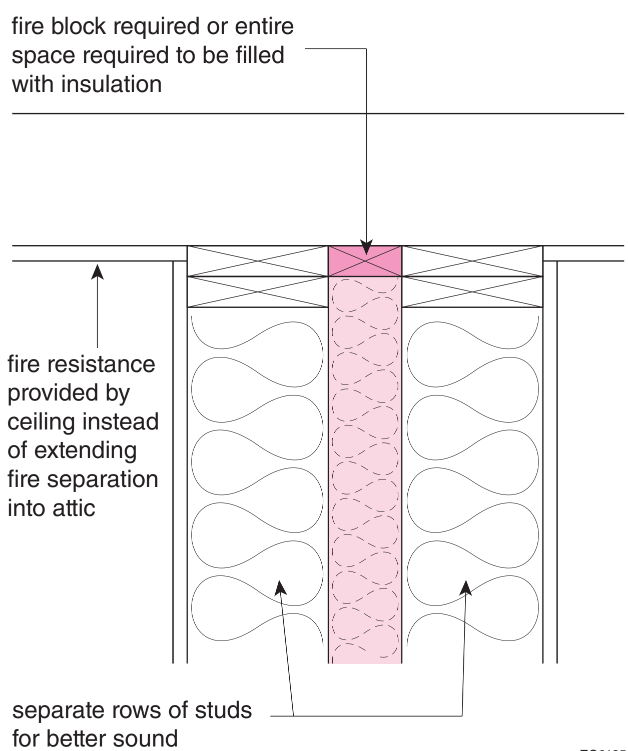


Figure 9.10.-8
Vertical fire separation ending at the ceiling that separates two entities other than dwelling units

9.10.9.11. Separation of Residential Occupancies

This Article describes the fire separations required between residential and other occupancies because a residential suite in a building with other major occupancies is exposed to risks from the activities of those occupancies. A fire separation can isolate the residential portion from such risks.

Major occupancies classified as mercantile or medium hazard industrial are considered to have substantially higher fire loads than others, and must be separated from residential occupancies by a higher rated fire separation (2 h). When only one or two dwelling units are involved, however, this rating can be reduced (1 h). Figures 9.10.-9 and 9.10.-10 show the extension of the fire separations to the roof for wood-frame and masonry construction.

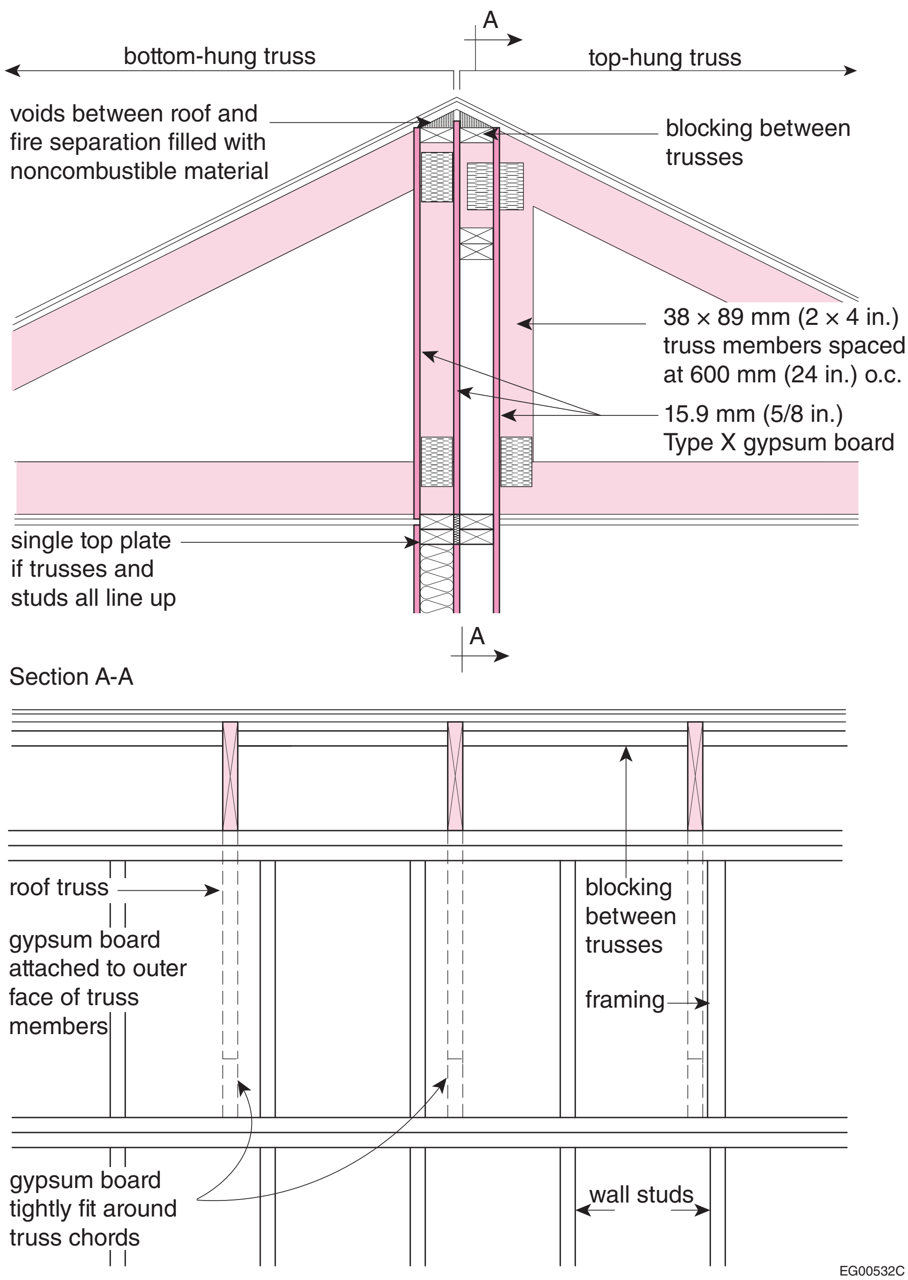


Figure 9.10.-9
Roof fire separation between two dwelling units: wood-frame construction

Major occupancies of Group D (business and personal services) or Group F, Division 3 (low hazard industrial) are assumed to have a lower fire load and present less risk to an adjacent residential occupancy. The separation for these from residential occupancies can also be reduced (1 h).

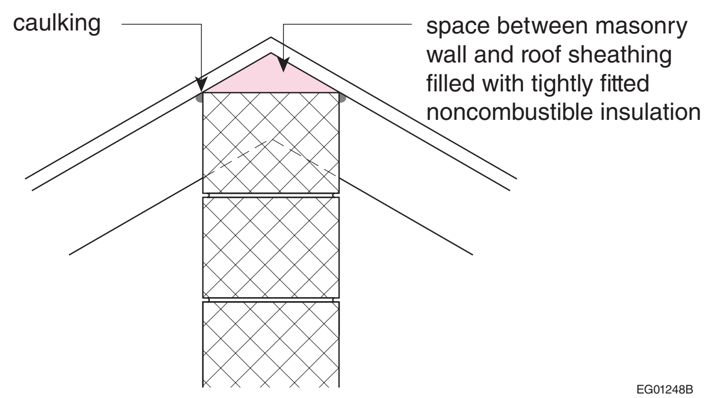


Figure 9.10.-10
Roof fire separation between two dwelling units: masonry construction

Example 4 – Calculating the Minimum Fire-Resistance Ratings Required for Loadbearing Assemblies in a Three-Storey Building Containing Group C and E Major Occupancies

The top storey of a three-storey combustible building is classified as a Group C (residential) major occupancy and contains four dwelling units (Figure A). The bottom storeys are classified as a Group E (mercantile) major occupancy. Find the minimum fire-resistance ratings required for the loadbearing building assemblies.

1. The minimum fire-resistance rating of the roof is the same as that required for the roof of a three-storey building of Group C major occupancy (NBC Article 9.10.2.3.). Therefore, the roof has no minimum fire-resistance rating (NBC Table 9.10.8.1.).
2. The loadbearing walls of the third storey are required to have the same minimum fire-resistance rating as the roof they support (NBC Article 9.10.8.3.) and, therefore, have no minimum fire-resistance rating.
3. The floor assembly on the third storey, which separates a residential major occupancy from a mercantile major occupancy, is required to have a minimum fire-resistance rating of 2 h since there are more than two dwelling units in the building (NBC Article 9.10.9.11.).

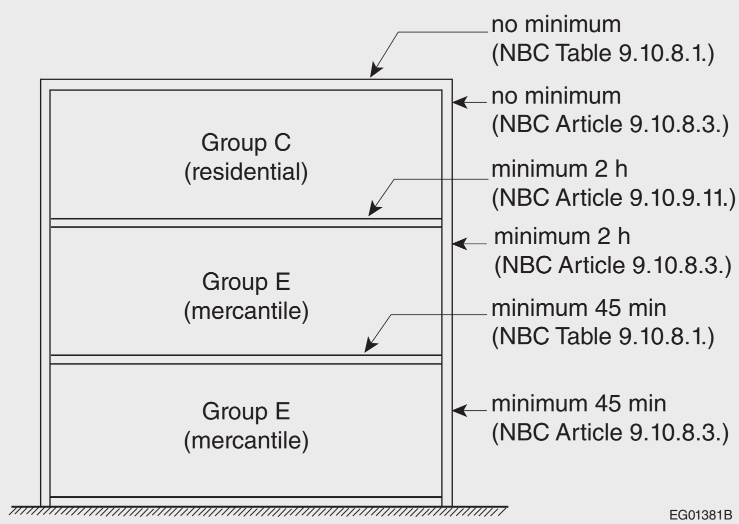


Figure A
Minimum fire-resistance ratings in a three-storey building containing Group C and E major occupancies

4. The loadbearing walls of the second storey are required to have the same minimum fire-resistance rating as the floor assembly they support (NBC Article 9.10.8.3.), 2 h.
5. The minimum fire-resistance rating for the floor assembly on the second storey is the same as that required for the floor assemblies of a three-storey building of Group E major occupancy (NBC Article 9.10.2.3.), 45 min (NBC Table 9.10.8.1.).
6. The loadbearing walls of the first storey are required to have the same minimum fire-resistance rating as the floor assembly they support (NBC Article 9.10.8.3.), 45 min.

Example 5 – Calculating the Minimum Fire-Resistance Ratings Required for Assemblies in a Two-Storey Building Containing Group C, D and F Major Occupancies

About half of the top storey of a two-storey building consists of office area classified as a Group D (business and personal services) major occupancy, and the remainder is a dwelling unit classified as a Group C (residential) major occupancy (Figure A). The bottom storey is a repair garage classified as a Group F, Division 2 (medium-hazard industrial) occupancy. Find the minimum fire-resistance ratings required for the building assemblies.

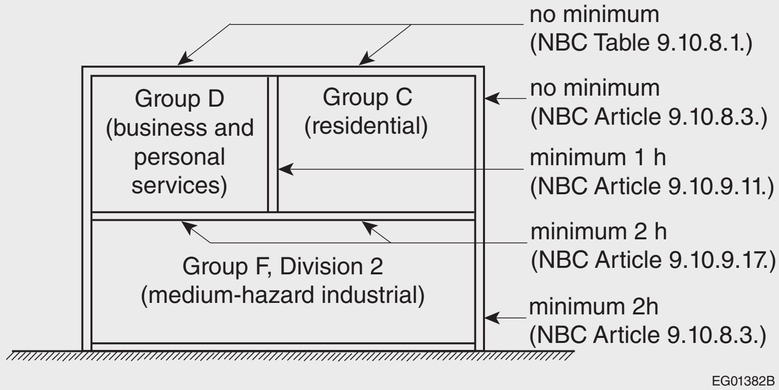


Figure A
Minimum fire-resistance ratings in a two-storey building containing Group C, D and F major occupancies

1. The top storey can be considered as either a Group C or Group D major occupancy for the purpose of NBC Article 9.10.2.3. since the requirements in NBC Table 9.10.8.1. are the same for both major occupancies. (If the requirements differed, the more restrictive requirement would be applied.) Accordingly, the minimum fire-resistance rating for the roof is the same as that required for the roof of a two-storey building of Group C (or Group D) major occupancy (NBC Article 9.10.2.3.). Therefore, the roof has no minimum fire-resistance rating (NBC Table 9.10.8.1.).
2. The loadbearing walls of the second floor are required to have the same minimum fire-resistance rating as the roof they support (NBC Article 9.10.8.3.) and, therefore, have no minimum fire-resistance rating.
3. The walls between the dwelling unit and the office area, which separate a residential major occupancy from a business and personal services major occupancy, are required to have a minimum fire-resistance rating of 1 h (NBC Article 9.10.9.11.).
4. The floor assembly on the second storey, which separates the dwelling unit and the office space from the repair garage, is required to have a minimum fire-resistance rating of 2 h (NBC Article 9.10.9.17.).
5. The loadbearing walls of the first storey are required to have the same fire-resistance rating as the floor assembly they support (NBC Article 9.10.8.3.), 2 h.

9.10.9.12. Residential Suites in Industrial Buildings

This Article limits the number of residential suites and, therefore, the number of occupants who can be exposed to the fire risks caused by medium-hazard industrial occupancies.

No more than one suite of residential occupancy is permitted in a building whose major occupancy is classified as Group F, Division 2.

9.10.9.13. Separation of Suites

This Article intends to ensure the protection of one suite against the spread of fire from another. Where a building is subdivided into suites (i.e., rental units), each presents a fire risk to others. These risks can be reduced by 45 min fire separations. Business and personal service occupancies, however, have such a low fire risk that such separations are not needed to protect one from another. In a building served by wide (mall-type) corridors, the risk that mercantile occupancies pose to one another or to business and personal service occupancies can be reduced by the use of sprinklers to eliminate the need for such separations (see Figure A in Example 4 and Figure A in Example 5).

9.10.9.14. Separation of Residential Suites

The requirements contained in this Article intend to isolate a fire that originates in one residential suite, thereby reducing the risk to life or property in adjacent suites or rooms. Fire separations contain a fire to a portion of a building to allow the safe evacuation of the building, and to allow firefighting to begin before the fire spreads. Storeys of multi-level suites are generally open to each other so that all levels can contribute to the fire load. Therefore, a higher fire resistance is necessary to isolate a fire in a multi-level suite than is required in a single-level suite.

As shown in Guide 9.10. Table 9.10.-A, dwelling units are required to be separated from each other (and from other parts of the building) by a 45 min fire separation if the dwelling unit contains one storey, and by a 1 h fire-separation if the dwelling unit contains two storeys or more, including basements. Most dwelling units in semi-detached and row houses, therefore, have to have at least a 1 h fire separation. This is also the case for attached bungalows, since most contain a basement storey.

Walls and floor-ceiling assemblies that separate suites from each other or dwelling units from ancillary spaces and common spaces in a house with a secondary suite are not required to be fire separations with fire-resistance ratings, if they provide a continuous, smoke-tight barrier comprised of gypsum board at least 12.7 mm (1/2 in.) thick installed on both sides of walls and the underside of the ceiling.

Although walls that separate adjacent properties are generally required to be firewalls, those that separate unstacked dwelling units are not. This applies to subdivided properties. It does not apply to suites that are regulated by strata title or condominium legislation. This type of building is considered to be of shared ownership.

Problems of interpretation sometimes arise concerning the requirement that dwelling units and other residential suites be protected by fire compartments. A suite, by definition, is a room or series of rooms under a single tenancy. A dwelling unit, therefore, is a suite, as is a hotel guest room. There is no specified size limit for a dwelling unit, however, and in some residential buildings, such as dormitories, very large areas are sometimes claimed to be dwelling units. Since the sleeping areas within dwelling units are unprotected from each other or from other activities, this can jeopardize the safety of the occupants unless all areas are under the same type of supervision as would occur in a normal household. Therefore, a dwelling unit should be interpreted as a household unit within its traditional meaning if unsafe conditions are to be avoided.

If dwelling units have been converted to boarding or lodging houses, however, each bedroom can be considered as a separate suite, since it is under a separate tenancy. It is considered to be unduly restrictive to require individual separations around each bedroom in the case of small units. Therefore, in a boarding house with eight or fewer boarders, the sleeping rooms do not need to be separated from the rest of the house or from each other, provided that the proprietor lives in the unit (and thereby exercises a similar type of control as a head of household), and that the rooms do not contain cooking equipment, since this might create a fire hazard. These types of uses include small bed and breakfast businesses.

9.10.9.15. Separation of Public Corridors

This Article contains requirements for public corridors, which serve as routes of escape from suites to exit facilities, to remain tenable in the event of a fire for a time sufficient to allow all suites to be evacuated. The fire separation between a corridor and adjacent suites or rooms is primarily intended to protect the corridor; however, it also protects suite occupants until rescue can be carried out.

If a storey is sprinklered, sprinklers will usually control the fire at an early stage. In such cases, the magnitude of the fire-resistance rating is less important, particularly in occupancies where everyone is awake, and evacuation can be carried out quickly. Narrow corridors can become smoke logged very quickly, however, and must be able to resist the entry of smoke by being constructed as a fire separation.

In general, corridors in residential occupancies are required to be separated from the remainder of the building by a fire separation having not less than a 45 min fire-resistance rating.

A public corridor in a house with a secondary suite does not need to be separated from the rest of a building by a fire separation if a continuous, smoke-tight barrier of at least 12.7 mm (1/2 in.) thick gypsum board is installed on both sides of the corridor walls and the underside of the floor-ceiling framing that separates the corridor from the remainder of the building.

9.10.9.16. Separation of Storage Garages

This Article requires that storage (parking) garages, where automobiles can initiate fires as a result of faulty electrical connections, and provide a source of volatile fuel in addition to their combustible components, be separated from the rest of a building. The risk of ignition, although low for individual cars, increases as the number of cars in a garage increases. In the case of private garages that serve individual dwelling units, the risk is insufficient to warrant the garage portion being isolated by a rated fire separation, although measures are necessary to confine fumes and gases to the garage. Where parking garages serve more than one dwelling unit or other occupancies, the risk of fire is greater and a rated separation is necessary to isolate the potential fire hazard to protect adjacent occupancies. Since more than one automobile can be involved in the same fire, this separation is increased when six or more cars are parked.

Where a private garage interconnects with the dwelling it serves, it is considered to be part of the unit and is not required to be in a separate fire compartment, but it is required to be a barrier to the passage of exhaust gases and gasoline vapours (NBC Subsection 9.25.3.). Because fire separations are not necessarily airtight, airtight measures are required, regardless of whether a fire separation is required. In addition, every door between a garage and a building needs to be tight-fitting, weatherstripped and have a self-closing device to restrict the passage of gases and exhaust fumes (NBC Article 9.10.13.15.).

Where a garage is open to the adjacent attic space above the dwelling unit it serves, a gas-tight barrier in the ceiling of a dwelling unit will also provide protection. Unit masonry walls forming the separation between a dwelling unit and an adjacent garage should be provided with two coats of sealer or plaster, or covered with gypsum board on the side of the wall exposed to the garage. All joints must be sealed to ensure continuity of the barrier.

Precautions must also be taken in designing the warm air supply outlets for heated garages to prevent the entry of exhaust and gasoline fumes into the living areas. These must not be connected to the house duct system (NBC Article 9.33.4.9.).

9.10.9.17. Separation of Repair Garages

The requirements in this Article intend to provide adequate fire separation between repair garages and other occupancies. Repair garages represent a greater potential fire hazard than parking garages by virtue of the repair activities associated with them, and the amount and nature of products found therein. A higher level of fire resistance is therefore needed for fire separations to isolate such hazards from other activities unrelated to the repair garage. This is intended to allow time to evacuate adjoining occupancies and restrict the spread of fire until firefighting can start.

A repair garage must be separated from other occupancies by a fire separation with a fire-resistance rating of at least 2 h. The fire resistance can be reduced to 1 h for a one-storey building that is a mercantile occupancy, operated as a single unit. Where a repair garage contains a dwelling unit, the fire separation must also be a smoke-tight barrier.

9.10.9.18. Exhaust Ducts Serving More than One Fire Compartment

This Article requires that ducts serving more than one fire compartment remain in negative pressure so that the likelihood of fire spread from one fire compartment to another via exhaust ducts is reduced. If more than one branch duct has an individual fan that exhausts air into a common duct in a shaft, the common duct will become pressurized, and any duct whose fan ceases to operate will have a reverse flow of air from the common duct. In the event of a fire, this could cause smoke or hot gases to circulate from duct to duct. Placing the exhaust fan near the top of the common duct puts the entire duct under negative pressure. Air from all branch ducts will therefore flow into the common duct, thereby keeping smoke and fire from spreading from unit to unit.

9.10.9.19. Central Vacuum Systems

This Article requires central vacuum systems to be limited to a single suite to minimize the risk of fire spreading from one suite to another via a central vacuum system.

9.10.10. Service Rooms

9.10.10.1. Application

This Article states that NBC Subsection 9.10.10. applies to all service rooms in all buildings except service rooms in dwelling units. An exemption for dwelling units from the requirement for the isolation of service rooms is permitted due to the cost and inconvenience of such a requirement relative to the modest fire risk.

Typical examples of service rooms include boiler rooms, furnace rooms, incinerator rooms, garbage handling rooms and rooms to accommodate air-conditioning or heating appliances, pumps, compressors and electrical equipment. Rooms such as elevator machine rooms and common laundry rooms are not considered to be service rooms.

9.10.10.2. Service Room Floors

This Article exempts floors immediately below service rooms from having a fire-resistance rating. Service rooms are required to be separated by fire-resistant construction from the remainder of a building to confine a fire originating in a service room to that room. The purpose is not to protect the service room from the rest of the building; therefore, the floor below the service room is not required to have a fire-resistance rating.

9.10.10.3. Separation of Service Rooms

This Article states the value of the fire-resistance rating required for the fire separation between a service room and the remainder of the building. Service rooms with equipment that create a fire risk are isolated by appropriate fire separations to keep fire from spreading before the building can be evacuated and firefighting can start. However, if there is no equipment to create a fire hazard, or if the storey is sprinklered, a fire separation is not necessary given the reduced risk of fire spread.

9.10.10.4. Location of Fuel-Fired Appliances

This Article identifies the types of fuel-fired appliances that are required to be housed in service rooms separated from the rest of a building. Fuel-fired appliances are a potential fire source and can expose a building to fire risk unless they are located in service rooms isolated from the remainder of the building by appropriate fire separations. These separations will permit the remainder of the building to be evacuated in the event of a fire and allow firefighting to start before it can spread to other parts of the building. However, certain small capacity appliances, and appliances designed for use outside of a service room, have a low fire risk, making fire separations unnecessary.

Fuel-fired appliances (not fireplaces or cooking appliances) must be located in a service room that is separated from the remainder of the building by a fire separation having a fire-resistance rating of at least 1 h. Fuel-fired space-heating appliances, space-cooling appliances, service water heaters and laundry appliances do not need to be separated from the remainder of the building if the appliances serve only one suite, or serve a building with a building area not more than 400 m^2 (4 306 $ft.^2$), and a building height of not more than two storeys.

Where the appliances serve a house with a secondary suite (including their common spaces), a fire separation with a fire-resistance rating is not required where both sides of all wall assemblies and the underside of all floor and ceiling framing separating the appliance room from both dwelling units or their common spaces are protected by a continuous, smoke-tight barrier consisting of at least 12.7 mm (1/2 in.) thick gypsum board.

9.10.10.5. Incinerators

This Article requires that incinerators and garbage fuel supply be isolated from a building by using various construction and connection specifications. The risk is sufficiently high to justify separating this operation from the remainder of a building with a 2 h fire separation to confine the fire until the building is evacuated and firefighting can start. Other fuel-fired appliances not related to the incineration operation can compound the fire risk by providing another ignition source, and must therefore be located elsewhere.

9.10.10.6. Storage Rooms

This Article sets the minimum fire-resistance rating for the walls of storage rooms to minimize the hazard posed by the live embers, which can be present in garbage. Public storage areas are also notorious as a source of fire in residential buildings because of vandalism and the unpredictable nature of the materials that are stored therein. Such areas are therefore isolated from the remainder of the building by fire separations to contain a fire until occupants have evacuated and firefighting can start. If the storage area is sprinklered, however, sprinklers may control the fire at an early stage and the fire separation does not have to be as great to contain the fire.

9.10.11. Firewalls

A basic fire safety principle is that events and activities on one property should not cause harm to another property. When a wall is built on a property line, therefore, it must be built in such a way that it will remain intact if a building on either side is completely destroyed.

A firewall is a particular type of fire separation that is of noncombustible construction and has a fire-resistance rating of at least 2 h.

A firewall may be constructed of materials other than masonry and concrete, provided that it requires no more than a 2 h fire-resistance rating, that the design conforms to NBC Part 4, and that the assembly is protected against damage that would compromise the integrity of the assembly. The fire-resistance rating and damage protection of a firewall may be provided by a fire and damage-resistant membrane on a structural frame, or by separate components (one that provides the fire-resistance rating, and another one that protects the firewall against damage).

Party walls on property lines are generally required to be firewalls, but continuous fire separations with at least a 1 h fire-resistance rating are permitted for row housing. Firewalls are also used to subdivide larger buildings into portions that, for the purpose of determining whether or not a building falls within the scope of NBC Part 9, may be considered as separate buildings. The requirements for the construction of firewalls are found in NBC Subsection 3.1.10. These include the requirement for connections and supports for structural framing members connected to or supported on a firewall to be designed in such a way as that the collapse of these framing members will not cause the collapse of the firewall.

In the types of buildings covered by the NBC, walls that separate dwelling units within a building need not be constructed as firewalls, even if they separate two properties. However, walls between units must be constructed as rated fire separations. Figure 9.10.-11 illustrates the essential differences between firewalls and ordinary fire separations between dwelling units.

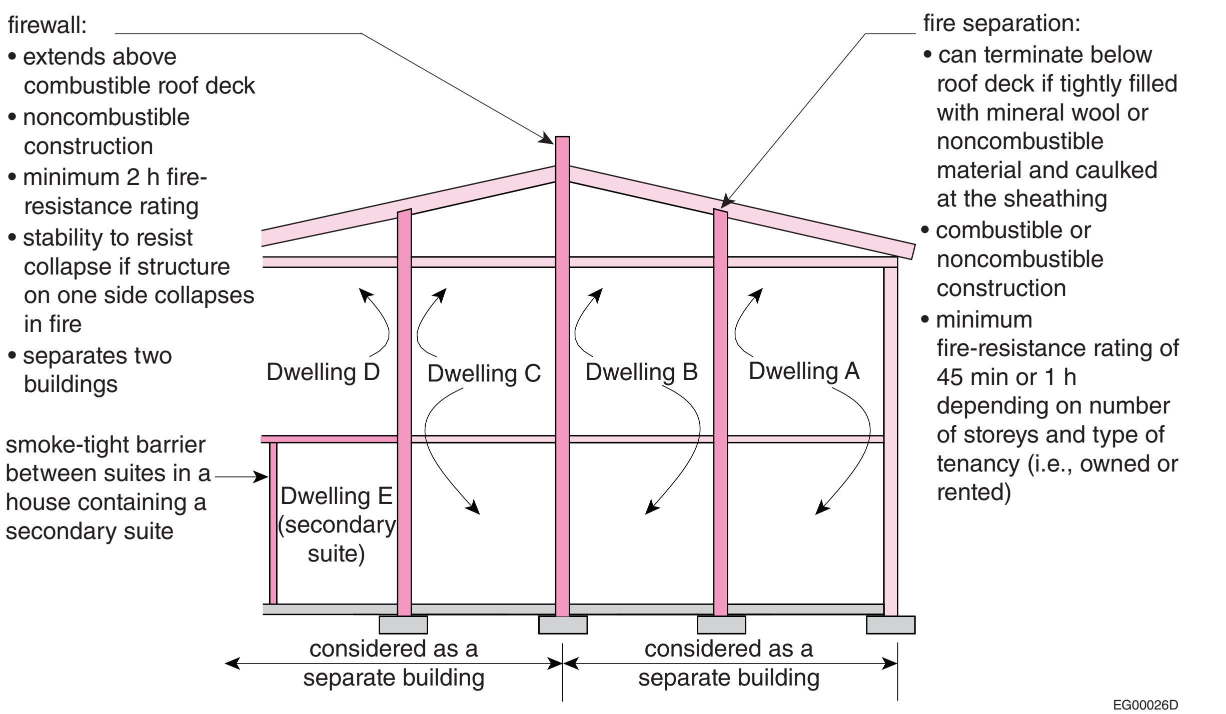


Figure 9.10.-11
Party walls constructed as firewalls or fire separations

9.10.11.1. Required Firewalls

This Article requires, with a number of exceptions listed in NBC Article 9.10.11.2., that a party wall on a property line be constructed as a firewall.

A party wall is a wall jointly owned and used by two parties under easement agreement or by right in law, and is erected at or upon a line that separates two parcels of land that are, or are capable of being, separate real estate entities. With the exception of some Part 9 residential occupancies, both NBC Part 3 and NBC Part 9 require that, where party walls are constructed (on property lines), they be constructed as 2 or 4 h firewalls.

The buildings on each side of a party wall that is constructed as a firewall are considered as separate buildings (NBC Article 1.3.3.4. of Division A). Where two parties share a party wall on a property line, each party is responsible for fire safety in their unit; however, each is also subject to the risk of a fire from activities in the adjoining units. The separating party wall is intended to provide a significant degree of fire protection between the adjacent units, often exceeding even that required between suites in multiple-unit residential and non-residential occupancies.

When a building spans a property line, constructing a party wall on the property line is not mandated by the NBC, but subdividing the building at the property line is an option the owner can consider. The NBC permits a building constructed on more than one property to be designed as a single undivided building, whether the properties have a common owner or not. However, if a subdividing wall is constructed on the property line within the building for the purpose of separating the two real estate entities, and is shared by two different owners, the wall would, by definition, be deemed a party wall. As such, this party wall would need to meet the construction requirements for party walls, depending on the building's occupancy classification and size.

A building that spans two or more properties, but does not have a party wall at the property line, may need to address the NBC requirements for party walls in the future.

9.10.11.2. Firewalls Not Required

This Article indicates under which conditions a party wall does not have to be constructed as a firewall.

Where a party wall on a property line separates two dwelling units where there is no dwelling unit above another, or separates a dwelling unit and a house with a secondary suite or two houses with secondary suites, this party wall need not be constructed as a firewall, but must be constructed as a continuous fire separation that extends from the top of the footings to the underside of the roof, with a fire-resistance rating of at least 1 h. These party walls do not create separate buildings (Figures 9.10.-12 and 9.10.-13).

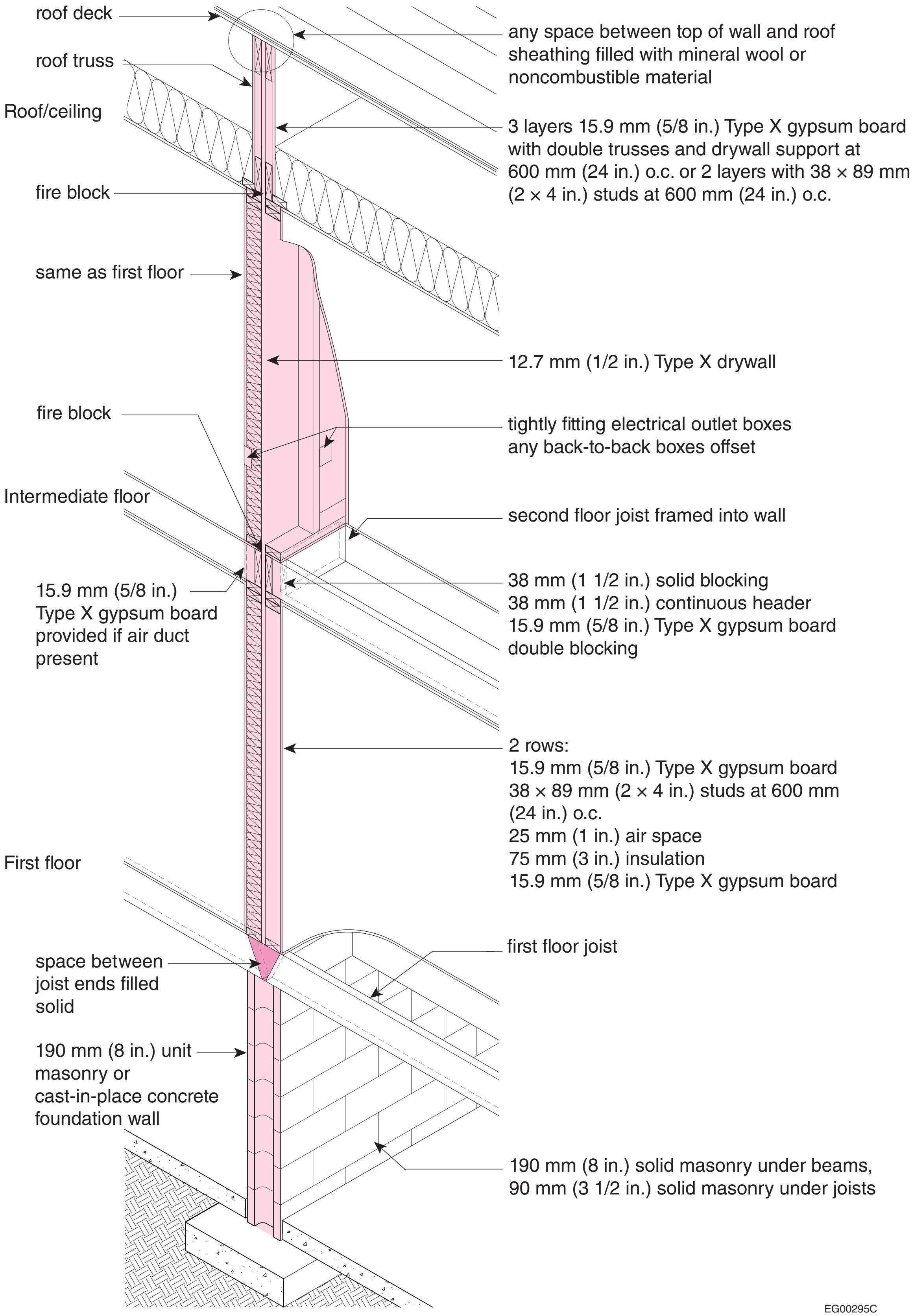


Figure 9.10.-12
Example of a wood-frame party wall constructed as a fire separation having not less than a 1 h fire-resistance rating

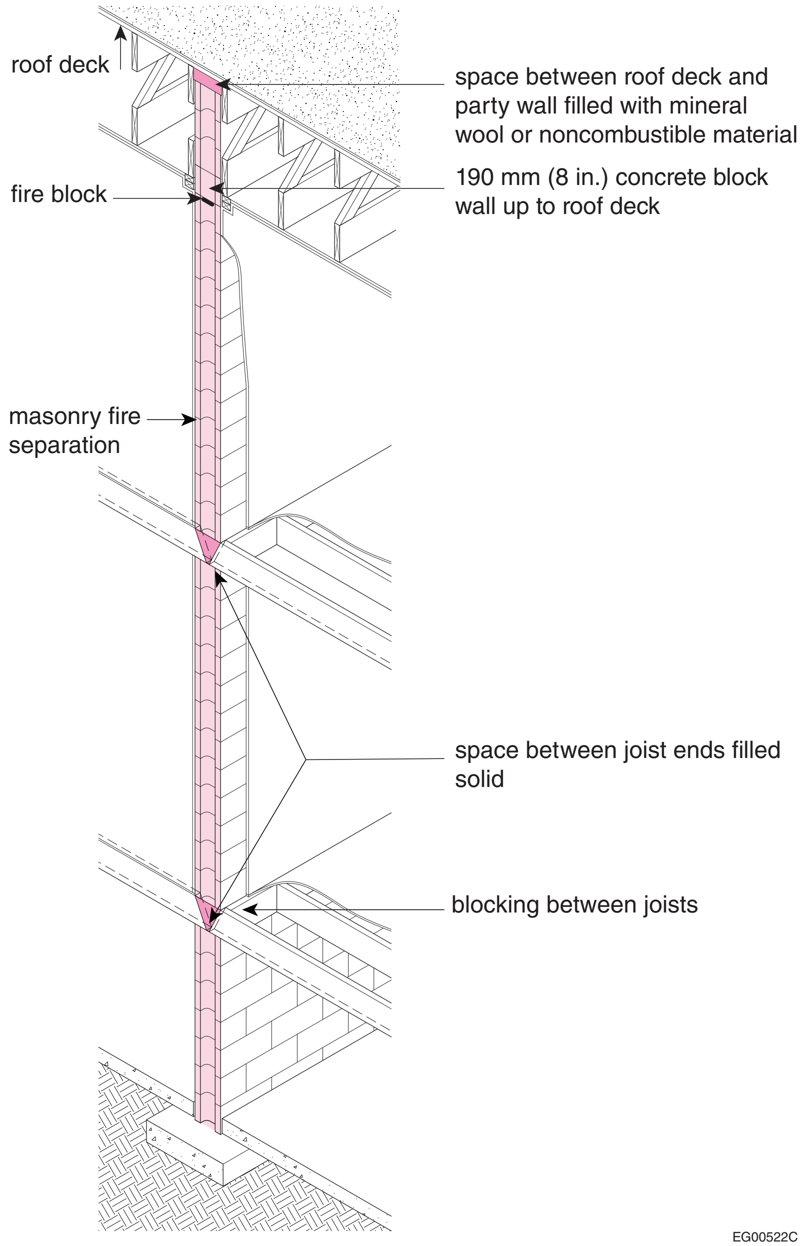


Figure 9.10.-13
Example of a masonry party wall constructed as a fire separation having not less than a 1 h fire-resistance rating

If a building has more than two houses with secondary suites, a party wall must be constructed as a firewall to create separate buildings, each having not more than two adjacent houses with a secondary suite. This restriction is based on the assumption that in row houses, the level of fire risk with respect to more than two houses with secondary suites located side-by-side could be higher because of the higher occupant load.

Any space between the top of the wall and the roof sheathing must be packed with mineral wool insulation or noncombustible material.

9.10.11.3. Construction of Firewalls

This Article requires that the construction of firewalls be carried out according to the requirements set out in NBC Part 3, so that if a building on one side of a firewall is completely destroyed by fire, the building on the other side is not affected.

The ends of a noncombustible firewall must be continuous to the edge and the top of the building, and as shown in Figure 9.10.-14, combustible material cannot be placed across the end of the noncombustible firewall.

Combustible material must not extend across the end of a firewall.

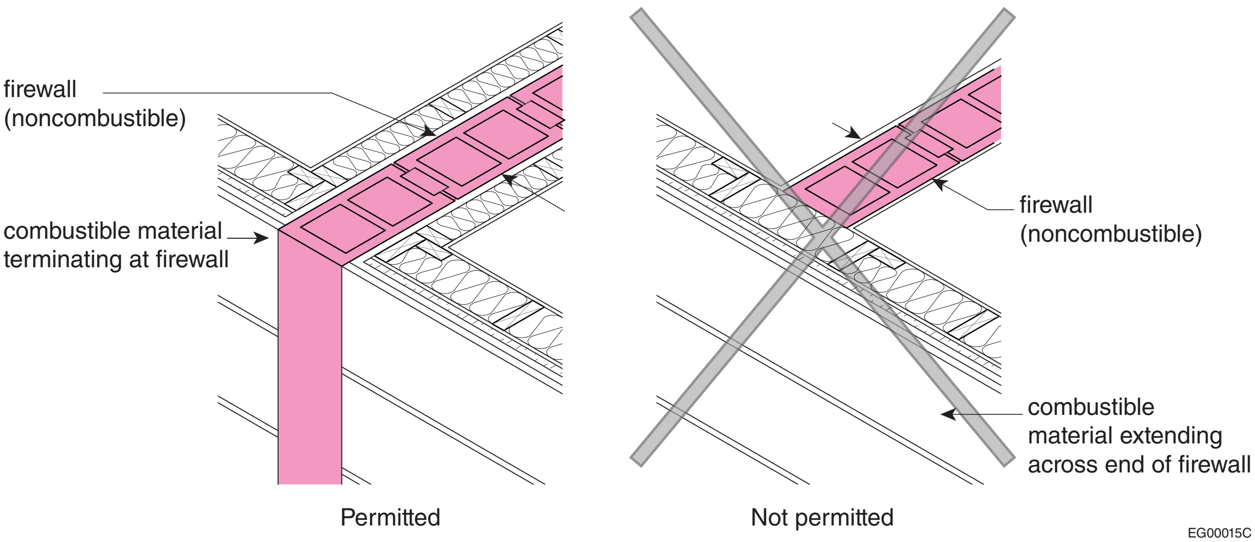


Figure 9.10.-14
Junction of a firewall with combustible construction

9.10.12. Prevention of Fire Spread at Exterior Walls and between Storeys

9.10.12.1. Termination of Floors or Mezzanines

This Article requires that mezzanines and floor areas end in a way that confines fires to their level of origin, to permit the safe evacuation of a mezzanine level, and facilitate firefighting by containing the fire to a single level. Where a mezzanine is very small, or where its occupants are able to see the conditions on the floor below, the mezzanine can be evacuated quickly before conditions become untenable.

A mezzanine is any intermediate floor assembly within a storey, including balconies. Mezzanines can range from small balconies to substantial floor areas. Whether or not a mezzanine space is allowed to interconnect with adjacent space in the same storey, or may be compartmented, depends on its size and design.

If a mezzanine is not considered to add to the storey height of the building (see Guide 9.1.1.1., Application, Mezzanines and Lofts), its floor assembly is not required to be designed as a fire separation. Such mezzanines are also allowed to interconnect with the adjacent space. If, on the other hand, the mezzanine is considered to add to the storey height, the mezzanine must be enclosed by fire separations with a fire-resistance rating at least equal to that of the other floors (see Guide 9.10.8.6., Mezzanines), unless the special compensating measures described in NBC Subsection 3.2.8. are implemented. The fire separation enclosing a mezzanine may be constructed to the roof, to the floor above, or to the floor below to create the compartment. NBC Clause 3.2.8.1.(1)(a) requires that the fire separation terminate at the floor or roof above.

9.10.12.2. Location of Skylights

This Article limits the location of skylights, and reduces the exposure of walls in upper storeys to fire extending from skylights in a roof below to permit the safe evacuation of unaffected levels, and to facilitate firefighting by confining the fire to a single level.

Skylights in the roof of one fire compartment are required to be located at a horizontal distance of at least 5 m (16 ft. 5 in.) away from adjacent windows in the exposed wall (Figure 9.10.-15).

9.10.12.3. Exterior Walls Meeting at an Angle

This Article limits the location of unprotected openings in walls that meet at an angle of 135° or less, and intends to minimize the heat radiation exposure of a window in one fire compartment to a window in another compartment. If the windows are on the same plane (i.e., 180° to one another), there is little or no exposure hazard. As the angle decreases, the radiation hazard increases, and when the angle reaches 135°, there is sufficient radiation from one window to another to cause a fire risk that could spread fire from one fire compartment to another (see Guide 9.9.4.5., Openings in Exterior Walls of Exits, and 9.9.4.6., Openings Near Exit Doors). To reduce this risk, the windows are kept apart and the wall between them made sufficiently fire resistant to stay in place until the fire can be extinguished.

Where the exterior walls of two adjacent fire compartments or in different dwelling units, ancillary spaces, or common spaces in a house with a secondary suite meet at an external angle of 135° or less, the horizontal distance from an unprotected window in one compartment or unit to the nearest unprotected window in another compartment or unit must be at least 1.2 m (3 ft. 11 in.) (Figure 9.10.-16). The non-glazed wall portion within this 1.2 m (3 ft. 11 in.) distance must have a fire-resistance rating at least equal to that required for the wall between the compartments or units.

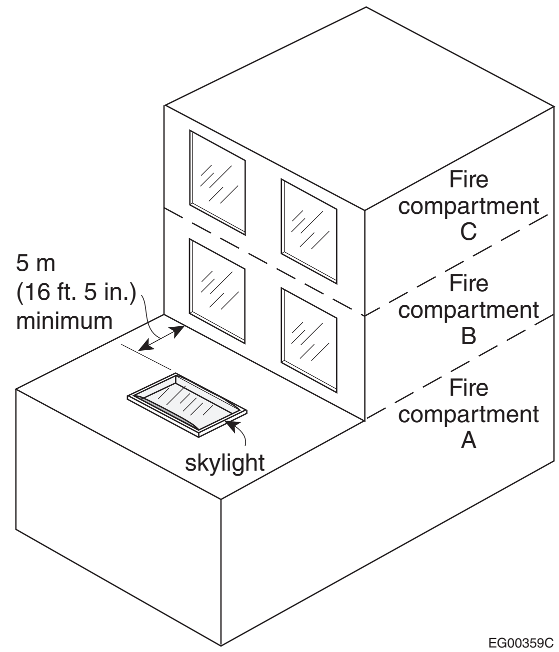


Figure 9.10.-15
Minimum horizontal distance between windows in an exposed wall and a skylight in an unsprinklered fire compartment

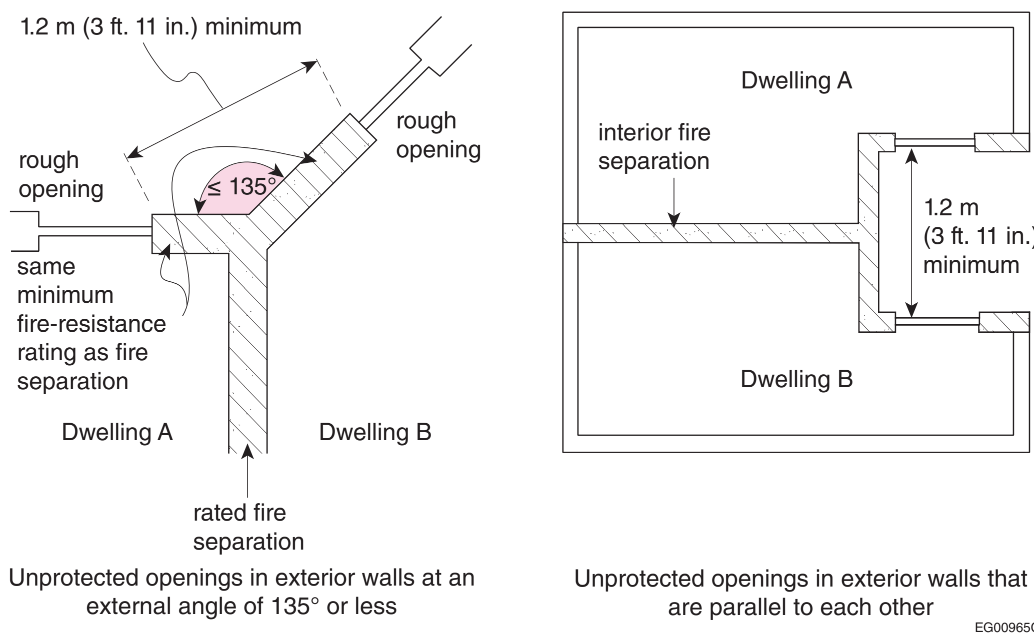


Figure 9.10.-16
Minimum horizontal distance between unprotected openings in external walls

Where interior walls between dwelling units, ancillary spaces or common spaces in a house with a secondary suite are not constructed as fire separations, the exterior wall of each dwelling unit, ancillary space or common space within the 1.2 m (3 ft. 11 in.) of the interior smoke-tight wall needs to be finished on the interior with not less than 12.7 mm (1/2 in.) thick gypsum board. No windows are permitted to be located within this distance.

9.10.12.4. Protection of Soffits

This Article sets the requirements for soffits above windows to delay the entry of fire into an attic space, so that a building can be safely evacuated, and that firefighting can be facilitated by keeping the fire contained within the suite in which it originated. Fire issuing out of a window close to a soffit can enter the attic space through a soffit vent, or by burning through the soffit. If the attic space is common to a number of residential suites, an attic fire can involve all units simultaneously and render the separations between them useless. This risk is reduced by not locating soffit vents in the vicinity of windows, and by making the soffits more fire resistant.

With few exceptions, any soffit enclosing a projection that is less than 2.5 m (8 ft. 2 in.) vertically above a window or door, less than 1.2 m (3 ft. 11 in.) from either side of a window or door, or enclosing certain attic or roof spaces or floor spaces cannot have unprotected openings (such as vents) and needs to be protected where the soffit encloses:

(a) a common attic space or roof space that spans more than two suites of residential occupancy, and projects beyond the exterior wall of the building,

(b) a floor space where an upper storey projects beyond the exterior wall of a lower storey, and a fire separation is required between the floors,

(c) a floor space where an upper storey projects beyond the exterior wall of a lower storey, and the floor separates dwelling units from each other, or from a dwelling unit from an ancillary or common space in a house with a secondary suite, or

(d) a floor space where an upper storey projects beyond the exterior wall of a lower storey, and the projection is continuous across a vertical separation separating two suites, or continuous across a wall separating dwelling units from each other or a dwelling unit from an ancillary or common space in a house with a secondary suite.

Protection can be provided by several materials including metal, wood products and gypsum board, as shown in Figure 9.10.-17.

The materials required to protect soffit spaces in certain locations do not necessarily have to be the finish materials. They can be installed behind the finishes chosen for the soffits or in lieu of these.

In the case of a projecting soffit at the edge of an attic or roof space that is completely separated from the remainder of that attic or roof space by fire blocks, protection is not required and vents are permitted.

If the suites below a common attic or roof space, and all the rooms with windows are sprinklered, then this soffit protection is not required. NFPA 13D, "Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes," does not require certain closets and bathrooms to be sprinklered. However, if these rooms contain openings in the outside wall below the soffit and the soffit is not protected, then the rooms must be sprinklered.

If the rooms with openings in suites spanning a common attic or roof space are sprinklered, as well as those situated above or below a projecting floor (including closets and bathrooms), protection of the soffit is not required.

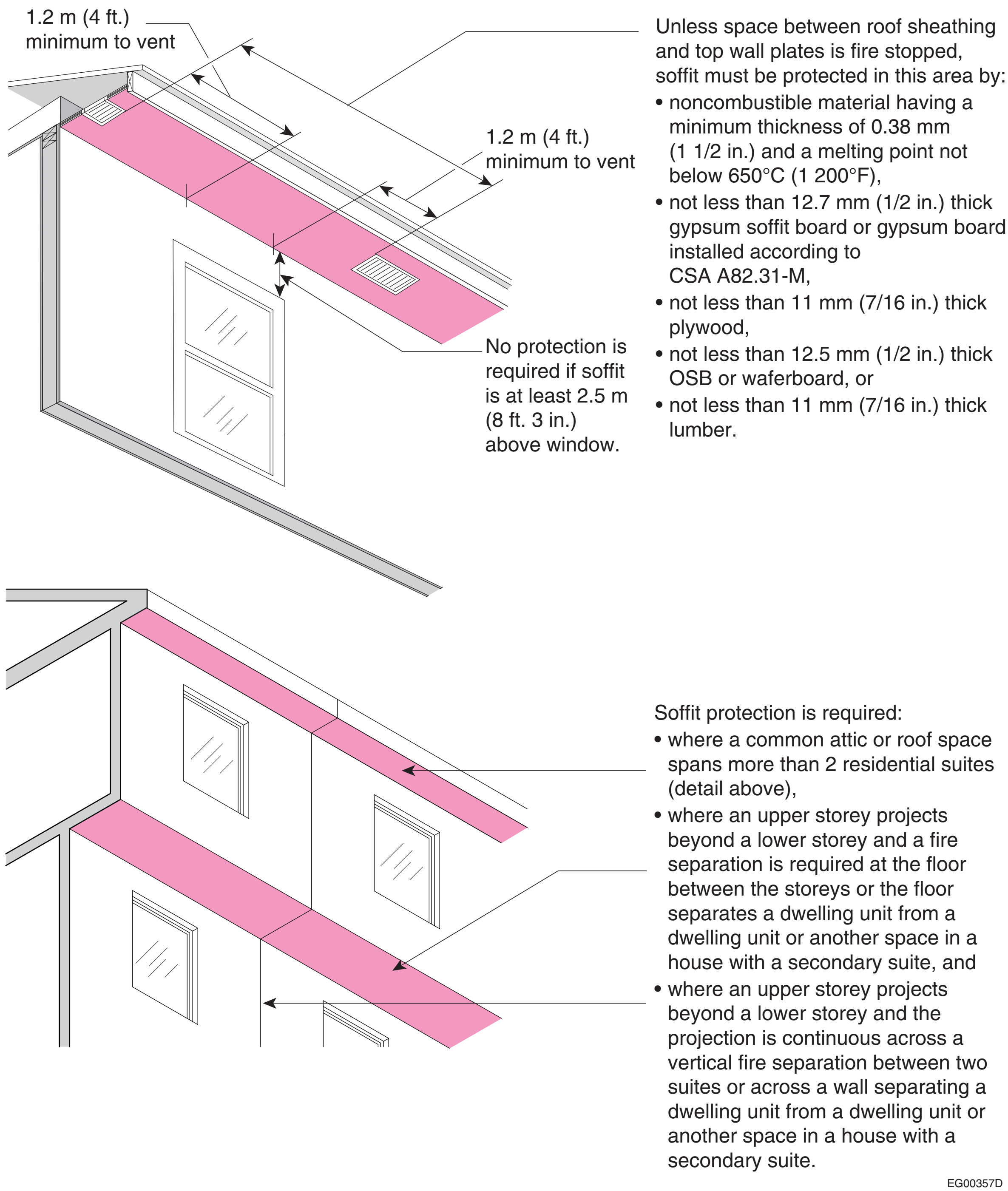


Figure 9.10.-17
Soffit protection

9.10.13. Doors, Dampers and Other Closures in Fire Separations

9.10.13.1. Closures

This Article sets the minimum fire-protection ratings for closures. It also provides exceptions to rated closures.

The purpose of closures is to hinder the passage of fire across an opening in an assembly required to act as a fire separation for a time commensurate with the rating period required for the fire separation. All devices that close off openings through fire separations are referred to as “closures.” These must be tested and rated. Ratings for closures, however, are referred to as “fire protection ratings” rather than “fire-resistance ratings.” Although the fire exposure temperatures are similar to those used in tests for fire-resistance ratings, the criteria for meeting a given rating are different. The term “fire-protection rating” is used to avoid confusing the two rating systems.

Openings in required fire separations must be protected with closures conforming to NBC Table 9.10.13.1. Since it is difficult to achieve higher ratings for closures, they have traditionally been permitted to have lower ratings than are required for the rest of the separation. This is tolerated on the basis that they usually form only a small part of the total separation, they are non-loadbearing, and fire loads are not adjacent to them. Closure ratings are based on the entire assembly, including hardware, closing mechanism, frames and latches.

9.10.13.2. Solid Core Wood Door as a Closure

This Article permits the use of generic, solid core wood doors as closures when such doors have not been tested and labelled; however, it also sets limits on the clearances at the bottom, top and sides of those doors.

Doors are the most common of all types of closures. In small buildings, where 45 min fire separations are common, 45 mm (1 3/4 in.) thick, solid core wood doors are sometimes used. Solid core doors are required in smoke barriers, but these need not be rated or labelled.

Solid core wood doors used as closures in a rated fire separation such as in a public corridor in an apartment building are required to conform to CAN/ULC-S104, “Fire Tests of Door Assemblies.” This standard regulates a number of construction features to ensure that the doors will provide at least a 20 min fire-protection rating if subjected to the standard fire test. Such a door is required to be identified by markings that show the manufacturer’s or seller’s name, and that it is a fire door with a 20 min rating.

Most doors in fire separations are required to be self-closing and equipped with a latch to hold them closed under fire conditions. The only exception is for doors in corridors that serve suites in Group D (business and personal services) occupancies (see NBC Article 9.10.13.10.).

9.10.13.3. Unrated Wood Door Frames

This Article permits the use of generic wood door frames in closure assemblies when such door frames have been neither tested nor rated.

Where a door is required to provide a 20 min rating or be a 45 mm (1 3/4 in.) thick, solid core wood door, the door frame must be at least 38 mm (1 1/2 in.) thick if the frame has not been tested or rated.

9.10.13.4. Doors as a Means of Egress

This Article indicates that there are additional requirements for doors (e.g., dimensions, direction of swing, hardware) when doors are used as a means of egress.

9.10.13.5. Wired Glass as a Closure

This Article permits, under certain conditions, wired glass to be used as a closure in a vertical fire separation, that will remain in place for at least 45 min, even though it has not been rated in a fire test.

Wired glass and glass block are common types of closures in fire separations. Properly installed, this type of closure can provide a 1 h fire-protection rating. Wired glass must be mounted in steel frames and be structurally supported at suitable intervals (Figure 9.10.-18).

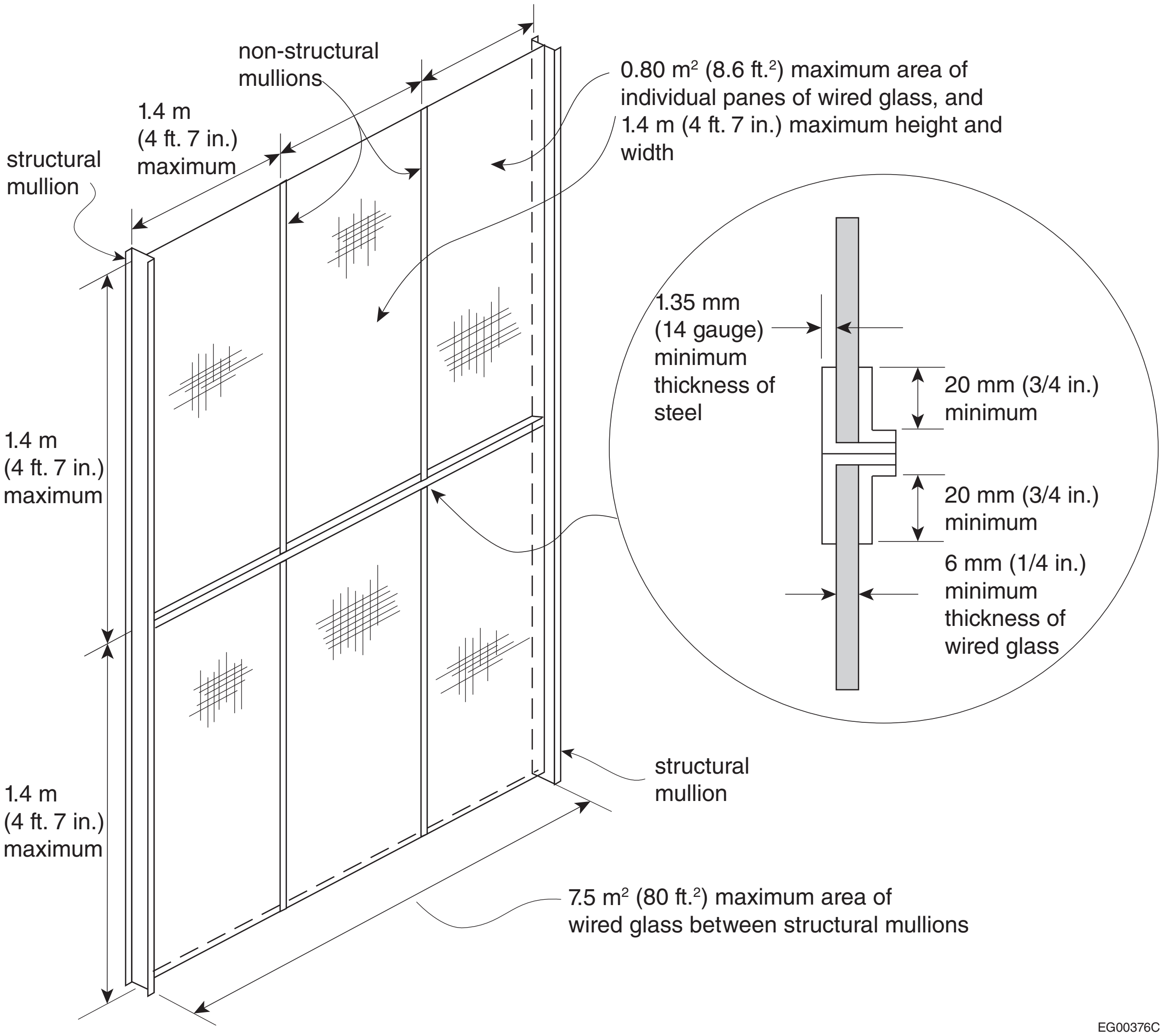


Figure 9.10.-18
Requirements for wired glass used as a closure in a vertical fire separation required to have a fire-resistance rating of not more than 1 h

9.10.13.6. Steel Door Frames

This Article permits the use of generic steel door frames for doors required to have a 20 min fire-protection rating, even though the frames have not been tested and labelled, in order to meet the purpose of NBC Article 9.10.13.1.

9.10.13.7. Glass Block as a Closure

This Article permits the use of generic glass blocks as closures in a fire separation. Typically, and when constructed in accordance with the requirements of NBC Article 9.20.9.6., glass block can be expected to remain in place for at least 45 min even though it may not have been rated in a fire test.

9.10.13.8. Maximum Size of Opening

This Article indicates the maximum allowable size of openings permitted in a fire separation so that a closure will still prevent the spread of fire for its rated time. The maximum dimension permitted for a closure in an unsprinklered location is based on the maximum size that can be tested by existing test furnaces, and is limited to 11 m² (118 ft.²), with no dimension of the opening being greater than 3.7 m (12 ft. 2 in.) in any direction.

In sprinklered locations, the cooling effect of sprinklers is considered to justify a larger maximum size closure given the results of the tests conducted on smaller closures. They can be up to 22 m^2 (237 $ft.^2$) with no dimension larger than 6 m (19 ft. 8 in.) in any direction.

9.10.13.9. Door Latch

This Article requires a latch on every swing-type door in a fire separation to provide a closure that will deter the spread of fire for its rated time. Many doors subjected to fire on one side will warp, and if not restrained by a latch, they may warp to the extent that flames will issue around the door. Also, significant draft pressures can be created that may cause a door to swing open.

9.10.13.10. Self-closing Device

This Article requires that self-closing devices be installed on every door in a fire separation to keep fire-rated doors from being accidentally left open in the event of a fire. An exemption is permitted for suite entrance doors in business and personal services occupancies (Group D). This is justified on the basis that the fire risk in such occupancies is less than in other occupancies, and that, because the occupants are awake, evacuation is fairly rapid. Where such doors are in dead-end corridors, however, the risk is increased and door closers are required to maintain the integrity of the corridor to allow the occupants to escape.

9.10.13.11. Hold-Open Devices

This Article allows fire doors to be held in the open position for the sake of convenience, provided measures are taken so that such doors will provide appropriate protection against smoke and fire spread.

Hold-open devices are sometimes used as a convenience in areas of heavy traffic. Such doors are designed to close automatically when smoke is detected or the fire alarm system activates. In less critical occupancies, the doors may be closed by heat-actuated devices, such as fusible links, or on the operation of the sprinkler system.

9.10.13.12. Service Room Doors

This Article indicates the direction service room doors must swing. There is a risk that doors to furnace rooms with fuel-fired equipment could be blown open in the event of a rapidly developing fire or an explosion. If the doors lead to a corridor or a room containing a large number of people, it may be impossible for the occupants to escape. To decrease this risk, such doors are required to swing inward so as to be able to provide greater resistance to explosion pressures. In all other cases, service room doors are required to swing outward to facilitate rapid escape from the service room.

9.10.13.13. Fire Dampers

This Article provides requirements for devices that enable ducts penetrating a fire separation to be closed in the event of fire, so as to prevent fire spread across a fire separation. In most cases, a duct that penetrates an assembly required to be a fire separation with a fire-resistance rating needs to be equipped with a fire damper.

Where a duct passes completely through a rated fire separation, it provides a potential passageway for fire and hot gases. To maintain the integrity of the separation, a fire damper is usually required in the plane of the separation. This device is also required to have a fire-protection rating. It is normally held in the open position by a fusible link, and is installed so that it will stay in place if the duct collapses (Figure 9.10.-19). The fusible link and damper must be accessible for testing and inspection.

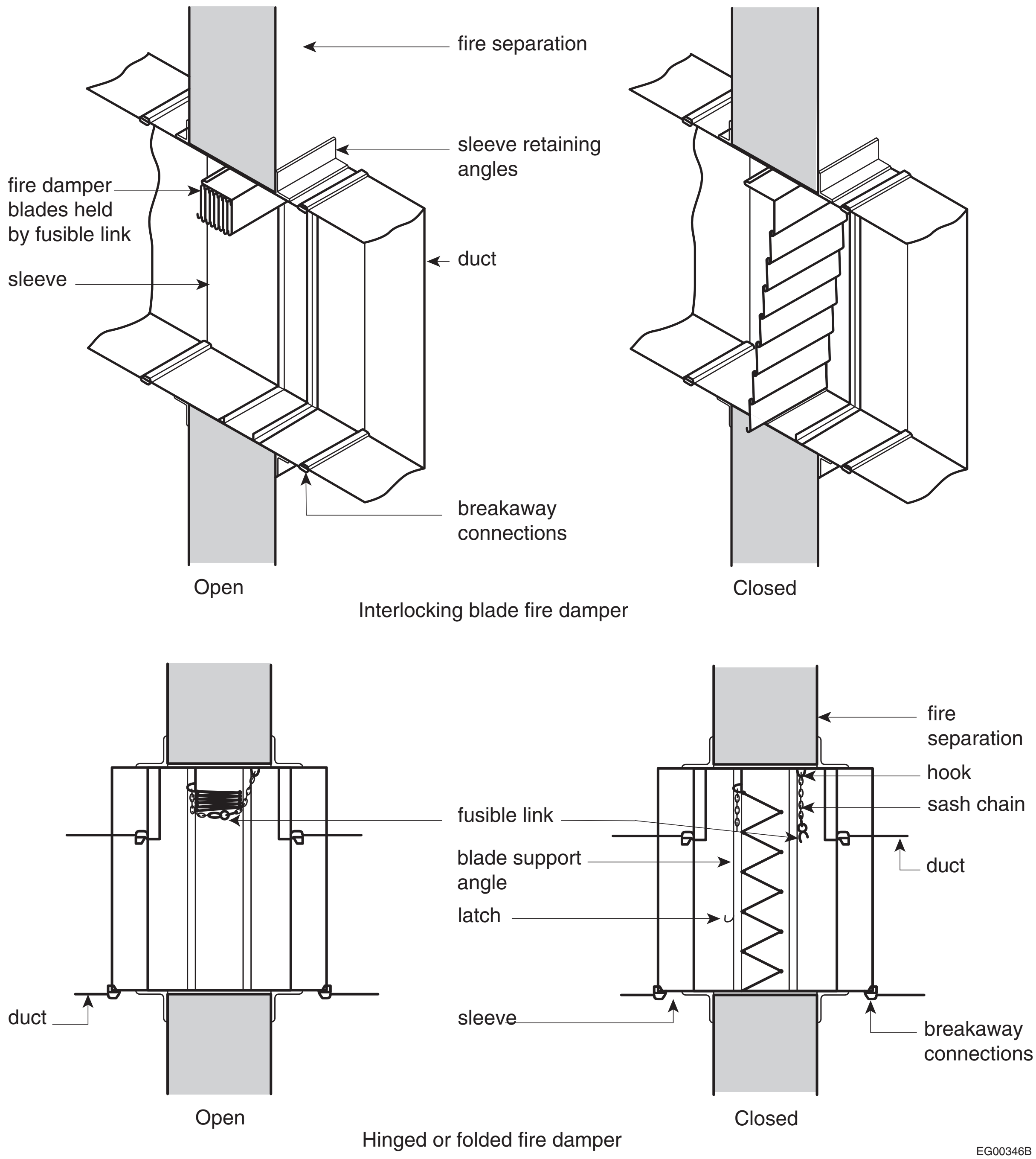


Figure 9.10.-19
Typical fire dampers

In some cases, ducts can penetrate a fire separation without appreciably affecting its performance, and no damper is necessary. For example, exhaust ducts penetrating a fire separation around a vertical shaft are not required to have fire dampers if the shaft is exhausted in such a way, and the ducts are terminated in such a way, that smoke or fire entering the shaft via one duct is unlikely to be drawn into a duct leading to another fire compartment (Figure 9.10.-20).

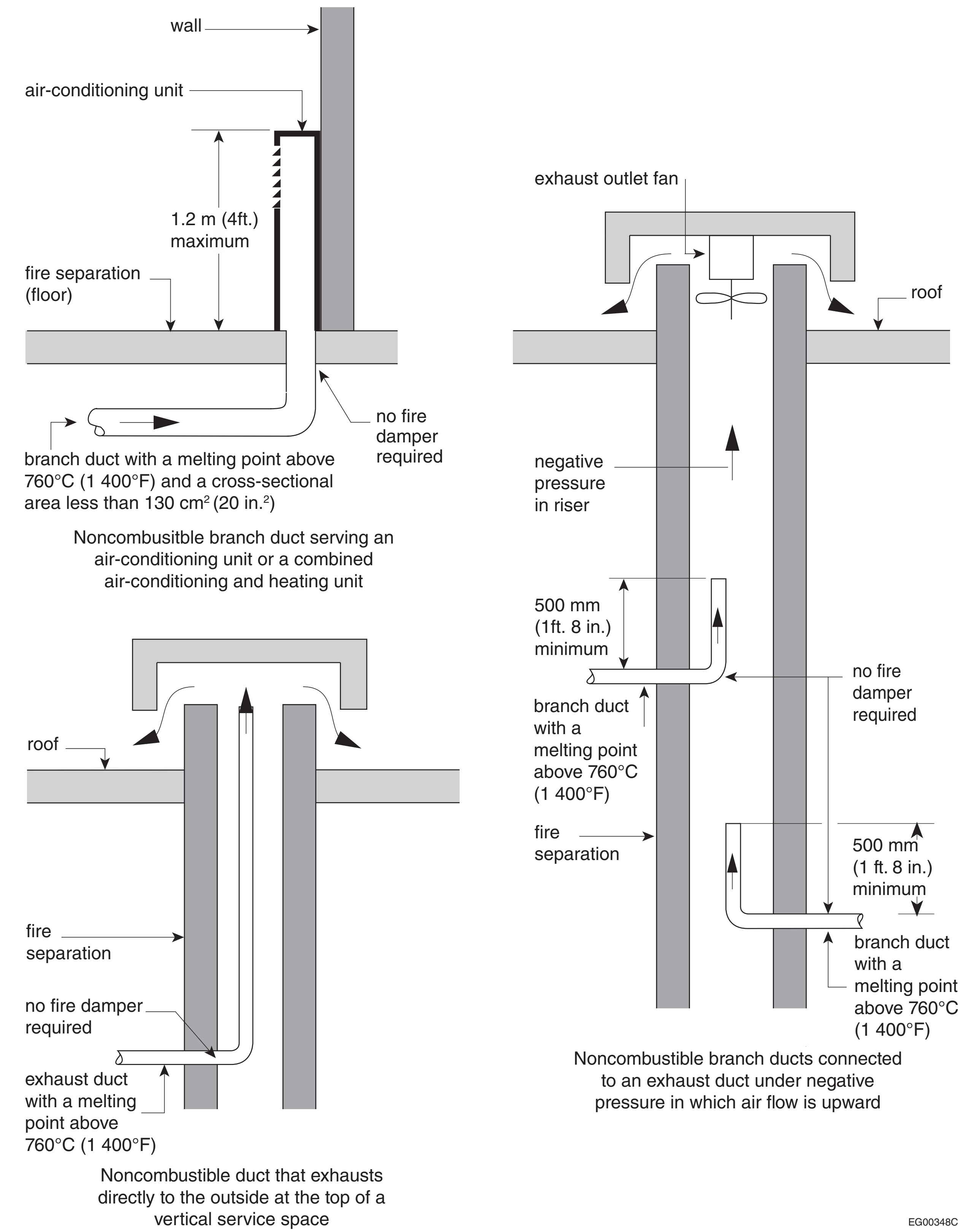


Figure 9.10.-20
Locations where fire dampers are not required

9.10.13.14. Fire Stop Flaps

This Article requires that fire stop flaps in ceiling membranes referred to in NBC Sentence 9.10.5.1.(4) conform to CAN/ULC-S112.2, "Fire Test of Ceiling Firestop Flap Assemblies," and activate at a temperature approximately 30°C above the normal maximum temperature that occurs in the ducts, whether the air duct system is operating or shut down.

Where a ceiling membrane, such as gypsum board, contributes to the required fire-resistance rating of an assembly, openings through the membrane may allow heat to enter the assembly and reduce its fire-resistance rating. Various measures can be used to avoid this possibility, one of which is the installation of fire stop flaps at the openings (Figure 9.10.-21). Like fire dampers, fire stop flaps are held open by fusible links that release the flaps in the event of a fire to maintain the integrity of the membrane. Unlike fire dampers, which are intended to close off an opening that penetrates through the entire assembly, fire stop flaps merely preserve the continuity of the membrane in which they are installed. There are various types of both fire dampers and fire stop flaps.

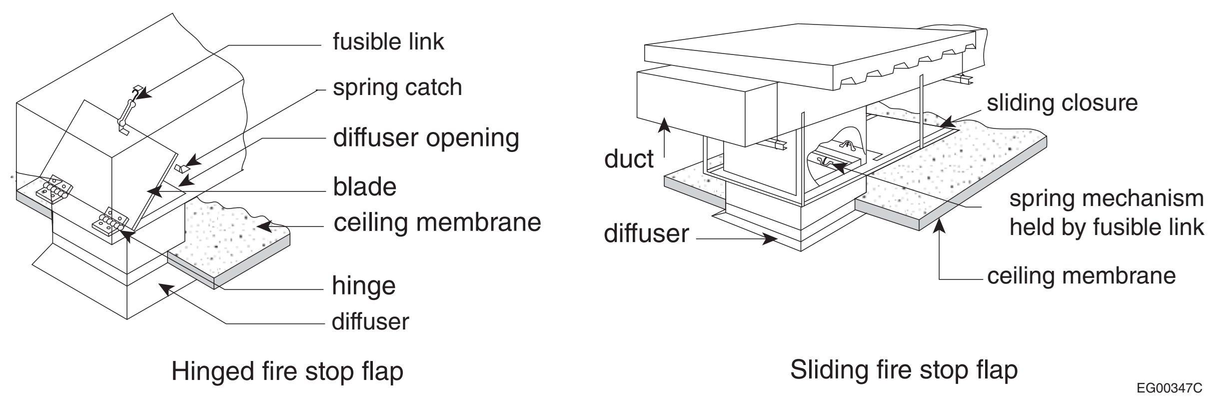


Figure 9.10.-21
Typical fire stop flaps

9.10.13.15. Doors between Garages and Dwelling Units

This Article requires that doors between a garage and a dwelling unit be constructed so as to reduce the passage of exhaust fumes and gasoline vapours into habitable areas. To reduce this risk, any door from the garage to the house must be weatherstripped and have an automatic door closer to keep the door from being accidentally left open (Figure 9.10.-22). Since there is always some leakage past the weatherstripping under wind conditions, doors from spaces where people sleep should not have a direct entrance to a garage.

9.10.13.16. Door Stops

This Article requires that door stops for free-swinging doors be used to keep them from damaging fire separations. Fire separations that depend on membranes such as gypsum board to achieve a required rating can be damaged if a door is allowed to swing against the wall. A door stop avoids this damage and helps to maintain the effectiveness of the separation.

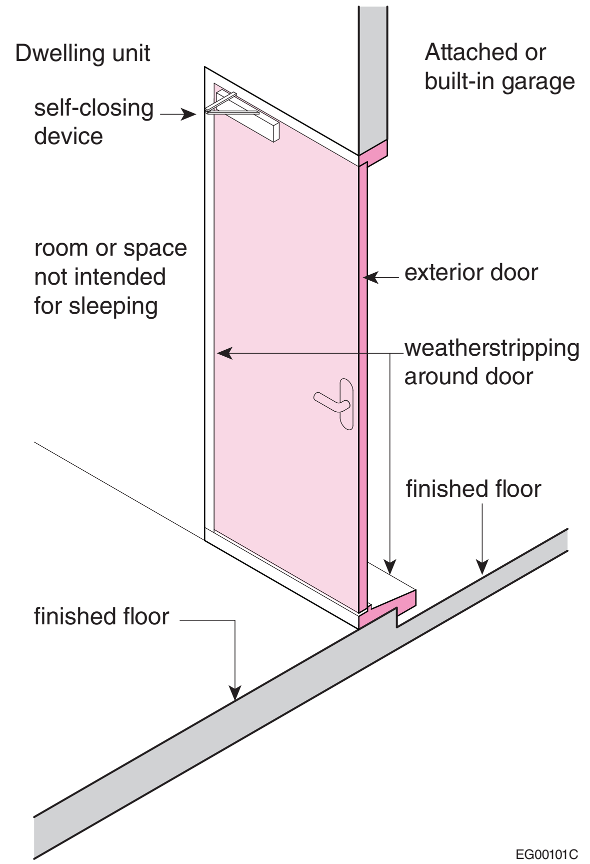


Figure 9.10.-22
Doors between an attached or built-in garage and a dwelling unit

9.10.14. Spatial Separation Between Buildings

Introduction

The NBC spatial separation requirements intend to reduce the likelihood of fire spread between buildings. An important principle of fire protection is that one person's property should not be allowed to damage another's.

The likelihood of fire spreading between buildings can be reduced by:

- limiting how close a building can be to a property line or an imaginary line between buildings located on the same property (limiting distance),
- limiting the area (size and number) of windows, doors and other openings through which flames and radiation can affect neighbouring buildings,
- designing exterior wall constructions with required fire ratings to reduce the likelihood of walls becoming a radiant heat threat to neighbouring buildings,
- designing interior spaces as fire compartments with rated fire separations to reduce the area of exposing building faces, and
- sprinklering buildings in order to help detect and suppress fires in their early stages, and reduce the probability of fire spreading to other buildings (the presence of sprinklers does not reduce the amount of material in a compartment that is available as fuel during a fire, but it does limit the quantity of material burning at a given time).

General Information for Spatial Separation

As some of the basic principles of spatial separation apply to both NBC Subsections 9.10.14. and 9.10.15., they are both covered here for the sake of clarity, and to avoid needless repetition. The general information is structured under the following headings:

- Application
- Fire Spread Due to Radiation – Unprotected Openings, Construction and Fire Load
- Compartmentation and Exposing Building Face
- Sprinklering
- Area and Location of Exposing Building Face (NBC Articles 9.10.14.2. and 9.10.15.2.)
- Limiting Distance and Fire Department Response (NBC Articles 9.10.14.3. and 9.10.15.3.)
- Unprotected Openings (NBC Article 9.10.14.4.) and Glazed Openings (NBC Article 9.10.15.4.)
- Maximum Allowable Areas for Unprotected and Glazed Openings
- Designing for Maximum Aggregate Unprotected or Glazed Opening Area
- Areas and Spacing of Individual Openings
- Construction of Exposing Building Faces (NBC Articles 9.10.14.5. and 9.10.15.5.)
- Combustible Projections
- Location and Protection of Projecting Roof Soffits

Application (NBC Articles 9.10.14.1. and 9.10.15.1.)

NBC Subsection 9.10.14. applies to all buildings that qualify for design under NBC Part 9, except for buildings that contain only dwelling units, with no dwelling units above each other, unless one of those units is a secondary suite.

NBC Subsection 9.10.15. applies to buildings that contain only dwelling units and do not have one dwelling unit above another except where there is only one unit above or below another and one of those units is a secondary suite. See Guide 9.10.15.1., Application, for a list of housing types that fall under NBC Subsection 9.10.15.

The requirements for certain detached garages and accessory buildings that serve a single dwelling unit are provided in both NBC Subsections 9.10.14. and 9.10.15.

Fire Spread Due to Radiation – Unprotected Openings, Construction and Fire Load

Fire spreads from one building to another principally by thermal radiation through windows and other unprotected openings. There are many things that may contribute to the radiation intensity, and several are more significant than cladding. At any given distance, the radiation intensity will depend on the total area of windows radiating heat. The intensity varies inversely as the square of the distance from the source — if the distance is doubled, the radiation intensity will be only 25% as great. For this reason, the closer one building is to a property line or assumed line between two buildings on the same property, the smaller the allowable area of windows and other unprotected openings (e.g., unrated walls and doors).

The radiation reaching an adjacent building is the total from all radiating sources. Since the radiating windows are at different distances from any given point on an adjacent building, the calculations necessary to determine the more critical exposure condition become very complicated. To simplify the regulation of window openings, certain assumptions were made that approximate real conditions. Windows were assumed to be very small and uniformly spaced over the entire face of the building. This simplified the calculation of maximum radiation intensity by allowing the maximum area of windows (or, the more general term, "unprotected openings") to be expressed as a percentage of the area of the exposing building face.

Radiation intensity also depends on the magnitude of the fire load. Mercantile and medium-hazard industrial occupancies are considered to have twice the radiation intensity of other occupancies, and the areas of windows permitted for any given limiting distance from the property line are restricted accordingly.

Compartmentation and Exposing Building Face

If a building is not divided into fire compartments, all windows are assumed to act as radiating sources, and the area of the exposing building face is assumed to extend from the ground to the top ceiling. If the building is divided into 45 min fire compartments, the exposing building face can be taken as the exterior wall of each fire compartment. This usually results in a smaller limiting distance since the exposing building face is much smaller and the amount of radiation is therefore less (NBC Articles 9.10.14.2. and 9.10.15.2.) (See also the detailed discussion in Guide 9.10., Introduction, under the heading Compartmentation).

Fire separations hinder the rapid spread of fire from one compartment to another. If the fire-resistance rating is sufficiently high, a fire will be contained in the compartment of fire origin until firefighters are able to extinguish the fire. If there are no fire separations, the entire building face is assumed to expose another building.

Sprinklering

Sprinkler systems have proven to be effective in detecting and controlling fires in their early stages, thereby reducing the potential severity of a fire. Sprinklering is not required for any Part 9 buildings; however, where sprinkler systems are voluntarily installed, NBC Part 9 allows for the reduction of other requirements such as the separation of spaces, soffit protection and flame-spread ratings. Similarly, spatial separation requirements are less stringent where a building or building compartment is sprinklered. Specific instances of these relaxed requirements are discussed in NBC Subsections 9.10.14. and 9.10.15.

Area and Location of Exposing Building Face (NBC Articles 9.10.14.2. and 9.10.15.2.)

Exposing building face is a defined term referring to the exterior face of a building or a fire compartment that exposes another building to heat radiation (see Compartmentation and Exposing Building Face above).

Where the exterior wall of a building is a single plane parallel to the property line or an imaginary line between two buildings on the same property, the location of the exposing building face is taken to be the face of the wall. Where the wall is stepped back or skewed relative to the property line, different approaches for determining the location of the exposing building face apply to buildings compared to houses. The simpler case of planar facades parallel to the property line is described here. To determine the location of the exposing building face for stepped or skewed walls, see Guide 9.10.14.2. and 9.10.15.2., Area and Location of Exposing Building Face.

Figure 9.10.-23(a) shows a typical apartment building where the floor construction provides a horizontal fire separation with at least a 45 min fire-resistance rating, and the suites are separated from each other by a vertical fire separation with at least a 45 min fire-resistance rating. In Figure 9.10.-23(a), the area of the exposing building face is the area of the exterior wall of each suite, $H_w \times L_w$, and the area of the unprotected opening is $H_o \times W_o$. In office buildings with open floor areas, the compartmentation may only be at each floor level. For example, in Figure 9.10.-23(b), the area of the exposing building face is the area of the exterior wall of the entire floor level, $H_w \times L_w$, and the area of unprotected openings is $3(H_o \times W_o)$, assuming all openings are the same size.

Another example is provided in Figure 9.10.-24.

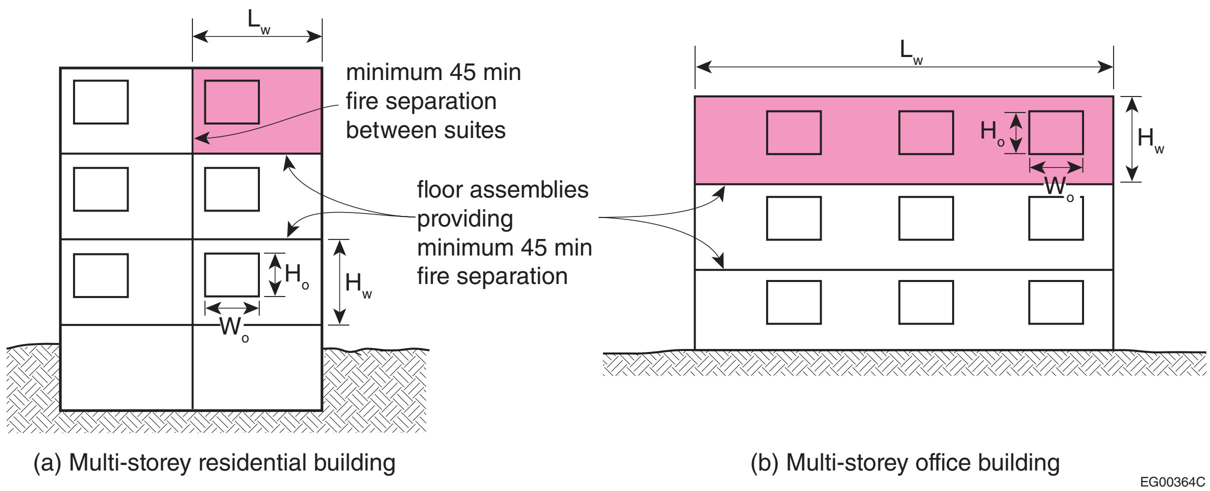


Figure 9.10.-23
Determination of the area of the exposing building face

Limiting Distance and Fire Department Response (NBC Articles 9.10.14.3. and 9.10.15.3.)

"Limiting distance" is another concept that is used in establishing spatial separation. It is the distance from an exposing building face to a property line, the centre line of a street or public thoroughfare, or an imaginary line between two buildings or two fire compartments on the same property.

The original calculations on which the requirements for spatial separations in the NBC were based were for distances between buildings. A building permit, however, only regulates the property for which it was issued, not adjacent properties. The calculated distances were, therefore, reduced and measured to the property line (or centre line of a street, or an assumed line between two buildings on the same property), with the understanding that any building on the opposite side of the line would adhere to the same spatial separation criteria (Figure 9.10.-25).

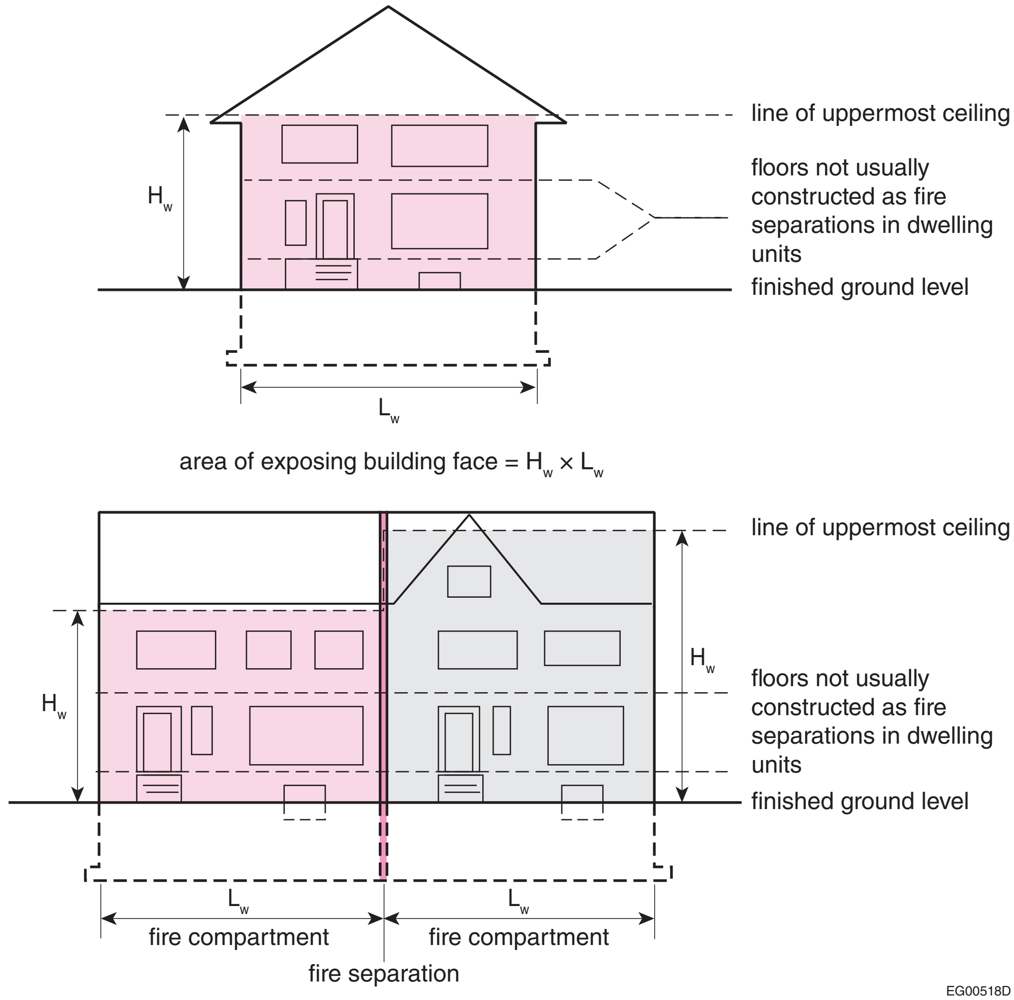


Figure 9.10.-24
Determination of the area of the exposing building face

The limiting distance is measured at right angles to the exposing building face. Compartmentation (fire separations) has the effect of reducing the area of exposing building faces.

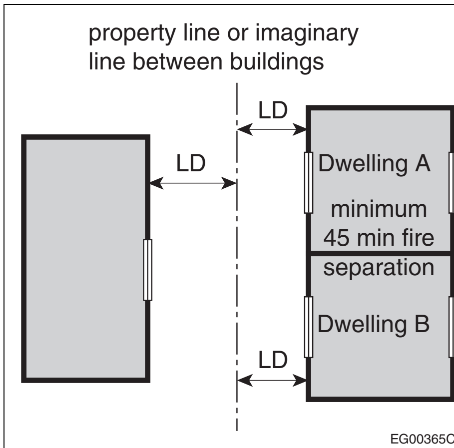


Figure 9.10.-25
Measurement of limiting distance, LD

The limiting distance is based on the ability of a fire department arriving quickly to reduce the likelihood of fire spread between buildings.

The total time from the start of a fire until its suppression by the fire department depends on the time taken for a series of actions. NBC Sentences 9.10.14.3.(1) and 9.10.15.3.(1) are only concerned with the time from receipt of notification of a fire by the fire department until the arrival of the first fire department vehicle at the building. They specify a 10 min time limit that must be met in response to more than 90% of the calls to the building served by the fire department. This reliability level and provision for flexibility is essentially consistent with NFPA 1710, "Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments."

Where the 10 min limit cannot be met by the fire department at least 90% of the time, NBC Sentence 9.10.14.3.(1) specifies that a value corresponding to half the actual limiting distance be used in requirements that depend on limiting distance to define other criteria.

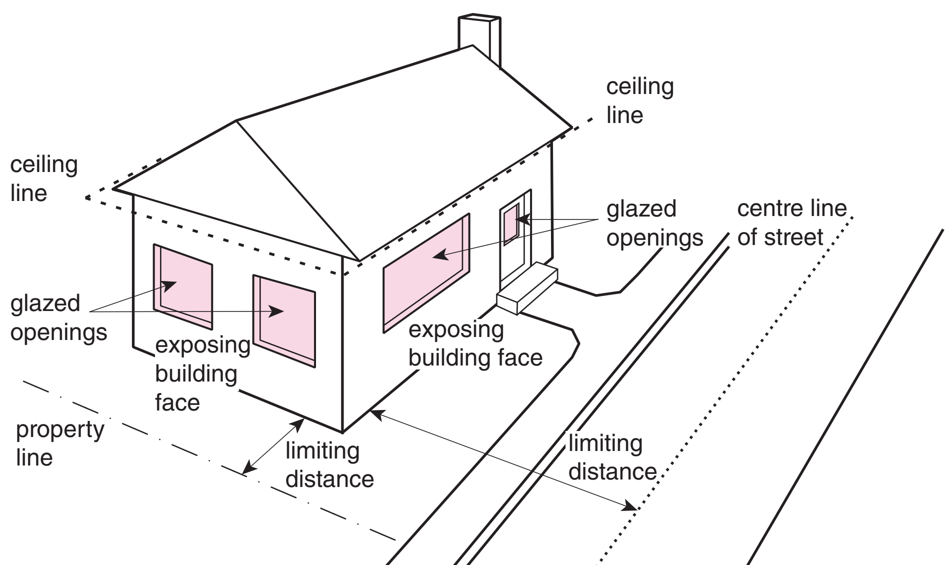
For new subdivisions, legal agreements may be made for the construction of fire stations to serve those areas. The fire department response time in those subdivisions may temporarily exceed 10 min until the fire station is constructed.

Unprotected Openings (NBC Article 9.10.14.4.) and Glazed Openings (NBC Article 9.10.15.4.)

NBC Subsection 9.10.14. uses the term "unprotected opening." It means any opening other than one equipped with a closure having the required fire-protection rating, or any part of a wall forming part of the exposing building face that has a fire-resistance rating less than that required for the exposing building face. Unprotected openings include windows, doors and openings for electrical and mechanical services.

NBC Subsection 9.10.15. uses the term "glazed opening." Glazed openings include windows and glazed portions of doors. The area of glazed openings is measured to the rough opening of the window or door, not to the edges of the glazing.

The area of unprotected or glazed openings allowed on a building face is based on the distance from an exposing building face to a property line, the centre line of a street or public thoroughfare, or an imaginary line between two buildings or two fire compartments on the same property (Figure 9.10.-26).



$$\text{percentage area of glazed openings} = \frac{\text{area of glazed openings}}{\text{area of exposing building face}} \times 100$$

Figure 9.10.-26
Calculation of the percentage area of glazed openings for an exposing building face

Maximum Allowable Areas for Unprotected and Glazed Openings

The tables of allowable areas for unprotected openings and glazed openings in NBC Part 9 (NBC Tables 9.10.14.4.-A and 9.10.15.4.) are extracts from the more extensive tables in NBC Part 3.

The tables in NBC Part 3 take into account the effect that the shape of the exposing building face has on the heat radiation that reaches another building. If a fire compartment is very long relative to its height, there will be less cumulative radiation on an adjacent building because many of the windows will be relatively far away. As the shape of the exposing building face, based on the ratio length and height, approaches a square, the cumulative radiation from an equal area of windows will be greater. The tables in NBC Part 3 divide the shapes of the exposing building face into three ranges for the purpose of regulating the maximum allowable window areas. To simplify the tables for NBC Part 9, only the area limits based on the middle range of shapes were used.

Since the tables in NBC Parts 3 and 9 for limiting unprotected openings and glazed openings have the same basis, either version can be used (NBC Articles 9.10.14.4. and 9.10.15.4.) In some cases, there is an advantage to using the more extensive NBC Part 3 tables, since doing so can result in reduced limiting distances for the same exposing building face characteristics and thus better lot utilization. However, where the aspect ratio of the fire compartment is 3 to 1 or less, the table in NBC Part 9 may result in smaller limiting distances.

In all cases, no unprotected openings or glazed openings are permitted less than 1.2 m (3 ft. 11 in.) from the property line. This is an overriding condition due primarily to the fact that flame fronts extend beyond the plane of the window and can, therefore, project the heat radiation source closer to an adjacent building.

Designing for Maximum Aggregate Unprotected or Glazed Opening Area

Designing a building or house that meets the requirements for spatial separation is an iterative process. One approach for determining the maximum unprotected or glazed opening areas for a given limiting distance uses the following steps:

1. develop a building concept (desired location on the property, height, shape),
2. determine the limiting distances for each face of the building,
3. undertake the conceptual design of its architectural features such as its wall openings, internal layout and fire compartments,
4. calculate the exposing faces' areas,
5. use NBC Table 9.10.14.4.-A or NBC Table 9.10.15.4. to see if the conceptual design complies with the NBC requirements, and proceed to Step 7 if it does or Step 6 if it does not,
6. adjust the parameters, such as the limiting distance and the arrangement of the exterior walls (for example, reduce the size or number of windows, move openings away from the property line if possible); adjust the interior compartmentation with fire separations to reduce the areas of the exposing wall and consider sprinklering or the use of wired glass), and
7. ensure that the design complies with the maximum allowable concentration of openings (NBC Table 9.10.14.4.-A or NBC Table 9.10.15.4. as applicable) — adjust as necessary.

Alternatively, the desired area of unprotected openings could be established first, and then used to determine the required limiting distance.

Areas and Spacing of Individual Openings

Because the requirements that limit the maximum opening areas assumed that smaller openings would be evenly distributed over the exposing building face, the NBC also limits the area of individual openings and their proximity to one another wherever the limiting distance is 2 m (6 ft. 7 in.) or less. Exceptions are provided for sprinklered buildings and for openable bedroom windows with an unobstructed openable area of 0.35 m^2 (3.8 $ft.^2$) where the window is installed to fulfill the requirement in NBC Subsection 9.9.10. for emergency egress.

Construction of Exposing Building Faces (NBC Articles 9.10.14.5. and 9.10.15.5.)

If the non-window portion of a wall fails prematurely during a fire, the contributing radiation for which the limiting distances were calculated will be exceeded. To reduce this risk, the exposing building face must have a minimum fire-resistance rating under some circumstances. This varies depending on the maximum area of unprotected or glazed openings (and therefore the limiting distance) and the fire load (as related to occupancy classification). Except for houses, this also applies to the gable end wall above the exposing building face, since fire may enter an attic from below and very quickly involve the entire gable end if the wall is unrated.

In NBC Subsection 9.10.14., exterior wall construction is dependent on the percentage of the wall that is allowed to have openings. This is a way of relating the wall's proximity to the property line to the wall area and fire load (i.e., occupancy). The smaller the permitted area of wall openings, the greater the exposure hazard. Hence, the smaller the percentage of openings permitted, the greater the level of protection the wall must have.

In NBC Subsection 9.10.15., where the only applicable occupancy is residential houses, the minimum requirements for determining the maximum glazed opening and type of cladding-sheathing are simpler and less stringent than those for buildings. Construction is related directly to limiting distance.

The level of fire resistance required is intended to contain the fire to the building where it originated. The requirements pertaining to noncombustibility for buildings other than houses are intended to keep a wall from being consumed during a fire, which would add to the exposure risk. Noncombustible cladding will therefore provide added protection for adjacent buildings.

Combustible Projections

Experience has shown that combustible elements attached to the face of a building can transmit fire to an adjacent building as a result of direct flame impingement if they are too close to a property line (or to another building). Therefore, such elements are kept sufficiently far back from the property line to make flame impingement unlikely.

An exemption is granted for projections without solid faces of one- and two-family residential buildings, such as balconies with open railings, that face garages and accessory buildings serving single dwelling units. This is justified on the basis of past experience where such combustible elements have not been a serious problem. For other buildings, combustible balconies, platforms, canopies, stairs and overhanging eaves are required to be kept back from the property line (1.2 m (3 ft. 11 in.)) or from other buildings on the same property (2.4 m (7 ft. 11 in.)) if they are more than 1 m (3 ft. 3 in.) above the ground.

Combustible appendages with solid faces on the exterior of buildings, such as for fireplaces and chimneys, and that project beyond what is normally considered to be the exposing building face, can result in bridges to spread fire to adjacent buildings. It is recognized that these types of projections present more vertical surface area compared to platforms, canopies and eave projections, and may be enclosed by constructions that are essentially the same as exterior walls. These constructions, however, do not enclose habitable space, are of limited width, and may not extend a full storey in height. Consequently, NBC Sentences 9.10.14.5.(8) and 9.10.15.5.(7) allow these projections beyond the exposing building face of buildings and houses if they are provided with additional fire protection.

Figure 9.10.-27 illustrates projections that extend within 1.2 m (3 ft. 11 in.) of the property line where additional protection must be provided. Where a projection extends within 0.6 m (2 ft.) of the property line, it must be protected to the same extent as is a building face that has a limiting distance of less than 0.6 m (2 ft.). Where a projection extends to less than 1.2 m (3 ft. 11 in.), but not less than 0.6 m (2 ft.) of the property line, it must be protected to the same degree as an exposing building that has a limiting distance of less than 1.2 m (3 ft. 11 in.).

Protection is also required on the underside of a projection that is more than 0.6 m (2 ft.) above the finished ground level, which is measured at the exposing building face.

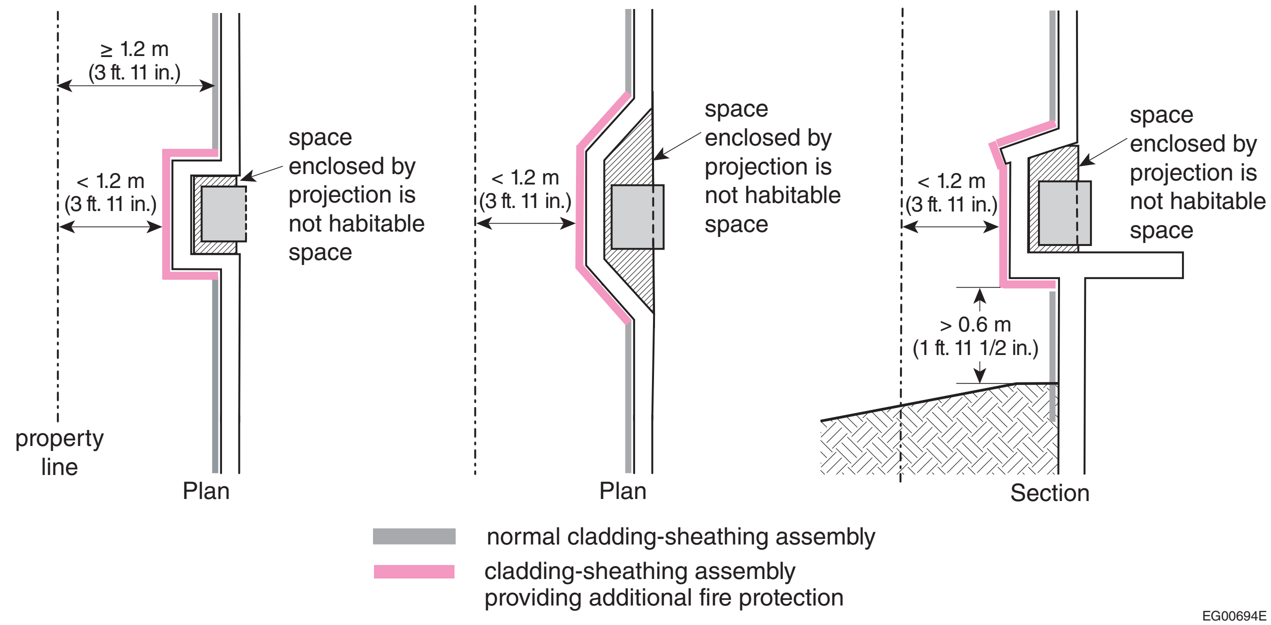


Figure 9.10.-27
Protection of projections

Location and Protection of Projecting Roof Soffits

Figure 9.10.-28 shows the requirements for the location and protection of projecting roof soffits that are in close proximity to a property line. The face of a roof soffit is permitted to project to the property line only where it faces a street, lane or public thoroughfare. In such an arrangement, no building or soffit will be present on the other side of the property line.

9.10.14.1. Application

This Article states that NBC Subsection 9.10.14. applies to Group D, Group E, Group F, Divisions 2 and 3 buildings, and to Group C (residential) buildings that include spaces other than individual dwelling units or, with one exception, where the dwelling units are located one above another.

These residential buildings include apartments and stacked townhouses. The above-mentioned exception refers to residential buildings that contain only dwelling units, and where there are either no dwelling units above another, or not more than one dwelling unit above another where one of those units is a secondary suite (houses with secondary suites). These are addressed in NBC Subsection 9.10.15.

Detached garages and accessory buildings, even when they serve houses, are addressed in NBC Subsection 9.10.14.

Refer to NBC Section 9.9. for requirements pertaining to openings near unenclosed exit stairs and ramps, openings near exit doors, and the location of skylights in the roofs of buildings that have walls exposed to a fire hazard from an adjoining roof.

9.10.14.2. Area and Location of Exposing Building Face

This Article states the calculation rules that apply to the area and location of the exposing building face. If a building face has an irregular shape, it can be difficult to use the NBC tables, because they assume a simple rectangular shape. To overcome this problem, assume a vertical plane between the building and the property line, parallel to the latter, located so that it just touches the part of the building closest to the property line. The building, including the openings and fire compartments, is projected into this plane at right angles to it. This projection becomes the new location for the building for the purpose of determining the type of construction required for the exterior walls.

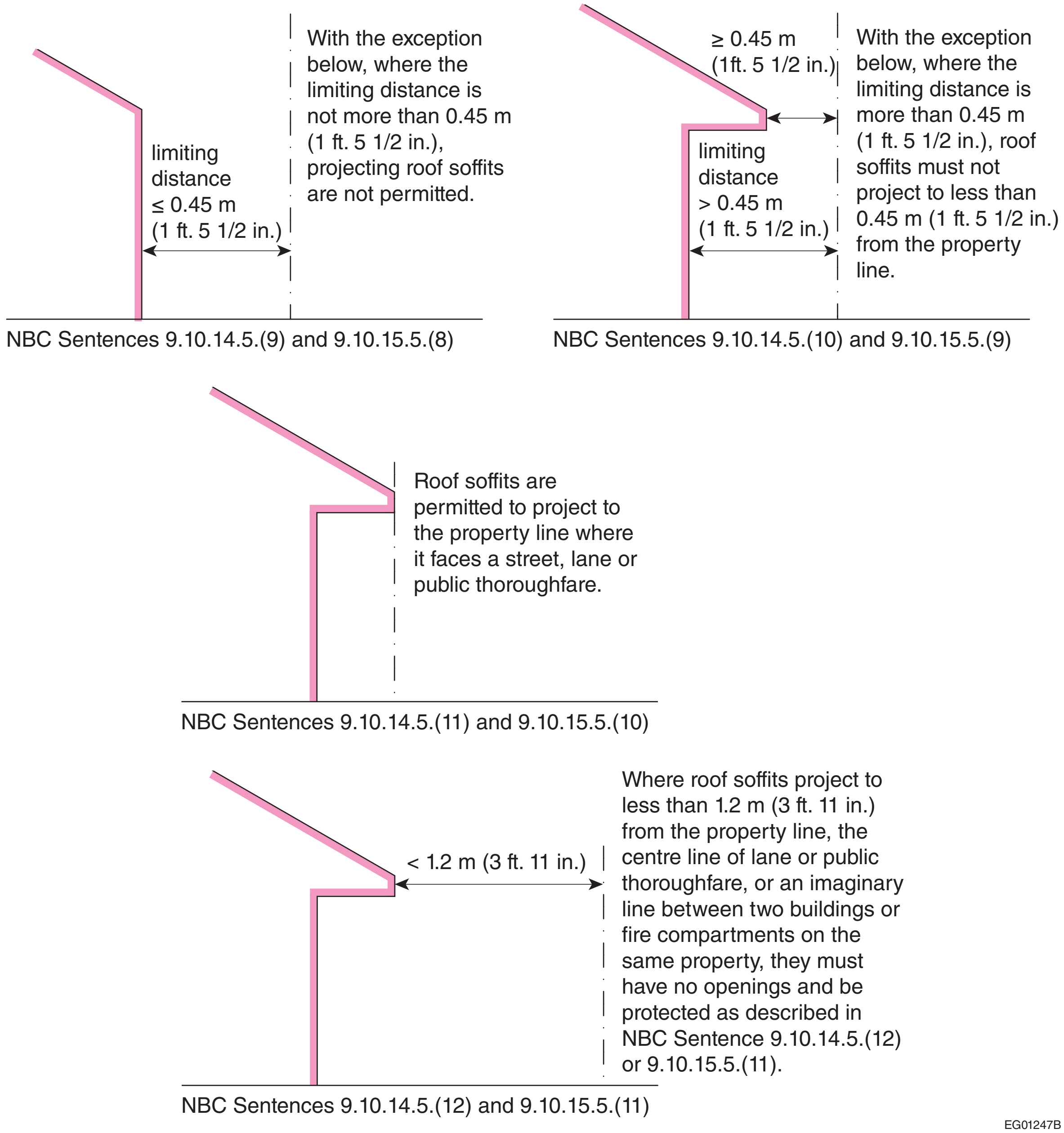


Figure 9.10.-28
Location and protection of projecting roof soffits

For the purpose of determining the maximum aggregate area of unprotected openings in an irregularly shaped or skewed exterior wall (using NBC Table 9.10.14.4.-A), the location of the exposing building face is taken as a vertical plane located so that there are no unprotected openings between the vertical plane and the line to which the limiting distance is measured.

Where NBC Table 9.10.14.4.-A is used to determine the maximum allowable aggregate area of glazed openings, the exposing building face can be divided into individual vertical portions measured from the ground to the uppermost ceiling (Figure A). Every portion of the wall must conform to the values in the row of NBC Table 9.10.14.4.-A that correspond to the appropriate occupancy classification and the maximum total area of exposing building face (see column 2 of the Table) that is equal to the sum of all portions of the exposing building face (NBC Sentence 9.10.14.2.(1)).

Example 6 – Determining the Maximum Area of Unprotected Openings in an Irregularly Shaped Exposing Building Face

Find the maximum area of unprotected openings and the minimum construction requirements for each portion of the irregularly shaped exposing building face shown in Figure A of a building classified as a business and personal services occupancy.

1. LD_1 is the limiting distance for the purpose of using NBC Table 9.10.14.4.-A to determine the maximum area of unprotected openings (NBC Sentence 9.10.14.2.(2)). The total area of the exposing building face is $A_1 + A_2 + A_3 = 110$ m². Therefore, according to NBC Table 9.10.14.4.-A, the maximum areas of unprotected openings, P_1, P_2 and P_3, for each portion of the exposing building face are 12%, 12% and 0% of the portion area, respectively:
   $P_1 \leq 30 \times 0.12 = 3.6$ m²
   $P_2 \leq 50 \times 0.12 = 6$ m²
   $P_3 = 30 \times 0 = 0$ m²

2. LD_3 is the limiting distance used for the purpose of using NBC Table 9.10.14.5.-A to determine the required construction type, cladding type and fire-resistance rating (NBC Sentence 9.10.14.2.(3)). According to NBC Table 9.10.14.5.-A, the minimum construction requirements for each portion of the exposing building face are:

Portion of Exposing Building Face	Maximum Percentage Area of Unprotected Openings	Minimum Fire-Resistance Rating	Type of Construction	Type of Cladding
1	12%	1 h	Combustible or noncombustible	Noncombustible
2	12%	1 h	Combustible or noncombustible	Noncombustible
3	0%	1 h	Noncombustible	Noncombustible

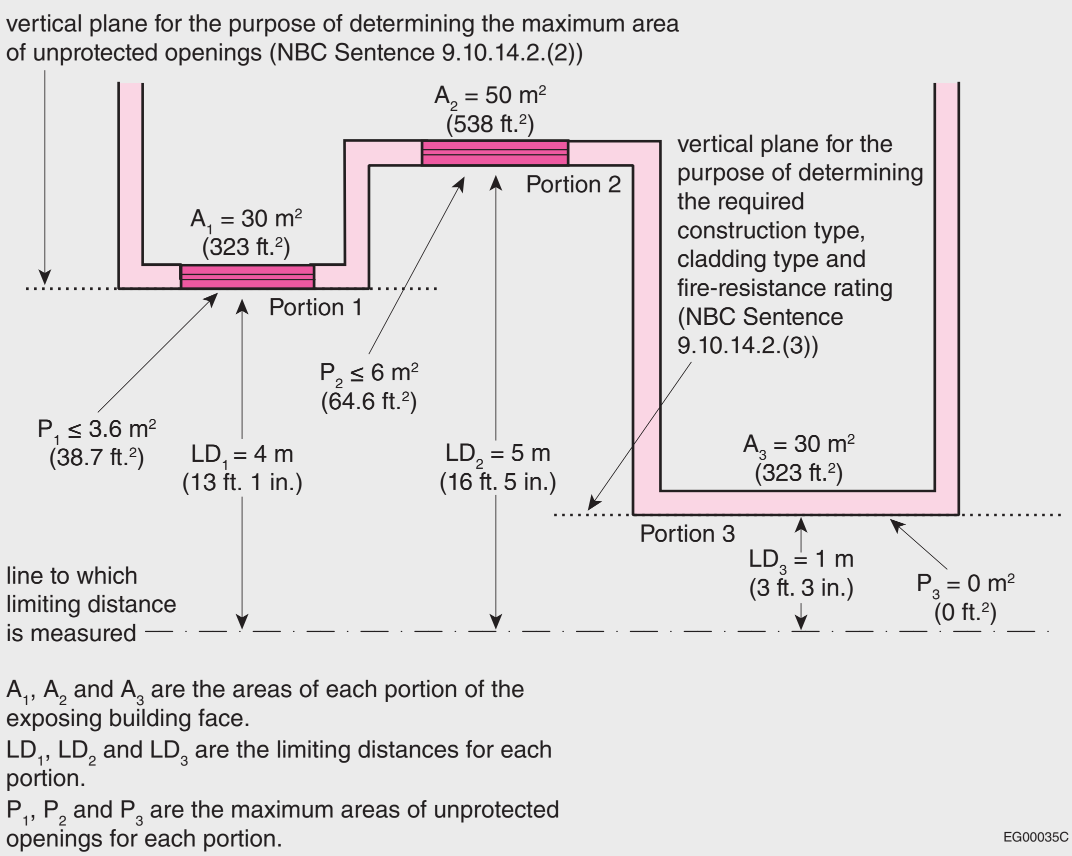


Figure A
Determination of the maximum area of unprotected openings in an irregularly shaped exposing building face

9.10.14.3. Limiting Distance and Fire Department Response

Where the fire department response time exceeds the 10 min maximum set for early action against fire spread from one building to another, this Article requires that the limiting distance values be reduced. See Guide 9.10.14., General Information for Spatial Separation.

9.10.14.4. Openings in Exposing Building Face

This Article indicates the maximum allowable areas of openings in an exposing building face, as well as the spacing, location, and protection of those openings.

See Guide 9.10.14., General Information for Spatial Separation. For buildings, the maximum permitted aggregate area is specified in NBC Table 9.10.14.4.-A.

Example 7 – Determining the Limiting Distance for an Exposing Building Face in a Mercantile Occupancy (Group E)

Find the limiting distance for an exposing building face 20 m long and 3 m high with an unprotected window area of 15 m^2 in an unsprinklered mercantile occupancy.

$$\text{Area of exposing building face} = 20 \times 3 = 60\,\text{m}^2$$
$$\text{Percentage area of unprotected openings} = \frac{15}{60} = 25\%$$
$$\text{Aspect ratio of exposing building face} = 20 : 3 = 6.7 : 1$$

1. Since this is a mercantile occupancy, NBC Table 9.10.14.4.-A applies. Since there is no entry in the Table for an exposing building face area of 60 m^2, the limiting distance is interpolated from those for exposing building face areas of 50 m^2 and 100 m^2.

   For an exposing building face area of 50 m^2, the limiting distance for an unprotected opening area of 25% falls between 4.0 and 6.0 m, and by interpolation is equal to:

   $$4.0 + \left[\left(\frac{25-14}{29-14}\right) \times (6.0-4.0)\right] = 5.5\,\text{m}$$

   For an exposing building face area of 100 m^2, the limiting distance for an unprotected opening area of 25% falls between 6.0 and 8.0 m, and by interpolation is equal to:

   $$6.0 + \left[\left(\frac{25-17}{28-17}\right) \times (8.0-6.0)\right] = 7.5\,\text{m}$$

   For an exposing building face area of 60 m^2, the limiting distance is found by interpolating between 7.5 and 5.5 m, and is equal to:

   $$5.5 + \left[\left(\frac{60-50}{100-50}\right) \times (7.5-5.5)\right] = 5.9\,\text{m}$$

2. According to NBC Table 3.2.3.1.-B, for an exposing building face area of 60 m^2 and an aspect ratio of 6.7:1, which falls within 3:1 to 10:1, the limiting distance for an unprotected opening area of 25% is 6.0 m.

3. According to NBC Subclause 9.10.14.4.(1)(c)(ii), for a mercantile occupancy, the limiting distance is equal to the square root of twice the unprotected opening area. Therefore, for an unprotected opening area of 15 m^2, the limiting distance is:

   $$\sqrt{2 \times 15} = 5.5\,\text{m}$$

   Since the least restrictive value can be used, the limiting distance for the exposing building face is 5.5 m (16 ft. 5 in.).

Example 8 – Determining the Limiting Distance for an Exposing Building Face in a Low-Hazard Industrial Occupancy (Group F, Division 3)

A low-hazard industrial building has an exposing building face 35 m long and 4 m high. Find the limiting distance for this exposing building face if the building is sprinklered and has fixed wired glass windows in steel frames that constitute 30% of the exposing building face area.

$$\text{Area of exposing building face} = 35 \times 4 = 140\,\text{m}^2$$
$$\text{Aspect ratio of exposing building face} = 35 : 4 = 8.7 : 1$$

1. Since this is a low-hazard industrial occupancy, NBC Table 9.10.14.4.-A applies. However, this Table applies to unprotected openings (i.e., ordinary glass windows) in unsprinklered buildings. Therefore, according to NBC Sentences 9.10.14.4.(6) and 9.10.14.4.(7), for the purpose of using this Table, a wired glass area of 30% in a sprinklered building would be equivalent to an unprotected opening area of:

$$\frac{30}{4} = 7.5\%$$

According to the NBC Table 9.10.14.4.-A, the limiting distance for an exposing building face area of 140 m^2 (i.e., over 100 m^2) with an unprotected opening area of 7.5% is halfway between 1.5 and 2.0 m, or 1.75 m.

2. In applying NBC Table 3.2.3.1.-A, the limiting distance for an exposing building face area of 140 m^2 at an aspect ratio of 8.7:1 is interpolated from those for exposing building face areas of 100 m^2 and 150 m^2 at an aspect ratio of 3:1 to 10:1

For an exposing building face area of 100 m^2, the limiting distance is halfway between 1.2 and 1.5, or 1.35 m. For an exposing building face area of 150 m^2, the limiting distance is halfway between 1.5 and 2.0 m, or 1.75 m.

Therefore, the limiting distance for an exposing building face area of 140 m^2 is:

$$1.35 + \left[\left(\frac{140 - 100}{150 - 100}\right) \times (1.75 - 1.35)\right] = 1.67\,\text{m}$$

3. According to NBC Subclause 9.10.14.4.(1)(c)(i), for a low-hazard industrial occupancy, the limiting distance is equal to the square root of the unprotected opening area.

The equivalent unprotected opening area is:

$$0.075 \times 140 = 10.5\,\text{m}^2$$

Therefore, the limiting distance is:

$$\sqrt{10.5} = 3.2\,\text{m}$$

4. Since the least restrictive value can be used, the limiting distance for the exposing building face is 1.67 m (5 ft. 4 1/2 in.), as determined under NBC Part 3.

Alternative Method of Determining Maximum Unprotected Opening Area where Limiting Distance is at Least 1.2 m (NBC Clause 9.10.14.4.(1)(c))

There is also an alternative method for calculating limiting distances. A calculation to determine the allowable unprotected opening area, where the limiting distance is at least 1.2 m (3 ft. 11 in.), is based on the limiting distance squared, or half the limiting distance squared depending on occupancy. In buildings with lighter fire loads (residential, business and personal services, and low-hazard industrial), the aggregate unprotected opening area must not exceed the limiting distance squared. For occupancies with higher fire loads (mercantile and medium-hazard industrial), aggregate unprotected opening area must not exceed one half of the limiting distance squared. These square rules are easier to apply than NBC Table 9.10.14.4.-A, since no interpolation is necessary.

Openings in Walls Having a Limiting Distance Less than 1.2 m (NBC Sentence 9.10.14.4.(2))

Fire issuing from windows can extend a metre or so beyond the face of the building, and may thereby affect adjacent properties. Therefore, openings less than 1.2 m (3 ft. 11 in.) from the property line must be protected with fire-rated closures conforming to NBC Table 9.10.13.1. Wired glass or glass block cannot be used because these will permit heat to radiate even if they resist the passage of flames for the required time.

Areas and Spacing of Individual Unprotected Openings (NBC Sentences 9.10.14.4.(3) to (5))

Because the maximum aggregate unprotected opening area limits assume relatively small individual openings distributed over the exposing building face, the NBC limits the area and proximity of individual unprotected openings for smaller limiting distances.

For limiting distances of 2 m (6 ft. 7 in.) or less, the maximum area of individual unprotected openings can be determined by calculation or by referring to NBC Table 9.10.14.4.-B.

As no unprotected openings are permitted at limiting distances less than 1.2 m (3 ft. 11 in.), the formula may only be used where the limiting distance is at least 1.2 m (3 ft. 11 in.). Exceptions are provided for buildings that are sprinklered and for openable bedroom windows with an unobstructed opening area of not more than 0.35 m^2 (3.8 $ft.^2$) in area that is installed in accordance with NBC Article 9.9.10.1.

Allowance for Wired Glass and Glass Block (NBC Sentence 9.10.14.4.(6))

Both wired glass fixed in steel frames and glass block will stay in place in a fire for much longer than will ordinary glass. They have a higher force resistance compared to windows and glazed doors, which prevents the flame front from extending outward from the opening, and which also significantly reduces the amount of radiation reaching the exposed building.

For this reason, twice the area of ordinary glass is permitted for wired glass or glass block for the same distance from the property line.

Allowance for Sprinklers (NBC Sentence 9.10.14.4.(7))

When a building is sprinklered, the sprinklers are actuated at a relatively early stage of fire development, and have the effect of greatly reducing radiation intensity. Such buildings, therefore, are permitted to have twice the window area as non-sprinklered buildings, provided that all the rooms are sprinklered, including closets and bathrooms with unprotected openings. NFPA 13D, "Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes," does permit closets and bathrooms to be unsprinklered. However, if this spatial separation doubling option were chosen, these rooms would require sprinklering if they contained unprotected openings. If both wired glass (or glass block) and sprinklers are used, the glass area is permitted to be four times that for unsprinklered buildings with ordinary glass windows.

Exceptions to Limits on Unprotected Opening Area (NBC Sentences 9.10.14.4.(8) to (11))

Certain buildings and building elements are exempted from the general requirements for spatial separations, either because of traditional practices, or because of successful experiences.

Open-air parking garages: Open-air parking garages can dissipate heat fairly quickly, so even though they have large areas of unprotected openings, the heat build-up is insufficient for them to be a major exposure hazard to adjoining buildings. Typical car fires, even if occurring adjacent to an exterior wall, will not expose an adjacent building to a significant fire risk if the limiting distance is maintained at a fairly modest 3 m (9 ft. 10 in.).

Display windows in commercial buildings: When an exposing face of a building is at street level and faces the street, it is in an ideal location for firefighting. Experience has shown that such locations rarely lead to fires being spread across the street as a result of radiation, even if the entire face of the building is unprotected (i.e., glass display windows), probably because of the ease of firefighting. Ground floor windows of commercial buildings used for display purposes tend to be large, but they are exempt from area restrictions if they face the street.

Detached Garages and Accessory Buildings: Generally, unprotected opening areas in detached garages and accessory buildings must comply with the requirements that apply to other buildings. An exception is provided for the exposing building face of detached garages and accessory buildings that face a single dwelling unit, where these serve that particular dwelling unit, where they are on the same property as that dwelling unit, and where that dwelling unit is the only major occupancy on the property.

9.10.14.5. Construction of Exposing Building Face and Walls above Exposing Building Face

This Article lists the types of construction that are permitted on exposing walls, as determined by their percentage of openings and their proximity to the property line. See Guide 9.10.14., General Information for Spatial Separation.

Minimum Construction Requirements (NBC Sentence 9.10.14.5.(1))

With some exceptions, which are described in NBC Sentences 9.10.14.5.(2) and (3), the level of protection that exterior walls of buildings are required to ensure against the spread of fire to other buildings is provided in NBC Table 9.10.14.5.-A.

The percentage of openings permitted in an exposing building face depends on its limiting distance. By specifying the type of construction for various ranges of allowable openings, the construction is indirectly related to its limiting distance. This can be confusing since the construction is specified on the basis of the percentage of openings permitted (assuming no sprinklers and ordinary glazing). Table 9.10.-C relates the specified levels of construction directly to the limiting distances to avoid this ambiguity. The "User's Guide – NBC 1995, Fire Protection, Occupant Safety and Accessibility (Part 3)"[3] includes a more comprehensive discussion on the determination of limiting distances for various building shapes.

In addition to the risk posed to other buildings from heat radiation from unprotected openings, claddings that can ignite also pose a threat. The NBC regulates where noncombustible claddings can be used as a function of how close the cladding is to a property line (or imaginary line for more than one building on one property).

Table 9.10.-C summarizes the information contained in NBC Tables 9.10.14.4.-A and 9.10.14.5.-A for buildings covered by NBC Subsection 9.10.14. This Table does not reflect the various exceptions permitted for combustible cladding. For these exceptions, see the following section.

Table 9.10.-C
Minimum Limiting Distances for Buildings Covered by NBC Subsection 9.10.14.

Occupancy	Maximum Area of Exposing Building Face, m^2	Minimum Limiting Distance, m							
		Combustible Construction				Noncombustible Construction			
		Minimum Fire-Resistance Rating							
		0	45 min	1 h	2 h	0	45 min	1 h	2 h
Detached garage or accessory building serving a single dwelling unit	All areas	0.6	0	0	0	0.6	0	0	0
Group C (except for above); Group D; Group F, Division 3	10	5.0	2.2(1)	1.4(1)	1.4(1)	5.0	2.2(1)	0(1)	0(1)
	20	6.0	2.7(1)	1.5(1)	1.5(1)	6.0	2.7(1)	0(1)	0(1)
	30	7.0	3.1(1)	1.7(1)	1.7(1)	7.0	3.1(1)	0(1)	0(1)
	40	8.0	3.4(1)	1.8(1)	1.8(1)	8.0	3.4(1)	0(1)	0(1)
	50	8.0	3.7(1)	2.0(1)	2.0(1)	8.0	3.7(1)	0(1)	0(1)
	100	11.0	5.0(1)	2.2(1)	2.2(1)	11.0	5.0(1)	0(1)	0(1)

(3) User's Guide – NBC 1995, Fire Protection, Occupant Safety and Accessibility (Part 3), NRCC 40383, National Research Council of Canada, Ottawa, 1996.

Table 9.10.-C (Continued)

Occupancy	Maximum Area of Exposing Building Face, m²	Minimum Limiting Distance, m							
		Combustible Construction				Noncombustible Construction			
		Minimum Fire-Resistance Rating							
		0	45 min	1 h	2 h	0	45 min	1 h	2 h
Group E; Group F, Division 2	10	6.0	6.0	3.0	2.0(1)	6.0	6.0	3.0	0(1)
	20	8.0	8.0	3.8	2.4(1)	8.0	8.0	3.8	0(1)
	30	9.0	9.0	4.5	2.7(1)	9.0	9.0	4.5	0(1)
	40	11.0	11.0	5.1	3.0(1)	11.0	11.0	5.1	0(1)
	50	12.0	12.0	5.5	3.2(1)	12.0	12.0	5.5	0(1)
	100	16.0	16.0	7.5	4.3(1)	16.0	16.0	7.5	0(1)

Notes to Table 9.10.C.:

(1) Noncombustible exterior cladding required.

Exemptions for Type of Cladding (NBC Sentences 9.10.14.5.(2) and (3))

Minor elements of cladding that are required to be noncombustible may be of combustible material provided that they are distributed over a building face, and not concentrated in any one area. Examples of minor combustible elements include door and window trim and some decorative elements.

Two exceptions are provided to the specifications for noncombustible cladding.

(1) Where the maximum permitted area of unprotected openings is more than 10% of the exposing building face, cladding may be combustible if it is tested in conformance with CAN/ULC-S134, "Fire Test of Exterior Wall Assemblies."

(2) Where the maximum permitted area of unprotected openings is more than 25%, but not more than 50% of the exposing building face, the requirement for noncombustible cladding may be relaxed provided that one of the following five criteria are met:
- the limiting distance is greater than 5 m (16 ft. 5 in.),
- the limiting distance is greater than 2.5 m (8 ft. 2 in.) provided that the area of exposing building face does not exceed certain limits depending on its width to height ratio, as stated in NBC Table 9.10.14.5.-B,
- the building or fire compartment is sprinklered,
- the cladding is wood-based and conforms to particular requirements, or
- the cladding is vinyl and conforms to particular requirements.

The 2.5 m (8 ft. 2 in.) limiting distance is in addition to the option provided in NBC Part 3. It is based on the premise that the radiation from the exposing building face is limited given the aspect ratios of height and width of the exposing building face noted in NBC Table 9.10.14.5.-B.

The exposing building face limits are based on the width to height ratio for the lower 2.5 m (8 ft. 2 in.) limiting distance. A longer, lower, unprotected opening in an exposing building face will radiate less to an area on an adjacent building than one in an exposing building face whose shape resembles a square.

Where wood-based siding or vinyl is used, it must comply with the applicable requirements in NBC Section 9.27. and be installed without furring, or with furring of limited thickness, to reduce fire propagation in the furred space, and over gypsum board or masonry to avoid involving the backing assembly, should the cladding ignite. The flame-spread rating must not be greater than 25 to reduce fire spread over the surface of the material. Where vinyl is used, the material must not be more than 2 mm (3/32 in.) thick to limit the volume of material that might become involved in a fire.

Garage or Accessory Building Serving Only One Dwelling Unit (NBC Sentences 9.10.14.5.(4) and (5))

The rationale for increasing the fire protection level for the exposing walls of detached garages and accessory buildings relative to their proximity to the property line is the same as described for other buildings. However, a lower level of fire protection is permitted for these garages, depending on their proximity to a single dwelling unit on the same property. This is rationalized on the basis of cost, as well as experience.

Such structures are also generally very small, and their incidence of fires in relation to other building fires is low. There is insufficient risk, therefore, to spatially separate a house from its garage or carport.

The walls of a detached garage or accessory building serving only one dwelling unit require a fire-resistance rating of 45 min, only if the limiting distance is less than 0.6 m (2 ft.). Combustible cladding is permitted in all cases.

A complete exemption for detached garages and accessory buildings serving single dwelling units only applies to the exposing building face facing the dwelling unit it serves, provided that the dwelling is the only major occupancy on the property.

Figure 9.10.-29 shows the general requirements for garages.

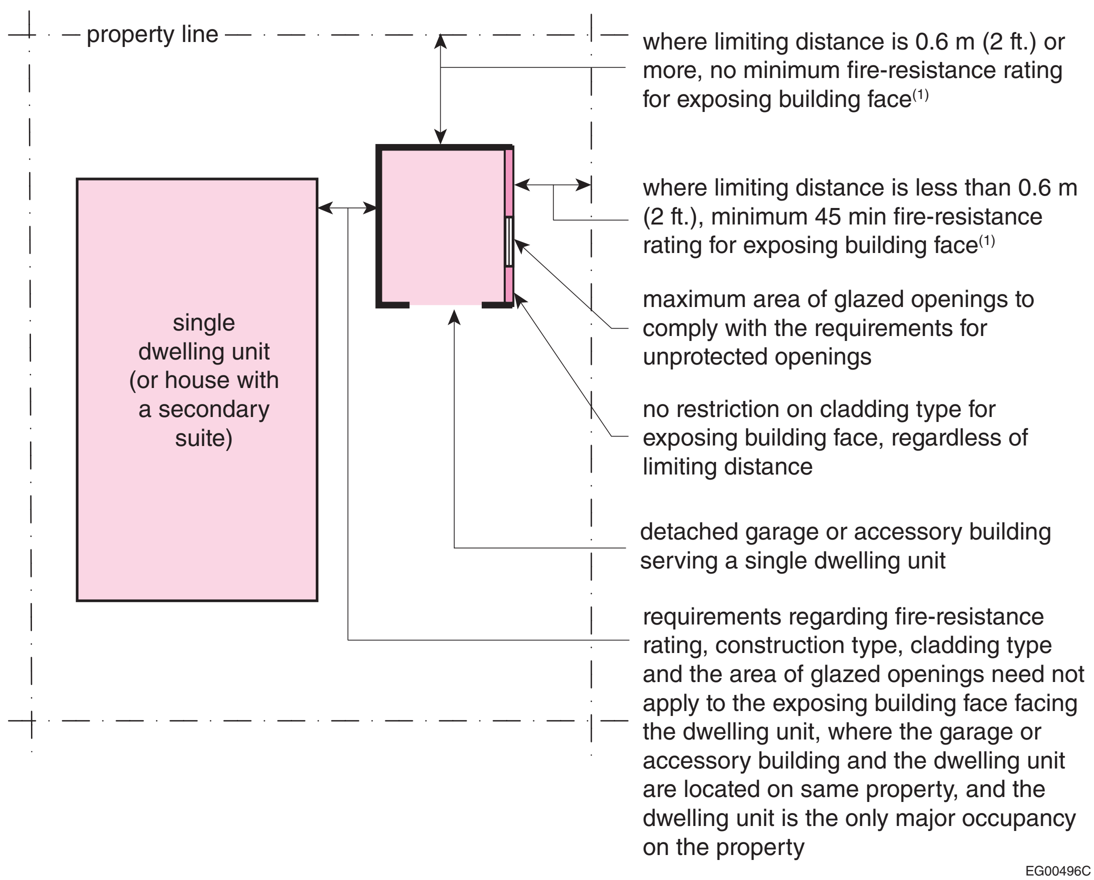


Figure 9.10.-29
Minimum fire-resistance ratings for a detached garage or accessory building serving a single dwelling unit

Note to Figure 9.10.-29:

(1) The limiting distance must be halved where the fire department response time exceeds 10 min in 10% or more of all calls to the building and any storey in the building is unsprinklered (NBC Article 9.10.14.3.).

Heavy Timber and Steel Columns (NBC Sentence 9.10.14.5.(13))

This Article exempts heavy timber and steel columns located outside of a building from having to be protected from fire exposure in that building by exterior walls. Such columns are not required to have a fire-resistance rating if they are 3 m (9 ft. 10 in.) or more away from an exposing building to avoid the risk of flame impingement.

9.10.15. Spatial Separation Between Houses

General Information for Spatial Separation is provided at the start of Guide 9.10.14., Spatial Separations Between Buildings.

Somewhat less stringent and less complicated fire protection measures are needed to avoid one person's property damaging another's as a result of fire spread when buildings are smaller and contain only dwelling units.

9.10.15.1. Application

This Article states that NBC Subsection 9.10.15. applies to buildings that contain only dwelling units, and have either no dwelling units above another dwelling unit or only one dwelling unit above another where one of those is a secondary suite.

More specifically, the buildings to which NBC Subsection 9.10.15. applies include:
- individual houses with or without a secondary suite,
- semi-detached houses where each house may contain a secondary suite, and
- row houses, where any house may contain a secondary suite.

NBC Subsection 9.10.15. does not apply to stacked townhouses, stacked duplexes or stacked dwelling units other than a house with a secondary suite.

Refer to NBC Section 9.9. for the requirements that pertain to openings near unenclosed exit stairs and ramps, openings near exit doors, and the location of skylights in the roofs of buildings that have walls exposed to a fire hazard from an adjoining roof.

9.10.15.2. Area and Location of Exposing Building Face

This Article describes the methods for determining the area of an exposing building face.

The location of the exposing building face and the determination of the area that applies to a simple case of planar exterior walls parallel to the property line are described in Guide 9.10.14., General Information for Spatial Separation.

The area of the exposing building face is the width of an exterior wall times the height, measured from the finished ground level to the uppermost ceiling. Where the dwelling units are separate fire compartments divided by means of vertical fire separations having fire-resistance ratings of at least 45 min, the exposing building face is the distance between the fire separations multiplied by the height, measured from the finished ground level to the uppermost ceiling. Note that, where a house contains a secondary suite, the two dwelling units are not separated by fire separations, so that the entire house is a single fire compartment.

Analysis by the National Fire Laboratory(4) found that where a wall is stepped back relative to a property line, each portion of the wall can have its own limiting distance. This allows larger window areas in those sections of the wall that are situated further from the property line. The exposing building face of houses can be divided as best suits the architectural design in order to achieve the maximum window area where desired without increasing the risk of fire spread to a neighboring building. On skewed walls (walls not parallel to the property line), it is permitted to divide the exposing building face into any number of parts, and then determine a limiting distance for each one of those parts. (Sample formulas for these calculations are shown in Guide 9.10.15.4., Glazed Openings in Exposing Building Face.)

Consequently, where NBC Table 9.10.15.4. is used to determine the maximum permitted aggregate area of glazed openings, the exposing building face can be divided into individual vertical portions measured from the ground to the uppermost ceiling. The maximum aggregate area of glazed openings permitted in any portion of the wall located at a given limiting distance shall conform to the values in the row of NBC Table 9.10.15.4. that correspond to the maximum total area of exposing building face (see column 1 of the Table) that is equal to the sum of all portions of the exposing building face (NBC Sentence 9.10.15.4.(2)).

Where the exposing building face of any section of an exterior wall enclosing a single room or space, or a combination room or space, has a limiting distance of 2 m (6 ft. 7 in.) or less, that section of the exposing building face serving the room or space cannot be divided into portions for the purpose of calculating the area of exposing building face (see NBC Sentence 9.10.15.4.(5)). This is intended to avoid concentrations of glazed openings close to the property line where these serve the same area or space, and could act as a single radiator.

(4) K. Sumathipala, Committee Paper on Allowable Openings in Exterior Walls for Stepped Exterior Faces, National Fire Laboratory, National Research Council of Canada, Ottawa, 1992.

For determining the type of cladding/sheathing assembly permitted, and the fire-resistance rating required for walls that are skewed or staggered, the exposing building face is individually determined for each section of the wall.

9.10.15.3. Limiting Distance and Fire Department Response

This Article requires that, when the fire department response time exceeds the 10 min maximum set for early action against the spread of fire from one building to another, the limiting distance values be reduced. See Guide 9.10.14., General Information for Spatial Separation.

9.10.15.4. Glazed Openings in Exposing Building Face

This Article sets the maximum allowable area of glazed openings, as well as their spacing, location and protection. See Guide 9.10.14., General Information for Spatial Separation.

The method for determining unprotected openings for separate limiting distances is shown in Example 9.

Maximum Aggregate Area of Glazed Openings (NBC Sentence 9.10.15.4.(1))

The limits that are placed on the openings in exposing building faces of houses apply only to glazed openings such as windows, sliding doors and hinged doors with glazing. The area of glazed opening is measured to the rough opening of the window or door, not just to the edge of the glazing.

The maximum permitted aggregate area of glazed openings can be determined using NBC Table 9.10.15.4., NBC Subsection 3.2.3., or by calculating the area that is equal to or less than the limiting distance squared, where the limiting distance is not less than 1.2 m (3 ft. 11 in.). Where the tables in NBC Part 3 are used, the limits for unprotected openings apply to glazed openings.

Determination of Maximum Areas of Glazed Openings and Construction for Irregular Shapes or Skewed Exterior Walls (NBC Sentence 9.10.15.4.(2))

As mentioned, studies at the NRC National Fire Laboratory have shown that, where an exposing building face is stepped back from the property line or is at an angle to the property line, it is possible to increase the percentage of glazing in those portions of the exposing building face further from the property line without increasing the amount of radiated energy that would reach the property line in the event of a fire in such a building. The requirements pertaining to the construction of those portions of the exposing building face can also be reduced.

Examples 9 to 12 show how NBC Sentences 9.10.15.4.(1) and (2), and 9.10.15.5.(1), (2) and (3) can be applied to exposing building faces that are stepped back from or not parallel to the property line. The following procedure can be used to establish the maximum permitted area of glazed openings for such facades:

1. Calculate the total area of the exposing building face (i.e., the façade of the fire compartment) as described in the definition of exposing building face.
2. Identify the portions into which the exposing building face is to be divided. It can be divided into any number of portions, not necessarily of equal size.
3. Measure the limiting distance for each portion. The limiting distance is measured along a line perpendicular to the wall surface from the point closest to the property line.
4. Establish the line in NBC Table 9.10.15.4. from which the maximum permitted percentage area of glazed openings will be read. The selection of the line depends on the maximum area of exposing building face for the whole fire compartment, including all portions, as determined in Step 1.
5. On that line, read the maximum percentage area of glazed openings permitted in each portion of the exposing building face according to the limiting distance for that portion.
6. Calculate the maximum area of glazed openings permitted in each portion. The area is calculated from the percentage found applied to the area of that portion.

NBC Table 9.10.15.4. is used to determine the maximum area of glazed openings. The examples do not show the maximum concentrations or spacings of glazed openings. They are examples of how the requirements are to be applied.

Example 9 – Determining the Maximum Area of Glazed Openings in an Irregularly Shaped Exposing Building Face

Find the maximum area of glazed openings for each portion of the irregularly shaped exposing building face shown in Figure A.

1. LD_1 is the limiting distance for the purpose of using NBC Table 9.10.15.4. to determine the maximum area of glazed openings (NBC Sentence 9.10.15.2.(3)). The total area of the exposing building face is $A_1 + A_2 + A_3 = 120\ m^2$. Therefore, according to NBC Table 9.10.15.4., NBC Subclause 9.10.15.2.(1)(b)(iii) and NBC Sentence 9.10.15.4.(2), the maximum areas of glazed openings, P_1, P_2 and P_3, for each portion of the exposing building face are 8%, 12% and 0% of the portion area, respectively:
   $P_1 \leq 50 \times 0.08 = 4\ m^2$
   $P_2 \leq 30 \times 0.12 = 3.6\ m^2$
   $P_3 = 40 \times 0 = 0\ m^2$
2. LD_3 is the limiting distance for the purpose of determining the required cladding-sheathing assembly and fire-resistance rating (NBC Sentence 9.10.15.2.(4)).

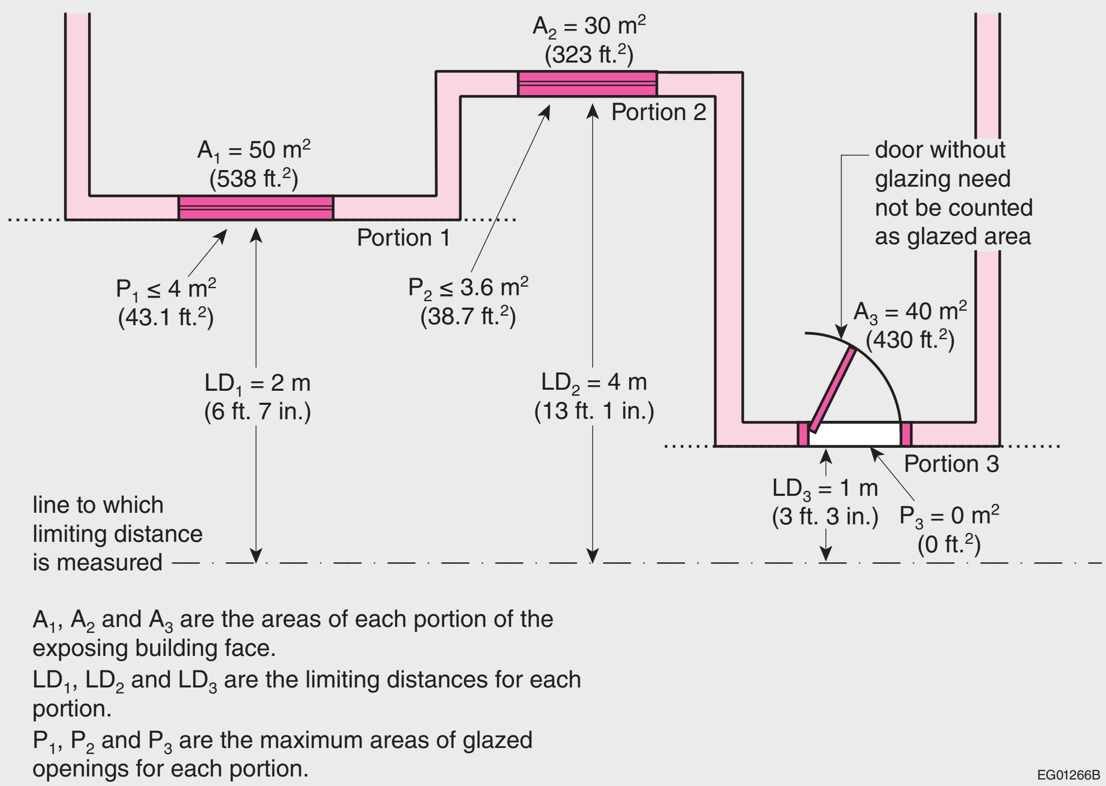
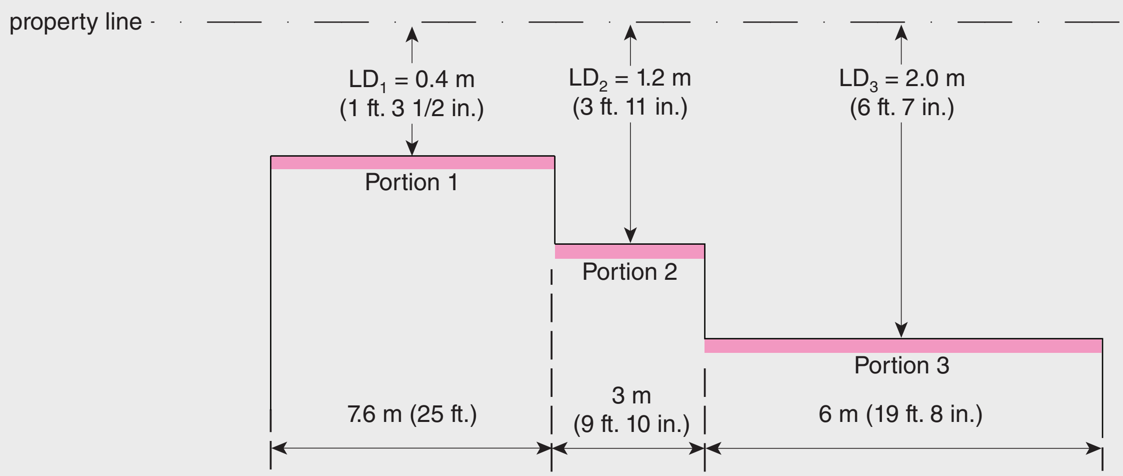


Figure A
Determination of the maximum area of glazed openings for the exposing building face of a staggered wall of a house

Example 10 – Determining the Required Minimum Fire-Resistance Rating, Cladding Type and Maximum Area of Glazed Openings for the Exposing Building Face of a Stepped Wall of a House

A house has a stepped wall with an exposing building face having three portions with limiting distances, LD_1, LD_2 and LD_3 (Figure A). The requirements in NBC Subsection 9.10.15. relating to fire-resistance rating, cladding type, and the maximum area of glazed openings are applied to each portion of the exposing building face individually. In this case, a minimum 45 min fire-resistance rating and noncombustible cladding are required for Portion 1 of the exposing building face, but there are no restrictions on cladding type and no minimum fire-resistance rating for Portions 2 and 3. No glazed openings are permitted in Portion 1; for Portions 2 and 3, the maximum percentage areas of glazed openings are 7% and 11%.



	Portion 1	Portion 2	Portion 3
Minimum 45 min fire-resistance rating	required(1)	not required(2)	not required(2)
Type of cladding	noncombustible(1)	no restrictions(2)	no restrictions(2)
Maximum percentage area of glazed openings(3)	0%	7%	11%
Maximum area of glazed openings	0	$3 \times 2.4 \times 0.07 = 0.50$ m^2 (5.4 ft.^{2})	$6 \times 2.4 \times 0.11 = 1.58$ m^2 (17 ft.^{2})

Total length of exposing building face = 16.6 m (54 ft. 5 1/2 in.)
Height of exposing building face = 2.4 m (7 ft. 10 in.)
Total area of exposing building face = 16.6 x 2.4 = 40 m^2 (430 ft.^{2})

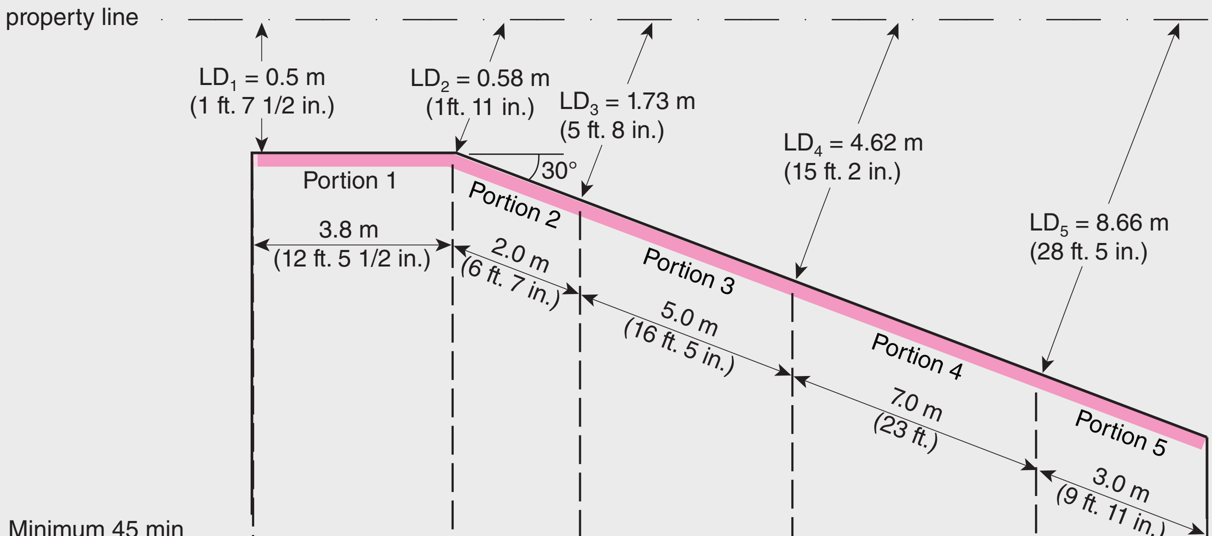
EG00417E

Figure A
Determination of the required minimum fire-resistance rating, cladding type and maximum area of glazed openings for the exposing building face of a stepped wall of a house

Notes to Figure A:
(1) See NBC Sentence 9.10.15.5.(2).
(2) See NBC Sentence 9.10.15.5.(3).
(3) See NBC Table 9.10.15.4., NBC Subclause 9.10.15.2.(1)(b)(iii) and NBC Sentence 9.10.15.4.(2).

Example 11 – Determining the Required Minimum Fire-Resistance Rating, Cladding Type and Maximum Area of Glazed Openings for the Exposing Building Face of a Skewed Wall of a House

In this example, the exposing building face of a skewed wall of a house is divided into five portions with limiting distances, LD_1 to LD_5 (Figure A). The requirements in NBC Subsection 9.10.15. relating to fire-resistance rating, cladding type and maximum area of glazed openings are applied to each portion of the exposing building face individually. Any arbitrary division of the exposing building face is acceptable as long as these requirements are respected for each portion. In this case, a minimum 45 min fire-resistance rating and noncombustible cladding are required for Portions 1 and 2 of the exposing building face, but there are no restrictions on cladding type and no minimum fire-resistance rating for Portions 3 to 5. No glazed openings are permitted in Portions 1 and 2; for Portions 3, 4 and 5, the maximum percentage areas of glazed openings are 9% (determined by interpolation), 28% and 100%.



	Portion 1	Portion 2	Portion 3	Portion 4	Portion 5
Minimum 45 min fire-resistance rating	required(1)	required(1)	not required(2)	not required(2)	not required(2)
Type of cladding	noncombustible(1)	noncombustible(1)	no restrictions(2)	no restrictions(2)	no restrictions(2)
Maximum percentage area of glazed openings(3)(4)	0%	0%	9%	28%	100%
Maximum area of glazed openings	0	0	5.0 × 2.4 × 0.09 = 1.08 m² (11.6 ft.²)	7.0 × 2.4 × 0.28 = 4.70 m² (50.6 ft.²)	3.0 × 2.4 × 1.0 = 7.20 m² (77.5 ft.²)

Total length of exposing building face = 20.8 m (68 ft. 3 in.)
Height of exposing building face = 2.4 m (7 ft. 10 in.)
Total area of exposing building face = 20.8 × 2.4 = 50 m^2 (538 $ft.^2$)

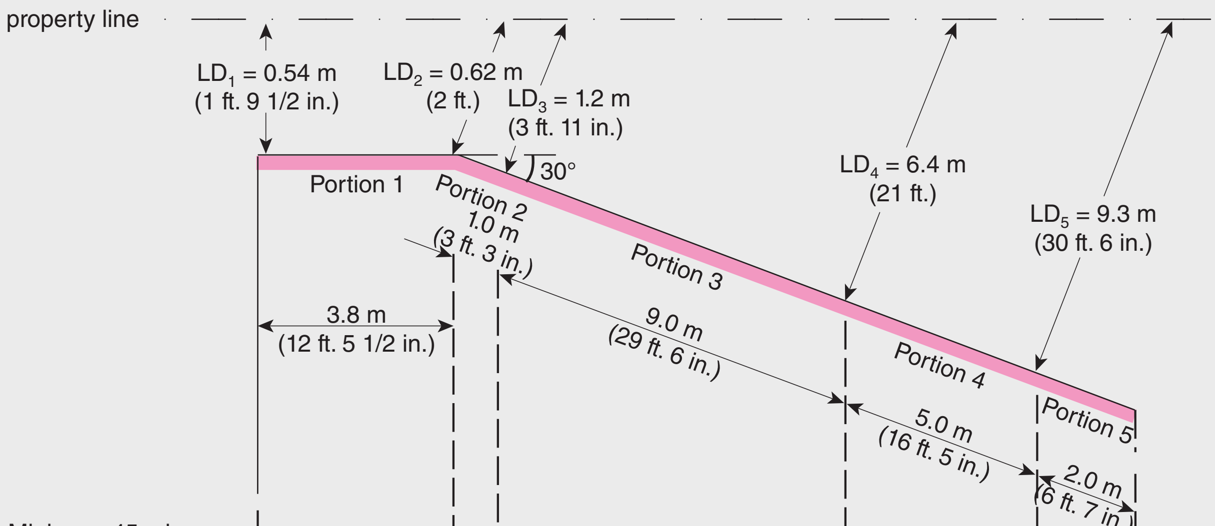
EG00378E

Figure A
Determination of the required minimum fire-resistance rating, cladding type and maximum area of glazed openings for the exposing building face of a skewed wall of a house

Notes to Figure A:
(1) See NBC Sentence 9.10.15.5.(2).
(2) See NBC Sentence 9.10.15.5.(3).
(3) See NBC Table 9.10.15.4., NBC Subclause 9.10.15.2.(1)(b)(iii) and NBC Sentence 9.10.15.4.(2).
(4) To simplify the determination of the maximum area of glazed openings, choose the column for the lesser limiting distance nearest to the actual limiting distance. Interpolation for the actual limiting distance is also acceptable and may result in a slightly larger maximum area of glazed openings. Interpolation can only be used for limiting distances greater than 1.2 m (3 ft. 11 in.).

Example 12 – Determining the Required Minimum Fire-Resistance Rating, Cladding Type and Maximum Area of Glazed Openings for the Exposing Building Face of a Skewed Wall of a House

In this example, the exposing building face of the same skewed wall as in Example 11 is divided into five different portions with limiting distances, LD_1 to LD_5 (Figure A). In this case, the required minimum fire-resistance ratings and cladding types are the same as in Example 11. No glazed openings are permitted in Portions 1 and 2; for Portions 3, 4 and 5, the maximum percentage areas of glazed openings are 7%, 57% and 100%.



Minimum 45 min fire-resistance rating	required(1)	required(2)	not required(2)	not required(2)	not required(2)
Type of cladding	noncombustible(1)	noncombustible(2)	no restrictions(2)	no restrictions(2)	no restrictions(2)
Maximum percentage area of glazed openings(3)(4)	0%	0%	7%	57%	100%
Maximum area of glazed openings	0	0	9.0 × 2.4 × 0.07 = 1.51 m² (16.2 ft.²)	5.0 × 2.4 × 0.57 = 6.84 m² (73.6 ft.²)	2.0 × 2.4 × 1.0 = 4.8 m² (15.7 ft.²)

Total length of exposing building face = 20.8 m (68 ft. 3 in.)

Height of exposing building face = 2.4 m (7 ft. 10 in.)

Total area of exposing building face = 20.8 × 2.4 = 50 m^2 (538 $ft.^2$)

EG00379E

Figure A

Determination of the required minimum fire-resistance rating, cladding type and maximum area of glazed openings for the exposing building face of a skewed wall of a house

Notes to Figure A:

(1) See NBC Sentence 9.10.15.5.(2).
(2) See NBC Sentence 9.10.15.5.(3).
(3) See NBC Table 9.10.15.4., NBC Subclause 9.10.15.2.(1)(b)(iii) and NBC Sentence 9.10.15.4.(2).
(4) To simplify the determination of the maximum area of glazed openings, choose the column for the lesser limiting distance nearest to the actual limiting distance. Interpolation for the actual limiting distance is also acceptable and may result in a slightly larger maximum area of glazed openings. Interpolation can only be used for limiting distances greater than 1.2 m (3 ft. 11 in.).

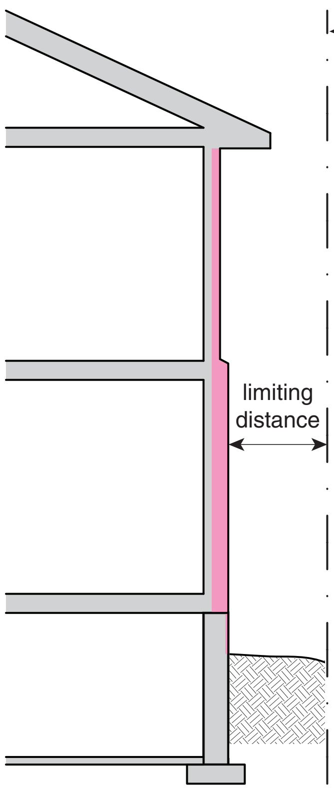
Area of Glazed Openings for a Dwelling Unit Facing a Detached Garage or Accessory Building (NBC Sentence 9.10.15.4.(6))

Where a dwelling unit faces a detached garage or accessory building that serves only that dwelling unit, the limit on the area of glazed openings need not apply to the exposing building face, provided that the two buildings are on the same property, and that the dwelling unit served by the garage is the only major occupancy on the property.

9.10.15.5. Construction of Exposing Building Face of Houses

This Article determines the types of construction permitted on exposing walls, as determined by the percentage of openings and their proximity to the property line. See Guide 9.10.14., General Information for Spatial Separation.

Although the rationale for increasing the level of fire protection of exposing walls of houses in relation to their proximity to the property line is the same as for other buildings, a lower level of protection is permitted for dwelling units, provided that either such units are not stacked one above another, or that not more than one unit is stacked on top of another, and that one of these two is a secondary suite. This relaxation is largely related to the cost of providing a higher level of fire protection. However, it is also rationalized on the basis of past performance, and the fact that the risk to life is very minimal in such locations.



Limiting Distance (LD)	Minimum Fire-Resistance Rating	Cladding Type	Maximum Area of Glazed Openings
LD < 0.6 m (2 ft.)	45 min	• metal or noncombustible • vinyl over gypsum sheathing or masonry • wall assembly complies with NBC Clause 3.1.5.5.(1)(b)(1)	0%
0.6 m (2 ft.) ≤ LD < 1.2 m (3 ft. 11 in.)	45 min	• metal or noncombustible • combustible over gypsum sheathing or masonry • vinyl over gypsum sheathing or masonry • wall assembly complies with NBC Clause 3.1.5.5.(1)(b)(2)	0%
LD ≥ 1.2 m (3 ft. 11 in.)	—	combustible (no restrictions)	See NBC Table 9.10.15.4.

EG00013C

Figure 9.10.-30
Construction requirements for exposing building faces of houses depending on the limiting distance

Notes to Figure 9.10.-30:
(1) See NBC Sentence 9.10.15.5.(2).
(2) See NBC Sentence 9.10.15.5.(3).

Minimum Construction Requirements (NBC Sentences 9.10.15.5.(1) to (3))

The construction requirements apply to exposing building faces and any exterior wall that is located above an exposing building face that encloses an attic or roof space.

Three levels of stringency are specified depending on limiting distance. These are described below, and illustrated in Figure 9.10.-30.

Where the limiting distance is less than 0.6 m (2 ft.), the exposing building face and walls above must have a fire-resistance rating of at least 45 min, have metal or noncombustible cladding, have vinyl cladding with specified properties and installation, or the assembly must be tested.

Where the limiting distance is equal to or greater than 0.6 m (2 ft.) and less than 1.2 m (3 ft. 11 in.), the same fire resistance and cladding requirements apply, except that wood-based cladding is also permitted provided it complies with the various property and installation criteria.

In the case of a limiting distance of 1.2 m (3 ft. 11 in.) or more, no limitations apply.

Although aluminum siding is not considered noncombustible because of its low melting point, it is permitted to be installed where noncombustible cladding is otherwise required because of its limited contribution to fire load.

When vinyl siding is installed where noncombustible siding is otherwise required, it must be installed directly (without furring members) where the limiting distance is less than 0.6 m (2 ft.). It may be installed without furring or on furring that is not more than 25 mm (1 in.) thick where the limiting distance is equal to or greater than 0.6 m (2 ft.), but less than 1.2 m (3 ft. 11 in.). These limits reduce flame propagation behind the cladding. In either case, it must be installed over 12.7 mm (1/2 in.) gypsum board or over masonry to avoid fire spread into the assembly. The vinyl must have a flame-spread rating not greater than 25, and be no more than 2 mm (2/32 in.) thick exclusive of fasteners, joints and local reinforcements to limit contribution to a fire.

Similarly, when wood-based cladding is installed where noncombustible cladding is otherwise required, it may be installed without furring or on furring that is not more than 25 mm (1 in.) thick. It must be installed over 12.7 mm (1/2 in.) gypsum board or over masonry to avoid fire spread into the assembly. The cladding must have a flame-spread rating not greater than 25 to limit contribution to a fire.

Exception for a Dwelling Unit Facing a Detached Garage or Accessory Building (NBC Sentence 9.10.15.5.(4))

Where a detached garage or accessory building serving a single dwelling unit is on the same property as the dwelling unit it serves, and where that dwelling unit is the only major occupancy on the property, the exposing building face of the dwelling unit facing the garage or accessory building is exempt from the fire-resistance rating and cladding requirements that would otherwise apply.

9.10.16. Fire Blocks

9.10.16.1. Required Fire Blocks in Concealed Spaces

This Article determines where fire blocks are required. The function of fire blocks is to reduce the extent of fire spread in buildings until evacuation can be safely carried out, and to allow firefighting to commence before damage to a building becomes extensive.

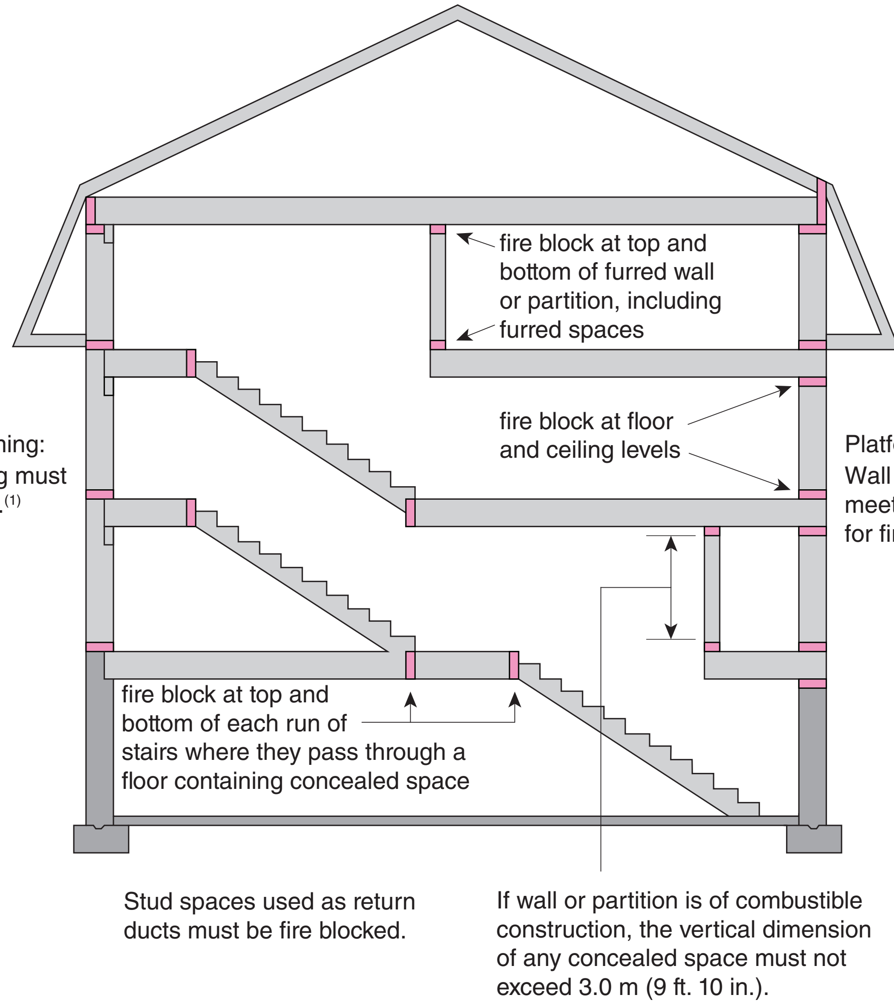
Fires originating in concealed spaces, or that gain entry through openings in enclosing membranes, can travel undetected from one part of the building to another. This may jeopardize the occupants‘ escape, and make firefighting very difficult.

It may also neutralize the effectiveness of fire compartments in controlling the extent of fire damage. Unless such spaces are completely filled with insulation or are made from material that will limit flame travel (i.e., a flame-spread rating of 25 or less), or the width of the concealed space is less than 25 mm (1 in.) to limit air supply, fire blocking must be provided at strategic locations to restrict the spread of fire.

In small spaces, such as stud, joist and furring spaces, fire blocking usually consists of the same material as the framing and furring. In larger spaces, such as attics and soffits, sheet material is generally used such as 12.7 mm (1/2 in.) gypsum board, 12.5 mm (1/2 in.) plywood, oriented strandboard (OSB) or waferboard, or 0.38 mm (28 gauge) sheet steel. A double layer of board lumber is also permitted if the joints are staggered between layers. Fire blocks can be pierced by piping, wiring or ducts, provided the openings around the penetrations are tight-fitting or sealed with a fire-resisting material.

Concealed spaces that are very shallow (25 mm (1 in.) or less), or that are filled with mineral wool, do not facilitate the propagation of fire within the space, making it unnecessary to install fire blocks.

Figure 9.10.-31 shows where fire blocking is required in a typical house.



Fire Block Materials
• 0.38 mm (0.015 in.) sheet steel • 12.7 mm (1/2 in.) gypsum board • 12.5 mm (1/2 in.) plywood, OSB or waferboard • 2 layers of 19 mm (3/4 in.) lumber with staggered joints • 38 mm (1 1/2 in.) lumber

EG00020C

Figure 9.10.-31
Fire block locations and materials

Note to Figure 9.10.-31:
(1) See Figures 9.10.-36 and 9.23.-1.

A building's overhanging eaves and appendages, such as exterior passageways, balconies and canopies, create spaces where fire can spread horizontally within concealed spaces. Vertical fire blocks are, therefore, required at horizontal intervals of not more than 20 m (65 ft. 7 in.), and at locations where the construction extends across the ends of fire separations, such as in row housing with gambrel-type roofs (Figure 9.10.-32). This requirement applies to both sprinklered and unsprinklered buildings.

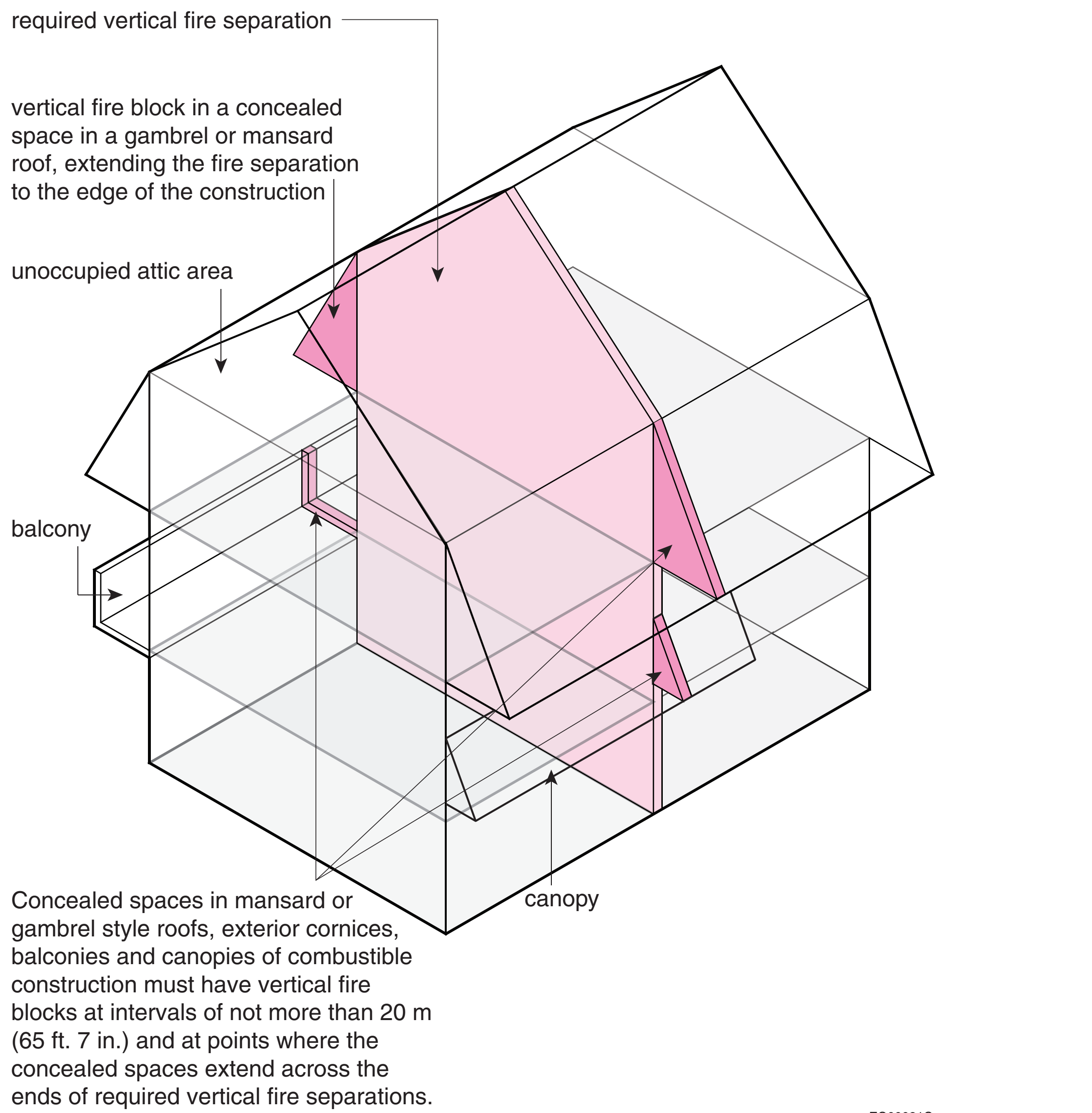


Figure 9.10.-32
Fire block locations in horizontal concealed spaces

Attic spaces are known to contribute to fire spread. Fire can enter such spaces through the overhanging soffits or from openings in the attic ceiling. Fire can also originate within the attic as a result of improper electrical installations (e.g., loose connections or overheated recessed lights). To reduce the speed of fire travel through large unoccupied attic areas and roof spaces, fire blocking is required at suitable intervals (not more than 20 m (65 ft.)), so that the individual open areas are kept reasonably small (at least 300 m² (3 220 ft.²)). In the case of truss roofs, sheet type fire blocking is usually fastened to the sides of trusses at suitable intervals.

Figure 9.10.-33 shows the fire blocking of a mansard roof.

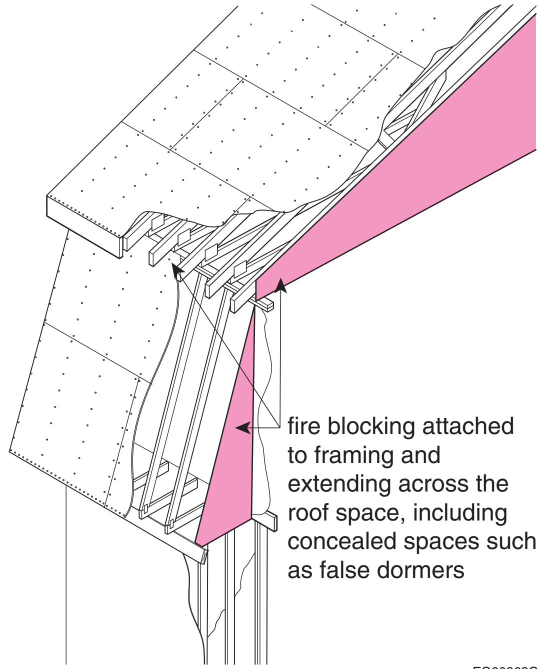


Figure 9.10.-33
Fire blocking in concealed spaces in a mansard roof

The framing of an opening for stairs through a wood joist floor normally requires a framing member for structural integrity at the top and bottom of each stairway and, in so doing, provides a fire block as seen in Figure 9.10.-34.

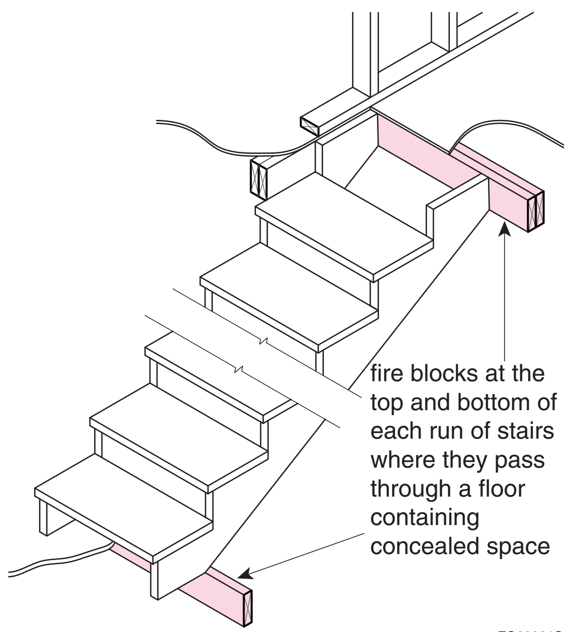


Figure 9.10.-34
Fire blocks for stairs

9.10.16.2. Required Fire Blocks in Wall Assemblies

This Article indicates where fire blocking is required in walls. Wall assemblies that have concealed spaces greater than 25 mm (1 in.) in depth created by furring and spaces between the studs require fire blocks every 3 m (9 ft. 10 in.) vertically and every 20 m (65 ft. 7 in.) horizontally, unless the exposed construction materials within the space are noncombustible, have a flame-spread rating of not more than 25, or are filled with insulation. The value of the flame-spread rating of the combustible materials determines the permitted extent of the concealed space between fire blocks. The materials to be considered include all construction materials regulated by the NBC, including the framing and building services that are located in the concealed space.

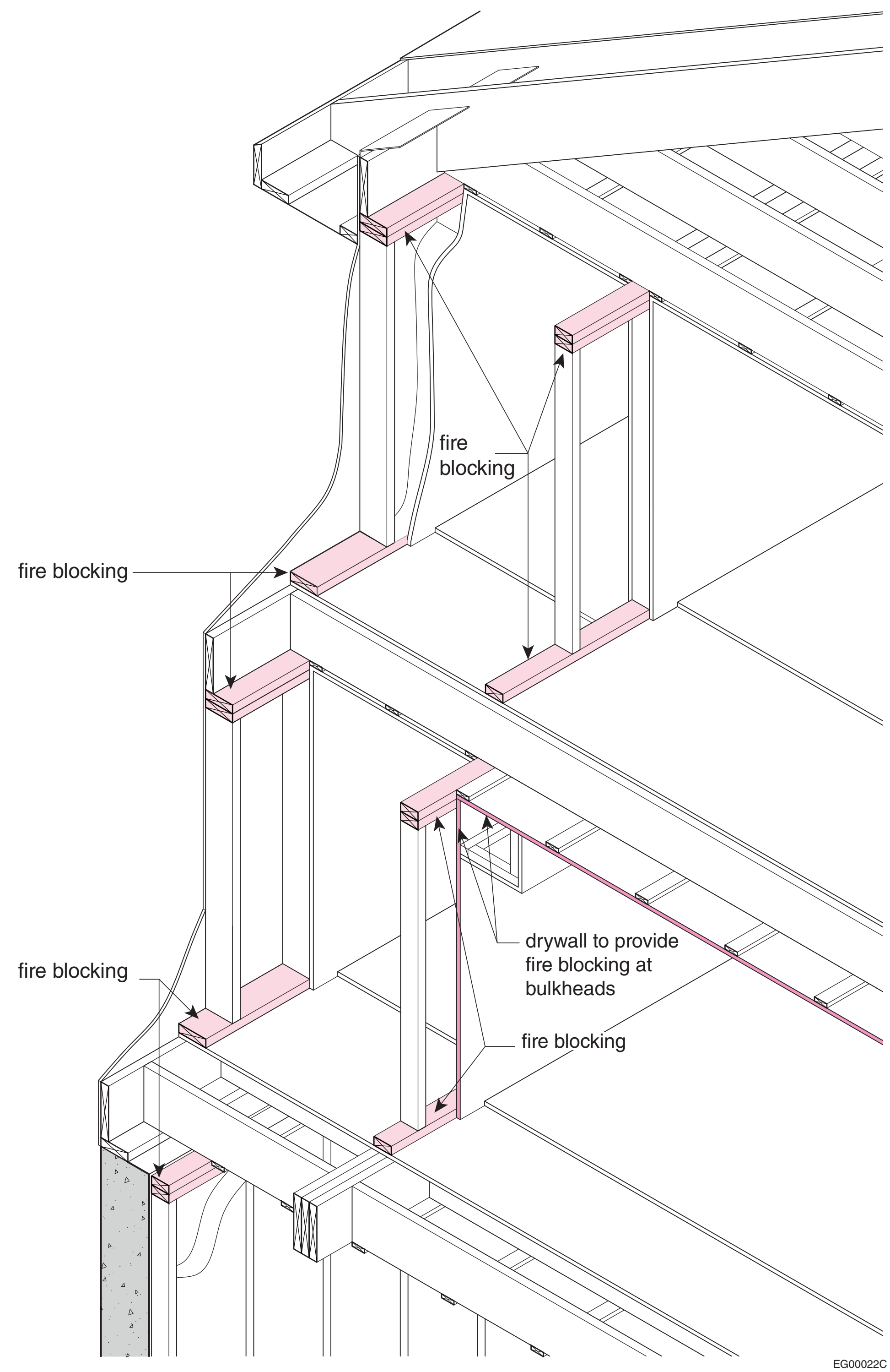


Figure 9.10.-35
Fire blocking within wood framing

In platform frame construction, many of these requirements are met as a result of normal framing practices. This is illustrated in Figure 9.10.-35.

In balloon frame construction where the stud spaces are continuous through two or more storeys, the spaces between the studs have to be blocked off at each level to restrict fire spread (Figure 9.10.-36).

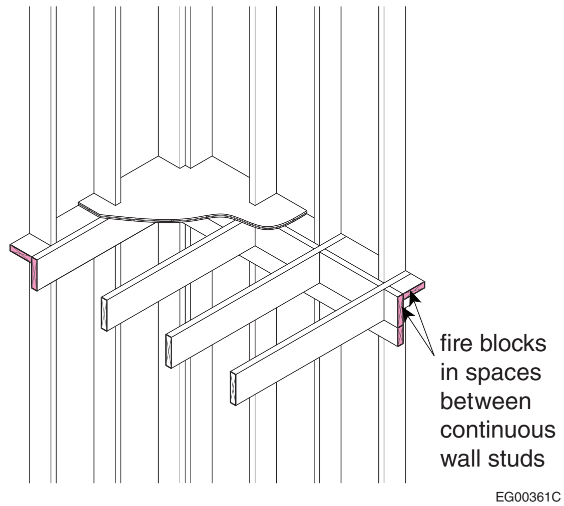


Figure 9.10.-36
Fire blocks for balloon framing

Concealed spaces in walls should not interconnect with concealed spaces above or below them. Coved ceilings that can create pathways between the wall space and either floor spaces or attic spaces should be fire blocked at the bottom of the cove to prevent communication between the horizontal and the vertical spaces (Figure 9.10.-37).

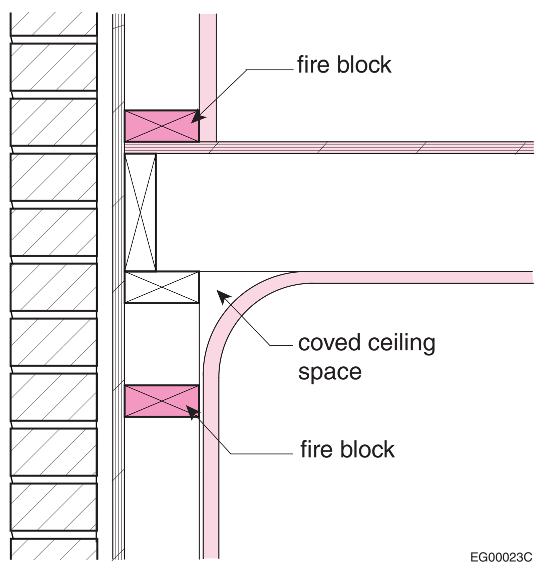


Figure 9.10.-37
Fire blocks for coved ceilings

Furring or strapping can also create spaces that allow fire spread. These should also be blocked off at each floor level and at the ceiling level if the ceiling membrane provides part of the required fire resistance (Figure 9.10.-38). Since furring can be installed either horizontally or vertically, both the horizontal and vertical spacings of fire blocks are limited (20 m (65 ft. 7 in.) and 3 m (10 ft.), respectively).

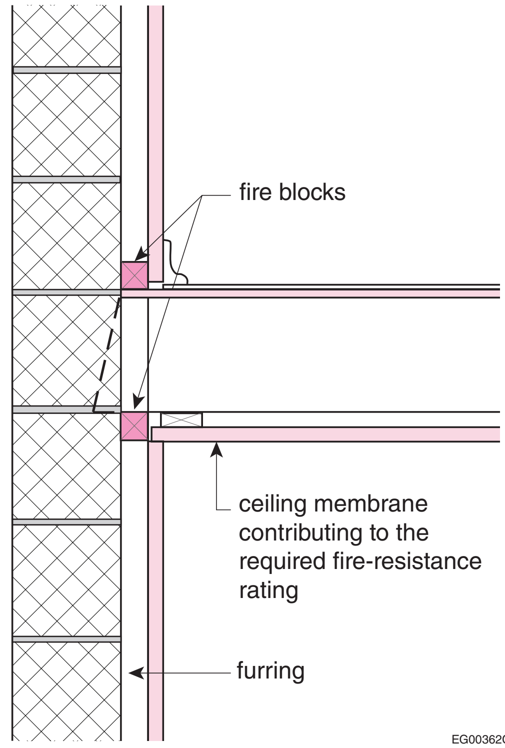


Figure 9.10.-38
Fire blocking of furring at ceiling level

9.10.16.3. Fire Block Materials

This Article sets the requirements for the construction of fire blocks, including acceptable materials capable of resisting the spread of fire within a concealed space for sufficient time to permit the safe evacuation of the occupants, and to allow firefighting to commence before significant damage has occurred.

Materials for fire blocking include 0.38 mm (28 gauge) sheet steel, 12.7 mm (1/2 in.) gypsum board, 12.5 mm (1/2 in.) plywood, OSB or waferboard, two layers of 19 mm (3/4 in.) lumber with staggered joints, or 38 mm (1 1/2 in.) lumber.

In a building permitted to be of combustible construction, semi-rigid fibre insulation board produced from glass, rock or slag is permitted to be used to block the vertical space in a double-frame wall assembly formed at the intersection of the floor assembly and the walls, provided the width of the vertical space does not exceed 25 mm (1 in.), and that the insulation board has the required density, is securely fastened to one set of studs, extends from below the bottom of the top plates in the lower storey to above the top of the bottom plate in the upper storey, and completely fills the portion of the vertical space between the headers and between the wall plates. Figure 9.10.-39 shows the location of the semi-rigid fibre insulation board at the intersection between walls and floors in wood-frame construction. The figure is intended to illustrate the fire block detail and not a design of a fire separation.

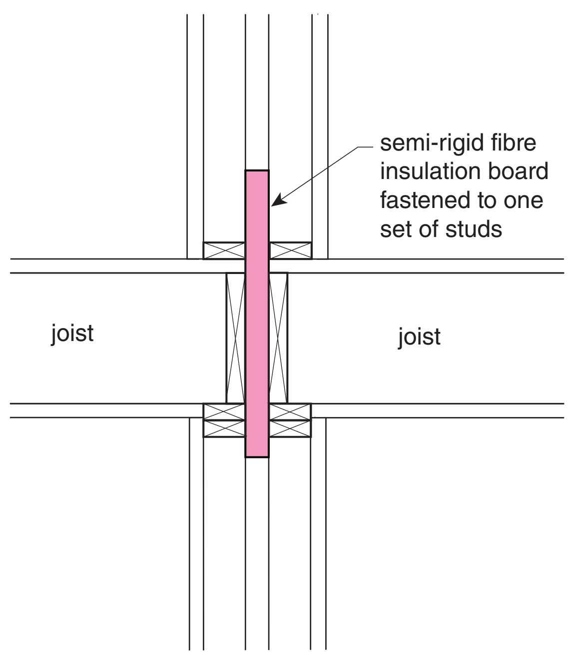


Figure 9.10.-39
Fire block in a double-frame wall assembly

9.10.16.4. Penetration of Fire Blocks

This Article is intended to ensure that the effectiveness of fire blocks is maintained at penetrations for sufficient time to permit the safe evacuation of the occupants, and to allow firefighting to commence before significant damage has occurred. This requirement is satisfied by the use of generic fire stops such as mineral wool, gypsum plaster or Portland cement mortar, as well as rated fire stops.

9.10.17. Flame-Spread Limits

The rate of fire spread within a compartment is influenced by the properties of the materials that line the interior surfaces. The flame-spread test used to rank lining materials for Code purposes in Canada is based on the use of the Steiner tunnel test apparatus.

9.10.17.1. Flame-Spread Rating of Interior Surfaces

This Article sets maximum allowable flame-spread ratings. The flame-spread characteristics of wall and ceiling surfaces affect the rate of fire spread in a building. The purpose of flame-spread limits is to allow occupants sufficient time to be safely evacuated, and to allow firefighting to start before damage becomes extensive.

NBC Appendix D, Table D-3.1.1.-A, lists the flame-spread ratings for a number of common generic finish materials. Painted or papered gypsum board, gypsum plaster, concrete and masonry are shown with a flame-spread rating of 25 or less. Bare or painted lumber is shown to be 150 or less, the same as for most common plywood (11 mm (7/16 in.) thickness). The flame-spread rating of plywood increases, however, as the thickness decreases. The flame-spread rating of plywood with a thickness of less than 11 mm (7/16 in.) may exceed 150, unless the plywood is treated with a flame retardant.

Conventional wood trim, wood doors, and certain plastic materials are not able to meet the low flame-spread limits established for wall and ceiling surfaces in critical areas such as public corridors and exits. While wood products can be treated, and plastic materials formulated to provide lower flame-spread ratings, it is considered more practical to allow a small portion (10%) of the surface area to exceed the flame-spread rating required for the general surface areas.

For the same reason, doors are also allowed to have a higher flame-spread rating. Moulded plastic bathroom fixtures may also exceed the limits specified for most wall surfaces. The surface area of bathrooms, however, is relatively small. This, combined with the fact that relatively few fires occur in bathrooms, has justified relaxing flame-spread limits in residential suites. Table 9.10.-D summarizes the maximum flame-spread ratings for the wall and ceiling finishes in various locations.

Table 9.10.-D
Maximum Flame-Spread Ratings

Location	Surface	Maximum Flame-Spread Rating	
		At least 90% of the surface area(1)	Remaining surface area(1)
Exits	Ceiling	25	150
	Wall	25(2)	150(2)
Public corridors, unsprinklered	Ceiling	25	150
	Wall		
	entire, or	75	150
	top half and	25	150
	bottom half	150	150
Public corridors, sprinklered	Ceiling	150	150
	Wall	150	150
Bathrooms within residential suites	Ceiling	200	200
	Wall	200	200
Exterior exit passageway that provides the sole means of egress	Ceiling, including soffit	25	150
	Wall, including guard	25	150
Other(3)	Ceiling	150	150
	Wall	150	150
Not within dwelling units	Door or garage door	200	200
Within dwelling units	Door other than garage door	No limit	No limit

Notes to Table 9.10.D.:

(1) Skylights, glazing, combustible doors, and combustible light diffusers and lenses are not considered in the calculation of wall and ceiling areas (NBC Article 9.10.17.6.).

Table 9.10.-D (Continued)

(2) In lobbies used as exits, at least 75% of the wall area is required to have a flame-spread rating of not more than 25 (NBC Sentence 9.10.17.3.(2)).
(3) Except as otherwise provided, the exposed surface of every interior wall and ceiling, including skylights and glazing, is required to have a surface flame-spread rating of not more than 150 (NBC Sentence 9.10.17.1.(1)).

Floor surfaces are less critical than wall and ceiling surfaces in propagating fire. Therefore, floors are not subject to flame-spread limits in NBC Part 9. Sparks from fireplaces and carelessly discarded smoking materials can start carpet fires due to the ease of ignition of some synthetic fibres. This potential hazard has led to the regulation of carpets under the federal Hazardous Products Act. The Act, which regulates the advertising, sale and importation of hazardous products, is administered federally and not locally. All such carpeting is required to be tested for ease of ignition.

9.10.17.2. Ceilings in Exits or Public Corridors

This Article limits the acceptable flame-spread rating for the ceilings in exits or public corridors to not more than 25 on at least 90% of the exposed surface so that they remain usable long enough to enable egress. Since fires tend to propagate along the upper surfaces, the flame-spread limit for ceilings must be kept low.

9.10.17.3. Walls in Exits

This Article limits the acceptable flame-spread rating for the walls of exits to not more than 25 on at least 90% of the exposed surface so they remain usable long enough to enable egress. Exit wall surfaces can play an important role in flame spread, particularly in stairwells that connect two or more floors. Fire travels more quickly vertically than horizontally, and when doorways are opened, stairwells can act as conduits for fire from one level to another. Exit walls are, therefore, also required to have a low flame-spread rating to limit this. This requirement may be slightly relaxed in an exit lobby where only one storey is involved (principally to allow the use of wainscoting as a decorative feature along the lower portion).

9.10.17.4. Exterior Exit Passageways

This Article limits the acceptable flame-spread rating for the walls and ceilings of an exterior passageway that is the only means of egress to not more than 25 on at least 90% of the exposed surface so that it remains usable long enough to enable egress. Up to 10% of the total wall area and ceiling area is permitted to have a surface flame-spread rating of not more than 150. Experience has shown that fire can travel quickly along exterior passageways, particularly in dry weather accompanied by high winds. Such passageways can be ignited by fire issuing from the window of an adjacent suite. If such passageways are the only escape routes, they must be kept tenable until evacuation is complete, and the flame-spread ratings of the various components are kept very low to limit the propagation of flame.

9.10.17.5. Walls in Public Corridors

This Article limits the acceptable flame-spread rating for the walls in public corridors to not more than 75 or to not more than 25 on at least 90% of the upper half of the wall so they remain usable long enough to enable egress. Since only one storey is involved, the flame-spread rating for corridor walls is permitted to be higher than that for exit walls. Since flames tend to spread faster along the upper surfaces of a corridor, the lower parts of such walls are permitted to have a higher flame-spread rating (to permit the use of wainscoting), provided the rating for the upper half of the wall is reduced to compensate for this.

9.10.17.6. Calculation of Wall and Ceiling Areas

This Article excludes doors, skylights and plastic glazing or lighting elements from the calculation of wall and ceiling area (see Guide 9.10.17.8., Light Diffusers and Lenses).

9.10.17.7. Corridors Containing an Occupancy

This Article sets the flame-spread rating of the wall and ceiling surfaces of an occupancy in a public corridor to the more stringent one for public corridors. To improve the usefulness or convenience in certain building designs, public corridors are sometimes enlarged at certain locations to permit their use for a purpose other than an access to an exit. There is nothing to prevent this as long as the enlarged portion complies with all of the requirements for public corridors, including the flame-spread limits.

9.10.17.8. Light Diffusers and Lenses

This Article allows light diffusers and lenses to have higher flame-spread ratings than the surfaces where they are mounted. Many plastic light diffusers and lenses have flame-spread ratings that exceed the limits set for ceiling surfaces. An increased flame-spread rating is considered to be acceptable as long as such items are designed to fall out of their frames before ignition based on CAN/ULC-S102.3, “Fire Test of Light Diffusers and Lenses.”

9.10.17.9. Combustible Skylights

This Article limits the number and spacing of skylights in corridors. Most plastic skylights have flame-spread ratings that exceed the limits set for ceiling surfaces. These are not designed to fall out in the event of a fire and can, therefore, create a potential hazard if they are very large or located too close to one another. When used in corridors that are required to be separated from the remainder of the floor area, the area and spacing of skylights must be limited to reduce the chance of fire spread.

Since plastic skylights are permitted to have higher flame-spread ratings than is required for ceilings in public corridors, individual skylights are not permitted to be larger than 1 m^2 (10 $ft.^2$) in area and must be spaced at least 1.2 m (4 ft.) apart to restrict flame propagation.

9.10.17.10. Protection of Foamed Plastics

This Article describes the protection required for elements made of foamed plastic.

Foamed plastics, because of their good insulating properties and low density, are not able to absorb heat from fire as quickly as other common building materials. Therefore, in rooms lined with foamed plastics, fires have a more rapid build-up of temperature than in rooms lined with conventional finishes, leading to an earlier flashover (i.e., the point at which the air temperature in the room becomes high enough to ignite most exposed combustible materials, causing the room to be enveloped in flame) and reducing the time available for escape.

For this reason, foamed plastics that form part of a wall or ceiling assembly are not permitted to be exposed and must be protected to delay the flashover time. Where buildings do not contain a Group C major occupancy, sheet metal that has a melting point not less than 650°C (1 200°F) and that is not less than 0.38 mm (28 gauge) thick can serve this purpose. The sheet metal must be mechanically fastened to the supporting assembly independent of the insulation. The interior finishes identified in NBC Subsections 9.29.4. to 9.29.9., which include plaster, gypsum board, plywood, hardboard, insulating fibreboard, particleboard, OSB and waferboard, can also be used for this purpose, as can any thermal barrier that meets the requirements of NBC Sentence 3.1.5.15.(2). Foamed plastics in noncombustible construction (which is normally not encountered in Part 9 buildings, except in firewalls or in walls close to a property line) require the somewhat higher standard of protection afforded by the thermal barriers specified in this Sentence.

Factory-assembled wall, floor and ceiling panels containing foamed plastics are permitted to be used for walk-in coolers and freezers, provided the panels are constructed and tested as described in NBC Sentence 9.10.17.10.(2).

Thermosetting foamed plastic insulation with a flame-spread rating of not more than 200 is permitted to be used in factory-assembled doors in garages serving a single dwelling unit, provided the insulation is covered on the interior with a metallic foil (aluminum would be acceptable), the assembly does not contain air spaces, and the overall flame-spread rating of the assembly does not exceed 200. These doors cannot be built or modified on site because of the need for quality control.

9.10.17.11. Walls and Ceilings in Bathrooms

This Article sets the maximum allowable flame-spread rating for bathrooms to not more than 200. The fire incidence rate in bathrooms is much lower than in most other parts of residential suites. In addition, bathrooms are usually very small and generally have little effect on the rate of fire spread within a suite. These areas are, therefore, permitted to have a slightly higher flame-spread rating than the other areas of the suite. From a practical perspective, the increased rating permits the use of plastic for bathroom fixtures and appliances, which does not generally meet the flame-spread limits required for walls.

9.10.17.12. Coverings or Linings of Ducts

This Article sets the maximum allowable flame-spread rating for the coverings or linings of ducts, in order to keep them from contributing to fire spread via a duct system. Combustible linings and coverings used in heating and cooling ducts can contribute to fire spread throughout the area served by the duct if the flame spread is not kept sufficiently low. The flame-spread ratings for the duct coverings and linings is regulated by NBC Articles 3.6.5.4. and 9.33.6.4.

9.10.18. Alarm and Detection Systems

Fire alarm and detection systems (heat and smoke) installed in an interconnecting network throughout a building are intended to warn all occupants of fire for general evacuation. Whether such a system is required depends on the use of the building, the number of occupants and the number of storeys in the building.

Although alarm and detection systems are primarily intended for occupant safety, early discovery of fire can also significantly affect the resulting property damage by allowing fire extinguishment to start at an earlier stage.

The simple, self-contained smoke detecting devices commonly installed in suites and houses are referred to as "smoke alarms," in order to distinguish them from other fire alarm and detection systems. Smoke alarms are intended to warn only the occupants in the suite in which they are installed (see NBC Article 9.10.19.). The exception is for houses with a secondary suite where an activated alarm in one suite is required to notify the occupants in the other suite.

9.10.18.1. Access Provided through a Firewall

This Article requires that alarm and detection systems be interconnected for interconnected floor areas on both sides of a firewall having an access through it. Although a firewall is constructed so that it makes a building on one side independent of the building on the other side in the event of a complete burnout, when access is provided through the firewall, there is still a risk that smoke on one side could contaminate the other side.

9.10.18.2. Fire Alarm Systems Required

This Article indicates where fire alarm systems are required to warn occupants about the existence of a fire so that they can evacuate quickly. Fire alarms are necessary if it is unlikely that all occupants would be made aware of the existence of a fire within a short time. Thus, the need for alarms is dependent on the state of alertness of the occupants (asleep or awake), the activities within the occupancy that may contribute to fire risk, the number of people, and the vertical separation of the occupants.

As a general rule, a fire alarm system is required in sprinklered buildings. However, a fire alarm system need not be installed in buildings where the sprinkler system is installed in accordance with NFPA 13D, "Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes," and in buildings that contain fewer than nine sprinklers supplied from the domestic water system.

Occupants in residential buildings are more at risk than in the other occupancies covered in NBC Part 9, because sleeping accommodations are provided. If sleeping accommodations are provided for more than 10 persons, an alarm and detection system is required. If, however, a residential building is designed so that each suite has direct access to an exterior exit leading to ground level, such as in houses or in motels, an alarm and detection system is not required. The same applies to residential buildings where no more than four suites share a public corridor or exit stairway (such as four-unit apartment buildings).

The more storeys a building contains, the more important an alarm and detection system becomes, because communication between storeys is more difficult. Except for residential buildings with the exit facilities described above, buildings that contain four storeys are required to have an alarm or detection system, regardless of the number of occupants (this includes three-storey buildings with basements).

A fire alarm is required for buildings with more than 300 occupants or in buildings where the occupant load for any major occupancy exceeds the values in NBC Table 9.10.18.2. If an industrial building has more than 75 people above or below the first storey, an alarm and detection system is also required. In other occupancies, the risk is not considered as significant, and twice as many people are permitted. If the total building population exceeds 300, however, an alarm and detection system is required for all occupancies except open-air parking garages. These are exempted from alarm requirements if there is no other occupancy in the building.

9.10.18.3. Design and Installation Requirements

This Article provides a reference to the requirements that pertain to the installation of alarm and detection devices and their associated systems. The design and installation of alarm systems need to conform to NBC Part 3.

Alarm systems are designed to be actuated both manually (at signal boxes near each required exit) and automatically (by electrical signals from smoke and heat detectors). Except for the vertically divided buildings previously mentioned, the alarms must sound in all occupancies throughout a building, and in some cases even in adjacent buildings, if they are separated by a firewall that allows access between buildings (NBC Article 9.10.18.1.).

Single-stage fire alarm systems sound a general alarm signal immediately on the actuation of a signal box or an automatic detecting device. This is the system typically used in buildings within the scope of NBC Part 9. Two-stage systems are generally used in larger buildings or in more critical occupancies. These systems precede the general alarm by an alert signal. This allows a short time interval for the source of the alarm signal to be investigated. If a false alarm is discovered, the system can be deactivated before the general alarm sounds automatically.

9.10.18.4. Rooms and Spaces Requiring Heat Detectors or Smoke Detectors

This Article provides the requirements for warning systems that protect occupants in residential buildings to ensure that those systems permit evacuation while the escape routes are still tenable. Dwelling units are exempted because they are provided with smoke alarms. Sprinklered buildings are also exempted because sprinklers will usually control fires at an early stage in their development, before they are a threat to life safety.

There are two basic types of fire detectors:

(1) Heat detectors sense an abnormal rise in ambient air temperature. Although heat detectors are dependable and seldom cause false alarms, they are not as quick to respond to fire as smoke detectors. They are deployed in areas where quick response is not essential for life safety, such as in high-fire-risk areas in non-habitable parts of the building.

(2) Smoke detectors sense smoke particles or ionized gases resulting from combustion, and sometimes both. Smoke detectors react more quickly to fire conditions than do heat detectors, and are therefore deployed in escape routes.

Smoke detectors are required in public corridors in residential buildings and in exit stairways in all occupancies where an alarm and detection system is required. These areas, which are critical for evacuation, can only be used while they remain tenable, so the earliest possible warning of fire must be provided.

Fire detectors must also be provided in locations where fires occur with greater frequency (and that are generally unoccupied), such as storage rooms, service rooms that are not within dwelling units, chutes, janitors room, rooms where hazardous materials are used or stored, elevator hoistways, chute shafts, and separate laundry rooms in residential buildings. These can be either heat or smoke detectors. A sprinkler system equipped with a water-flow alarm can also be used in lieu of fire detectors.

9.10.18.5. Smoke Detectors in Recirculating Air-Handling Systems

This Article limits the risk of air-handling systems spreading smoke between suites in the event of a fire. Smoke not only obscures vision and creates breathing discomfort, it can also contain lethal concentrations of toxic gases. This not only creates untenable conditions throughout a building, but also interferes with evacuation. Since air circulation systems can spread smoke from storey to storey or from suite to suite, they must be designed to shut down on a signal from a smoke detector within the ducts in buildings where an alarm and detection system is required.

In dwelling units, however, floors are open to each other via stairwells, and smoke will move throughout the unit even if the system is shut down. In addition, smoke alarms are provided to alert the occupants (NBC Subsection 9.10.19.), making detectors in the air-handling system within a dwelling unit unnecessary.

9.10.18.6. Portions of Buildings Considered as Separate Buildings

This Article defines when portions of buildings can be considered separate buildings for the purpose of determining fire alarm and detection requirements.

Portions of buildings completely separated from adjoining parts must have their own exit systems to the exterior if there is no access across the separation. If a building is divided by vertical fire separations (1 h minimum), so that there is no communication between segments (except for piping and wiring), each segment can be considered as if it were a separate building in determining the need for an alarm and detection system. The separation will permit each portion to be evacuated through an exit system that will not be contaminated by fire in another portion. Therefore, each portion is considered to be a separate building with respect to the building's fire alarms.

This mainly affects strip shopping plazas, where a change in tenancy in one separated segment will not affect the requirements in the other separated tenancies. However, in applying this relaxation, a portion of the building including only service or storage rooms is not permitted to be considered as a separate building, even if it satisfies the requirements for a fire separation. This is because such rooms are normally unoccupied and a separate alarm and detection system would serve little purpose, as there would be no one there to hear it.

9.10.18.7. Central Vacuum Systems

This Article requires central vacuum systems to switch off automatically in the event of a fire in a building with a fire alarm system. This will minimize the spreading of smoke and fire from one suite to another. Central vacuum systems can contribute to the spread of smoke and fire if they continue to operate in the event of a fire. If a fire should enter the vacuum system, it can be drawn across separations and into the dust receptacle where a second fire could start. For this reason, central vacuum systems serving more than one dwelling unit or storey in a building are required to have an alarm system designed to shut down upon alarm activation.

9.10.18.8. Open-Air Storage Garages

This Article establishes that a fire alarm system is not required in open-air storage (parking) garages. The amount of natural ventilation makes it unlikely that egress routes would become smoke-logged or that travel to an exit would be restricted in the event of a fire. In addition, the occupant load for such structures is very low and evacuation in the event of a fire would be rapid.

9.10.19. Smoke Alarms

Smoke alarms are the simple, self-contained smoke detecting devices commonly installed in suites and houses. These smoke alarms should not be confused with detection devices that are connected to a central alarm for a building, which are used in larger buildings (NBC Subsection 9.10.18.).

9.10.19.1. Required Smoke Alarms

This Article indicates where smoke alarms are required. Except for houses with a secondary suite, smoke alarms are intended to alert only the occupants of the suite in which they are installed. These devices are self-contained and both detect smoke and sound an alarm. They are designed to detect smoke particles or ionization (and sometimes both). Their use has rapidly increased as their cost has decreased, and they have been a significant factor in the reduction of fire deaths in Canada.

Every dwelling unit is required to have at least one smoke alarm, without exception. Each sleeping room is required to have a smoke alarm. Ancillary spaces and common spaces in houses with a secondary suite are required to have smoke alarms.

To reduce the possibility of nuisance, smoke alarms in different dwelling units are not interconnected, and smoke detectors are installed in corridors to warn others.

9.10.19.2. Sound Patterns of Smoke Alarms

This Article contains the requirements relative to the sound patterns of smoke alarms. The sound patterns of smoke alarms shall meet the temporal patterns of alarm signals or be a combination of temporal and voice relay. The intent of this requirement is to ensure that the occupants are notified of a potential fire threat for a timely evacuation of the suite.

9.10.19.3. Location of Smoke Alarms

This Article indicates where smoke alarms are required in dwelling units. Since the prime purpose of a smoke alarm is to wake the sleeping occupants in the suite in which the fire originated, smoke alarms are installed in each bedroom and in the hallway that serves them. To avoid any delay in warning due to the time it takes for smoke to travel from storey to storey, and to allow for the fact that other habitable rooms can be used for sleeping, additional smoke detectors must be installed on other storeys, including basements.

A smoke alarm installed in the living area and wired to sound another smoke alarm located near bedrooms is the ideal solution (Figure 9.10.-40).

A smoke alarm is not required on each level in a split-level dwelling unit given that each level does not count as a separate storey. However, where the sleeping areas are on two levels of a single storey in a split-level dwelling unit, an additional smoke alarm must be installed so that both areas are protected (Figure 9.10.-41).

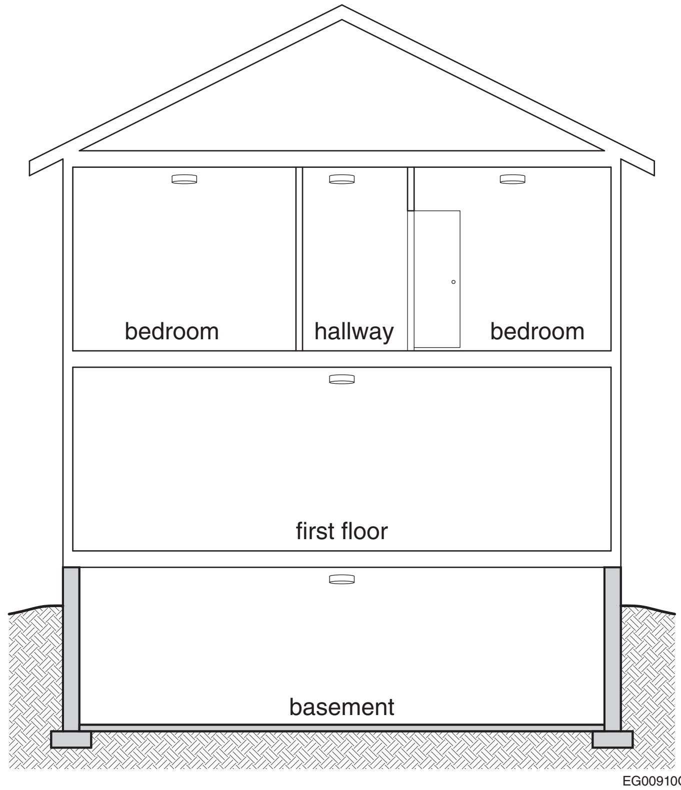


Figure 9.10.-40
Locations of smoke alarms in a dwelling unit

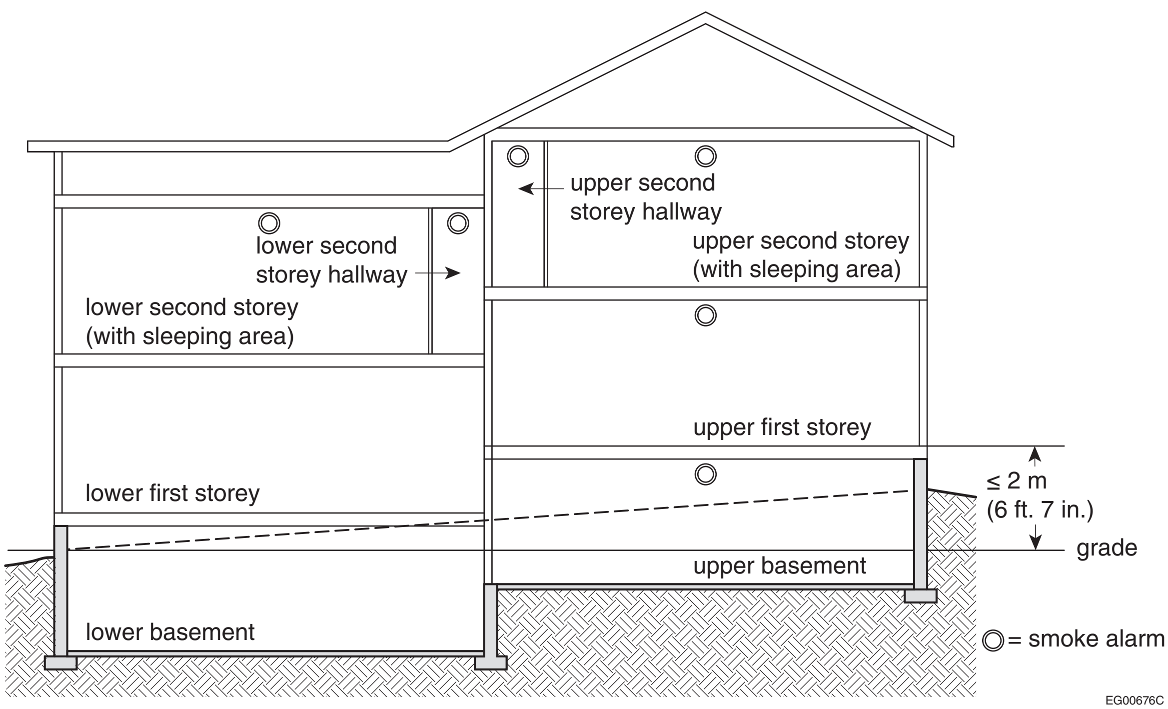


Figure 9.10.-41
Locations of smoke alarms in a two-storey split-level dwelling unit

9.10.19.4. Power Supply

This Article deals with the power supply of smoke alarms. In new constructions, smoke alarms must be connected to an electrical circuit that has no switches that could render the device inactive. The circuit may include lights because, unlike receptacles, they are unlikely to overload a circuit and trip a breaker. However, it is recommended that smoke alarms not be connected to circuits that serve stairway lighting. In the event of power supply interruption, smoke alarms are required to have a battery as an alternative power supply that can continue to provide power for at least 7 days, and sound an alarm for at least 4 min. In existing buildings, battery-operated units are permitted.

Suites of residential occupancy are permitted to be equipped with smoke detectors in lieu of smoke alarms provided that the smoke detectors are capable of independently sounding audible signals within individual suites and are installed in accordance with CAN/ULC-S524, "Installation of Fire Alarm Systems." These smoke detectors are required to sound an alarm only in individual suites, not throughout the rest of the building.

Smoke detectors are intended to function as smoke alarms (localized alarm to a given suite) for multi-unit buildings such as hotels and motels. The advantage of this type of installation is that the detector would be monitored by a fire alarm panel and the alarm could be investigated.

9.10.19.5. Interconnection of Smoke Alarms

This Article requires that smoke alarms in dwelling units be interconnected. A smoke alarm that sounds on one storey may not be sufficiently audible on another to wake sleeping occupants. By interconnecting all alarms, the alarms are audible on all levels, regardless of where the smoke is detected.

Smoke alarms in houses with a secondary suite must be linked so that the activation of any one smoke alarm causes all smoke alarms to activate in the two dwelling units, including their common spaces.

Requirements for houses with a secondary suite were developed seeking a balance between safety and practicality. One trade-off made was to permit a smoke barrier with not less than 12.7 mm (1/2 in.) gypsum board separating the suites in lieu of a fire separation. The justification for this compromise was based partly on the requirement that the suite's smoke alarms be linked, so that a warning would be provided to both in the event of fire.

9.10.19.6. Silencing of Smoke Alarms

This Article enables the temporary interruption of alarms. To discourage manual disconnection due to nuisance alarms, a manually operated device is provided in the circuitry of an alarm system in a dwelling unit so that the smoke alarm can be temporary silenced for up to 10 min, after which the alarm automatically reactivates.

Residential occupancy suites equipped with smoke detectors in lieu of smoke alarms, as permitted by NBC Sentence 9.10.19.4.(3), need not incorporate the manually operated silencing device.

9.10.19.7. Instructions for Maintenance and Care

This Article requires that smoke alarms remain functional. Smoke alarms that require periodic maintenance are required to have maintenance instructions posted in a permanent location for periodic reference.

9.10.19.8. Residential Fire Warning Systems

This Article permits smoke detectors forming part of a residential fire warning system to be used in lieu of the smoke alarms required by NBC Articles 9.10.19.1. and 9.10.19.3. in buildings where a fire alarm system is not required or installed. The fire warning system must meet the installation and other requirements of the Article.

9.10.20. Firefighting

9.10.20.1. Windows or Access Panels Required

This Article requires access panels or windows for firefighter access to facilitate the rescue of occupants who are unable to escape from a building, as well as to help restrict the amount of fire damage to a building. Windows or access panels are not required for dwelling units with no other dwelling units above them, nor are they required for houses with a secondary suite.

For unsprinklered buildings, access must be provided for firefighters to enter each storey from the exterior (street side) to fight the fire or to rescue occupants. Firefighters normally have to carry bulky equipment such as air tanks, so that openings have to be larger than needed solely for escape. Access is normally provided on the upper storeys by windows glazed with ordinary glass (which can be broken easily), although special access panels or doors can also be used, as in the case of basements.

A window or access panel must be provided on the second and third storeys. The window or access panel must face a street, be at least 1 100 mm (43 in.) high and 550 mm (22 in.) wide and be located not more than 900 mm (35 in.) above the floor.

9.10.20.2. Access to Basements

This Article requires that a door or window or other opening be made available from each basement to facilitate the rescue of occupants who are unable to escape from a building, as well as help limit fire damage. Basements are a source of fire risk because they are usually used for storage purposes, and are often the location of heating equipment. This requirement does not apply to houses with a secondary suite.

Unsprinklered basements that are more than 25 m (82 ft.) long and serve more than one dwelling unit are required to have direct access to the outdoors to at least one street. The access needs to be at least 1 100 mm (43 in.) high and 550 mm (22 in.) wide, and be located not more than 900 mm (35 in.) above the floor. The access to the basement can also be provided by an interior stair accessible from the outdoors.

9.10.20.3. Fire Department Access to Buildings

This Article contains the requirements for the design and location of fire department access to facilitate the rescue of occupants who are unable to escape from a building, as well as limit fire damage.

Firefighters and their vehicles must have unobstructed access to every building so that firefighting can proceed without delay when they arrive. Every building, therefore, is required to be accessible to fire department vehicles in all seasons. If the only access to a building is by means of a private roadway or yard at some distance from a public street, steps must be taken to ensure accessibility.

The width of the access route, radius of curves, overhead clearances, and the ability to support loads must be considered in relation to the fire department equipment. The location of fire hydrants and the connections for the fire department pumpers must also be planned for maximum effectiveness. The local fire department should, therefore, be consulted prior to the design and construction of such access routes.

While the requirements for such access in NBC Part 9 are written in very general terms, those in NBC Part 3 are very specific and should be consulted if more clarification is required.

A clear path of travel for the firefighters between the fire truck and the building should be provided so that the distance required to carry hose lines and ladders is relatively short. In a building divided so that there is no access inside the building from one segment to another (e.g., a strip shopping plaza or row housing), the access route should be located so that the path of travel to each entrance is reasonably short.

In addition to other considerations taken into account in the planning of fire department access routes, special variations could be permitted for a house or residential building that is protected with an automatic sprinkler system. The sprinkler system must be designed in accordance with the appropriate NFPA standard, and adequate water supply pressure and quantity must be ensured. These considerations could apply to buildings that are located on the sides of hills and that are not conveniently accessible by roads designed for firefighting equipment. They could also apply to infill housing units that are located behind other buildings on a given property.

If a pumper is used to boost the available water supply, it does this by drawing from a water source (usually a hydrant) and pumping either directly through the hose lines to the fire or into fire department connections on the building, which in turn feed hose lines or automatic sprinklers within the building. While the pumper need not be located immediately adjacent to the building to accomplish this, it should be reasonably close to reduce friction loss in hoses and keep the travel distance for the firefighter within reasonable limits.

If a building is not equipped with a fire department connection, an access route should be provided to permit the vehicle to park near the hydrant. Where hydrants are not close, an access route should permit the vehicle to be reasonably close to the principal entrance of the building. In this way, the length of the access route from the hydrant to the vehicle, plus the path of travel for the firefighter from the vehicle to the building, is not excessive. This will permit the firefighter to connect supply lines from the pumper to a hydrant, drive the pumper reasonably close to the building and then proceed on foot with additional hose lines.

9.10.20.4. Portable Extinguishers

This Article requires that portable extinguishers be installed in all buildings other than dwelling units to facilitate the early extinguishment of fires. Portable extinguishers serve to reduce the amount of fire damage by enabling occupants to contain or extinguish fires before firefighters arrive.

Portable extinguishers are the first line of defence against a fire. A smoke alarm provides detection but not suppression. Portable fire extinguishers are to be installed in all buildings except in dwelling units. The size and spacing of extinguishers is usually governed by NFPA 10, "Portable Fire Extinguishers."

9.10.20.5. Freeze Protection of Fire Protection Systems

This Article intends to ensure that fire protection systems function reliably during the cold season. Fire protection systems are required to be protected against freezing to reduce the probability that low temperatures will render inoperable fire protection equipment when it is needed.

9.10.21. Fire Protection for Construction Camps

9.10.21.1. Requirements for Construction Camps

This Article provides a reasonable degree of fire safety for the occupants of construction camps located in areas without organized firefighting capabilities, and intends to facilitate firefighting by local personnel to reduce the amount of fire damage.

Construction camps can vary in size and complexity from simple bunkhouses to complexes that provide the full range of amenities that would be expected in any community. The requirements for construction camps in NBC Part 9 apply only to those whose occupancy and size fall within the scope of NBC Part 9. Construction camps that fall within the scope of NBC Part 3 must conform to all the appropriate requirements in that Part, the same as for any other building.

The fire safety and egress requirements that apply to buildings generally also apply to construction camps. Because of the special nature of these camps, however, certain deviations from these requirements are necessary. The requirements for construction camps, therefore, must be applied in the context of other NBC requirements. In other words, NBC Subsection 9.10.21. should not be read in isolation from other requirements.

The remote location of typical construction camps, and the amount of abuse they have to withstand in being moved from one location to another over construction roads, creates a number of practical problems in their design. Material must be selected to withstand rough handling, and compensating safety measures must be introduced to overcome the lack of a community fire service.

9.10.21.2. Separation of Sleeping Rooms

This Article requires that fire protection measures be provided to ensure that sleeping occupants have sufficient time to escape from a fire originating outside their sleeping room. Dwelling units are exempted on the basis that these are equipped with smoke alarms, and have a small occupant load, enabling rapid escape in the early stages of a fire.

Gypsum board, normally used to provide appropriate fire-resistance levels for wood-frame construction, cannot withstand the demands of relocation without appreciable damage in many cases. The added weight of gypsum board must also be considered, since this can affect the portability of construction camps. Generally, a less friable material such as plywood is preferred for use in camps, where the interior finish may be subjected to rough handling.

While it is fairly easy to develop fire resistance with gypsum board, it is more difficult to develop practical systems with plywood, which does not have the same fire-resisting qualities. Wood studs protected with a layer of 11 mm (7/16 in.) Douglas fir plywood would have a 30 min rating (NBC D-2.3. in Appendix D). Wood-frame floors would require two layers of 11 mm (7/16 in.) plywood on the underside to receive the same rating. Each 11 mm (7/16 in.) layer of plywood would add an extra 10 min to this rating. Achieving a 45 min or 1 h rating, therefore, requires a substantial thickness of plywood.

Because of the practical difficulties of achieving the rating normally specified for wood construction, a 30 min rating is permitted between each sleeping room, and between sleeping rooms and the rest of the building. To reduce the risk of fire spread, however, corridors are required to have a reduced flame-spread rating (25 over 90% of the walls and ceiling). If, on the other hand, 45 min fire resistance can be attained, the flame spread in corridors can be the same as in other buildings (see Table 9.10.-D).

9.10.21.3. Floor Assemblies between the First and Second Storey

This Article requires that occupants on the second storey of a building in a construction camp be protected from fire originating on the first storey of that building for sufficient time to escape. Dwelling units are exempted from this requirement on the basis that these are equipped with smoke alarms, and have a small occupant load, enabling rapid escape in the early stages of a fire.

9.10.21.4. Walkways Connecting Buildings

This Article requires a fire-resistance rating between a walkway and a building to provide enough time to allow connected buildings to be evacuated, and to give local personnel an opportunity to confine a fire to the building of origin to reduce the amount of potential damage.

In some camp designs, the various buildings are interconnected by a series of enclosed walkways to permit workers to go from one building to another without going outdoors. To reduce the possibility of fire spreading by means of these walkways, a 45 min fire separation is required where the walkways join each building (see Guide 9.10.21.6., Flame-Spread Ratings).

9.10.21.5. Spatial Separations

This Article requires that buildings be separated from one another to reduce their exposure to each other. Although construction camp buildings are generally required to conform to the same spatial separations as other buildings, they need not be spaced more than 10 m (32 ft. 10 in.) apart.

9.10.21.6. Flame-Spread Ratings

This Article provides limits on the permissible flame-spread ratings of building materials to slow the spread of fire, and thereby facilitate the escape of occupants. The walls and ceiling surfaces of enclosed walkways that allow workers to go from one building to another without going outdoors are required to have a low flame-spread rating (25 over 90% of the walls and ceiling). This requirement does not apply to dwelling units.

Corridors leading to and from sleeping rooms that have a fire-resistance rating of not less than 45 min need to be built according to NBC Subsection 9.10.17.

9.10.21.7. Smoke Detectors

This Article requires that smoke alarms be installed in sleeping areas in construction camp buildings with more than 10 persons. The smoke alarm warns all building occupants of a fire in its initial stage, so that the escape routes will be tenable until the building is evacuated. This slightly more stringent requirement partially compensates for the reduced fire resistance.

9.10.21.8. Portable Fire Extinguishers

This Article requires that portable fire extinguishers be installed in each construction camp building to reduce the amount of fire damage by enabling occupants to contain or extinguish minor fires before additional firefighting assistance arrives.

9.10.21.9. Hose Stations

This Article provides for additional firefighting capability where hand-held extinguishers are not able to extinguish a fire. This will further reduce the likelihood and amount of fire damage.

The lack of a community fire department requires that alternative measures be taken to protect individual construction camp buildings in the event of a fire. Each building providing sleeping accommodations to more than 30 persons, for example, must be provided with a hose station near an exit (which will not be subjected to freezing) equipped with a 19 mm (3/4 in.) hose designed to reach every part of the structure. The hose station is required to be connected to a central water supply or to a storage tank and pumping system. This is in addition to portable extinguishers required in the corridors (NBC Article 9.10.21.8.).

9.10.22. Fire Protection for Gas, Propane and Electric Cooktops and Ovens

9.10.22.1. Installation of Cooktops and Ovens

This Article provides a standard method of installing natural gas and propane cooktops and ovens so that the installation is safe.

The installation requirements for gas cooking ranges must conform to the requirements of CSA B149.1, "Natural Gas and Propane Installation Code," for clearances from the cooktop or oven to combustible materials immediately adjacent to, or directly above the cooktop or oven. The clearances will be specified on the label attached to the appliance. This natural gas code is administered by the gas inspector and the Gas Safety Branches in most provinces. The standard requires specialized testing of the appliance to ensure that the gas safety features are incorporated. This may be a positive shut off of the gas valve should the pilot light extinguish and the escaping gas not be ignited. This would reduce the chance of unburned gas escaping into an occupied room.

9.10.22.2. Vertical Clearances above Cooktops

This Article establishes minimum vertical clearances above cooktops.

A vertical clearance of at least 750 mm (30 in.) must be provided between the level of the cooktop burners or elements and the framing, finishes and cabinets installed above the cooktop (Figure 9.10.-42). The minimum vertical clearance is reduced to 600 mm (24 in.) where the framing, finishes and cabinets are noncombustible or are protected by a metal hood that projects 125 mm (5 in.) beyond the framing, finishes and cabinets.

The requirement to provide a minimum vertical clearance does not apply to microwave ovens or range hoods, which are permitted to be installed at a lower level for ease of use. CSA C22.1, "Canadian Electrical Code, Part I," requires that microwave ovens comply with CAN/CSA-C22.2 No. 150, "Microwave Ovens" (see NBC Note A-9.10.22.). Microwaves that comply with this standard are considered to be safely located when they are installed according to the manufacturer's instructions.

9.10.22.3. Protection around Cooktops

This Article deals with the protection of combustible surfaces around cooktops.

Because of the risk of stovetop fires, combustible wall framing, finishes and cabinets within 450 mm (17 3/4 in.) of the area where a gas or electric cooktop is to be located must be protected above the level of the heating elements or burners by a material providing fire resistance at least equivalent to that provided by 9.5 mm (3/8 in.) thickness of gypsum board (see Figure 9.10.-42). Counter-top splash boards and back plates are exempted from this requirement.

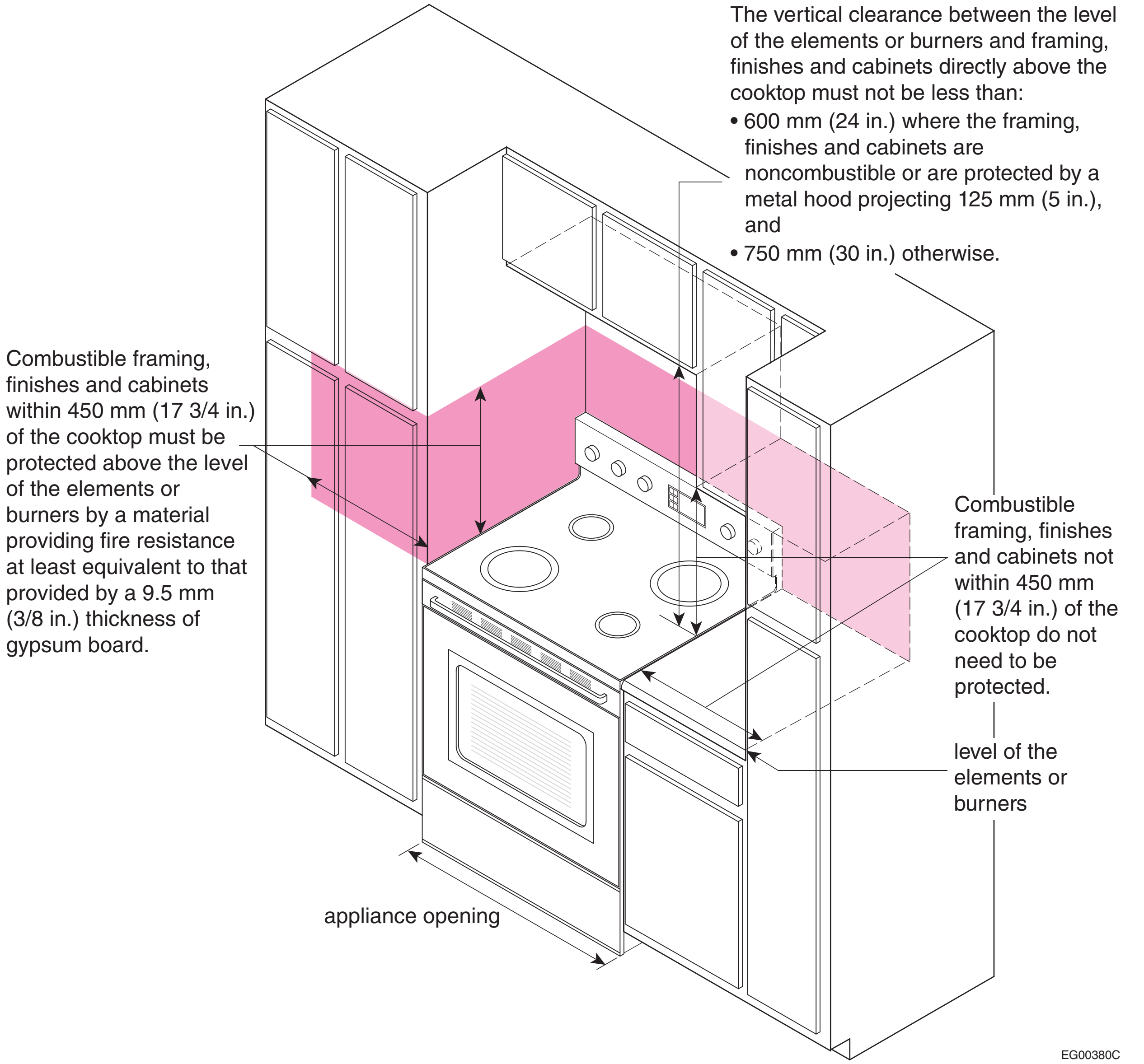


Figure 9.10.-42
Minimum vertical clearances above and protection around cooktops

Section 9.11.
Sound Transmission

Introduction

The noise protection provisions of this Section deal with the transmission of airborne noise between a dwelling unit and every other space in a building where noise may be generated. Thus, these provisions apply to the separating assemblies and adjoining constructions between semi-detached houses, between row houses, and between dwelling units and adjacent spaces in multi-unit residential buildings. Their purpose is to make airborne noise originating in an adjacent dwelling unit or space less objectionable to the occupants of a dwelling unit. This Section does not address the transmission of outside noise, impact noise, or vibration.

9.11.1. Protection from Airborne Noise

This Subsection requires measures for the minimization of the transmission of airborne noise. Other aspects of noise transmission should also be considered.

Airborne Sound

Airborne sound is transmitted between adjoining spaces directly through the separating wall, floor and ceiling assemblies. Flanking sound transmission is the leakage of airborne sound through openings and construction intersections.

The sound transmission class (STC) rating describes the sound transmission through the separating wall or floor/ceiling assembly (direct transmission path), whereas the apparent sound transmission class (ASTC) takes into consideration the sound transmission through both the separating assembly (direct transmission path) and its flanking assemblies (flanking transmission paths). Therefore, from the occupants' point of view, the best indicator of noise protection between two spaces is the ASTC rating.

As a key principle, it is important to follow a "whole-system" approach when designing or constructing assemblies that separate dwelling units because the overall sound insulation performance of walls and floors is also influenced by fire protection measures and the structural design of the assemblies. Likewise, changes to the construction of assemblies to meet sound transmission requirements may have fire and structural implications. Another key principle is that enhancing the performance of the separating assembly does not automatically enhance the system's performance.

For horizontally adjoining spaces, the separating assembly is the intervening wall, and the pertinent flanking surfaces include those of the floor, ceiling, and wall assemblies that have junctions with the separating wall assembly, normally at its edges. For each of these junctions, there is a set of sound transmission paths. Figure 9.11.-1 illustrates the horizontal sound transmission paths at the junction of a separating wall assembly with a flanking floor/ceiling assembly.

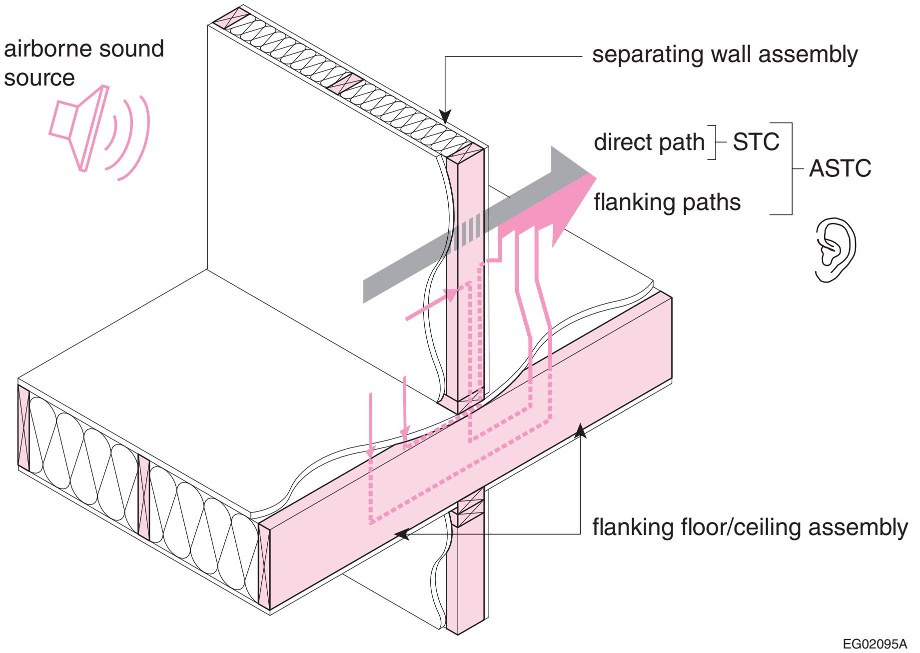


Figure 9.11.-1
Horizontal sound transmission paths at the junction of a separating wall assembly with a flanking floor/ceiling assembly

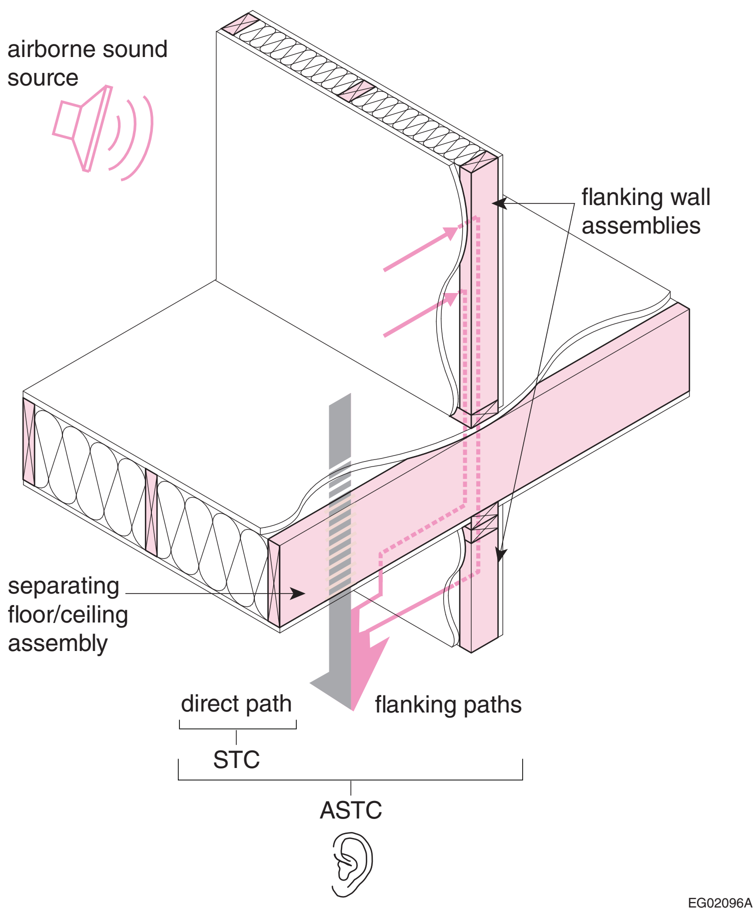


Figure 9.11.-2
Vertical sound transmission paths at the junction of a separating floor/ceiling assembly with two flanking wall assemblies

For vertically adjoining spaces, the separating assembly is the intervening floor/ceiling, and the pertinent flanking surfaces include those of the wall assemblies in the upper and lower rooms that have junctions with the separating floor/ceiling assembly, normally at its edges. For each of these junctions, there is a set of sound transmission paths. Figure 9.11.-2 illustrates the vertical sound transmission paths at the junction of a separating floor/ceiling assembly with two flanking wall assemblies.

Sound Leaks

The metrics used to characterize the sound insulation performance of assemblies separating dwelling units do not account for the adverse effects of air leaks in those assemblies, which can transmit or "leak" sound. The calculations and laboratory testing used to determine STC and ASTC ratings are performed on intact assemblies having no penetrations or doors.

Sound leaks can occur where a wall meets another wall, the floor or the ceiling. They can also occur where wall finishes are cut to allow the installation of equipment or services. The following are examples of measures for controlling sound leaks:
- avoid back-to-back electrical outlets or recessed medicine cabinets;
- carefully seal cracks and openings so that assemblies are effectively airtight;
- apply sealant below the plates in stud walls, between the bottom of gypsum board and the structure behind, around all penetrations for services, and in locations where cracks or holes are likely to develop;
- include sound-absorbing material inside the wall, even if not required.

The reduction of air leakage is also addressed to some extent by the smoke tightness requirements in the NBC.

Impact Noise

Section 9.11. has no requirements for the control of impact noise transmission. However, footsteps and other impacts can cause severe annoyance in buildings with multiple dwelling units. Builders concerned about quality and reducing occupant complaints will ensure that floors are designed to minimize impact noise transmission. A recommended criterion is that bare floors (tested without a carpet) should achieve an impact insulation class (IIC) of 55. Some lightweight floors that satisfy this requirement may still elicit complaints about low-frequency impact noise transmission. Adding carpet to a floor will increase the IIC rating, but will not necessarily reduce low-frequency noise transmission. Good footstep noise reduction requires fairly heavy floor slabs or floating floors. Impact noise requirements are being considered for inclusion in future editions of the NBC.

The most frequently used test methods for impact noise are ASTM E 492, "Laboratory Measurement of Impact Sound Transmission Through Floor-Ceiling Assemblies Using the Tapping Machine," and ASTM E 1007, "Field Measurement of Tapping Machine Impact Sound Transmission Through Floor-Ceiling Assemblies and Associated Support Structures."

Equipment Noise

Elevators, garbage chutes, plumbing fixtures, fans, and heat pumps are common sources of noise in buildings. To reduce the annoyance resulting from these noise sources, they should be placed as far as possible from living and sleeping areas. Vibrating parts should be isolated from the building structure using resilient materials such as neoprene or rubber.

Noise from equipment can also be transmitted through ductwork, as either airborne or structure-borne sound. Noise reduction can be achieved by isolating the noise sources from the building structure and ductwork. For example, equipment can be mounted on vibration-absorbing pads, or ventilation equipment can be connected to ductwork by flexible connectors. Lining ductwork with a sound-absorbing material can also reduce the transmission of noise.

The minimization of noise transmission through ductwork and the isolation of noise sources are not required by the NBC, but are recommended as good practice.

9.11.1.1. Required Protection

This Article sets minimum ASTC and STC ratings and other requirements for construction separating a dwelling unit from every other space in a building where noise may be generated. In general, the separating assembly and adjoining constructions must together provide an ASTC rating of at least 47, or the separating assembly must provide an STC rating of at least 50 and adjoining constructions must conform to NBC Article 9.11.1.4.

For a house containing a secondary suite, a somewhat lower level of protection from airborne noise is acceptable because the occupants of each dwelling unit are only affected by noise from one other dwelling unit. This Article specifies three ways of separating the dwelling units in a house with a secondary suite from every other space in the house where noise may be transmitted, which will provide the required level of protection. The first is to use construction whose joist spaces are filled with sound-absorbing material of not less than 150 mm (6 in.) nominal thickness, whose stud spaces are filled with sound-absorbing material, having a resilient channel on one side of the separation spaced 400 or 600 mm (16 or 24 in.) on centre, and having gypsum board not less than 12.7 mm (1/2 in.) thick on ceilings and on both sides of walls. The second is to use construction providing an STC rating of not less than 43. The third is to use a separating assembly and adjoining constructions providing an ASTC rating of not less than 40.

9.11.1.2. Determination of Sound Transmission Ratings

This Article specifies how STC and ASTC ratings are to be determined.

An STC rating is a measure of the ability of a separating assembly to resist airborne sound transmission. STC ratings must be determined in accordance with ASTM E 413, "Classification for Rating Sound Insulation," using the results from measurements carried out in accordance with ASTM E 90, "Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements."

An ASTC rating is a measure of the apparent resistance to airborne sound transmission of a separating assembly, which takes into account sound transmission through both the separating assembly and its flanking wall and floor/ceiling assemblies. ASTC ratings must either be determined in accordance with ASTM E 413 using the results from measurements carried out in accordance with ASTM E 336, "Measurement of Airborne Sound Attenuation between Rooms in Buildings," or be calculated in accordance with NBC Article 5.8.1.4. or 5.8.1.5.

9.11.1.3. Compliance with Required Ratings

This Article specifies how compliance with the required STC and ASTC ratings is to be demonstrated.

For STC ratings, compliance must be demonstrated through measurements carried out in accordance with NBC Sentence 9.11.1.2.(1) or through the construction of separating assemblies conforming to NBC Table 9.10.3.1.-A or 9.10.3.1.-B, as applicable. For ASTC ratings, compliance must be demonstrated through measurements carried out in accordance with NBC Sentence 9.11.1.2.(2) or through the construction of separating assemblies conforming to NBC Table 9.10.3.1.-A or 9.10.3.1.-B, as applicable, that have an STC rating of not less than 50 in conjunction with flanking assemblies constructed in accordance with NBC Article 9.11.1.4.

NBC Tables 9.10.3.1.-A and 9.10.3.1.-B present separating assemblies that comply with NBC Section 9.11. However, selecting an appropriate separating assembly on the basis of its STC is only one part of the solution for reducing airborne sound transmission between adjoining spaces: to fully address the sound insulation performance of the whole system, the flanking assemblies connected to the separating assembly must conform with NBC Article 9.11.1.4.

9.11.1.4. Adjoining Constructions

This Article contains requirements for adjoining constructions (flanking wall, floor and ceiling assemblies), which apply where the required protection from airborne noise is provided in accordance with NBC Clause 9.11.1.1.(1)(b) and where compliance is demonstrated in accordance with NBC Clause 9.11.1.3.(2)(b).

Tables 9.11.-A to 9.11.-D present generic options for the design and construction of junctions between separating and flanking assemblies. Constructing according to these options is likely to meet or exceed an ASTC rating of 47. Other designs may be equally acceptable if their resistance to airborne sound transmission can be demonstrated to meet or exceed the minimum ASTC rating on the basis of measurements or calculations carried out in accordance with NBC Sentence 9.11.1.2.(2). However, some caution should be applied when designing solutions that go beyond the options provided in these Tables: for example, adding more material to a wall could negatively impact its sound performance or have no effect at all.

Table 9.11.-A presents compliance options for the design and construction of separating wall assemblies with flanking floor, ceiling and wall assemblies in horizontally adjoining spaces.

Table 9.11.-A
Options for the Design and Construction of Junctions and Flanking Surfaces Between Separating Wall Assemblies in Horizontally Adjoining Spaces for Compliance with NBC Clause 9.11.1.1.(1)(b)

<table>
<tr><td rowspan="2">Type of Separating Wall Assembly with STC ≥ 50 from NBC Table 9.10.3.1.-A</td><td colspan="3">Options for Design and Construction of Junctions(1) to Address Horizontal Sound Transmission Paths</td></tr>
<tr><td>Bottom Junction (between separating wall and flanking floors)</td><td>Top Junction (between separating wall and flanking ceiling)</td><td>Side Junctions (between separating wall and flanking walls)</td></tr>
<tr><td rowspan="2">W4 to W6 (single stud)

W8 to W12 (staggered studs)</td><td>

- for additional material layer and finished flooring, see NBC Table 9.11.1.4.
- subfloor on both sides of wall is plywood, OSB, waferboard (15.5 mm (5/8 in.) thick) or tongue and groove lumber (≥ 17 mm (11/16 in.) thick)
- floor is framed with wood joists, wood I-joists or wood trusses spaced ≥ 400 mm (16 in.) o.c., with or without absorptive material(2) in cavities
- floor joists or trusses are oriented parallel to separating wall (non-loadbearing case) or perpendicular to separating wall but are not continuous across junction (loadbearing case)

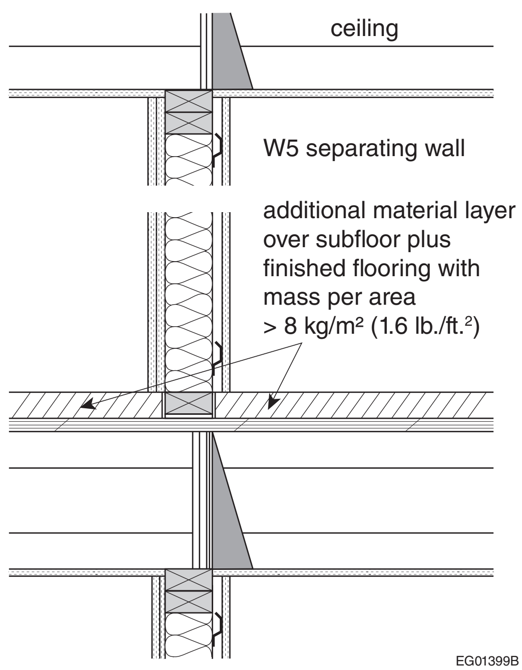
</td><td>

- ceiling is framed with wood joists, wood I-joists or wood trusses, with or without absorptive material(2) in cavities
- ceiling joists or trusses are oriented parallel to separating wall (non-loadbearing case) or perpendicular to separating wall but are not continuous across junction (loadbearing case)
- gypsum board ceiling is fastened directly to bottom of ceiling framing or on resilient metal channels(3)

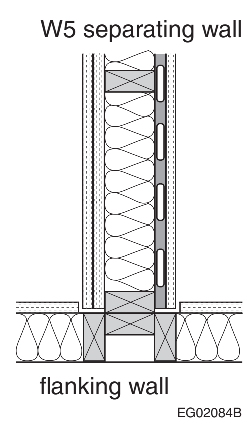
</td><td>

- gypsum board panels on flanking walls end or are cut at separating wall and are fastened directly to framing or on resilient metal channels(3)
- flanking wall is framed with single row of wood studs, staggered studs on a single 38 x 140 mm (2 x 6 in. nominal) plate, or 2 rows of 38 x 89 mm (2 x 4 in. nominal) wood studs on separate 38 x 89 mm (2 x 4 in. nominal) plates, with or without absorptive material(2) in cavities
- flanking wall framing is structurally connected to separating wall and terminates where it butts against framing of separating wall or is continuous across junction

</td></tr>
<tr><td colspan="2">Example Showing Side View of Bottom and Top Junctions



</td><td>Example Showing Plan View of Side Junctions



</td></tr>
</table>

Table 9.11.-A (Continued)

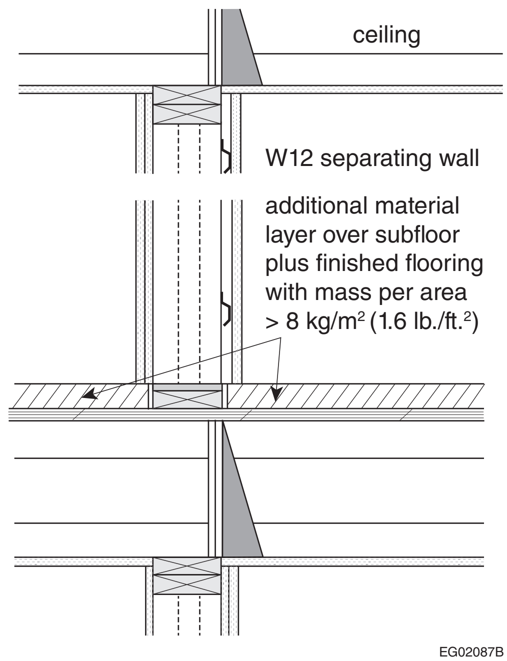
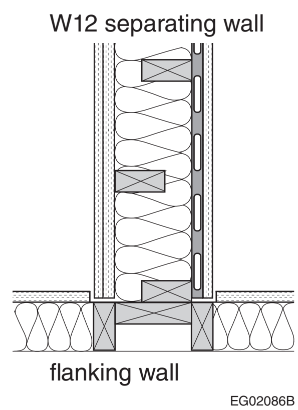
<table>
<tr><th rowspan="2">Type of Separating Wall Assembly with STC ≥ 50 from NBC Table 9.10.3.1.-A</th><th colspan="3">Options for Design and Construction of Junctions(1) to Address Horizontal Sound Transmission Paths</th></tr>
<tr><th>Bottom Junction (between separating wall and flanking floors)</th><th>Top Junction (between separating wall and flanking ceiling)</th><th>Side Junctions (between separating wall and flanking walls)</th></tr>
<tr><td></td><td colspan="2">Example Showing Side View of Bottom and Top Junctions

</td><td>Example Showing Plan View of Side Junctions

</td></tr>
<tr><td>W13 to W15</td><td>• for additional material layer and finished flooring, see NBC Table 9.11.1.4.
• subfloor on both sides of wall is plywood, oriented strandboard (OSB), waferboard (15.5 mm (5/8 in.) thick) or tongue and groove lumber (≥ 17 mm (11/16 in.) thick)
• floor is framed with wood joists, wood I-joists or wood trusses spaced ≥ 400 mm (16 in.) o.c., with or without absorptive material(2) in cavities
• floor joists or trusses are oriented parallel to separating wall (non-loadbearing case) or perpendicular to separating wall but are not continuous across junction (loadbearing case)
• near leaf of separating wall is supported on "designated" joist</td><td>• wood joists, wood I-joists or wood trusses are oriented perpendicular or parallel to separating wall, with or without absorptive material(2) in cavities
• joist framing at junction is supported on near leaf of separating wall
• gypsum board ceiling panels end at wall framing and are fastened directly to bottom of ceiling framing or on resilient metal channels(3)</td><td>• flanking wall framing is fastened to adjacent leaf of separating wall
• flanking wall is framed with single row of wood studs, staggered studs on a single 38 x 140 mm (2 x 6 in. nominal) plate, or 2 rows of 38 x 89 mm (2 x 4 in. nominal) wood studs on separate 38 x 89 mm (2 x 4 in. nominal) plates, with or without absorptive material(2) in cavities
• gypsum board panels on flanking walls end or are cut at framing of separating wall and are fastened on resilient metal channels(3) or directly to framing of flanking wall if that framing and any sheathing are not continuous across the junction</td></tr>
</table>

Table 9.11.-A (Continued)

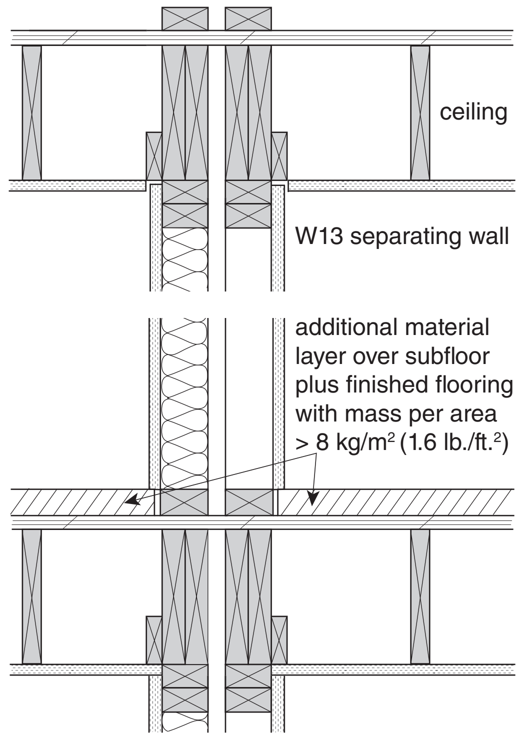
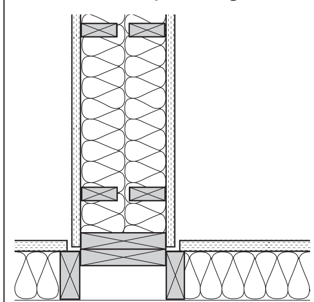
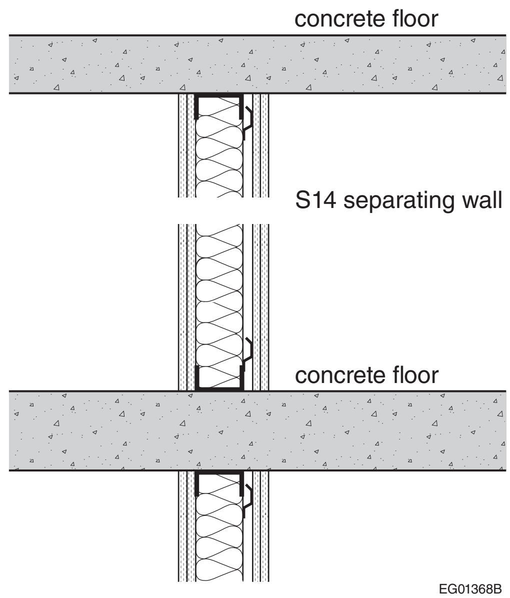
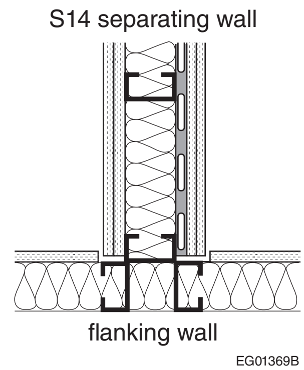
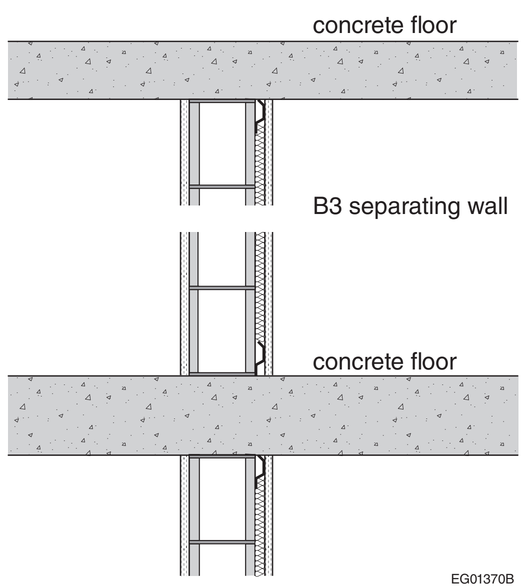
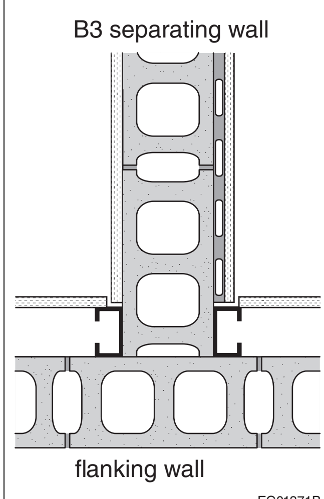
Type of Separating Wall Assembly with STC ≥ 50 from NBC Table 9.10.3.1.-A	Options for Design and Construction of Junctions[(1)] to Address Horizontal Sound Transmission Paths		
	Bottom Junction (between separating wall and flanking floors)	Top Junction (between separating wall and flanking ceiling)	Side Junctions (between separating wall and flanking walls)
	Example Showing Side View of Bottom and Top Junctions 		Example Showing Plan View of Side Junctions 
S1 to S15	• F1 concrete floor assembly from NBC Table 9.10.3.1.-B with mass per area not less than 300 kg/m² (60 lb./ft.²) (e.g., normal-weight concrete with average thickness of 130 mm (5 1/8 in.)) • with or without an additional material layer or finished flooring	• F1 concrete floor assembly from NBC Table 9.10.3.1.-B with mass per area not less than 300 kg/m² (60 lb./ft.²) (e.g., normal-weight concrete with average thickness of 130 mm (5 1/8 in.)) • with or without gypsum board ceiling suspended below concrete floor	• flanking wall framing is structurally connected to separating wall and terminates where it butts against framing of separating wall or is continuous across junction • gypsum board panels on flanking walls end or are cut at separating wall and are fastened directly to framing or on resilient metal channels[(3)] • flanking wall consists of steel framing (loadbearing or non-loadbearing steel studs) or concrete blocks with mass per area not less than 200 kg/m² (40 lb./ft.²) (e.g., normal-weight hollow-core concrete block units[(4)] with a gypsum board lining supported on framing providing a cavity not less than 50 mm (2 in.) deep) • with or without absorptive material[(2)] in cavities behind gypsum board of flanking walls

Table 9.11.-A (Continued)

<table>
<tr><td rowspan="2">Type of Separating Wall Assembly with STC ≥ 50 from NBC Table 9.10.3.1.-A</td><td colspan="3">Options for Design and Construction of Junctions(1) to Address Horizontal Sound Transmission Paths</td></tr>
<tr><td>Bottom Junction (between separating wall and flanking floors)</td><td>Top Junction (between separating wall and flanking ceiling)</td><td>Side Junctions (between separating wall and flanking walls)</td></tr>
<tr><td></td><td colspan="2">Example Showing Side View of Bottom and Top Junctions

</td><td>Example Showing Plan View of Side Junctions

</td></tr>
<tr><td rowspan="2">B1 to B10</td><td>• same options as stated above for walls S1 to S15</td><td>• same options as stated above for walls S1 to S15
• junction at top of concrete block assembly is loadbearing or non-loadbearing resilient joint</td><td>• same options as stated above for walls S1 to S15</td></tr>
<tr><td colspan="2">Example Showing Side View of Bottom and Top Junctions

</td><td>Example Showing Plan View of Side Junctions

</td></tr>
</table>

Notes to Table 9.11.A.:

(1) See also Table 9.11.-B.

Table 9.11.-A (Continued)

(2) Sound-absorptive material is porous (closed-cell foam was not tested) and includes fibre processed from rock, slag, glass or cellulose fibre with a maximum density of 32 kg/m^3 (2.0 lb./ft.^{3}). See Notes (6) and (8) of NBC Table 9.10.3.1.-A and Note (5) of NBC Table 9.10.3.1.-B for additional information.

(3) Resilient metal channels are formed from steel having a maximum thickness of 0.46 mm (25 gauge) with slits or holes in the single "leg" between the faces fastened to the framing and to the gypsum board (see NBC Figure A-9.10.3.1.-D). ASTM C 754, "Installation of Steel Framing Members to Receive Screw-Attached Gypsum Panel Products," describes the installation of resilient metal channels.

(4) Normal-weight concrete block units conforming to CSA A165.1, "Concrete Block Masonry Units," have aggregate with a density not less than 2 000 kg/m^3 (125 lb./ft.^{3}); 190 mm (7 1/2 in.) hollow-core units are 53% solid, providing a wall mass per area over 200 kg/m^2 (40 lb./ft.^{2}); 140 mm (5 1/2 in.) hollow-core units are 75% solid, providing a wall mass per area over 200 kg/m^2 (40 lb./ft.^{2}).

Table 9.11.-B presents options for improving the sound insulation performance of separating wall systems beyond that achieved by implementing the options presented in Table 9.11.-A. The suggested performance improvement options are listed in order of approximate acoustic priority and are interdependent; i.e., if options at the top of the list are not implemented, then options at the bottom of the list will have much less effect.

Table 9.11.-B
Options for the Construction of a Separating Wall System to Further Improve the Sound Insulation Performance Achieved with the Options in Table 9.11.-A

Type of Separating Wall Assembly with STC ≥ 50 from NBC Table 9.10.3.1.-A	Performance Improvement Options for Junctions Between Separating Wall Assemblies and Flanking Floor and Ceiling Assemblies
W4 to W6, W8 to W12	• Increase mass per area of additional material layer and finished flooring over subfloor (e.g., concrete or gypsum concrete topping) • Choose separating wall assembly with higher STC rating • Orient floor and ceiling joists parallel to separating wall (non-loadbearing case) • Add resilient layer under additional material layer over subfloor or between additional material layer and finished flooring • Support gypsum board panels of ceiling on resilient metal channels[1] • Support gypsum board panels of flanking walls on resilient metal channels[1]

W13 to W15	• If seismic or other structural requirements permit, choose a fire block detail at floor/wall junction in accordance with NBC Subsection 9.10.16. that does not provide a rigid connection between the two rows of framing of the separating wall (e.g., subfloor not continuous across junction and semi-rigid fibre insulation board filling the gap in accordance with NBC Article 9.10.16.3.). In this case, an additional material layer would not be necessary. Also, choose separating wall assembly with higher STC rating (e.g., more absorptive material[2] in cavities and/or more gypsum board).
	• If having a rigid structural connection at the floor/wall junction (such as subfloor continuous across the junction) is required for seismic or other structural reasons, obtain a higher ASTC rating as follows:
	    • Increase combined mass per area of additional material layer over subfloor and finished flooring (e.g., concrete or gypsum concrete topping)
	    • Choose separating wall assembly with higher STC rating (e.g., more absorptive material[2] and/or more gypsum board)
	    • Support gypsum board panels of ceiling on resilient metal channels[1]
	    • Support gypsum board panels of flanking walls on resilient metal channels[1]
	    • Add resilient layer under additional material layer over subfloor or between additional material layer and finished flooring

Table 9.11.-B (Continued)

Type of Separating Wall Assembly with STC ≥ 50 from NBC Table 9.10.3.1.-A	Performance Improvement Options for Junctions Between Separating Wall Assemblies and Flanking Floor and Ceiling Assemblies
S1 to S15	• Choose separating wall assembly with higher STC rating • Increase thickness of concrete floor slab and/or add material layer and finished flooring over subfloor • Add gypsum board ceiling on framing supported under the floor above, with cavity not less than 100 mm (4 in.) deep • Add resilient layer under additional material layer over subfloor or between additional material layer and finished flooring • Support gypsum board panels of flanking walls on resilient metal channels(1) if steel studs are loadbearing type
B1 to B10	• Choose separating wall assembly with higher STC rating • Add gypsum board ceiling supported below concrete floor with cavity not less than 100 mm (4 in.) deep and sound-absorptive material(2) in cavity • Increase thickness of concrete floor slab and/or add material layer and finished flooring over subfloor • Add resilient layer under additional material layer over subfloor or between additional material layer and finished flooring and increase mass per area of additional material layer and finished flooring (e.g., floating concrete or gypsum concrete topping) • Support gypsum board panels of flanking walls on resilient metal channels(1) if steel studs are loadbearing type

Notes to Table 9.11.B.:

(1) Resilient metal channels are formed from steel having a maximum thickness of 0.46 mm (25 gauge) with slits or holes in the single “leg” between the faces fastened to the framing and to the gypsum board (see NBC Figure A-9.10.3.1.-D). ASTM C 754, “Installation of Steel Framing Members to Receive Screw-Attached Gypsum Panel Products,” describes the installation of resilient metal channels.

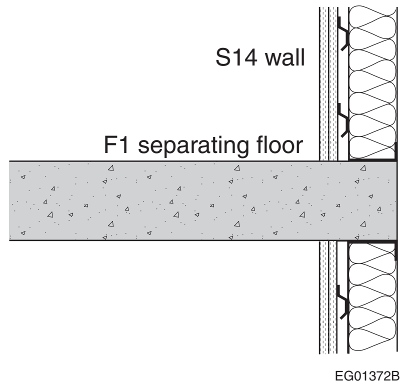
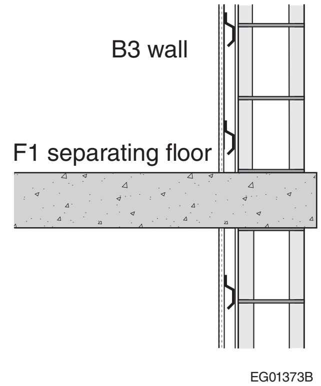
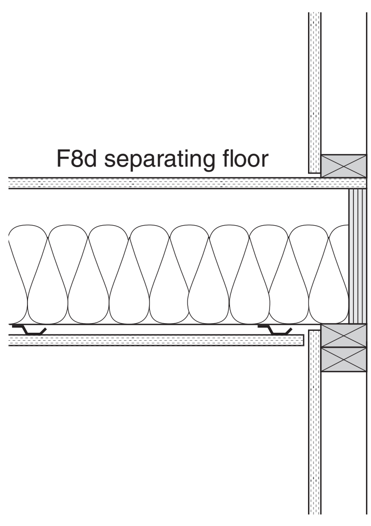
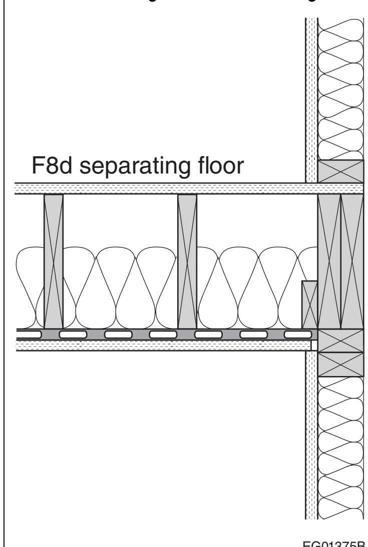
(2) Sound-absorptive material is porous (closed-cell foam was not tested) and includes fibre processed from rock, slag, glass or cellulose fibre with a maximum density of 32 kg/m^3 (2.0 lb./ft.^{3}). See Notes (6) and (8) of NBC Table 9.10.3.1.-A and Note (5) of NBC Table 9.10.3.1.-B for additional information.

Table 9.11.-C presents compliance options for the design and construction of separating floor/ceiling assemblies with flanking wall assemblies in vertically adjoining spaces.

Table 9.11.-C
Options for the Design and Construction of Junctions and Flanking Surfaces Between Separating Floor/Ceiling Assemblies in Vertically Adjoining Spaces for Compliance with NBC Clause 9.11.1.1.(1)(b)

Type of Separating Floor/Ceiling Assembly with STC ≥ 50 from NBC Table 9.10.3.1.-B	Options for Design and Construction of Junctions(1) to Address Vertical Sound Transmission Paths	
	Junctions with Flanking Steel-Framed Walls	Junctions with Flanking Concrete Walls
F1 (with or without gypsum board ceiling)	• floor ends at flanking wall assembly (T-junction) or extends beyond it (cross-junction) • steel framing of flanking walls is loadbearing or non-loadbearing, with a single row of steel studs, staggered studs, or 2 rows of studs, with studs spaced not less than 400 mm (16 in.) o.c., with or without absorptive material(2) in cavities • flanking wall structure is fastened to separating concrete floor but is not continuous across junction • gypsum board on flanking walls is not continuous across junction and is fastened directly to wall framing or on resilient metal channels(3)	• floor ends at flanking wall assembly (T-junction) or extends beyond it (cross-junction) • one wythe of concrete blocks with mass per area not less than 200 kg/m^2 (40 lb./ft.^{2}) (e.g., normal-weight hollow-core concrete block units(4)) • loadbearing (solid) or non-loadbearing (resilient) junction between top of flanking concrete block wall and floor structure • gypsum board lining is supported on wood or steel framing providing a cavity not less than 50 mm (2 in.) deep, with or without absorptive material(2) in cavities • gypsum board on flanking walls is not continuous across junction and is fastened directly to wall framing or on resilient metal channels(3)

Table 9.11.-C (Continued)

Type of Separating Floor/Ceiling Assembly with STC ≥ 50 from NBC Table 9.10.3.1.-B	Options for Design and Construction of Junctions[1] to Address Vertical Sound Transmission Paths	
	Junctions with Flanking Steel-Framed Walls	Junctions with Flanking Concrete Walls
	Examples Showing Side View of Junctions	
		
F8 to F38	Junctions with Flanking Loadbearing or Non-Loadbearing Walls	
	• wood studs of flanking wall are 38 x 89 mm (2 x 4 in. nominal) or 38 x 140 mm (2 x 6 in. nominal) and spaced 400 mm (16 in.) or 600 mm (24 in.) o.c. • flanking wall framing consists of single row of wood studs, staggered studs on a single 38 x 140 mm (2 x 6 in. nominal) plate, or 2 rows of 38 x 89 mm (2 x 4 in. nominal) wood studs on separate 38 x 89 mm (2 x 4 in. nominal) plates, with or without absorptive material[2] in wall cavities • gypsum board panels on flanking walls end or are cut near floor framing and are fastened directly to wall framing or supported on resilient metal channels[3]	
	Example Showing Side View of Junctions in Flanking Loadbearing Wall	Example Showing Side View of Junctions in Flanking Non-Loadbearing Wall
		

Notes to Table 9.11.C.:

(1) See also Table 9.11.-D.

(2) Sound-absorptive material is porous (closed-cell foam was not tested) and includes fibre processed from rock, slag, glass or cellulose fibre with a maximum density of 32 kg/m³ (2.0 lb./ft.³). See Notes (6) and (8) of NBC Table 9.10.3.1.-A and Note (5) of NBC Table 9.10.3.1.-B for additional information.

(3) Resilient metal channels are formed from steel having a maximum thickness of 0.46 mm (25 gauge) with slits or holes in the single "leg" between the faces fastened to the framing and to the gypsum board (see NBC Figure A-9.10.3.1.-D). ASTM C 754, "Installation of Steel Framing Members to Receive Screw-Attached Gypsum Panel Products," describes the installation of resilient metal channels.

(4) Normal-weight concrete block units conforming to CSA A165.1, "Concrete Block Masonry Units," have aggregate with a density not less than 2 000 kg/m³ (125 lb./ft.³); 190 mm (7 1/2 in.) hollow-core units are 53% solid, providing a wall mass per area over 200 kg/m² (40 lb./ft.²); 140 mm (5 1/2 in.) hollow-core units are 75% solid, providing a wall mass per area over 200 kg/m² (40 lb./ft.²).

Table 9.11.-D presents options for improving the sound insulation performance of separating floor/ceiling assemblies beyond that achieved by implementing the options presented in Table 9.11.-C. The suggested performance improvement options are listed in order of approximate acoustic priority and are interdependent; i.e., if options at the top of the list are not implemented, then options at the bottom of the list will have much less effect.

Table 9.11.-D
Options for the Construction of a Separating Floor System to Further Improve the Sound Insulation Performance Achieved with the Options in Table 9.11.-C

Type of Separating Floor/Ceiling Assembly with STC ≥ 50 from NBC Table 9.10.3.1.-B	Performance Improvement Options for Junctions Between Separating Floor/Ceiling Assemblies and Flanking Wall Assemblies
F1 (with or without gypsum board ceiling)	• Add heavier additional material layer over subfloor and/or resilient layer under additional material layer or between additional material layer and finished flooring • Add gypsum board ceiling supported at least 100 mm (4 in.) below concrete floor with minimal structural connection (e.g., ceiling framing supported resiliently) and sound-absorptive material(1) in cavity • Support gypsum board of flanking walls of lower room on resilient metal channels(2) (if framed with loadbearing studs)
F8 to F38	• Add heavier additional material layer over subfloor and/or resilient layer under additional material layer or between additional material layer and finished flooring • Add more/heavier gypsum board to ceiling and increase spacing of resilient metal channels(2) to 600 mm (24 in.) o.c. • Support gypsum board of flanking loadbearing walls of lower room on resilient metal channels(2) • Support gypsum board on flanking non-loadbearing walls of lower room on resilient metal channels(2)

Notes to Table 9.11.D.:

(1) Sound-absorptive material is porous (closed-cell foam was not tested) and includes fibre processed from rock, slag, glass or cellulose fibre with a maximum density of 32 kg/m^3 (2.0 lb./ft.^{3}). See Notes (6) and (8) of NBC Table 9.10.3.1.-A and Note (5) of NBC Table 9.10.3.1.-B for additional information.

(2) Resilient metal channels are formed from steel having a maximum thickness of 0.46 mm (25 gauge) with slits or holes in the single “leg” between the faces fastened to the framing and to the gypsum board (see NBC Figure A-9.10.3.1.-D). ASTM C 754, “Installation of Steel Framing Members to Receive Screw-Attached Gypsum Panel Products,” describes the installation of resilient metal channels.

Floor Treatments

The sound insulation performance of lightweight framed floors can be improved by adding floor treatments, i.e., additional layers of material over the subfloor (e.g., concrete topping, OSB or plywood) and finished flooring or coverings (e.g., carpet or engineered wood). Table 9.11.-E presents the mass per area values based on thickness and density of a number of generic floor treatment materials (the values for proprietary products may be different; consult the manufacturer’s current data sheets for their products’ values).

Table 9.11.-E
Mass per Area of Floor Treatment Materials

Floor Treatment Material	Thickness, mm (in.)	Density, kg/m³ (lb./ft.³)	Mass per Area, kg/m² (lb./ft.²)
Materials Typically Having a Mass per Area Less Than 8 kg/m² (1.6 lb./ft.²)			
Medium-density fibreboard	2.9–6.1 (0.114–0.240)	790–810 (49.3–50.6)	2.3–5.0 (0.47–1.02)
Plywood – generic softwood	12.5–13.3 (0.492–0.524) 15.5–16.3 (0.610–0.642)	450–500 (28.1–31.2)	5.6–6.6 (1.15–1.35) 7.0–8.1 (1.43–1.66)
Ceramic tile	8.4 (0.331)	700–1 000 (43.7–62.4)	5.9–8.4 (1.21–1.72)
Materials Typically Having a Mass per Area Greater Than 8 kg/m² (1.6 lb./ft.²) but Less Than 16 kg/m² (3.3 lb./ft.²)			
Particleboard	11.3–19.2 (0.445–0.756)	710–755 (44.3–47.1)	8.1–14.5 (1.66–2.97)
Oriented strandboard	14.3–15.8 (0.563–0.622) 17.3–18.8 (0.681–0.740)	600–680 (37.5–42.5)	8.6–10.7 (1.76–2.19) 10.4–12.8 (2.13–2.62)
Medium-density fibreboard	13.9–21.1 (0.547–0.831)	640–755 (40.0–47.1)	8.9–15.9 (1.82–3.26)
Plywood – generic softwood	25.5 (1.004)	450–500 (28.1–31.2)	11.5–13.1 (2.36–2.68)
Materials Typically Having a Mass per Area Greater Than 16 kg/m² (3.3 lb./ft.²) but Less Than 32 kg/m² (6.6 lb./ft.²)			
Medium-density fibreboard	25.0–32.1 (0.984–1.264)	640–740 (40.0–46.2)	16.0–23.7 (3.28–4.85)
Materials Typically Having a Mass per Area Greater Than 32 kg/m² (6.6 lb./ft.²)			
Gypsum concrete	25.0 (0.984)	1 840–1 870 (114.9–116.7)	46.1–46.7 (9.44–9.56)
Concrete	40.0–50.0 (1.575–1.969)	2 015–2 380 (125.8–148.6)	80.6–119.0 (16.51–24.37)

Section 9.12. Excavation

Introduction

Most foundation preparations involve the excavation of either soil or rock. This Section deals with some of the general requirements for all excavations and the requirements for the minimum depth of excavation depending on the type of soil conditions, superstructure and whether or not the foundation encloses heated spaces.

9.12.1. General

9.12.1.1. Removal of Topsoil and Organic Matter

This Article requires the removal of topsoil and organic matter from unexcavated areas.

This will help to make the space beneath a building inhospitable to insect pests and vermin, and to keep it from generating objectionable odours that might migrate into the structure above (see Figure 9.12.-1).

For an additional level of insect resistance where termites are known to occur, stumps, roots and other wood debris must be removed to a depth of at least 300 mm (12 in.) in order to protect the structure.

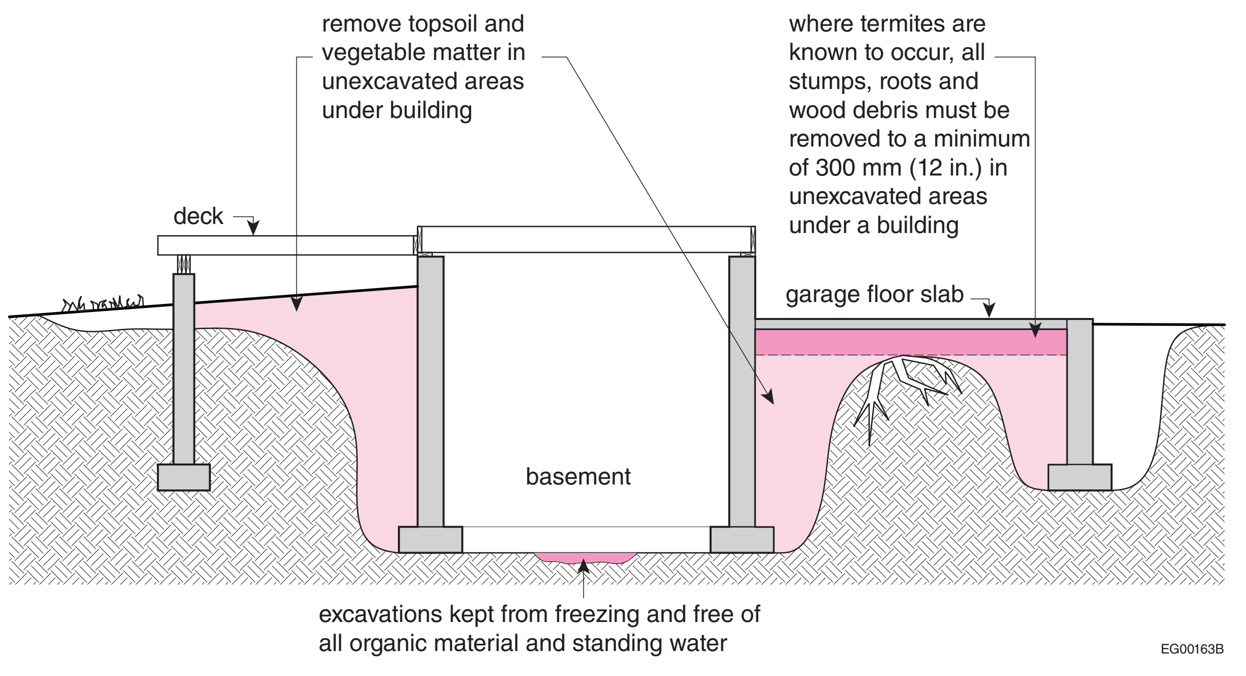


Figure 9.12.-1
Removing topsoil and organic matter

9.12.1.2. Standing Water

This Article requires that excavated areas be kept free of water to keep the soil beneath the foundation from becoming saturated. Standing water can reduce the soil's load-carrying capacity, or make it susceptible to frost heave.

9.12.1.3. Protection from Freezing

This Article requires that the bottom of an excavation be kept from freezing during construction to avoid uneven frost heave and subsequent uneven subsidence on thawing.

Soil expands as it freezes, and this frost heaving varies with the soil moisture content, the type of soil and the depth of freezing. Protecting excavations from freezing during construction is necessary to avoid uneven settlement under footings. Foundations constructed on such soils will therefore settle as the soil thaws. Differential settlement will likely damage the foundation and the structure it supports.

9.12.2. Depth

9.12.2.1. Excavation to Undisturbed Soil

This Article requires that excavations extend to undisturbed soil to provide adequate bearing strength and avoid uneven settlement. Soils that are disturbed or loosened from digging may lose their natural compaction. Therefore, a foundation constructed on such soils will settle. If the settlement is uneven, damage to the foundation or the structure it supports may occur.

9.12.2.2. Minimum Depth of Foundations

This Article sets minimum depths for foundations based on the type of soils and based on the use of the protected space to reduce the possibility of damage to a foundation or the building it supports by extending it below the ground to a depth where the amount of potential differential movement is tolerable to the supported construction.

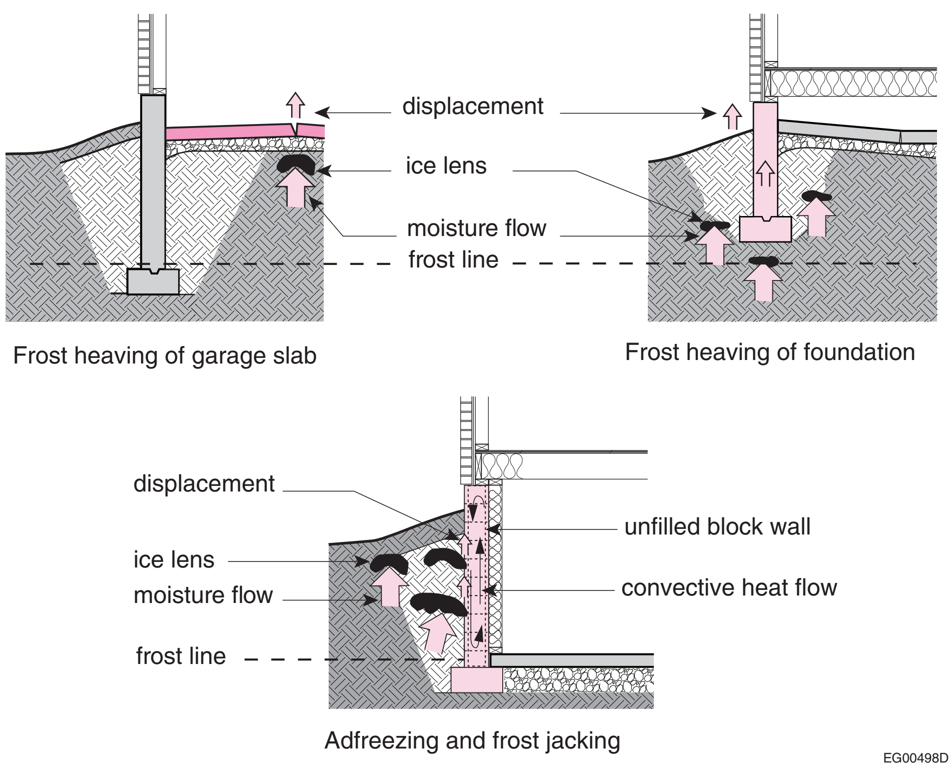


Figure 9.12.-2
Effects of frost

To reduce damage to and failure of foundations due to frost heave, it is important that they be constructed to an adequate depth. The minimum depth required depends on a number of factors, of which winter heating of the space enclosed by the foundation is the most significant. Where the enclosed space is heated and the foundations are insulated in a manner that allows the heat to warm the soil beneath the footings, there is little reason for footings to be below the normal level of frost penetration.

The severity of frost heaving depends on the type of soil and its drainage characteristics, the availability of moisture near the foundations, and the prevailing weather and climate conditions. The depth of frost penetration may fluctuate from year to year depending on the severity of the weather and the amount of snow cover. Therefore, the depth of frost penetration should be calculated according to past experience in the area in which the building is to be constructed. An estimate of the depth of frost penetration can be made on the basis of the freezing index. The freezing index is the annual average cumulative total of the number of degree-days below freezing that occur during cold weather.

Frost heaving of building footings and foundations can create major problems (Figure 9.12.-2). Frost heaving can occur when moisture in the soil below the footings freezes and expands. Frost heaving will not occur if there is no moisture in the soil, or if frost is prevented from reaching the footing by providing sufficient footing depth or by providing heat to the footings.

The depth of frost penetration can be reduced locally through the placement of insulation above and around the exterior of the footings. The amount of insulation required to protect footings must be designed according to NBC Part 4.

Adfreezing is more likely to occur in heavy soils that are more difficult to drain. When heat from the building is restricted from reaching the outside of the foundation wall, the soil adjacent to the foundation wall can freeze to it. This can result in lifting (frost jacking) or cracking of the foundation wall. Adfreezing can be minimized by ensuring that water in the soil does not come into contact with the wall, or by placing a slip plane (polyethylene) between unheated foundation walls and the soil.

Figure 9.12.-3 illustrates the relationship of frost indices to the depth of frost penetration. Where the winter is colder than normal and snow cover is limited, frost depth will be greater.

All excavations for foundations must extend to undisturbed soil. The minimum depths for foundations containing a heated basement or crawl space and for foundations containing no heated space are listed in NBC Table 9.12.2.2. (Figure 9.12.-4).

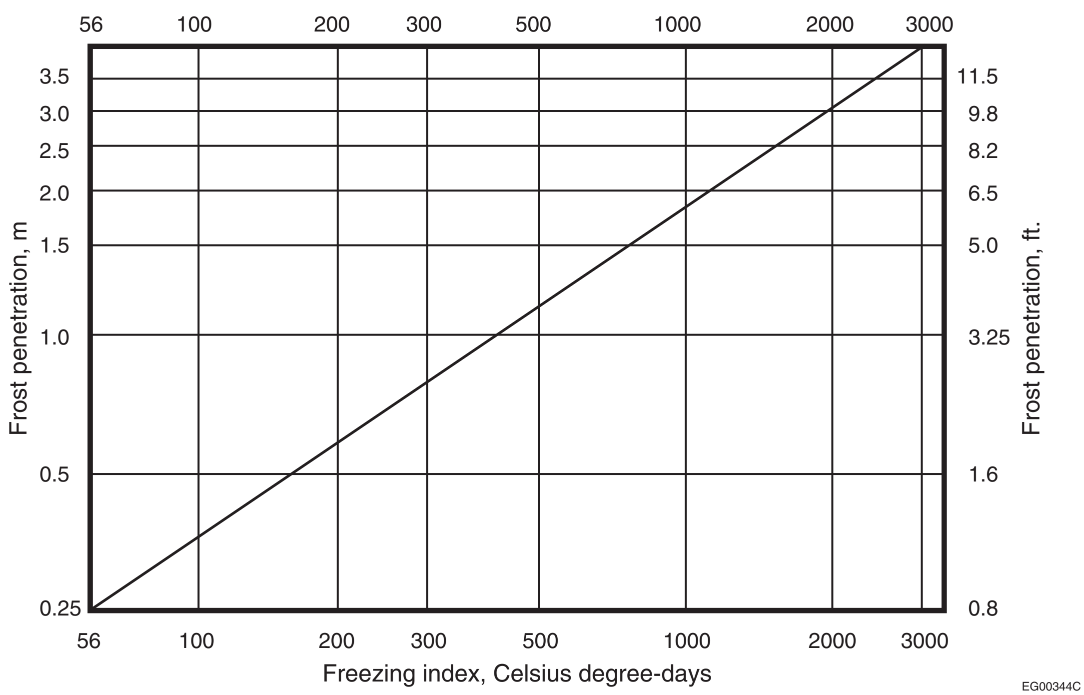


Figure 9.12.-3
Plot of frost penetration versus freezing index

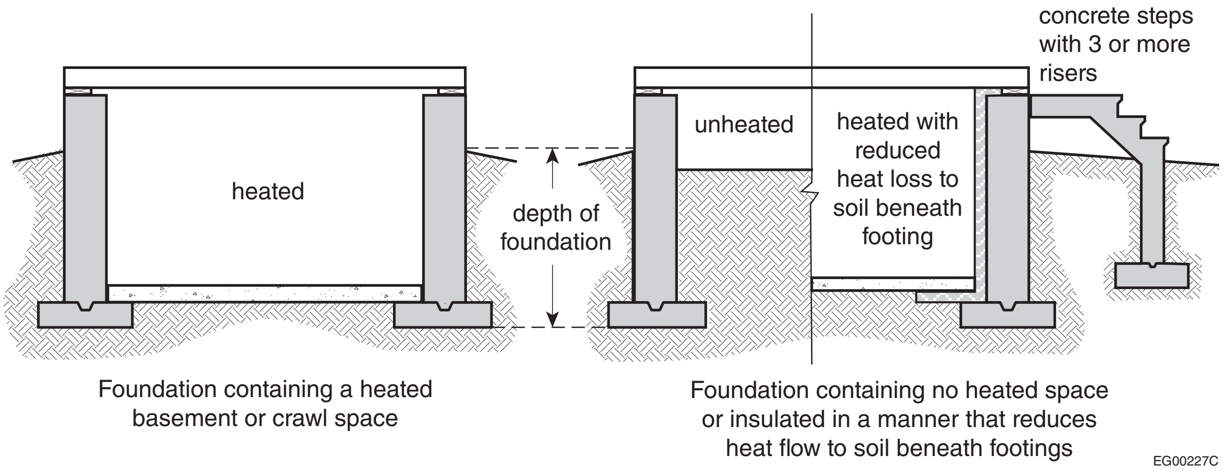


Figure 9.12.-4
Depth of foundation

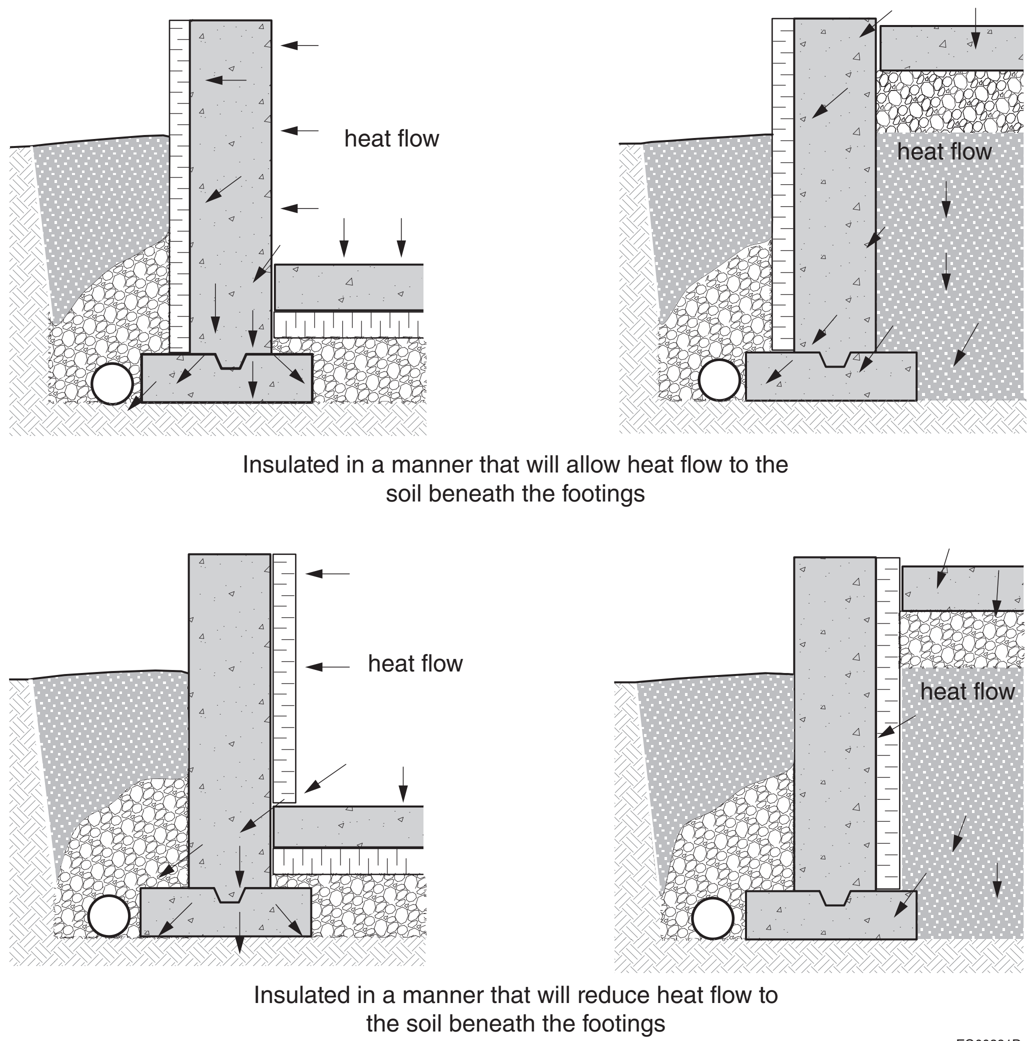


Figure 9.12.-5
Foundation insulation and heat flow to the soil beneath the footings

In cases where a foundation is not heated (e.g., unheated crawl spaces, exposed piers, unheated garages), the depth of the footings is an important factor if the soil is subject to frost heaving. This is also the case where the enclosed space is heated but the foundations are insulated in a manner that restricts heat transfer to the soil beneath the footings as shown in Figure 9.12.-5.

Small buildings are less liable to be damaged by soil movement. Manufactured homes, for example, are usually designed for road transport. Their rigid structure distributes localized ground movement from piers over a fairly large area of the building structure, allowing substantial movement without damage. This structural system permits their construction on shallow foundations that are defined by NBC Articles 9.15.1.3. and 9.23.6.3.

One-storey accessory buildings that are 55 m^2 (590 $ft.^2$) or less, and that have a distance from the ground to the undersides of the joists of 600 mm (2 ft.) or less, including detached garages, are normally not seriously damaged by foundation movement since they are generally of wood-frame construction and do not have finishes that are likely to crack (such as gypsum board). These can also be supported on surface foundations. If the walls of either accessory buildings or manufactured homes are of masonry or masonry veneer, however, damage can be expected if the buildings are on frost-susceptible soil; this would make surface foundations unacceptable.

Foundation depths for decks and other accessible exterior platforms can be less than the minimums in NBC Table 9.12.2.2. if the deck is not more than one storey and not more than 55 m^2 (590 $ft.^2$) in area, the distance from the ground to the underside of the joists is 600 mm (2 ft.) or less, the deck does not support a roof and its movement will not affect the structure it serves (Figure 9.12.-6).

Where decks or other accessible exterior platforms are supported on shallow foundations subject to movement, a means for levelling the structure must be provided by a space below with a clear height under the platform of at least 600 mm (2 ft.) and a width of at least 600 mm (2 ft.) or by installing the decking in a manner that allows easy removal.

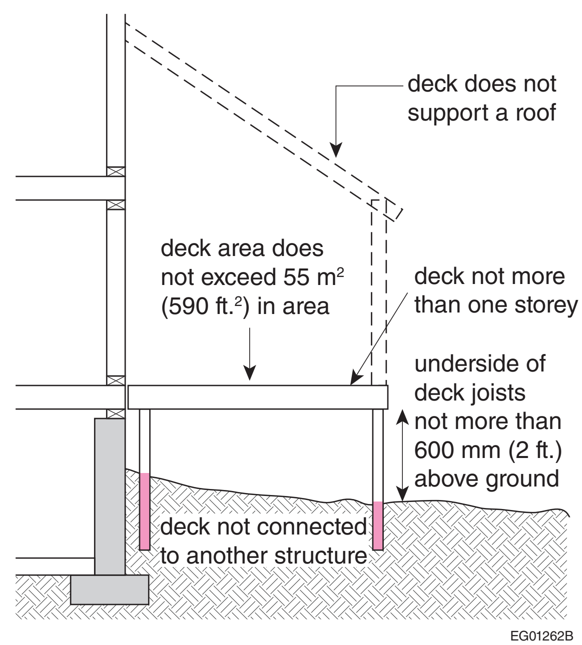


Figure 9.12.-6
Conditions for reduced foundation depth for decks

Coarse granular material such as gravel and sand are relatively unsusceptible to frost heaving. If these materials are able to drain to the depth of frost penetration, there is little danger of damage. If soil adjacent to a foundation is not well drained, the water in the spaces between the soil particles will freeze and expand to cause some upward movement. Fine-grained soils such as silt and clay are subject to much more serious movement. Not only are these soils very slow draining, but they can also create horizontal layers of ice in the process of freezing. Water can be drawn to the freezing zone for considerable distances to build up thick layers of ice, which can cause substantial upward movement or frost heave beneath foundations. Therefore, footings for foundations in such soils must be located below the depth of frost penetration if the foundations are unheated.

Clay soils are also subject to volume change with changes in soil moisture content. Some clays are more sensitive than others and can exhibit significant seasonal volume changes (see Guide 9.4., Structural Requirements). The seasonal fluctuation in moisture is less pronounced as the depth is increased. The depth to which potentially damaging seasonal foundation movement will occur depends on the prevailing climate and weather, such as the amount of rainfall and drying conditions. A minimum depth of 1.2 m (4 ft.) for foundations in clay soils is considered to provide reasonable protection against such movement.

Heat loss from basements usually results in less frost heave near the foundation, but the potential for heaving gradually increases as the distance from the foundation increases. As a result, exterior steps supported on the surface of the ground tend to slope upward away from a foundation in winter. As the outer part of the step moves up, the top of the step moves inward against the foundation. The greater the number of risers, the greater the magnitude of the inward movement. This may push the wall inward, or the steps outward. Concrete steps with more than two risers are therefore required to have foundations extending below frost level if the soil is subject to frost heaving. The steps shown in Figure 9.8.-9 could be supported on the ground surface.

9.12.3. Backfill

9.12.3.1. Placement of Backfill

This Article requires backfill to maintain the structural integrity of the foundation. If a foundation wall is designed to be laterally supported at the top by the floor system and backfilling is to be carried out before the floor is in place, the wall may fail unless it is temporarily supported. One method for providing temporary support is shown in Figure 9.12.-7.

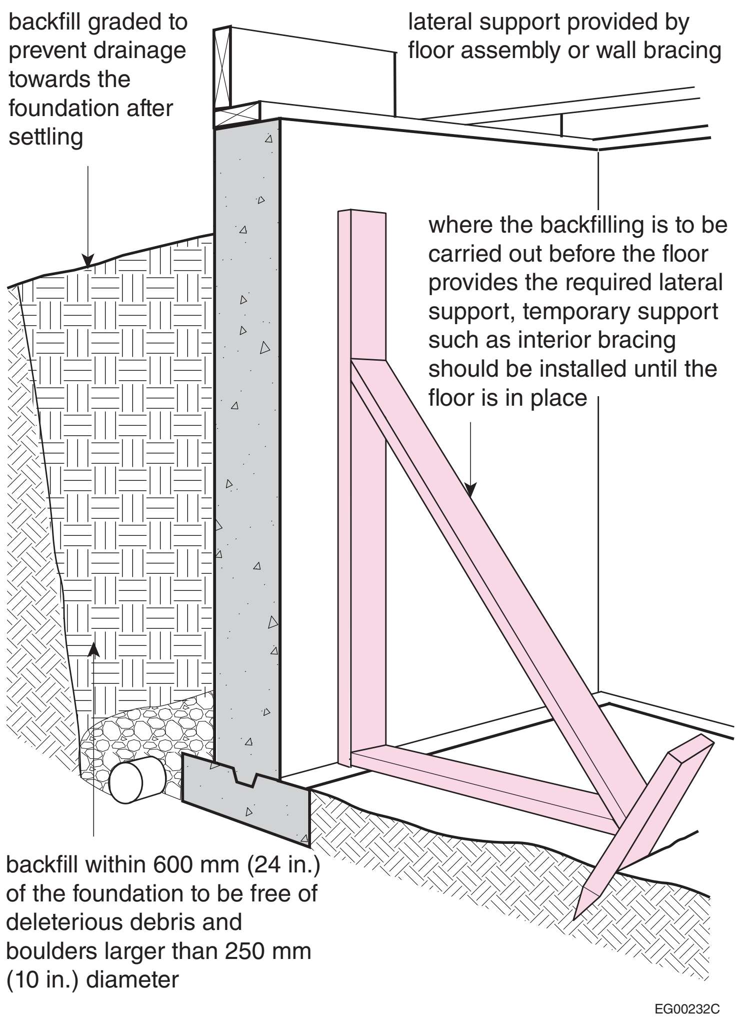


Figure 9.12.-7
Bracing foundation walls

Care must be taken during backfilling to avoid damaging the drainage tile, the foundation wall, any externally applied thermal insulation, and dampproofing or waterproofing membrane.

9.12.3.2. Grading of Backfill

This Article requires the grading of backfill to help keep surface water from seeping into a building and causing problems resulting from excessive moisture. Backfill against foundation walls should be coarse granular material that will allow any water to drain vertically to the footings before it reaches the wall surfaces. The top 30 mm (1 1/4 in.) or so of backfill should be relatively impervious to allow as much water as possible to drain away from the building before the water soaks into the ground and into the granular layer.

The two principal causes of basement wall leaks are inadequate grading around the foundation and poor footing drainage. Improper grading may cause drain water from the roof, driveway and surrounding area to flow towards the foundation walls rather than away from them, which may cause basement walls to leak and other related problems. Although some consolidation of the soil takes place during backfilling as a result of equipment operation, this is usually not very effective. Subsequent settlement will take place over time as voids in the fill gradually collapse.

The ground surface around a building should have a sufficient initial slope away from the building so that future settlement will not cause drainage towards the foundation. The amount of added slope required depends on the degree of consolidation achieved during backfilling, but on average, a settlement of 50 to 100 mm (2 to 4 in.) can be expected near the foundation wall. It is considered good practice to provide a positive slope away from the foundation for 1.5 to 2 m (5 to 7 ft.) if the size of the lot permits.

Rigid glass-fibre insulation is sometimes installed adjacent to the wall before backfilling to drain water to the footing drain, as well as to provide thermal insulation. Installing a drainage layer will also minimize the likelihood of adfreezing and potential frost jacking of the foundation. The provision of a vertical drainage layer, while considered to be good practice, is not a requirement in NBC Part 9. A number of proprietary systems can be used.

9.12.3.3. Deleterious Debris and Boulders

This Article limits the type of material that can be included in backfill to reduce future soil settlement adjacent to the foundation, which could lead to water leakage into the building and potential moisture-related problems.

Deleterious material includes, but is not limited to:

- organic material and other material subject to decomposition and compaction, which could have an adverse effect on grading around the building,
- materials that will off-gas and potentially pose a health hazard, and
- materials that are incompatible with the materials used in the foundations, footings, drainage materials or components, or other elements of the building whose required performance would be adversely affected.

Backfill within 600 mm (2 ft.) of foundations must be free of deleterious materials and boulders larger than 250 mm (10 in.) in diameter. Heavy equipment should be kept away from foundation walls so that additional loads (surcharges) are not placed on them.

Pyritic shales are also subject to movement and should be avoided for backfilling. See NBC Article 9.4.4.4. for a description of problematic soils.

9.12.4. Trenches beneath Footings

9.12.4.1. Support of Footings

This Article addresses trenching below the footing that is required for services. It requires that the soil in the trench be compacted by tamping to the footing base, or be filled with concrete having a strength of at least 10 MPa (1 400 psi), as illustrated in Figure 9.12.-8.

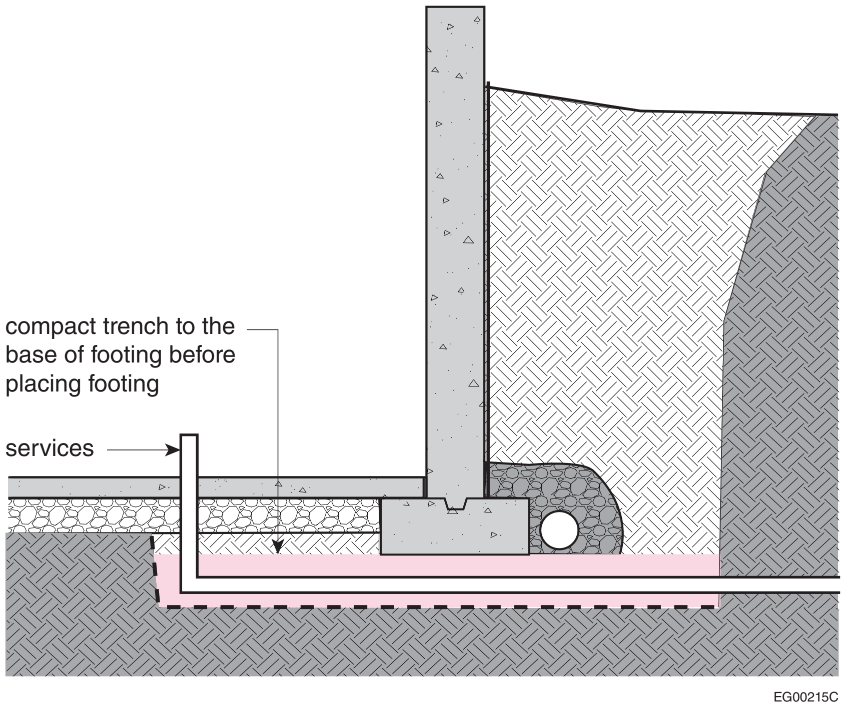


Figure 9.12.-8
Compacting after trenching

Section 9.13. Dampproofing, Waterproofing and Soil Gas Control

Introduction

Except for garage floors, concrete and masonry construction in contact with the ground is required to be dampproofed if it encloses space. This applies to both habitable and non-habitable space. Waterproofing of walls and floors is required if hydrostatic pressure is present. In addition, measures have to be taken to restrict the entry of soil gases, such as radon.

9.13.1. General

9.13.1.1. Scope and Application

This Article states that NBC Section 9.13. presents measures to control the ingress of water, moisture and soil gas, and indicates the scope of application of NBC Subsections 9.13.2., 9.13.3. and 9.13.4.

9.13.2. Dampproofing

The purpose of dampproofing is to limit the entry of capillary water and water vapour into finished building space. In an enclosed building that is heated in winter, soil moisture can add to the moisture load of the occupied space inside the building and raise humidity levels to a point where a variety of problems may occur. These range from simple condensation on windows to decay of structural members.

The purpose of dampproofing floors-on-ground is to restrict the entry of soil moisture. Garage floors are exempted because garages are not usually heated to elevated levels in winter, and the air is not recirculated to the habitable areas where it could add to the total moisture load for the building. Floors on granular fill are also exempted because the fill provides a capillary break, reducing the likelihood of soil moisture wicking into the slab.

Although surface water is controlled largely by grading away from the foundation and by the use of roof drainage, some water does enter the soil close to the building. This is controlled by the use of footing drains (NBC Subsection 9.14.3.) or a granular drainage layer (NBC Subsection 9.14.4.) to carry any residual water away from the building. Dampness coming from the soil adjacent to the foundation is controlled by dampproofing the foundation walls and floor.

A suitable drainage medium adjacent to the foundation wall can be provided to allow a path for soil moisture to drain down to the footing and to keep water away from the foundation wall. Coarse granular material, rigid fibreglass batts or proprietary systems incorporating rigid plastic membranes have been used for this purpose (see NBC Subsection 9.14.2.).

The control of moisture transfer through foundations is needed to prevent damage to the interior finish material and basement contents, and to protect the long-term integrity of the building structure. The measures that are used to control moisture transfer through foundation walls are also intended to control indoor humidity levels and contribute to the reduction of soil gas and radon entry into basements, thereby contributing to a healthy interior environment.

There are four sources of moisture associated with foundations:
(1) surface water,
(2) soil moisture,

(3) groundwater, and
(4) construction materials moisture.

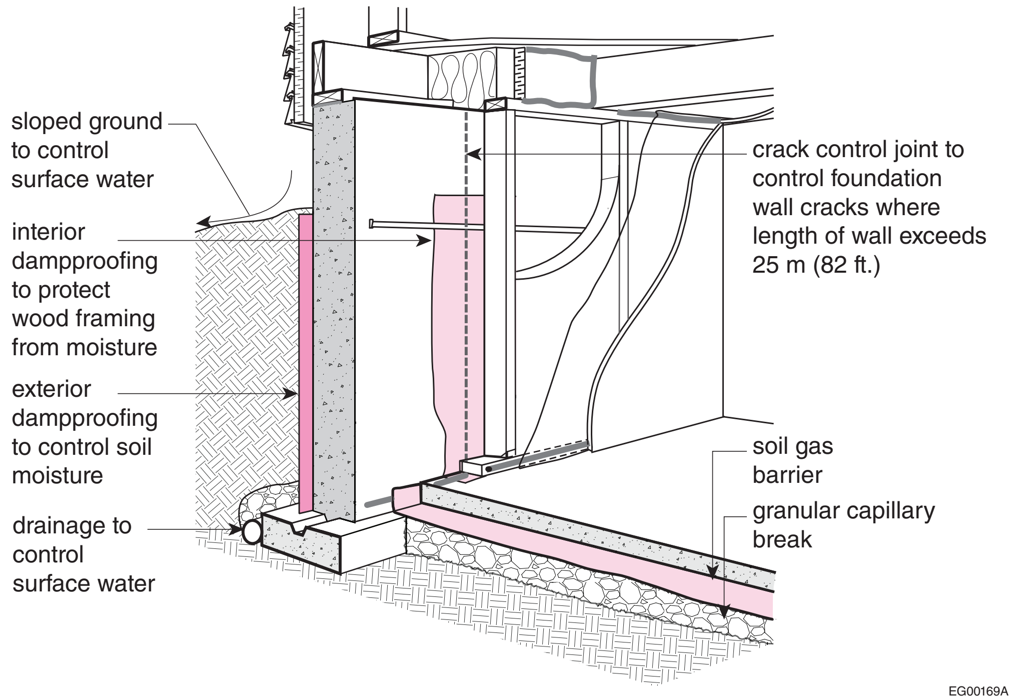


Figure 9.13.-1
Controlling moisture where no hydrostatic pressure is present

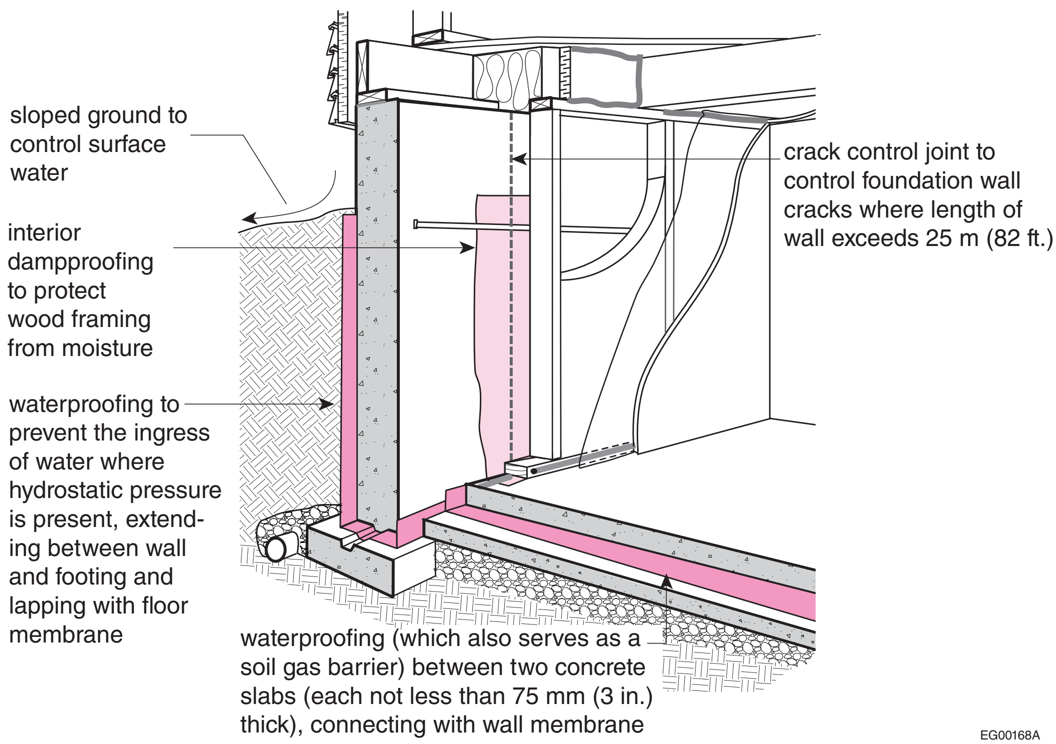


Figure 9.13.-2
Controlling moisture where hydrostatic pressure is present

Figures 9.13.-1 and 9.13.-2 show the methods that are used to manage moisture.

Surface water from rain and snow-melt is controlled through the use of eavestroughing and grading. Soil moisture, in the form of water or water vapour, is controlled by dampproofing materials and drainage. Where the groundwater table is high enough to cause hydrostatic pressure against the foundation, it is controlled by waterproofing combined with a structural design capable of resisting water pressures.

Construction moisture, principally water in concrete, is best controlled by allowing adequate curing and drying time before enclosing.

9.13.2.1. Required Dampproofing

This Article indicates where dampproofing is required. Dampproofing is applied to foundation walls to seal the small pores that are always present in concrete and parging to reduce the capillary water migration through concrete, parging and masonry block. Dampproofing does not provide waterproofing, and should not be confused with waterproofing (NBC Subsection 9.13.3.).

Foundation walls below grade and floors-on-ground are required to be dampproofed. A floor-on-ground does not need to be dampproofed if it is in a garage or an unenclosed portion of a building, or if it is installed over not less than 100 mm (4 in.) of coarse clean granular material containing not more than 10% of material that will pass a 4 mm (No. 4) sieve (see also NBC Article 9.16.2.1.).

Figure 9.13.-3 illustrates where dampproofing is required for exterior foundation walls and floors-on-ground. Note that dampproofing is not required on foundation walls located below the base of floors-on-ground.

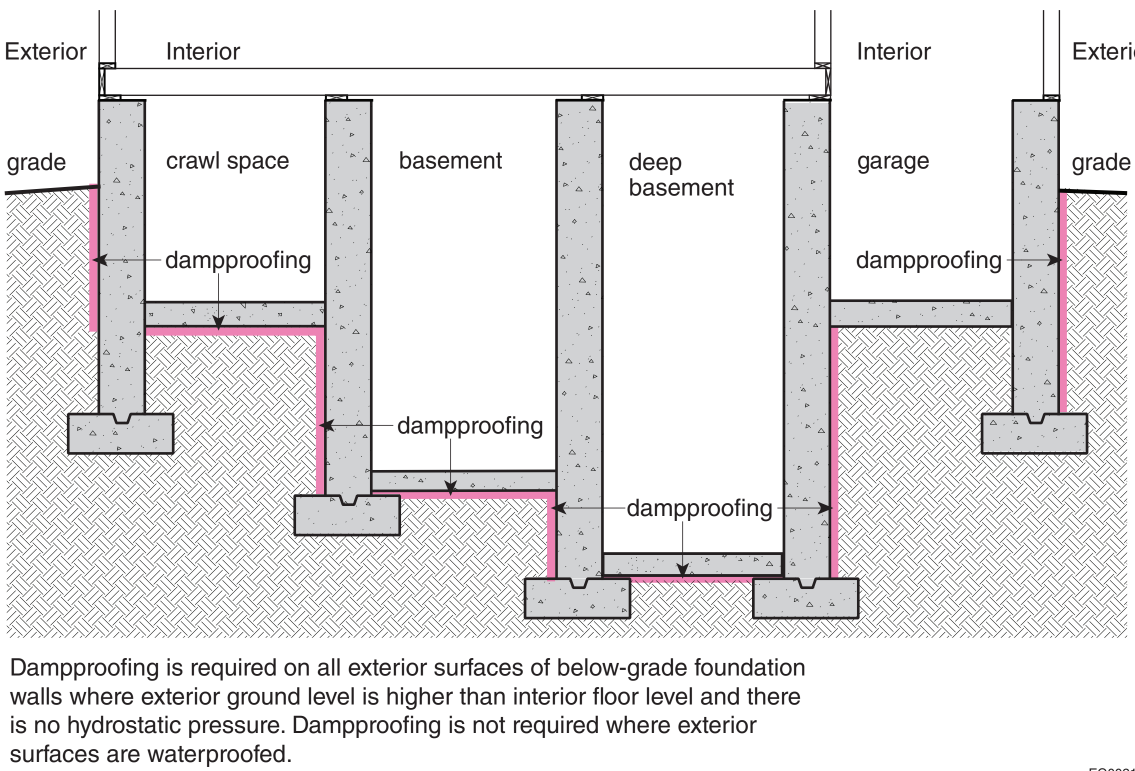


Figure 9.13.-3
Locations where dampproofing is required

Although there are many proprietary dampproofing systems for walls available, the commonly used generic systems consist of emulsified asphalt, cut-back asphalt, or tar. Emulsified systems are water-based, so they must be kept above the freezing point. Cut-back systems are not emulsified, but are thinned with mineral spirits, and can be applied at lower temperatures (down to about −10°C (14°F)). Both types of systems must be applied to clean and dry surfaces and protected from water during the application and curing of each coat.

9.13.2.2. Dampproofing Materials

This Article establishes performance requirements and appropriate characteristics for dampproofing materials, which can be fulfilled by complying with one of the listed standards or one of the prescriptive solutions provided.

9.13.2.3. Preparation of Surface

This Article contains requirements for the preparation of surfaces to be dampproofed. This preparation is intended to create a clean, even and continuous base for the application of dampproofing on foundation surfaces to ensure that the dampproofing can effectively control the entry of capillary water and water vapour into the finished building space.

Areas in which dampproofing is to be carried out must be kept free of water during the application and curing of the dampproofing system. The surfaces must be clean and dry, and must also be free of ice, snow, frost, dust, dirt, oil, grease, cracks, projections, depressions, loose particles and debris because such substances and imperfections could be detrimental to the performance of the dampproofing material. The surfaces must be prepared in accordance with the instructions of the dampproofing material manufacturer. Where dampproofing materials are to be applied on insulated concrete form (ICF) walls, the instructions of the ICF wall manufacturer must be followed.

Because dampproofing materials are not typically able to bridge gaps or pores of any appreciable size, the exterior face below ground level of unit masonry walls to be dampproofed must be parged with mortar not less than 6 mm (1/4 in.) thick (Figure 9.13.-4). The mortar must be coved over the footing so that it covers the junction between the wall and the footing to provide an even surface for dampproofing and to ensure that water drains away from the wall.

In the case of concrete walls to be dampproofed, holes (e.g., those resulting from the removal of form ties) and recesses must be sealed with cement mortar or a mastic or sealant that is compatible with the dampproofing material. Honeycombed areas in the walls should be parged to provide an even surface.

Dampproofing on walls normally consists of two coats of asphalt, a prime coat and a top coat, which are applied to provide a coverage of at least 1 L/m^2 (2 gal./100 ft.^{2}) over the wall surface below ground level. Either emulsion or cut-back asphalt can be applied by using brush, roller or spray techniques.

9.13.2.4. Application of Dampproofing Material

This Article requires that dampproofing be applied from the finished ground level to the top of the exterior of the footing, that dampproofing be installed in accordance with the manufacturer's instructions with regard to surface priming, conditions during application, application quantity and rate, and curing times (unless otherwise stated in NBC Subsection 9.13.2.), and that joints, cracks and penetrations be sealed to maintain the continuity of the dampproofing where the dampproofing material is not capable of bridging such discontinuities.

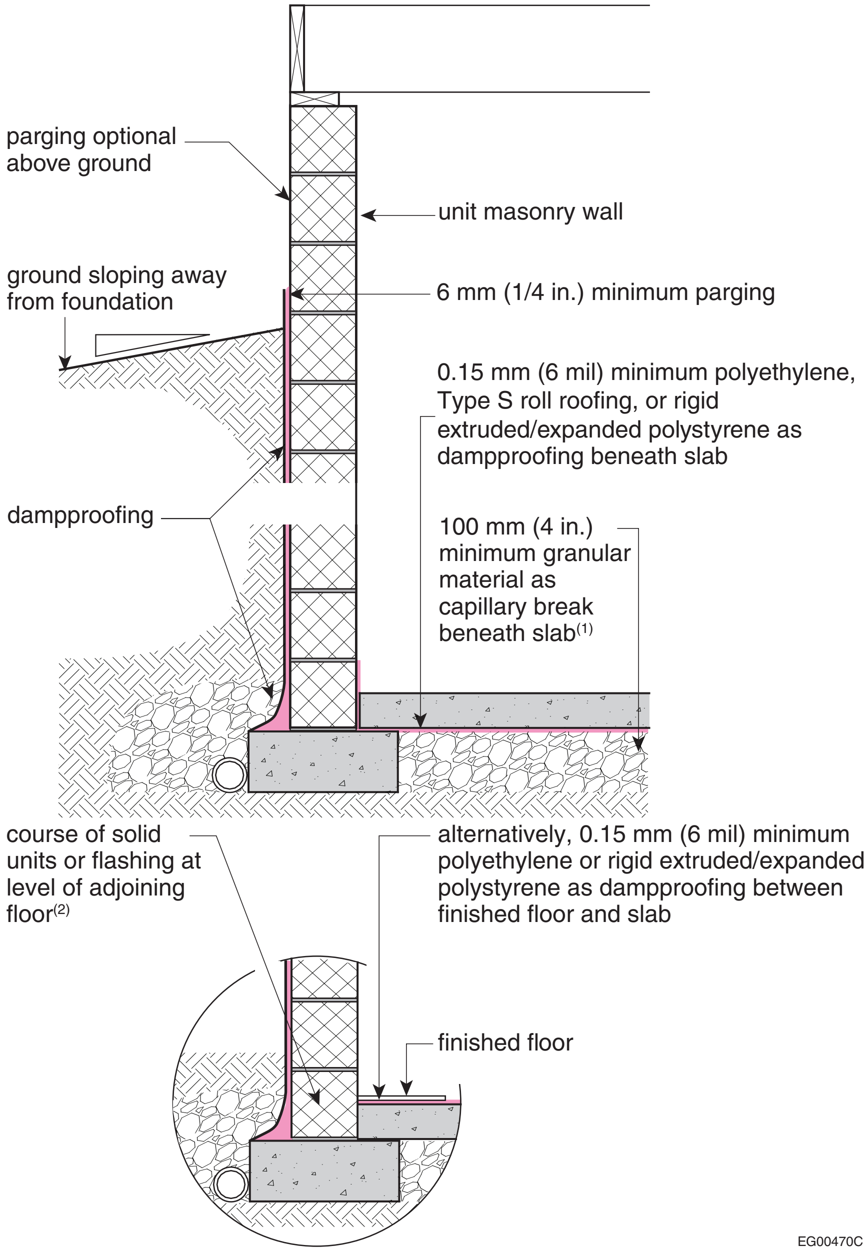


Figure 9.13.-4
Dampproofing of unit masonry foundation walls and floors-on-ground

Notes to Figure 9.13.-4:

(1) See NBC Article 9.16.2.1. Dampproofing need not be provided for a floor-on-ground installed over not less than 100 mm (4 in.) of coarse clean granular material containing not more than 10% of material that will pass a 4 mm (No. 4) sieve (NBC Article 9.13.2.1.).

(2) See NBC Article 9.25.3.4.

9.13.2.5. Moisture Protection for Interior Finishes

This Article requires that protection for interior surfaces be provided in proximity to concrete or masonry foundations. Excess water from cast-in-place concrete and ground moisture tends to migrate toward interior spaces, particularly in the spring and summer. Where moisture-susceptible materials, such as finishes or wood members, are in contact with foundation walls, the moisture needs to be controlled by installing a moisture barrier on the interior surface of the foundation wall that extends from the underside of the interior finish up the face of the wall to a point just above the level of the ground outside.

The reason the moisture barrier on the interior surface of the foundation wall must be stopped near ground level is to allow any moisture that finds its way into the finished wall cavity from the interior space (through leaks in the air or vapour barrier) to diffuse to the exterior. If the vapour permeance of dampproofing membranes or coatings exceeds 170 ng/(Pa·s·m^2) (3 perm), the moisture barrier may be carried full height. If their vapour permeance is less than 170 ng/(Pa·s·m^2) (3 perm), there is a risk of moisture being trapped on the interior surface of the moisture barrier. The permeance limit corresponds to the lower limit for breathable building membranes, such as asphalt-impregnated sheathing paper.

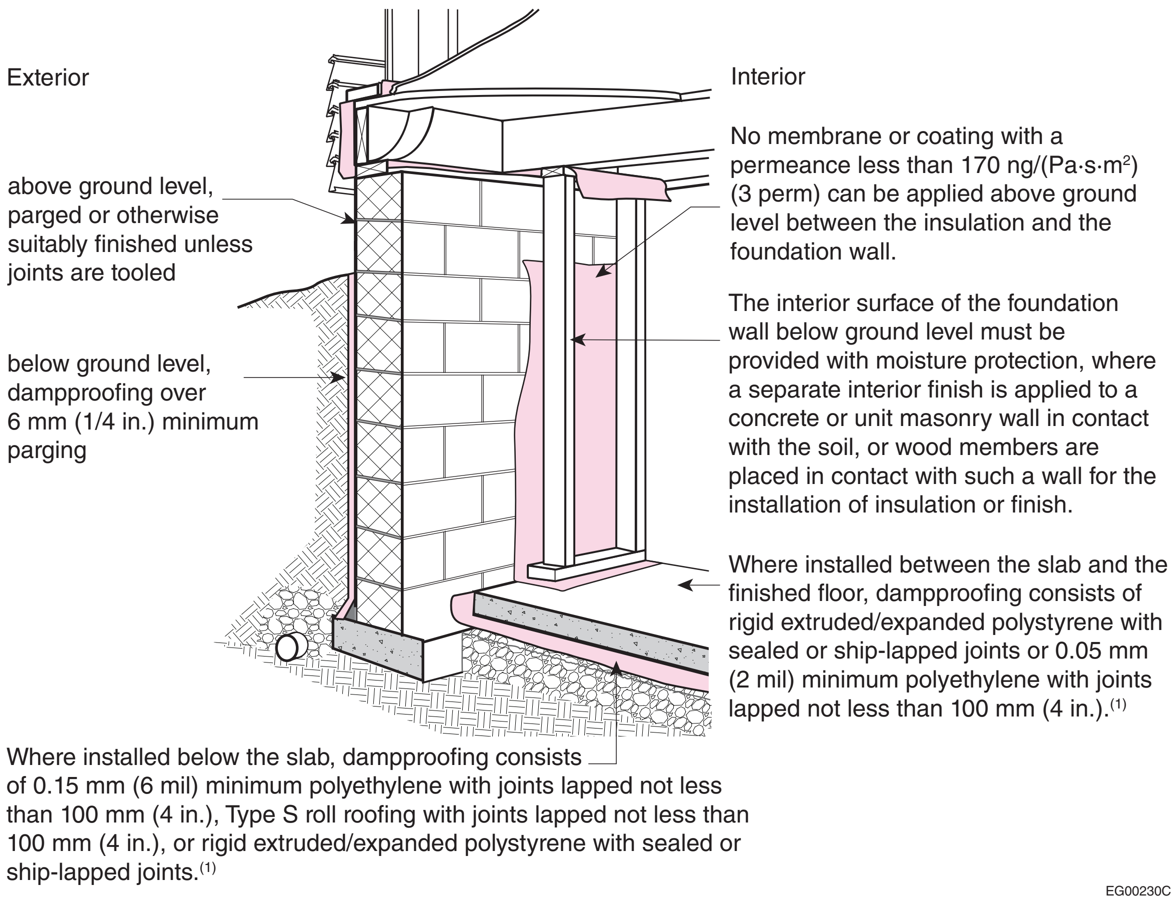


Figure 9.13.-5
Moisture protection for interior finishes

Note to Figure 9.13.-5:

(1) Dampproofing need not be provided for a floor-on-ground installed over not less than 100 mm (4 in.) of coarse clean granular material containing not more than 10% of material that will pass a 4 mm (No. 4) sieve (NBC Article 9.13.2.1.).

Some insulation products can also be used as interior moisture barriers. They have shown acceptable performance when applied over the entire foundation wall because they also provide vapour barrier and moisture barrier functions. When sealed to the other elements of the air barrier system, they can also serve the air barrier function. Where a single product provides all these functions, there is no risk of trapping moisture between two functional barriers with low water vapour permeance.

The moisture barrier should extend from the floor to the highest level of the interior insulation or finish, but not higher than the exterior finished ground level. However, where insulation functions as both moisture protection for interior surfaces and as a vapour barrier (NBC Subsection 9.25.4.), the insulation needs to be applied over the full height of the wall.

In winter, moisture from a house tends to diffuse through interior finishes and the wall insulation to condense on the interior surface of the foundation wall. This is controlled by installing a continuous vapour barrier on the warm side of the insulation that extends the full height of the interior wall (Figure 9.13.-5).

9.13.2.6. Dampproofing of Floors-on-Ground

This Article contains requirements for dampproofing of floors-on-ground, which are intended to limit the movement of soil moisture and soil gas through concrete slabs into basements.

All floors-on-ground, except those in garages, those in unenclosed portions of buildings, and those installed over not less than 100 mm (4 in.) of coarse clean granular material containing not more than 10% of material that will pass a 4 mm (No. 4) sieve, are required to be dampproofed (NBC Article 9.13.2.1.). The granular material beneath slabs acts as a means for the removal of any soil gas and as a capillary break between the wet subsoil and the underside of the slab.

Where granular material is not provided, dampproofing is commonly installed below the slab. In this arrangement, the dampproofing must consist of a polyethylene film not less than 0.15 mm (6 mil) thick or Type S roll roofing with joints lapped not less than 100 mm (4 in.). Rigid extruded or expanded polystyrene with sealed or ship-lapped joints is also acceptable as the dampproofing, provided it has sufficient compressive strength to support the floor assembly and has a water vapour permeance that complies with NBC Sentence 9.13.2.2.(2). Alternatively, dampproofing can be installed between the slab and a finished floor. In this arrangement, the dampproofing must consist of a polyethylene film not less than 0.05 mm (2 mil) thick with joints lapped not less than 100 mm (4 in.) or rigid extruded or expanded polystyrene with sealed or ship-lapped joints as described above.

9.13.3. Waterproofing

Waterproofing is intended to reduce the likelihood of groundwater leaking into building assemblies and interior spaces located below ground level. Such leakage could lead to structural deterioration, property damage and health risks.

If the water table rises more than 200 mm (8 in.) above the top of a floor-on-ground, the buoyant pressure on the slab will exceed its weight. Since slabs designed to resist such pressures are expensive, floor elevations are normally raised to reduce hydrostatic pressure.

The wall thicknesses in NBC Section 9.15. are based on the assumption that free-draining backfill is used, which does not result in water pressure on foundation walls. Where free-draining backfill is not used, and where walls are subject to hydrostatic pressure, wall design in accordance with NBC Part 4 is required, and the walls must be waterproofed.

9.13.3.1. Required Waterproofing

This Article indicates the situations where waterproofing is required to prevent the ingress of water into building assemblies and interior spaces. Where hydrostatic pressure occurs, assemblies separating interior space from the ground must be waterproofed. Roofs of underground structures must also be waterproofed.

Hydrostatic pressure occurs when the groundwater table rises above building assemblies. Drainage systems, which are required around the base of footings, eliminate hydrostatic pressure on the assemblies above as long as the footings are below the water table. However, footing drains can become ineffective if they are blocked or have an inadequate capacity. Certain sites tend to be wet and poorly drained because of topography or soil conditions; as a result, when snow melts or during periods of heavy rain, below-grade spaces may be subjected to hydrostatic pressure. Walls and floors subject to hydrostatic pressure from a high water table must be designed to resist such pressure.

9.13.3.2. Waterprofing Materials

This Article establishes performance requirements and appropriate characteristics for waterproofing materials and systems, which can be fulfilled by complying with one of the listed standards.

There are many proprietary waterproofing systems, but a commonly used generic system consists of two membranes bonded with emulsified or non-emulsified asphalt (Figure 9.13.-6). Emulsified asphalts are water-based, so they must be kept above the freezing point. They are normally reinforced with glass-fibre fabric or felt membrane. Cut-back and hot-applied asphalts are not emulsified, but are thinned with mineral spirits, and can be applied at lower temperatures (down to about −10°C (14°F)). These asphalts can be reinforced with glass fibre or asphalt sheathing or with roofing paper.

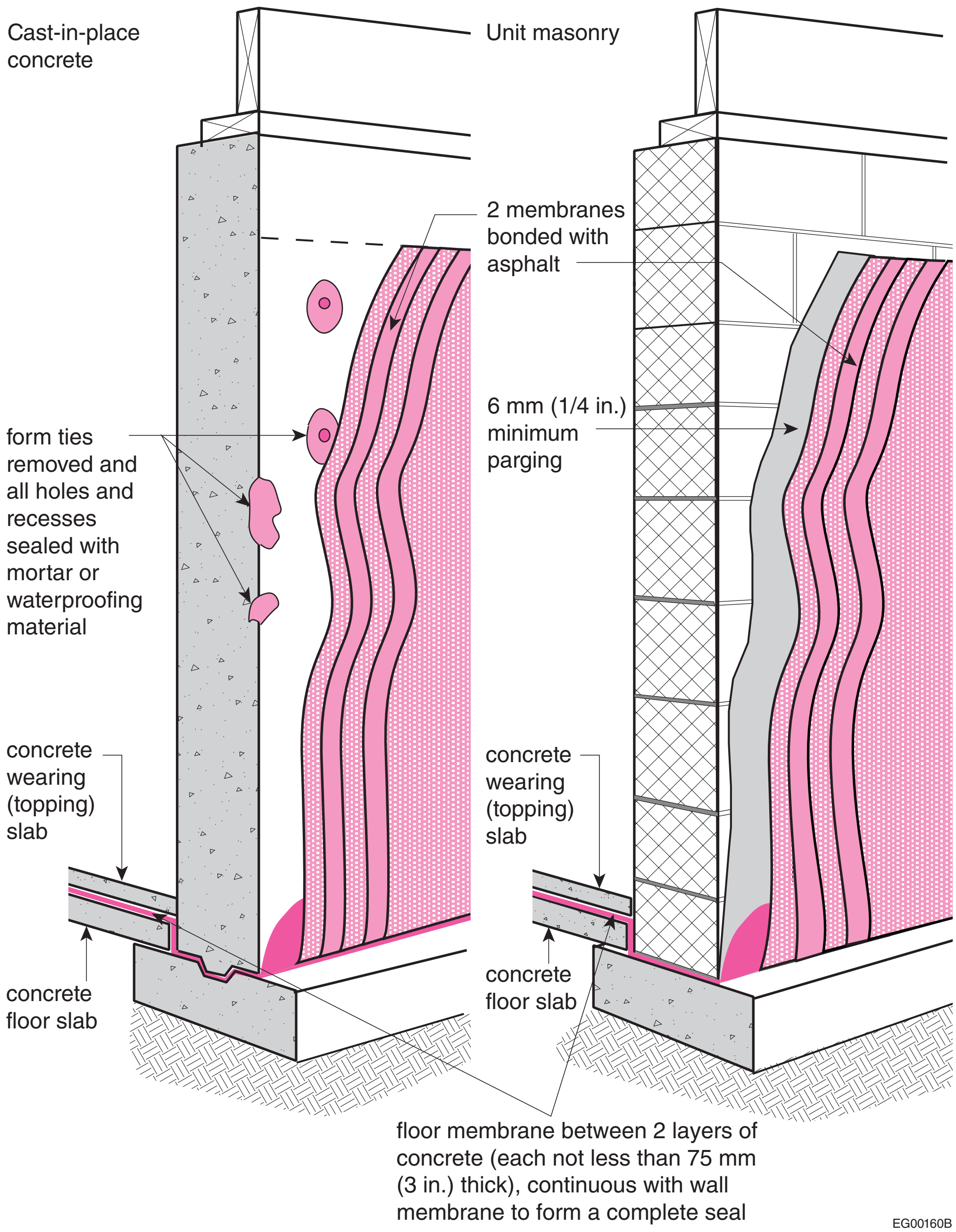


Figure 9.13.-6
Waterproofing of floors and walls

9.13.3.3. Preparation of Surface

This Article contains requirements for the preparation of surfaces to be waterproofed. This preparation is intended to create an even base for the application of waterproofing on building assemblies.

In general, surfaces to be waterproofed must be prepared in accordance with the instructions of the waterproofing material manufacturer. Where waterproofing materials are to be applied to ICF walls, the instructions of the ICF wall manufacturer must be followed. Surfaces to be waterproofed must be clean and dry, and must be free of ice, snow, frost, dust, dirt, oil, grease, loose particles and debris. They must also be made smooth by removing projections and depressions.

9.13.3.4. Application of Waterproofing Membranes

This Article establishes requirements for the installation and continuity of waterproofing and for its protection during application, curing and backfilling.

Waterproofing must be installed so that it is continuous across joints and at junctions between different building elements.

9.13.3.5. Floor Waterproofing System

This Article indicates how waterproofing is to be applied to basement floors-on-ground. The waterproofing membrane must be installed between two layers of concrete and must be made continuous with the wall membrane to form a complete seal, as shown in Figure 9.13.-6.

9.13.4. Soil Gas Control

Soil gas control aims to reduce the entry of soil gases into enclosed building spaces to levels that will not pose a significant health risk to occupants. Most commonly, soil gas is air and water vapour, but can also include radon, methane or other pollutants such as pesticides or fertilizers, which could cause adverse health effects. Of these, radon gas is the only one addressed more specifically in NBC Part 9. This is because radon gas ingress can be addressed through relatively simple, generic measures for all buildings. The same is not true for other dangerous gases such as methane.

All buildings are required to have a basic resistance against the ingress of soil gas. The two principal methods of minimizing the presence of soil gases in buildings are the sealing of the interface between the soil and the conditioned space (as much as reasonably practicable), and the depressurization of the ground below the air barrier.

Other code requirements also play a role in providing a general resistance to soil gas ingress such as requirements for ground cover in crawl spaces (NBC Section 9.18.), requirements for the control joints to reduce the cracking of foundation walls (NBC Article 9.15.4.9.), airtight seals on sump pits covers (NBC Article 9.14.5.2.), dampproofing (NBC Subsection 9.13.2.), and balanced ventilation (NBC Article 9.32.3.8.).

Specific resistance against radon ingress into conditioned spaces is achieved by having a gas-permeable layer (NBC Article 9.13.4.2.) under a continuous and sealed air barrier (NBC Subsection 9.25.3.), and having a connection that can be used to vent the gas permeable layer in the future (NBC Article 9.13.4.3.).

General Background

Radon Control in Buildings

Radon is a colourless, odourless, radioactive gas that occurs naturally. It results from the breakdown of uranium in soil, rock and water. Radon gas particles are constantly transferred from the ground to the outdoor air, but the radon concentration in outdoor air is very low (approximately 20–30 Bq/m^3), and therefore not a concern. However, radon gas that enters occupied space can be in concentrations that could lead to an increased risk of lung cancer. The indoor concentration of radon depends on

- the concentration of radon in the soil, and
- the ability of the building envelope to deter movement of air (gas) from the ground into conditioned building space, which is a function of the pressure differential across the building assemblies below ground and the integrity of the air barrier system.

Building Pressurization

One method used in the past to exclude soil gas from below-grade living space was to pressurize the conditioned building space to prevent any soil gas from leaking in the below-ground building assemblies. This required regulation of the air pressure on the inside of the envelope relative to the air pressure in the soil.

However, there is a safe range for the interior pressure in a building set by the need to minimize outward leakage of warm, moist interior air through a building envelope. The limit for depressurization depends on the presence and performance of spillage-susceptible combustion appliances present in the house and the need to limit drawing in soil gas.

This means that controlling the entry of soil gases by building or basement pressurization is problematic since it could lead to condensation problems in the building envelope due to exfiltration. This leaves depressurization of the soil abutting the envelope as the most practical method of achieving the desired outward pressure difference.

9.13.4.1. Application and Scope

This Article indicates that NBC Subsection 9.13.4. applies to the construction of wall, floor and underground roof assemblies that separate conditioned space from the ground to resist inflow of soil gases. It also applies to the provision of a rough-in to allow for the future removal of gases from the soil should testing indicate that this is required.

9.13.4.2. Protection from Soil Gas Ingress

This Article requires that all buildings be protected from soil gas ingress. Although there are regions in Canada where radon or other soil gases are known to be a problem, it cannot be concluded, at the time of construction, that such a problem may not be encountered at any other location. First, a reliable and comprehensive radon map for Canada does not exist. Second, it is possible for there to be high radon concentrations in individual buildings and no elevated concentrations in neighbouring buildings. Last, it is very difficult to detect a problematic radon concentration during construction.

For all these reasons, NBC Subsection 9.25.3. requires the installation of an air barrier system in all buildings to provide protection from all soil gases by providing a means to depressurize the space between the air barrier and the ground to mitigate high concentrations of radon.

In order to provide a basic resistance against the ingress of air from the ground in all houses and buildings that could admit soil gases, including radon, all wall, roof and floor assemblies separating conditioned space from the ground are required to be protected by an air barrier conforming to NBC Subsection 9.25.3.

NBC Sentence 9.13.4.2.(2) requires that dwelling units and buildings containing residential occupancies be provided with a rough-in for a radon extraction system conforming to NBC Article 9.13.4.3.

Unheated (not conditioned) crawl spaces are not required to be protected against the ingress of radon because venting an unheated crawl space can be used as an effective radon mitigation system should it become necessary. Even heated crawl spaces can be exempted from the requirement to provide a rough-in for a future radon extraction system if the crawl space remains accessible, such that a person could easily install a connection to the sub-slab or sub-air barrier space to be used for the radon extraction system (see NBC Sentence 9.13.4.2.(2)).

For all other occupancies covered under NBC Part 9, protection from radon ingress and the means to alleviate high concentrations of radon in the future, should this become necessary, can also be provided in accordance with NBC Article 9.13.4.3. or can be designed in accordance with NBC Parts 5 and 6.

The criterion used by Health Canada to establish the guideline for acceptable radon concentration is the time that occupants spend inside buildings. Health Canada recommends installing a means for the future removal of radon in buildings that are occupied by persons for more than four hours per day. NBC Sentence 9.13.4.2.(3) may, therefore, not apply to buildings or portions of buildings that are intended to be occupied for less than four hours a day. Addressing a radon problem in such buildings in the future, should that become necessary, can also be achieved by providing a means for increased ventilation at times when these buildings are occupied.

9.13.4.3. Providing the Rough-in for a Subfloor Depressurization System

This Article requires that provisions be made for the future removal of radon from the soils should testing after construction is complete indicate that this is required. It is not required that a full system be installed and activated. Instead, a rough-in for a subfloor depressurization is required. The rough-in is low in cost, especially when compared to the cost of adding it later should radon be identified as a problem.

NBC Article 9.13.4.3. contains two sets of requirements: NBC Sentence 9.13.4.3.(2), which describes the criteria for subfloor depressurization systems using performance-oriented language, and NBC Sentence 9.13.4.3.(3), which describes one particular acceptable solution using more prescriptive language. In some cases, subfloor depressurization requires a solution other than the one described in NBC Sentence 9.13.4.3.(3), for example, where compactible fill is installed under slab-on-grade construction.

Floors-on-ground need to be provided with a rough-in for subfloor depressurization consisting of either one of the following two methods:

(1) A gas-permeable layer is provided between the air barrier and the ground to allow for the depressurization of the space. This layer could be coarse sand, a dimpled membrane, or other products that allow the extraction of gas that has been collecting. An inlet that allows for effective depressurization of the gas-permeable layer, and an outlet that permits connection to depressurization equipment is sealed to maintain the integrity of the air barrier system, and is clearly labelled to indicate that it is intended for the removal of radon from below the floor-on-ground. An example is a sump chamber that is sealed to the floor air barrier and can be connected and used to draw and exhaust air from beneath the floor-on-ground.

(2) A clean, granular material layer and a pipe at least 100 mm (4 in.) in diameter through the floor are provided. The pipe is located near the centre of the floor, with its bottom end opening into the required granular layer. The top must be fitted with an airtight cap. The pipe permits connection to the depressurization equipment, and is labelled to indicate that it is intended solely for the removal of radon from below the floor-on-ground. The pipe must be installed vertically to extend through the floor at or near its centre (Figure 9.13.-7). The bottom end of the pipe must open into the required layer of granular fill. The granular fill around the pipe must be at least 150 mm (6 in.) deep for a radius of not less than 300 mm (12 in.) around the pipe. To ensure the free flow of air in the space below a floor-on-ground, not less than 100 mm (4 in.) of coarse clean granular material (containing no more than 10% of material that would pass through a 4 mm (No. 4) sieve) must be installed under the rest of the floor-on-ground.

The extraction opening (the pipe) should not be blocked and should be arranged such that air can be extracted from the entire space between the air barrier and the ground. This will ensure that the extraction system can maintain negative pressure underneath the entire floor (or in heated crawl spaces underneath the air barrier).

Locating the capped pipe near the centre of the floor might restrict floor layout options. If it is desired to locate the pipe rough-in close to an exterior wall or into a service area of a basement, perforated pipe can be used to connect the vertical pipe to the center of the floor. If the subfloor space is interrupted by internal footings, it is important to ensure that the collection system is capable of depressurizing all areas should this become necessary.

Further information on protection from radon ingress can be found in the following Health Canada publications:
- Radon: A Guide for Canadian Homeowners, and
- Guide for Radon Measurements in Residential Dwellings (Homes)

Since radon concentration in vent gases can be quite high, it is best to vent at the roof level. Some simple steps can be taken during the initial construction of a building to facilitate the future installation of the system. This could include locating the rough-in pipe cap below a suitable interior wall, and pre-drilling the wall top and bottom plates, particularly those not accessible from a basement or an attic, in order to provide a place for a future vent pipe, should it ever be required.

Testing for Radon and Activating the Depressurization System

The provision of subfloor depressurization capability, an effective air barrier for soil gas control, and rough-in for future radon removal (if required) are required for all buildings. Testing for radon is the responsibility of the building owner after building occupancy has taken place. Testing for radon is not expensive and is recommended by Health Canada. Since the radon level in a house can vary significantly during the year, the test should be of sufficient duration to provide a reasonable indication of the concentration. The minimum period for testing should be three months or as recommended by Health Canada.

Continuous readout monitor can be used for testing or monitoring, but should be capable of displaying the results in Bq/m³ and calculating at least 30-day averages. Such readout monitors should be located as recommended by the manufacturer and installed within the lowest area of the building intended to be occupied for more than four hours per day. The National Environmental Health Association - National Radon Proficiency Program (NEHA-NRPP), and the National Radon Safety Board (NRSB) certify radon measuring devices.

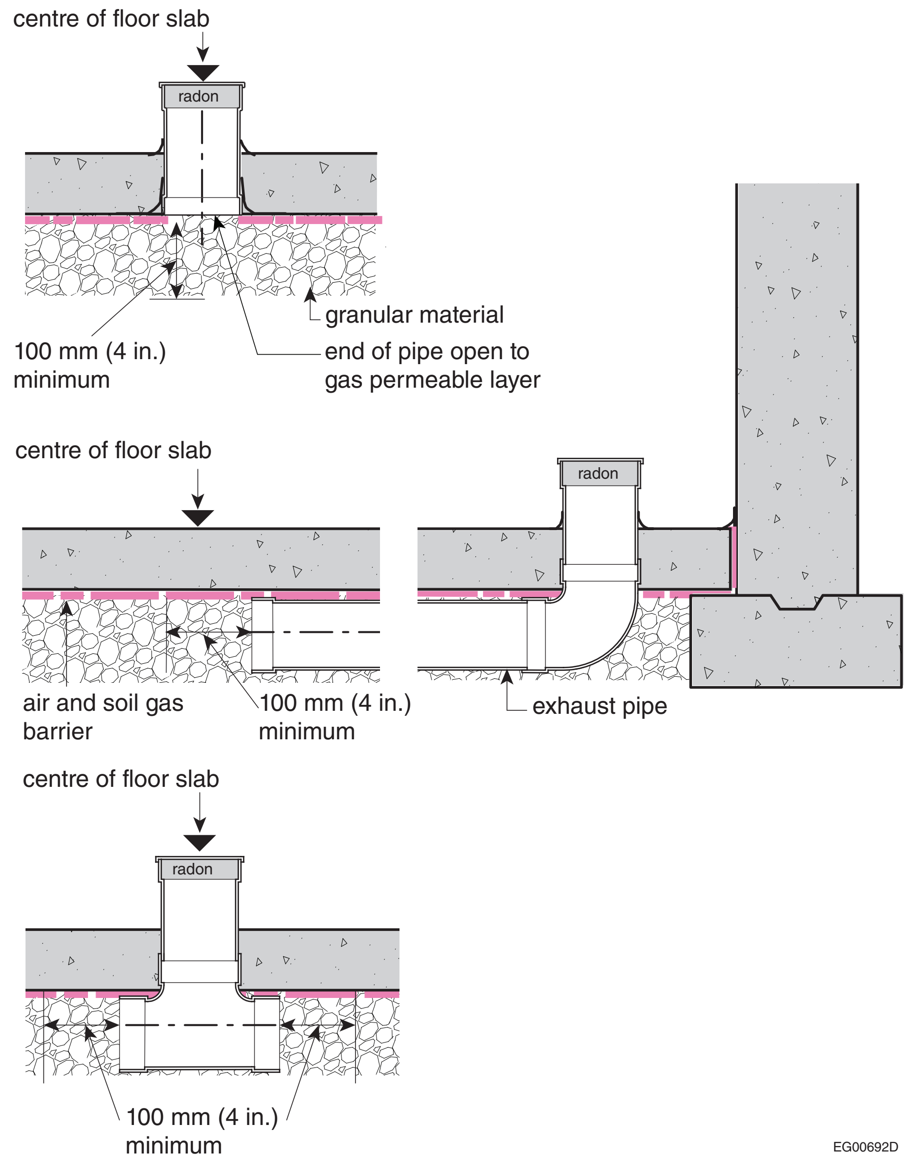


Figure 9.13.-7
Acceptable configurations for the extraction opening in a depressurization system

Design Considerations for Radon Mitigation Systems

The preferred testing location is centrally in the basement or the main floor for houses without basements. The current guideline specified by Health Canada is 200 Bq/m³ as an annual average concentration. If the results of the test indicate a concentration exceeding the Canadian Action Level, the completion of a subfloor depressurization system may be necessary to reduce the radon concentration to a level below the guideline specified by Health Canada.

Activation of the subfloor depressurization system requires that the rough-in pipe be uncapped and connected to a ventilation system exhausting to the outside. Exhaust pipes passing through unheated spaces should be insulated. The exhaust fan should be located outside the occupied space where noise will not be a nuisance.

It is best to locate the fan as close to the final outlet end of the ventilation system as possible, so that the pressurized portion of the system downstream of the fan will not be located in or adjacent to the living space. If the pressurized portion of the system were to pass through the living space, then any leak in the system would have the potential to spill high concentrations of soil gas into the living space, worsening the situation the system was intended to correct. The fan should be of a type suitable for the application and capable of continuous operation.

Two types of complete subfloor depressurization systems are shown in Figure 9.13.-8.

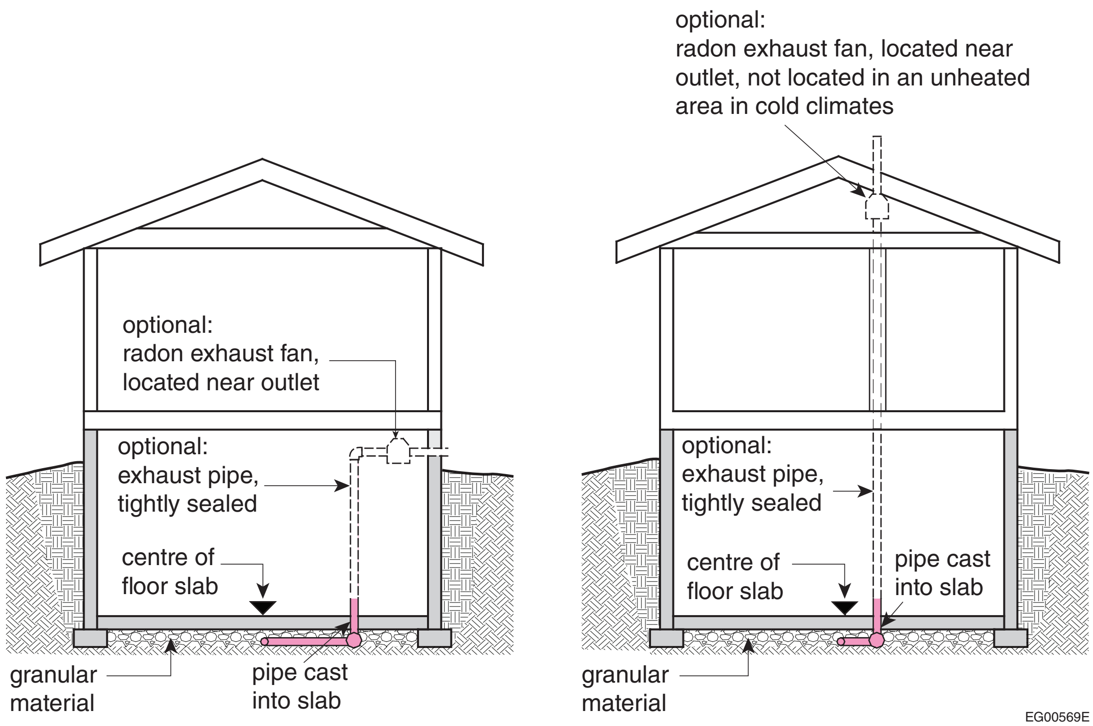


Figure 9.13.-8
Two types of subfloor depressurization systems

A building should be retested for radon after completion and activation of the depressurization system.

Extending the Vent Pipe

The extension of the pipe should be at least 100 mm (4 in.) in diameter and should be insulated to minimize condensation. If the pipe discharges independently through the roof, it should be located not less than 3 m (9 ft. 10 in.) from any other opening and extend not less than 300 mm (12 in.) above the roof's surface.

Alternatively, the pipe can discharge through an attic gable or an exterior wall. In the latter case, because the exhausted air may contain unacceptable concentrations of radon, re-infiltration of exhausted air into occupied space should be avoided by locating the discharge pipe not less than 300 mm (12 in.) above grade, not closer than 3 m (9 ft. 10 in.) from any other opening.

Where necessary, the exhaust opening should be protected against the entry of animals and the ingress of precipitation by the use of louvres, weather cowls or other suitable means, but care should be taken not to create flow restrictions and ice build-up.

Installing the Exhaust Fan

An exhaust fan of a type recommended by the manufacturer as suitable for radon mitigation, and as capable of continuous operation should be connected to the radon vent pipe. Ideally, the exhaust fan should be located outside the living space so that the noise it generates will not annoy occupants. It is also best to locate the fan as close as possible to the discharge pipe so that the pressurized portion of the system downstream of the fan is not located in or adjacent to the living space. If the pressurized portion of the system were to pass through a living space, then a leak in the system could spill high concentrations of radon into the living space. Where the fan is connected to the discharge pipe within conditioned space, the number of joints in the pipe leading from that fan to the exterior should be minimized.

Other Design Considerations

Where a subfloor depressurization system is being operated at high flow rates, excessive amounts of cold air may be drawn from the outside through the drainage system during the winter months, which may cause the soil beneath the footings to freeze, which could cause damage to the building, or which may cause condensation on the inside of the foundation wall, which could have adverse effects on the health of occupants. Where such conditions are known to exist, measures should be taken to minimize such potential adverse effects.

Section 9.14. Drainage

Introduction

Drainage is required around foundation walls to reduce the possibility of moisture entering into the finished building space. Together with surface grading and dampproofing/waterproofing requirements, effective drainage constitutes an important part of water management around a building structure during its lifetime.

9.14.1. Scope

Basement dampness is a common building problem that can damage building materials and cause mould. Proper attention to foundation and surface drainage can help minimize such problems.

9.14.1.1. Application

This Article states that the requirements in NBC Section 9.14. deal with surface drainage and subsurface drainage.

9.14.1.2. Crawl Spaces

This Article clarifies that drainage requirements for crawl spaces are located in NBC Subsection 9.18.5.

9.14.1.3. Floors-on-Ground

This Article clarifies that drainage requirements under floors-on-ground are located in NBC Subsection 9.16.3.

9.14.2. Foundation Drainage

9.14.2.1. Foundation Wall Drainage

This Article requires that the bottom of each exterior foundation wall be drained to keep water away from it. Rainwater and snow-melt that do not drain away from a foundation and into a drainage system will seep into the soil next to the foundation. If the water cannot percolate downward quickly through the soil to a level below the footings, the soil can become saturated and can even create hydrostatic pressure against the foundation and beneath the floor. This can cause leakage into the basement or crawl space.

Figure 9.14.-1 shows some of the common strategies used to direct water away from building foundations.

Free-draining mineral fibre insulation or granular backfill may be installed adjacent to the exterior of the foundation wall to facilitate drainage of soil moisture. Water drained by this drainage layer must be carried away from the foundation by the footing drains or the granular drainage layer in order to prevent it from developing hydrostatic pressure against the wall. Where used, the insulation or crushed rock must extend to the drain at the footing level, or must be connected to the drain by the installation of granular material. The drainage layer should be topped with low permeance soil. The use of drainage layers is voluntary and does not eliminate the need for dampproofing or waterproofing.

Site grading and the disposal of surface drainage can also affect the performance of basements. Final grading around the building should allow for the future settlement of backfill, in order to ensure that water will be directed away from the foundation. A driveway that slopes towards the garage or house may be unavoidable because of site conditions or the design of the house. Where this occurs, a catch basin must be provided to intercept the water and drain it to a suitable location.

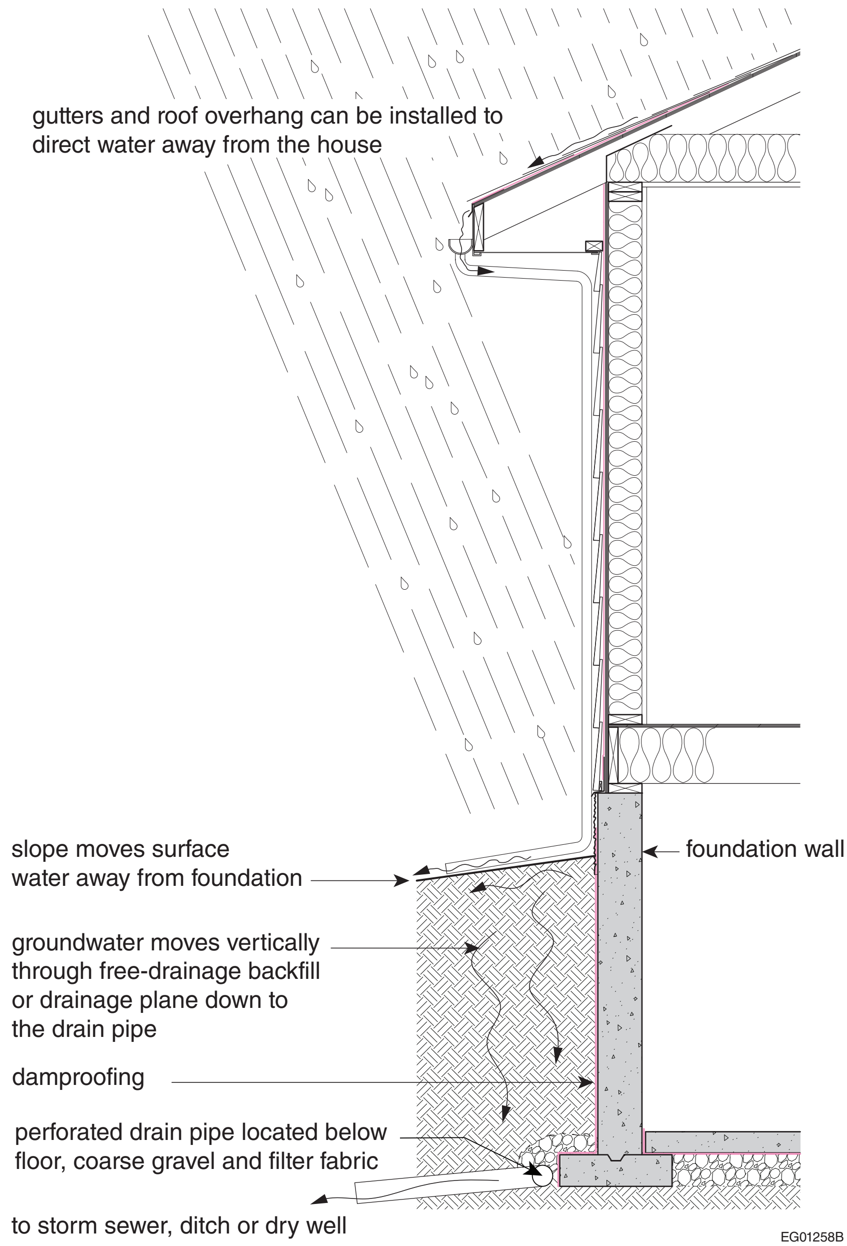


Figure 9.14.-1
Water management strategies

Note to Figure 9.14.-1:
(1) For clarity, thermal and moisture protection are not shown.

In some areas, roof drains are connected directly to the footing drains. While this disposes of roof drainage and eliminates the need for splash blocks to prevent soil erosion from downspouts, it also makes the footing tile vulnerable to periodic overloading and can result in basement wall leaks in periods of heavy rain. This becomes particularly important if the footing drains have a tendency to silt up and become less efficient. While not an NBC requirement, it is preferable to remove roof drain water separately to avoid loading the footing tile.

Foundation drainage can be provided by tile and pipe (NBC Subsection 9.14.3.) or by a granular layer (NBC Subsection 9.14.4.). For both methods, water must be removed in accordance with NBC Subsection 9.14.5.

9.14.3. Drainage Tile and Pipe

9.14.3.1. Material Standards

This Article establishes, through reference to standards, the characteristics for piping used for foundation drainage that will enable them to withstand the expected earth pressures due to backfilling, and to be durable for the expected life of the building.

9.14.3.2. Minimum Size

This Article requires that pipes be at least 100 mm (4 in.) in size to provide sufficient capacity for water removal for foundation drainage.

9.14.3.3. Installation

This Article describes the installation procedures for drain tile or pipe used for foundation drainage. The firm base reduces pipe settlement, which could cause patches of soil saturation and a consequent reduction in the soil's loadbearing capacity. Spacing and cover over butted drain tile allow water to enter from the bottom while keeping soil from dropping in from the top. Granular fill over drain tiles or pipes extends their effective drainage influence, and keeps soil particles from clogging them.

A variety of materials can be used for subsurface drainage. Clay tile pipe was once commonly used and is still used occasionally. This pipe was normally 300 mm (12 in.) long and 100 mm (4 in.) in diameter, with individual pieces spaced about 6 to 10 mm (1/4 to 3/8 in.) apart to allow the entry of water. The top halves of these joints were protected with asphalt paper or polyethylene film before the tiles were covered with crushed rock or coarse granular fill. This reduced the possibility of soil being washed into the piping.

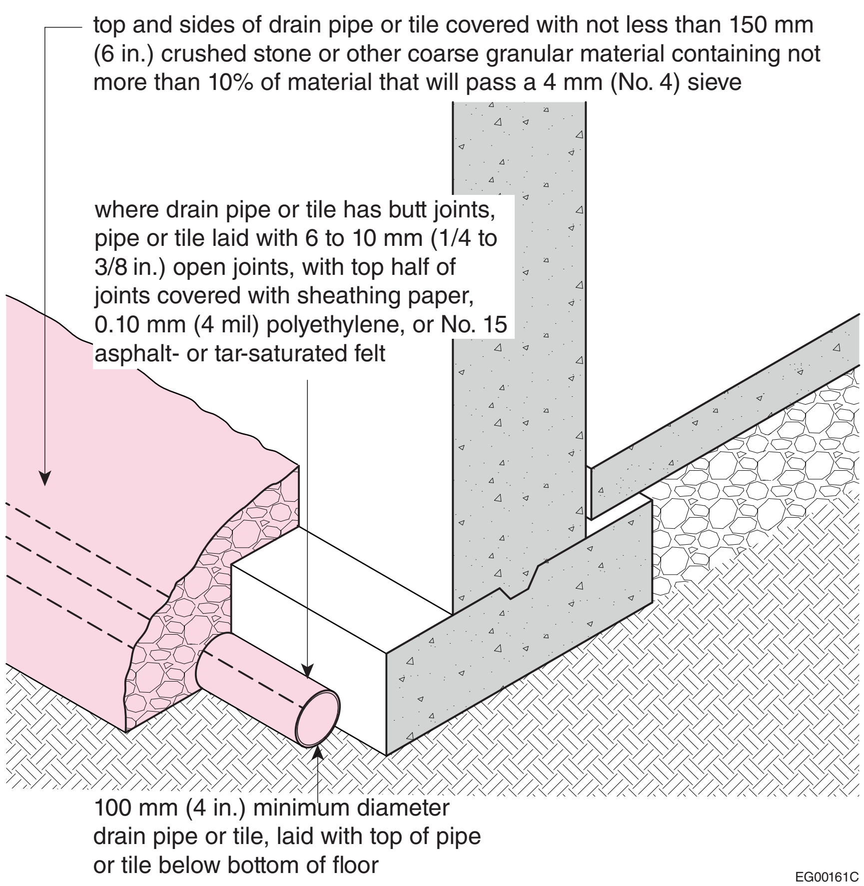


Figure 9.14.-2
Installation of drain pipe or tile

Lightweight polyethylene drainage pipe replaced clay tile as the most popular choice for drainage pipe. The concentric grooves on the pipe allow it to bend so that it can be shipped in long coils and installed in one piece around the perimeter. Slots in the pipe allow the water to enter the pipe. However, the thin, flexible walls make it a fragile product that can be damaged and crushed during backfill or maintenance operations if care is not taken.

Another product that is less subject to collapse and is frequently used is rigid perforated polyvinyl chloride (PVC) pipe (Figure 9.14.-2). These newer products, like clay tiles, must be laid on a firm base and be covered with about 150 mm (6 in.) of crushed rock or granular fill. The crushed rock increases the water-collecting area around the pipe, and keeps the soil from coming into contact with the pipe surface. Silty soil, however, can find its way into the piping and can eventually block the drainage. Although it is not required by the NBC, some builders cover the crushed rock with a filter fabric to keep soil from entering the pipe. Drain tile and drain pipe should be laid level or with a slight slope. High and low points should be avoided.

9.14.4. Granular Drainage Layer

9.14.4.1. Type of Granular Material

This Article establishes the characteristics needed for soil to allow rapid percolation of water, when soil is used as a drainage layer beneath a foundation. The granular material should be a continuous layer of crushed stone or some other clean, granular material with not more than 10% of the material passing a 4 mm (No. 4) sieve.

Pyritic shales are subject to movement and should only be used in a concentration that will not cause problems. See NBC Article 9.4.4.4. for a description of problematic soils.

9.14.4.2. Installation

This Article requires a sufficient drainage flow capacity through a granular drainage layer to keep water away from the floor and foundation walls.

The development of permanent wood foundations led to the introduction of granular drainage layers below footings and floors-on-ground. Although intended initially for wood foundations, this alternate drainage system is now permitted in lieu of the perimeter footing drainage for all basements. The voids in the granular layer (which usually consists of crushed rock) allow subsurface water to flow towards a collecting sump, where it is drained to a sewer, ditch or dry well.

9.14.4.3. Grading

This Article requires grading underneath a granular drainage layer to direct water away from floors and foundation walls to a central collecting point (sump) for disposal, and so that the entire area can be drained to a sump.

9.14.4.4. Wet Site Conditions

This Article applies to wet site conditions, and requires that sufficient drainage flow capacity be provided through the upper portion of a granular drainage layer whose lower portion may be mixed with mud from the excavation and rendered less permeable. When granular material is placed in muddy excavations, the mud will mix with the bottom part of the granular layer and fill the voids needed to drain the water. A sufficient thickness of drainage material should, therefore, be placed to ensure that the top 125 mm (5 in.) is free of mud.

9.14.5. Drainage Disposal

9.14.5.1. Drainage Disposal

This Article requires the removal of drain water from the area immediately around a building to a sewer, drainage ditch or dry well (Figure 9.14.-3).

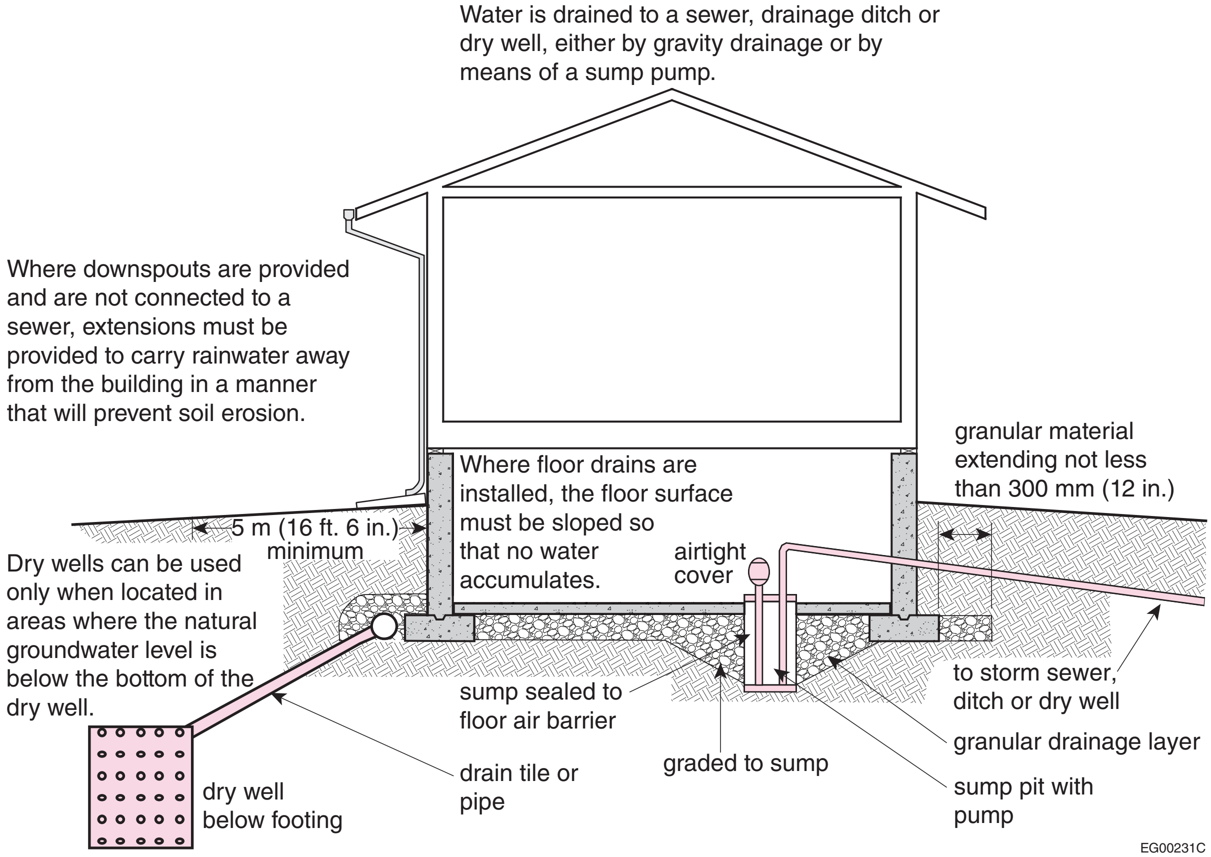


Figure 9.14.-3
Sumps, dry wells and drainage

9.14.5.2. Sump Pits

This Article describes the required characteristics of a collecting reservoir for drain water with sufficient capacity to allow a sump pump to operate on an appropriate on/off cycle when gravity drainage from the collection point is not possible. Sump cover is provided to reduce the amount of moisture and soil gas entering the building, and to keep the sump from being a hazard to the occupants.

9.14.5.3. Dry Wells

This Article limits the possibility of using dry wells for the disposal of drainage water to areas where the natural groundwater level is below the dry well. Dry wells must be located at least 5 m (16 ft.) away from the building.

Where it is not practicable to drain water to a ditch or sewer, a dry well can be used. Dry wells provide for an alternative disposal of foundation drainage water, away from the area immediately around the building, directing water away from floors-on ground and foundation walls. This approach will only work, however, if the natural groundwater table is below the bottom of the dry well. If the soil is clay, the rate of drainage may be too slow for the dry well to be effective. Dry wells can be lined with loose stone to create a large void, but are more commonly backfilled with large rocks or crushed stone that will readily accept drain water and allow it to percolate into the surrounding soil.

The dry well size depends on the amount of water to be drained and the porosity of the surrounding soil. For porous soil conditions, a dry well of 1 to 1.5 m (3 to 5 ft.) in diameter, extending below frost level, should be adequate for most house foundations. The stone fill in the dry well should be covered with an impervious material such as polyethylene film before the top layer of less permeable soil such as clay is added.

9.14.6. Surface Drainage

9.14.6.1. Surface Drainage

This Article provides a general requirement for surface drainage directing water away from a building so that less water will have to be managed through the drainage layer and the soil immediately adjacent to the building.

The drainage of surface water away from foundations is a key aspect of moisture control. Most water leakage problems in buildings arise during winter thaws, spring snow-melt or periods of heavy or prolonged rainfall. Sloping the earth away from buildings is the easiest means of improving surface drainage. Some surface water, however, will usually percolate through the soil in the vicinity of the foundation.

9.14.6.2. Drainage away from Wells or Septic Disposal Beds

This Article requires that foundation drainage be directed away from wells and septic disposal beds. Surface drainage water can be contaminated from a variety of sources, including animal and bird droppings, garbage and decaying animal matter. It can therefore pose a health risk if it drains into well water. Surface drainage water can also saturate disposal fields of septic systems, causing effluent to rise to the surface and create a potential health risk.

9.14.6.3. Window Wells

This Article requires window wells to be drained down to the foundation drainage system to reduce the risk of leakage through the window itself or through the foundation wall or the build-up of hydrostatic pressure in the vicinity of the window well.

9.14.6.4. Catch Basin

This Article requires the installation of a catch basin for driveways that slope toward a house to keep surface drainage water from entering a garage.

9.14.6.5. Downspouts

This Article points to applicable provisions in NBC Article 9.26.18.2., which requires downspouts not connected to a sewer to be directed away from a building in a manner that prevents soil erosion.

Section 9.15. Footings and Foundations

Introduction

Footing and foundation construction is a fundamental aspect of a building's performance and service life.

9.15.1. Application

9.15.1.1. General

This Article indicates the types of footings and foundations covered in NBC Section 9.15. These are the ones most commonly used for small buildings, and are based on certain limiting soil conditions. It is important to stay within these limits in order not to exceed the allowable bearing pressure on the soil, or the allowable tensile stresses in the foundation wall. Where a building is constructed on soil with a lower load-carrying capacity, has an occupancy that imposes heavier design loads, or has a type of superstructure that imposes higher dead loads, the foundation must be designed for the appropriate conditions in conformance with NBC Part 4.

Footing sizes that can be used in NBC Part 9 are based on soils with a certain bearing capacity. For concrete or unit masonry foundation walls on concrete footings and wood-frame foundation walls on wood or concrete footings on stable soils and not subject to surcharge, soils must have an allowable bearing pressure of at least 75 kPa (1 500 psf). This is a fairly conservative estimate of what most soil types can bear. Loose sand and loose gravel, however, have a bearing capacity of only 50 kPa (1 000 psf) and require footings that are 50% larger than those shown in NBC Table 9.15.3.4.

Soft clay has an allowable bearing pressure of only 40 kPa (800 psf), and footings must be almost twice as large as the listed sizes. Therefore, foundations on soils with these lower bearing capacities are required to be designed either in conformance with NBC Section 9.4., or with the more rigorous design procedures in NBC Part 4.

Because decks, balconies, verandas and similar platforms support occupancies, they are, by definition, considered as buildings or parts of buildings. Consequently, the requirements in NBC Section 9.15. pertaining to footings and foundations apply to these constructions.

Not all soil types are permitted to be designed under NBC Section 9.4. Filled ground, for example, is not covered. This type of soil can be extremely variable and requires very careful assessment in foundation design. Conditions such as this, which are not covered in NBC Sections 9.4. or 9.15., must be designed in conformance with NBC Section 4.2. Where permafrost is present, the NBC requires that foundations be designed by a competent designer in accordance with NBC Part 4.

Foundation wall thicknesses in NBC Section 9.15. are based on the assumption that the earth will exert a pressure against the wall as if it were a liquid with a density of 480 kg/m^3 (30 lb./ft.^{3}) (or about half that of water). This assumes that the soil is well drained. If a hydrostatic pressure occurs as a result of a rising water table, the walls specified in this Section would be greatly over-stressed and would not be acceptable.

Flat Insulating Concrete Form Foundation Walls

Insulating concrete form (ICF) walls are concrete walls that are cast into polystyrene forms that remain in place after the concrete has cured. Flat ICF walls are solid ICF walls where the concrete is of uniform thickness over the height and width of the wall.

NBC Section 9.15. applies to flat ICF foundation walls and concrete footings that are not subject to surcharge on stable soils with an allowable bearing pressure of at least 75 kPa (1 500 psf). The foundations and footings must be for buildings of light-frame or flat ICF construction not more than two storeys high with a maximum floor to floor height of 3 m (9 ft. 10 in.), containing only a single dwelling unit.

Structural Considerations

Foundations carry their own weight and the loads transferred to them from the superstructures they support to the ground. Vertical loads include the weight of the superstructure itself (dead load) and that of its occupants and contents (live load) in combination with the roof snow load. Wind and earthquake loads must also be resisted by the foundation.

Where foundations extend into the ground and enclose space such as basements and crawl spaces, they must also adequately resist lateral soil and water pressures acting against them. Foundations should not settle significantly or unevenly over time. They should remain unaffected by the freezing and thawing of soils, and moisture expansion and contraction in the soil.

Figure 9.15.-1 illustrates a number of structural considerations.

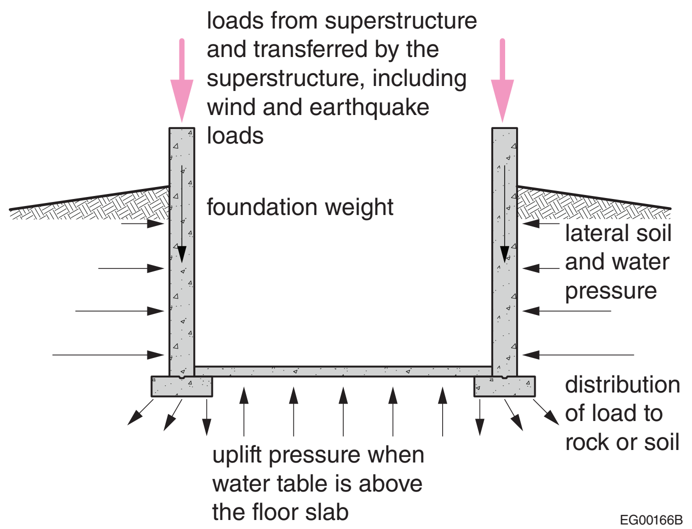


Figure 9.15.-1
Structural considerations for footings and foundations

Moisture

The moisture resistance of foundation wall and floor assemblies is especially important where the basement is used for living space. The NBC requires that water on and in the ground be controlled to minimize moisture transfer through walls and floors (NBC Section 9.13. and NBC Article 9.14.2.1.). It is also necessary to ensure that soil moisture will not adversely affect the durability of the materials it contacts.

Heat Transfer

The control of heat flow through foundations has become increasingly important in response to demands for higher levels of comfort and energy conservation. The thermal insulation requirements for foundations that are prescribed in the NBC, however, only address the prevention of surface condensation and comfortable conditions for the occupants. In practice, insulation is installed in most buildings to address energy issues, and this insulation is sufficient to meet the condensation and comfort requirements.

Soil Gas

All conditioned spaces of buildings are required to have protection against the ingress of soil gas. For foundation walls, protection against soil gas is provided by having a suitable drainage layer abutting the foundation to vent gas and having an air barrier that is continuous and sealed to the basement floor air barrier in conformance with NBC Subsection 9.25.3.

9.15.1.2. Permafrost

This Article indicates that the design of foundations in permafrost requires special design procedures, which are covered in NBC Part 4.

9.15.1.3. Foundations for Deformation-Resistant Buildings

This Article indicates that a manufactured home constructed on a chassis that provides sufficient rigidity for highway travel is considered to be sufficiently resistant to damage due to differential foundation movement to permit its support on surface foundations, regardless of soil conditions.

Most foundation requirements assume that the supported structure will be site-built construction, with little tolerance for foundation movement. These requirements are overly restrictive for many factory-built buildings, which are designed to resist deformation while in transit. Shallow foundations are often quite adequate for these buildings.

A test to measure a unit's resistance to damage caused by racking is provided in one of the CSA Z240 standards, CSA Z240.2.1, "Structural Requirements for Manufactured Homes."

Where a unit has been shown to pass that test, it can be placed on a shallow foundation complying with another of the CSA Z240 standards, CSA Z240.10.1, "Site Preparation, Foundation and Anchorage of Manufactured Homes."

9.15.2. General

9.15.2.1. Concrete

This Article points to requirements for concrete that provide adequate strength and durability for use in foundations. Concrete material and installation must comply with NBC Subsection 9.3.1. While curing, concrete must be protected from rain and freezing conditions to ensure it achieves adequate strength and durability. Formwork must remain in place until setting has taken place and once removed, measures must be taken to keep the concrete moist until curing is well advanced.

9.15.2.2. Unit Masonry Construction

This Article provides the requirements for various unit masonry constructions, in order to ensure that they have adequate strength and durability for use in foundations. Concrete block used for foundation construction needs to have a compressive strength over the net cross-sectional area of the block of not less than 15 MPa (2 000 psi). Where concrete block foundation walls are required to be reinforced, the NBC specifies the mortar, grout and method of grout placement.

9.15.2.3. Pier-Type Foundations

This Article ensures that where pier-type foundations are used, they have adequate strength to support superstructure loads. The variable nature of pier-type foundations and their supported loads makes prescriptive requirements impractical, except in the case of one-storey buildings where the superstructure loads and wind forces are relatively small.

Pier foundations are more commonly used for manufactured homes and decks, and for seasonal homes and extensions to houses where the bearing soil is not moisture-susceptible or frost-susceptible. Where buildings exceed one storey, or the piers are spaced more than 3.5 m (11 ft.) apart, they must be specifically designed for the application.

Piers typically consist of concrete cast into circular forms, concrete block, wooden cribs and, in some cases, precast concrete. Typical pier sizes range from 150 to 250 mm (6 to 10 in.) for circular piers and 190 to 290 mm (7 1/2 to 11 1/2 in.) for concrete blocks. For one-storey buildings, any of these sizes should be capable of carrying the vertical loads from residential buildings for the 3.5 m (11 ft.) maximum allowable spacing along the framing members.

Where concrete block is used for piers, blocks must be laid with cores placed vertically, and when the width of the building is 4.3 m (14 ft.) or less, placed with their longest dimension at right angles to the longest dimension of the building for greater lateral stability.

For stability, piers should not be higher than three times the smallest dimension of the base. For example, 200 mm (8 in.) diameter piers should not be more than 600 mm (24 in.) above the ground.

Piers that extend below the frost level can still be subjected to frost action. If soil freezes to the sides of the piers, they can be lifted by adfreezing as the frost penetrates deeper into the soil. Such piers should, therefore, be anchored to their footing and reinforced against tensile stresses. Such frost actions can be minimized if the foundation is backfilled with granular material with good drainage, at least to the bottom of the pier, or the pier is wrapped with a material, such as polyethylene, to provide a slip plane.

9.15.2.4. Wood-Frame Foundations

This Article indicates, by reference to a standard, how wood-frame foundations are required to be constructed. Permanent wood foundations must comply with either NBC Part 4 or with CSA S406, “Permanent Wood Foundations for Housing and Small Buildings.” Additional information is available in the CWC book “Permanent Wood Foundations.”

Tables in CSA S406 describe the size and spacing of the framing, and the thickness of plywood required to withstand soil pressures from various heights of backfill, and the vertical superstructure loads that may be expected for one-storey, two-storey and three-storey buildings. These tables, together with numerous other details provided in the standard, greatly simplify the design process and enable walls to be designed without further engineering calculations.

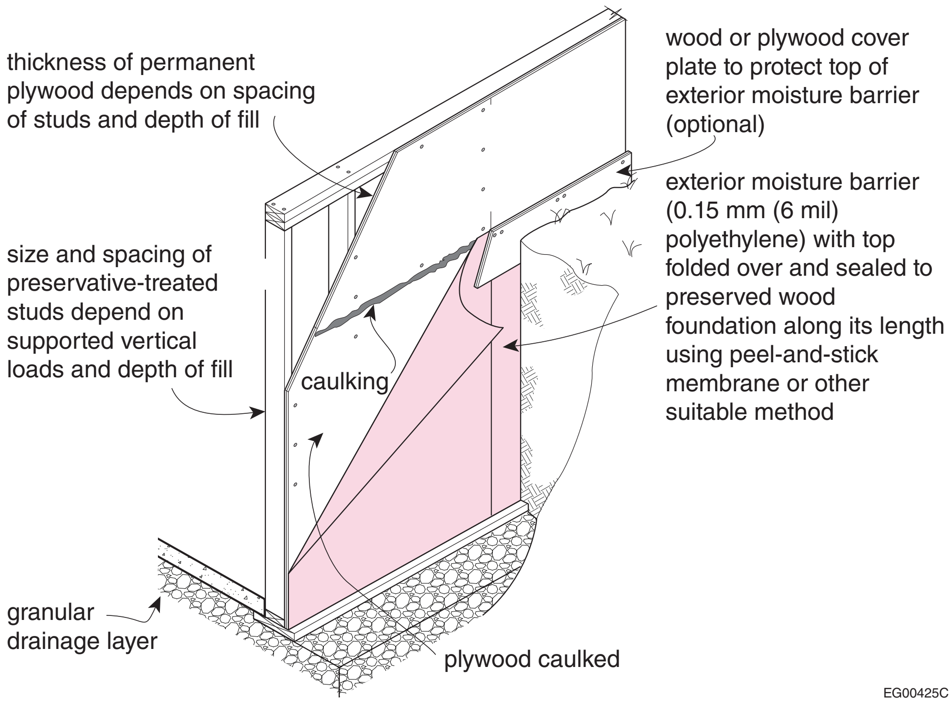


Figure 9.15.-2
Typical permanent wood foundation

The degree of preservative retention required for wood to achieve a desired service life depends on the severity of exposure conditions. Because the exposure condition of wood in contact with the ground is severe, and the replacement of foundations is expensive and inconvenient, the preservative retention required for wood for such use is high compared with the retention requirements for many other applications.

To avoid the use of lumber with insufficient preservation, only lumber or plywood identified by appropriate certification marks should be used. The mark must show the name of the certifying agency, the letters PWF (or FBT) to indicate it is for use in foundations, and the designation O322, which indicates the CSA standard that regulates the certification procedure. The mark also shows a four-digit number. The first two digits identify the treatment plant, and the last two identify the year of treatment.

Permanent wood foundations may be built with either wood or concrete footings. The floor system can also be constructed with preservative-treated wood or concrete. Figure 9.15.-2 shows a typical wood-frame basement wall. The exterior dampproofing is somewhat different than for concrete and masonry walls. Typically, polyethylene film is used to separate the plywood from the soil. The joints between plywood panels are caulked prior to the application of the polyethylene. No caulking is provided along the bottom, however, so that if water is able to get behind the polyethylene, it can drain out and not be trapped against the wall. Not all caulking materials are compatible with polyethylene film. Chemical-curing elastomeric or solvent-curing polymer-based butyl-polyisobutylene caulking is recommended in CSA S406.

Tabular data and figures in CSA S406 are based on the general principles provided in CSA O86, "Engineering Design in Wood," with the following assumptions:

- soil bearing capacity is 75 kPa (1 500 psf) or more,
- clear spans for floors are 8 m (26 ft. 3 in.) or less,
- floor loadings are 1.9 kPa (40 psf),
- foundation stud lengths are up to 3 m (9 ft. 10 in.) for wood sleeper and slab floor foundations, and up to 3.6 m (11 ft. 10 in.) for suspended wood floor foundations,
- top of granular layer to top of suspended wood floor is 600 mm (2 ft.),
- lateral load from soil pressure is equivalent to fluid pressure of 4.7 kPa per metre (30 psf per foot) of depth,
- ground snow load is up to 4 kPa (84 psf),
- basic snow load coefficient is 0.55,
- roof loads are carried to the exterior wall, and
- dead loads are:
  - 0.50 kPa (11 psf) for the roof,
  - 0.50 kPa (11 psf) for the floor,
  - 0.32 kPa (7 psf) for the wall with siding,
  - 1.94 kPa (40 psf) for the wall with masonry veneer, and
  - 0.27 kPa (6 psf) for the foundation wall.

9.15.3. Footings

Footings not only provide a firm level base on which walls, columns, piers, fireplaces and chimneys may be erected, but they also spread the relatively high loads from such structures to a wider area, thus reducing the amount of potential settlement. Footings need to rest on undisturbed soil, rock or compacted granular fill, and the fill should not contain pyritic material in a quantity that could cause damage (see Guide 9.4.4.4., Soil Movement).

The footings sizes in NBC Section 9.15. are for typical residential buildings. If the design floor load of an occupancy exceeds 2.4 kPa (50 psf), or if the floor joists exceed 4.9 m (16 ft.) in length, the footing sizes listed in this Section do not apply, and the footings need to be increased by formula or designed in conformance with NBC Part 4. NBC Table 4.1.5.3. lists the design floor loads for different types of occupancies.

9.15.3.1. Footings Required

This Article states where footings are required, and allows an exception under piers or monolithic concrete walls where the safe loadbearing capacity of the soil or rock is not exceeded.

Soils vary in their capacity to carry foundation loads. When the pressure on the soil beneath a foundation is too high, excessive foundation settlement and building damage may occur, particularly if the settlement is not uniform. Footings are therefore used beneath foundations to spread the foundation load over a wider area, thereby reducing the bearing pressure and reducing the risk of building damage. Some types of foundation elements have enough bearing area without footings to not exceed the safe loadbearing capacity of the soil or rock.

Footings are intended to transfer and distribute the loads they support to the ground so as not to exceed the safe loadbearing capacity of the soil or rock on which they rest. Footings must be provided under loadbearing walls, pilasters, columns, deck piers, and masonry fireplaces and chimneys (Figure 9.15.-3). Where a solid concrete wall provides adequate bearing area, such footings are not required (see Figure 9.15.-1).

9.15.3.2. Support of Footings

This Article sets the requirements for the ground on which footings can rest to reduce excessive foundation settlement and consequent building damage. Footing design needs to take service connections into account. The need to consider service connections may arise prior to, during, and after the construction of footings, in which case the requirements in NBC Article 9.12.4.1. may apply. See Figure 9.12.-8.

9.15.3.3. Application of Footing Width and Area Requirements

This Article states the application of footing requirements in NBC Part 9, and sets the limits beyond which footings will have to be designed according to NBC Part 4 to ensure that the bearing pressure exerted by a foundation wall or column will not cause excessive soil settlement and consequent building damage. These limitations correspond with typical construction of housing and small buildings permitted under NBC Part 9.

Where the supported joist span of a building with light wood-frame construction is larger than 4.9 m (16 ft.), there are two ways to determine the width of footings. The width can be determined according to the formula in this Article (see Example 13) or according to NBC Section 4.2.

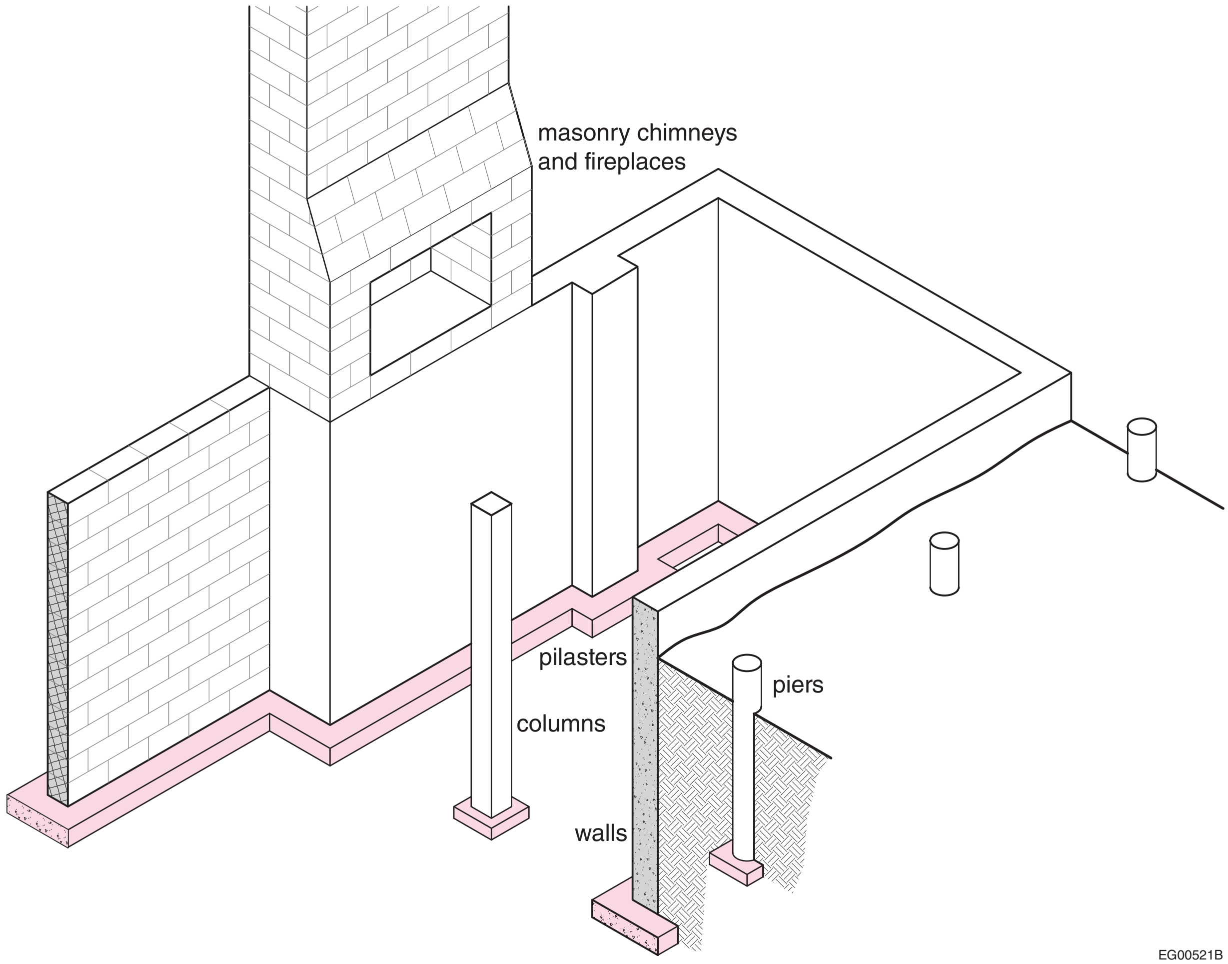


Figure 9.15.-3
Locations where footings are required

9.15.3.4. Basic Footing Widths and Areas

This Article lists the minimum footings widths and areas based on anticipated loads. The footing sizes in NBC Table 9.15.3.4. are based on typical construction consisting of a roof, not more than three storeys, and centre bearing walls or beams. For this reason, NBC Clause 9.15.3.3.(1)(b) stipulates a maximum supported joist span of 4.9 m (16 ft.).

The prescriptive requirements for house footings are based on the limitations and assumptions depicted in Figure 9.15.-4, and are intended to deal with the majority of situations encountered.

It has become common to use parallel-chord wood trusses or wood I-joists to span greater distances in floors of small buildings. Where these spans exceed 4.9 m (16 ft.), minimum footing sizes may be based on the method shown in Example 13.

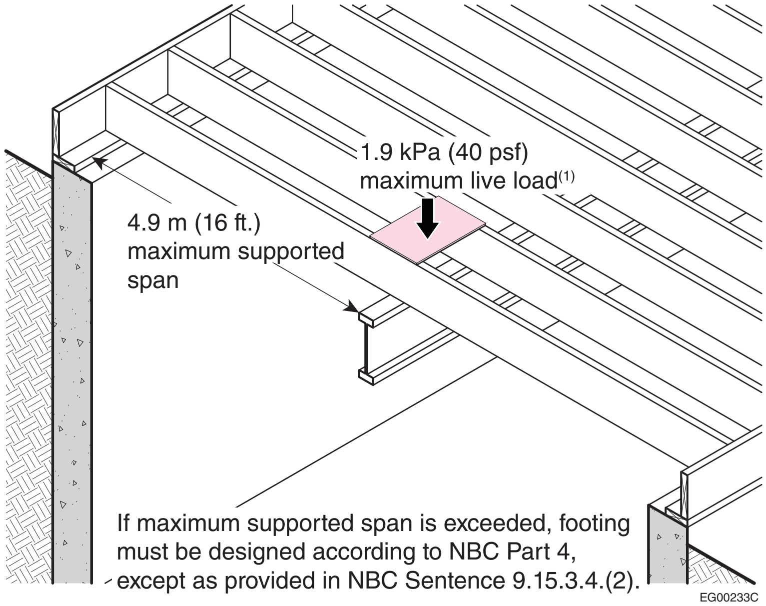


Figure 9.15.-4
Maximum spans and live loads

Note to Figure 9.15.-4:

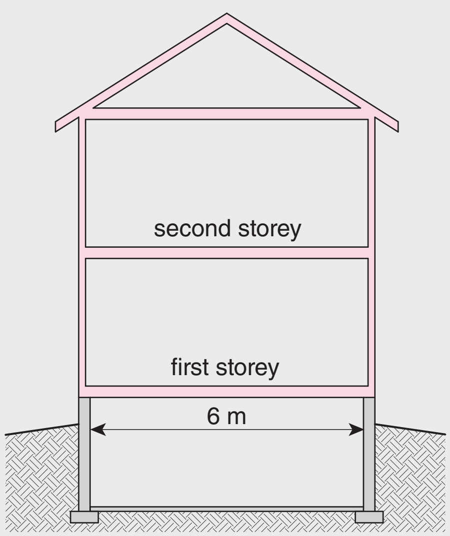
(1) The 1.9 kPa (40 psf) maximum live load is the specified live load for residential floors. The footing sizes specified in NBC Subsection 9.15.3. can carry live loads not exceeding 2.4 kPa (50 psf).

Example 13 – Minimum Footing Sizes for Spans Greater Than 4.9 m (16 ft.)

It has become common to use flat wood trusses or wood I-joists to span greater distances in floors of residential buildings. Where these spans exceed 4.9 m, minimum footing sizes can be determined according to the following method (NBC Article 9.15.3.3.):

1. Determine the span of joists for each storey that will be supported on a given footing. Sum these lengths (sum_1).
2. Multiply the number of storeys by 4.9 (sum_2).
3. Determine the ratio of (sum_1)/(sum_2).
4. Multiply the minimum footing size determined from NBC Table 9.15.3.4. by this ratio.

For a two-storey house built using wood I-joists spanning 6 m:



sum_1 = 6 m + 6 m = 12 m

sum_2 = 2 × 4.9 m = 9.8 m

Minimum footing ratio = 12 m/9.8 m = 1.22

Multiply the minimum footing width from NBC Table 9.15.3.4. by the minimum footing ratio:

350 mm × 1.22 = 427 mm

Therefore, the minimum required footing width for the house is 427 mm (17 in.).

EG00238D

Figure A
Example calculation of minimum footing sizes for spans greater than 4.9 m (16 ft.)

Although not required, the normal practice in small buildings is to make the footings at least 200 mm (8 in.) wider than the wall so that they extend about 100 mm (4 in.) on either side.

In granular-type soils such as sand, gravel, or silt, a high water table weakens the loadbearing capacity of the soil. Where the water table level below the bottom of the footing in these soils is less than the minimum footing width required by NBC Table 9.15.3.4., the footing width must be doubled, as illustrated in Figure 9.15.-5. A compacted layer of soil may be used to raise the bottom of the footing sufficiently to avoid this requirement.

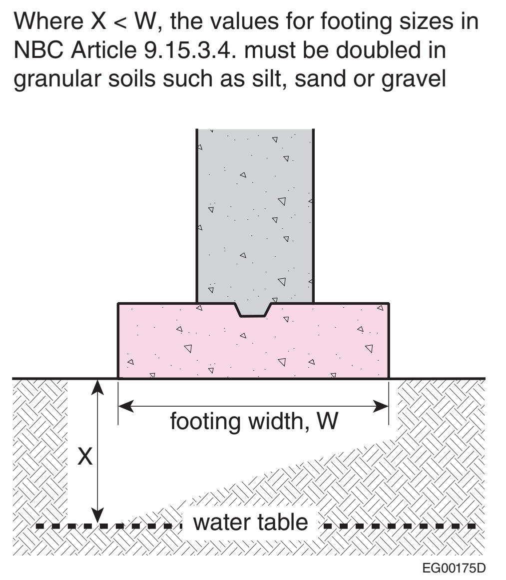


Figure 9.15.-5
Footings on gravel, sand or silt with a high water table

Where the maximum supported span of floor joists exceeds 4.9 m (16 ft.), or the maximum live load exceeds 2.4 kPa (50 psf), footings must be designed for the increased load. The design live load for floors in houses is 1.9 kPa (40 psf). Example 13 shows a method for calculating footing sizes where the span of supported floor joists exceeds 4.9 m (16 ft.).

The footing areas required for columns in NBC Table 9.15.3.4. are valid only if the columns are spaced not more than 3 m (9 ft. 10 in.) apart. If they were more than 3 m (9 ft. 10 in.) apart, the footing sizes would have to be increased proportionally (see Example 16).

9.15.3.5. Adjustments to Footing Widths for Exterior Walls

This Article requires that the size of the footing that supports exterior walls be increased in certain situations. Footing sizes depend on the supported load and the bearing capacity of the soil beneath the footing. The larger the load, the larger the footings required. Likewise, the lower the bearing capacity of the soil, the larger the footings required. The minimum footing sizes prescribed by the NBC are based on the building height and type of interior or exterior wall construction.

The footing sizes for exterior walls in NBC Table 9.15.3.4. already take into account the weight of the foundation wall, so that they require no additional increase. The footings for interior loadbearing walls, however, are based on wood-frame walls only, and must be increased in size for each storey of masonry supported.

The footing widths for exterior walls in NBC Table 9.15.3.4. need to be increased for each storey of masonry veneer over wood-frame construction (Example 14), of masonry construction (Example 15), or of flat ICF wall construction that is supported by the foundation wall.

Although no footing sizes are given for pier foundations, these may be calculated from the soil bearing values in NBC Table 9.4.4.1. if the weight of the building and the design loads to be carried are known. For typical manufactured homes, the required area of individual footings in square metres is approximately equal to

$$6.8 \times \frac{d}{p}$$

where
d = the spacing between piers (metres), and
p = the allowable soil-bearing pressure (kPa) in NBC Table 9.4.4.1.

Example 14 – Width of Footings

A foundation wall supports a two-storey wood-frame house. Brick veneer is used on the first storey, and stucco on the second. Find the size of footings required.

1. From NBC Table 9.15.3.4., the minimum footing width for exterior walls with no masonry veneer is equal to 350 mm.

   For one storey of masonry veneer, this is increased by 65 mm (NBC Article 9.15.3.5.).

   Therefore, the total required width for exterior wall footings

$$= 350 + 65$$
$$= 415\,\text{mm}$$

2. If interior supports for floors are columns, footing pads for columns are 0.75 m^2 (8.07 $ft.^2$) (NBC Table 9.15.3.4., 870 × 870 mm).
3. If floors are supported on interior wood-frame bearing walls, the minimum width for interior strip footings is 350 mm (13 3/4 in.) (NBC Table 9.15.3.4.).

9.15.3.6. Adjustments to Footing Widths for Interior Walls

This Article requires that the size of footings supporting interior walls be increased in certain conditions.

The footing widths in NBC Table 9.15.3.4. need to be increased for each storey of interior loadbearing masonry walls or flat ICF wall supported by a foundation on the footings.

Example 15 – Width of Footings for Three-Storey Masonry Construction

A foundation wall supports a three-storey masonry apartment building. The interior support for the floors is a loadbearing masonry wall that extends up through the top storey. Find the footing sizes required.

1. From NBC Table 9.15.3.4., the minimum footing width for exterior walls with no masonry veneer = 450 mm.

   For three storeys of masonry, this is increased by 3 × 130 mm, or 390 mm (NBC Article 9.15.3.5.).

   Therefore, the total required width for exterior wall footings

$$= 450 + 390$$
$$= 840\,\text{mm}\ \ (33\ \text{in.})$$

2. From NBC Table 9.15.3.4., the minimum footing width for interior loadbearing walls with no masonry = 500 mm.

   For three storeys of masonry above the basement, plus the interior basement bearing wall, this is increased by 4 × 100 mm, or 400 mm (NBC Article 9.15.3.6).

   Therefore, the total required width for interior wall footings

$$= 500 + 400$$
$$= 900\,\text{mm}\ \ (36\ \text{in.})$$

9.15.3.7. Adjustments to Footing Area for Columns

This Article permits an adjustment of footing area to support loads from interior columns. The sizes of column footings are based on the assumptions and limitations discussed previously (Figure 9.15.-6). The maximum spacing between columns is assumed to be 3.0 m (9 ft. 10 in.). Where this is exceeded, the size of the column footing in NBC Table 9.15.3.4. must be increased accordingly.

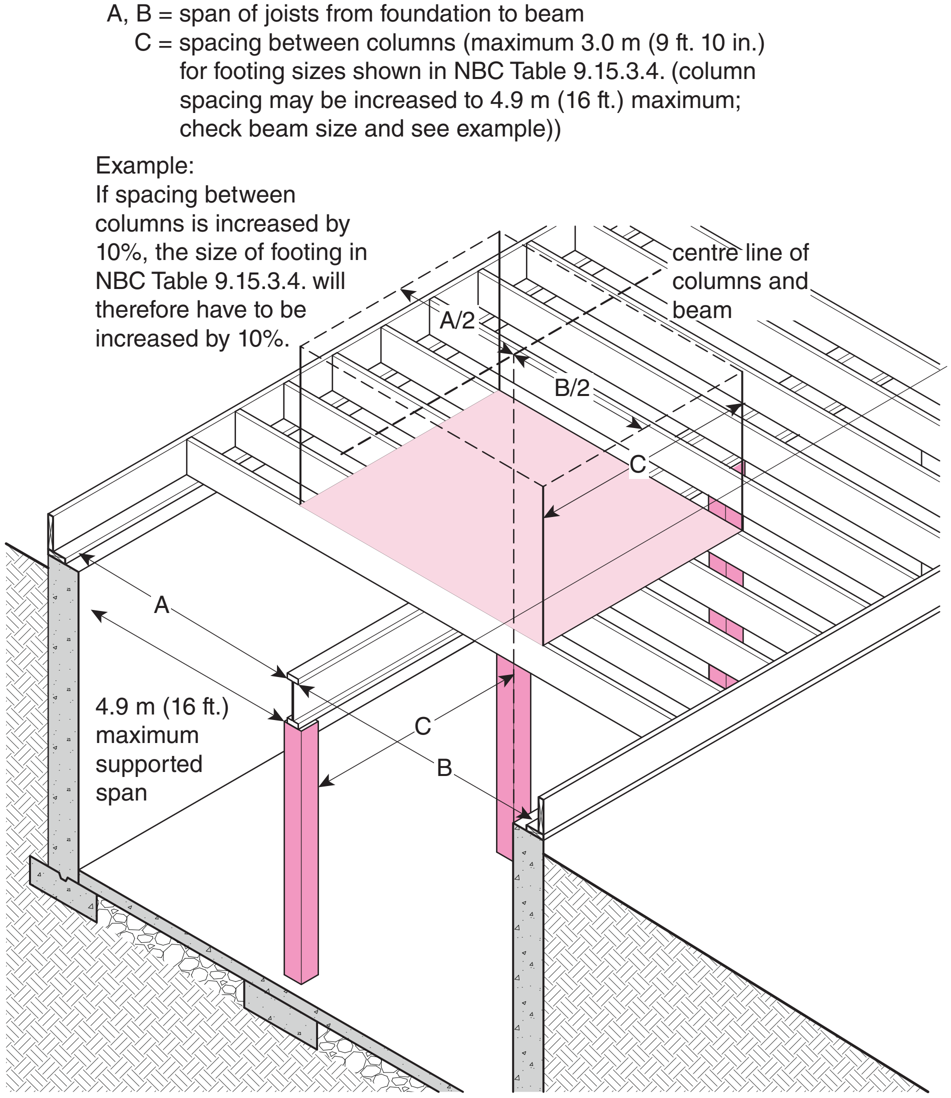


Figure 9.15.-6
Determining footing size for columns

Example 16 – Footing Sizes for Columns

In Example 14, the required column footing area is 0.75 m² (8 ft.²) (two floors supported) when columns are spaced up to 3.0 m (9 ft. 10 in.) apart. If the columns are to be spaced 4 m (13 ft. 1 in.) apart, the required footing area

$$= \frac{4}{3} \times 0.75\,\mathrm{m}^2$$
$$= 1.0\,\mathrm{m}^2 \ \left(11\ \mathrm{ft.}^2\right)$$

(i.e., 1 000 × 1 000 mm) (NBC Article 9.15.3.7.).

Footing sizes for columns in NBC Part 9 are based on spacings of 3 m (9 ft. 10 in.). If the spacing is increased by a certain percentage, then the footing area must also be increased by at least the same percentage. For example, if the column spacing is increased from 3 m (9 ft. 10 in.) to 4 m (13 ft. 1 in.), an increase of 33%, the footing area of the columns in a one-storey house (see NBC Table 9.15.3.4.) would have to be increased from 0.4 m^2 to 0.53 m^2 (4.3 $ft.^2$ to 5.7 $ft.^2$).

Foundations for masonry chimneys and fireplaces can be designed using the provisions of the NBC. Strip footings can be designed in a similar fashion to that applied to the construction of interior foundation walls supporting masonry (see Figure 9.15.-7). The number of storeys of masonry supported must correspond to the storey height of the chimney or fireplace.

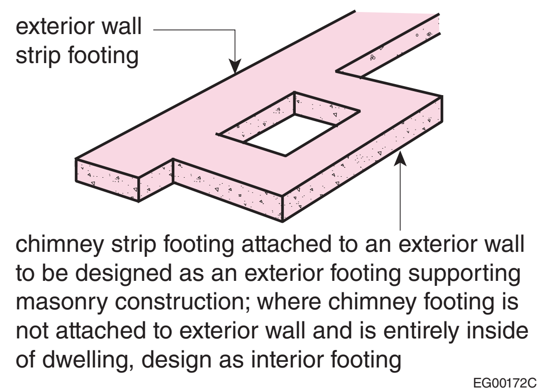


Figure 9.15.-7
Strip footing for chimney and fireplace

Concrete slab foundations must be designed by an individual competent in foundation design.

9.15.3.8. Footing Thickness

This Article sets the minimum thickness to provide footings that have sufficient flexural strength for the portion of the footing that is cantilevered beyond a supported wall and to reduce the probability of concrete footings being too thin and drying out prematurely before the concrete has properly cured, which would result in low-strength concrete.

When a footing supports a foundation, the soil exerts a pressure beneath the footing. Where a footing is wider than the foundation wall (or column) it supports, the portion that projects beyond the wall (or column base) is bent upward. If unreinforced, such footings tend to fail along shear lines that extend downward at an angle of about 45º from the face of the wall. To be within this shear line, therefore, the footing projection is limited to the footing thickness, unless the footing projection is reinforced.

If the supported loads require very wide footings, their thickness may become excessive. The cost of additional excavation and concrete may justify the use of reinforcing or other appropriate measures to reduce the thickness of the footing.

The concrete footing thickness, T, must be at least equal to the footing projection, P (unless the footing is reinforced), and be not less than 100 mm (4 in.) (Figure 9.15.-8). Note that as special soil conditions or footing loads increase, so must footing thickness.

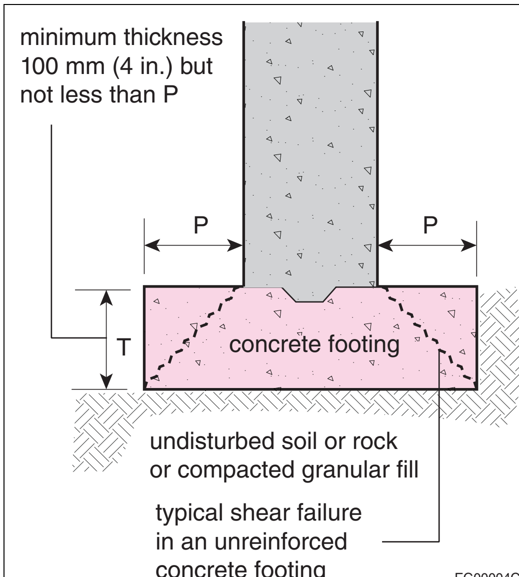


Figure 9.15.-8
Minimum footing thickness

Example 17 – Footing Thickness

Find the footing thickness required for the exterior foundation wall and the interior loadbearing wall in Example 15, assuming the foundation wall is 200 mm (8 in.) thick and the interior bearing wall is 150 mm (6 in.) thick.

1. Width of exterior footing = 840 mm. Extension beyond face of wall

$$= \frac{840 - 200}{2}$$
$$= 320\,\mathrm{mm}$$

The minimum required unreinforced footing thickness is 320 mm (NBC Article 9.15.3.8.).

2. Width of interior footing = 900 mm.
3. Extension beyond wall face

$$= \frac{900 - 150}{2}$$
$$= 375\,\mathrm{mm}$$

Therefore, the required minimum footing thickness = 375 mm (15 in.) (NBC Article 9.15.3.8.).

Example 18 – Footing Thickness for Columns

Find the footing thickness for the column in Example 16 supported on a 1.0 m² footing if the columns are 140 × 140 mm.

1. The extension beyond the face of the column

$$= \frac{1\,000 - 140}{2}$$
$$= 430\,\mathrm{mm}$$

Therefore, the minimum required unreinforced concrete thickness = 430 mm (NBC Article 9.15.3.7.).

2. The thickness is somewhat excessive and could be reduced by providing a 300 × 300 mm pedestal on top of the footing (flush with the top of the slab).

With the pedestal, the minimum required footing thickness is

$$= \frac{1\,000 - 300}{2}$$
$$= 350\,\mathrm{mm}$$

3. If the space between columns were reduced to 3 m on centre, the size of the footing could be reduced to 870 × 870 mm as in Example 14.

For this column spacing and with a 300 × 300 mm pedestal, the required footing thickness

$$= \frac{870 - 300}{2}$$
$$= 285\,\mathrm{mm}\ \ (11\,\mathrm{in.})$$

9.15.3.9. Step Footings

This Article sets the maximum height of the rise and the minimum run distance for the horizontal section of step footings to avoid shear failure through the soil along the steep slope. If footings are placed on a slope, the vertical loads transferred to the footing will have a load component parallel to the footing. The greater the slope, the larger this component will be, and eventually a point will be reached where the footings will slide in the direction of the slope. In addition, footings on a sloping surface are wasteful in the use of concrete, since they must provide a horizontal top surface on which to build forms or erect masonry.

Therefore the footings on sloping sites can be built-in horizontal steps to prevent the excavations from becoming too deep. The instability of soil usually makes it impracticable to build steps higher than 600 mm (2 ft.). The horizontal distance between successive steps is also required to be at least 600 mm (2 ft.) to prevent excessive soil disturbance (Figure 9.15.-9).

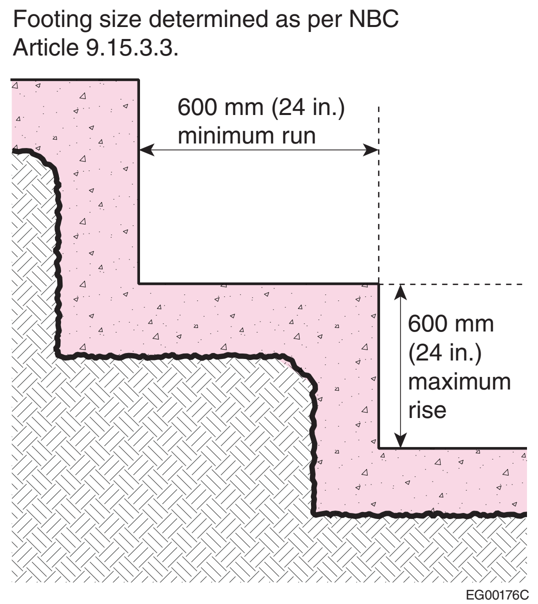


Figure 9.15.-9
Step footings

9.15.4. Foundation Walls

Foundation walls are intended to support the loads transferred to them from the building superstructure, and to safely resist any lateral soil and water pressures acting against them (Figure 9.15.-10). Where hydrostatic pressure is present, the foundation wall must be designed according to NBC Part 4. All of the requirements for concrete and masonry foundation walls are based on cement-based materials that have cured and attained their 28-day strength.

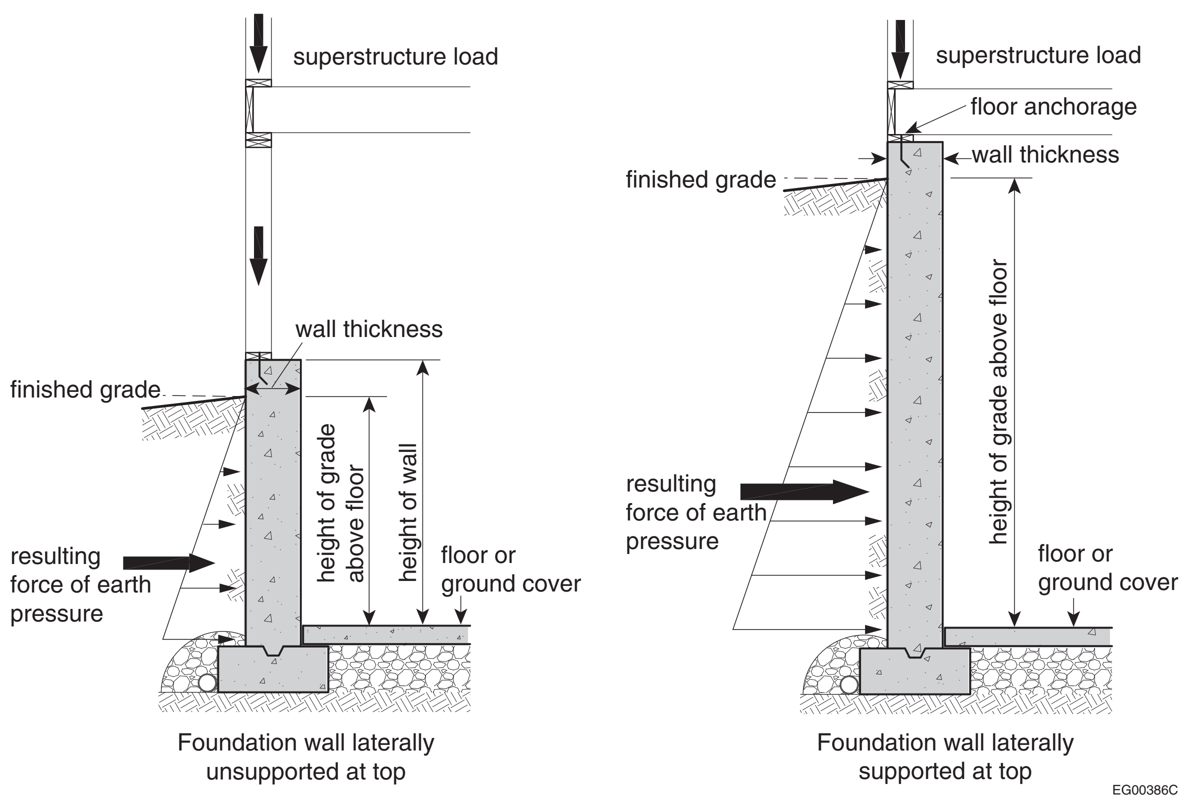


Figure 9.15.-10
Foundation walls

Reasonably thick cast-in-place concrete, masonry foundation walls, and flat ICF foundation walls are able to withstand the vertical loads from the superstructure of most Part 9 buildings with strength to spare. Both concrete and masonry, however, are relatively weak in tension. They are therefore reinforced with steel if the tensile forces become too great. Since foundation walls for residential and other small buildings are most often unreinforced, the most critical loads they are subjected to are the horizontal loads due to earth pressure.

If basement walls are supported at the top, tension stresses are created as the walls deflect inward. If the walls are unsupported at the top, they act as retaining walls, stabilized by the weight of the wall and the vertical superstructure loads. The greater the depth of backfill, the stronger the foundation wall must be to resist the horizontal forces.

NBC Part 9 describes approaches to the construction of foundations for typical cases. Special cases that are not explicitly provided for in the NBC may require special evaluation to determine NBC compliance or, in the case of pile foundations or foundations that fall outside the design limits described in NBC Part 9, compliance with NBC Part 4. The design procedures in NBC Part 4 must be executed by an individual competent and knowledgeable in the design of foundations.

9.15.4.1. Permanent Form Material

This Article indicates, by reference to a standard, the type of insulating material to be used on ICF walls. ICF walls are concrete walls that are cast into polystyrene forms, which remain in place after the concrete has cured. Flat ICF walls are solid ICF walls where the concrete is of uniform thickness over the height and width of the wall (Figure 9.15.-11).

ICF units are required to be manufactured of polystyrene conforming to performance requirements of CAN/ULC-S701, “Thermal Insulation, Polystyrene, Boards and Pipe Covering.“

9.15.4.2. Foundation Wall Thickness and Required Lateral Support

This Article provides Tables with the minimum foundation wall thickness based on lateral support for various construction types to provide foundations with sufficient strength to resist horizontal soil pressures and support the superstructure loads, including building contents. Exterior foundation walls that are laterally supported are better able to resist lateral loads, and are therefore permitted to be much thinner than walls that are not laterally supported. The requirements for lateral support are provided in NBC Article 9.15.4.3.

Soil exerts a pressure against foundation walls that increases with depth, much like a liquid. Foundations strong enough to resist such loads are usually strong enough to support the superstructure loads. NBC Table 9.15.4.2.-A is based on the design assumptions in NBC Article 9.4.4.6. and modified based on performance history.

NBC Table 9.15.4.2.-A applies to foundation walls of unreinforced concrete block or solid concrete up to 3 m (9 ft. 10 in.) in unsupported height. Foundation walls made of flat ICF units need to be not less than the greater of 140 mm (5 1/2 in.) or the thickness of the wall above. Flat ICF walls need to be laterally supported at their tops and bottoms.

NBC Table 9.15.4.2.-A does not relate thickness to the number of storeys supported because the vertical load-carrying capacity of these walls is higher than is required to carry the superstructure loads, even for the thinnest walls listed. For permanent wood foundation walls, however, the size of vertical loads is crucial and does affect the size and spacing of the framing members.

The minimum thickness for reinforced concrete block foundation walls is provided in NBC Table 9.15.4.2.-B. This table applies to foundation walls up to 3 m (9 ft. 10 in.) high.

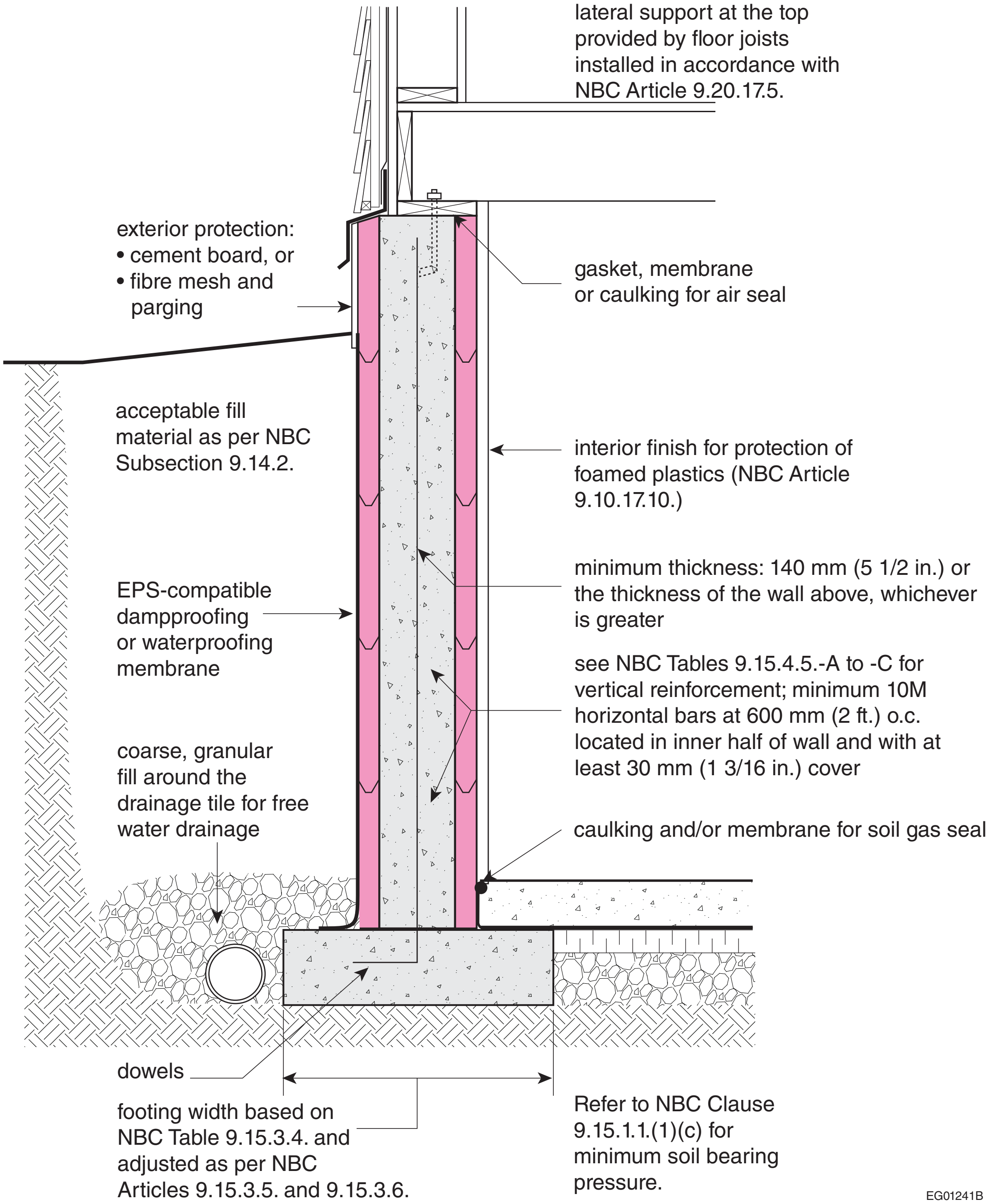


Figure 9.15.-11
Flat ICF foundation wall details

NBC Table 9.15.4.2.-B applies to foundation walls made of reinforced concrete block and that are laterally supported. It is limited to locations where stable soils are encountered, and where the wind loads on the exposed portion of the foundation are no greater than 0.70 kPa (15 psf). The prescribed thicknesses are intended to provide adequate resistance against lateral pressures and gravity loads transferred to the walls from the structure they support. Figure 9.15.-12 shows the factors affecting the required foundation wall thickness.

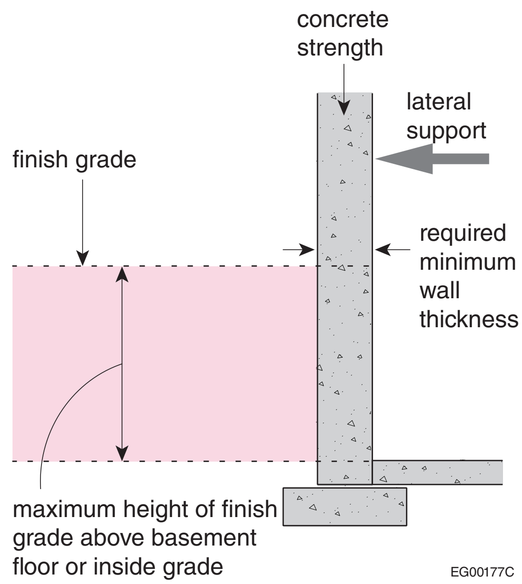


Figure 9.15.-12
Factors affecting the minimum thickness of unreinforced foundation walls

9.15.4.3. Foundation Walls Considered to be Laterally Supported at the Top

This Article indicates the conditions under which foundation walls are considered to be laterally supported at the top. Foundation walls, if supported at the top, act much like simple beams in resisting soil pressures. This means their ability to resist earth pressures is dependent on the resistance to overturning provided by the weight of the superstructure and the weight of the foundation wall. Since walls supported at the top are able to withstand much more earth pressure than unsupported walls, it is necessary to establish what constitutes adequate support. Where openings are created for windows, the walls are weakened, because the portion under the window is unsupported. Therefore, limitations are necessary on the extent of such openings in walls assumed to be supported at the top.

Exterior foundation walls are considered laterally supported at the top if:
- they support solid masonry construction,
- joists are embedded in the top of the foundation wall, or
- a floor system is anchored to the top of the foundation wall.

These conditions are illustrated in Figure 9.15.-13.

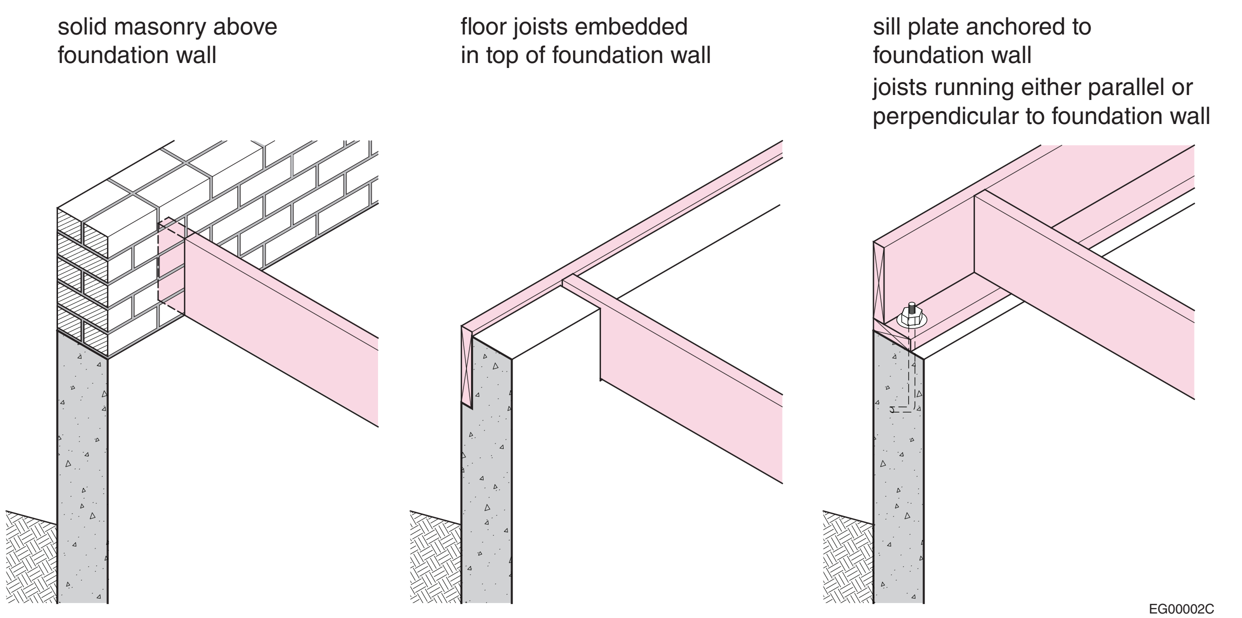


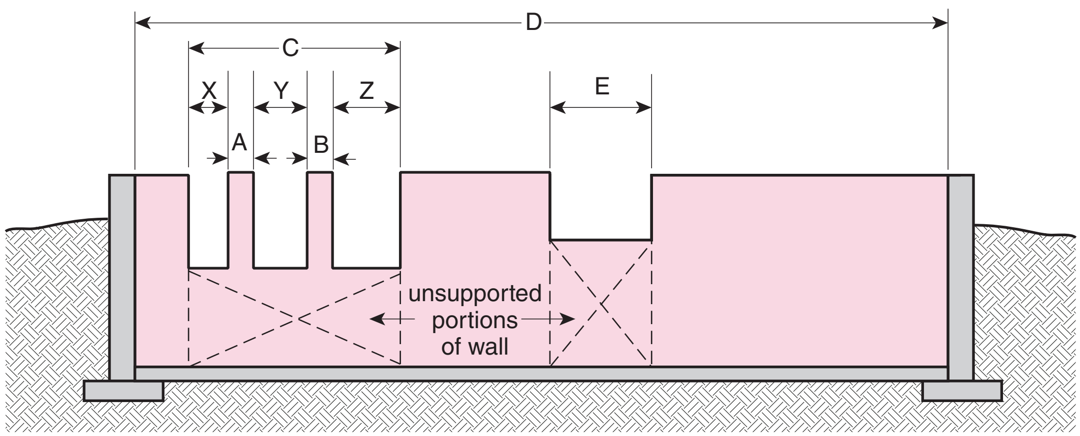
Figure 9.15.-13
Laterally supported walls

Window Openings

Window openings in a foundation wall weaken the ability of the wall to resist inward pressures. Any horizontal earth pressure on the portion of the wall beneath the window must be resisted by the weight of the wall, or be transferred to the masonry or concrete on either side of the opening. As the width of an individual window increases, the masonry or concrete becomes less able to transfer these loads, and a point is reached where the wall beneath the window may be pushed inward.

If windows are too close together, there is an insufficient amount of wall to withstand the load transferred from the wall beneath the window. This also must be controlled. Even if the openings are kept relatively small and reasonably spaced, however, as the percentage of wall openings increases, the overall strength of the wall decreases, and failure could occur.

When a foundation wall contains an opening greater than 1.2 m (4 ft.) in length, or contains openings whose combined total length exceeds 25% of the total wall length, then the portion of the wall beneath such openings is considered laterally unsupported, and the wall around the opening must be reinforced to withstand the earth pressure. In addition, when the length of solid wall between openings is less than the average length of the openings it separates, the openings are considered as a single opening. These conditions are shown in Figure 9.15.-14.



A < (X + Y)/2 and B < (Y + Z)/2; thus, C = X + Y + Z
C + E > 25% of D; thus, wall portions below C and E are laterally unsupported
C, E > 1.2 m (4 ft.); thus, wall portions below C and E are laterally unsupported

Where a foundation wall contains an opening more than 1.2 m (4 ft.) wide or contains openings with a total width that is more than 25% of the wall length, the portion of the wall beneath such openings must be considered laterally unsupported, unless the wall around the openings is reinforced to withstand earth pressure.

Where the width of solid wall between openings is less than the average width of the openings, the combined width of such openings must be considered as a single opening for the purposes of the sentence above.

EG00003B

Figure 9.15.-14
Portions of walls that are laterally unsupported

9.15.4.4. Foundation Walls Considered to be Laterally Supported at the Bottom

This Article indicates the conditions under which flat ICF foundation walls are considered to be laterally supported at the bottom. Foundation walls are required to be supported at the bottom so that soil pressure does not cause a wall to move. Lateral support can be provided by constructing a shear key or installing dowels in the footings. Support may also be provided by a floor-on-ground that is poured against the inner face of a foundation wall.

9.15.4.5. Reinforcement for Flat Insulating Concrete Form Foundation Walls

This Article indicates the reinforcement required for flat ICF foundation walls.

Vertical reinforcement requirements for flat ICF foundation walls are provided in NBC Tables 9.15.4.5.-A to -C.

9.15.4.6. Extension above Ground Level

This Article sets the minimum extension of foundation walls above ground level. The extension of a foundation above ground level is intended to avoid the entry of rainwater run-off and snow-melt over the top edge of the wall, and to protect water-sensitive materials supported on the foundation from prolonged wetting.

Foundation walls must extend a minimum of 150 mm (6 in.) above the ground. If a cladding is used that is adversely affected by moisture, such as wood or wood-based siding, clearance between the finished ground level and the bottom of the cladding must be a minimum of 200 mm (8 in.) (NBC Article 9.27.2.4.). This also applies to stucco over wood-frame construction (NBC Article 9.28.1.4.). These conditions are illustrated in Figure 9.15.-15.

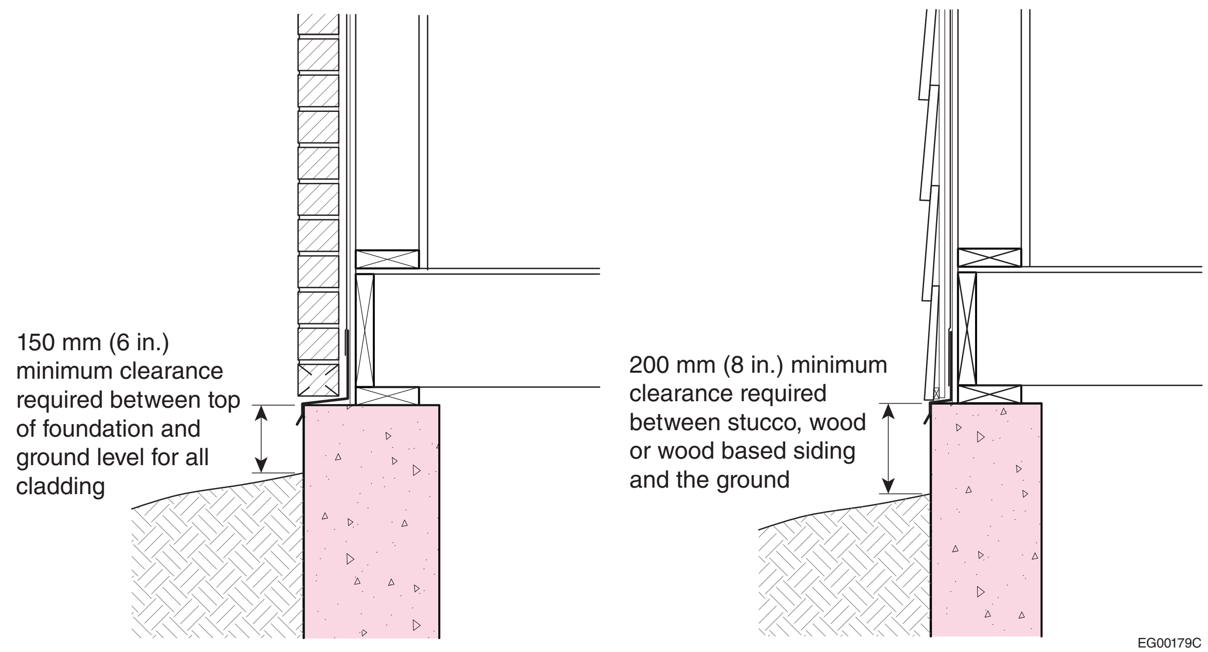


Figure 9.15.-15
Extension above ground level

9.15.4.7. Reduction in Thickness

This Article permits that the thickness at the top of a foundation wall be reduced for the purpose of supporting joists, but requires compensating measures when a foundation wall is reduced in this fashion.

Where masonry veneer is used for the exterior finish, it is sometimes preferred to extend the veneer close to the ground level rather than have exposed foundation extending above grade. This usually occurs where a basement is used for habitable space, and the basement walls extend above grade more than usual to permit larger windows. This practice does not significantly weaken the wall, since the masonry veneer is carried on the unreduced portion of the wall, and the portion below the ground level is full size. The reduced wall thickness must not be less than 90 mm (3 1/2 in.) as shown in Figure 9.15.-16.

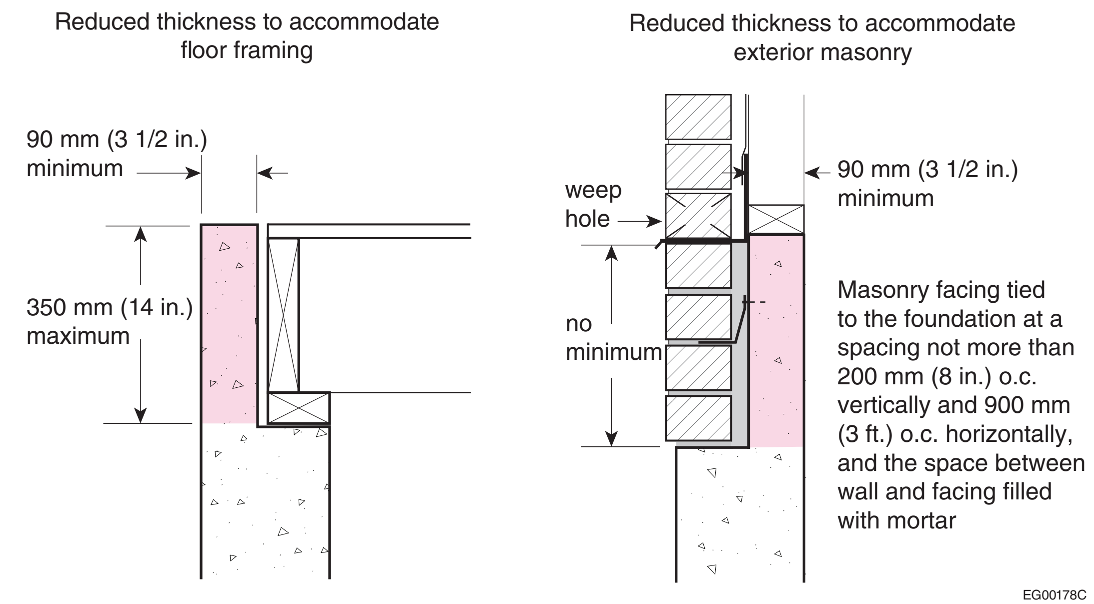


Figure 9.15.-16
Allowable reduction in wall thickness

9.15.4.8. Corbelling

This Article refers to the requirements in NBC Article 9.20.12.2. that pertain to the corbelling of a masonry superstructure so that it will not become unstable when it extends over the edge of a supporting foundation. See Guide 9.20.12.2., Corbelling for Cavity Walls, and Figure 9.20.-19.

9.15.4.9. Crack Control Joints

This Article sets minimum distances for the location of joints in foundation walls designed to reduce cracks so that the entry of soil drainage water and moisture can be minimized.

Both cast-in-place concrete and concrete block shrink over time as a result of curing and drying. To control shrinkage cracking, concrete block masonry units are either steam cured or autoclaved by the producer, and are required to satisfy permissible limits on linear drying shrinkage. Even so, some shrinkage may be expected for both cast-in-place concrete and concrete masonry foundation walls.

Crack control joints may be necessary to accommodate this shrinkage. These joints are designed to move apart slightly as the wall shrinks, while maintaining a watertight surface. These are required to be installed not more than 15 m (45 ft.) apart when the foundation walls are longer than 25 m (75 ft.). Figure 9.15.-17 illustrates the requirements for crack control joints in foundations and two approaches for sealing the joints.

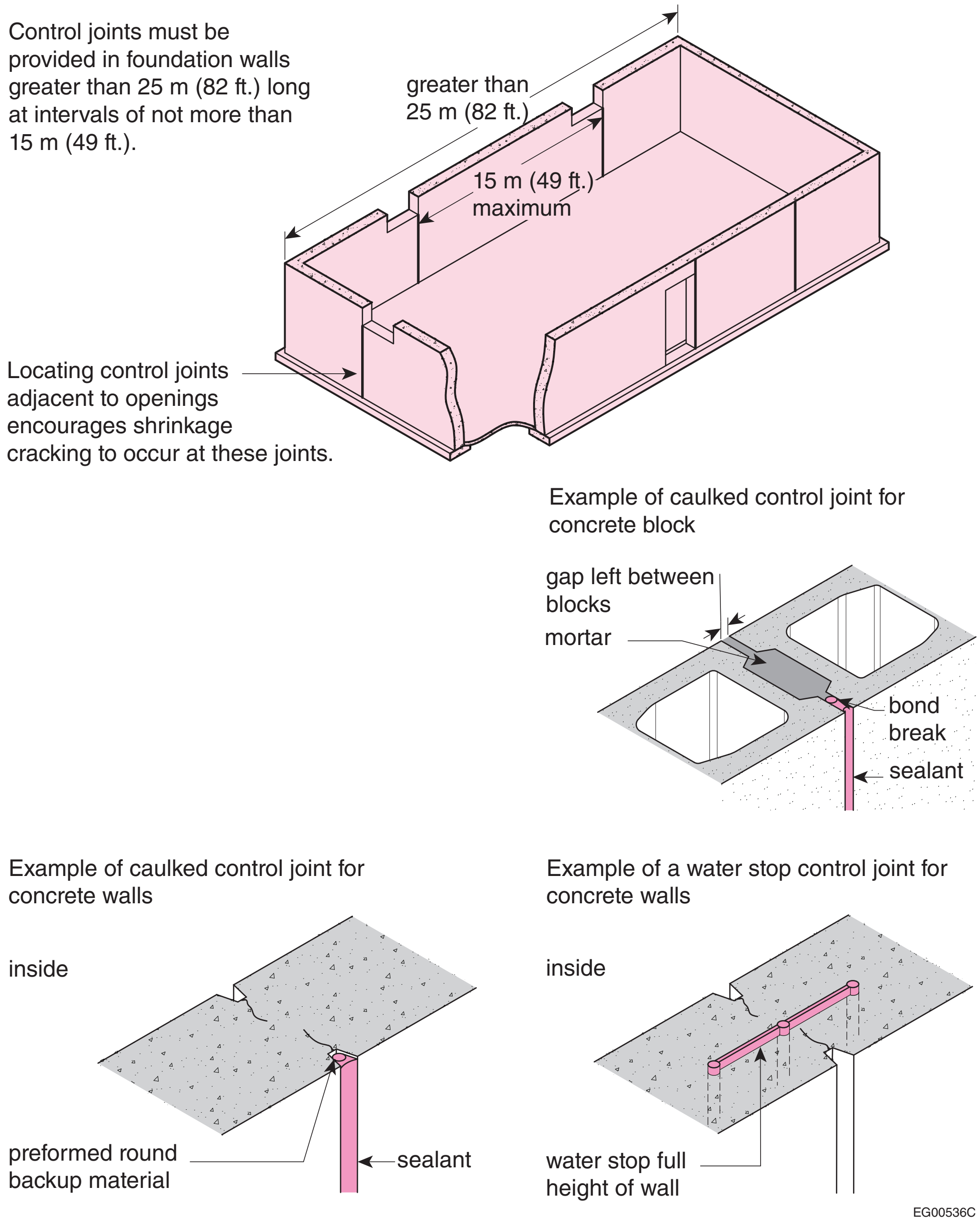


Figure 9.15.-17
Crack control joints

Where possible, crack control joints should be placed adjacent to a window opening, where the concentration of tensile stresses encourages shrinkage cracks to occur.

9.15.4.10. Interior Masonry Walls

This Article points to the requirements in NBC Section 9.20. for interior masonry walls acting as foundation walls so that they are constructed to have adequate strength to support anticipated loads.

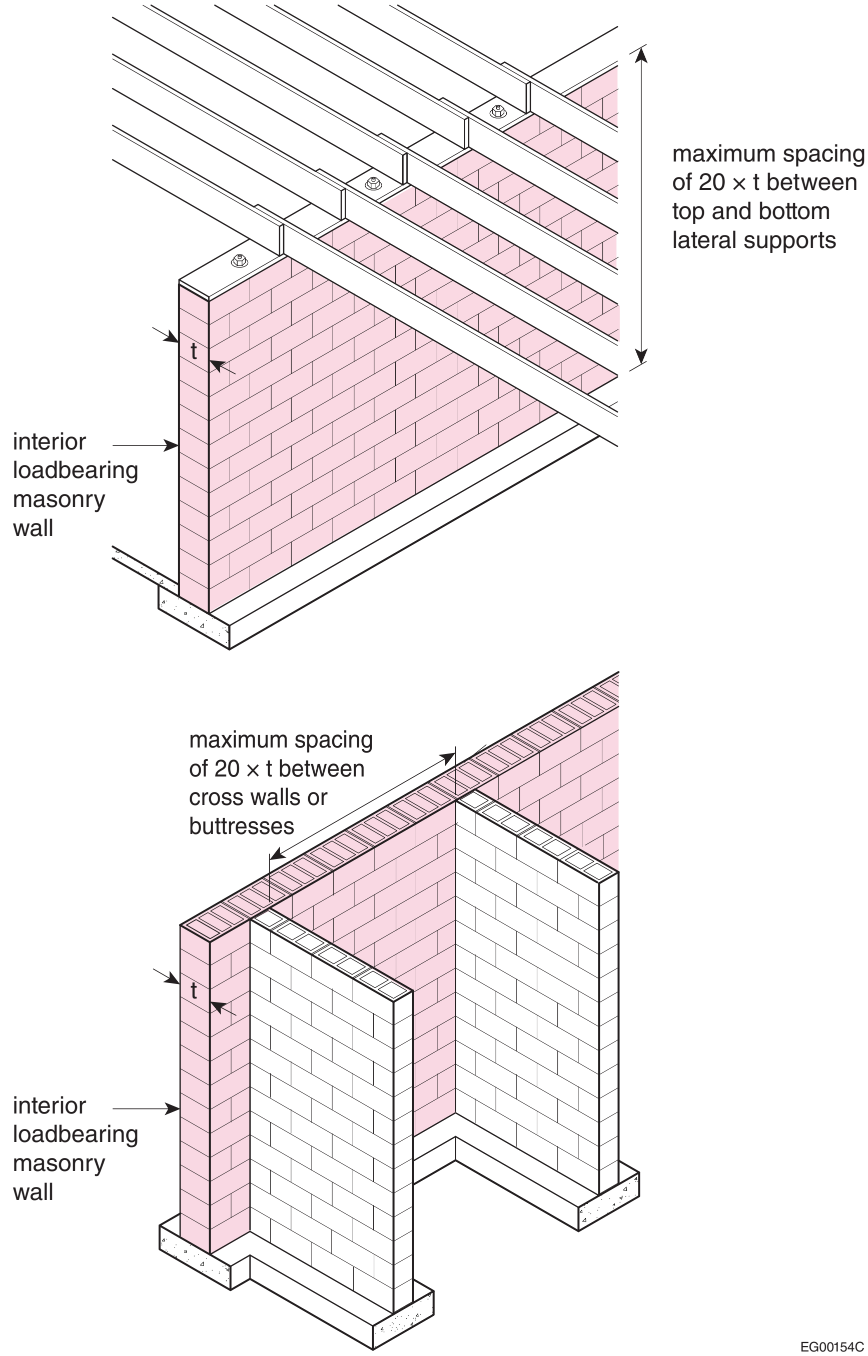


Figure 9.15.-18
Lateral support of interior loadbearing masonry walls

The minimum width for an interior loadbearing masonry wall depends on the spacing of its lateral support. Such walls must be laterally supported by floor or roof construction, or by intersecting masonry walls or buttresses. The maximum spacing of such supports can be no greater than 20 times the wall thickness, as illustrated in Figure 9.15.-18 (NBC Article 9.20.10.1.).

9.15.5. Support of Joists and Beams on Masonry Foundation Walls

Proper support of joists and beams will ensure that loads are safely transferred to the foundation and, ultimately, to the ground.

9.15.5.1. Support of Floor Joists

This Article requires the strengthening of the top of a hollow block foundation wall so that it has sufficient strength to support the superstructure loads. A second purpose is to control the entry of termites into the wall cavity. An exemption for wood-frame construction supported on a sill plate is rationalized on the basis that the plate is capable of distributing joist loads to the foundation given the lightness of frame construction. (The siding is overlapped to keep rainwater from entering the top of the foundation.)

Where joists are supported on hollow block foundation walls the voids in the top course are to be filled with no less than 50 mm of concrete, grout or mortar. Alternatively, the hollow block foundation wall can be capped by a course of 100% solid masonry at least 50 mm in height or hollow or semi-solid masonry units that have the top course completely filled with mortar, grout, or concrete.

Hollow block walls need not be capped if the wall supports wood-frame construction, and if masonry veneer is not used (Figure 9.15.-19). Where there is no mortar fill in the top course of block, the sill plate would have to be anchored with a bend or washer to engage the concrete block. The use of a wood sill plate beneath the joists is considered an adequate means of spreading the load from normal frame construction.

The capping of hollow block walls is required in regions known to have termites, regardless of the type of siding used.

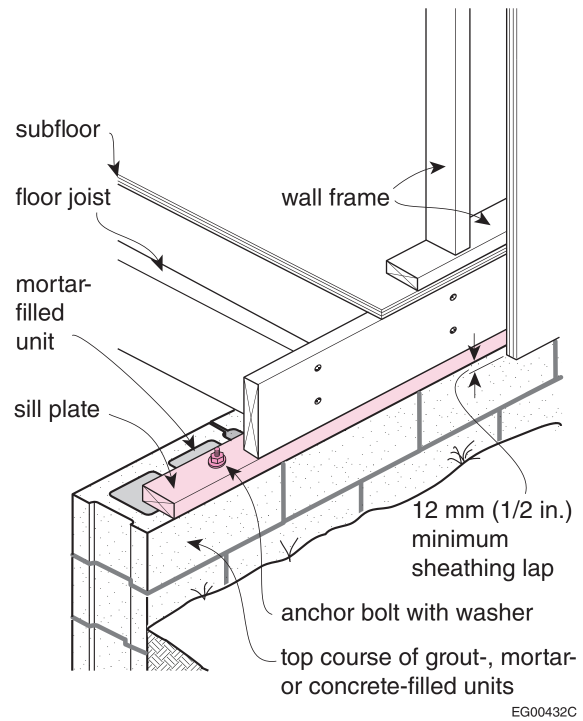


Figure 9.15.-19
Support of floor joists

Note to Figure 9.15.-19:
(1) Building envelope requirements are not shown.

9.15.5.2. Support of Beams

This Article requires special measures where beams are supported to provide foundation walls that will not be over-stressed at beam support locations. These requirements also intend to protect the ends of floor beams from rain, which could cause decay, and from termite entry.

Beams framing into hollow block walls impose a fairly high concentrated load that could over-stress the masonry shell if the beams were supported directly on the hollow block. A minimum 89 mm (3 1/2 in.) length of solid support is required for such beams, except as stated in the notes to NBC Span Tables 9.23.4.2.-H to -K (NBC Article 9.23.8.1.), which is considerably more than the thickness of the face shell of the masonry. Therefore, capping must be provided beneath the beam to distribute the load across the masonry (Figure 9.15.-20). It is also necessary to ensure that wood beams are adequately protected from the effects of weather to prevent decay (NBC Article 9.23.9.1.).

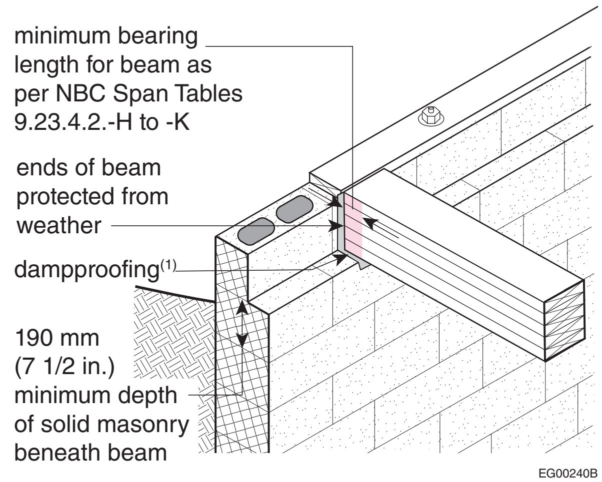


Figure 9.15.-20
Beam supported by masonry

Note to Figure 9.15.-20:
(1) Dampproofing is required if the beam is supported on concrete and is less than 150 mm (6 in.) above the ground, unless the beam is pressure-treated with a wood preservative (NBC Article 9.23.2.3.).

9.15.5.3. Pilasters

This Article requires that pilasters be provided under beams that are framed into thin foundation walls (140 mm (6 in.) or less in thickness). The pilasters must measure at least 90 × 290 mm (4 × 11 in.) and must be bonded or tied to the masonry wall. The top 200 mm (8 in.) of the pilaster must be of solid masonry construction (i.e., solid masonry units, or hollow or semi-solid masonry units filled with concrete, grout or mortar) in order to distribute the load evenly from the supported beam to the pilaster as shown in Figure 9.15.-21.

9.15.6. Parging and Finishing of Masonry Foundation Walls

The parging and finishing of concrete block or poured concrete foundation walls is intended for the following reasons:

- above-ground portions of masonry foundation walls must be made reasonably rain-tight,
- below-ground portions of masonry block walls must be parged before dampproofing or waterproofing is applied in order to provide a smooth surface suitable for the application of dampproofing or waterproofing, and
- form ties for concrete foundation walls must be removed at least flush with the foundation both above ground level, in order to resist water ingress, and below ground level, in order to provide a smooth surface for dampproofing and waterproofing.

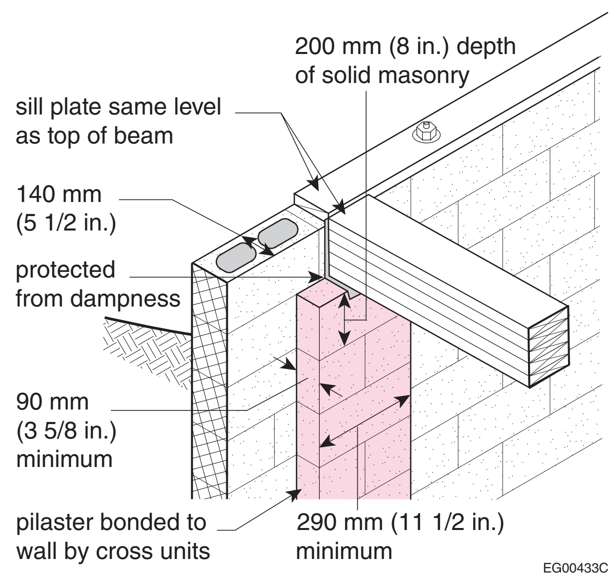


Figure 9.15.-21
Pilaster support for a beam framed into a foundation wall 140 mm (6 in.) thick

9.15.6.1. Foundation Walls below Ground

This Article requires the parging of concrete block walls to provide an even and continuous base for the application of dampproofing or waterproofing. Parging and finishing are an important line of defence for controlling moisture transfer through foundations. Figure 9.15.-22 illustrates the parging and finishing requirements for unit masonry foundation walls.

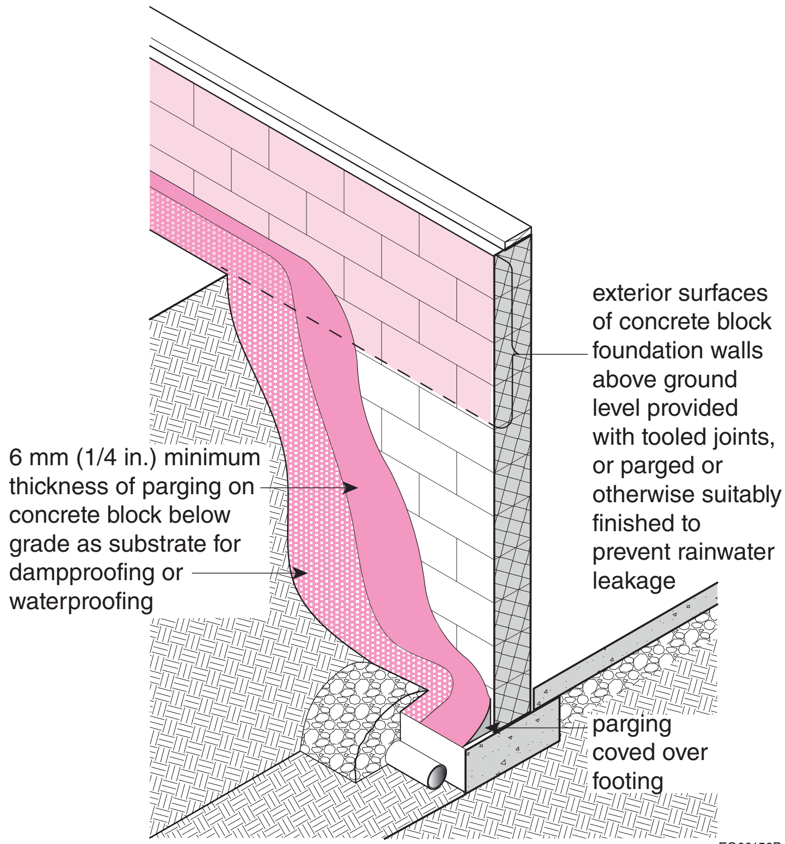


Figure 9.15.-22
Parging of concrete block foundation walls

9.15.6.2. Foundation Walls above Ground

This Article requires tooled joints or parging for the above-ground portion of every foundation wall to resist the entry of rainwater through mortar joints in concrete block foundation walls. Tooling the joint brings the mortar into closer contact with the masonry, thus reducing leakage.

9.15.6.3. Form Ties

This Article requires that form ties be removed in order to provide a suitable base for the application of dampproofing or waterproofing on the exterior of foundation walls. An additional benefit is a reduced risk of injury that may arise as a result of accidental contact with ties on the inside. Figure 9.15.-23 illustrates the filling of form tie holes in a concrete wall.

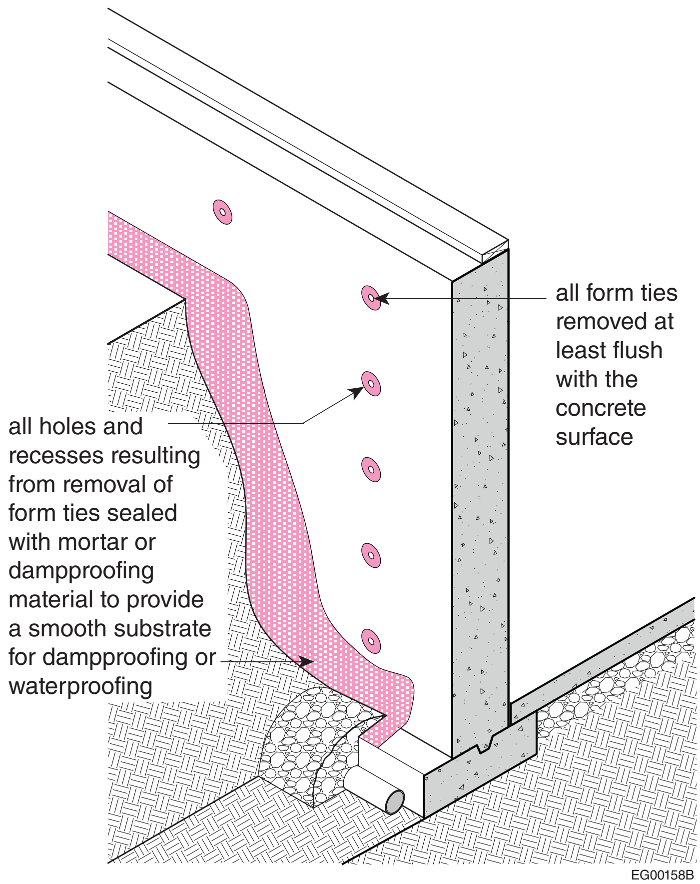


Figure 9.15.-23
Filling form tie holes

Section 9.16.
Floors-on-Ground

Introduction

Floors-on-ground are usually concrete, but other materials such as treated wood may also be used. Concrete floors-on-ground may be designed as either structural or non-structural slabs. Structural slabs are designed to support the weight of a building and its contents. The slab must be designed to transfer these loads to the ground without damage to the slab. When located near the surface of the ground, a slab is vulnerable to the effects of seasonal soil shrinkage, and this must be taken into account in clay soils (see Guide 9.4.4.4., Soil Movement). Since structural slabs require the services of an experienced designer, they must conform to the requirements in NBC Part 4, rather than those in NBC Section 9.16.

9.16.1. Scope

Floors-on-ground are required in all spaces in a dwelling where access is provided to the space and where a floor supported by the structure is not provided, except crawl spaces.

9.16.1.1. Application

This Article states the application of NBC Section 9.16. to non-structural floors-on-ground that rely on soil or granular fill for support. This includes concrete slabs and wood-frame floors.

9.16.1.2. Structural Floors

This Article indicates that the design requirements for structural floors are contained in NBC Part 4. Structural floors refers to slabs that transfer the loads of the building to the ground. They are often concrete slabs-on-grade with an integral footing.

9.16.1.3. Required Floors-on-Ground

This Article requires that, except for crawl spaces, each space in a dwelling unit that is provided with an access opening must have a floor. The floor is intended to protect the ground cover from damage, and to assist in restricting the entry of soil moisture and soil gases into the building.

9.16.1.4. Dampproofing and Waterproofing

This Article refers to requirements contained in NBC Section 9.13. for dampproofing and waterproofing.

9.16.2. Material beneath Floors

Concrete slabs placed directly on soil tend to wick moisture from the soil. The placement of a layer of coarse granular fill beneath floors-on-ground provides a barrier to the wicking of moisture into the concrete. It acts as dampproofing (NBC Subsection 9.13.2.) and as a gas permeable layer within the subfloor depressurization system (NBC Subsection 9.13.4.). In conjunction with an air barrier system (NBC Subsection 9.25.3.), it reduces the potential for entry into the building of moisture from the soil and soil gas.

9.16.2.1. Required Installation of Granular Material

This Article provides the minimum specifications that pertain to granular fill required to satisfy the functions it fulfills for dampproofing or for soil gas control or simply as a sanitary layer underneath a floor-on-ground.

The granular material constitutes a capillary break between the soil and a floor-on-ground to restrict the rise of soil moisture to the floor above. It also allows for depressurization beneath the slab to remove soil gases should the concentration of soil gas exceed safe limits within the dwelling.

Not less than 100 mm (4 in.) of coarse, clean, granular material (containing no more than 10% of materials that will pass a 4 mm (No. 4) sieve) is required under all floors-on-ground, except for those in unconditioned garages or carports.

The exemption for garages is rationalized on the basis that there is a required gas seal between a garage and the remainder of a dwelling. An exemption for carports and certain types of industrial buildings is rationalized on the basis that these are open to the outside air. An exemption for accessory buildings is rationalized on the basis that these are unoccupied most of the time.

9.16.2.2. Support of Floors

This Article limits the choices of materials that can be used as fill under floors-on-ground to reduce the risk of excessive settlement and consequent damage. The Article requires that material susceptible to changes in volume as a result of changes in moisture content or freezing cannot be used to support floors-on-ground (see Guide 9.4.4.4., Soil Movement). Granular fill must be compacted unless the material is coarse, clean aggregate, containing not more than 10% of material that will pass a 4 mm (No. 4) sieve.

9.16.3. Drainage

Unless it can be shown to be unnecessary, grading or drainage is required to prevent water ingress. Where groundwater levels might cause hydrostatic pressures beneath the floor-on-ground, a poured concrete slab designed to resist these pressures is required. Where gravity drainage is possible, basement floor slabs must be sloped to drain to prevent the accumulation of water (see also NBC Article 9.31.4.3.).

9.16.3.1. Control of Water Ingress

This Article requires grading or drainage for floors-on-ground to intercept and remove the groundwater resulting from rain or snow-melt before it can migrate to the underside of the slab or ground, and eventually enter a building. If not removed, this water could add to the moisture load in the building and create problems ranging from window condensation to structural deterioration.

9.16.3.2. Hydrostatic Pressure

This Article requires structural design according to NBC Part 4 for floors to ensure that floor slabs have sufficient resistance against hydrostatic pressure. When the groundwater level rises above the floor level, hydrostatic pressure is created on the underside of the floor, which tends to push the floor upward. Such forces may be sufficient to cause concrete slabs to heave and break, or wooden floors to float. One method of counteracting this problem is to provide a structural concrete slab designed to resist such forces.

9.16.3.3. Floor Drains

This Article requires the sloping of floor slabs towards floor drains, where they are provided, to facilitate the disposal of water that spills or leaks onto a concrete floor slab.

9.16.4. Concrete

9.16.4.1. Surface Finish

This Article requires that floor surfaces be smooth and even, and does not permit adding dry cement to absorb excess water. The requirements intend to provide a surface suitable for the direct application of thin floor finishes as well as a surface that is sufficiently hard and durable to withstand the effects of pedestrian traffic without undue deterioration and act as an effective adhesive base for certain floor finishes. Not allowing the use of dry cement during floor finishing is intended to promote concrete hardness to resist surface crumbling (i.e., dusting) from pedestrian traffic.

9.16.4.2. Topping Course

This Article contains requirements for a topping course to provide a floor surface that is sufficiently hard and durable to achieve the purpose of NBC Article 9.16.4.1. If the concrete slabs are too thin, they may dry out before the concrete has properly cured, thus giving rise to low-strength concrete.

Although concrete slabs on ground are generally placed in one lift, it may be more convenient at times to place the slab in two lifts. The second lift is a topping layer (at least 20 mm (3/4 in.) thick) laid over a rough cast slab of normal thickness (75 mm (3 in.)). If the topping is too thin, it will tend to craze when shrinkage occurs, and may not provide a suitable base for the final finish. The topping course is a mixture of Portland cement and sand, with as low a slump as can be conveniently placed.

9.16.4.3. Thickness

This Article requires that concrete floors-on-ground have sufficient flexural strength to limit cracking. When a load is applied to the top of a slab, it is distributed over a wider area beneath the slab. The thicker the slab, the greater will be the ground area over which the load is distributed given the increased slab stiffness. If the slab is too thin, the load may be large enough to deflect the ground beneath the slab, causing it to crack. The required slab thickness is intended to provide sufficient slab stiffness to avoid this for the loads normally encountered in buildings covered by NBC Part 9.

The minimum thickness for concrete floors-on-ground is 75 mm (3 in.), and the concrete must be trowelled smooth and even. A bond-breaking material (such as polyethylene film) must be provided between the slab and footings or any underlying rock in order to allow the concrete slab to shrink without cracking.

Figure 9.16.-1 shows some of the important requirements for concrete floors-on-ground.

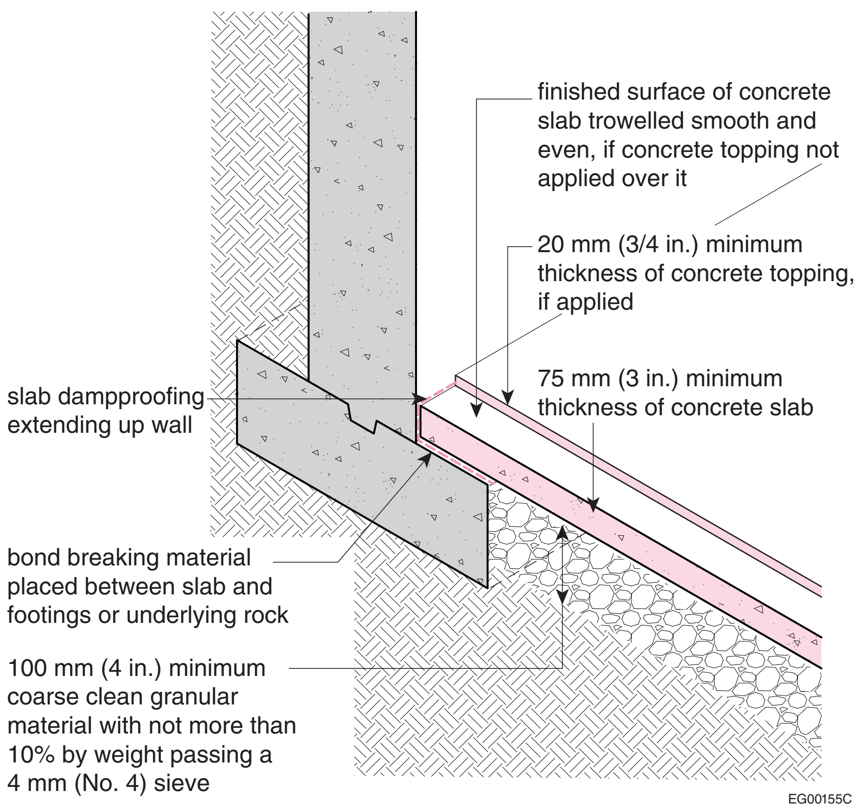


Figure 9.16.-1
Requirements for concrete floors-on-ground

Since garage and carport floor slabs may be exposed to de-icing salts, they must be constructed with a reasonable degree of salt resistance. Concrete for such slabs is, therefore, required to have a higher strength than the basement slabs, and must have air entrainment (5 to 8%) to increase its resistance to salt action (NBC Article 9.3.1.6.).

9.16.4.4. Bond Break

This Article requires a bond break to reduce, in concrete slabs, the amount of cracking caused by shrinkage, which occurs as the slab cures and dries (see Figure 9.16.-1). The bond break allows the slab perimeter to move inward as the slab shrinks, thereby relieving the slab of the tensile stresses that would have otherwise resulted.

Some authorities recommend crack control joints in the slabs at intervals from 4.5 to 6.0 m (15 to 18 ft.) (usually intersecting at columns) to encourage cracks to locate in symmetrical lines rather than randomly. The joints, about 0.25 of the depth of the slab, may be cut into the concrete as soon as it is hard enough to support the weight of a power saw. Alternatively, plastic strips may be recessed into the fresh concrete to provide lines of weakness.

Shrinkage cracks around the perimeter of the slab and around drain openings may provide points of entry for termites. Where termites are known to occur, these cracks should be filled with asphalt, coal tar or other termite-resistant caulking.

9.16.5. Wood

9.16.5.1. Wood-Frame Floors

This Article, through reference to a standard, requires that wood-frame floors supported on the ground resist decay for the expected life of a building. A second purpose is to increase the likelihood that such floors will resist the inward thrust from the walls that occurs due to earth pressure. While CSA S406, “Permanent Wood Foundations for Housing and Small Buildings,” describes suspended floors as well as floors-on-ground, the provisions related to the support of end and side walls do apply to floors-on-ground.

Section 9.17. Columns

Introduction

Columns transfer beam loads down to solid bearing. In basements, columns carry the load directly to the footings, which distribute the concentrated loads over a wider area. The beam loads depend on the type of occupancy, the size of the supported floor or roof assembly, and the number of floors that are carried by the beams.

9.17.1. Scope

This Section applies to columns used to support:
- beams carrying loads from not more than two wood-frame floors,
- beams or header joists carrying loads from not more than two levels of wood-frame balconies, decks or other accessible exterior platforms, and
- carport roofs.

9.17.1.1. Application

This Article indicates the applicability of NBC Section 9.17. The column sizes described in NBC Section 9.17. are based on experience in residential construction, where the loads are relatively small, partly due to the occupancy and partly due to the type of construction and size of the buildings. When the limited application of the prescriptive requirements are exceeded, columns must be subjected to structural analysis in accordance with NBC Part 4 to verify that they will have sufficient strength to carry the anticipated loads.

To prevent columns from being overloaded, the application of NBC Section 9.17. is limited to wood-frame construction and occupancies with relatively light design live floor loads (2.4 kPa (50 psf)). The floor size is limited to the maximum size that normally occurs in wood-frame construction (5 m (16 ft.) joist span). If the columns support more than two floors, or if the joist spans or floor loads exceed these limits, the column sizes are required to be calculated for the specific design conditions in conformance with NBC Part 4.

9.17.2. General

Columns are used to support horizontal structural elements, such as beams, by transferring the loads they carry to the column footings. The failure of columns may be catastrophic. For this reason, it is important that they are correctly sized, securely fastened, and braced for lateral support.

9.17.2.1. Location

This Article indicates the proper location of columns on footings. If loadbearing columns are not located near the centres of their footings, the pressures beneath the footings will be greater near the column. This can cause uneven settlement under the footing, and under severe conditions could cause foundation failure.

9.17.2.2. Lateral Support

This Article intends to ensure that columns remain capable of supporting loads. In general, columns are required to be laterally supported. Lateral support can be provided by connections to the supporting members or by bracing the column directly. There is an exception for columns that support deck joists whose bottoms are not more than 600 mm (2 ft.) above the ground, and where the deck does not support a superstructure.

Because the NBC does not provide prescriptive criteria to describe the minimum required lateral support, constructions are limited to those that have demonstrated effective performance over time and those that are designed according to NBC Part 4. Verandas on early 20th century homes provide one example of constructions whose floor and roof are typically tied to the rest of the building to provide effective lateral support. Large decks set on tall columns, however, are likely to require additional lateral support even where they are connected to a building on one side.

9.17.3. Steel Columns

The most common types of columns used in residential buildings are adjustable tubular steel columns. These are proprietary columns that have an adjusting screw at one end to allow them to be adjusted precisely to the proper height to support the beam loads.

9.17.3.1. Size and Thickness

This Article specifies a minimum diameter and thickness for steel columns. Adjustable columns are either one-piece or two-piece types. The two-piece type has telescoping sections that allow the tubes to be extended or contracted, and permit their use over a wider range of ceiling heights. Adjustable steel columns are required to be load tested and identified by a label.

The allowable load (based on a safety factor of 2.25) must be shown on the label together with the manufacturer's name and the standard to which it is tested (CAN/CGSB-7.2, "Adjustable Steel Columns"). The design load, however, is not permitted to be less than 36 kN (8 000 lbf). For larger loads, steel columns need to be designed in accordance with NBC Part 4.

The load carried by the beam must be determined in order to calculate the safe spacing of the columns. The permitted live floor loads of 2.4 kPa (50 psf), and the spans described for steel beams, wood beams and floor joists are such that the load on columns could exceed 36 kN (8 000 lbf), the maximum allowable load on columns prescribed in CAN/CGSB-7.2. In the context of NBC Part 9, loads on columns are calculated by multiplying the supported area and the live load per unit area, using the supported length of joists and beams. The supported length is half of the joist spans on each side of the beam and half the beam span on each side of the column.

Dead load is not included based on the assumption that the maximum live load will not be applied over the whole floor. Designs according to NBC Part 4 must consider all applied loads.

The requirements for steel pipe columns are shown in Figure 9.17.-1. For other types of steel columns, it is necessary to demonstrate that these have an equivalent loadbearing capacity.

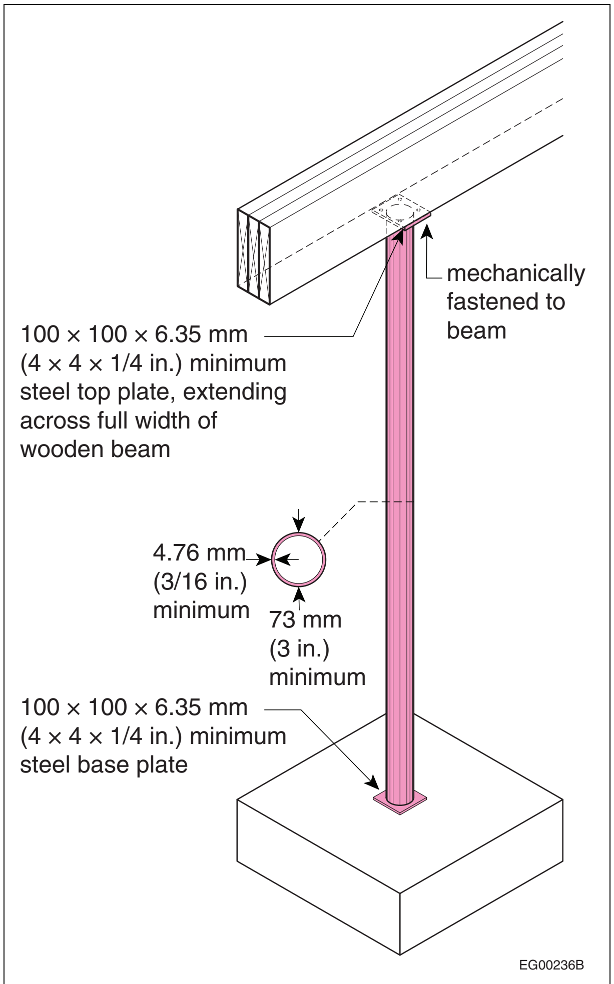


Figure 9.17.-1
Steel columns

9.17.3.2. End Bearing Plates

This Article describes where end bearing plates for steel columns are required. Steel pipe columns must have a plate at their top and bottom to distribute the load from the beam to the column and from the column to the concrete. The purpose is to spread the column load over a sufficient area to avoid crushing of the concrete at the bottom support, or crushing of wood at the top where the column supports a wooden beam. The top plate, normally drilled to facilitate its attachment to the beam, is not needed if the column is welded directly to a steel beam. The bottom plate may be anchored to the floor with mechanical fasteners or embedded in the concrete floor slab to give the column stability.

9.17.3.3. Paint

This Article requires that steel columns be provided protection against corrosion. Exterior steel columns must be treated with at least one coat of rust-inhibiting paint to maintain their long-term structural integrity.

9.17.3.4. Design of Steel Columns

This Article references CAN/CGSB-7.2, “Adjustable Steel Columns,” for loads up to 36 kN (8 000 lbf). Steel columns supporting loads exceeding this maximum should be designed in accordance with NBC Part 4.

9.17.4. Wood Columns

9.17.4.1. Column Sizes

This Article indicates the minimum sizes for wood columns, and references NBC Article 9.35.4.2. for columns in garages and carports.

When a wood column is subjected to a vertical load, its resistance to buckling will depend on its slenderness ratio (the length divided by the least dimension). The larger the slenderness ratio, the greater the tendency to buckle. Therefore, if a column is built up with a series of wooden members, it will not be as strong as a one-piece column of the same cross-section, unless the individual pieces are joined to act in unison. Figure 9.17.-2 shows how nails or bolts may be used to connect individual laminations together.

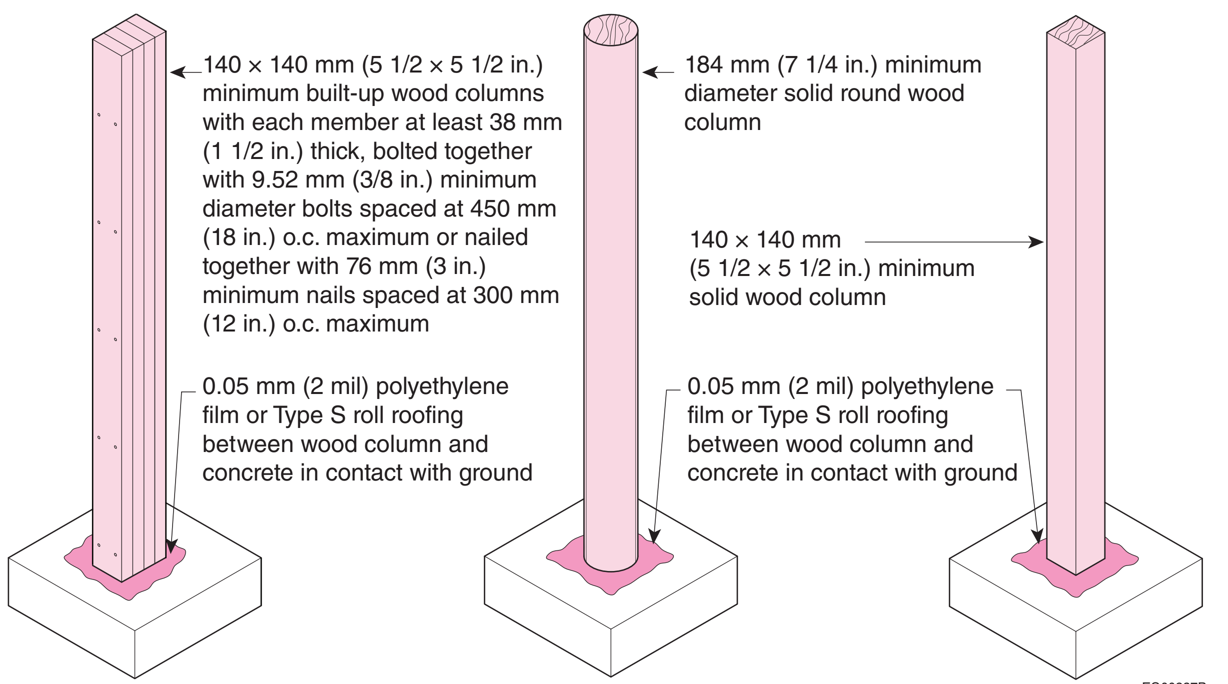


Figure 9.17.-2
Types of wood columns

Note to Figure 9.17.-2:
(1) See NBC Article 9.3.2.9. for termite and decay protection requirements.

Stability at the base of a wood column can be achieved by embedding a bolt in the concrete and mounting the column over it, or using steel angles and bolts. Wood columns supported on concrete in contact with ground must be separated by 0.05 mm (2 mil) polyethylene or Type S roll roofing to reduce the risk of decay. The use of concrete pedestals to raise the footing level above the general basement floor level is also considered good practice, although this is not a requirement.

9.17.4.2. Materials

This Article describes the various types of wood columns, and indicates how the various members in built-up wood columns are fastened together to act as a unit to carry the anticipated loads. Glued-laminated columns require engineering analysis and manufacturing supervision beyond the scope of Part 9. These must be designed in accordance with structural requirements found in NBC Part 4.

9.17.4.3. Columns in Contact with Concrete

This Article requires that wood columns be protected from decay caused by moisture, which occurs on concrete from the ground or from surface condensation on the concrete in summer.

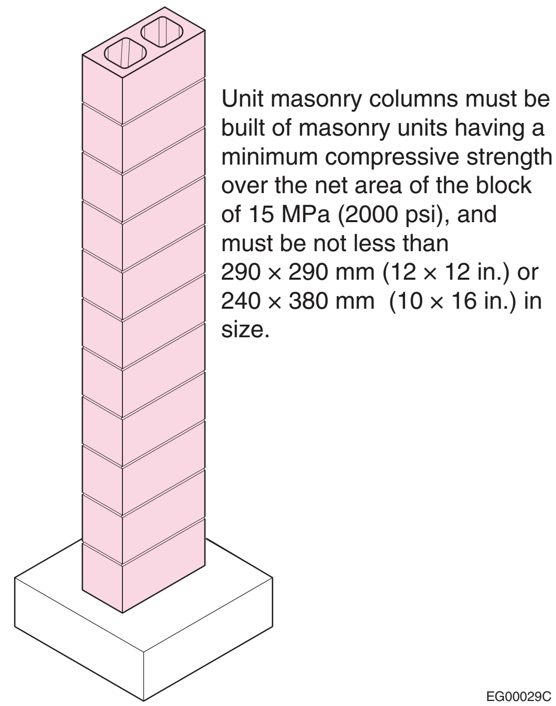


Figure 9.17.-3
Unit masonry columns

9.17.5. Unit Masonry Columns

9.17.5.1. Materials

This Article references a standard and requires that unit masonry columns be built of masonry units having a minimum specified compressive strength of 15 MPa (2 000 psi).

9.17.5.2. Sizes

This Article sets minimum permitted sizes for masonry columns, as shown in Figure 9.17.-3.

9.17.6. Solid Concrete Columns

9.17.6.1. Materials

This Article references NBC Section 9.3. for requirements pertaining to solid concrete columns.

9.17.6.2. Sizes

This Article indicates the minimum permitted sizes for concrete columns. Requirements for solid concrete columns are shown in Figure 9.17.-4. Like unit masonry columns, solid concrete columns must have a minimum compressive strength of 15 MPa (2 000 psi).

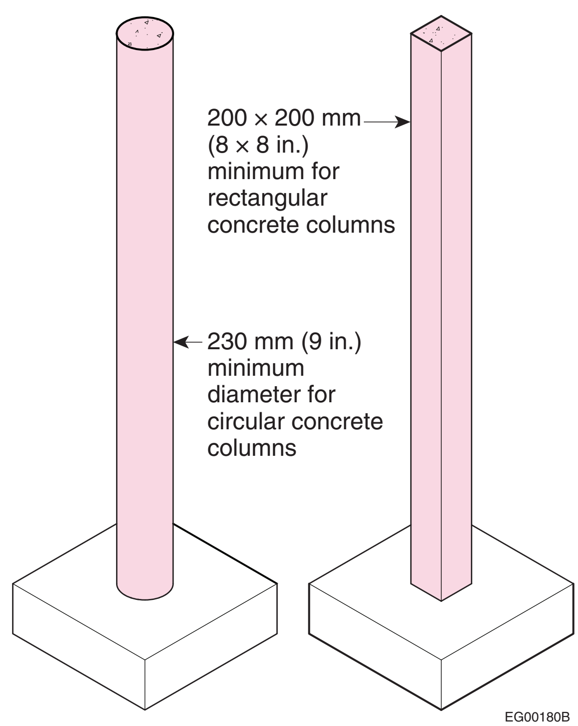


Figure 9.17.-4
Solid concrete columns

Section 9.18.
Crawl Spaces

Introduction

Crawl spaces are enclosed spaces between the underside of a floor assembly and the ground below, where the clearance is less than the 2 m (6 ft. 7 in.) required for a basement. Crawl spaces are often used to give access to ducts, pipes, cables and other utilities. There are heated and unheated crawl spaces. Depending on the configuration of the crawl space and its interaction with the rest of the building, requirements for crawl spaces range from being similar to those for occupied space to those for ancillary buildings.

9.18.1. General

9.18.1.1. Application

This Article indicates the application of NBC Section 9.18. Where crawl spaces are unheated and relatively open to the outside air (25% or more open walls), there is sufficient air change to prevent moisture build-up and no special measures are required to prevent soil moisture from reaching the habitable areas. Structures such as manufactured homes, which are usually supported on piers, require no special precautions unless the perimeter walls are enclosed by skirting.

Insulation, air sealing and vapour barrier requirements for heated and unheated crawl spaces are addressed in NBC Section 9.25. NBC Section 9.25. divides building spaces into conditioned and unconditioned spaces, and determines required insulation, air barrier and vapour barrier requirements accordingly. Heated crawl spaces must be heated according to NBC Section 9.33.

9.18.1.2. Foundations

This Article indicates that when the enclosing walls of a crawl space support loads from the superstructure, they act as foundation walls and need to comply with NBC Section 9.15. Where heat transfer through the foundation walls of crawl spaces is sufficient to cause condensation or to compromise occupant comfort, heated crawl spaces are required to have their walls insulated and be provided with air barrier systems and vapour barriers in conformance with NBC Section 9.25.

Typical crawl spaces for site-built buildings have foundation walls constructed in much the same manner as basements except that a concrete floor may not always be provided. Foundations for unheated crawl spaces are subjected to frost action from inside, as well as outside, the crawl space. Where unheated crawl spaces extend below ground level, the frost penetration may be greater than might be anticipated from the outside ground level.

9.18.1.3. Heated and Unheated Crawl Spaces

This Article indicates the conditions under which a crawl space is considered to be a heated space and to indicate that requirements for heating, insulation, vapour barriers and air leakage are located elsewhere in the NBC.

A crawl space is considered to be heated when it:
- is used as a hot air plenum,
- contains heating ducts that are not sealed or insulated, or
- is not isolated from the interior heated space (e.g., by an insulated and sealed floor above and, in some configurations, by an insulated and sealed wall separating it from an adjoining basement space).

9.18.2. Access

9.18.2.1. Access Openings

This Article describes the requirements for access to crawl spaces for inspection and servicing. Smaller openings for single dwelling units are rationalized on the basis of past experience. Access hatches or doors are required to reduce heat loss into unheated crawl spaces, or from heated crawl spaces to the exterior if they are located in exterior walls.

Access normally consists of a hatchway 500 × 700 mm (20 × 28 in.) for dwelling units, and 550 × 900 mm (20 × 36 in.) for other buildings fitted with a door or hatch. Where a crawl space communicates with an adjacent basement, the door or hatch on the access is not considered necessary.

Figure 9.18.-1 illustrates the requirements for access, ground cover and ventilation of unheated crawl spaces.

Figure 9.18.-2 illustrates the requirements for access, ground cover and ventilation of heated crawl spaces.

9.18.3. Ventilation

Proper drainage, ground cover and ventilation is required to minimize moisture in both unheated and heated crawl spaces.

9.18.3.1. Ventilation of Unheated Crawl Spaces

The ventilation requirements for unheated crawl spaces minimize the build-up of moisture within unheated crawl spaces resulting from the evaporation of soil moisture. In severe cases, moisture can increase to the point of causing wood decay. Vent distribution is intended to encourage cross-ventilation and more rapid dissipation of moisture to the exterior. Moisture can also enter the vents from rainwater or snow-melt if the vents are not shielded. Screening is also necessary to keep insects from entering the crawl space.

Unheated crawl spaces are considered to be outside the heated envelope. As such, they must be vented to the outside, certain ground covers to control humidity are prescribed, and any assembly separating the crawl space from occupied conditioned space must incorporate insulation, air barrier systems, and vapour barriers.

Screened openings (equal to about 0.2% of the floor area) are required in the perimeter walls to provide cross ventilation in unheated crawl spaces. These are intended to be left open during the period when the outdoor air moisture content is low, but covers should be provided so that they can be closed in very cold weather or when the outdoor air moisture content is high.

9.18.3.2. Ventilation of Heated Crawl Spaces

This Article indicates that heated crawl spaces are subject to the same ventilation requirements as are other heated spaces. Mechanical ventilation conforming to NBC Section 9.32. must be provided if a crawl space is heated. In this case, the crawl space would be treated as a basement for the purposes of applying the requirements of NBC Section 9.32.

Ground covers to control moisture and soil gases are required, and where heat transfer is sufficient to cause condensation on the interior or to compromise occupant comfort, the walls must incorporate insulation, vapour barrier and air barrier systems, the same as do all other walls.

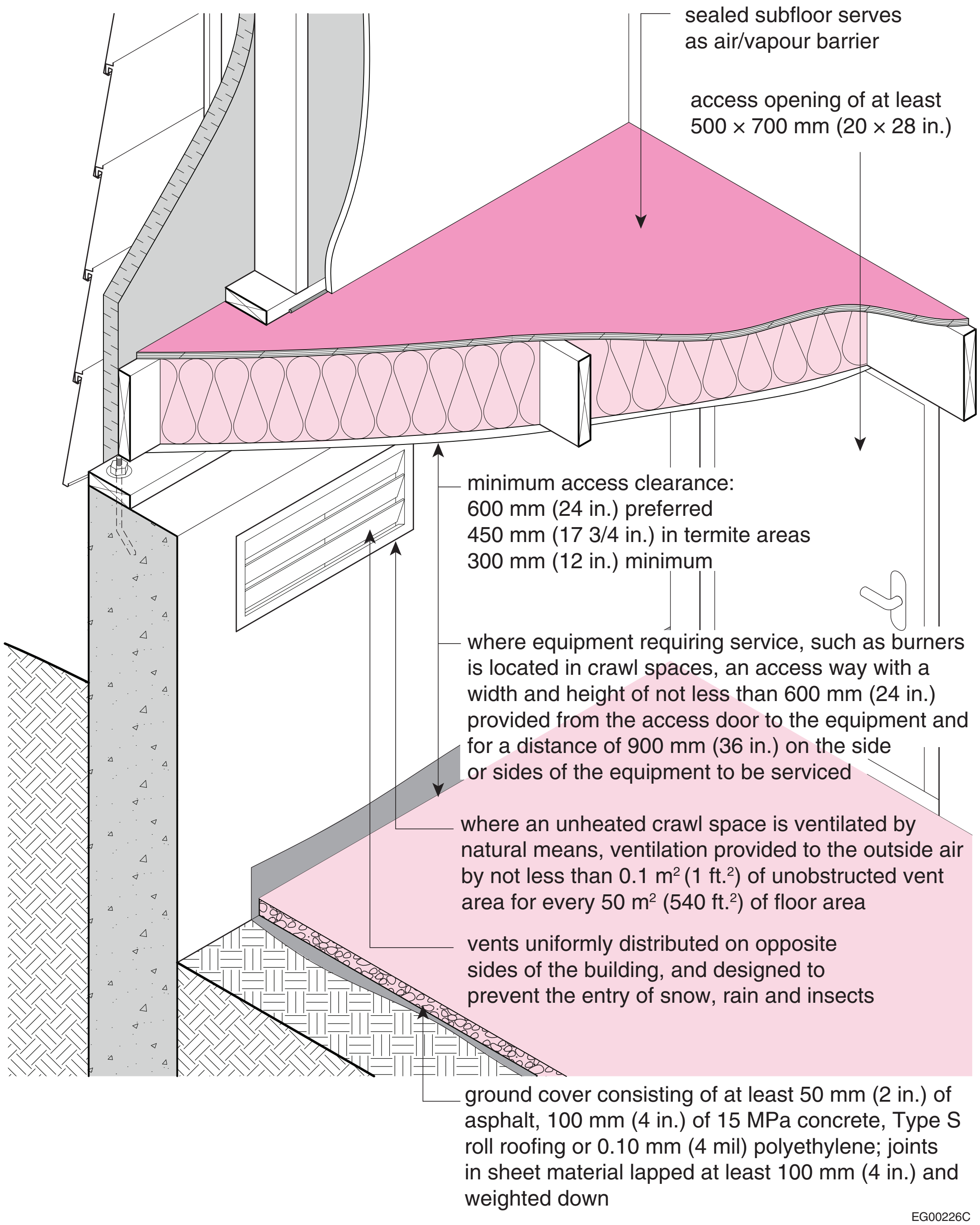


Figure 9.18.-1
Requirements for unheated crawl spaces

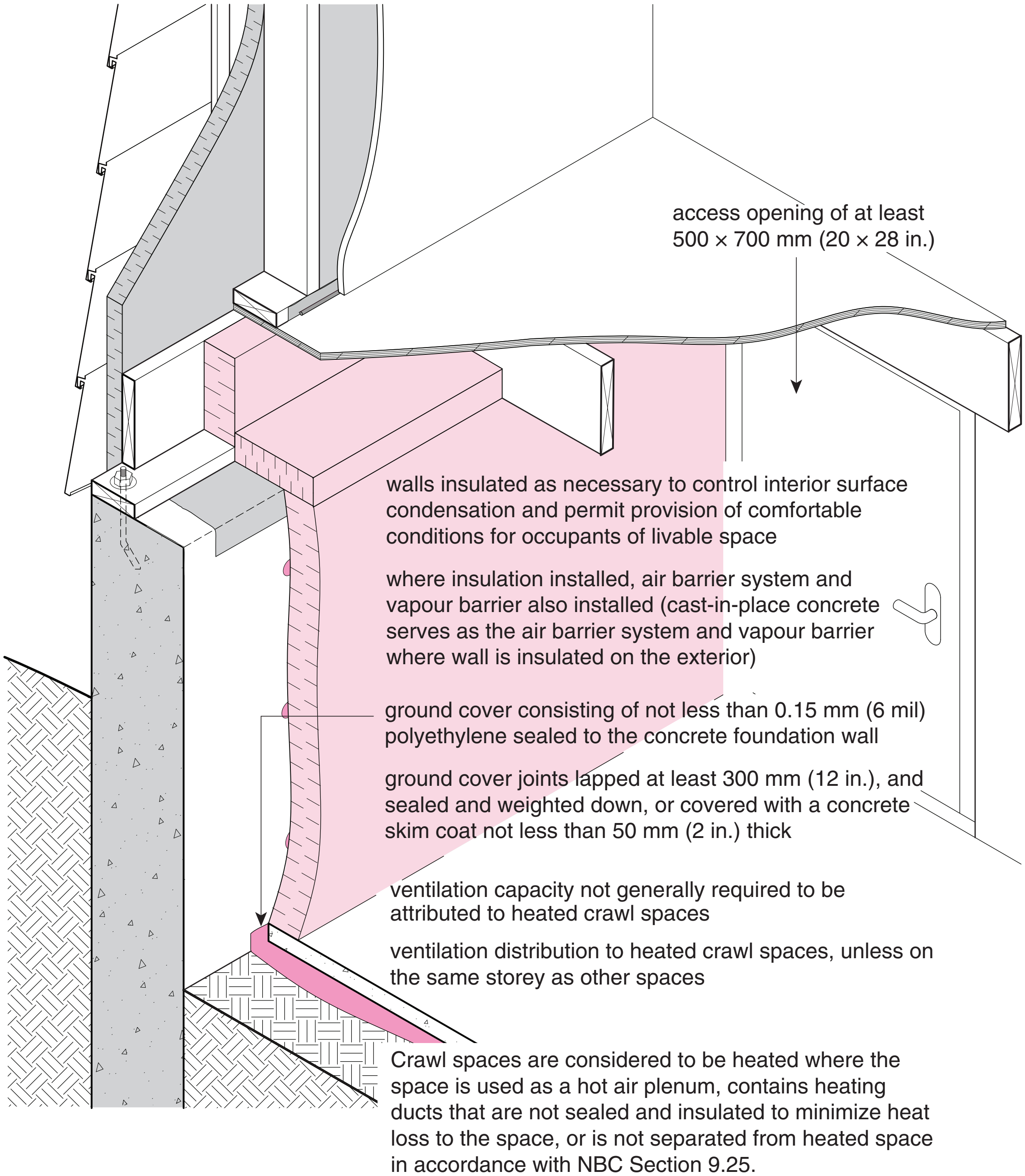


Figure 9.18.-2
Requirements for heated crawl spaces

9.18.4. Clearance

9.18.4.1. Access Way to Services

This Article requires sufficient clearance within a crawl space to allow access to equipment that requires periodic servicing. All crawl spaces must be provided with an access way to any services they may contain. The access way must be at least 600 mm (24 in.) high and wide from the access door to the equipment, and for a distance of 900 mm (36 in.) on the side or sides of the equipment to be serviced.

Certain crawl spaces may not require access for construction purposes so that less clearance is needed. As the space decreases, however, ventilation becomes less and less efficient so there may be a greater risk of moisture accumulation. Adequate access to install the ground cover is required.

Ground clearances are also determined based on the potential for termite infestation. NBC Article 9.3.2.9. specifies a 450 mm (18 in.) clearance, unless suitable preservative treatment of wood framing members is provided. In any case, a minimum clearance from the ground to the framing members of 300 mm (12 in.) is recommended to allow spaces for access, retrofitting of heating and plumbing systems, as well as rough-ins for radon mitigation systems and ventilation.

9.18.5. Drainage

9.18.5.1. Drainage

This Article indicates drainage requirements to control water ingress in crawl spaces. Since crawl spaces for site-built structures usually extend below ground level, they can collect surface drainage unless preventative measures are taken. Surface drainage must be directed away from the building by grading and perimeter drainage tile installed around the building below floor level (usually at the base of the footing), the same as is required for basements.

At certain sites some water may inevitably find its way into the crawl space. Where gravity drainage is possible, the floor of the crawl space should be sloped to a drain to dispose of any water accumulation. Drainage of the foundation wall must conform to NBC Article 9.14.2.1. and the floor to NBC Article 9.16.3.3.

If trenches are provided in crawl spaces to service equipment or plumbing cleanouts, these serve as water collectors and must also be sloped to a drain. If water is allowed to accumulate and no drainage is provided, the effect of the ground cover is negated and moisture-related problems could result.

9.18.6. Ground Cover

To control moisture problems, attention must be given to drainage, ground cover, and ventilation. Of these, ground cover is one of the most important considerations. Evaporation of moisture into the crawl spaces from the ground surface can add a substantial moisture load to a building, and may affect the house above the crawl space, as well as the crawl space itself.

If the air in the crawl space becomes too humid, the equilibrium moisture content of any wood exposed to it may reach a level that will initiate decay. Ground cover also fulfills the function of minimizing ingress of soil gas into crawl spaces. This is less critical for unheated crawls spaces, which are vented to the exterior; however, it is critical for heated crawl spaces, which may be insulated and sealed and may communicate with interior space.

9.18.6.1. Ground Cover in Unheated Crawl Spaces

This Article indicates the ground cover requirements for unheated crawl spaces to restrict ground moisture resulting from evaporation from entering the crawl spaces, because such moisture could contribute to moisture-related problems such as wood decay. The ground cover is not required to be an air barrier against soil gas infiltration into the unheated crawl space because future venting of the space, should it be required, would satisfy the requirement for soil gas control (NBC Subsection 9.13.4.).

The floor of unheated crawl spaces must be covered with a vapour-resisting membrane such as 0.10 mm (4 mil) polyethylene film, suitably lapped where joints occur (at least 100 mm (4 in.)) and weighted down, usually with crushed stone, sand or a concrete skim coat. A 100 mm (4 in.) concrete slab (15 MPa (2 000 psi)) can also be used. If the crawl space is to be used for storage purposes, or entered occasionally for any other reason, a concrete floor is preferred to avoid damaging the ground cover.

9.18.6.2. Ground Cover in Heated Crawl Spaces

This Article indicates the ground cover requirements for heated crawl spaces to restrict soil gas ingress and ground moisture.

Heated crawl spaces require a ground cover consisting of 0.15 mm (6 mil) polyethylene with the joints lapped at least 300 mm (12 in.). The ground cover must be evenly weighted down with a ballast material or covered with at least 50 mm (2 in.) of concrete. The ground cover must be a barrier to air and soil gas as specified in NBC Subsection 9.13.4. and installed as part of the air barrier system in accordance with NBC Subsection 9.25.3.

This means it must be sealed to the foundation walls and all penetrations must be sealed. However, a rough-in for radon mitigation (as required in NBC Article 9.13.4.3.) is not required in crawls spaces without floor-on-ground, as long as the heated crawl space is accessible so that a the rough-in could be installed at a later date if necessary and without much cost and disruption.

9.18.7. Fire Protection

9.18.7.1. Crawl Spaces as Warm Air Plenums

This Article indicates the fire protection measures required where a crawl space is used as a warm air plenum. When crawl spaces are used as warm air plenums, the warm air from the furnace plenum is blown into the crawl space, which then becomes pressurized. Registers to allow warm air up into the living areas are not attached to any ductwork, but rely on the crawl space air pressure to force the warm air up through the registers. Such systems are not able to regulate air distribution in buildings of more than one storey because there are no ducts to the upper storeys.

In crawl spaces used as warm air plenums, the warm air from the furnace is introduced into the crawl space by ducts, usually 2 m (6 ft. 7 in.) or less in length, that direct the air towards the extremities of the crawl space. Registers in the floor allow the warm air to reach the rooms above without connecting ducts, since the furnace blower pressurizes the crawl space (Figure 9.18.-3).

This type of heating system is workable only in one-storey buildings. Although similar systems have been attempted experimentally in two-storey buildings, they have not been successful. Typically, houses with crawl spaces are heated with conventional ducted systems. At least one warm air supply outlet must be installed for each 80 m² (860 ft.²) of crawl space floor area.

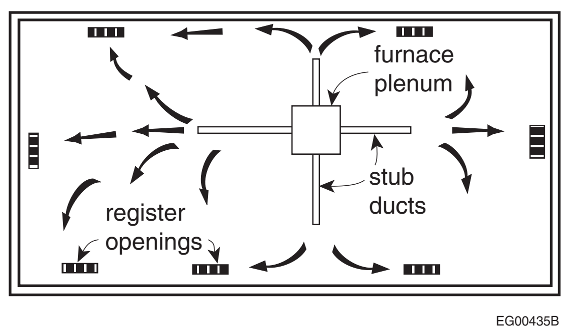


Figure 9.18.-3
Air flow in a pressurized crawl space plenum

The air in the crawl space is warmer than room air and results in comfortable floors in the winter. Since there are no connecting ducts between the registers and the steel ducts, however, any moisture in the crawl space is rapidly introduced into the habitable areas. The warm airflow across the crawl space surface evaporates ground moisture much more rapidly than in crawl spaces with ducted heating.

Since a crawl space used as a heating plenum is open to the habitable space via the registers, additional precautions are necessary to reduce the risk of fire originating in the crawl space. If the ground cover is combustible, noncombustible receptacles must be provided beneath the open registers to catch burning materials that fall through the openings. The receptacles must extend 300 mm (12 in.) beyond each side of the opening and have turned-up edges to gather debris (Figure 9.18.-4). In addition, the lining materials exposed to the interior of the crawl space must have a flame-spread rating of not more than 150. This applies to exposed foamed plastic insulation and air/vapour barriers.

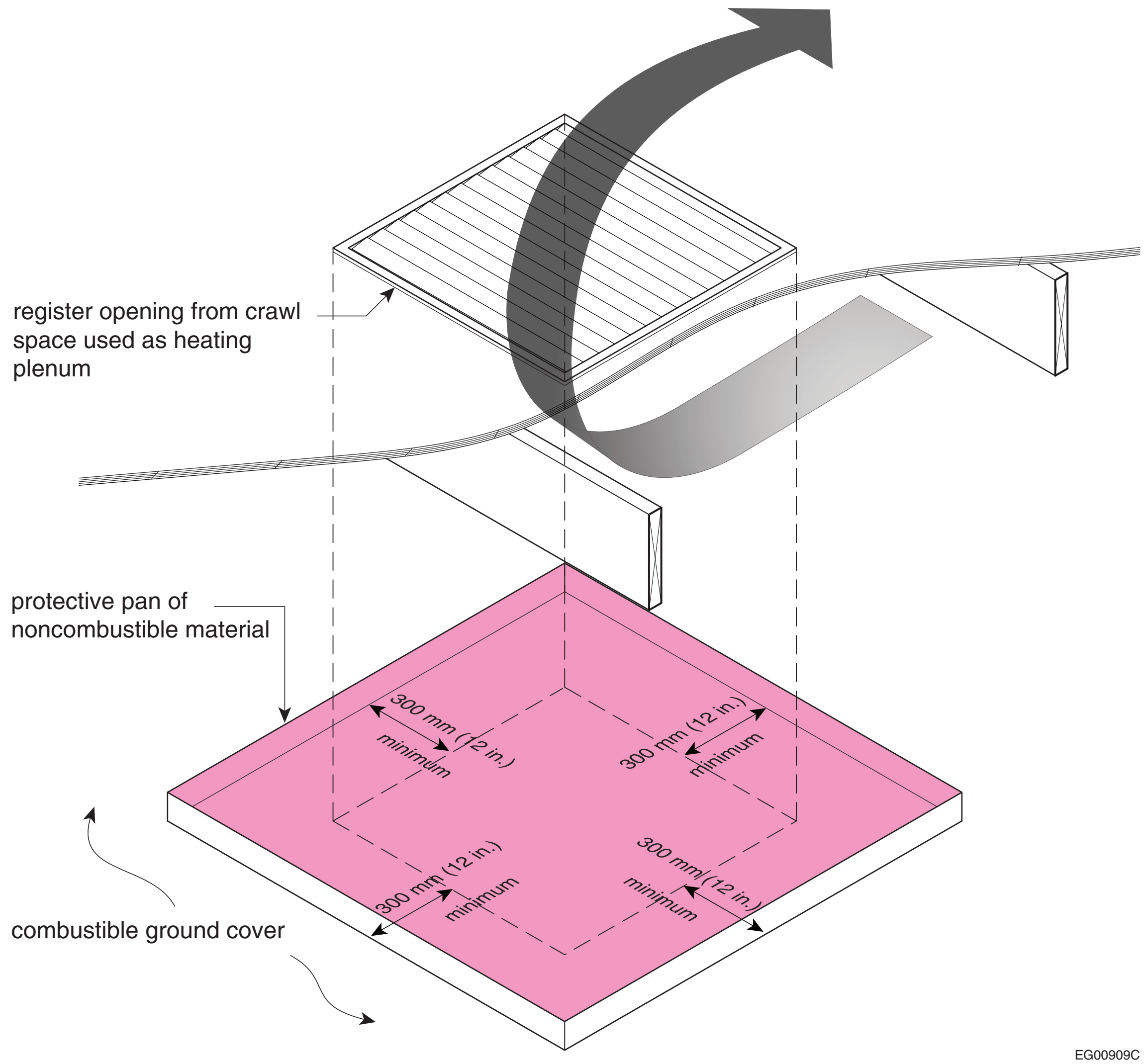


Figure 9.18.-4
Fire protection for crawl space used as a heating plenum

Since manufactured houses are entirely factory insulated, they are designed to be erected over unheated space. Some types of manufactured houses are less prone to potential damage from frost action by virtue of their steel chassis support system. For other types of construction, however, it can be more efficient to insulate the exterior foundation walls rather than the floor above, and add heat to the crawl space to provide more comfortable floors.

Section 9.19. Roof Spaces

Introduction

Roof spaces separate the roof membrane from the conditioned spaces of a building. To protect the integrity of the entire roof assembly, roof spaces need to permit the transfer of any moisture in the spaces to the exterior.

9.19.1. Venting

9.19.1.1. Required Venting

This Article requires that roof venting provide a means for allowing moisture that may have found its way into an attic or roof space to escape to the exterior. Excess moisture resulting from winter condensation can raise the moisture level in such spaces to the point where wood can begin to decay. Water leakage into the conditioned space below may also occur when the winter frost and ice build-up melts. An exemption is provided to allow certain factory-built structures that are designed with exceptionally airtight ceiling construction to have no roof vents.

Almost all moisture that enters the roof space is due to air leakage, and this is the most difficult moisture transfer mechanism to control. Virtually all roof spaces can be expected to accumulate some moisture during the winter. Provided the air leakage is reasonably controlled by the air barrier system and the humidity in the building is not excessive, ventilation of the roof space can generally dissipate the moisture quickly enough during the spring to prevent the development of significant problems.

Roof space venting can reduce summer heat build-up that can shorten the service life of roof materials and increase space cooling needs. Roof space ventilation also helps to reduce the likelihood of ice damming by removing warm air where roofs are subject to milder sub-zero temperatures or significant snow cover (Figure 9.19.-1).

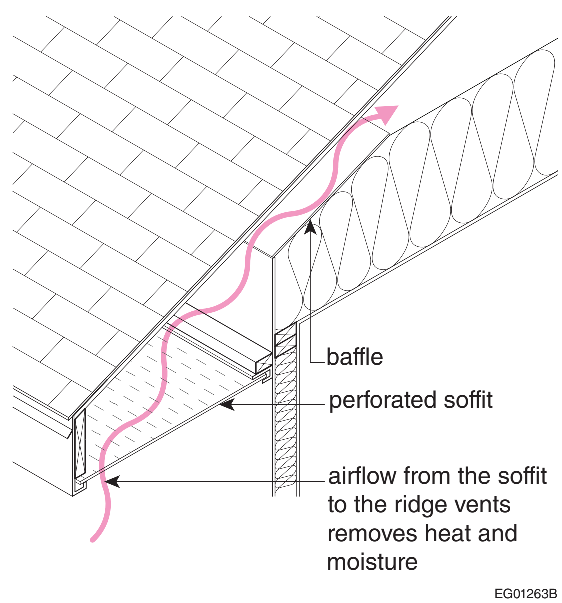


Figure 9.19.-1
Removing heat and moisture from roof spaces

When loose-fill or batt-type insulation is installed above the ceiling, it must be protected on the room side by a vapour barrier and an air barrier system to prevent moisture from entering the roof space and condensing during the winter. While vapour barriers are generally effective in preventing significant moisture flow by diffusion, the effectiveness of air barrier systems in controlling moisture transferred by air leakage depends to a large extent on how carefully they are installed.

An exception is provided in NBC Sentence 9.19.1.1.(1) for some specialized ceiling-roof assemblies such as those used in some factory-built buildings that have been shown to be sufficiently airtight to prevent excessive moisture accumulation. In these cases, ventilation is not required.

9.19.1.2. Vent Requirements

This Article requires sufficient vent area to transfer to the exterior any moisture that may collect in roof spaces before it can create problems. Vents not only reduce the amount of winter moisture accumulation, but also allow the roof or attic space to dry out more quickly in the spring when the temperature rises to a level that might initiate wood decay. In low-sloped roofs, the roof sheathing is closer to the source of moisture leakage from the space below, and condensation and frost build-up can occur before the moisture escapes through the roof vents. Therefore, greater vent area is required for such roofs, both to reduce moisture build-up and to hasten subsequent spring drying.

The distribution of vents on opposite sides of a roof is intended to encourage cross-ventilation, while top and bottom distribution is intended to take advantage of convection currents to move heated air to the highest part of the roof to escape. If there is no common attic space (e.g., flat roofs, cathedral ceilings) and there is no interconnection between joist spaces, the only way the roof can be effectively vented is by venting each joist space. If the vents allow the entry of snow or rainwater, this will add to the moisture load and the risk of problems previously noted.

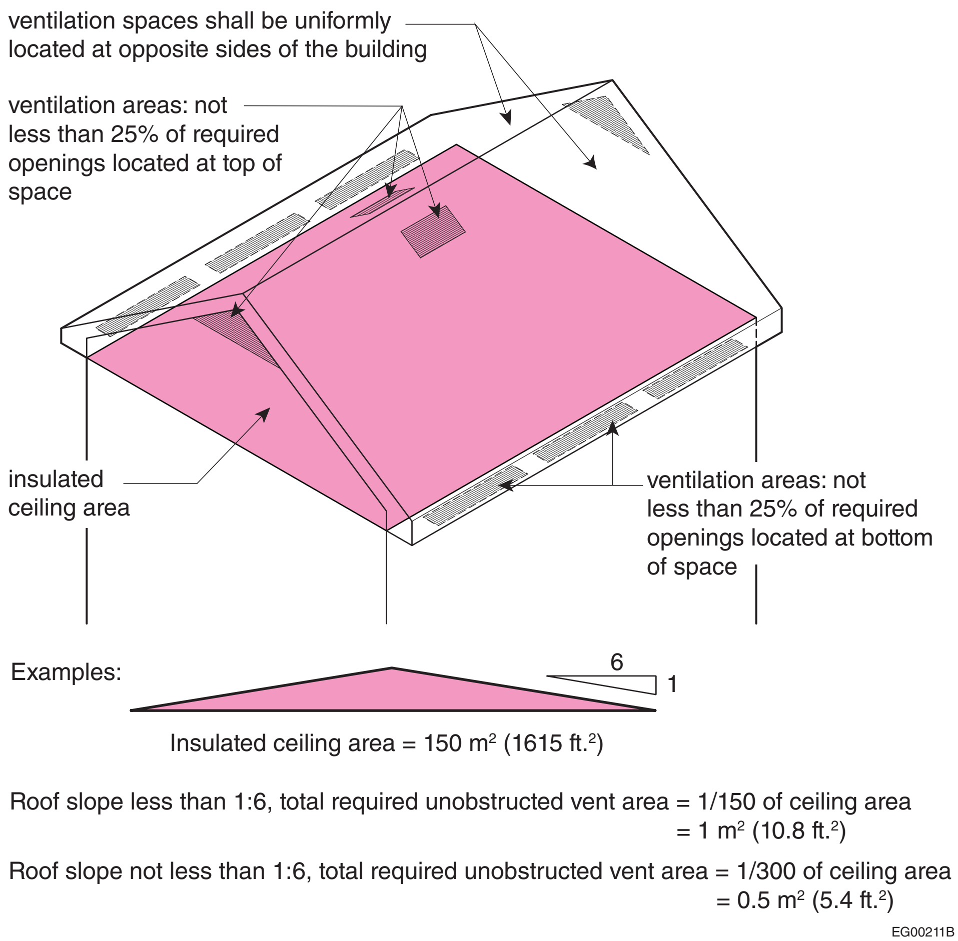


Figure 9.19.-2
Attic ventilation area and location

Where the difference in elevation between the eave and the ridge is reasonably large (1:6 or greater slope) and where the roof has vents equally distributed at the ridge and eave, ventilation can be assisted by stack action as well as by wind.

A net vent area equal to 1/300 of the insulated ceiling area is required to vent roof spaces for roofs with high attics. Higher attics allow the moisture from air leakage to disperse over a larger area so that its removal by ventilation is much more rapid. Roofs with low attic spaces or no attics at all (flat roofs or cathedral ceilings) are not only more difficult to ventilate effectively, but frost and ice build-up tends to accumulate on the sheathing close to the moisture source. The moisture concentrations can result in greater damage to the ceiling than widely dispersed condensation when the air temperature rises in the spring.

For this reason, low-pitched roofs (less than 1:6) and roofs without attics led to additional precautions being required. These roofs are required to have a net ventilation area 1/150 of the insulated ceiling area (twice that of roofs with high attics).

Ventilation can be provided by any combination of ridge, eave or gable end vents, but they must be distributed uniformly on opposite sides of the building with not less than 25% of the required openings located at the top of the space, and not less than 25% at the bottom. The required area and location of roof vents is shown in Figure 9.19.-2.

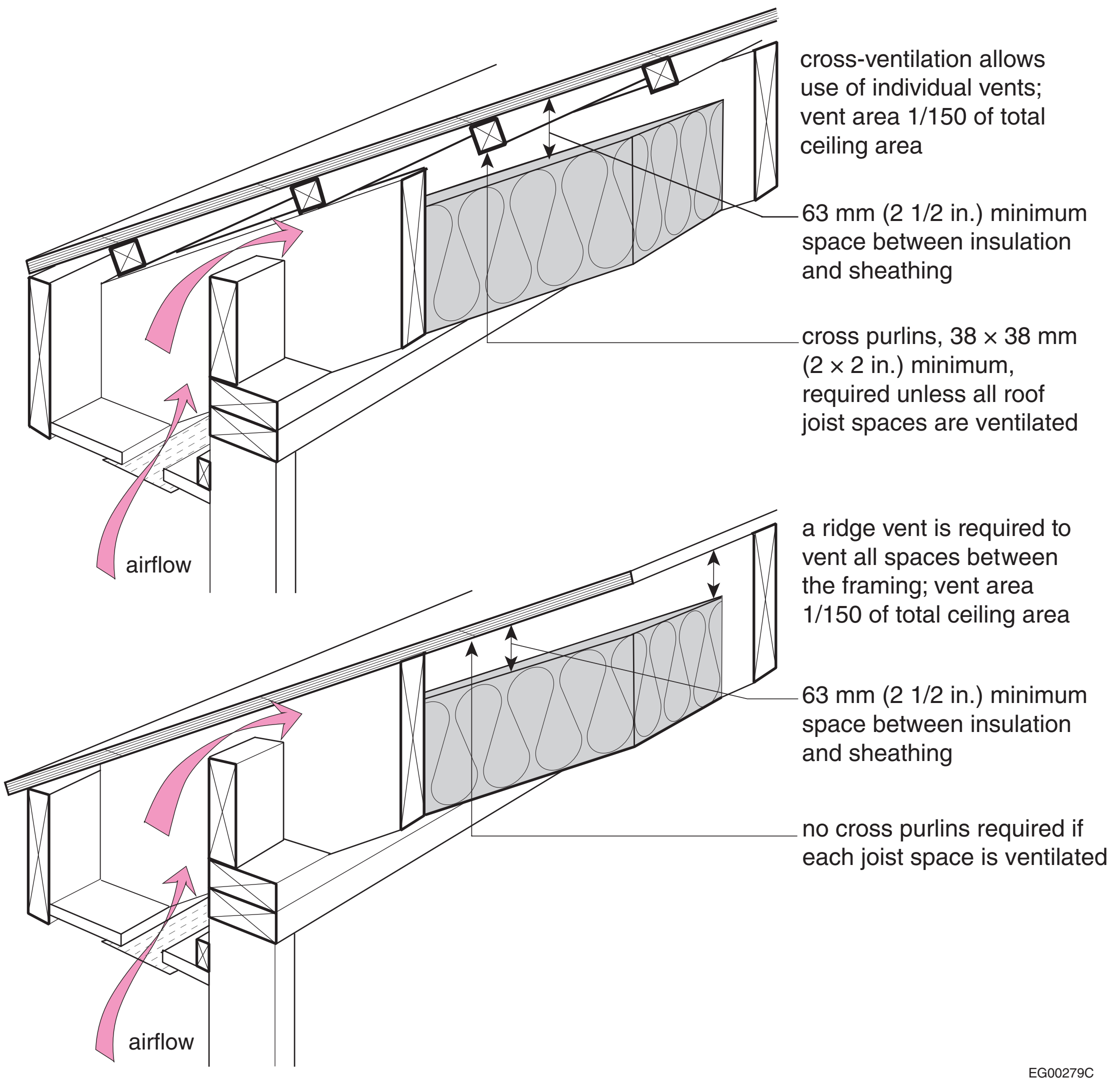


Figure 9.19.-3
Ventilation for roof spaces over cathedral ceilings

Although the ideal location of venting has been debated, it is generally concluded that the most efficient arrangement is a combination of continuous ridge venting with continuous soffit venting, and the least efficient was individual roof vents. Between these extremes, the various other venting arrangements seemed to be comparable (gable-end louvers only, continuous ridge vent only, continuous soffit vent only, roof louvers with soffit vents, and gable-end louvers with soffit vents).

All roofs that do not have an attic space, such as flat roofs or roofs supporting cathedral ceilings, must have a vented space between the insulation and the roof sheathing. The space must be at least 38 mm (1 1/2 in.) (Figure 9.19.-3).

Purlins at least 38 × 38 mm (2 × 2 in. nominal) are required to vent flat roofs where the joist spaces are not individually vented to permit the venting of all spaces (Figure 9.19.-4).

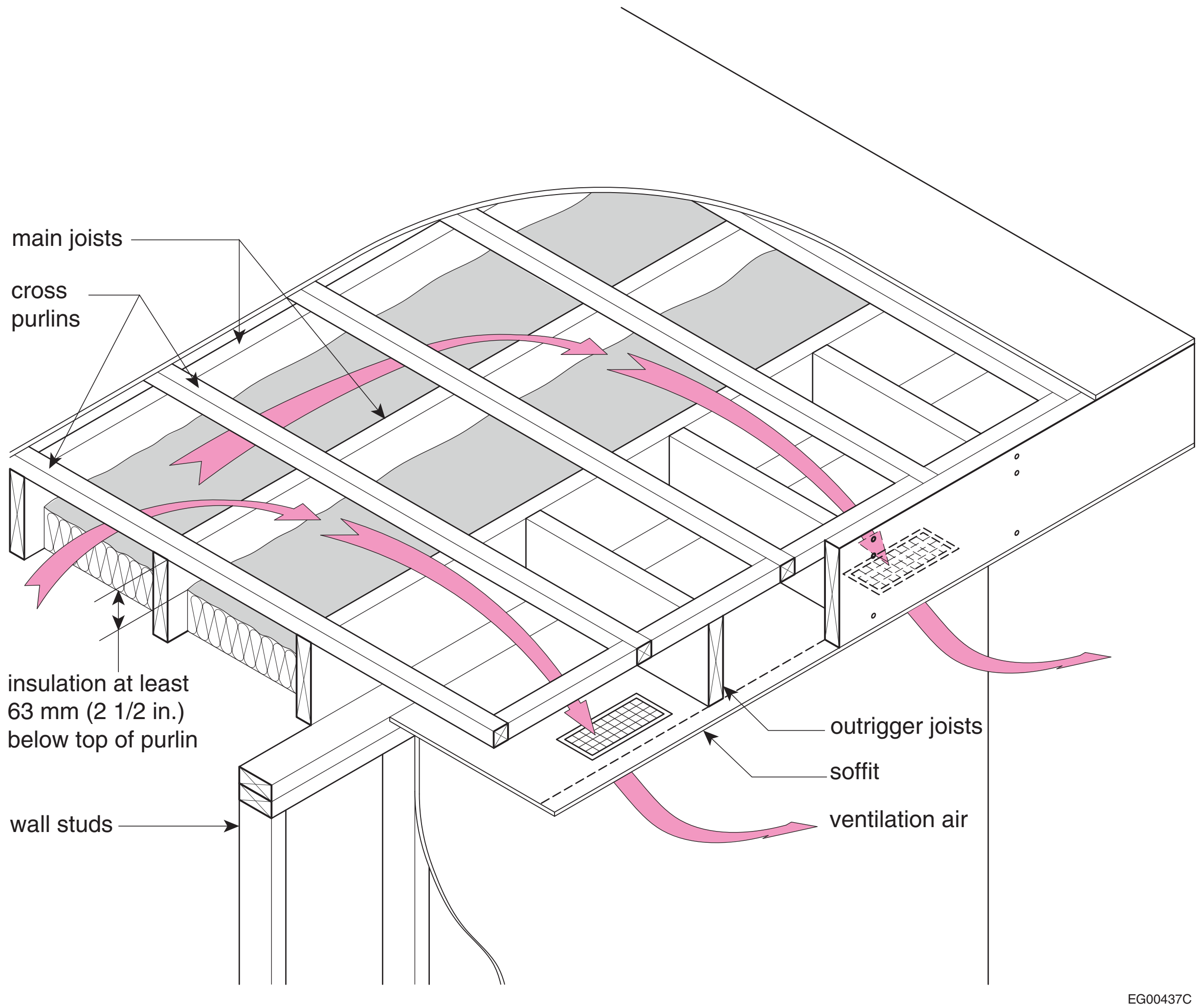


Figure 9.19.-4
Cross purlins for the ventilation of flat roofs

When the roof sheathing is attached to the same joists that carry the ceiling, a series of channels are created above the insulation. Ventilation by wind action will be most effective when the wind is parallel to the joists and will become increasingly less effective when the wind is at right angles to the joists. This is not addressed in the NBC.

The vent area refers to net area, and not to the rough opening size needed for the vent. The net area must take into account the constrictions in the air passageway through the vent and the presence of any screening. Screening can reduce the net area by 40 to 60%, depending on the mesh size and openings. The net area of proprietary metal vents is usually stamped on them to allow the purchaser to calculate the number of vents required. The calculation of vent area is required to conform to CAN3-A93-M, “Natural Airflow Ventilators for Buildings.”

9.19.1.3. Clearances

This Article requires that sufficient clearance be provided to ensure adequate ventilation flow. Unless air can flow freely between the insulation and the roof deck to reach a vent to the exterior, venting will not be effective. As this space is reduced, the resistance to airflow increases.

Where thick insulation is used in attics, particularly attics with low roof slopes, the insulation could completely close off the air space at the lower part of the roof so that the air from the soffit vents cannot reach the attic space. The insulation thickness must be reduced at these locations either by cutting the insulation on the slope to provide clearance between the insulation and the roof deck, or by depressing the insulation by means of specially designed void forms installed between the roof framing against the deck (Figure 9.19.-5).

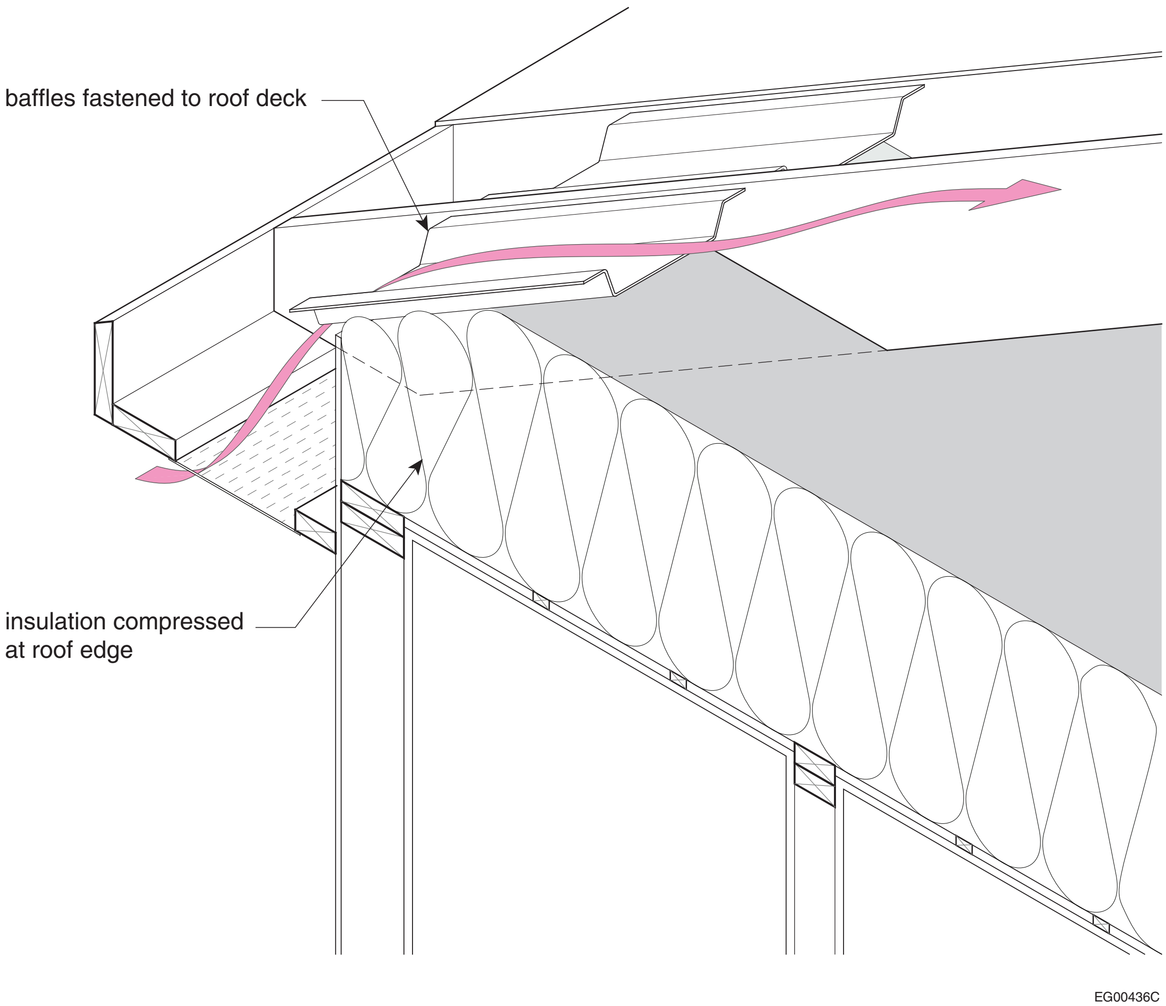


Figure 9.19.-5
Baffles to create vent spaces

Insulation must be installed in a manner that ensures that a 63 mm (2 1/2 in.) air space is provided between the insulation and roof sheathing. Where baffles (Figure 9.19.-5) are used to contain the insulation at the junction of a sloped roof and an exterior wall, the clearance can be reduced to 50 mm (2 in.), as long as the overall ventilation area meets the requirements of NBC Article 9.19.1.2. Alternatively, the roof framing members can be increased in depth to create additional insulation space.

Blown-in insulation may be accidentally placed over the top plate and onto the soffit vents. To prevent the blockage of ventilation routes, measures should be taken to prevent the insulation from entering the soffit or the soffit vents should be installed after insulating is complete.

9.19.1.4. Mansard or Gambrel Roof

This Article indicates the ventilation requirements for mansard and gambrel roofs. Gambrel and mansard shaped roofs in modern houses may be considered as part roof (the top portion) and part wall (the lower portion), even though both slopes are covered with roofing material. The top portion of a gambrel or mansard shaped roof is therefore required to be vented the same as any other roof. The lower portions, in most cases, are really a wall with a sloping exterior and are not required to be vented because experience has shown that wall spaces do not require venting to reduce potential moisture-related problems.

In the past, it had been common practice to vent both the upper and lower roof spaces of mansard or gambrel roofs by means of soffit vents in the lower portions. Experience showed this to be an unsatisfactory arrangement that led to a number of moisture-related problems. This is no longer permitted, therefore, and the venting for the upper portion is now required to be provided in equal proportions at the junctions between the two slopes and at the ridge (Figure 9.19.-6).

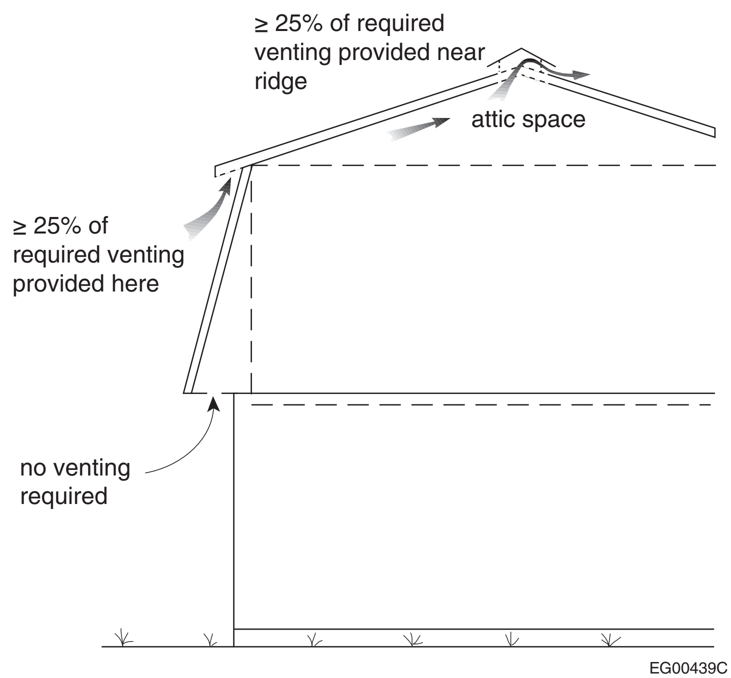


Figure 9.19.-6
Venting of gambrel style roofs

9.19.2. Access

9.19.2.1. Access

This Article requires an access opening to permit periodic inspection where an attic or roof space is high enough to permit a person to enter. A hatch cover or doorway is also needed to resist heat loss and moisture leakage into the space.

Access is also useful to permit upgrading of insulation and rewiring, and for firefighting access. Access hatches located in the insulated ceiling are potential weak points in the ceiling air barrier. The NBC does not require that access to roof spaces be directly from the interior of the building. They can be located in gable ends or garage ceilings, where they will not lessen the integrity of the air barrier system.

Every attic must be accessible by a stair or hatchway if the distance from the top of the ceiling joists to the underside of the rafters is 600 mm (24 in.) or more over an area of at least 3 m^2 (32.25 $ft.^2$), with the length or width of the space at least 1 m (3 ft. 3 in.). The minimum dimensions for attic hatches are shown in Figure 9.19.-7.

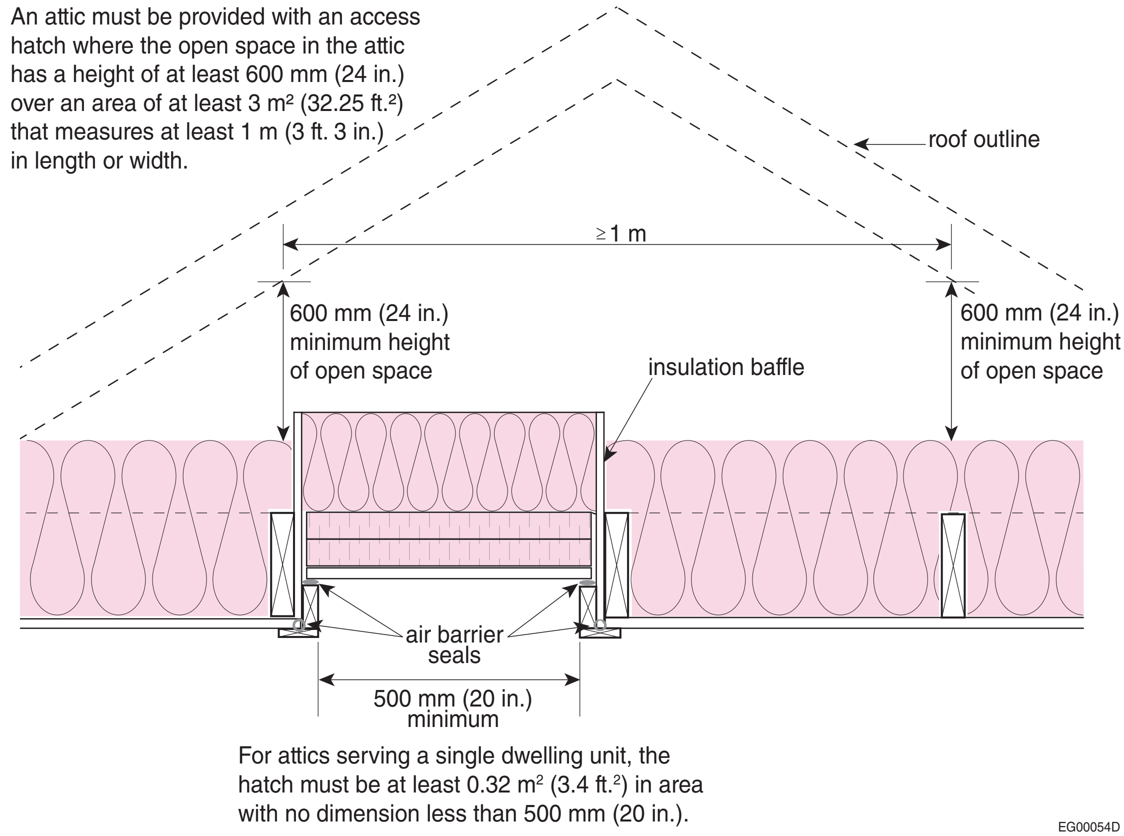


Figure 9.19.-7
Attic hatch

Section 9.20. Masonry and Insulating Concrete Form Walls Not In Contact with the Ground

Introduction

This Section contains requirements for above-grade masonry and flat insulating concrete form (ICF) walls.

9.20.1. Application

9.20.1.1. General

This Article indicates that NBC Section 9.20. applies to unreinforced masonry and masonry veneer walls not in contact with the ground that extend not more than 11 m (36 ft.) above the foundation walls, where the floor or roof assembly above the first storey is not of concrete construction.

Where lightweight floor and roof systems (e.g., with wood or steel framing) are used with masonry walls, the prescriptive requirements in NBC Section 9.20. can be followed or the more comprehensive requirements in NBC Part 4 can be applied (as set out in NBC Section 9.4.). However, masonry walls supporting concrete floors or roofs must be designed in accordance with NBC Part 4 because the requirements in NBC Section 9.20. do not consider seismic effects in a manner appropriate for this type of construction.

NBC Section 9.20. also applies to flat ICF walls not in contact with the ground that have a maximum floor-to-floor height of 3 m (9 ft. 10 in.), where the walls are erected in buildings that are not more than two storeys in height, that contain only a single dwelling unit, and that are located in areas where the seismic spectral response acceleration, $S_a(0.2)$, is not greater than 0.4.

Masonry and ICF walls beyond the scope of NBC Section 9.20. are subject to the structural design requirements in NBC Part 4. In addition to requiring structural analysis for seismic loads, climatic loads, and use and occupancy loads, NBC Part 4 requires that buildings and their structural members made of plain and reinforced masonry conform with CSA S304, “Design of Masonry Structures” (NBC Subsection 4.3.2.).

9.20.1.2. Earthquake Reinforcement

This Article indicates the cases in which earthquake reinforcement is required for masonry buildings.

Because of the heavy weight and brittle nature of unreinforced masonry, masonry buildings are susceptible to earthquake damage. The risk of earthquake damage increases with building height and with earthquake severity. Reinforcement can be incorporated into masonry to decrease this risk by increasing its resistance to lateral loads.

Not all regions of Canada are subject to the same seismic hazard. For example, coastal British Columbia and the St. Lawrence valley have a greater probability of experiencing a severe earthquake than other regions. The seismic hazard in various Canadian locations is characterized by spectral response acceleration values, $S_a(T)$, determined from earthquake records and geological considerations (NBC Table C-3 of Appendix C).

NBC Part 9 does not require seismic analysis of masonry buildings, but does require earthquake reinforcement of masonry buildings above a certain height in locations of moderate and high seismic hazard. In locations of high seismic hazard where $S_a(0.2) > 0.55$, loadbearing elements of masonry buildings of more than one storey need to have at least the minimum amount of steel reinforcement required by NBC Subsection 9.20.15 (Table 9.20.-A). In locations of moderate seismic hazard where $0.35 < S_a(0.2) \leq 0.55$, loadbearing elements of three-storey masonry buildings need to have at least this minimum amount of steel reinforcement. Earthquake reinforcement is not required in locations of low seismic hazard where $S_a(0.2) \leq 0.35$.

Table 9.20.-A
Masonry Buildings Requiring Earthquake Reinforcement[(1)]

$S_a(0.2)$	Building Height, storeys		
	1	2	3
$S_a(0.2) \leq 0.35$	n/a	n/a	n/a
$0.35 < S_a(0.2) \leq 0.55$	n/a	n/a	✓
$S_a(0.2) > 0.55$	n/a	✓	✓

Notes to Table 9.20.A.:

(1) ✓ = earthquake reinforcement conforming to NBC Subsection 9.20.15. is required.

9.20.2. Masonry Units

9.20.2.1. Masonry Unit Standards

This Article requires that masonry units comply with one of the listed standards.

A variety of types of masonry units are available, including fired clay, concrete, sand–lime, glass, and natural stone units. Masonry units should possess the necessary characteristics to fulfill their intended function under expected exposure and load conditions, such as dimensional stability, freeze–thaw durability, structural strength, and resistance to water absorption. Masonry units may be loadbearing or non-loadbearing. They may be exposed to the weather or to soil, or may be completely sheltered. The physical properties of masonry units, including strength and weathering ability, are regulated by various standards.

Masonry units made of fired clay are available with a wide range of properties. Exterior grade (EG) brick (as specified in CAN/CSA-A82, "Fired Masonry Brick Made from Clay or Shale") is intended for use under most exposure conditions and is used throughout Canada as face brick. On the other hand, the water absorption characteristics of interior grade (IG) brick (as specified in CAN/CSA-A82) make it unable to adequately resist freeze–thaw cycles. Therefore, IG brick is generally used as back-up masonry that will not be exposed to the weather.

9.20.2.2. Used Brick

This Article permits the use of used bricks, as long as they are free of old mortar, soot and other surface coatings and conform to NBC Article 9.20.2.1.

9.20.2.3. Glass Blocks

This Article indicates applications where glass blocks are not permitted to be used.

Glass blocks must not be used as loadbearing units whose breakage could result in structural failure of a supported element. They are also prohibited from being used in the construction of fireplaces or chimneys, where they could create a fire hazard as a result of their inability to resist high temperatures and heat radiation.

At present, the NBC does not reference a specific standard governing glass blocks. Their installation must be performed according to the same general practices used in the installation of masonry veneer.

9.20.2.4. Cellular Concrete

This Article indicates that masonry made of cellular concrete (also known as foamed concrete) must not be used in contact with the soil or exposed to the weather.

Cellular concrete masonry readily absorbs water and is subject to damage from freeze–thaw cycles. Consequently, this type of masonry is not permitted to be used in locations where it will be exposed to soil moisture or the weather.

Cellular concrete blocks are not currently manufactured in Canada, and CAN3-A165.4-M, "Autoclaved Cellular Units," has been withdrawn from CAN/CSA-A165 Series, "CSA Standards on Concrete Masonry Units."

If cellular concrete units are acquired from the US or elsewhere, their freeze–thaw performance should be carefully considered.

9.20.2.5. Stone

This Article requires that stone be sound and durable. The intent of this requirement is to ensure that stone has the necessary characteristics to fulfill its intended purpose, including dimensional stability, freeze–thaw durability, compressive and flexural strength, and resistance to water absorption. There are a number of ASTM standards that specify minimum performance requirements for various types of natural stone intended for use in exterior applications.

9.20.2.6. Concrete Blocks Exposed to the Weather

This Article requires that concrete blocks exposed to the weather have density and water absorption characteristics conforming to concrete type A, B, C or D as described in CSA A165.1, "Concrete Block Masonry Units." This requirement ensures a minimum level of performance with respect to resistance to freeze–thaw deterioration (durability).

In CSA A165.1, concrete blocks are classified as concrete type A, B, C or D on the basis of the density of the concrete material used to manufacture the blocks. Type A units are typically referred to as "normal weight" units and type D units as "lightweight" units. Each concrete type has a maximum water absorption.

The density of concrete blocks affects the sound insulation performance and the fire-resistance rating of masonry constructed with the blocks. However, the density classifications in CSA A165.1 are not to be confused with the concrete types used to establish fire-resistance ratings in NBC Part 3.

CSA A165.1 also classifies concrete block units on the basis of their compressive strength.

9.20.2.7. Compressive Strength

This Article establishes minimum compressive strength values for different types of concrete blocks, which depend on whether or not the concrete blocks are exposed to weather (NBC Table 9.20.2.7.). These minimum compressive strength values are intended to ensure that masonry constructed with concrete blocks will have the necessary strength to resist the anticipated loads and that the concrete blocks will resist chipping during normal transport and handling.

Solid or hollow concrete blocks exposed to weather are required to have a compressive strength over their net area of at least 15 MPa (2 000 psi), which is the most common concrete block strength in Canada. Cellular concrete blocks are not permitted to be used in locations exposed to the weather (see NBC Article 9.20.2.4.).

9.20.3. Mortar

9.20.3.1. Mortar Materials

This Article contains requirements for materials for mortar.

The compressive strength of a masonry wall depends not only on the compressive strength of the masonry units, but also on that of the mortar. The tensile strength of a masonry wall depends on the strength of the bond between the mortar and the masonry units.

The essential properties of mortar, including its workability, tensile and compressive strength, bond strength, and durability, depend on the characteristics of the cementitious materials (also known as binders), water and aggregates used in the mortar. The requirements in this Article ensure that these constituent materials will have the necessary characteristics to provide a mortar that will fulfill its intended purpose.

Cementitious materials, including cement and lime materials, and aggregates for mortar and grout need to comply with CSA A179, "Mortar and Grout for Unit Masonry." Water and aggregates used in mortar must be clean and free of significant amounts of deleterious materials.

Two types of mortar formulations are commonly used in Canada: Portland cement–lime and masonry cement. The extent of use of each type of mortar formulation varies from region to region.

In Portland cement–lime mortars, the lime improves workability, and the cement increases compressive strength, bond strength and durability. The greater the proportion of lime to cement, the better the workability, but the lower the compressive strength, bond strength and durability. It is, therefore, desirable to strike a balance between the amounts of lime and cement to produce a mortar with the combination of properties most suitable for a particular application.

Lime used in mortar must be hydrated. If lime putty is used, the putty must be made by slaking quicklime in water for not less than 24 h or by soaking hydrated lime in water for not less than 12 h. Lime putty is not essential to produce good mortar, but is used in mortars for historic restoration. In mortars for modern masonry construction, dry hydrated lime is typically used. Pure lime mortars are not used in modern masonry construction.

9.20.3.2. Mortar and Grout Mixes

The Article contains requirements for mortar and grout. NBC Table 9.20.3.2.-A lists the mortar types that are permitted for different applications, and NBC Table 9.20.3.2.-B specifies mix proportions for the permitted mortar types. NBC Table 9.20.3.2.-C specifies mix proportions for grout.

Different mortar strengths are necessary for different applications. Type S mortars, which contain a higher proportion of cement, generally provide higher compressive and bond strength than Type N mortars. Type S mortars are best suited for loadbearing exterior applications, but are also suitable for non-loadbearing exterior applications. For foundation walls and columns, which must resist earth pressures, Type S mortar must be used. Type N mortars are suitable for exterior non-loadbearing applications, such as masonry veneer, and for interior applications.

The materials for mortar must be mixed in the proper proportions to produce a mortar that is suitable for the exposure conditions and structural requirements of the intended application. Similarly, the materials for grout must be mixed in the proper proportions to produce a grout with suitable strength and with suitable workability to completely fill all voids and cells to be filled in the masonry, without excessive bleeding or segregation.

All the mortars and grouts specified in NBC Tables 9.20.3.2.-B and 9.20.3.2.-C contain Portland cement, which provides compressive strength, bond strength, resistance to deterioration, and other necessary properties. To achieve the expected performance of the mortar or grout and the finished masonry, the Portland cement must be properly set (hydrated).

Mortar that has started to set before the masonry units are laid can have reduced workability in its plastic state and lower bond and compressive strength in the finished masonry. To help prevent this loss of performance, this Article sets time limits for the use and placement of mortar, which depend on the air temperature (because the speed of hydration of cement depends on the air temperature). Mortar must be used and placed in final position within 2.5 h of mixing when the air temperature is less than 25°C (77°F) and within 1.5 h of mixing when the air temperature is 25°C (77°F) or higher. Similarly, mortars and grouts containing a set-control admixture must be used and placed in final position within the time limits stipulated by the manufacturer. Grout used for reinforced masonry must be placed in accordance with the requirements of CSA A371, "Masonry Construction for Buildings." Where the time limits for use and placement are exceeded, the mortar or grout must be discarded.

Extremes (both high and low) in the temperature of the air, the constituent materials of the mortar or grout, and the masonry units during construction can affect the setting of the mortar or grout and the performance of the finished masonry. Hot and cold weather masonry construction necessitates alternative mixing procedures and protection of materials and completed work (see CSA A371).

9.20.4. Mortar Joints

9.20.4.1. Thickness

This Article indicates that mortar joints for burned clay brick and concrete masonry units must be 10 mm (3/8 in.) thick, and that the permitted tolerances in head and bed joints must not be more than ± 5 mm (± 3/16 in.).

9.20.4.2. and 9.20.4.3. Laying of Masonry Units

These Articles contain requirements for laying masonry units.

In addition to providing structural strength, masonry in exterior applications must provide protection from precipitation. Water penetration rarely occurs through the masonry units themselves, but is more likely to occur at the joints between the masonry units. Filling the bed and head joints between masonry units with mortar minimizes the passage of water. Therefore, solid masonry units must be laid with full bed and head joints, except for head joints left open for weep holes and ventilation, and hollow masonry units must be laid with mortar applied to the head and bed joints of both inner and outer face shells (Figure 9.20.-1). In addition, vertically aligned webs of hollow masonry units must be laid in a full bed of mortar under the starting course, in all courses in columns, and where the webs are adjacent to cells or cavities that are to be filled with grout.

Tooling of mortar joints should be done when the mortar is thumb-print hard. A number of different types of mortar joints are shown in Figure 9.20.-2, which have varying water-shedding abilities. Weathered, V-shaped and concave joints are believed to shed water most readily. Concave joints are most often used in masonry construction because of their water-shedding ability and the high degree of material compaction effected during tooling of this type of joint.

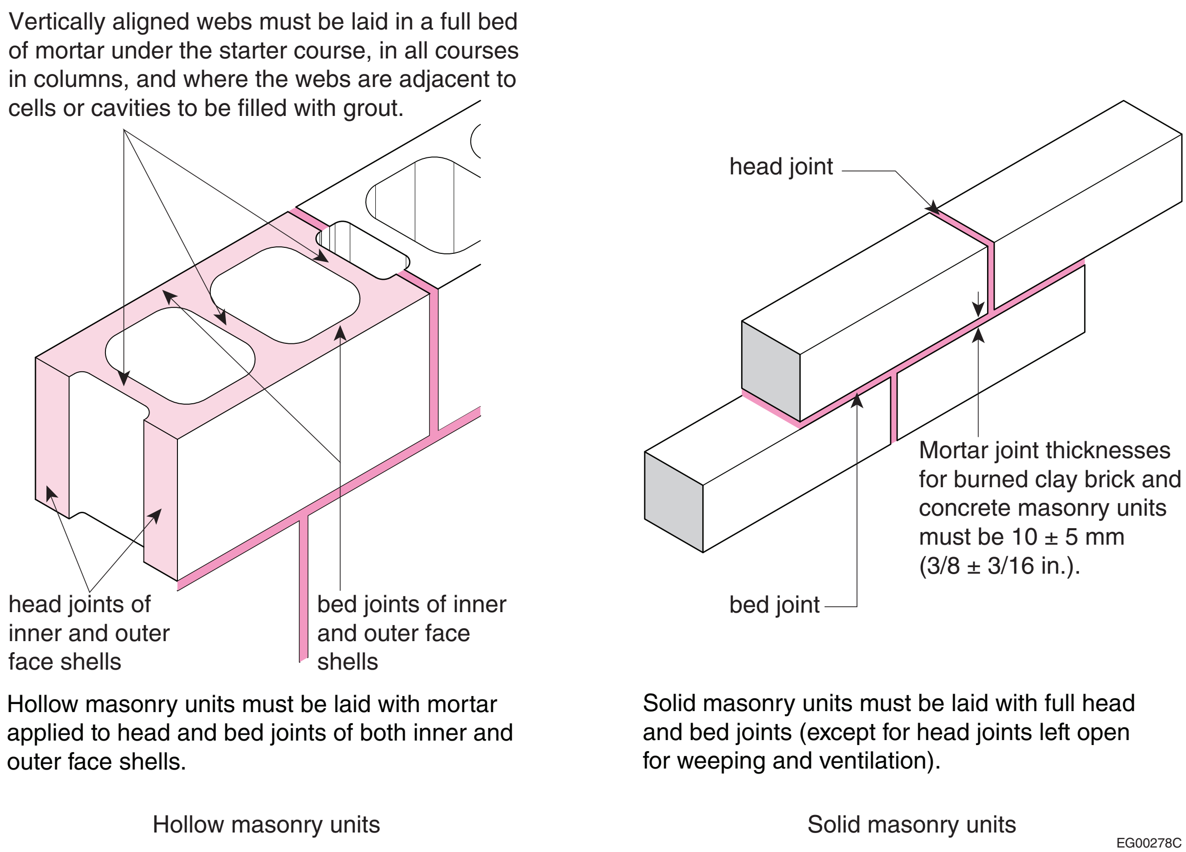


Figure 9.20.-1
Mortar joint requirements for solid and hollow masonry units (NBC Articles 9.20.4.1., 9.20.4.2. and 9.20.4.3.)

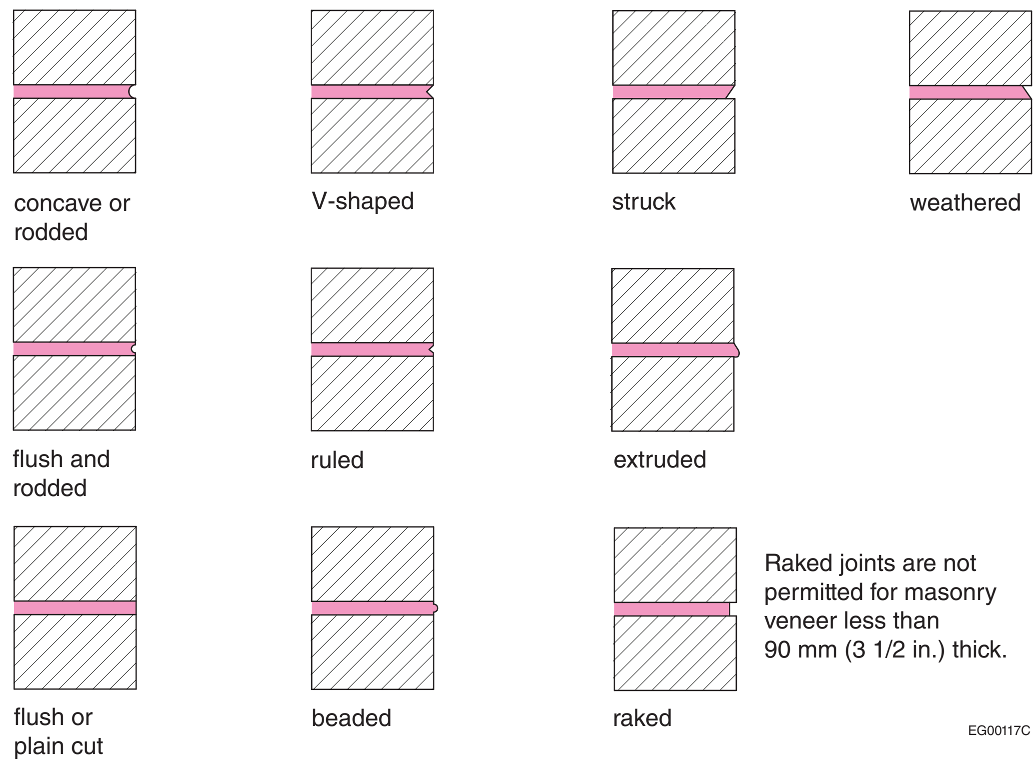


Figure 9.20.-2
Types of mortar joints (NBC Article 9.20.6.4.)

9.20.5. Masonry Support

9.20.5.1. Masonry Support

This Article describes the support required for masonry and masonry veneer.

Because of its considerable mass and rigidity, masonry must be supported on rigid members that are dimensionally stable and deformationally compatible with the masonry. Therefore, this Article requires that all masonry, with the exception of masonry veneer, be supported on masonry, concrete or steel.

Although wood framing is not normally used as a bearing support for masonry veneer because of its shrinkage characteristics and its generally low structural rigidity, masonry veneer is permitted to be supported on foundations of wood frame construction (e.g., permanent wood foundations), provided they are constructed in conformance with NBC Sentence 9.15.2.4.(1). To conform with NBC Sentence 9.15.2.4.(1), foundations of wood frame construction must comply with CSA S406, “Permanent Wood Foundations for Housing and Small Buildings,” or NBC Part 4. This requirement ensures that the rigidity of the support is compatible with the stiffness of the masonry veneer being supported and that any differential movement that may be harmful to the performance of masonry veneer is minimized or accommodated. Experience has indicated that when wood foundations have been designed to support the anticipated loads, the masonry veneer being supported performs satisfactorily.

9.20.5.2. Lintels or Arches

This Article describes the support required for masonry placed over openings.

Since unreinforced masonry has little tensile strength, it must be supported above door and window openings. This support can be provided by a steel, masonry or reinforced concrete lintel designed to carry the anticipated load. Alternatively, the masonry above the opening can be supported by a masonry arch in which the masonry units are all in compression (Figure 9.20.-3). This Article contains prescriptive requirements for steel angle lintels supporting masonry veneer; steel angle lintels supporting masonry other than veneer, masonry and reinforced concrete lintels, and masonry arches must conform to the structural design requirements in NBC Part 4.

Steel angle lintels supporting masonry veneer above openings must have a bearing length of at least 90 mm (3 1/2 in.) (i.e., each end of the lintel must be supported by at least 90 mm (3 1/2 in.)). The maximum allowable spans for such lintels are listed in NBC Table 9.20.5.2. Steel angle lintels supporting masonry must be prime painted or otherwise protected from corrosion.

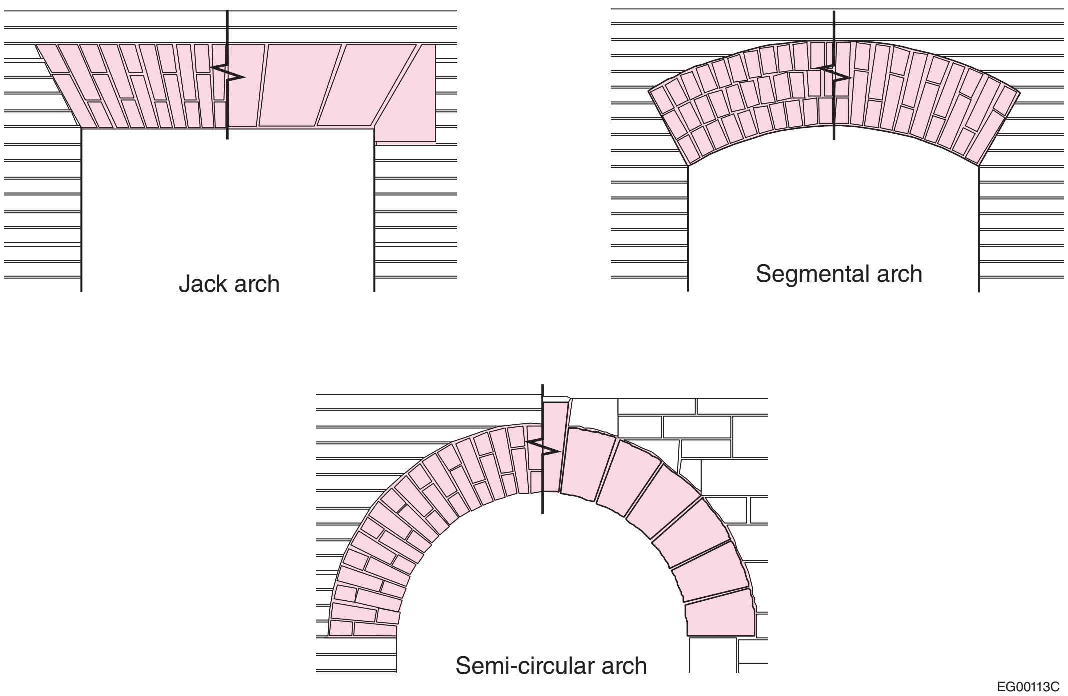


Figure 9.20.-3
Masonry arches

9.20.6. Thickness and Height

9.20.6.1. Thickness of Exterior Walls

This Article establishes minimum thicknesses for exterior masonry walls. These minimum thicknesses are intended to ensure that the walls have sufficient strength and stability to support the anticipated vertical loads, including dead loads, live loads due to use and occupancy, and snow loads, and to resist the anticipated wind loads.

The minimum thicknesses of exterior masonry walls other than cavity walls are illustrated in Figure 9.20.-4.

Table 9.20.-B summarizes the minimum thicknesses for masonry walls other than cavity walls.

Table 9.20.-B
Minimum Thicknesses for Masonry Walls Other Than Cavity Walls (NBC Articles 9.20.6.1., 9.20.6.3. and 9.20.6.4.)

Type of Masonry Wall	Building Height, storeys	Minimum Wall Thickness
Exterior	1	140 mm (5 1/2 in.)(1)
	2	Top storey: 140 mm (5 1/2 in.)(1) Bottom storey: 190 mm (7 1/2 in.)
	3	Top storey: 140 mm (5 1/2 in.)(1) Bottom 2 storeys: 190 mm (7 1/2 in.)
Interior loadbearing	≤ 3	1/20 of the lateral support spacing(2)
Interior non-loadbearing	≤ 3	65 mm (2 9/16 in.) or 1/36 of the lateral support spacing,(2) whichever is greater
Veneer	≤ 3	75 mm (3 in.)

Notes to Table 9.20.B.:
(1) Walls must be not more than 2.8 m (9 ft. 2 in.) high at the eaves and not more than 4.6 m (15 ft.) high at the peaks of gable ends.
(2) See NBC Article 9.20.10.1.

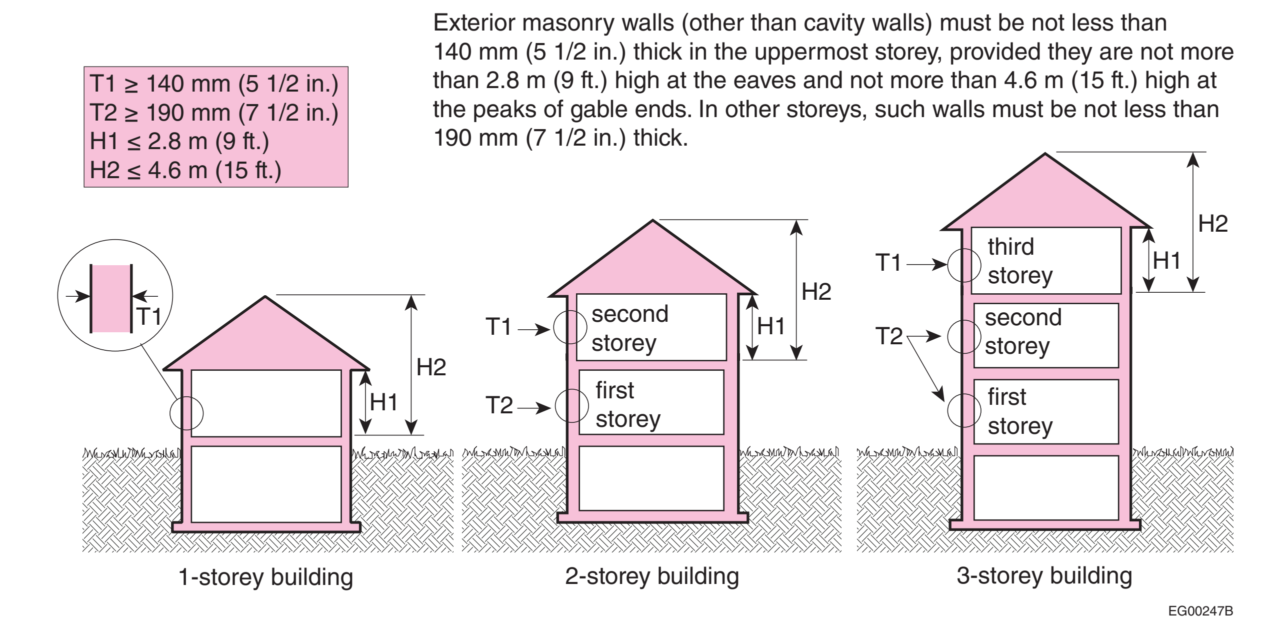


Figure 9.20.-4
Minimum thicknesses of exterior masonry walls other than cavity walls

9.20.6.2. Cavity Walls

This Article establishes minimum thicknesses for masonry cavity walls, which are summarized in Table 9.20.-C. These minimum thicknesses are intended to ensure that the walls have sufficient strength and stability to support the anticipated vertical loads, including dead loads, live loads due to use and occupancy, and snow loads, and to resist anticipated wind loads.

Traditionally, cavity walls were used to provide protection from rainwater penetration, as well as to provide thermal insulation. The cavities in modern cavity walls normally contain both insulation and an air space, but may be completely filled with insulation for additional thermal resistance.

In cavity walls, inner and outer wythes are separated by a cavity. The two wythes are tied to each other, usually with fairly rigid metal ties, so that they act in unison and mutually contribute to supporting vertical and horizontal design loads.

The width of the cavity must be at least 50 mm (2 in.) and not greater than 150 mm (6 in.). If the cavity is too narrow, there will be insufficient space to keep mortar squeezed from joints from bridging the cavity. If it is too wide, the two wythes will act independently of each other, weakening the wall.

Figure 9.20.-5 illustrates the dimensional requirements for cavity walls.

Table 9.20.-C
Minimum Thicknesses for Masonry Cavity Walls

Type of Joint	Minimum Unit Width, mm (in.)	Maximum Wall Height, m (ft.)	Minimum Wall Thickness, mm (in.)
Not raked	75 (3)	6 (20)(1)	230 (9)(1)
Raked	90 (3 1/2)	11 (36)(2)	Top 7.6 m (24 ft. 11 in.): 230 (9) Remaining portion: 330 (13)

Notes to Table 9.20.C.:
(1) This value applies where 75 mm (3 in.) wide units are used.
(2) See NBC Clause 9.20.1.1.(1)(a).

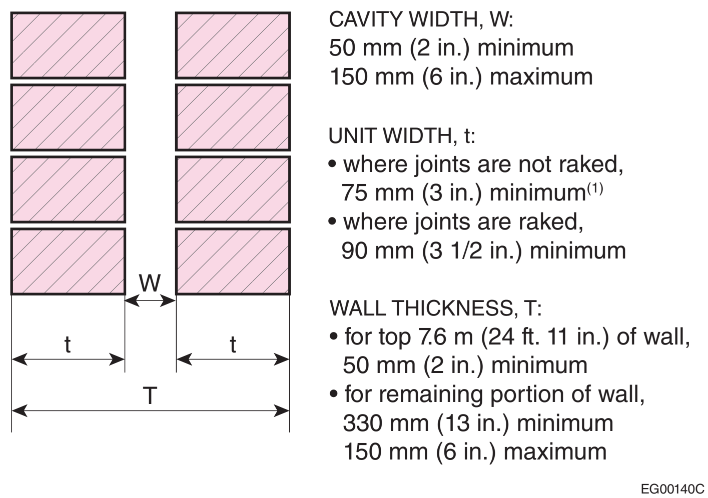


Figure 9.20.-5
Dimensional requirements for masonry cavity walls

Note to Figure 9.20.-5:
(1) Where 75 mm (3 in.) wide units are used, the wall height above the top of the foundation wall must not exceed 6 m (19 ft. 8 in.).

9.20.6.3. Thickness of Interior Walls

This Article establishes minimum thicknesses for interior masonry walls. These minimum thicknesses are intended to ensure that the walls will have sufficient strength and stability to resist normal impact forces and, in the case of loadbearing walls, to support the anticipated vertical loads.

The thickness of an interior masonry wall is determined on the basis of the spacing of the lateral support for the wall as provided in NBC Article 9.20.10.1. For loadbearing interior walls, the thickness must not be less than 1/20 of the lateral support spacing (Table 9.20.-B). For non-loadbearing interior walls, the thickness must not be less than 1/20 of the lateral support spacing or 65 mm (2 1/2 in.), whichever is greater.

9.20.6.4. Masonry Veneer

This Article contains requirements for masonry veneer, which are intended to ensure that the veneer has sufficient stability to support its own weight and to resist the anticipated wind forces.

This Article distinguishes between two basic types of masonry veneer: self-supporting and individually supported. In self-supporting masonry veneer, the masonry units are each laid in a bed of mortar, and the self-weight of the veneer is progressively transferred to the foundation or other supporting member below. The veneer is mechanically connected to a structural backing using masonry ties that resist lateral wind loads.

The thickness and metal-tie requirements for self-supporting masonry veneer are very different from those for cavity walls, even when the veneer is applied over a masonry wall and an air space is left between the veneer and the wall. In this case, the masonry wall alone is assumed to carry all the design live loads.

Self-supporting masonry veneer must consist of solid masonry units not less than 75 mm (3 in.) thick. When self-supporting masonry veneer is applied over a wood-frame wall, an air space at least 25 mm (1 in.) wide must be provided between the veneer and the wall.

In individually supported masonry veneer, the masonry units are each individually supported by a structural backing. Such masonry veneer must be designed in accordance with NBC Part 4. Veneer that is adhered to a structural backing (commonly referred to as "adhered veneer"), whether a natural product, such as natural stone, or a manufactured product, such as clay brick slices or lightweight concrete stone, is not considered to be masonry, is not self-supporting, and must be designed in accordance with NBC Part 4.

Masonry veneer of hollow masonry units should not be used, as it has been shown to perform poorly with respect to moisture management.

Mortar joints in masonry veneer can be finished (tooled) in a variety of ways to give different architectural effects (see Figure 9.20.-1). However, masonry veneer less than 90 mm (3 1/2 in.) thick must have unraked joints. To create a raked joint, about 6 to 12 mm (1/4 to 1/2 in.) of the mortar is removed from the exterior face of the joint shortly after the masonry units are laid, before the mortar begins to set. The minimum veneer thickness of 90 mm (3 1/2 in.) ensures that raked joints will have sufficient bearing area for structural purposes, will have sufficient width to resist the penetration of precipitation, and will provide sufficient embedment for masonry ties.

9.20.6.5. Parapet Walls

This Article contains requirements for parapet walls, which are intended to ensure that the walls have sufficient strength and stability to withstand the anticipated wind and live loads.

Parapet walls must be solid masonry, with the cells of hollow or semi-solid units being filled with mortar, grout or concrete, that extends from the top of the parapet to not less than 300 mm (12 in.) below the adjacent roof level. This requirement is intended to ensure that the parapet walls keep rainwater or meltwater from moving into any cavities or interior spaces in order to prevent freeze–thaw deterioration of the parapet and damage to interior finishes.

The height of parapet walls above the adjacent roof surface must be not more than three times their thickness. Since they are unsupported at the top and are exposed to wind, parapet walls may lack adequate stability if they are built too high for their thickness.

9.20.6.6. Stone or Concrete Facings

This Article indicates that slab and panel facings of precast concrete and natural or artificial stone must conform to NBC Subsection 4.3.2., which references CSA S304, "Design of Masonry Structures."

9.20.7. Chases and Recesses

9.20.7.1. Maximum Dimensions

This Article establishes a maximum depth and width for chases and recesses, which tend to weaken masonry walls. Masonry normally has sufficient reserve strength to permit the construction of chases and recesses with dimensions not exceeding these limits.

Chases are long, narrow channels in masonry walls, which are constructed to house piping, ducts or wiring. Recesses, on the other hand, are rectangular in shape and are usually constructed to house electrical panels, standpipe and hose equipment, or other services.

9.20.7.2. Minimum Wall Thickness

This Article prohibits the construction of chases and recesses in masonry walls not having at least a minimum wall thickness.

The thicker a masonry wall, the greater the depth permitted for a chase or recess constructed in it (NBC Article 9.20.7.1.). In thin walls, a chase or recess of a practical depth causes an unacceptable reduction in strength. For this reason, chases and recesses are not permitted in walls less than 190 mm (7 1/2 in.) thick. Recesses—but not chases—are permitted to be constructed in walls 190 mm (7 1/2 in.) thick, provided they do not exceed the dimensions illustrated in Figure 9.20.-6.

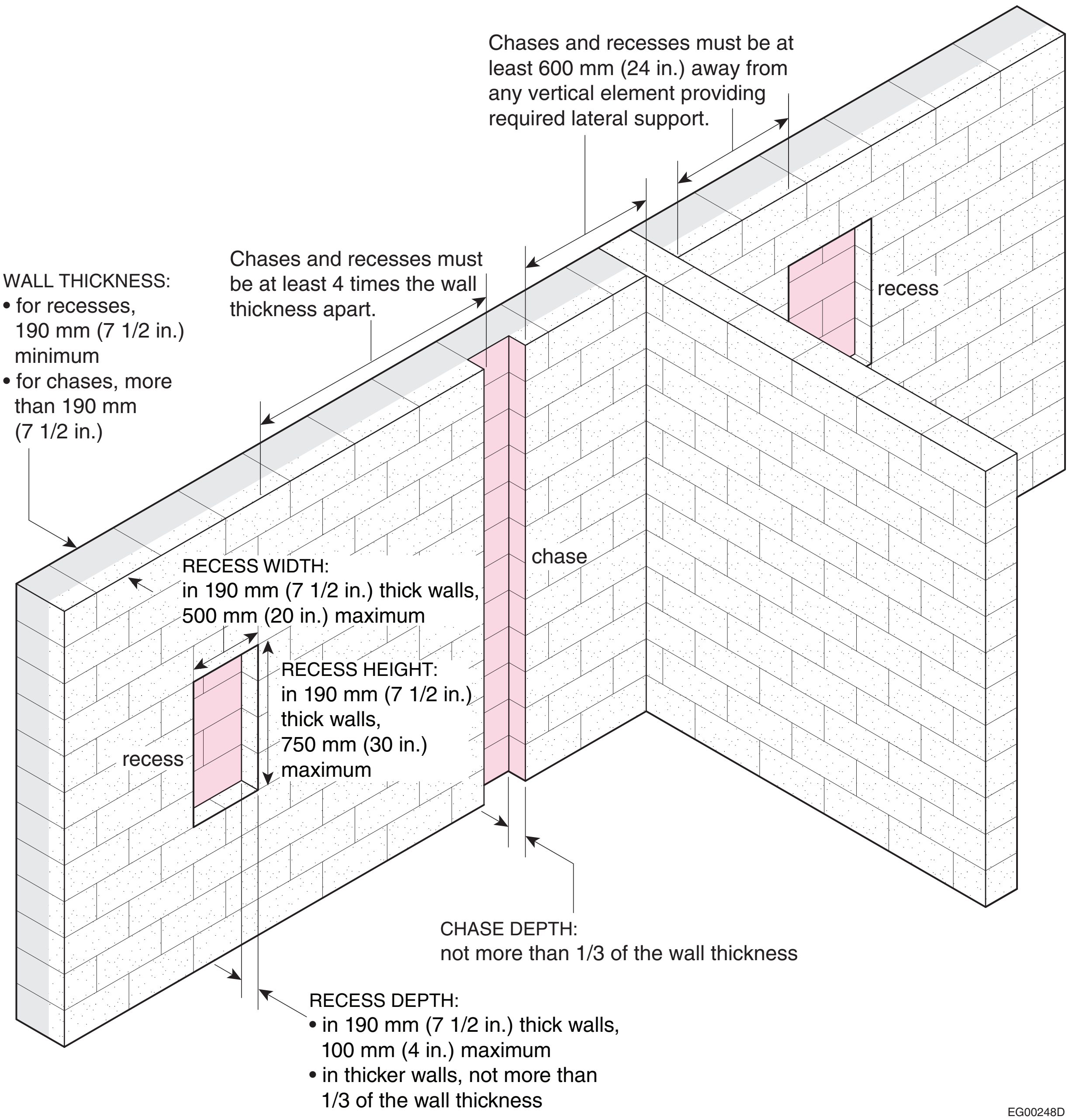


Figure 9.20.-6
Requirements for chases and recesses in masonry walls

9.20.7.3. Separation of Chases or Recesses

This Article limits the spacing of chases and recesses from one another and from vertical elements providing required lateral support.

The resistance of a masonry wall to concentrated vertical loads and shear forces due to wind depends on its ability to act as a single unified system. When chases or recesses are constructed in a wall, they create zones of weakness that tend to divide the wall into a number of partially connected portions. In particular, when chases and recesses are constructed too close to a cross wall, buttress, pilaster or other vertical element providing required lateral support to a wall, they restrict the support to a small portion of the wall and thereby reduce the effectiveness of the vertical element.

9.20.7.4. Non-Conforming Chases or Recesses

This Article requires that chases and recesses that do not conform to the limits specified in NBC Articles 9.20.7.1. to 9.20.7.3. be considered as openings. Any masonry supported above such a chase or recess must be supported by a lintel or arch as provided in NBC Article 9.20.5.2.

In situations where a recess exceeding the dimensional limits is desired, it may be feasible to design the recess as an opening similar to a window and to use a lintel to carry the weight of the masonry above the recess as well as any superimposed loads. By designing the recess in this way, the structural integrity of the wall will not be compromised.

9.20.7.5. Chases or Recesses Cut into Walls

This Article indicates that chases and recesses must not be cut into walls made with hollow masonry units after the units are in place.

Cutting chases and recesses into walls made with hollow masonry units damages the integrity of the units. Instead, chases and recesses should be constructed with units of sizes that permit bonding and tying around the chase or recess to maintain the structural integrity of the wall.

9.20.8. Support of Loads

9.20.8.1. Capping of Hollow Masonry Walls

This Article describes the capping required for loadbearing walls of hollow masonry units supporting roof or floor framing members. Capping ensures that the top of such walls has sufficient bearing area to prevent crushing of supported wooden members and over-stressing of the face shells of the masonry units beneath the loads.

Loadbearing hollow masonry walls that support roof or floor framing members must be capped with not less than 50 mm (2 in.) solid masonry or must have a top course of hollow units filled with concrete (Figure 9.20.-7). This capping can be omitted if the roof framing is supported on a wood plate not less than 38 × 89 mm (2 × 4 in. nominal), which is securely fastened to the top of the wall. These solutions are intended to evenly distribute the load from the supported members.

9.20.8.2. Cavity Walls Supporting Framing Members

This Article contains requirements for masonry cavity walls supporting framing members. These requirements are intended to prevent crushing of supported wooden members and over-stressing of the face shells of masonry units beneath the loads.

Floor joists supported on masonry cavity walls must be supported on solid masonry units not less than 57 mm (2 1/4 in.) high (Figure 9.20.-7). Floor joists are supported on the inner wythe only and must not project into the cavity. This configuration protects the floor joists from the deleterious effects of rain leakage through the outer wythe.

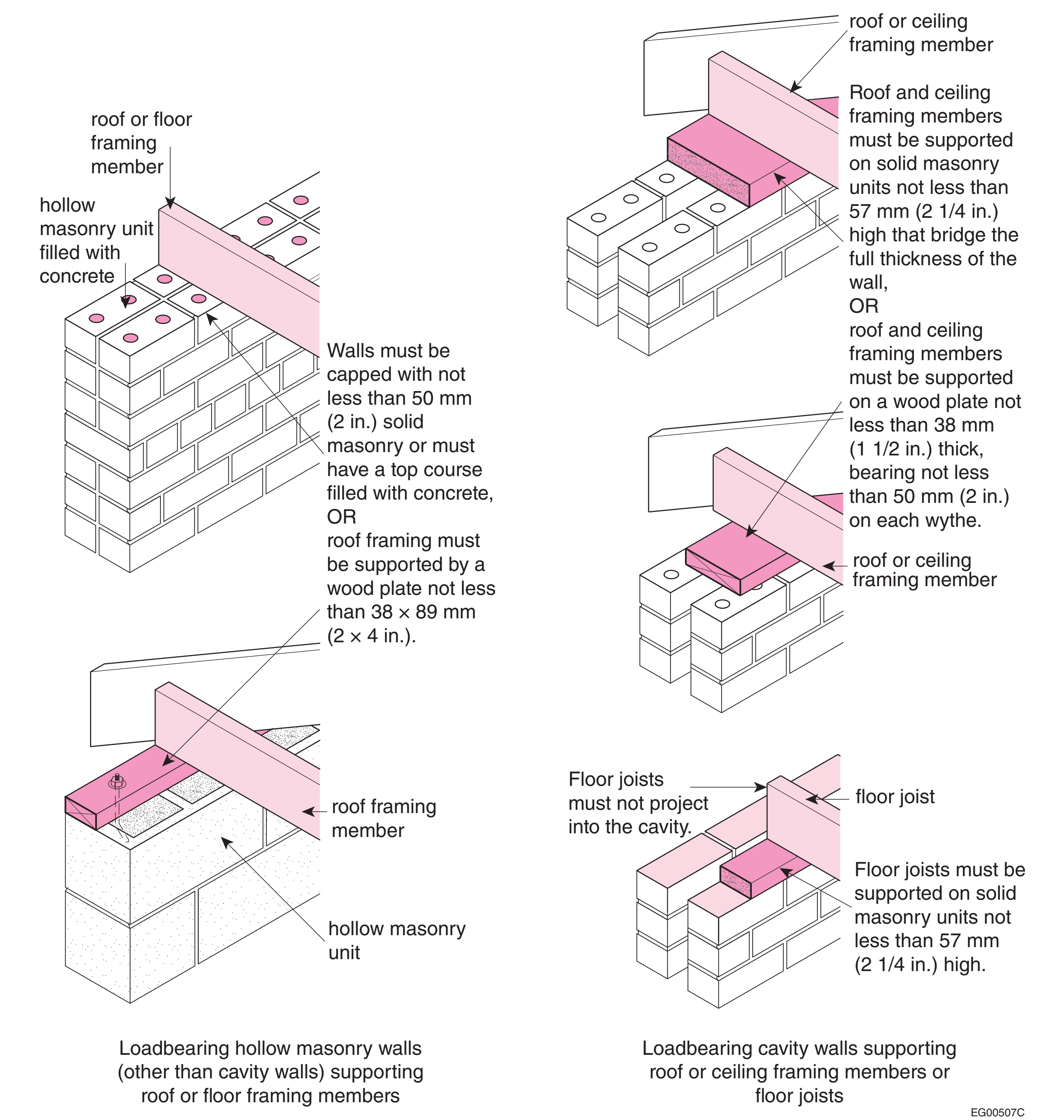


Figure 9.20.-7
Requirements for hollow masonry walls and cavity walls supporting framing members

The load from roof and ceiling framing members, however, must be spread over both wythes. Roof and ceiling framing members that bear on masonry cavity walls must be supported on solid masonry units not less than 57 mm (2 1/4 in.) high that bridge the full thickness of the wall or on a wood plate not less than 38 mm (1 1/2 in.) thick that bears not less than 50 mm (2 in.) on each wythe (Figure 9.20.-7). The wood plate or solid masonry units connect the two wythes at the top of the wall so that the supported loads are shared between the two wythes, reducing loading eccentricity and improving the stability of the wall.

9.20.8.3. Bearing of Beams and Joists

This Article requires the bearing area under beams and joists to be sufficient to carry the supported load. This requirement is intended to prevent crushing of supported wooden members.

Loads from beams are much larger than those from joists. Therefore, beams supported on masonry must have an end bearing length of at least 90 mm (3 1/2 in.), whereas floor, roof and ceiling joists supported on masonry must have an end bearing length of at least 40 mm (1 9/16 in.).

9.20.8.4. Support of Beams and Columns

This Article requires that beams and columns supported on masonry walls be supported on pilasters where the thickness of the masonry wall or wythe is less than 190 mm (7 1/2 in.) thick.

Loads from beams and columns, which can be very high, may over-stress thin walls. To prevent this problem, pilasters (which are often thickened portions of the wall) are constructed to distribute and carry these loads (see Figure 9.15.-21 for an example of a pilaster in a masonry foundation wall). For maximum resistance to buckling, pilasters should be bonded to the wall.

9.20.8.5. Projection of Masonry Veneer Beyond Supporting Members

This Article limits the distance that masonry veneer of solid masonry units can project beyond its bearing support. Masonry veneer that projects too far beyond its support will be unstable, and structural collapse may result.

Masonry veneer must not project more than one third of its thickness beyond the support (Figure 9.20.-8). For rough stone veneer, the average projection of the units and the average thickness of the veneer are used to establish the maximum projection.

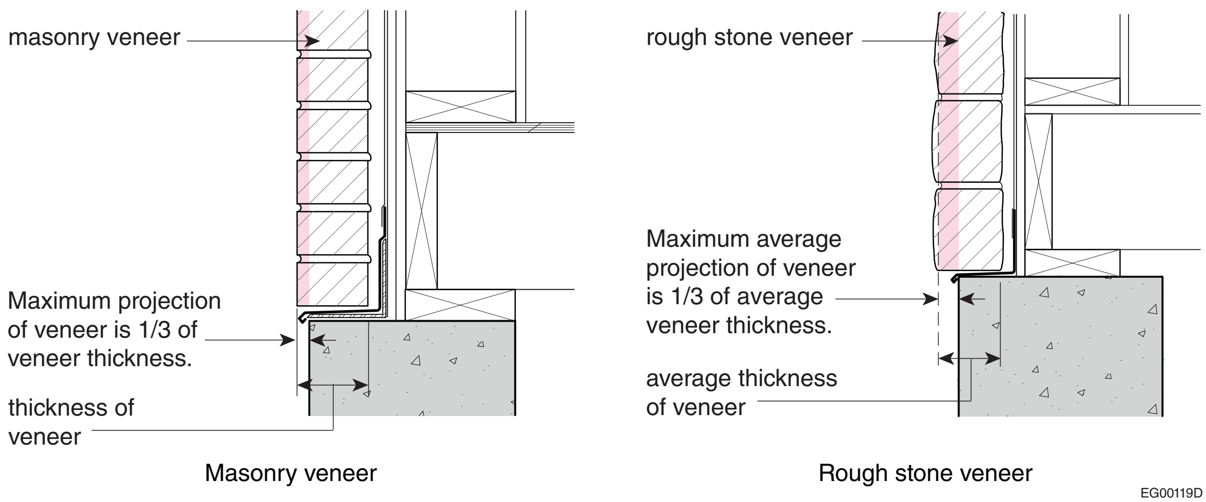


Figure 9.20.-8
Maximum projection of masonry veneer beyond its support

9.20.9. Bonding and Tying

9.20.9.1. Joints to be Offset or Reinforced

This Article contains requirements for the offsetting of masonry joints.

Mortar joints are usually weaker in tension than the units they bond together. Vertical head joints are much weaker than horizontal bed joints because the mortar in vertical joints is not pressed into intimate contact with the units by the weight of the masonry as it cures.

Therefore, vertical joints in adjacent masonry courses must be offset from one another (the offset should be at least 25% of the unit length) or each wythe must be reinforced with the equivalent of not less than two horizontal corrosion-resistant steel wires of 3.76 mm (5/32 in.) in diameter placed in the horizontal joints at vertical intervals not exceeding 460 mm (18 in.). The reinforcing wires must be lapped at joints by at least 150 mm (6 in.).

9.20.9.2. Bonding or Tying of Other than Masonry Veneer

This Article requires that, in masonry walls consisting of two or more wythes other than masonry veneer, the wythes be bonded together with masonry bonding units as described in NBC Article 9.20.9.3. or tied together with metal ties as described in NBC Article 9.20.9.4. This requirement ensures that the wythes of a wall act together to resist lateral loads, which strengthens the wall.

In a cavity wall, the ties and bonding units transfer loads perpendicular to the wall, but are assumed not to resist loads parallel to the wall. Therefore, composite action between the two wythes is assumed not to occur. Accordingly, the stiffness of the cavity wall is the sum of the stiffnesses of the individual wythes. Two identical wythes that are bonded or tied together with a cavity between them provide a stiffness equal to twice that of a single wythe.

9.20.9.3. Bonding

This Article contains requirements for bonding wythes in multi-wythe masonry walls with masonry bonding units. Bonding adjacent wythes together enhances the load-carrying capacity of the walls.

Masonry bonding units must extend at least 90 mm (3 1/2 in.) into adjacent wythes, and must be spaced not more than 600 mm (24 in.) vertically and horizontally for brick and 900 mm (36 in.) on centre for block and tile. The bonding units must make up not less than 4% of the wall surface area.

9.20.9.4. Tying

This Article contains requirements for tying wythes in multi-wythe masonry walls.

In general, metal ties of the individual rod type are used to tie wythes together. However, other types of ties (e.g., longitudinal ties and cross ties welded together to form a ladder or truss configuration) are permitted to be used, provided it can be shown that they provide walls that are at least as strong and as durable as those made with individual rod-type metal ties. Individual rod-type metal ties must be corrosion-resistant, must be completely embedded in mortar, except for the exposed portion within the cavity of cavity walls, and must be staggered from course to course. Other requirements for individual rod-type ties are illustrated in Figures 9.20.-9 and 9.20.-10.

In cavity walls, because the ties between the two wythes span an open cavity, they flex when the wythes deflect under lateral loading and are not effective at making the two wythes act as a single wall (i.e., they are not sufficiently stiff to provide composite action between the two wythes). However, the ties do increase the stability of the individual wythes under vertical loads and increase their resistance to wind loads by allowing the wythes to provide lateral support to one another.

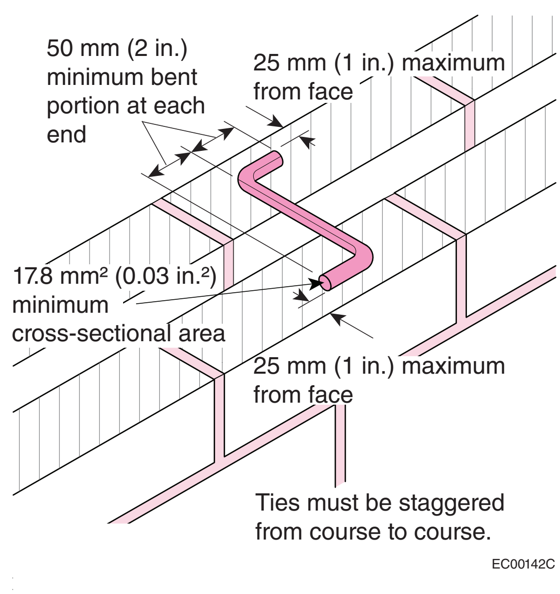


Figure 9.20.-9
Tying wythes in masonry cavity walls together with metal ties of the individual rod type

In walls other than cavity walls and masonry veneer walls, the space between wythes tied together with individual rod-type ties must be completely filled with mortar (Figure 9.20.-10). Filling this space with mortar limits the flexing of the ties across the space. In the resulting solid masonry wall, there is composite action between the wythes, and the wall acts structurally as a single unit rather than as two or more wythes in series. In such walls, ties must be located within 300 mm (12 in.) of openings and spaced not more than 900 mm (36 in.) apart around openings.

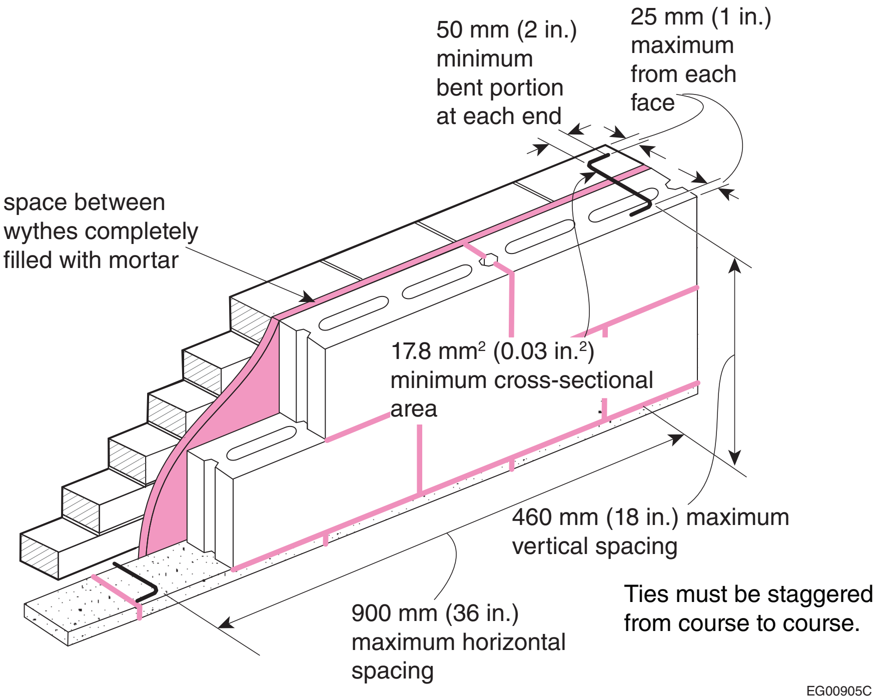


Figure 9.20.-10
Tying wythes in masonry walls (other than cavity walls and masonry veneer walls) together with metal ties of the individual rod type

9.20.9.5. Ties for Masonry Veneer

This Article requires that straps be used to tie masonry veneer that is 75 mm (3 in.) or more in thickness and that rests on a bearing support to masonry backing or to wood framing members. The straps improve the stability of masonry veneer by providing intermediate lateral support. In particular, the straps increase the veneer's resistance to horizontal forces (e.g., wind, seismic and accidental forces) and to buckling due to its weight.

The straps used to tie masonry veneer are relatively thin galvanized-metal strips with a corrugated surface for bonding with the mortar (Figure 9.20.-11). Their flexibility ensures that the veneer is not affected if wood framing to which it is tied shrinks.

The straps must be corrosion-resistant, not less than 0.76 mm (1/32 in.) thick, not less than 22 mm (7/8 in.) wide, and shaped to provide a key with the mortar. Straps fastened to wood framing members must be bent at a right angle within 6 mm (1/4 in.) of the fastener and must be fastened with corrosion-resistant 3.18 mm (1/8 in.) diameter screws or spiral nails having a wood penetration not less than 63 mm (2 1/2 in.).

Straps can be installed against any of the wall sheathings listed in NBC Table 9.23.17.2.-A, provided the straps are in contact with the exterior surface of the sheathing or the sheathing membrane applied over the sheathing, and the sheathing beneath the ties is not unduly compressed. When installing straps against compressible sheathing, care should be taken to avoid crushing the sheathing.

Maximum vertical and horizontal tie spacings are listed in NBC Table 9.20.9.5. For masonry veneer tied to wood framing members, the tie spacing depends on the stud spacing. For typical framing with a stud spacing of 400 mm (16 in.) on centre, a horizontal tie spacing of 400 or 800 mm (16 or 32 in.) can be used, depending on whether the ties are nailed to every stud or to every second stud. Where a stud spacing of 600 mm (24 in.) is used, the ties must be nailed to each stud and must have a maximum vertical spacing of 500 mm (20 in.). Similar tie spacings are used for masonry veneer tied to masonry backing.

Masonry veneer that is individually supported by masonry or wood-frame backing is regulated by NBC Part 4. NBC Subsection 4.3.2. references CSA A371, "Masonry Construction for Buildings," which contains requirements for this type of masonry veneer. Individually supported masonry veneer, which is thinner than self-supporting masonry veneer, is attached to the backing by using mortar, for small units, or metal anchors, for large units.

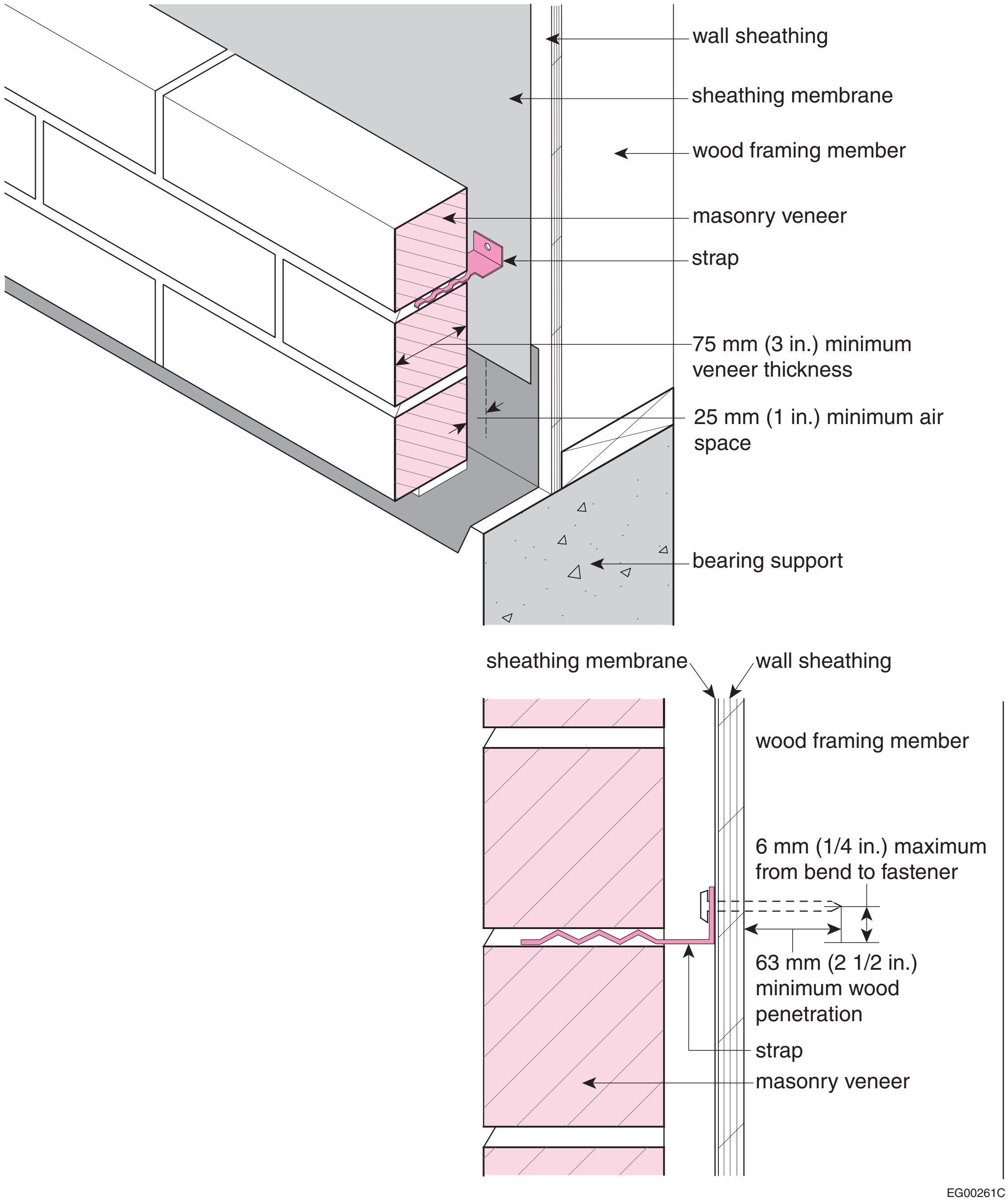


Figure 9.20.-11
Tying masonry veneer to wood framing with straps

9.20.9.6. Reinforcing for Glass Block

This Article specifies the horizontal joint reinforcement required for glass block. Since glass blocks are not normally staggered from one course to another, the vertical joints between them are aligned, creating planes of weakness and increasing the potential for cracks. Therefore, horizontal joint reinforcement must be used to compensate for the weakened vertical planes.

Horizontal joints between glass blocks must be reinforced either with two bars of corrosion-resistant steel not less than 3.76 mm (5/32 in.) in diameter or with expanded metal strips not less than 75 mm (3 in.) wide. Where discontinuous, the reinforcement must be lapped not less than 150 mm (6 in.) within the joint.

The reinforcement must be spaced at vertical intervals of not more than 600 mm (24 in.) for units 200 mm (8 in.) or less in height, and must be installed in each horizontal joint for units more than 200 mm (8 in.) in height.

9.20.10. Lateral Support

9.20.10.1. Lateral Support Required

This Article requires that masonry walls be laterally supported by floor or roof construction or by intersecting masonry walls or buttresses.

Masonry walls behave somewhat like columns. Walls with a larger slenderness ratio (i.e., height or length divided by thickness) have a greater tendency to buckle under a given load. If intermediate lateral support is provided, the slenderness ratio is reduced and the wall is made more stable. Lateral support enables a wall to carry higher vertical loads and also helps the wall to resist wind loads. Therefore, limits are placed on the spacing of lateral supports, which depend on the thickness and application of the wall.

For loadbearing and exterior non-loadbearing walls, the spacing of the lateral supports must be not more than 20 times the wall thickness For interior non-loadbearing walls, which only have to support their own weight and resist accidental impacts, the support requirement is less restrictive: the spacing of the lateral supports must be not more than 36 times the wall thickness. For cavity walls, the wall thickness must be taken as two thirds of the sum of the thicknesses of the wythes or the thickness of the thicker wythe, whichever is greater.

Masonry walls can be laterally supported either vertically by intersecting masonry walls or buttresses (Figure 9.20.-12) or horizontally by floor or roof construction, which must be constructed to transfer lateral loads to walls or buttresses approximately at right angles to the laterally supported walls.

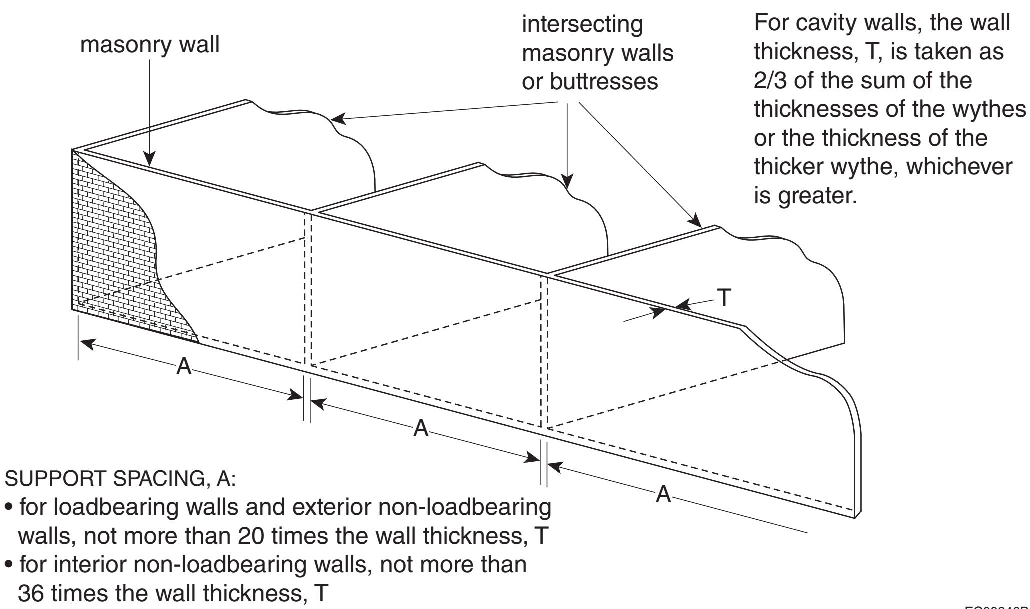


Figure 9.20.-12
Masonry wall support

9.20.11. Anchorage of Roofs, Floors and Intersecting Walls

9.20.11.1. Anchorage to Floor or Roof Assemblies where Masonry Walls Require Lateral Support

This Article contains requirements for the anchorage of masonry walls to floors and roofs that are intended to provide lateral support. The anchors must be sufficiently strong and must be placed at suitably small intervals to properly restrain the masonry walls.

Floors and roofs provide lateral support by acting as horizontal diaphragms that transfer horizontal forces to the cross walls beneath them. Joists that are parallel to masonry walls, however, are weaker in resisting horizontal forces than are the joists perpendicular to the walls. Therefore, where masonry walls are anchored to joists parallel to the wall, each anchor must extend across not less than three joists to develop sufficient strength.

If floor joists are close to grade level (not more than 1 m (39 in.) above grade), anchors are not necessary, since the earth pressure on the foundation provides sufficient lateral support.

Floor assemblies more than 1 m (39 in.) above grade and roof assemblies that provide lateral support to masonry walls must be anchored to the walls at a intervals of not more than 2 m (6 ft. 7 in.) with corrosion-resistant anchors that are not less than the equivalent of 40 mm (1 9/16 in.) by 4.76 mm (3/16 in.) thick steel straps. The anchors must be shaped to provide a mechanical key with the masonry and must be securely fastened to the horizontal support to develop the full strength of the anchor.

Figure 9.20.-13 illustrates one approach to the anchorage of a masonry wall to a floor assembly.

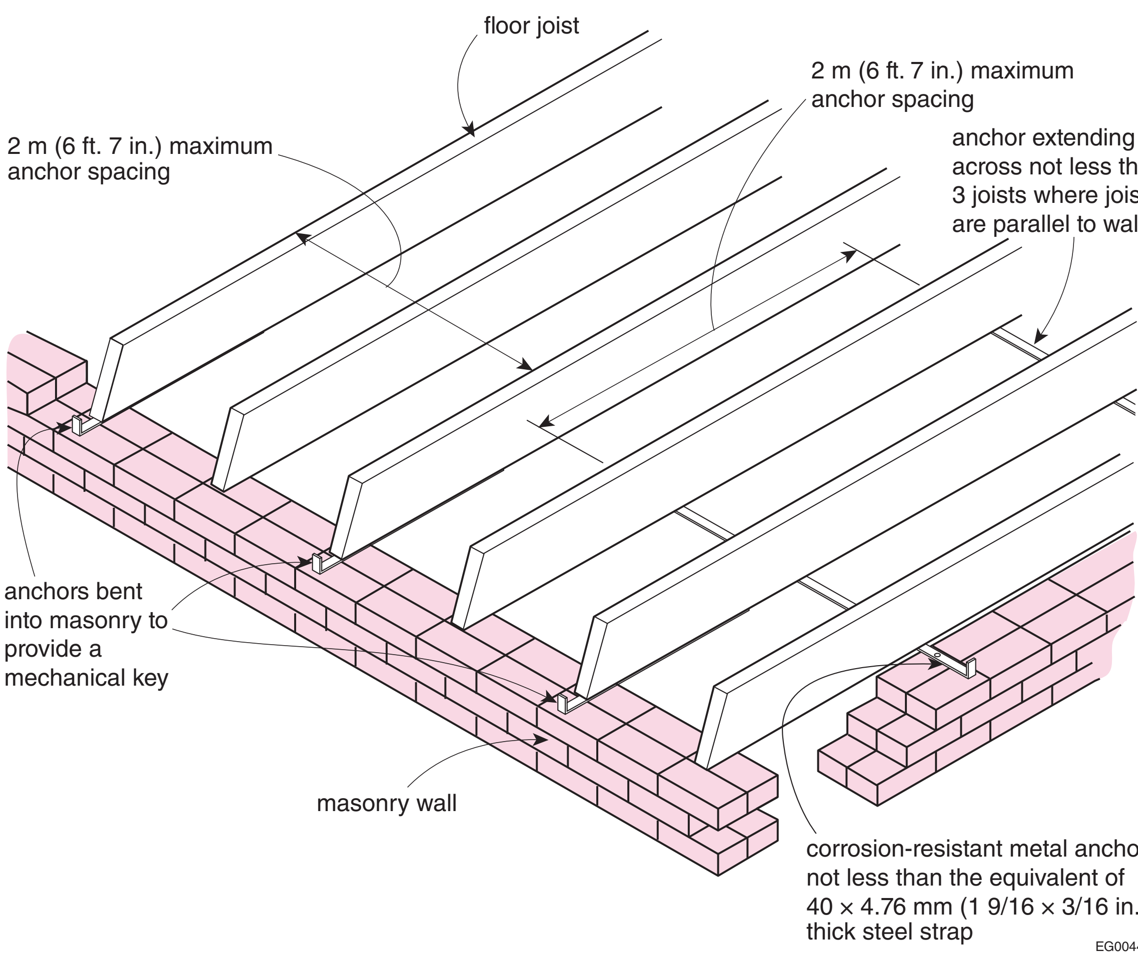


Figure 9.20.-13
Anchorage of a masonry wall to a floor assembly for lateral support

9.20.11.2. Bonding and Tying Intersecting Masonry Walls where Walls Require Lateral Support

This Article contains bonding and tying requirements for intersecting masonry walls that are intended to provide lateral support to other masonry walls. The intersecting masonry walls must be either bonded with the masonry wall or tied to wall by corrosion-resistant metal ties (Figure 9.20.-14).

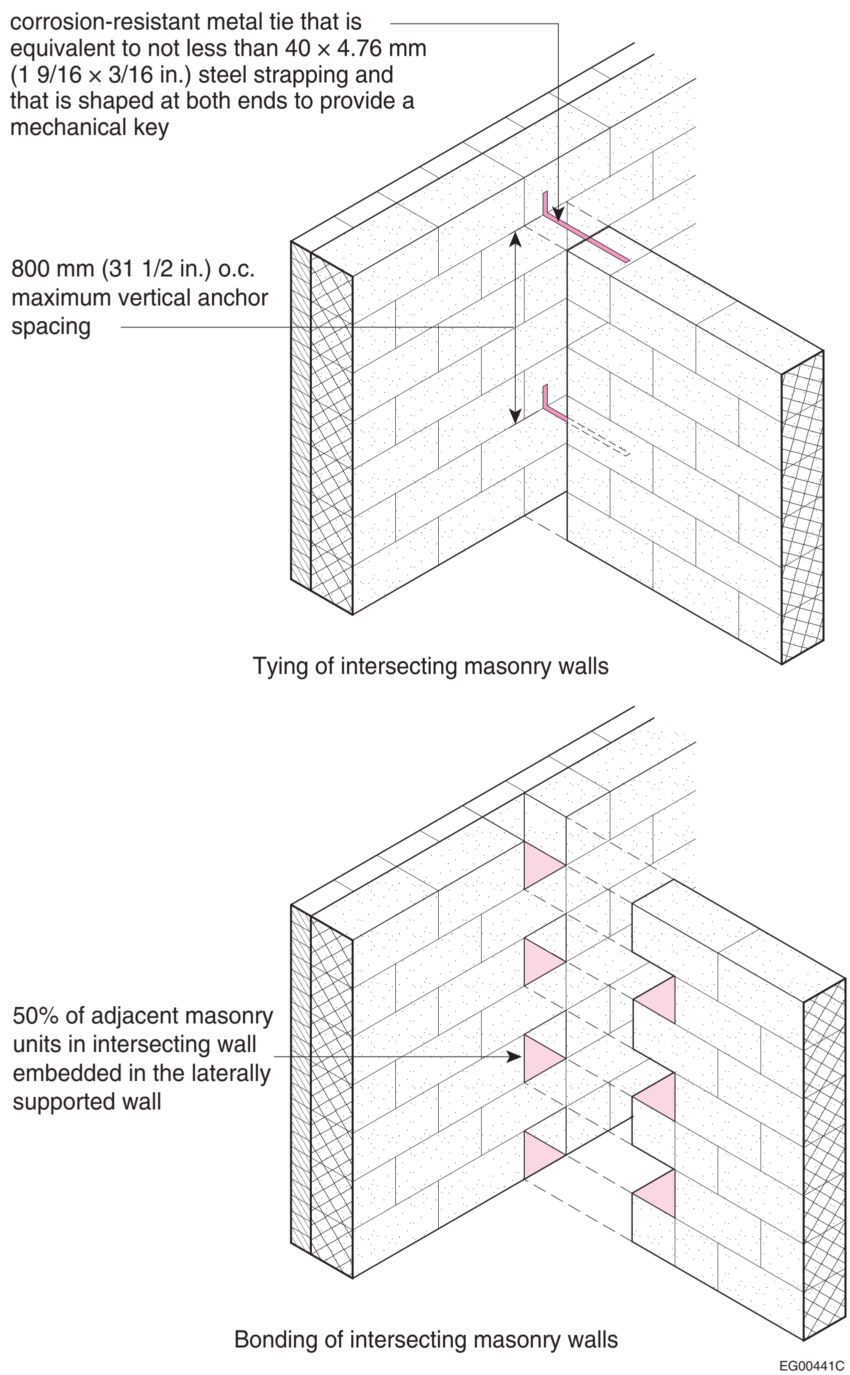


Figure 9.20.-14
Tying and bonding of intersecting walls for lateral support

9.20.11.3. Anchoring Intersecting Wood-Frame Walls to Masonry Walls

This Article contains requirements for anchoring wood-frame walls to masonry walls. Although wood-frame walls do not provide sufficient support to be considered as lateral supports for the purpose of NBC Article 9.20.10.1., they do contribute to the stability of masonry walls in resisting buckling forces.

Wood-frame walls that intersect with masonry walls must be anchored to the masonry walls with corrosion-resistant steel rods spaced not more than 900 mm (35 in.) on centre vertically (Figure 9.20.-15).

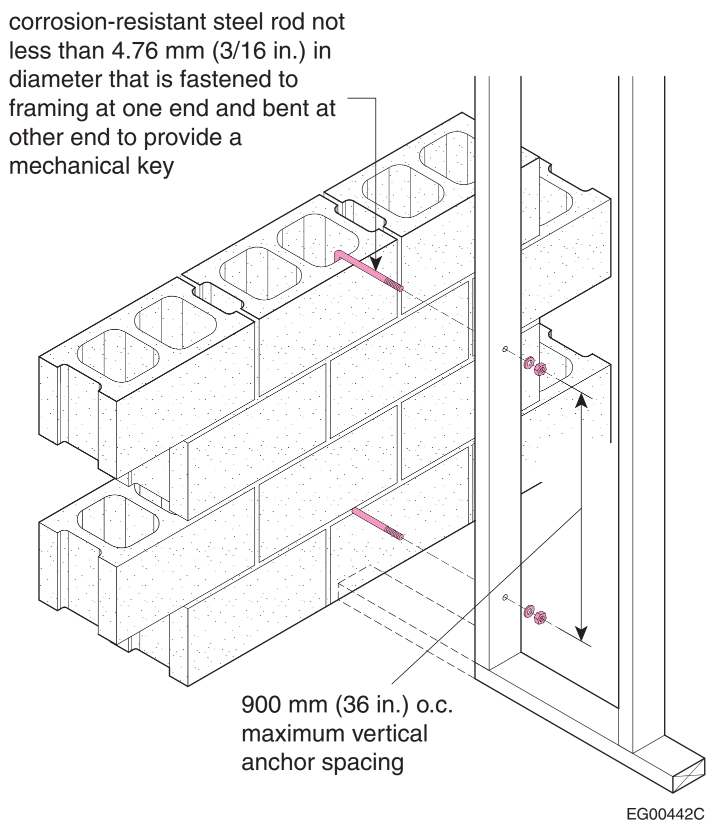


Figure 9.20.-15
Tying of wood-frame walls to masonry walls

9.20.11.4. Anchoring Wood-Frame Roof Systems to Masonry Walls

This Article requires that roof systems of wood-frame construction be anchored to exterior masonry walls.

In general, where wood-frame roof systems are supported on exterior masonry walls, they must be anchored firmly to resist wind forces by using anchor bolts that are not less than 12.7 mm (1/2 in.) in diameter (Figure 9.20.-16). The anchor bolts must be spaced not more than 2.4 m (7 ft. 10 in.) apart, must be embedded not less than 90 mm (3 1/2 in.) into the masonry, and must be fastened to a rafter plate of not less than 38 mm (1 1/2 in.) thick lumber.

Alternatively, wood-frame roof systems can be anchored to exterior masonry walls by nailing the wall furring strips to the side of the rafter plate to resist uplift and horizontal loads (Figure 9.20.-17).

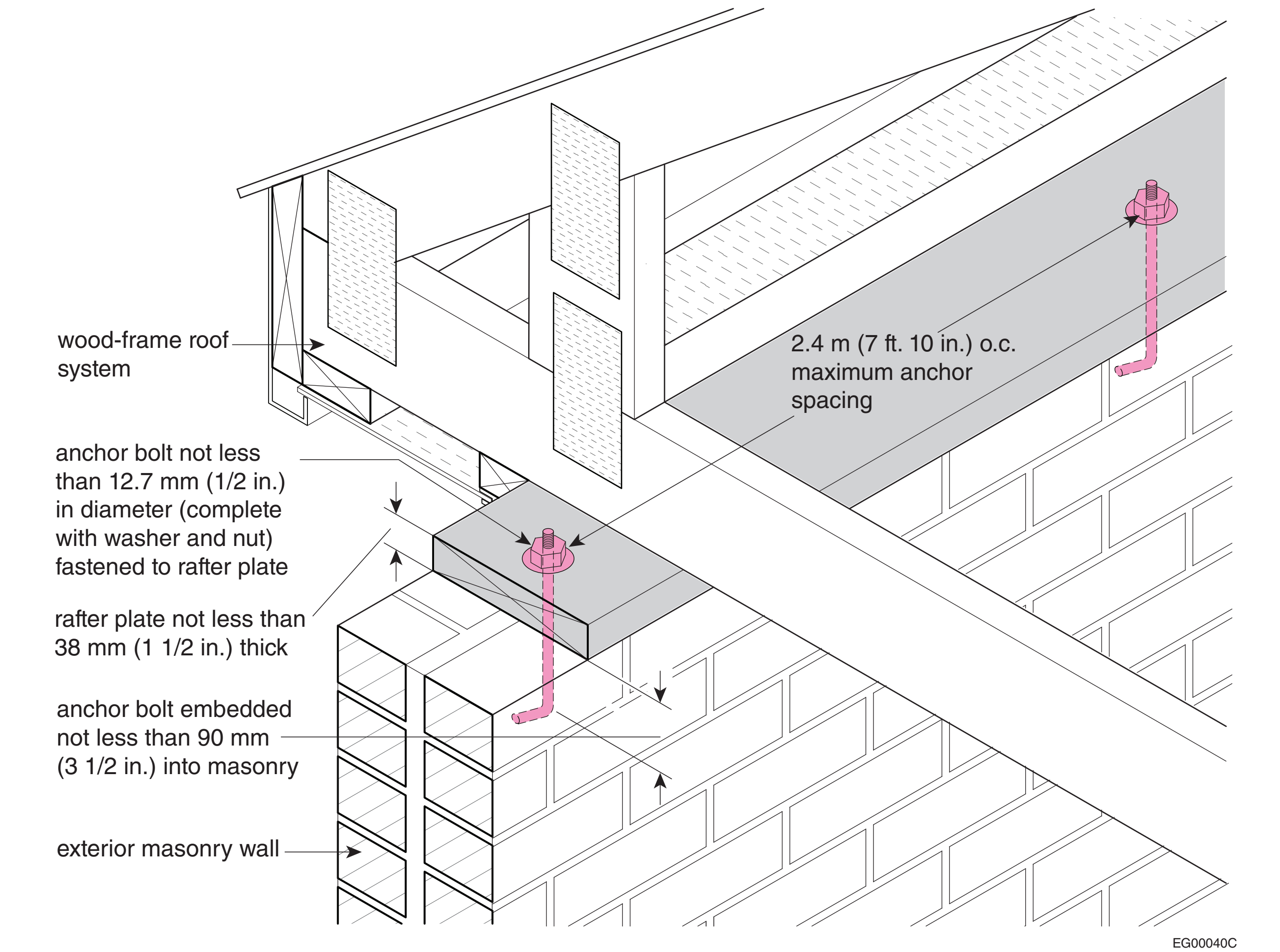


Figure 9.20.-16
Anchorage of a wood-frame roof system to an exterior masonry wall by using anchor bolts

9.20.11.5. Anchoring Masonry Cornices, Sills and Trim to Masonry Walls

This Article requires that masonry projecting beyond the wall face, such as cornices, sills and trim, have not less than 65% of its mass or 90 mm (3 1/2 in.), whichever is greater, within the wall or be adequately anchored to the wall with corrosion-resistant anchors (Figure 9.20.-18). This requirement ensures that either the centre of gravity of the projecting masonry rests within the wall or the projecting masonry is anchored firmly in position to prevent overturning and maintain stability.

9.20.11.6. Anchoring to Masonry Piers

This Article states that, where anchor bolts are to be placed in the top of a masonry pier, the pier must conform with NBC Sentence 9.15.2.3.(4) and must be capped with concrete or reinforced masonry not less than 200 mm (8 in.) thick. This configuration is intended to provide the anchor bolts with adequate resistance to column uplift forces caused by wind action.

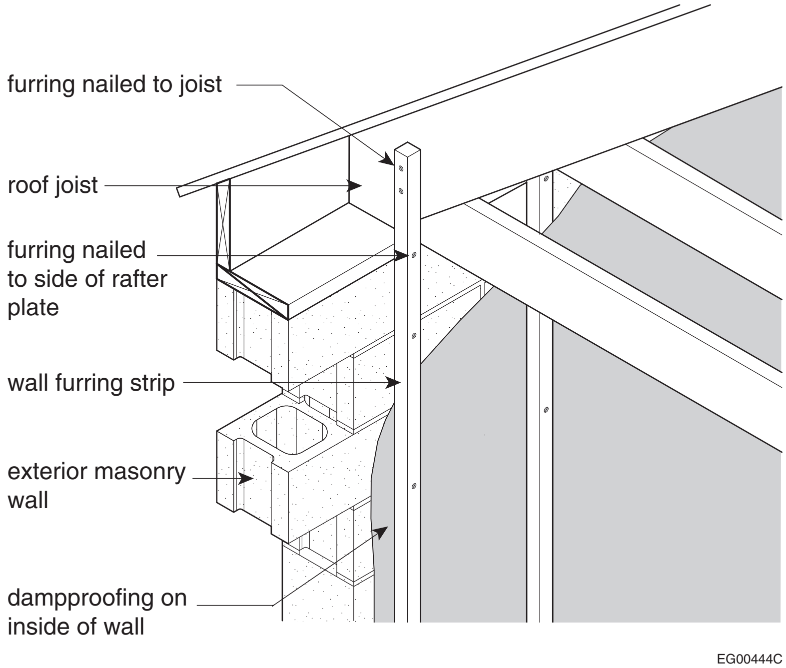


Figure 9.20.-17
Anchorage of a wood-frame roof system to an exterior masonry wall by nailing the wall furring strips to the side of the rafter plate

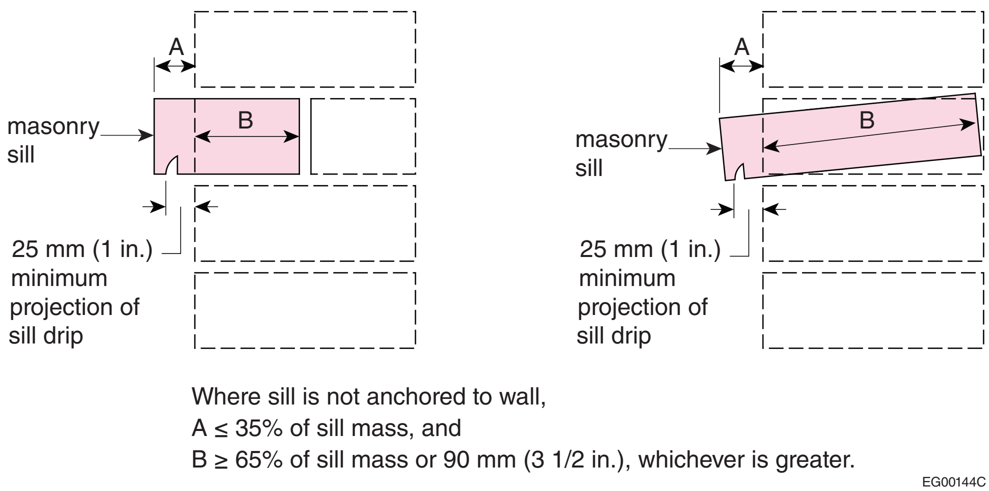


Figure 9.20.-18
Projecting masonry sills (NBC Articles 9.20.11.5. and 9.20.13.12.)

9.20.12. Corbelling

9.20.12.1. Corbelling

This Article contains requirements for corbelling of masonry walls.

It is sometimes necessary to corbel masonry walls so that supported masonry units project beyond the support. For example, corbelling may be necessary where an above-grade masonry wall is wider than a foundation wall below or where a cavity wall is wider than a solid masonry wall below. It may also be necessary in chimney and fireplace construction where the foundation wall is narrower than the supported masonry or where the masonry is reduced in thickness above the fire chamber.

However, corbelling can have a destabilizing effect on a masonry wall if it moves the centre of gravity of the supported masonry closer to the edge of the support. For this reason, the horizontal projection of any unit in the corbelling must not exceed 25 mm (1 in.) and the total projection of the corbelling must not exceed one third of the total wall thickness. All corbelling must consist of solid masonry units.

9.20.12.2. Corbelling for Cavity Walls

This Article indicates that, in general, cavity walls of greater thickness than the foundation wall on which they rest must not be corbelled, but are permitted to project 25 mm (1 in.) beyond the outer face of the foundation wall disregarding parging.

However, where the foundation wall supporting a cavity wall is unit masonry, it is permitted to be corbelled to meet flush with the inner face of the cavity wall (Figure 9.20.-19). To maintain stability, the total projection of the corbelling must not exceed one third of the foundation wall thickness. The projection of each course must not exceed half of the height or one third of the thickness of the corbelled unit.

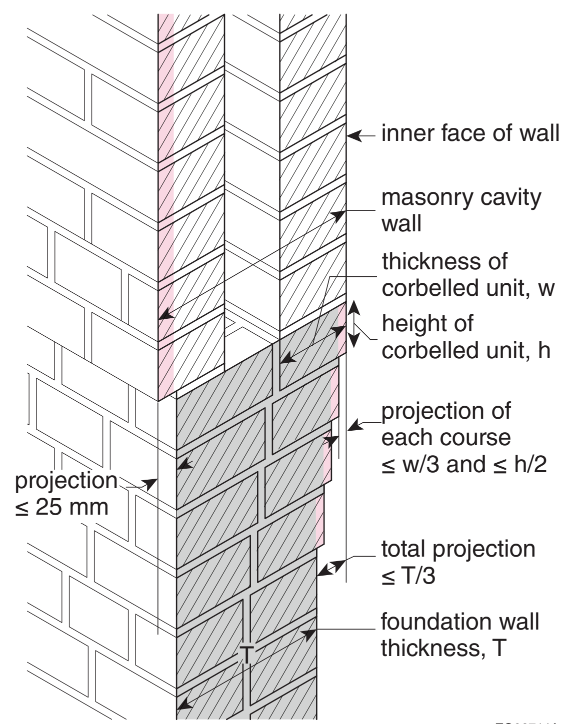


Figure 9.20.-19
Corbelling of a masonry foundation wall below a masonry cavity wall

9.20.12.3. Corbelling for Masonry Veneer

This Article places restrictions on corbelling of masonry veneer, which ensure that the centre of gravity of the masonry veneer rests on the supporting base to prevent overturning and maintain stability.

Masonry veneer resting on a bearing support is permitted to project not more than 25 mm (1 in.) beyond the supporting base where the veneer is not less than 90 mm (3 1/2 in.) thick. Where the veneer is less than 90 mm (3 1/2 in.) thick, the maximum permitted projection is 12 mm (1/2 in.).

9.20.13. Control of Rainwater Penetration

The penetration of rainwater into masonry construction must be controlled to minimize damage to the structure and to interior finishes. The provisions in this Subsection deal with the control of rainwater penetration into masonry walls through the use of flashing, weep holes, and protection for interior finishes. Numerous other provisions that are intended to control rainwater penetration into walls are found throughout the NBC.

9.20.13.1. Materials for Flashing

This Article requires that flashing materials for masonry walls conform to NBC Table 9.20.13.1. These materials are classified as suitable for exposed flashing, concealed flashing, or both. Exposed flashing must resist weather-related deterioration. Concealed flashing is integrated within the wall assembly and is not exposed directly to the outdoors.

Aluminum flashing in contact with masonry or concrete must be effectively coated or separated from the masonry or concrete by an impervious membrane. Since aluminum is chemically reactive towards concrete and mortar, aluminum flashing must be protected from direct contact with masonry or concrete to prevent premature failure of the flashing.

9.20.13.2. Fastening of Flashing

This Article requires the use of corrosion-resistant fastening devices for flashing. Where metal flashing is used, the fastening devices must be compatible with the flashing with respect to galvanic action. This requirement is intended to prevent premature failure of the flashing as a result of a chemical reaction between it and the fasteners.

9.20.13.3. Location of Flashing

This Article lists the locations in masonry and masonry veneer walls where flashing must be installed. The requirement to install flashing in these locations is intended to minimize moisture-related deterioration resulting from the penetration of water into or through masonry walls, such as damage to the masonry walls from freeze–thaw deterioration or corrosion, wood decay, and damage to interior finishes.

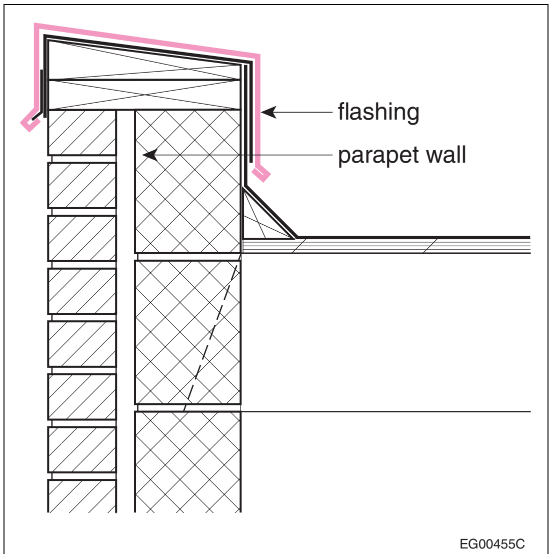


Figure 9.20.-20
Installation of flashing over a masonry parapet wall

Flashing is one of the key components used in masonry walls to control water penetration. To be effective, it should provide continuous protection. Corners and joints of the flashing should be sealed, and damaged flashing should be repaired before the masonry is laid. It should also be suitably terminated to help prevent the entry of water into the wall system or to direct water that has entered the wall system to the exterior.

Most water penetrates masonry walls through the joints between the masonry units rather than through the units themselves. Joints in a horizontal or near-horizontal plane, such as those in masonry window sills or on the tops of parapet walls, are particularly vulnerable to rainwater and meltwater penetration. Flashing must be installed across the top of parapet walls and down their back (Figure 9.20.-20) and under jointed masonry window sills, such as brick masonry sills that contain head joints. Flashing must also be installed over the heads of window and door openings in exterior walls (i.e., over the upper surface of the lintel or arch that supports the masonry over the opening) where the vertical distance between the top of the window or door frame and the bottom edge of the eave exceeds one quarter of the horizontal eave overhang. If this condition is not met, the eave overhang is not large enough to protect the masonry above the opening from driving rain.

Flashing must be placed beneath weep holes, which are only required for cavity walls and for masonry veneer walls having a cavity or air space (see NBC Article 9.20.13.8.).

9.20.13.4. Extension of Flashing

This Article requires that flashing installed beneath jointed masonry window sills or over the heads of openings extend from the front edge of the masonry up behind the sill or lintel.

In the case of a cavity wall or a masonry veneer over masonry backing wall, the flashing must extend from the front edge of the wall, across the cavity or air space, and up the face of the backing behind the sill or lintel (Figure 9.20.-21). This requirement is intended to minimize moisture-related deterioration resulting from the penetration of water into or through masonry walls, such as damage to the masonry walls from freeze–thaw deterioration or corrosion, wood decay, and damage to interior finishes. Extending the flashing upward behind sills or heads of openings keeps any rainwater or meltwater that has accumulated at the base of the flashing from moving inward through absorption or direct leakage.

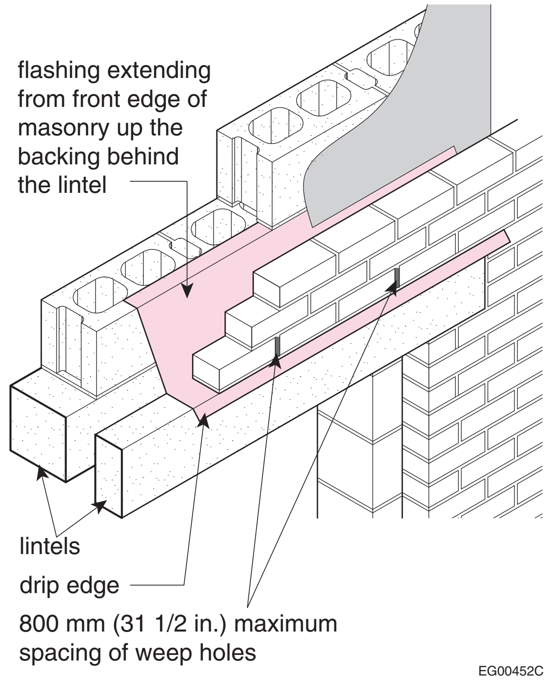


Figure 9.20.-21
Flashing and weep holes over heads of window and door openings in exterior cavity walls and masonry veneer/masonry backing walls (NBC Articles 9.20.13.3., 9.20.13.4. and 9.20.13.8.)

9.20.13.5. Flashing for Weep Holes in Masonry/Masonry Walls

This Article requires that flashing beneath weep holes in cavity walls and masonry veneer over masonry backing walls be bedded not less than 25 mm (1 in.), extend to not less than 5 mm (1/4 in.) beyond the outer face of the building element below the flashing, and be installed with a nominally horizontal slope toward the outside wythe (Figure 9.20.-22).

These requirements are intended to minimize moisture-related deterioration resulting from the penetration of water into or through masonry walls, such as damage to the masonry walls from freeze–thaw deterioration or corrosion, wood decay, and damage to interior finishes.

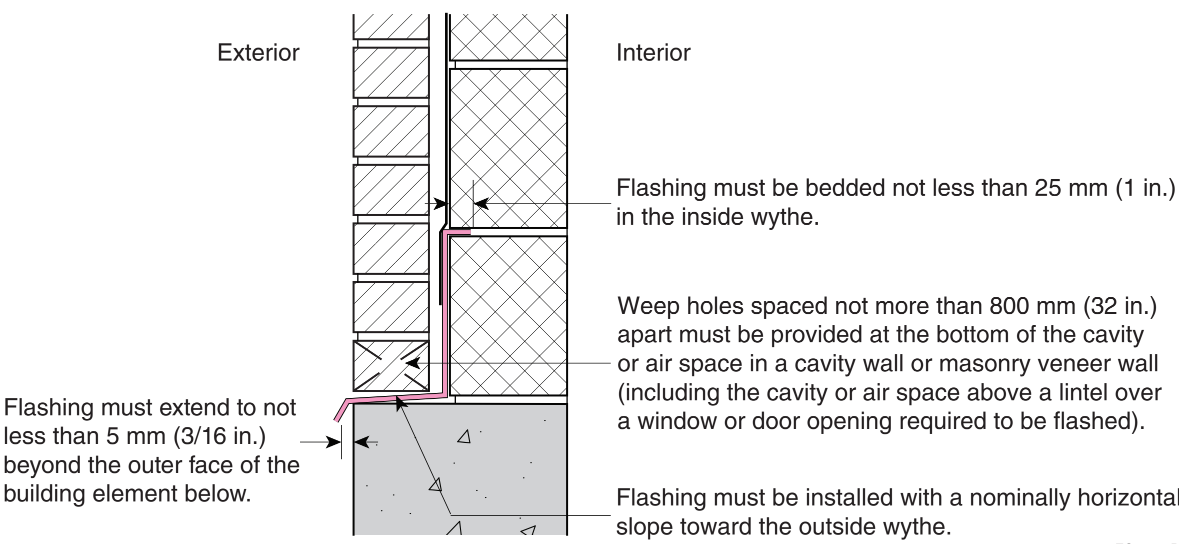


Figure 9.20.-22
Flashing beneath weep holes in cavity walls and masonry veneer over masonry backing walls (NBC Articles 9.20.13.3., 9.20.13.5. and 9.20.13.8.)

The flashing beneath weep holes at the bottom of a cavity or air space in a masonry wall collects any water that passes through the outer wythe and facilitates its evacuation to the exterior. The 5 mm (1/4 in.) extension of the flashing beyond the outer face of the building element below acts as a drip edge, which prevents water from running beneath the flashing and directs the dripping water away from the building element.

9.20.13.6. Flashing for Weep Holes in Masonry Veneer

This Article contains requirements for flashing beneath weep holes in masonry veneer walls. These requirements are intended to minimize moisture-related deterioration resulting from the penetration of water into or through masonry walls, such as damage to the masonry walls from freeze–thaw deterioration or corrosion, wood decay, and damage to interior finishes.

Where a wood-frame wall is sheathed with a sheathing membrane, a non-wood-based rigid exterior insulating sheathing, or a semi-rigid insulating sheathing with an integral sheathing membrane, the flashing must be installed behind the sheathing membrane or insulating sheathing (Figure 9.20.-23).

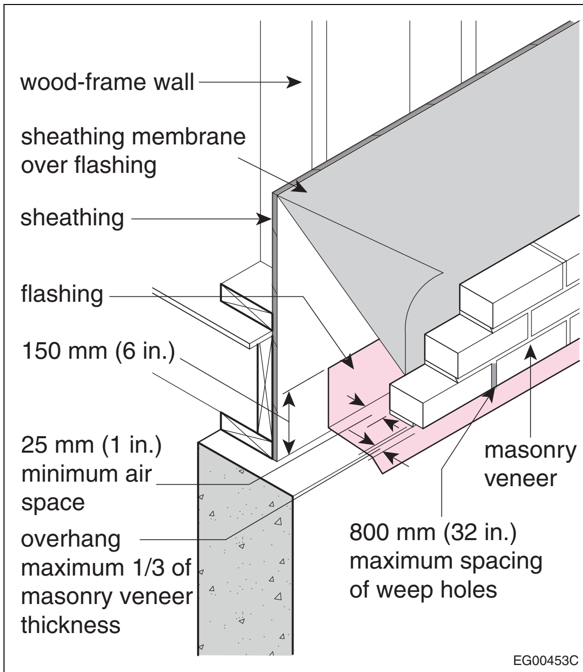


Figure 9.20.-23
Flashing beneath weep holes in masonry veneer over wood-frame walls (NBC Articles 9.20.6.4., 9.20.8.5., 9.20.13.3, 9.20.13.6. and 9.20.13.8.)

9.20.13.7. Flashing Joints

This Article requires that joints in flashing be made watertight. This requirement is intended to minimize moisture-related deterioration resulting from the penetration of water into or through masonry walls, such as damage to the masonry walls from freeze–thaw deterioration or corrosion, wood decay, and damage to interior finishes.

9.20.13.8. Required Weep Holes

This Article indicates the locations where weep holes are required.

Weep holes spaced not more than 800 mm (31 1/2 in.) apart must be provided at the bottom of cavities in cavity walls and at the bottom of cavities or air spaces in masonry veneer walls. This requirement is intended to minimize moisture-related deterioration resulting from the penetration of water into or through masonry walls, such as damage to the masonry walls from freeze–thaw deterioration or corrosion, wood decay, and damage to interior finishes. Weep holes allow any water that passes through the outer wythe in cavity walls and masonry veneer walls to drain to the exterior.

9.20.13.9. Protection of Interior Finish

This Article indicates how interior finishes are to be protected.

In general, exterior masonry walls should have a means of preventing any water that passes through the exposed masonry from reaching interior finishes. As exterior masonry walls other than cavity walls (i.e., solid masonry walls) do not have a cavity to intercept this water, interior finishes need to be protected by another means.

Where exterior masonry walls other than cavity walls (i.e., solid masonry walls) are not protected for their entire height by a roof of a carport or porch, rain may penetrate through the wall to its interior surface and damage the interior finish. Therefore, where the interior finish is a type that may be damaged by moisture, the interior surface of such walls must be covered with a sheathing membrane conforming to CAN/CGSB-51.32-M, “Sheathing, Membrane, Breather Type,” lapped not less than 100 mm (4 in.) at the joints, and flashing must be provided where water will accumulate, to lead it to the exterior. The sheathing membrane (e.g., No. 15 asphalt-saturated felt) should be installed over the masonry wall before it is furred to receive the interior finish. Flashing, which serves as a damp proof course, should be installed at the base of the wall and near the floor level of each storey so that it extends behind the interior surface of the sheathing membrane to prevent both the inward and downward movement of moisture (Figure 9.20.-24).

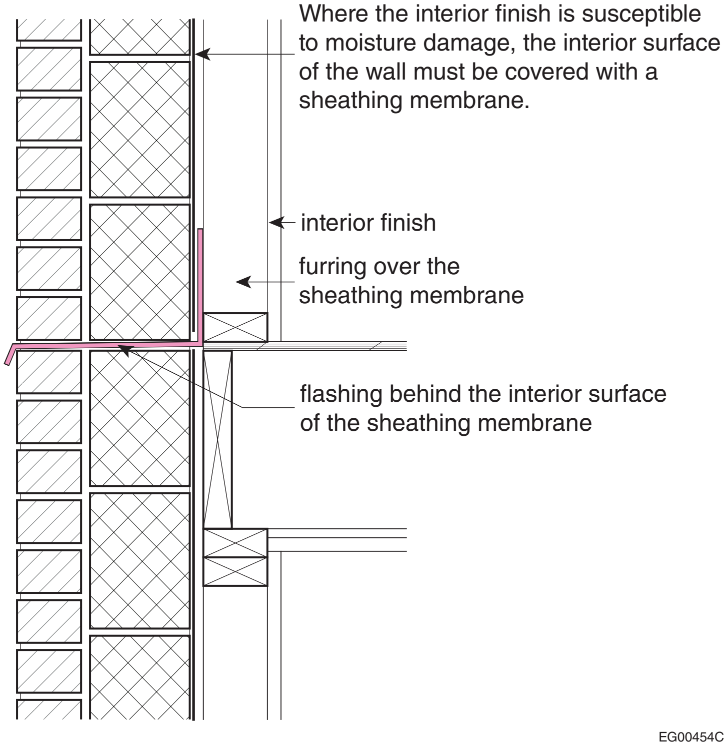


Figure 9.20.-24
Flashing and sheathing membrane for exterior masonry walls other than cavity walls described in NBC Sentence 9.20.13.9.(1)

The sheathing membrane can be omitted if insulation that effectively limits the passage of water (e.g., foamed plastic) is applied by a waterproof adhesive or mortar directly to parged masonry (Figure 9.20.-25). The adhesive or mortar should be applied to form a continuous bond between the masonry and the insulation to prevent water from running down between the masonry and the insulation and collecting in certain locations, where it could freeze and damage the wall, or leaking out through joints in the insulation, where it could damage interior finishes. If applying insulation directly to parged masonry is not practicable because the masonry has an irregular surface, then a sheathing membrane is required (and mechanical fasteners should be used to attach the insulation).

9.20.13.10. Mortar Droppings

This Article requires that cavity walls be constructed so that mortar droppings are prevented from forming a bridge to allow the passage of rainwater across the cavity. This requirement is intended to minimize moisture-related deterioration resulting from the penetration of water into or through masonry walls, such as damage to the masonry walls from freeze–thaw deterioration or corrosion, wood decay, and damage to interior finishes.

Mortar droppings should also be prevented from blocking the weep holes at the bottom of the cavity.

9.20.13.11. Caulking at Door and Window Frames

This Article requires that the junction of door and window frames with masonry be caulked in conformance with NBC Subsection 9.27.4. to restrict the entry of air and rainwater.

9.20.13.12. Drips beneath Window Sills

This Article requires that window sills with no flashing installed beneath them be provided with a drip not less than 25 mm (1 in.) from the wall surface (see Figure 9.27.-6). This requirement is intended to minimize moisture-related deterioration resulting from the penetration of water into or through masonry walls, such as damage to the masonry walls from freeze–thaw deterioration or corrosion, wood decay, and damage to interior finishes

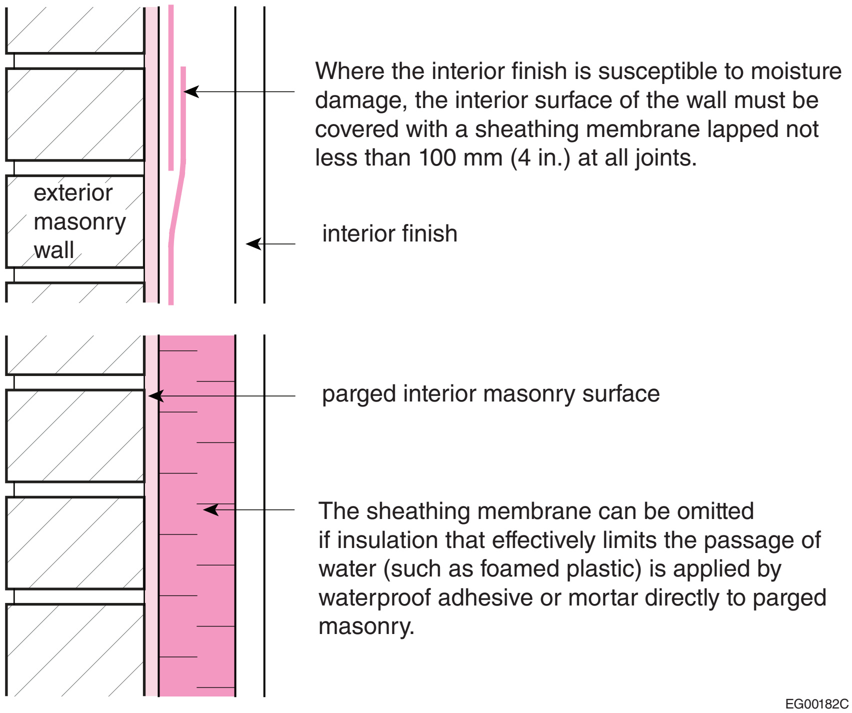


Figure 9.20.-25
Sheathing membrane or insulation for exterior masonry walls other than cavity walls described in NBC Sentence 9.20.13.9.(1)

9.20.14. Protection during Work

9.20.14.1. Laying Temperature of Mortar and Masonry

This Article requires that mortar and masonry be maintained at a temperature not below 5°C (41°F) during installation (i.e., laying) and for at least 48 h after installation. This requirement is intended to prevent mortar from freezing during installation and curing and to allow the mortar to achieve a sufficient set. Low temperatures impede mortar setting and can irreparably diminish the mortar strength.

This Article also specifies that frozen material is not permitted in mortar mix. Ice in the mix water or frozen lumps of aggregate can significantly weaken the mortar and delay the normal setting time.

9.20.14.2. Protection from Weather

This Article requires that the top surface of uncompleted masonry exposed to the weather be completely covered with a waterproofing material when construction is not in progress. This requirement ensures that masonry is protected from rain while it is curing. If it starts to rain before the mortar has set sufficiently to resist water, the rain may wash the mortar out of masonry that is not protected. The joints near the top of masonry walls are the most vulnerable and must be covered if work is suspended.

9.20.15. Reinforcement for Earthquake Resistance

9.20.15.1. Amount of Reinforcement

This Article establishes the minimum amount of steel reinforcement required for masonry walls that must be reinforced (see NBC Article 9.20.1.2.). This reinforcement helps the walls resist earthquake loads.

NBC Part 9 does not specify degrees of earthquake reinforcement. It merely requires that at least a minimum amount of steel reinforcement be provided for masonry buildings above a certain height in locations of intermediate and high seismic hazard. The total cross-sectional area of the steel reinforcement for a wall must be not less than 0.002 times the cross-sectional area of the wall. This reinforcement must be distributed such that not less than one third of the required steel area is installed either horizontally or vertically and the remainder is installed in the other direction.

Example 19 – Steel Reinforcement for Masonry Buildings

A three-storey masonry building with walls 200 mm thick is to be built in a location where $S_a(0.2) > 0.55$. Determine how much steel reinforcement is required.

1. According to NBC Article 9.20.1.2., steel reinforcement is required since $S_a(0.2) > 0.55$ and since the building has three storeys (see Table 9.20.-A).
2. The minimum cross-sectional area of steel reinforcement, A_t, required according to NBC Article 9.20.15.1. for each metre of wall length is:

$$\mathrm{A_t} \geq 1\,000\,\mathrm{mm} \times 200\,\mathrm{mm} \times 0.002$$
$$\mathrm{A_t} \geq 400\,\mathrm{mm}^2$$

3. If the masonry courses are 200 mm high and two steel rods 6 mm in diameter (28.3 mm² in area) are used in each horizontal joint, the cross-sectional area of steel reinforcement installed horizontally, A_h, per metre of wall height is:

$$\mathrm{A_h} = \frac{1\,000\,\mathrm{mm}}{200\,\mathrm{mm}} \times 2 \times 28.3\,\mathrm{mm}^2$$
$$\mathrm{A_h} = 283\,\mathrm{mm}^2$$

4. The minimum cross-sectional area of steel reinforcement to be installed vertically, A_v, per metre of wall length is determined from A_h as follows:

$$\mathrm{A_v} \geq 400\,\mathrm{mm}^2 - 283\,\mathrm{mm}^2$$
$$\mathrm{A_v} \geq 117\,\mathrm{mm}^2$$

However, according to NBC Article 9.20.15.1., A_v must not be less than 1/3 × A_t:

$$\mathrm{A_v} \geq \frac{1}{3}\left(400\,\mathrm{mm}^2\right)$$
$$\mathrm{A_v} \geq 133\,\mathrm{mm}^2$$

Therefore, the minimum number of vertical steel rods, N, per metre is:

$$\mathrm{N} \geq \frac{133\,\mathrm{mm}^2}{28.3\,\mathrm{mm}^2}$$
$$\mathrm{N} \geq 4.7$$

The maximum spacing of vertical steel rods, S, is:

$$\mathrm{S} \leq \frac{1\,000\,\mathrm{mm}}{4.7}$$
$$\mathrm{S} \leq 213\,\mathrm{mm}$$

Vertical steel rods installed at a spacing of 200 mm (8 in.) on centre would satisfy the vertical reinforcement requirement of NBC Article 9.20.15.1.

9.20.15.2. Installation Standard

This Article states that required reinforcement must be installed in conformance with the requirements for reinforced masonry contained in CSA A371, "Masonry Construction for Buildings."

9.20.16. Corrosion Resistance

9.20.16.1. Corrosion Resistance of Connectors

This Article states that carbon steel connectors required to be corrosion-resistant must be galvanized to at least the minimum standards in NBC Table 9.20.16.1. This requirement is intended to ensure that steel ties, anchors, connectors and rods used as connectors to provide structural stability in masonry construction will have a service life comparable to that of the building.

9.20.17. Above-Ground Flat Insulating Concrete Form Walls

ICF walls are concrete walls that are cast into polystyrene forms, which remain in place after the concrete has cured. Flat ICF walls are solid ICF walls in which the concrete is of uniform thickness over the height and width of the wall. This Subsection contains prescriptive requirements for generic ICF walls. Engineered ICF wall systems and ICF wall systems positively evaluated by CCMC are acceptable as alternative solutions.

9.20.17.1. Thickness of Flat Insulating Concrete Form Walls

This Article requires that the thickness of concrete in flat ICF walls not in contact with the ground be not less than 140 mm (5 1/2 in.). This requirement is intended to ensure that the walls will have adequate strength and stability for the expected loads. The thickness must be constant over the entire height of the wall (see NBC Article 9.15.4.2. for thickness requirements for flat ICF foundation walls).

9.20.17.2. Reinforcement for Flat Insulating Concrete Form Walls

This Article contains reinforcement requirements for flat ICF walls, which are intended to ensure that the walls will have adequate strength and stability for the expected loads. Flat ICF walls must be reinforced with 10M bars in both the vertical and horizontal directions (Figure 9.20.-26). The bars must be placed in the middle third of the wall cross-section.

9.20.17.3. Openings in Non-Loadbearing Flat Insulating Concrete Form Walls

This Article contains requirements for openings in non-loadbearing flat ICF walls, which are intended to ensure that the openings do not compromise the strength and stability of the walls.

No openings are permitted within 1 200 mm (4 ft.) of interior and exterior corners of exterior non-loadbearing flat ICF walls (Figure 9.20.-27). The minimum depth of concrete in portions of walls above openings in interior and exterior non-loadbearing flat ICF walls is 200 mm (8 in.) across the width of the opening. Openings that are more than 600 mm (2 ft.) but not more than 3 000 mm (10 ft.) in width must be reinforced at the top and bottom with one 10M bar. Openings that are more than 3 000 mm (10 ft.) in width must be reinforced on all four sides with two 10M bars.

9.20.17.4. Openings in Loadbearing Flat Insulating Concrete Form Walls

This Article contains requirements for openings in loadbearing flat ICF walls.

No openings are permitted within 1 200 mm (4 ft.) of interior and exterior corners of exterior loadbearing flat ICF walls.

Lintels conforming with NBC Span Table 9.20.17.4.-A, 9.20.17.4.-B or 9.20.17.4.-C must be provided over openings wider than 900 mm (3 ft.) in loadbearing flat ICF walls (Figure 9.20.-28). The lintels should be capable of transferring the expected loads to the wall portions adjacent to the openings. For openings wider than 1 200 mm (4 ft.), lintels must be reinforced for shear with 10M stirrups at a maximum spacing of half the distance from the bottom reinforcing bar in the lintel to the top of the lintel.

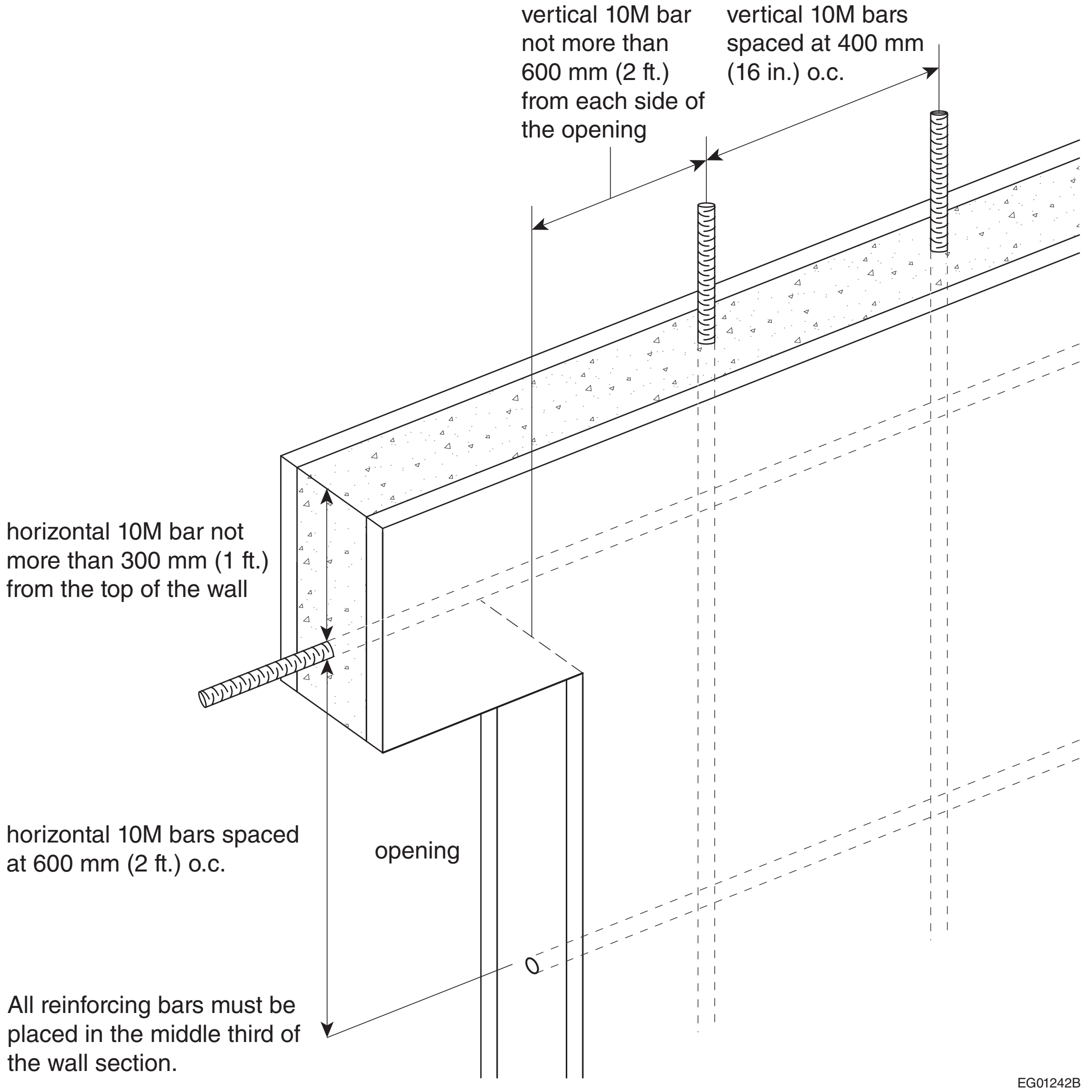


Figure 9.20.-26
Reinforcement for flat ICF walls

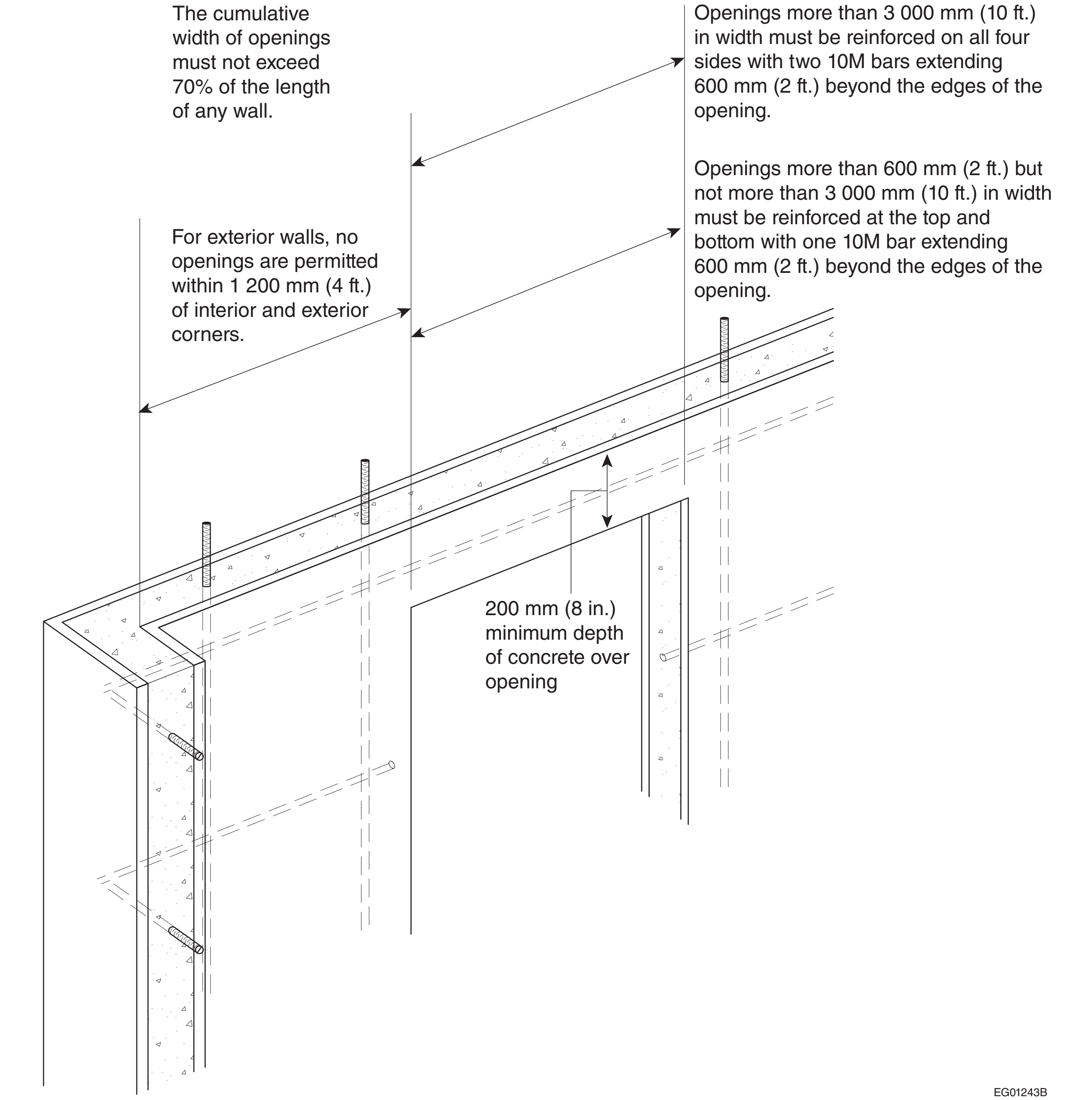


Figure 9.20.-27
Openings in non-loadbearing flat ICF walls

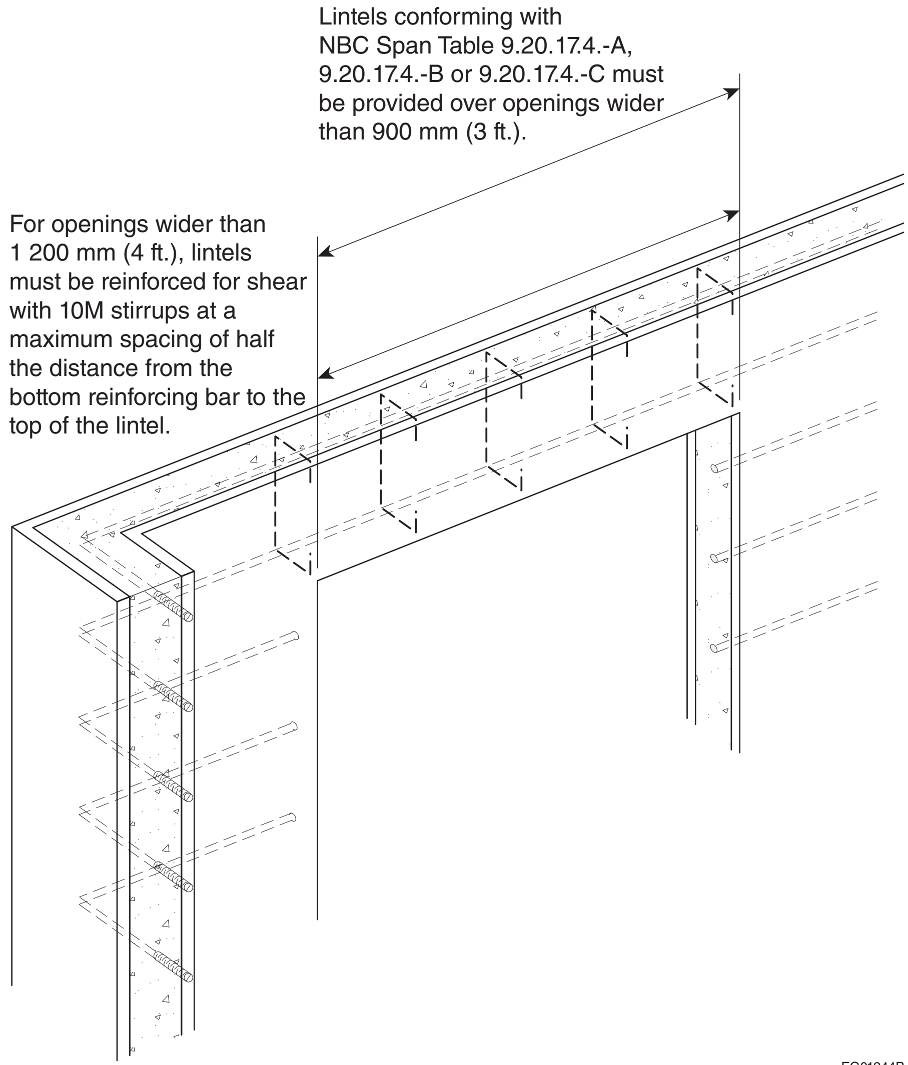


Figure 9.20.-28
Openings in loadbearing flat ICF walls

9.20.17.5. Framing Supported on Flat Insulating Concrete Form Walls

This Article contains requirements for framing supported on flat ICF walls. The connections at intersections between flat ICF walls and floor framing should be capable of transferring the expected loads. Floor framing supported on the side of flat ICF walls must be anchored as shown in Figure 9.20.-29. Maximum spacings for anchor bolts used to secure ledger boards to ICF walls for the support of floor framing are provided in NBC Table 9.20.17.5.

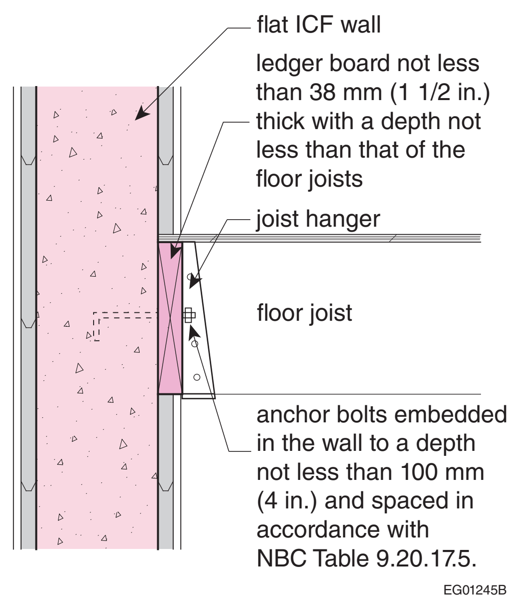


Figure 9.20.-29
Anchoring of floor framing on the side of flat ICF walls

9.20.17.6. Anchoring of Roof Framing to the Top of Flat Insulating Concrete Form Walls

This article contains requirements for the anchoring of roof framing to the top of flat ICF walls. The connections at intersections between flat ICF walls and roof framing should be capable of transferring the expected loads. Roof framing supported on the top of flat ICF walls must be fixed to the top plates, which must be anchored to the walls with anchor bolts placed in the centre of the wall and embedded not less than 100 mm (4 in.) into the concrete (Figure 9.20.-30). The bolts must be not less than 12.7 mm (1/2 in.) in diameter and spaced at not more than 1 200 mm (4 ft.) on centre.

9.20.17.7. Protection from Precipitation and Damage

This Article requires that above-ground flat ICF walls be protected from precipitation and damage in accordance with NBC Section 9.27.

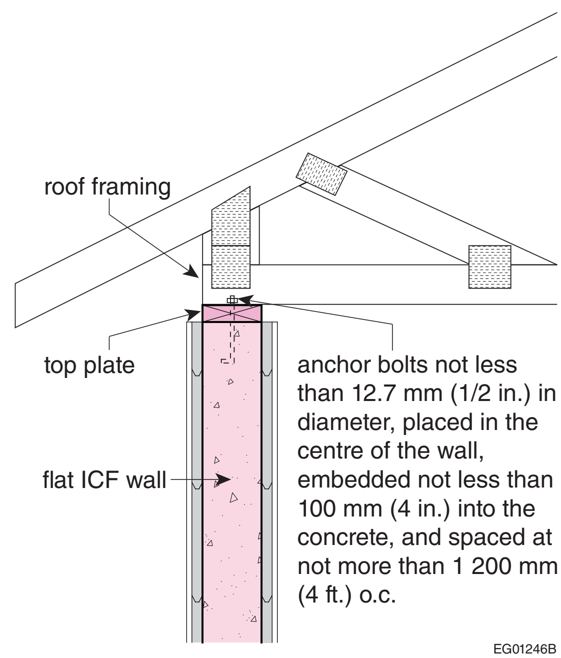


Figure 9.20.-30
Anchoring of roof framing to the top of flat ICF walls

Section 9.21. Masonry and Concrete Chimneys and Flues

Introduction

Chimneys are used to exhaust the by-products from the combustion of a fuel such as oil, gas, or wood. The chimney, by definition, is the entire structure provided to allow the exhaust of unwanted fumes or smoke. The liner is the inner surface of a chimney that is exposed to the exhausted by-products. The passage through which these fumes or smoke travel is referred to as a flue.

9.21.1. General

9.21.1.1. Application

This Article limits the application of the prescriptive requirements in NBC Section 9.21. Beyond this application, chimney and flue pipes require specialized design for the particular equipment served. This is specified in the installation standards applicable to the equipment.

Chimneys are subjected to a wide range of temperatures, as well as to corrosive flue gases, depending on the types of appliances they vent. Many of these exposure conditions require specialized design by experts. Larger chimneys also require individual engineering analysis to ensure their structural stability when subjected to wind and seismic loads.

The simplified prescriptive requirements in NBC Part 9 are restricted to rectangular chimneys that are not more than 12 m (40 ft.) in height, are constructed of masonry or concrete, and serve fireplaces or appliances having a total combined output of 120 kW (410 000 Btu/h) or less. These requirements do not apply to circular chimneys or smoke stacks normally associated with industrial or commercial installations. The latter must be designed in conformance with the requirements in NBC Parts 4 and 6. Vents and flues serving all other appliances such as stoves, cooktops, ovens and space heaters need to conform to NBC Subsection 9.33.10.

Solid-fuel burning appliances have a tendency to create creosote and soot deposits that can lead to chimney fires. Where prefabricated metal chimneys are used for solid-fuel burning appliances (including fireplaces), they must conform to the requirements of NBC Article 9.33.10.2.

Chimneys serving gas- or oil-burning equipment do not generally produce creosote and soot deposits that can lead to high-temperature chimney fires, so these systems can safely use lighter-duty metal chimneys or vents as specified in their respective installation codes (see NBC Article 9.21.3.6.).

9.21.1.2. Chimney or Flue Pipe Walls

This Article requires walls of any chimney or flue pipe to be constructed so as to be smoke and flame-tight. This is to keep flue gases from escaping from the chimney or flue pipe and creating a potential health or fire hazard.

9.21.2. Chimney Flues

9.21.2.1. Chimney Flue Limitations

This Article places limitations on chimney flues to avoid flue gas spillage into occupied space. The draft demands from a fireplace or incinerator may be sufficiently great to interfere with the draft for other connected appliances. This could cause the appliance to operate inefficiently, and even cause flue gas spillage into the building, where it could create a health hazard. For this reason, a chimney serving a fireplace or incinerator cannot serve any other appliance.

Flues serving solid-fuel-burning appliances such as wood stoves, prefabricated fireplaces and space heaters must conform to CSA B365, "Installation Code for Solid-Fuel-Burning Appliances and Equipment," and to the flue design requirements depending on the type of fuel used.

9.21.2.2. Connections of More Than One Appliance

This Article contains the requirements for the chimney flues that are connected to more than one appliance. These requirements are intended to prevent overloading the flue capacity, which could lead to back drafts and spillage of flue gas into the building. When more than one appliance is connected to the same flue, one appliance may affect the performance of another. Fireplaces and incinerators, for example, can create large volumes of flue gas that may interfere with the operation of other appliances.

In general, each appliance is required to have its own flue (Figure 9.21.-1). The connection of more than one appliance to a single flue is permitted subject to them being located on the same storey.

The requirement that the flue connection for solid-fuel burning flue appliances be at a lower level than those for other appliances is based on safety. Creosote dripping at the end of the flue connection entering the chimney flue could drip on the flue connection of the other flue appliance and cause a blockage, which could result in a fire hazard.

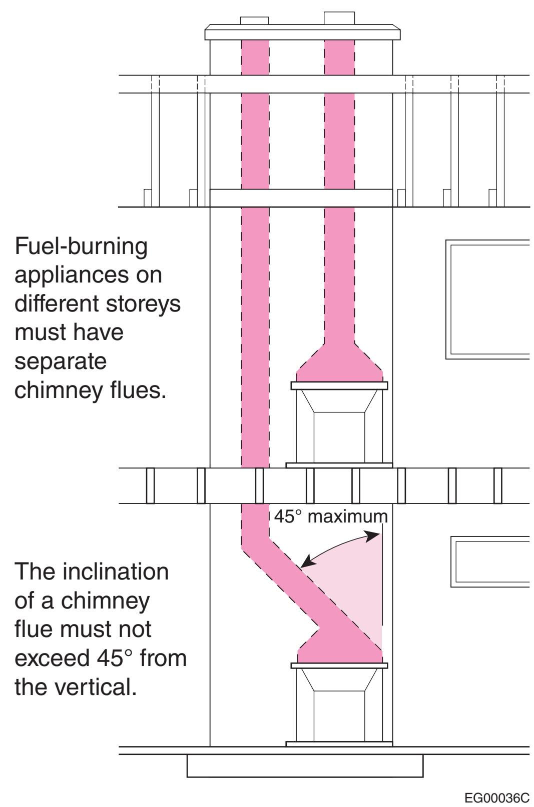


Figure 9.21.-1
Chimney flue limitations (NBC Articles 9.21.2.2. and 9.21.2.3.)

9.21.2.3. Inclined Chimney Flues

This Article limits the inclination of chimney flues to ensure the free passage of exhaust products, minimize soot accumulation, and facilitate chimney cleaning. To do this, a chimney flue must not be inclined more than 45° to the vertical (Figure 9.21.-1).

9.21.2.4. Size of Chimney Flues

This Article lists the requirements for the size of chimney flues. The chimney flue is the opening in the chimney that carries the flue gases. Sufficient flue gas capacity is needed in a chimney flue to vent the products of combustion from the appliance served to the exterior. The capacity of a chimney to vent an appliance depends on the size of the flue. The greater the heat output of the appliance, the greater the volume of flue gas that has to be vented, and hence the greater the flue area must be. Capacity is also a function of the height of the flue and flue gas temperature, since these affect the natural draft that moves the flue gas.

The cross-sectional area of the chimney flue is required to be at least equal to that of the flue pipe from the appliance that is connected to it. Rectangular flue liners range in size from 200 × 200 to 400 × 400 mm (8 × 8 to 16 × 16 in.), while circular liners vary from 116 to 448 mm (4 1/2 to 17 5/8 in.) in diameter, depending on the fireplace opening and chimney height. The size of rectangular liners is normally expressed as a nominal external dimension, while for circular liners it is an internal size.

The rectangular flue sizes in NBC Section 9.21. are based on standard masonry practices, as well as on the capacity of the flues to adequately vent the appliances. Small chimneys are ordinarily built with six bricks in each course. This will accommodate a small liner with a 200 × 200 mm (8 × 8 in.) flue. Larger chimneys generally have seven bricks per course and this accommodates a 200 × 300 mm (8 × 12 in.) flue liner.

9.21.2.5. Fireplace Chimneys

This Article lists the required size of fireplace chimneys that must provide sufficient flue gas capacity to vent the products of combustion from a fireplace to the exterior. As the height of a chimney flue is increased, its draft will also be increased, and hence its capacity to vent flue gas. The stipulated minimum sizes allow flue gases to vent adequately without building up pressure and venting into a room space. If a flue becomes too large, the buoyancy of the heated air is reduced, and there will be a tendency for the heated air to use the building as a flue.

The size of a chimney flue for a masonry fireplace must conform to either NBC Table 9.21.2.5.-A or Table 9.21.2.5.-B. Oval chimney flues are also permitted. See NBC Article 9.21.2.6.

9.21.2.6. Oval Chimney Flues

This Article places limitations on the shape of oval chimney flues. As the shape of an oval chimney becomes flatter, its perimeter (and boundary flow area) increases with respect to its cross-sectional area, making it less efficient in transporting flue gases. For this reason, oval flues are permitted where the width is not less than two-thirds the longer dimension.

9.21.3. Chimney Lining

9.21.3.1. Lining Materials

This Article requires that masonry or concrete chimneys have a lining made of certain material. Linings provide conduits for conveying flue gases that will resist the heat and the corrosive effects of flue gases and provide a smooth surface that will not unduly restrict the flow of flue gases to the exterior. Every chimney is required to have a liner extending from below the lowest flue pipe connection to above the chimney cap. Most liners consist of rectangular clay tile, although firebrick is used in larger chimneys with higher flue-gas temperatures. Stainless steel is also permitted and is most often used for upgrading existing chimneys when higher efficiency appliances are installed.

Liners shield the surrounding masonry from the corrosive effects of flue gases. They also streamline the interior surface of the flue and, thereby, reduce friction losses, permitting easier cleaning of accumulated creosote.

As appliances have become more efficient, flue-gas temperatures have become cooler. If the flue gas is cooled below its dew point (from 50 to 60°C (122 to 140°F)), moisture will condense and run down the liner. Exterior chimneys are not desirable, because they operate cooler than interior chimneys and are even more susceptible to condensation on the flue liner.

9.21.3.2. Joints in Chimney Liners

This Article contains requirements for joints in chimney liners that must be sealed to provide a gas-tight conduit for exhaust products. A second purpose is to restrict the leakage of flue gas condensate into the surrounding masonry. Such condensate can be corrosive to concrete or mortar and, by keeping the masonry wet, will make it susceptible to damage from freezing and thawing.

The joints of liners must be sealed to prevent any escape of smoke, fumes, or condensate into the assembly of the chimney. The mortar joints of clay or firebrick liners must be struck flush to make a smooth continuous surface that will reduce the build-up of soot on the liner and facilitate future cleaning.

Liquid-tight joints are difficult to achieve when typical square-end clay tile liners are used. Such liners are, therefore, required to be laid in a full bed of mortar as each liner section is added. Air-setting refractory mortar or Portland cement/sand mortar have higher resistance to flue-gas damage than does ordinary masonry mortar, and both are permitted for higher flue-gas temperatures (NBC Article 9.21.3.9.).

Refractory mortar is not permitted with oil or gas appliances, however, because of their low gas temperatures, which inhibit the mortar's setting. Where liner sections have to be cut, this should be done with a masonry saw to provide even joints. Preferably, such liners should have bevelled ends or bell-and-spigot joints so that condensate will not run out as it runs down the liner (although this is not specifically required).

9.21.3.3. Clay Liners

This Article requires, through reference to a standard, that clay flue liners be able to withstand the effects of flue gas temperatures. Clay liners must comply with CAN/CSA-A324-M, "Clay Flue Liners," and must be at least 15.9 mm (5/8 in.) thick, and able to resist softening or cracking at temperatures up to 1 100°C (2 102°F).

9.21.3.4. Firebrick Liners

This Article requires, through reference to a standard, that firebrick flue liners be able to resist the heat and corrosive effects of flue gases. Firebrick liners must comply with ASTM C 27, “Fireclay and High-Alumina Refractory Brick.” High temperature cement mortar for these liners must comply with CAN/CGSB-10.3, “Air Setting Refractory Mortar.”

9.21.3.5. Concrete Liners

This Article requires, through reference to a standard, that concrete flue liners be able to resist the heat and corrosive effects of flue gases. Concrete liners must conform to Clause 4.2.6.4. of CAN/CSA-A405-M, “Design and Construction of Masonry Chimneys and Fireplaces.”

9.21.3.6. Metal Liners

This Article requires that metal flue liners be able to resist the heat and corrosive effects of flue gases. Metal liners must be constructed of not less than 0.3 mm (30 gauge) stainless steel. Metal liners may be used only in chimneys serving gas- or oil-burning appliances, but under the provisions of NBC Division A, masonry chimneys with metal liners may be permitted to serve solid-fuel-burning appliances if tests show that such liners will provide an equivalent level of safety.

9.21.3.7. Installation of Chimney Liners

This Article requires that chimney liners be installed when the surrounding masonry or concrete is placed. Joints between flue liners should be constructed to resist the leakage of condensate into the surrounding masonry.

9.21.3.8. Spaces between Liners and Surrounding Masonry

This Article requires that a space be provided between liners and masonry. This space should not be filled with mortar. Only a sufficient amount of mortar should be placed between the tile and the mortar to stabilize each section at each joint. The space reduces the exterior surface temperature of the chimney, and allows the liner to expand vertically and horizontally, without cracking the masonry. If a liner is subjected to a serious thermal shock, such as can happen in a chimney fire, the space allows the liner to crack without damaging the surrounding masonry. This space should be at least 10 mm (3/8 in.) wide (Figure 9.21.-2).

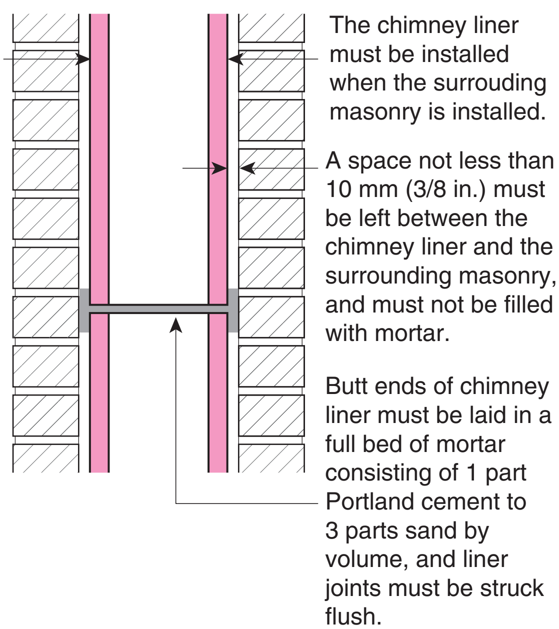


Figure 9.21.-2
Space between chimney liners and surrounding masonry

9.21.3.9. Mortar for Chimney Liners

This Article requires that only mortar suitable for high-temperature conditions be used. Chimneys for solid-fuel burning appliances generally operate at a temperature high enough to cause refractory mortar to set properly.

Chimney liners used for solid-fuel-, gas- or oil-burning appliances must be laid in a bed of mortar consisting of 1 part Portland cement to 3 parts sand by volume. As an alternative, chimney liners used for solid-fuel-burning appliances may use mortar that conforms to CAN/CGSB-10.3, “Air Setting Refractory Mortar.”

9.21.3.10. Extension of Chimney Liners

This Article states the limits for chimney liner extensions. Chimney liners are designed to be enclosed by masonry and are not intended to be free standing above the chimney cap, except for a nominal amount to keep rainwater flowing across the cap from running into the chimney flue.

A chimney liner is required to extend at least 200 mm (8 in.) below the lowest flue pipe connected to it. The liner is also required to extend at least 50 mm (2 in.) and not more than 100 mm (4 in.) above the chimney cap. Figure 9.21.-3 shows these and other requirements for liners.

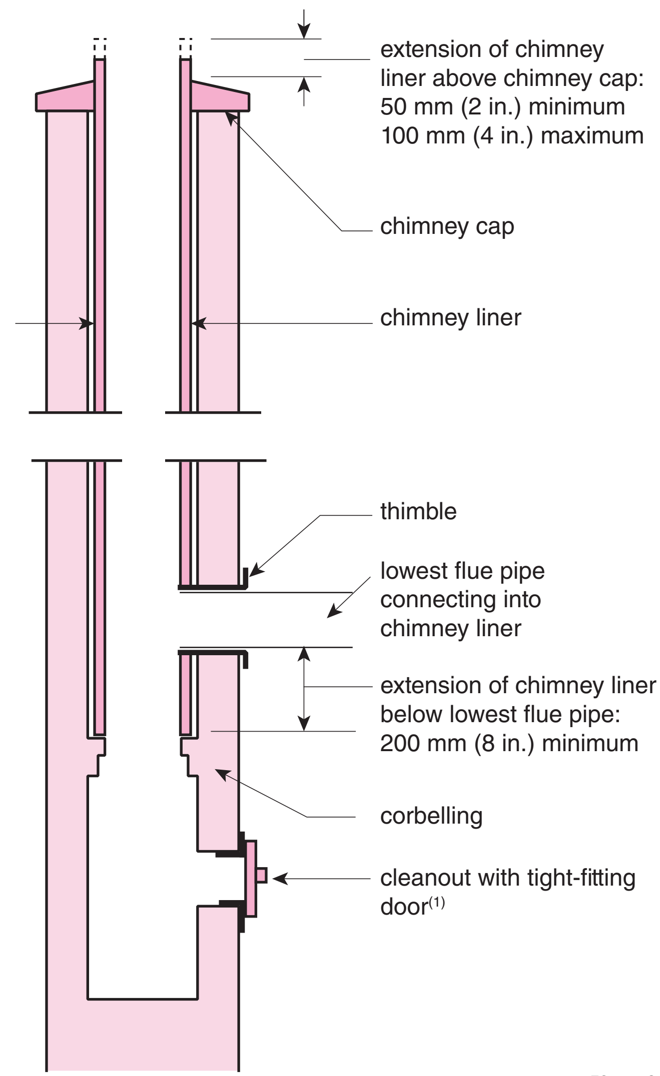


Figure 9.21.-3
Chimney liner extension requirements

Note to Figure 9.21.-3:

(1) Clearance of not less than 150 mm (6 in.) must be provided between a cleanout opening and combustible material (NBC Sentence 9.21.5.1.(2)).

9.21.4. Masonry and Concrete Chimney Construction

9.21.4.1. Unit Masonry

This Article refers to NBC Section 9.20. Chimneys of masonry construction must be durable and able to provide adequate resistance to wind forces and rain penetration.

9.21.4.2. Concrete

This Article refers to NBC Section 9.3. and requires that chimneys of concrete construction be durable and able to provide adequate resistance to wind forces, earthquake and rain penetration. A second purpose is to provide footings of sufficient strength to carry superimposed loads. Concrete used for chimney construction must conform to NBC Section 9.3.

9.21.4.3. Footings

This Article requires that footings spread the weight of concrete and masonry chimneys over a sufficient area of soil to avoid excessive settlement of the chimney that could result in chimney damage. Footings for chimneys need to be constructed in accordance with NBC Subsection 9.15.3.

9.21.4.4. Height of Chimney Flues

This Article sets the minimum height requirements for chimney flues to reduce the likelihood of downdrafts due to air currents close to the roof surface, which could cause backdrafting of the appliances served by a chimney. Air turbulence close to the roof surface can cause downdrafts in a chimney.

To minimize downdrafts, a chimney must extend at least 900 mm (36 in.) above the highest point of contact with the roof, as shown in Figure 9.21.-4. A chimney must also be not less than 600 mm (24 in.) above any part of the roof that is within 3 m (9 ft. 10 in.) of the chimney.

9.21.4.5. Lateral Stability

This Article contains the requirements for constructing and bracing a chimney which should have sufficient structural stability to resist anticipated wind forces. Exterior chimneys sometimes have to be extended a substantial distance above a roof (Figure 9.21.-4) and, as a result, need to be braced against wind action. Chimneys that do not extend more than 3.6 m (11 ft. 10 in.) above their adjacent roofs or walls and have no horizontal exterior dimension less than 400 mm (16 in.) are not required to be braced. All other chimneys need to be braced in accordance with NBC Subsection 4.3.2. to provide lateral stability for wind loads.

Where a chimney is fastened to a house framing with metal anchors, in accordance with CSA A370, "Connectors for Masonry," it is considered to have adequate lateral support. The portion of the chimney stack above the roof is considered as free standing and may require additional lateral support.

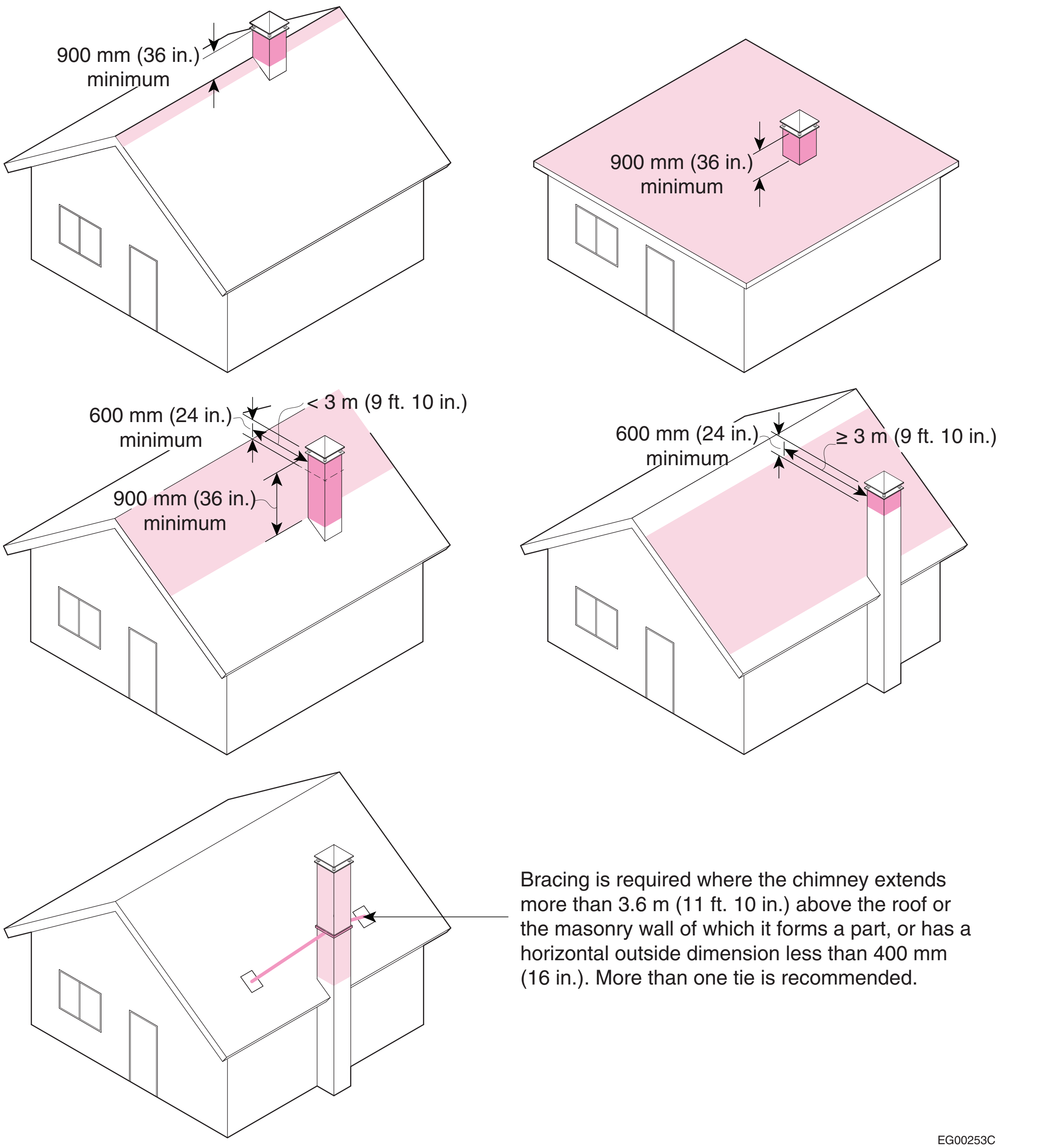


Figure 9.21.-4
Minimum heights of masonry and concrete chimneys

9.21.4.6. Chimney Caps

This Article requires that chimney caps limit the entry of rainwater into the top of masonry construction via cracks between the masonry units and between the masonry and chimney liner. Exposure of chimney masonry to rain can make it vulnerable to damage from freeze-thaw cycles. Chimneys must be protected with chimney caps to drain any rainwater away from the liner.

These caps are commonly made of concrete, either precast or cast-in-place, extending beyond the masonry units, with a drip edge so that water will not run under the cap. Sloping bricks can also be used, but these must be protected underneath by flashing to prevent water from entering the masonry below. Metal caps are also permitted and are also required to have drip edges to prevent water from wicking back beneath them.

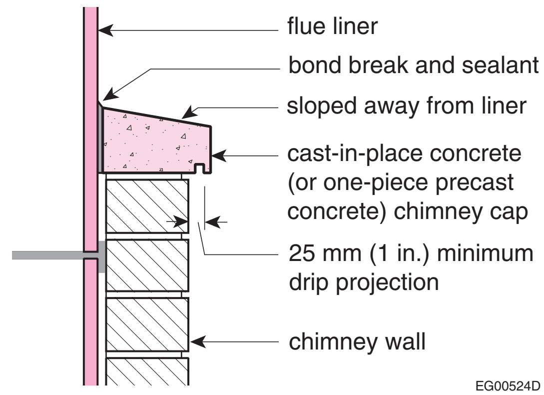


Figure 9.21.-5
Chimney cap requirements: cast-in-place concrete

Chimney caps must be sloped to allow water run-off, and be shaped to provide a drip not less than 25 mm (1 in.) from the chimney wall on the underside of the capping projection. Cast-in-place concrete caps must have a bond break between the cap and the liner to allow differential movement between the cap and the liner, and this joint must be sealed (Figure 9.21.-5). One-piece precast concrete caps should be installed similarly.

Jointed precast concrete or masonry caps require a flashing that runs from the liner out under the cap to form a drip edge (Figure 9.21.-6).

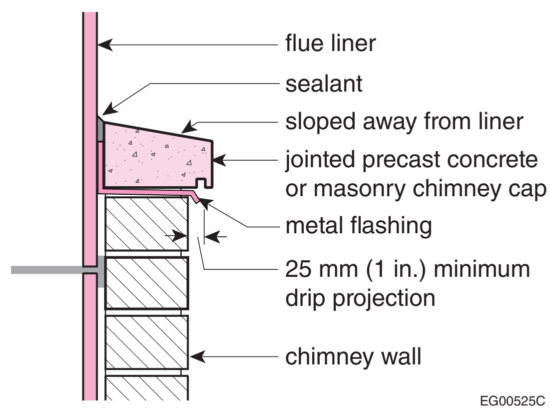


Figure 9.21.-6
Chimney cap requirements: jointed precast concrete or masonry

9.21.4.7. Cleanout

This Article requires that a cleanout opening be provided at the base of the chimney flue. Over time, the operation of a chimney will result in certain products of combustion, such as soot and creosote, being dislodged from the flue liner and collecting at the bottom of the flue, particularly during chimney cleaning. This material, being combustible, can create a fire hazard if ignited by a chimney fire. Provision is therefore made to clean out this residue by providing an access door near the bottom of the flue.

A tight-fitting metal door must be provided. Although cleanouts are required at the bottom of every chimney flue, in the case of fireplaces, the bottom of the flue opens to the fire chamber, making such cleanouts unnecessary. This should not be confused with an ash-dump that is sometimes provided in the fireplace floor.

9.21.4.8. Wall Thickness

This Article requires a minimum wall thickness for masonry chimneys. This is to provide chimneys of sufficient stability to resist anticipated wind forces and to reduce the outside surface temperature of chimneys to the point where they will not ignite combustible material at the designated clearances specified elsewhere in the NBC. Walls of masonry chimneys need to be constructed with sold masonry units at least 75 mm (3 in.) thick.

9.21.4.9. Separation of Flue Liners

This Article requires that flue liners in the same chimney be separated to keep joints in chimney liners from opening as a result of lateral instability. Open joints could allow the escape of flue gas and condensate into the masonry, and cause its deterioration from freezing and thawing action. An additional purpose is to make flues independent from the action of an adjacent flue should one flue liner fail.

Flue liners in the same chimney must be separated by not less than 75 mm (3 in.) of masonry or concrete, exclusive of clay liners, or 90 mm (3 1/2 in.) of firebrick where firebrick liners are used (Figure 9.21.-7). Where two liners are installed in the same chimney, they must be installed to resist lateral movement.

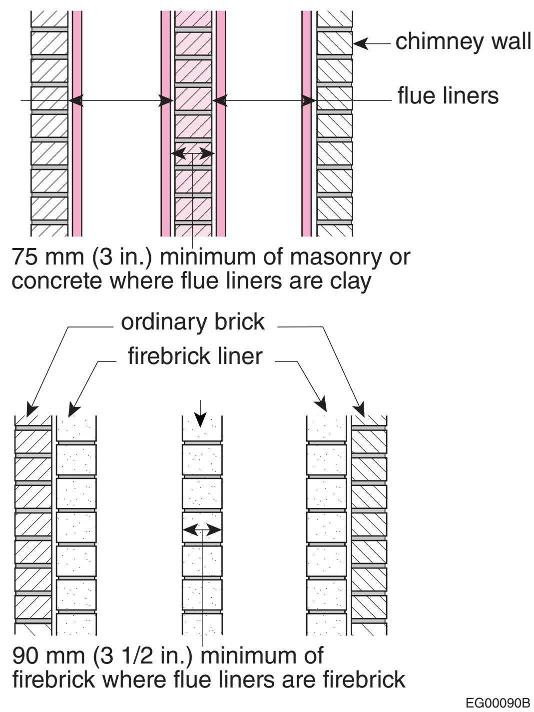


Figure 9.21.-7
Separation between liners

9.21.4.10. Flashing

This Article requires that the junctions between a masonry or concrete chimney and its adjacent assemblies be flashed to prevent the entry of rainwater or snow-melt into the interior space of the building and to minimize the entry of water into the structural assemblies. Water ingress can cause premature failure of exterior finishes through freeze-thaw stresses and deterioration of structural wood elements, both of which could ultimately lead to the collapse of these building elements. Water ingress could also lead to damage of interior finishes.

9.21.5. Clearance from Combustible Construction

9.21.5.1. Clearance from Combustible Materials

This Article requires a minimum clearance to prevent combustible materials adjacent to a chimney from reaching a level where the materials could be ignited. A space between the chimney and the adjacent combustible materials allows air to circulate and can dissipate much of the heat radiated from the chimney surface. Chimneys on the exterior of a building are able to lose heat more rapidly to the surrounding air than are interior chimneys. Chimney fires resulting from a build-up of creosote and soot are of particular concern, since these cause temperatures much in excess of normal operating temperatures.

A minimum of 50 mm (2 in.) of clearance is required for interior chimneys and 12 mm (1/2 in.) of clearance for exterior chimneys as shown in Figure 9.21.-8. An exterior chimney is one that has at least one surface exposed to the outside atmosphere or unheated space over the majority of its height. All other chimneys can be considered to be interior.

Metal cleanout doors that are required to be installed at the base of the flue can also be a fire hazard, particularly if they are not tight fitting. Hot debris from chimney fires can build up adjacent to the door, allowing it to radiate considerable heat. No combustible material should, therefore, be installed within 150 mm (6 in.) of such doors.

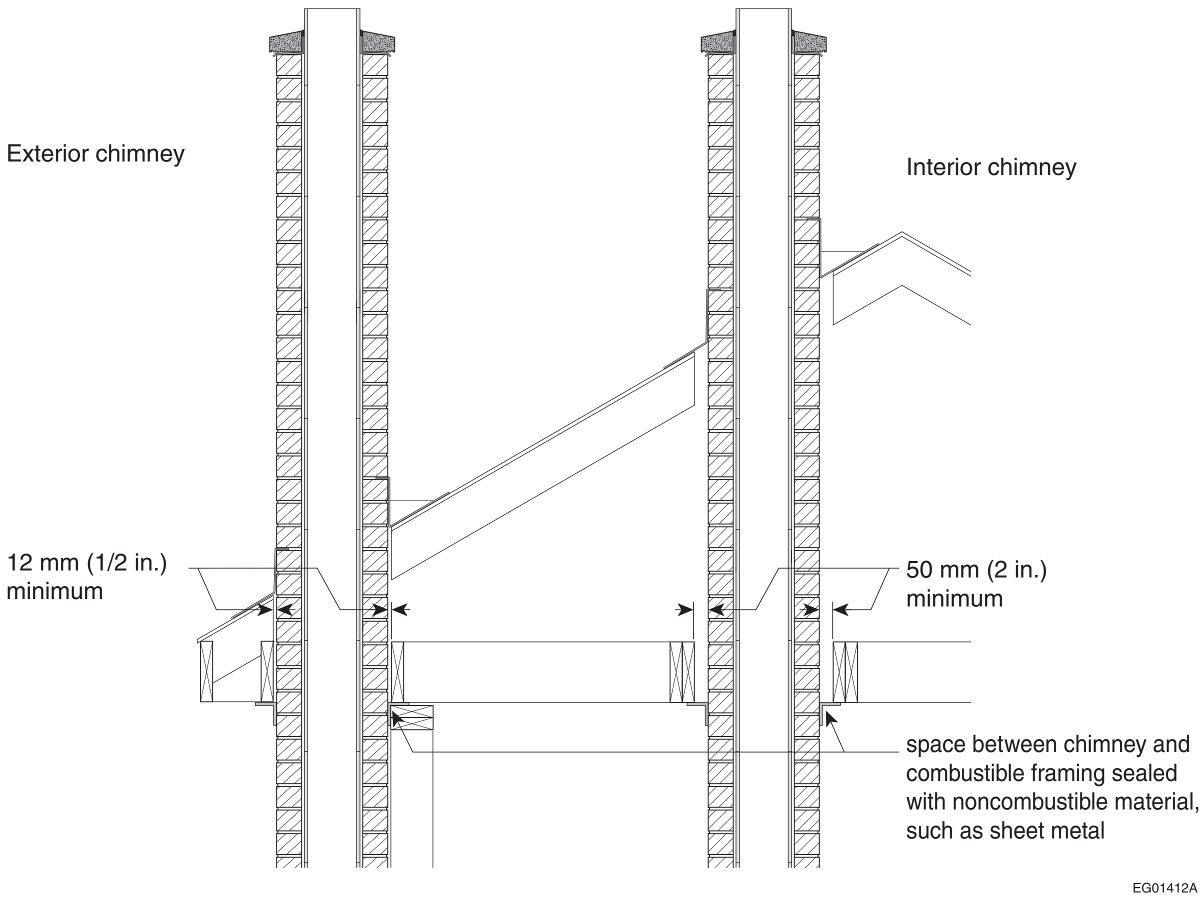


Figure 9.21.-8
Required clearances from combustible materials

Combustible subflooring and finish flooring are allowed to be closer to the chimney than is framing, because there is somewhat less heat build-up. This is due to the heat dissipation to the room air and the small depth of the exposed wood as compared to the floor framing. Wooden plaster grounds, trim or other combustible material should not be in contact with the masonry. Flooring materials require a minimum clearance of at least 12 mm (1/2 in.) from chimneys, as shown in Figure 9.21.-9.

9.21.5.2. Sealing of Spaces

This Article requires that the spaces between masonry or concrete chimneys and combustible framing be sealed to control the spread of fire from one level of a building to another. Where a chimney penetrates a floor assembly, the resulting gap between the framing and the chimney has to be fire-stopped with noncombustible material to prevent fire spread. This material can be located at the top or bottom (preferred) of the space, but not both. If fire-blocking is provided at the top and bottom, or if the space is filled, the temperature of nearby combustible materials can be increased significantly because air cannot circulate.

9.21.5.3. Support of Joists or Beams

This Article allows joists or beams to be supported on masonry walls that enclose chimney flues. In some cases, such as in large masonry fireplaces, it may be necessary to rely on the masonry for the support of combustible joists or beams, either because of the size of the fireplace or the layout of the room. The provision for a clearance between the chimney and framing is waived in such cases, if there is at least 290 mm (12 in.) of solid masonry between the wood and the flue. This thickness reduces the surface temperature of the masonry to the point where it will not ignite combustible materials.

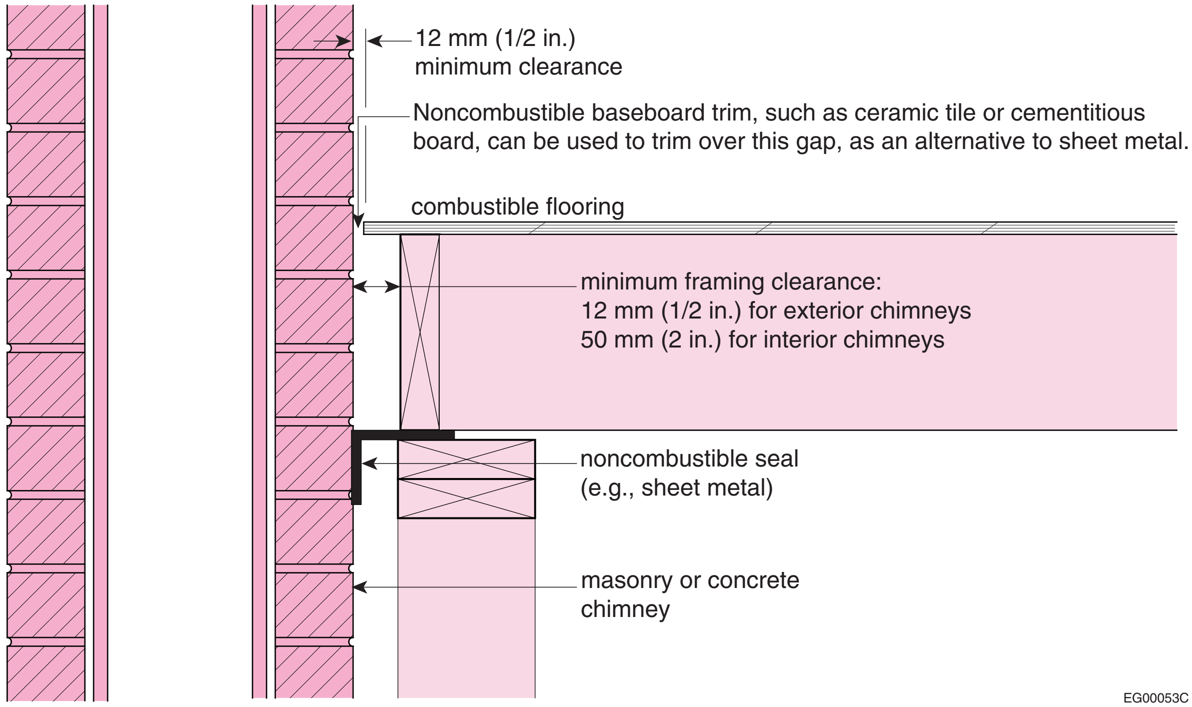


Figure 9.21.-9
Required clearances from combustible flooring

Section 9.22. Fireplaces

Introduction

Traditional masonry fireplaces are not energy efficient, but they are still quite common.

Figure 9.22.-1 shows a typical masonry fireplace and the terminology that refers to its constituent elements.

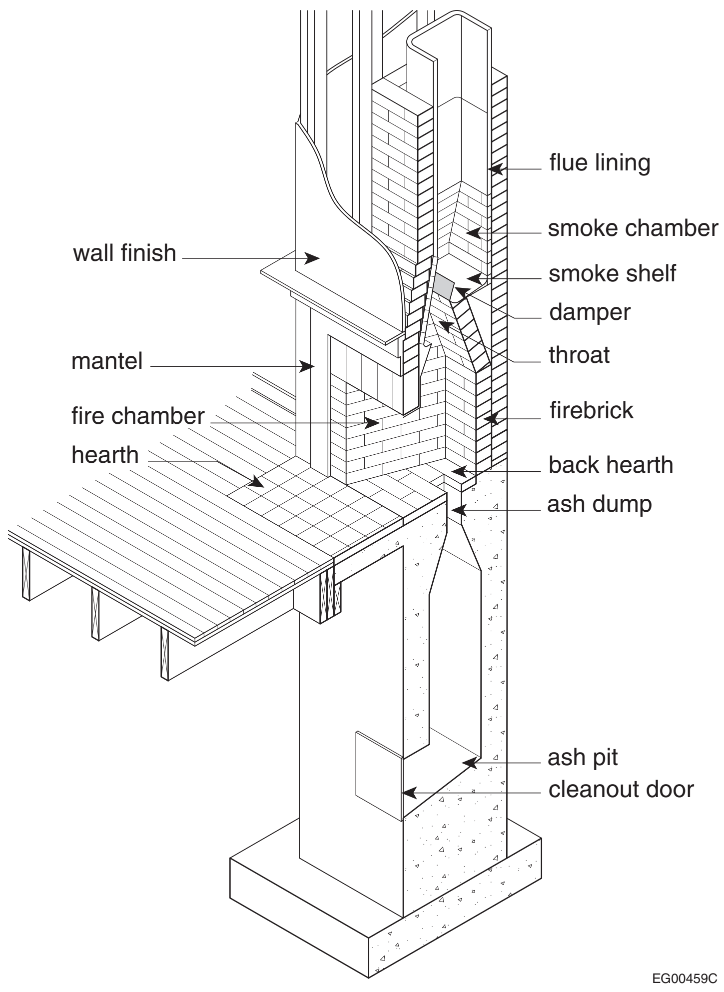


Figure 9.22.-1
Typical masonry fireplace

9.22.1. General

A fireplace should provide for the proper combustion of fuel and the safe exhausting of combustion by-products (smoke) to the outdoors. Installation should ensure that the maximum heat output of the fireplace does not cause occupants undue discomfort from overheating.

9.22.1.1. Application

This Article indicates that NBC Section 9.22. applies only to site-built masonry fireplaces.

9.22.1.2. Masonry and Concrete

This Article refers to NBC Sections 9.20. and 9.3. with certain exceptions. Masonry and concrete used to construct fireplaces, including their footings and hearths, must have the necessary characteristics to provide a safe and durable fireplace.

Masonry and concrete used in the construction of fireplaces must conform to the requirements of NBC Sections 9.20. and 9.3., respectively. For example, masonry over a fireplace opening must be supported with a steel or reinforced concrete lintel, or built with a masonry arch as described in NBC Subsection 9.20.5.

9.22.1.3. Footings

This Article refers to NBC Section 9.15. for fireplace footing requirements. Footings spread the weight of concrete or masonry fireplaces over a sufficient area of soil to avoid excessive settlement and consequent damage to the fireplace. Footings must be provided under all masonry and concrete fireplaces, and must rest on undisturbed soil, rock, or compacted granular fill in accordance with NBC Section 9.15.

The size of a footing will be determined by the size of the fireplace, its weight, and the bearing capacity of the soil. The required bearing area determined from these values will dictate the amount of footing projection needed beyond the face of the fireplace (or its foundation) to give this area. If the footing is unreinforced, its thickness must be at least equal to the projection, and not less than 100 mm (4 in.), as required in NBC Article 9.15.3.4.

9.22.1.4. Combustion Air

This Article references a standard where combustion air is supplied to the fire chamber. An air intake directly into a fire chamber can, under some conditions, become a horizontal chimney when wind-induced negative pressure at its outer end sucks products of combustion out of the fireplace, causing a fire hazard.

Ducting for combustion air provided directly to fireplaces and wood stoves must be installed in accordance with CAN/CSA-A405-M, "Design and Construction of Masonry Chimneys and Fireplaces." This allows the fireplace to be operated without affecting, or being affected by, other appliances or exhaust equipment. The opening of a window is not considered to be a sufficient supply source for combustion air since discomfort from drafts is likely to result in closure. Factory-built fireplaces should have combustion air provided in accordance with manufacturers' installation instructions.

An operating fireplace creates much more demand for air than other appliances. The draft created by a fireplace can be so significant that backdrafting of other appliances can occur. This can be hazardous, since it can drag flue gases from other appliances through the occupied living areas. A 100 mm (4 in.) intake can only provide a small portion of the air needed during maximum blaze. However, when the fire is in the die-down stage, an intake this size does little to isolate the fireplace from the pressure regime of the house. The pressure isolation is desirable to reduce the chances of spillage from the fireplace as a result of other exhaust appliances in the house. Research has shown that it would take an impractically large opening to provide this isolation in a house.

Where combustion air is supplied directly into a fire chamber, the fire chamber must be built in a manner that will allow it to perform the function of a horizontal chimney, which it may well have to do at some time during its life. Essentially, this means the use of noncombustible materials.

9.22.2. Fireplace Liners

9.22.2.1. Brick or Steel Liners

This Article requires that every fireplace have a liner made of steel or firebrick. The material used to line the fireplace's fire box should have adequate durability to withstand the effects of heating as well as the thermal shock of repeated heating and cooling.

9.22.2.2. Firebrick Liners

This Article references a standard, and contains the requirements for firebrick liner thickness and joints. Firebrick liners must be of adequate thickness, be laid with the appropriate mortar and have adequate resistance to the high temperatures associated with a fireplace fire chamber. This Article also intends to avoid through-leakage paths in the masonry, which could result in fire and health risks.

Except where provided with a steel liner, a fireplace must have at least 50 mm (2 in.) thick firebrick around the sides and the back and at least 25 mm (1 in.) on the floor. Firebricks are required to be laid with high temperature cement mortar that complies with CAN/CGSB-10.3, "Air Setting Refractory Mortar." The joints between firebricks must be offset from the surrounding masonry in the fireplace.

9.22.2.3. Steel Liners

This Article references a standard and installation instructions for steel liners. Steel liners for fireplaces must be capable of controlling the leakage of products of combustion through the masonry surrounding the fire chamber. The material used for liners must be durable and stable when exposed to the anticipated temperature conditions.

Fireplaces can be lined with steel, provided that their manufacturing and installation complies with CAN/ULC-S639-M, "Steel Liner Assemblies for Solid-Fuel Burning Masonry Fireplaces." Figure 9.22.-2 shows a steel liner incorporating an air circulating chamber.

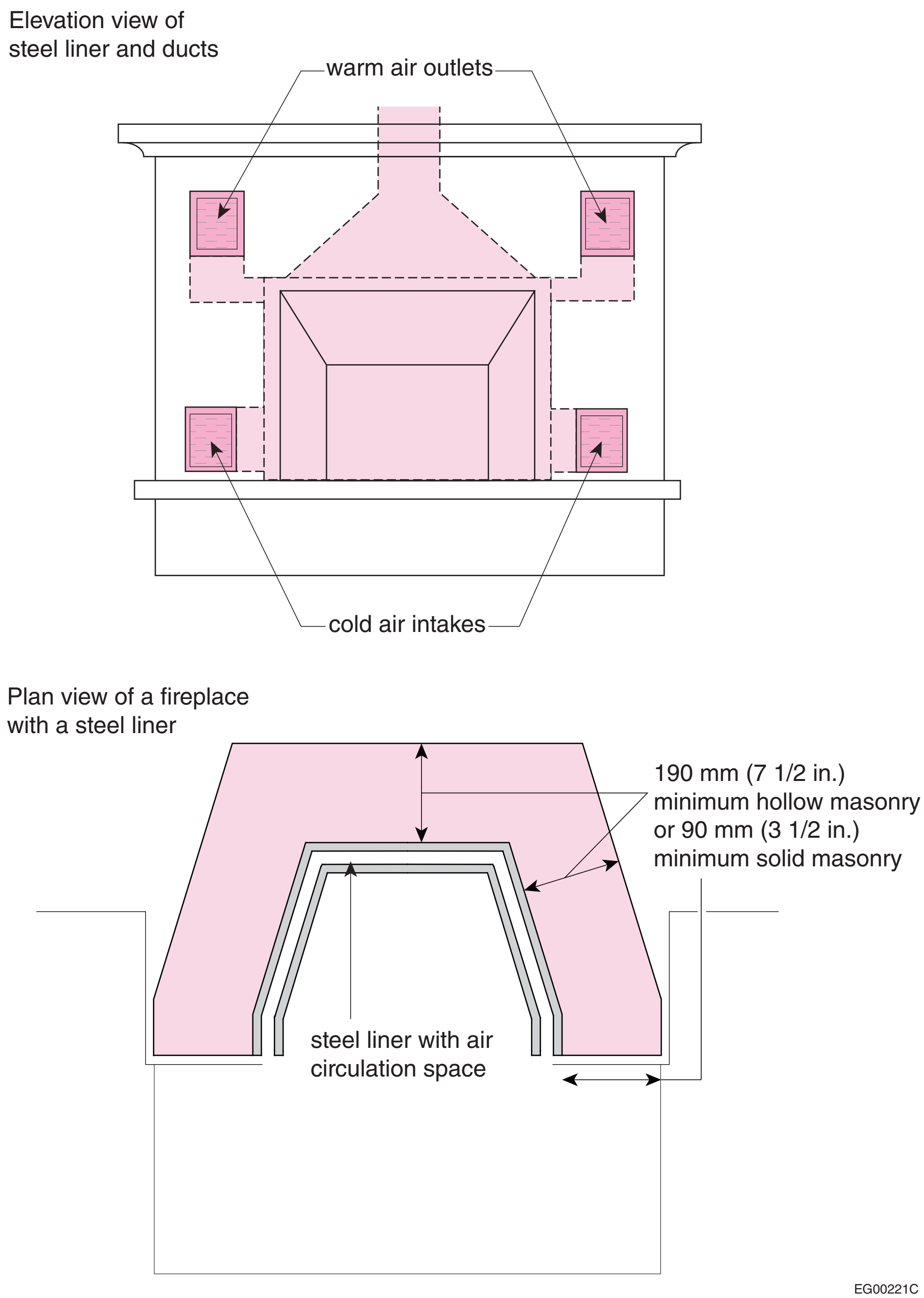


Figure 9.22.-2
Steel fireplace liner with air circulating chamber

9.22.3. Fireplace Walls

9.22.3.1. Thickness of Walls

This Article indicates the minimum thickness and the required materials for fireplace walls. Sufficient masonry thickness is needed so fireplaces will not create a fire hazard to the surrounding combustible materials at the clearances specified elsewhere in the NBC.

The thickness of the back and side walls of a fireplace, including the thickness of any firebrick liner, must not be less than 190 mm (7 1/2 in.) where a metal liner or a firebrick liner of less than 51 mm (2 in.) thickness is used (Figure 9.22.-3).

When a steel liner is used with an air circulating chamber surrounding the firebox, the back and sides of the fireplace must be constructed as illustrated in Figure 9.22.-2.

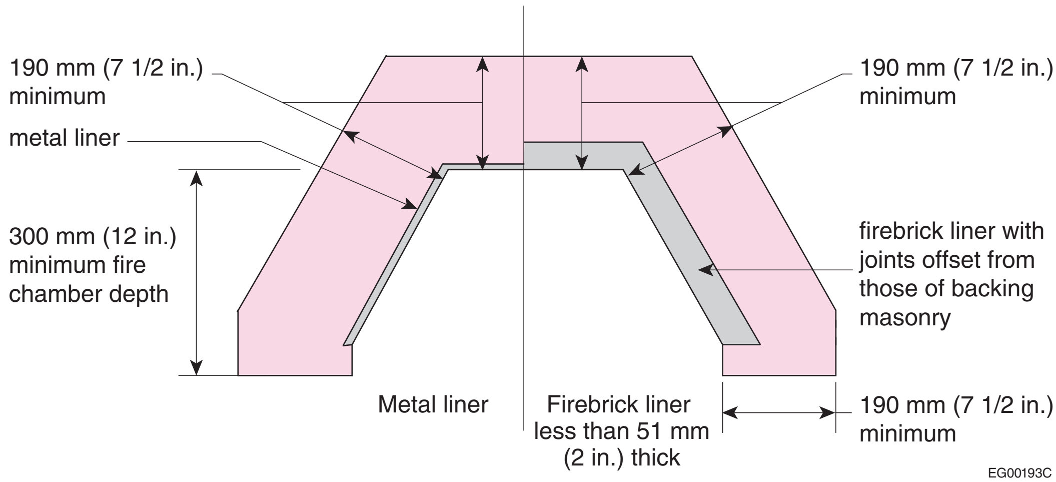


Figure 9.22.-3
Fireplace wall thickness

9.22.4. Fire Chamber

9.22.4.1. Fire Chamber Dimensions

This Article indicates the required distance from the back of the fire chamber to the plane of the fireplace opening. This is to reduce the probability of spillage of combustion products into the living space. The distance from the back of the fire chamber to the front face of the fireplace opening needs to be at least 300 mm (12 in.) (see Figure 9.22.-3).

9.22.5. Hearth

9.22.5.1. Hearth Extension

This Article sets minimum hearth dimensions. An area in front of the fireplace opening is required that will withstand the effect of heat radiation and burning embers from the fire chamber, without creating a fire hazard to surrounding combustible material.

The floor in front of the fireplace is subjected to heat radiation and occasional sparks. Therefore, a noncombustible hearth extension must be provided, which extends out in front and beyond the sides of the opening. The more elevated the hearth, the greater the risk of sparks projecting beyond the normal hearth extension shown. Therefore, the extension must be increased in size as the hearth elevation is increased.

Where the floor of a fire chamber is not more than 150 mm (6 in.) above the hearth extension, a fireplace must have its hearth extend out beyond the face of the fireplace at least 400 mm (16 in.) horizontally and 200 mm (8 in.) to either side. The extension of the hearth must be noncombustible (Figure 9.22.-4).

If the floor of a fire chamber is more than 150 mm (6 in.), but not more than 300 mm (12 in.) above the hearth extension, the hearth must extend an additional 50 mm (2 in.) out from the face of the fireplace. If the fire chamber floor is more than 300 mm (12 in.) above the hearth extension, this extension must be increased again by an additional 25 mm (1 in.) for each additional 50 mm (2 in.) in elevation above 300 mm (12 in.). Table 9.22.-A shows the required extensions for several heights of raised hearths.

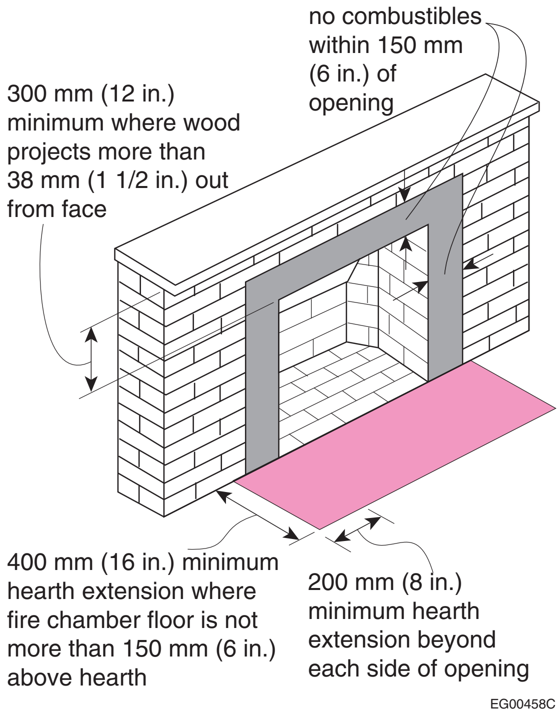


Figure 9.22.-4
Clearances around fireplace openings

Table 9.22.-A
Hearth Extensions for Raised Fire Chambers

Maximum Fire Chamber Elevation Above Hearth Extension (a),(1) mm (in.)	Minimum Depth of Hearth Extension (b),(1) mm (in.)
150 (6)	400 (16)
300 (12)	450 (18)
350 (14)	475 (19)
400 (16)	500 (20)
450 (18)	525 (21)

Notes to Table 9.22.A.:
(1) See Figure 9.22.-5.

9.22.5.2. Support of Hearth

This Article indicates the requirements for supporting the hearth extension that will withstand the effect of heat radiation and burning embers from the fire chamber without becoming a fire hazard to surrounding combustible material. Masonry arches to support hearth extensions are supported on the fireplace foundation near the fire chamber and by the floor framing out from the fire chamber. Such construction is now seldom used. A reinforced concrete apron is usually used instead. If the fire chamber is raised above the floor level, the heat intensity striking the hearth extension is decreased, allowing for the use of a thin concrete slab laid directly on the subfloor without creating a fire hazard.

The fire chamber floor and hearth extension must be supported on a reinforced concrete slab not less than 100 mm (4 in.) thick at its supports and, if cantilevered, not less than 50 mm (2 in.) at its unsupported edge.

When the hearth is relatively high above the floor (200 mm (8 in.) or more), the hearth extension (constructed with noncombustible materials such as reinforced concrete, ceramic tile or stone) can be laid directly on the subfloor because the increased elevation of the hearth reduces the heat radiated to the floor in front of the fireplace (Figure 9.22.-5).

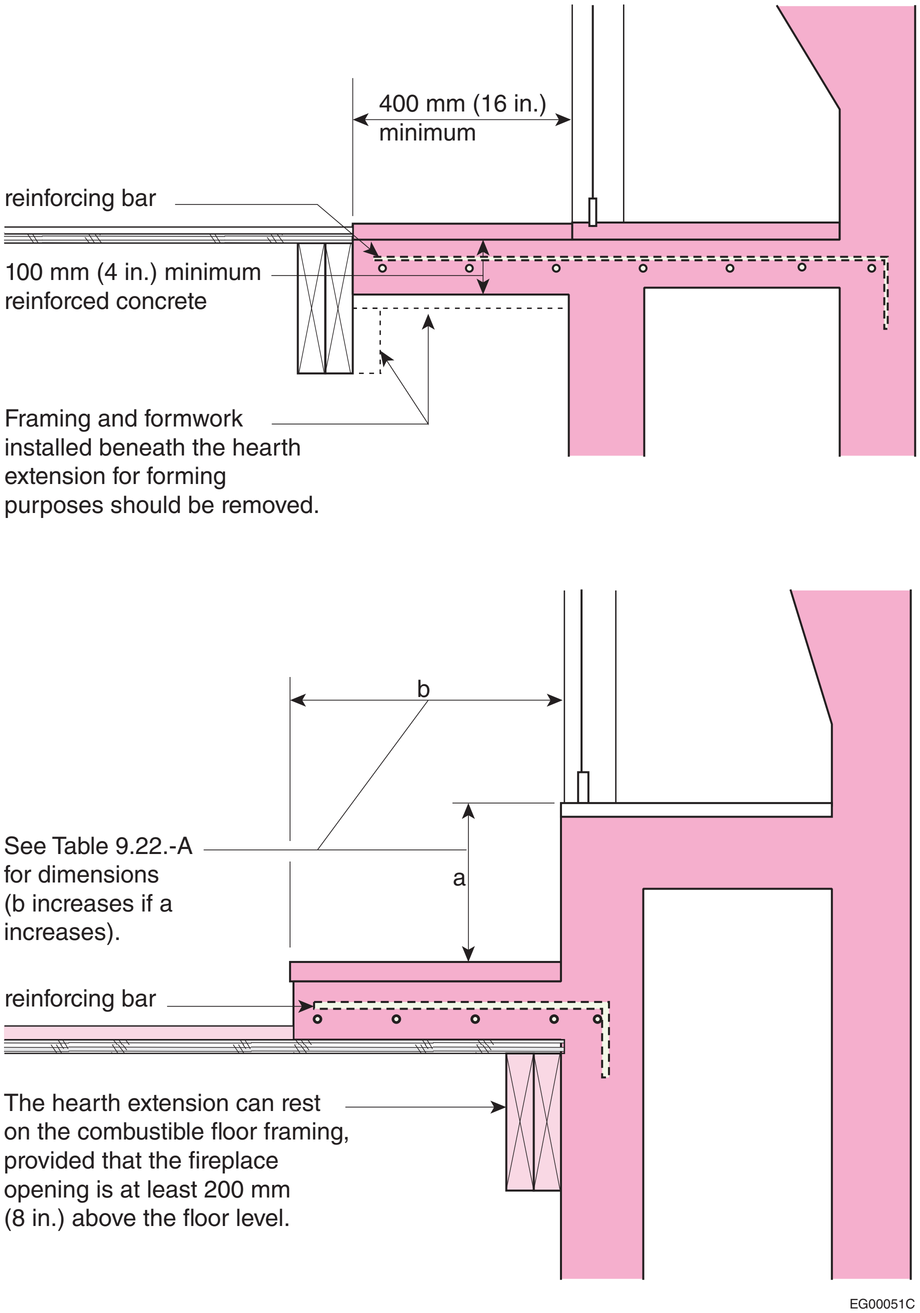


Figure 9.22.-5
Support of hearth extensions

A raised hearth also permits a reduction in the required thickness of the hearth extension to not less than 50 mm (2 in.) thick. When jointed surfacings are used, they must be constructed so that there is no danger of sparks or radiated heat impinging directly on the surface beneath the hearth extension through the joints or cracks. When stone is laid in a mortar bed, therefore, the mortar should be reinforced with mesh to reduce the risk of cracks. The joint between the fireplace and the hearth extension must also be flashed with sheet metal to prevent sparks from falling into the gap.

9.22.6. Damper

9.22.6.1. Required Damper and Size

This Article requires that every masonry fireplace be equipped with a metal damper installed in the throat of the fireplace to reduce air leakage when the fireplace is not in operation (see Figure 9.22.-1). This provides a means for conserving energy by reducing the amount of room air passing up the fireplace flue when the fireplace is not in operation.

9.22.7. Smoke Chamber

9.22.7.1. Slope of Smoke Chamber

This Article limits the slope of the smoke chamber sides. This is to provide a shape to the fireplace fire chamber that will direct the products of combustion upwards to the flue without creating excessive air turbulence in the fire chamber that could lead to spillage of smoke into the living area.

The smoke chamber slopes inward to concentrate the path of rising smoke up through the flue. This slope must be at least 45° to the horizontal as shown in Figure 9.22.-6.

9.22.7.2. Wall Thickness

This Article sets the requirements for minimum wall thickness to provide sufficient masonry to reduce the surface temperature of the exterior of the smoke chamber so that it will not create a fire hazard to surrounding combustible material at the clearances listed elsewhere in the NBC.

The smoke chamber located above the fireplace requires the same minimum thickness of masonry as the fireplace. The sides, front and back must be at least 190 mm (7 1/2 in.) thick; however, a thickness of 140 mm (6 in.) is allowed where the back wall is adjacent to the exterior.

9.22.8. Factory-Built Fireplaces

9.22.8.1. Conformance to Standard

This Article, through reference to a standard, requires that factory-built fireplaces be designed and installed so as not to create a fire hazard to adjacent combustible material. The installation of factory-built fireplaces must comply with CAN/ULC-S610-M, "Factory-Built Fireplaces."

Some general requirements are as follows:

- all prefabricated fireplaces must have prefabricated chimneys that are specifically tested for use with the fireplace;
- installation instructions provided by the manufacturer must accompany the fireplace;
- all parts and components must be made of noncombustible material;
- only factory supplied hardware is to be used for installation; and
- on-site cutting and make-fitting is strictly prohibited.

Other provisions in the standard include requirements for unit assembly, joints, fire block spacers, supports, radiation shields, flue dampers, caps, roof assemblies, fire screens, hearth assembly, combustion air, and doors. A prefabricated fireplace does not necessarily have to be enclosed in masonry. Tile or gypsum finishes may also be used. If a factory-built fireplace is installed in the basement, ensure it is certified for this type of installation.

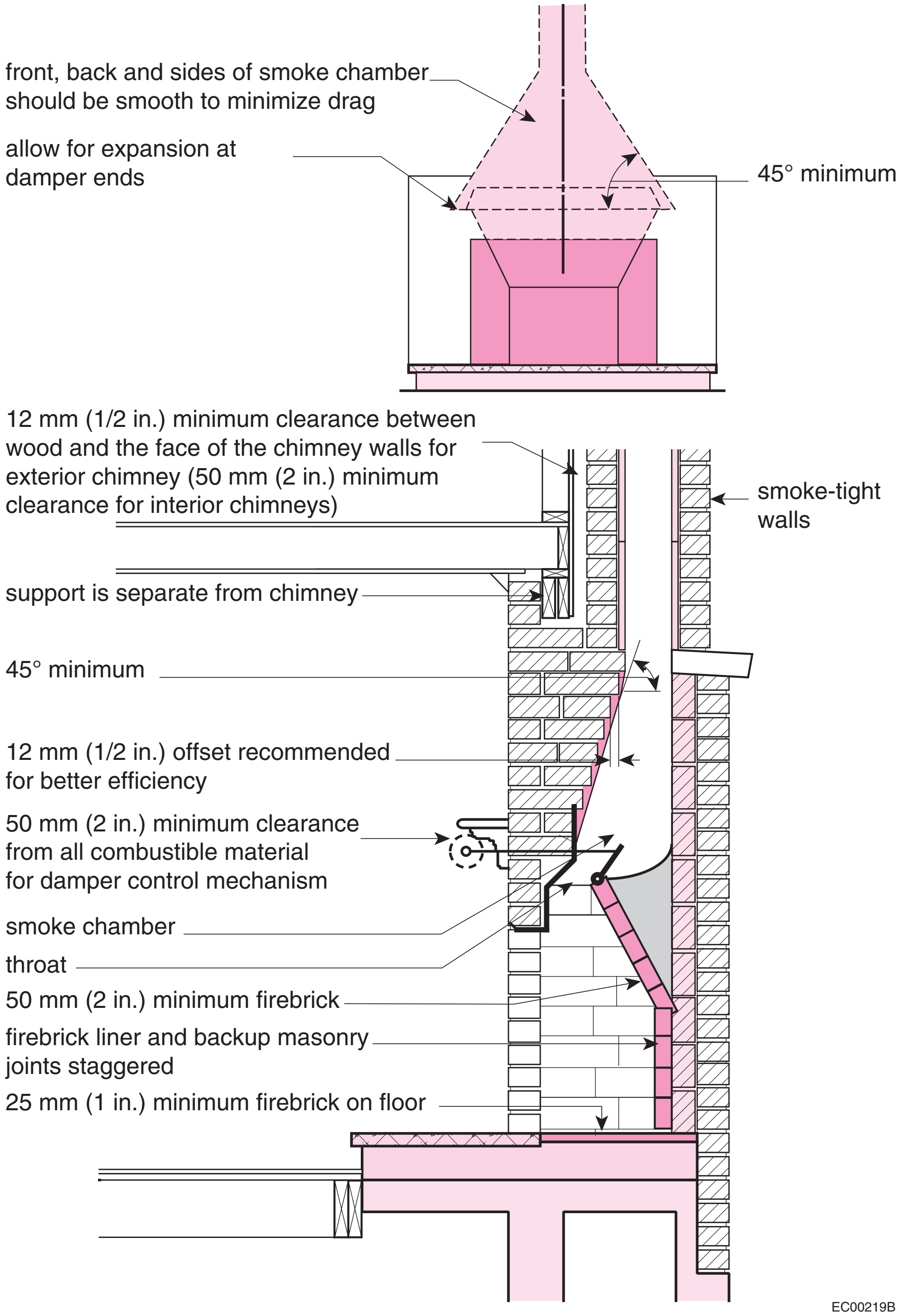


Figure 9.22.-6
Section through a typical fireplace and chimney

9.22.9. Clearance of Combustible Material

The high temperature associated with fireplaces requires that a generous clearance be provided between the masonry and any adjacent combustible framing.

9.22.9.1. Clearance to the Fireplace Opening

This Article requires a minimum clearance in front of a fireplace to combustible materials. A fireplace can expose combustible material on its face to fire in two ways: the masonry facing can conduct heat directly, and combustible material that projects out from the face may be exposed to heat radiation from the fire chamber. Combustible materials are, therefore, not permitted close to a fire chamber, and large projections such as mantels must be even further away to avoid the risk of ignition from radiation.

No less than 100 mm (4 in.) of clearance must be provided from the back and sides of a fireplace to interior wall framing (Figures 9.22.-7 and 9.22.-8). Clearances required from the fireplace to combustible framing at the backs and sides of the fireplace, where located in an exterior wall, can be reduced to 50 mm (2 in.) given the increased heat loss from masonry exposed to the outside air. The clearances required from the smoke chamber to combustible framing can be reduced to 50 mm (2 in.) for interior walls because of the cooler operating temperature of the smoke chamber. This clearance can be reduced to 25 mm (1 in.) for smoke chambers located in exterior walls for the reason previously stated.

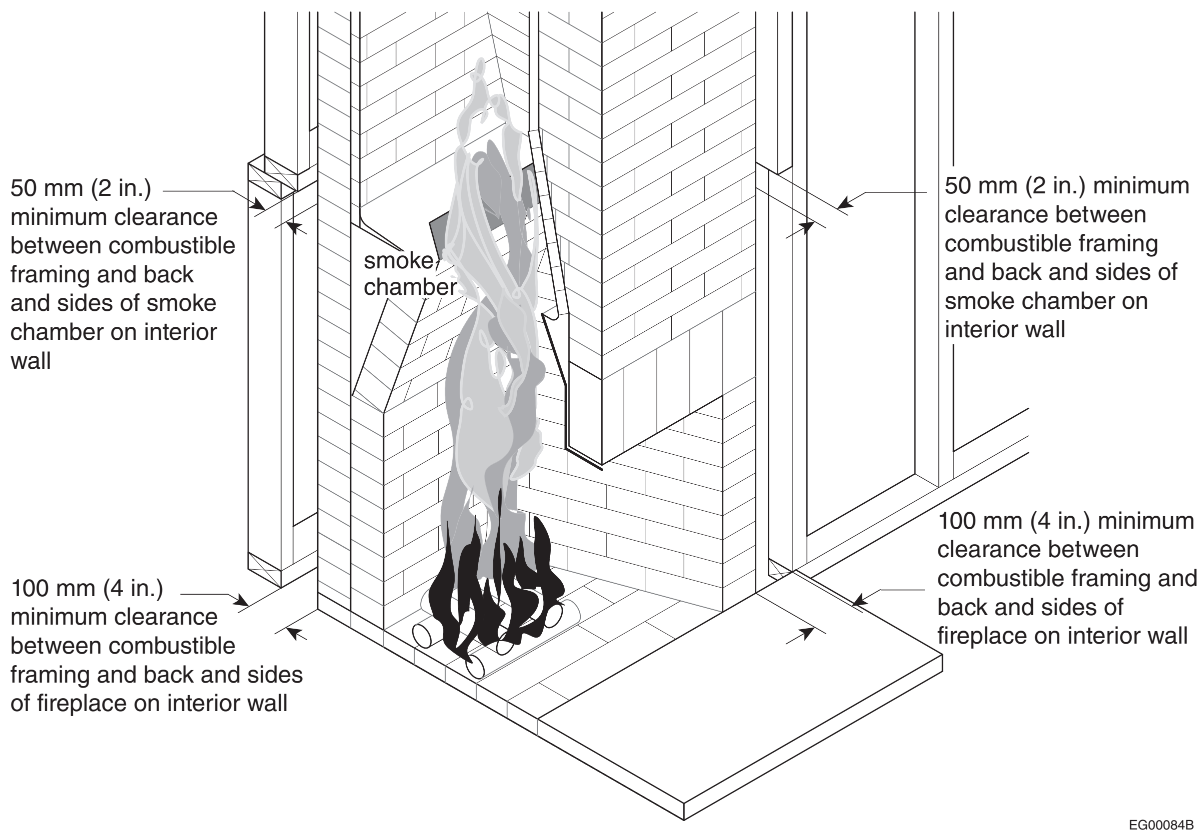


Figure 9.22.-7
Fireplace meeting an interior wall

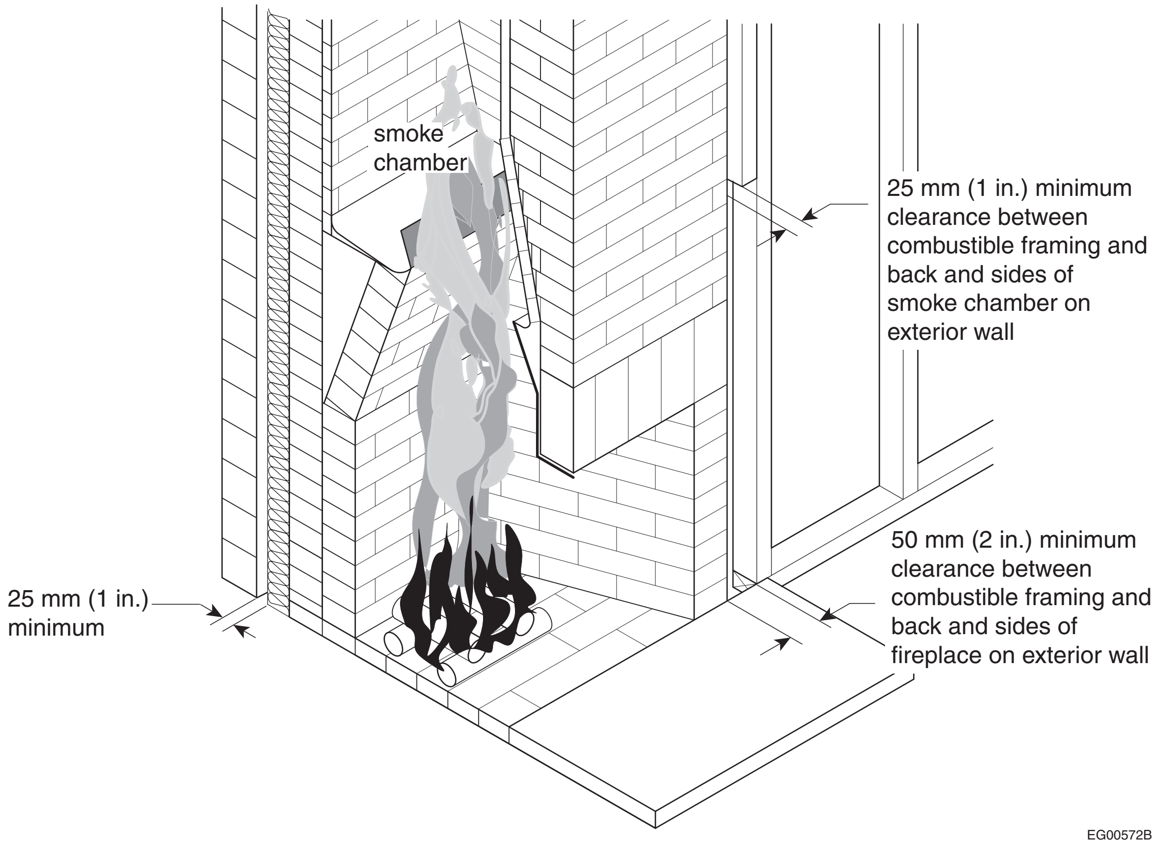


Figure 9.22.-8
Fireplace meeting an exterior wall

9.22.9.2. Metal Exposed to the Interior

This Article requires adequate separation between the heat source and combustible materials. The rate of heat conduction through steel is many times greater than that through masonry. Any metal that extends from the fire chamber to the surface of the fireplace (such as damper controls) tends to be much hotter than the surrounding masonry and can ignite combustible materials if they are too close.

9.22.9.3. Clearance to Combustible Framing

This Article requires a minimum clearance from the back and sides of a fireplace and smoke chamber to combustible materials. This is to avoid the ignition of combustible framing adjacent to the sides and back of a fireplace. Although the lining and back-up masonry reduce the temperature on the exterior masonry surface, the temperature can still be sufficiently high to ignite combustible materials if they are too close to the masonry. The smoke chamber above the fire chamber is cooler than the fire chamber and does not require as much clearance to reduce the fire risk.

Combustible materials must not be placed on or near the face of a fireplace within 150 mm (6 in.) of the fireplace opening (Figure 9.22.-9). Where combustible materials project more than 38 mm (1 1/2 in.) out from the face of the fireplace, the materials must be no less than 300 mm (12 in.) above the top of the opening.

Damper-operating mechanisms sometimes extend out through the face of the fireplace. The metal, being a good heat conductor, has been known to cause fires when allowed to come in contact with combustible mantels or trim. A clearance must, therefore, be provided between such mechanisms and the adjacent combustible material (at least 50 mm (2 in.)).

9.22.9.4. Heat-Circulating Duct Outlets

This Article requires a minimum clearance of combustible material above heat-circulating duct outlets from those outlets to avoid the ignition of combustible materials. A fireplace liner that allows air to circulate behind it can produce air at the outlets that is hot enough to create a fire hazard to adjacent combustible materials.

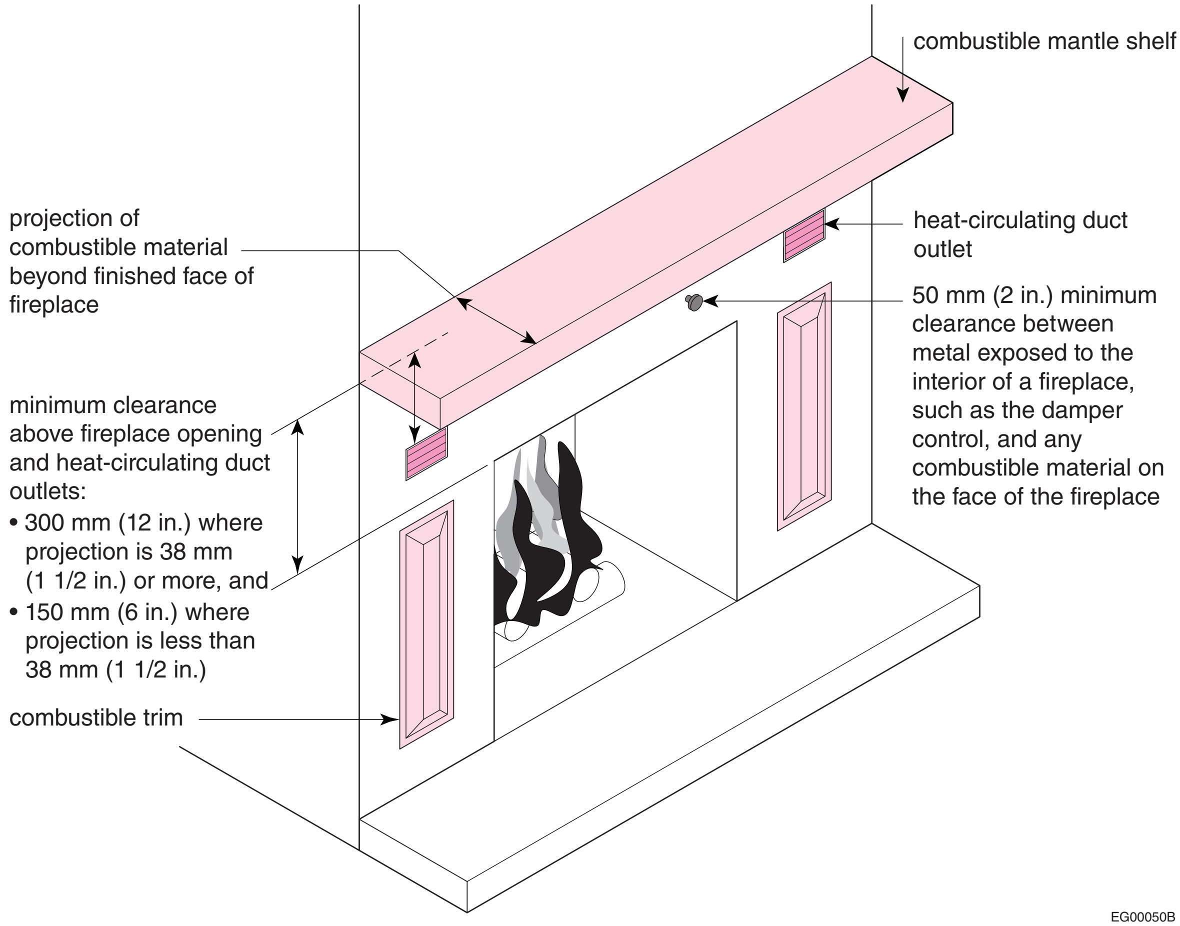


Figure 9.22.-9
Clearances around fireplaces

9.22.10. Fireplace Inserts and Hearth-Mounted Stoves

9.22.10.1. Appliance Standard

This Article requires, through reference to a standard, that fireplace inserts and hearth-mounted stoves be designed and constructed in such a manner that they will not create a health or fire risk. Increasing energy costs have created a demand for more efficient utilization of existing masonry fireplaces. Fireplaces are not only inefficient as energy converters, but with relatively leaky dampers, they can waste energy by allowing the continued flow of heated room air up the chimney when the fireplace is not operating.

Fireplace inserts are sealed into the fireplace opening and utilize the existing fireplace flue to vent the flue gases. They are regulated by CSA B365, "Installation Code for Solid-Fuel-Burning Appliances and Equipment," and ULC-S628, "Fireplace Inserts." As with factory-built fireplaces, the manufacturer must provide installation instructions with each unit that reflect the conditions for which it was tested and certified.

9.22.10.2. Installation

This Article requires, through reference to a standard, fireplace inserts and hearth-mounted stoves to be installed in such a manner that they will not create a health or fire risk. Fireplace inserts are normally installed in existing buildings as an energy conservation measure for existing masonry fireplaces.

Inserts that are not designed for removal for cleaning must have a factory-built chimney liner installed from the throat of the insert to the top of the chimney, a completely sealed connection between the chimney flue and insert, or a direct sealed connection to the smoke chamber with a clean out to any part of the smoke chamber that is inaccessible, in accordance with CSA B365, "Installation Code for Solid-Fuel-Burning Appliances and Equipment."

Section 9.23. Wood-Frame Construction

Introduction

Platform framing is the most common wood-frame construction method (Figure 9.23.-1). In this method, each floor is constructed independently of the walls and provides a working surface for the construction and erection of the wall framing for that storey. As a general rule, wall sections can be tipped into place without the need for heavy equipment.

Once very common, balloon framing is now only used occasionally. It involves the use of wall framing that extends more than one storey. Intermediate floors are then secured to the walls. While platform construction automatically provides fire blocking between floors, balloon framing requires that designated fire blocks be installed in all gaps between storeys that occur at floor and roof intersections.

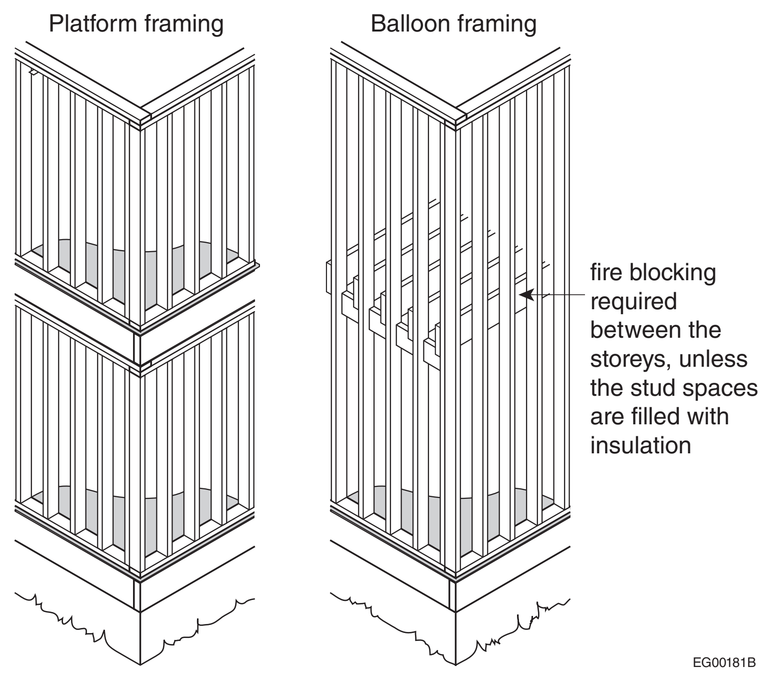


Figure 9.23.-1
Wood-frame construction methods

9.23.1. Application

9.23.1.1. Limitations

This Article indicates the limitations of NBC Section 9.23., which relies on prescriptive (empirical) requirements based to a large extent on past experience and performance, especially with smaller, residential-type structures. Other requirements are based on calculations with assumed loads, building sizes and occupancies. This is to avoid the possibility of structural failure when the loads on which the requirements were based are exceeded.

NBC Section 9.23. applies to wood-frame construction where wall, floor and roof planes are comprised of small repetitive wood or engineered wood members spaced not more than 600 mm (24 in.) apart, that have spans not exceeding 12.2 m (40 ft.), and that carry loads not exceeding 2.4 kPa (50 psf). Roof and floor framing members may be supported on widely spaced framing members. Wood members for all other applications, such as post, beam and plank construction and timber frame construction, must be designed in accordance with the requirements of NBC Part 4.

Alternative structural wood components such as wood I-joists are often used in wood-frame buildings. Where these components are used in lieu of lumber, the requirements in NBC Section 9.23. that specifically apply to lumber joists do not apply to these components, for example, the limits on spans and acceptable locations for notches and holes. However, requirements regarding the fastening of floor sheathing to floor joists still apply, and the use of wood I-joists does not affect the requirements for wall or roof framing. Manufacturers' instructions must be followed for engineered wood components, which behave differently than wood framing in terms of shrinkage and load bearing.

9.23.2. General

9.23.2.1. Strength and Rigidity

This Article requires that all members be framed and attached to provide buildings that will have adequate strength to withstand the anticipated loads due to occupancy, as well as wind, rain and snow loads, without appreciable damage to the building.

9.23.2.2. Protection from Decay

This Article requires that wood members be protected from decay to reduce the risk of wooden members decaying in locations where they are subject to high moisture levels. Wood supported on masonry or concrete in contact with the ground is subject to decay, unless the wood is treated with a preservative, or other appropriate measures are taken to keep it from being affected by the decay organisms. Untreated wood supported on a concrete slab or footing (such as basement walls and columns) must be separated by a moisture barrier.

Where the bottom of an untreated beam is below ground level, it must be surrounded by an air space to prevent contact with the concrete (Figure 9.23.-2). The space around the beam should be left open to allow air to circulate and should not be filled with insulation, vapour barriers or airtight materials. Where untreated framing members are within 150 mm (6 in.) of the surface of the ground, the framing must be separated from the supporting base by a moisture barrier.

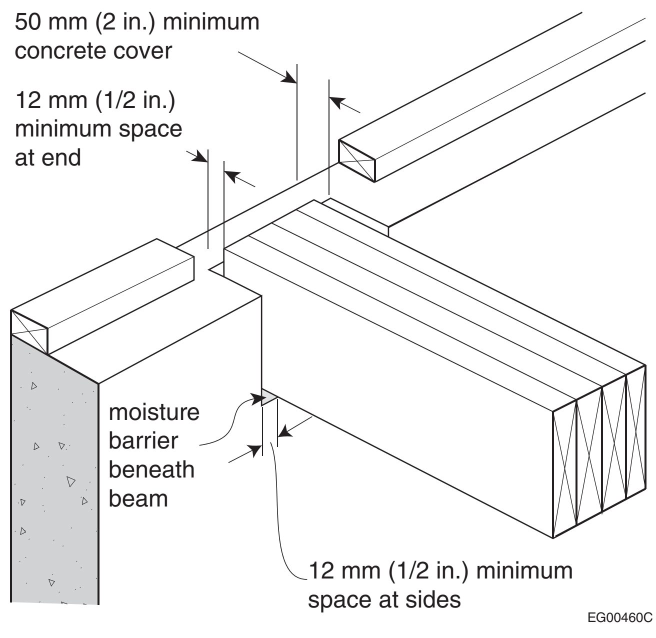


Figure 9.23.-2
Air space around untreated wood beam framing into concrete

Where wood joists frame into concrete walls, the wood must be treated with a preservative or be separated from the concrete as shown in Figure 9.23.-3.

9.23.2.3. Protection from Dampness

This Article requires the protection of wood from dampness. Concrete in contact with the ground is generally cooler than the ambient air, and is therefore subject to surface condensation in summer. There is also a risk that some soil moisture may migrate through the concrete to the surface.

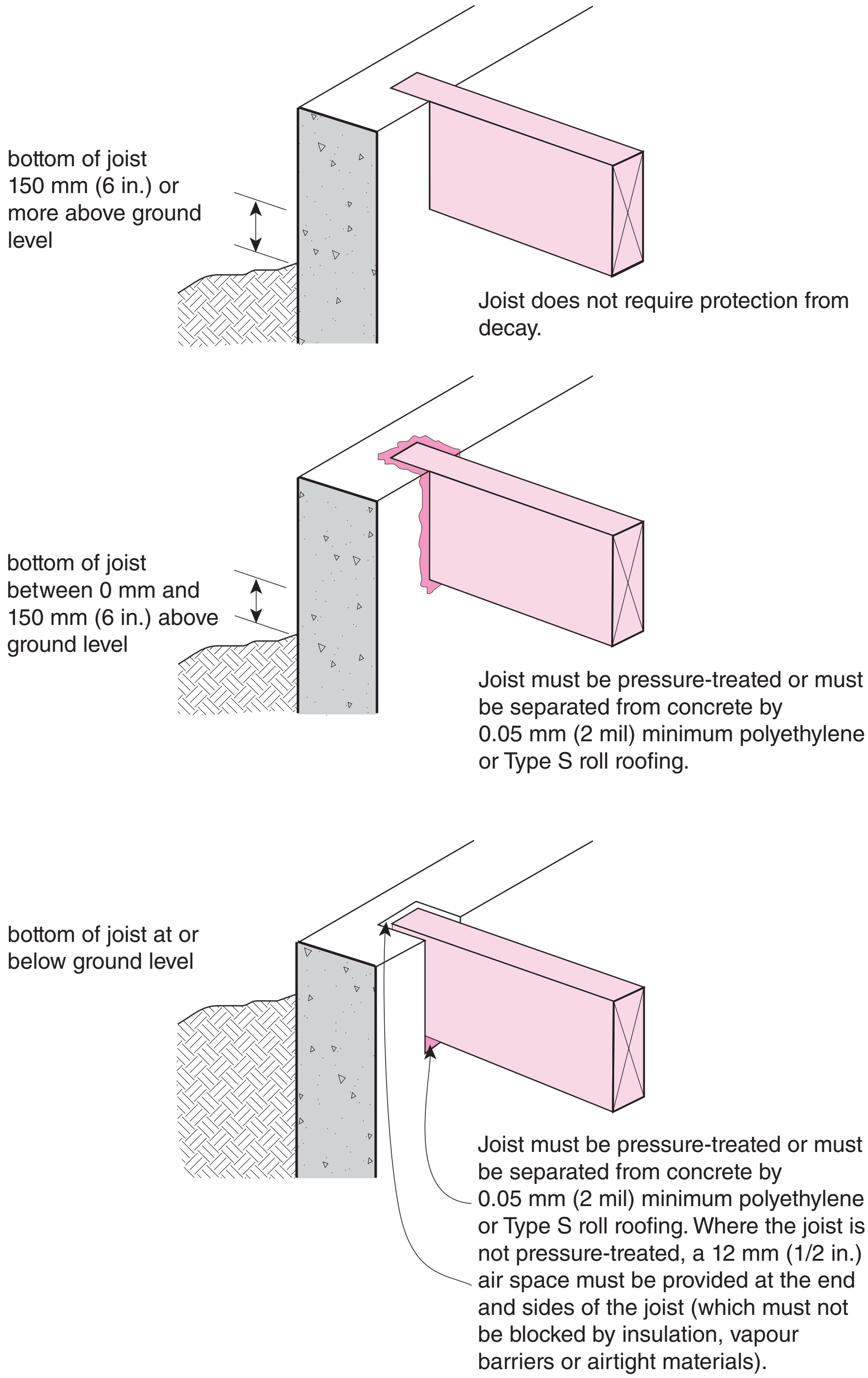


Figure 9.23.-3
Wood joists framing into concrete

Wooden members in contact with concrete (such as the sole plate in interior basement walls, basement columns, or strapping on basement walls) can absorb moisture, and are subject to decay if they are not treated with a preservative. The provision of dampproofing between the concrete and the wood is intended to keep such surface moisture from soaking into the wood, thereby reducing the risk of decay. If the concrete is above the level where it is affected by ground moisture, however, such as the sill plate on top of a basement wall, these precautions are not considered necessary.

Wood framing members that are supported on concrete in contact with the ground or fill must be protected from dampness as illustrated in Figure 9.23.-4.

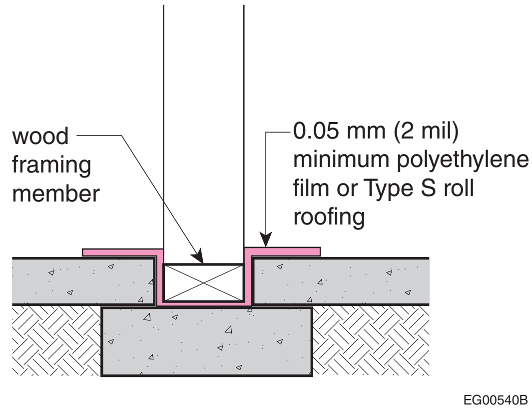


Figure 9.23.-4
Untreated wood framing member supported on concrete

9.23.2.4. Lumber

This Article refers to NBC Subsection 9.3.2. for the requirements pertaining to lumber. Lumber used should result in buildings that have adequate strength, protection from decay, and protection from dampness, as required in NBC Subsection 9.3.2. Lumber used for floors, roofs and walls is required to have a moisture content of not more than 19% at the time of installation (NBC Article 9.3.2.5.).

9.23.3. Fasteners

9.23.3.1. Standards for Nails and Screws

This Article, through reference to standards, defines the characteristics of nails and screws that will enable them to perform their intended functions in wood-frame construction. Nails must comply with either CSA B111, “Wire Nails, Spikes and Staples,” or with ASTM F 1667, “Driven Fasteners: Nails, Spikes, and Staples.” Nails are available in a large variety of sizes and shapes, each designed for a specific purpose. Common wire nails or common spiral nails are specified for most framing details. There are numerous alternative types of nails that can be used in construction, including power driven nails. The lengths and diameters of such alternatives should match the specified common wire nails or common spiral nails specified.

Nails must meet minimum shank diameters specified in NBC Article 9.23.3.1. NBC Note A-9.23.3.1.(2) explains how to adjust fastener spacing for smaller diameter nails. The goal is to provide a broader range of fasteners, including power driven nails, without reduction in structural capacity.

9.23.3.2. Length of Nails

This Article requires that nails have a minimum penetration length. Although the lengths of nails specified elsewhere in the NBC should be sufficient to provide the required structural strength, it is still possible to use such fasteners in a manner that does not develop the appropriate fastener strength. For example, if toe-nailing a member to a second member is at too steep an angle, there may be insufficient penetration into the second member. If a thick member is nailed to a thin member, there will be insufficient penetrations if the nailing is done from the side of the thick member.

9.23.3.3. Prevention of Splitting

This Article indicates the requirements intended to minimize wood splitting. Where nails cause wood to split, the strength of the resulting connection can be seriously reduced, and this may lead to structural failure. This risk can be reduced by locating the nails in such a way as to reduce the splitting. Nails must be staggered in the direction of the grain, and kept well in from the ends of the member to minimize any risk of splitting the wood.

9.23.3.4. Nailing of Framing

This Article indicates nails required for various joints and connections between structural members to ensure they develop the required strength to fulfill their function. Nailing requirements for framing members are listed in NBC Table 9.23.3.4.

Where the wall plate or sole plate of an exterior wall is not nailed to the floor joists, rim joists, or floor blocking in conformance with NBC Table 9.23.3.4., the wall can be fastened to the floor framing by nailing or stapling the exterior wall sheathing (plywood, waferboard or oriented strandboard (OSB)) to the floor framing. The nailing and stapling of sheathing must conform to NBC Table 9.23.3.5. These alternative methods of fastening the sole plates to the floor joists are intended to accommodate the use of factory-made, closed-wall panel sections, where direct nailing of the sole plates is not possible.

In very strong wind storms, the toe nails connecting the roof framing to the top plate are not adequate. In areas where the 1-in-50 hourly wind pressure (HWP) is equal to or greater than 0.8 kPa (16 psf), roof rafters, joists or trusses must be fastened to the wall framing with connectors (e.g., nails and/or strapping) that will resist a factored uplift load of 3 kN (680 lbf). Galvanized-steel straps 50 mm (2 in.) wide and not less than 0.91 mm (20 gauge) thick that are fastened at each end with at least four 63 mm (2 1/2 in.) nails are deemed to be suitable connectors for this requirement.

Where the seismic spectral response acceleration, $S_a(0.2)$, is within the values specified in NBC Sentence 9.23.11.4.(5), doubled top plates in braced wall bands must be fastened on each side of a splice with 76 mm (3 in.) long common steel wire nails or spiral nails, in accordance with NBC Table 9.23.11.4.

9.23.3.5. Fasteners for Sheathing or Subflooring

This Article contains requirements for the fastening of sheathing and subflooring to their supports.

Sheathing and subflooring not only provide support for the roofing, cladding and floor finish materials, but also act in a structural capacity to resist loads due to wind, snow, and use and occupancy. Wall and roof sheathing must, therefore, be fastened to withstand the anticipated wind loads or to act in concert with the framing to transfer the wind loads to transverse walls through diaphragm action. Subflooring may also have to act as a diaphragm to resist inward soil pressures or to transfer wind loads to transverse walls and must be fastened accordingly.

The fastening requirements for subflooring are provided in NBC Table 9.23.3.5.-A.

The fastening requirements for sheathing, which are provided in NBC Tables 9.23.3.5.-A to -C, depend on the 1-in-50 hourly wind pressure (HWP) and the seismic spectral response acceleration, $S_a(0.2)$, at the building location:

- In areas with low to moderate wind and seismic loads where HWP < 0.8 kPa (16 psf) and $S_a(0.2) \le 0.70$, the fastening of sheathing must conform to NBC Table 9.23.3.5.-A.
- In areas with high wind and/or seismic loads where 0.8 kPa (16 psf) ≤ HWP < 1.2 kPa (25 psf) and $S_a(0.2) \le 0.90$, or where $0.70 < S_a(0.2) \le 0.90$, the fastening of roof sheathing and sheathing in required braced panels must conform to NBC Table 9.23.3.5.-B.
- In areas with high wind and/or seismic loads where 0.8 kPa (16 psf) ≤ HWP < 1.2 kPa (25 psf) and $S_a(0.2) \le 1.8$, or where $0.90 < S_a(0.2) \le 1.8$, the fastening of roof sheathing and sheathing in required braced panels must conform to NBC Table 9.23.3.5.-C.
- In areas with extreme wind and/or seismic loads where HWP ≥ 1.2 kPa (25 psf) or $S_a(0.2) > 1.8$, the fastening of sheathing must conform to NBC Part 4.

Annular grooved nails, which are also referred to as ring thread nails, have a series of sharp concentric grooves on their shanks, which resist withdrawal. Because of their superior withdrawal resistance, the minimum lengths for annular grooved nails are smaller than those for smooth (common) nails and spiral nails. When resilient flooring is applied directly over an OSB, waferboard, particleboard or plywood subfloor, annular grooved nails must be used to fasten the subfloor to the supports (NBC Article 9.23.15.6.).

When floor joists shrink, the amount by which the nail heads project above the wood depends on the length of the fasteners in the wood. Nail popping, which may appear as a series of tiny bumps in the flooring, is reduced with annular grooved nails because of their shorter length.

Screws provide an even greater withdrawal resistance than annular grooved nails, and can be used to attach sheathing or subflooring. Flooring screws must have a minimum diameter of 3.2 mm (1/8 in.). The maximum spacings for screws are the same as those for nails.

Pneumatic nailers are often used to fasten framing members, sheathing and subflooring. The fasteners used in pneumatic nailers should be evaluated to ensure that they provide joint strengths equivalent to those provided by common nails. NBC Table A-Table 9.23.3.5.-B. provides recommended maximum nail spacings for different diameters of nails used to attach the edges of wall sheathing to the wall framing of wood-sheathed braced wall panels.

9.23.4. Maximum Spans

9.23.4.1. Application

This Article indicates the spans covered by NBC Section 9.23., which apply to floors serving residential areas, or where the uniformly distributed live load does not exceed the load described in NBC Table 4.1.5.3. The maximum spans are limited to avoid structural collapse, as well as any undue deformation under an appropriate uniform live loading.

Framing components in houses, such as beams, floor joists and floor decking, are selected based on strength and stiffness. The strength requirements determine the size of the component and are governed by the loads that are imposed and the strength of the material used. The stiffness requirements are intended to limit the cracking of ceiling finishes and vibration.

9.23.4.2. Spans for Joists, Rafters and Beams

This Article refers to NBC Span Tables for spans of wood joists, rafters and beams. Joists and rafters made from sawn lumber, as well as wood beams (solid, laminated or built-up), should have sufficient strength and stiffness to support anticipated loads without causing damage to any supported ceiling, or deformations that are aesthetically unpleasant. In the case of floor joists, the purpose is also to provide a floor system without objectionable vibration.

NBC Tables 9.23.4.2.-A to -L and 9.23.12.3.-A to -D provide guidance for determining the maximum spans for joists, rafters and beams that can meet the requirements for design under NBC Part 9. Supplementary span tables to those included in the NBC can be found in The Span Book, published by the CWC.

The spans listed in the tables are based on the shortest spans required to satisfy these criteria. The allowable design stresses and the 1/360 deflection limits under static loading have to be met. In addition, the joist spans must meet certain vibration criteria that take into account the effect of the subfloor as well as the type of bridging.

These additional criteria in many cases are the limiting ones, and should result in fewer occupant concerns about the springiness of floors. The vibration control span limits are based on an analysis of the reactions of a large number of occupants across Canada to various degrees of floor stiffness. The procedure for calculating spans to satisfy the vibration limits is given in NBC Note A-9.23.4.2.(2).

Floor Joists

Joist span tables are provided in NBC Tables 9.23.4.2.-A and -B. Allowable spans are measured between the edges of support.

NBC requirements apply to floors supported by sawn lumber joists where framing members are spaced apart not more than 600 mm (2 ft.) on centre. Where the joist spacing exceeds 600 mm (2 ft.), or if the framing is other than sawn lumber, such as light gauge steel, wood I-joists or other engineered systems, the floors are required to be designed in conformance with NBC Part 4.

Where lightweight concrete topping is used on floors, NBC Table 9.23.4.2.-B can be used to size joists.

Roof Joists and Rafters

Most new houses are constructed using prefabricated roof trusses designed and manufactured in accordance with “Truss Design Procedures and Specifications for Light Metal Plate Connected Wood Trusses,” published by the Truss Plate Institute of Canada. A truss is a structural frame relying on a triangular arrangement of webs and chords to transfer loads to reaction points. This arrangement gives them high strength-to-weight ratios, which permit longer spans than conventional framing, and offers greater flexibility in floor plan layouts. Light frame wood trusses are prefabricated by pressing galvanized steel truss plates into wood members that are pre-cut and assembled in a jig. Framing with traditional rafters and joists may still be used to accommodate architectural requirements.

Span tables for the selection of rafters and ceiling and roof joists are provided in NBC Tables 9.23.4.2.-C to -G. These tables are based on the specified snow loads calculated according to the following conditions:

- the entire roof width does not exceed 4.5 m (14 ft. 9 in.): 0.45 × 1-in-50-year ground snow load + associated 1-in-50-year rain load, and
- the entire roof width exceeds 4.5 m (14 ft. 9 in.): 0.55 × 1-in-50-year ground snow load + associated 1-in-50-year rain load.

These snow loads assume a uniform load distribution with no allowance for drifting as in NBC Part 4. The dead loads used in calculating the allowable roof framing spans are based on typical lightweight construction. The following variables must be identified prior to the use of the NBC Span Tables:

- species and grade of the wood to be used,
- specified snow load of the particular location,
- type of ceiling finish, and
- attic usage.

In the NBC Span Tables, the term "rafter" refers to a sloping wood member that supports the roof sheathing and encloses an attic space, but does not support a ceiling. The term "roof joist" refers to a horizontal or sloping wood framing member that supports the roof sheathing and the ceiling finish but does not enclose an attic space. Except where the roof slope is 1:3 or greater, support at the roof ridge is required. For rafters used where the roof slope is 1:3 or greater, ridge support is not required provided that ties are provided at the ceiling level to prevent the walls from moving outward.

Where rafters or roof joists are intended for use in a locality having a higher specified roof snow load than shown in the tables, the maximum member spacing may be calculated as the product of the member spacing and specified snow load shown in the span tables divided by the specified snow load for the locality being considered. The following examples show how this principle can be applied:

- for a 3.5 kPa (73 psf) specified snow load, use spans for 2.5 kPa (52 psf) and 600 mm (24 in.) on centre spacing but space members 400 mm (16 in.) on centre, and
- for a 4.0 kPa (84 psf) specified snow load, use spans for 2.0 kPa (42 psf) and 600 mm (24 in.) on centre spacing but space members 300 mm (12 in.) on centre.

The maximum spans in the NBC Span Tables are measured from the inside face or edge of support to the inside face or edge of support. In the case of sloping roof framing members, the spans are expressed in terms of the horizontal distance between supports rather than the length of the sloping member. The snow loads are also expressed in terms of the horizontal projection of the sloping roof. Spans for odd-size lumber may be estimated by straight line interpolation from the tables. These span tables may be used where members support a uniform live load only. Where the members are required to be designed to support a concentrated load, they must be designed in conformance with NBC Subsection 4.3.1.

Example 20 – Sizing of Roof Joists

A house being constructed in Terrace, British Columbia, requires roof joists supporting a gypsum board ceiling that are required to span a distance of 5 m using No. 1 Spruce–Pine–Fir. According to NBC Table C-2 in Appendix C, Terrace has a ground snow load of 5.4 kPa and an associated rain load of 0.6 kPa.

Find the size and spacing required for the roof joists.

1. The specified roof snow load is calculated as follows (NBC Article 9.4.2.2.):

$$\text{Snow load} = 0.55 \times 5.4 = 2.97\ \text{kPa}$$
$$\text{Associated rain load} = 0.6\,\text{kPa}$$
$$\text{Specified roof snow load} = 2.97 + 0.6 = 3.57\ \text{kPa}$$

2. Examine NBC Table 9.23.4.2.-E under Spruce–Pine–Fir (No. 1 and No. 2) to see which joists will span 5 m or more (or as close as possible).
3. Select size 38 × 286 mm (2 × 12 in. nominal) 400 mm on centre, which can support a specified roof snow load of 3.0 kPa.
4. Adjust spacing for 3.57 kPa specified roof snow load as follows:

$$\text{Maximum spacing} = (3.0/3.57) \times 400 = 336\,\text{mm}$$

If 1 220 × 2 440 mm (4 × 8 ft.) panels are used, the maximum spacing would probably be further reduced to 305 mm (12 in.) to be modular with the panels.

Example 21 – Sizing of Roof Rafters

A single-family home being built in St. Anthony, Newfoundland, requires rafters that will enclose an unfinished attic space in a roof with a slope of 1:2.4 (5/12). No. 2 or better Spruce–Pine–Fir is used and the total width of the house is 9 m measured to the inside of the wall plates. If 38 × 89 mm collar ties are used at mid-rafter span, find the size and spacing of rafters if the ground snow load is 6.1 kPa and the rain load is 0.6 kPa.

1. The specified roof snow load is calculated as follows:

$$\text{Snow load} = 0.55 \times 6.1 = 3.35\,\text{kPa}$$
$$\text{Associated rain load} = 0.6\,\text{kPa}$$
$$\text{Specified roof snow load} = 3.35 + 0.6 = 3.95\,\text{kPa}$$

2. Given 9 m as the total span of the roof, each rafter will have to span 4.5 m. Noting that collar ties are used at midspan, the span of each rafter is further reduced to 2.25 m.
3. Table NBC Table 9.23.4.2.-G shows maximum design loads of 2.5 kPa and 3.0 kPa.

   If spans for 3.0 kPa are used, spacing must be decreased by 3.0/3.95 = 0.759.

   Therefore, use spans for 600 mm spacing and decrease to 400 mm (400/600 = 0.667).
4. For No. 1 and No. 2 Spruce–Pine–Fir, with a design load of 3.0 kPa, and 600 mm spacing, 38 × 89 mm (2 × 4 in. nominal) rafters will span only 1.71 m, and 38 × 140 mm (2 × 6 in. nominal) rafters will span 2.45 m.
5. Select 38 × 140 mm (2 × 6 in. nominal) rafters, and reduce spacing to 400 mm (16 in.) on centre.

Built-up Wood Beams and Glued-Laminated Floor Beams

Built-up wood beam and glued-laminated floor beam selection tables are provided in NBC Tables 9.23.4.2.-H to -K. The allowable spans apply only where the floors serve residential areas, or where the uniformly distributed live load on floors does not exceed that specified for residential areas as described in NBC Table 4.1.5.3. The tables for built-up beam spans (NBC Tables 9.23.4.2.-H to -J) include 3-, 4- and 5-ply beams. See Guide 9.23.8.3., Built-up Wood Beams, for fabrication information.

The average joist lengths in the various wood beam tables are shown in increments of 0.6 m (2 ft.). For supported joist lengths intermediate between those shown in the tables, straight line interpolation may be used for determining the maximum beam span.

Roof Ridge Beams

Selection tables for built-up roof beams are provided in NBC Table 9.23.4.2.-L.

Example 22 – Beam Sizing

A two-storey house has a 9.0 m beam supported at each end on the foundation walls, and along its intermediate length by three equally spaced columns. Given that the joists on one side of the beam are both 3.7 m long, calculate the required beam size.

1. The supported joist length is 3.7 m.
2. The span of the beam is 9.0 m less 90 mm bearing at each end divided by the number of spaces spanned:

$$\text{Beam span} = \frac{9.0 - 0.18}{4} = 2.205\ \text{m}$$

3. For a built-up wood beam supporting two floors, NBC Table 9.23.4.2.-I applies.
4. Since the supported joist length is 3.7 m, the allowable span must be interpolated between the spans permitted for 3.6 m and 4.2 m.
5. Referring to NBC Table 9.23.4.2.-I No. 1 and 2 Spruce–Pine–Fir, for a 3.6 m supported length, a 4-ply 38 × 184 mm built-up beam can span 2.27 m, and that with a 4.2 m supported length, the same size beam (4-ply 38 × 184 mm) can span 2.11 m.
6. Using interpolation, calculate the maximum span for this 4-ply 38 × 184 mm beam with the requirement for a supported length of 3.7 m:

$$\text{Maximum span} = 2.27 + \left[\left(\frac{2.11 - 2.27}{4.2 - 3.6}\right) \times (3.7 - 3.6)\right] = 2.243\ \text{m}$$

   Therefore, the supported length of 3.7 m (12 ft. 2 in.) will require a maximum span of 2.243 m (7 ft. 4 in.), which is greater than the given span of 2.205 m (7 ft. 3 in.).

9.23.4.3. Steel Beams

This Article refers to a table for steel beams spans and references a standard. Steel beams that support floor joists must have sufficient strength to support the anticipated loads, and sufficient stiffness to provide floors without objectionable springiness. The depth of steel beams to span between columns is less than is required for wood beams, thereby permitting greater head room.

NBC Table 9.23.4.3. can be used to select steel beams for one- and two-storey houses. The strength of the steel must be at least equal to Grade 350 W steel as described in CSA G40.21, “Structural Quality Steel.” Steel beams to be used in exposed locations must be shop primed.

The spans in NBC Table 9.23.4.3. have been calculated based on the following assumptions:

- simply supported beam spans,
- laterally supported top flange,
- yield strength = 350 MPa (50 000 psi),
- deflection limit = L/360,
- live load: first floor = 1.9 kPa (40 psf); second floor = 1.4 kPa (29 psf), and
- dead load: = 1.5 kPa (31 psf) (0.5 kPa (10 psf) floor + 1.0 kPa (21 psf) partition).

The calculation used to establish the maximum spans for steel beams uses a revised live load reduction factor to account for the lower probability of a full live load being applied over the supported area in Part 9 buildings.

The average joist lengths in the steel beam table are shown in increments of 0.6 m (2 ft.). For supported joist lengths intermediate between those shown in the tables, straight line interpolation may be used in determining the maximum beam span.

Steel beam types are designated by a letter (S or W) followed by two numbers (e.g., S100 × 11). The S designation indicates that the flange surfaces adjacent to the web are sloped, such as in typical I-beams. The W designation indicates that the two surfaces of each flange are parallel, such as in wide-flange beams. The first number following the letter is the depth of the member in millimeters. The second number is the mass of the member per metre of length. Thus, a W150 × 22 beam is a wide-flange beam 150 mm (6 in.) in depth, and weighing 22 kg/m (15 lb./ft.)

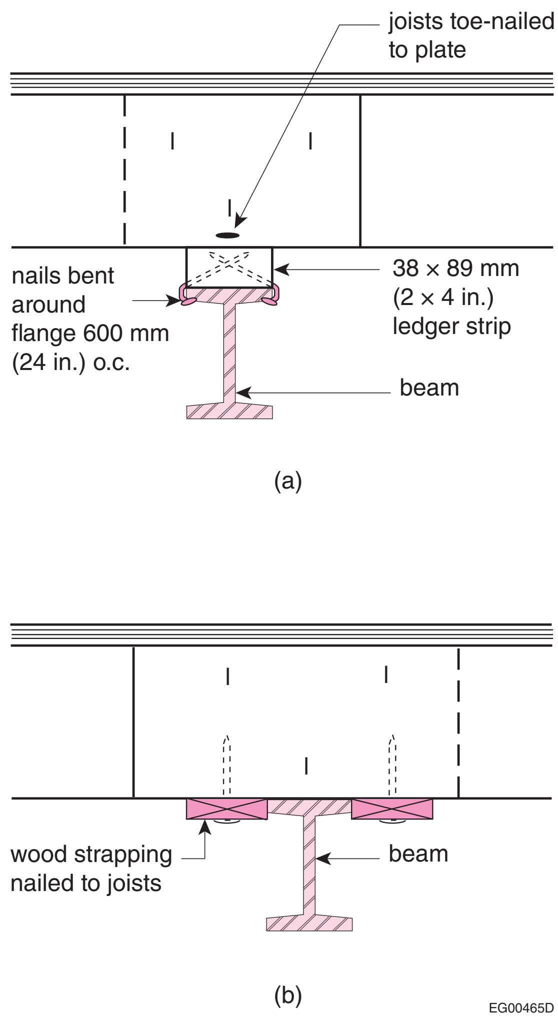


Figure 9.23.-5
Lateral support for steel beams

When steel beams are loaded, the top flange is in compression and behaves somewhat like a slender column. It tends to buckle sideways unless it is laterally supported, or the allowable load is reduced to safe levels. The beam tables in the NBC are based on the assumption that the floor system provides sufficient lateral resistance to prevent such buckling.

Where it is not possible to provide such support by nailing the framing members to the beams, restraint is usually provided by supporting the joists on a ledger strip fastened to the side of the beam (Figure 9.23.-5(a)) or by a row of strapping securely nailed to the underside of the joists next to the beam (Figure 9.23.-5(b)).

Example 23 – Steel Beam Selection

If a steel beam is used in Example 22 (two storeys), NBC Table 9.23.4.3. applies.

1. For a 3.6 m supported joist length, the smallest beam, W150 × 22, can span 4.1 m.
2. For a 4.2 m average joist span, the same beam can span 3.8 m.
3. The 3.8 m joist span for which the beam to be used lies between the values in 1 and 2; no interpolation is necessary to determine the allowable beam span since the beam is only required to span 2.25 m.

   Therefore, a W150 × 22 steel beam will meet the requirements.

9.23.4.4. Concrete Topping

This Article refers to tables that pertain to joist and beam spans supporting concrete topping. Concrete topping is sometimes provided over a wood-frame floor to provide greater sound resistance between dwelling units.

When a floor supports a concrete topping, the beam spans identified in the NBC tables, or the supported length of the floor joists, must be reduced to allow for the additional weight of the topping. Where a floor is required to support a concrete topping not more than 51 mm (2 in.) thick, the allowable spans in NBC Table 9.23.4.2.-B may be used. Allowable spans in NBC Tables 9.23.4.2.-H to -K must be multiplied by 0.8, or the supported length of the floor joists must be reduced to allow for the weight of the topping.

9.23.4.5. Heavy Roofing Materials

This Article requires that the spans of roof members be reduced when heavy roofing materials are used. The NBC Span Tables for rafters and roof joists assume that the roofing will consist of lightweight, asphalt-based roof coverings, wood shingles or shakes, or metal roofing. When roofing tiles of clay or concrete are used, the resulting roof load is considerably greater.

The design of roof joists or rafters supporting heavy roofing materials can be determined by reducing the spacing of members or shortening the spans in NBC Tables 9.23.4.2.-D to -G, and by reducing the spans of ridge beams and lintels in NBC Tables 9.23.4.2.-L and 9.23.12.3.-A to -D.

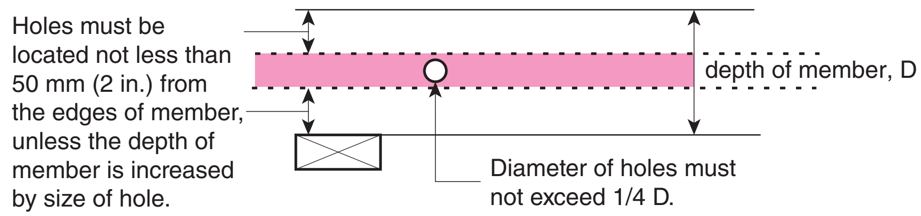
9.23.5. Notching and Drilling

9.23.5.1. Holes Drilled in Framing Members

This Article limits the size of holes permitted in framing members. Where members carry bending loads (i.e., joists, rafters and beams), the areas of highest bending stress occur at the top and bottom edges, and decrease to zero at the centre. Therefore, any holes drilled through such members should be located away from the edges and towards the centre axis to reduce their effect on strength. The size of the holes is also restricted for the same reason. Manufacturers' directions for the size and location of holes in wood I-joists and composite lumber products such as laminated veneer lumber must be followed.

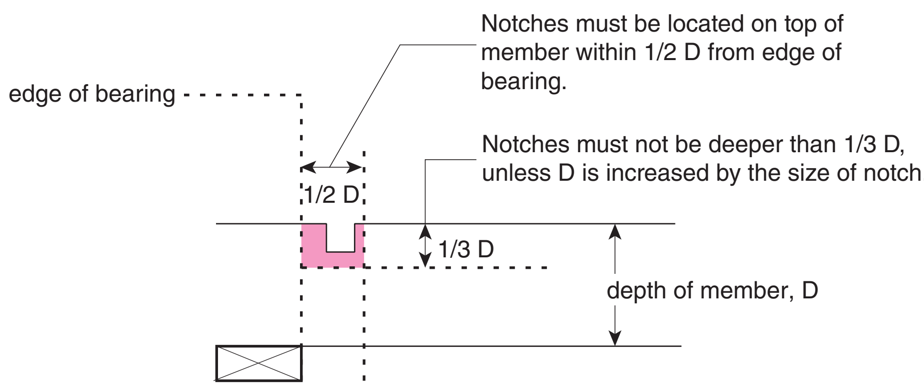
9.23.5.2. Notching of Framing Members

This Article limits the size of notches permitted in floor framing members. The drilling and notching of floor members to allow the passage of piping, ducts and other services is limited to prevent the members from being seriously weakened. Figure 9.23.-6 shows the notching and drilling limitations for dimension lumber floor members. Wood I-joists cannot be notched but holes, in accordance with manufacturers' instructions, are permitted.



Member Size	Maximum Hole Diameter
38 × 89 mm (2 × 4 in.)	not permitted
38 × 140 mm (2 × 6 in.)	35 mm (1 3/8 in.)
38 × 184 mm (2 × 8 in.)	46 mm (1 3/4 in.)
38 × 235 mm (2 × 10 in.)	58 mm (2 1/4 in.)
38 × 286 mm (2 × 12 in.)	71 mm (2 3/4 in.)

Drilling of holes in framing members



Member Size	Maximum Distance from Edge of Bearing	Maximum Depth of Notch
38 × 89 mm (2 × 4 in.)	44 mm (1 3/4 in.)	30 mm (1 1/8 in.)
38 × 140 mm (2 × 6 in.)	70 mm (2 3/4 in.)	46 mm (1 3/4 in.)
38 × 184 mm (2 × 8 in.)	92 mm (3 5/8 in.)	61 mm (2 3/8 in.)
38 × 235 mm (2 × 10 in.)	117 mm (4 5/8 in.)	78 mm (3 in.)
38 × 286 mm (2 × 12 in.)	143 mm (5 5/8 in.)	95 mm (3 3/4 in.)

Notching of framing members

EG00487B

Figure 9.23.-6
Drilling and notching of framing members

9.23.5.3. Wall Studs

This Article limits the size of holes and notches permitted in wall framing members. Wall studs can be notched and drilled within established limits as shown in Figure 9.23.-7. No more than one third of the depth of the stud can be drilled or notched if the stud is loadbearing. At least 40 mm (1 5/8 in.) of stud must remain undamaged if the stud is non-loadbearing. Larger notches and holes are possible if the stud is suitably reinforced.

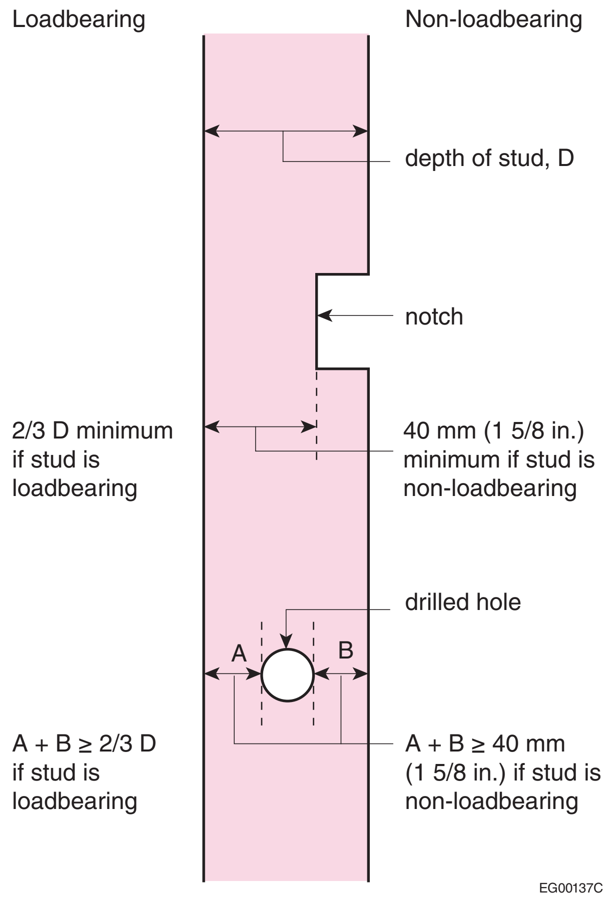


Figure 9.23.-7
Notching and drilling of wall studs

9.23.5.4. Top Plates

Top plates can be notched and drilled provided that the undamaged width of the top plate is not less than 50 mm (2 in.). Reinforcing the top plate can allow larger notches and holes to be used where necessary, as shown in Figure 9.23.-8.

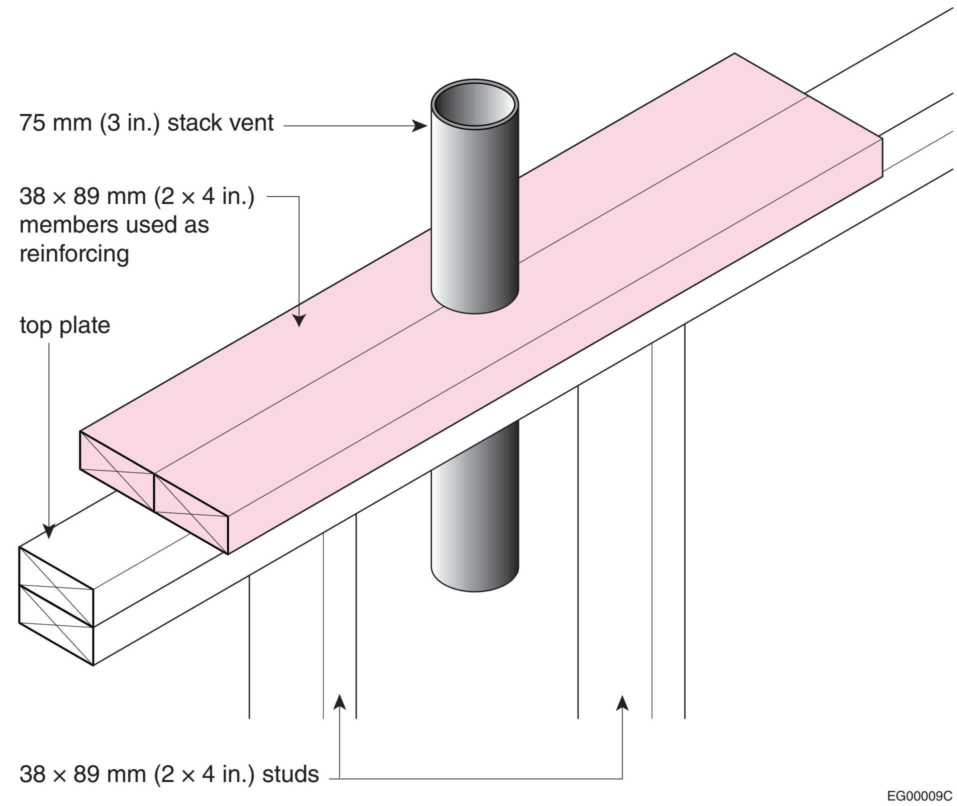


Figure 9.23.-8
Reinforcing top plates

9.23.5.5. Roof Trusses

This Article prevents the drilling or notching of roof trusses. Roof trusses are usually designed so that their members act as triangulated systems. The loss of any single element in the truss could lead to failure of the entire unit. Notching or drilling could, therefore, cause such members to fail under load, and is not allowed.

Roof truss members are much more sensitive to the effects of cutting and notching than are other framing members because of the efficient use of material in such structures. Truss members should not be notched or drilled. The open nature of trusses typically makes it easy to accommodate wiring and pipes.

In some cases, special roof trusses are used that provide livable space. The bottom chords of these trusses cannot be drilled in order to install services as though they were floor joists.

9.23.6. Anchorage

9.23.6.1. Anchorage of Building Frames

This Article requires that building frames of wood-frame construction be anchored to the foundation, unless a structural analysis of wind and earthquake pressures shows that anchorage is not required. This anchorage is intended to keep the superstructure from sliding or lifting away from the foundation in response to wind or seismic loads, and to keep the tops of foundation walls from being pushed inward as a result of earth pressure.

Anchorage must normally be provided by fastening the sill plate to the foundation with anchor bolts embedded in concrete (Figure 9.23.-9(a)) or by embedding the ends of the first floor joists in concrete (Figure 9.23.-9(b)).

When anchor bolts are used for anchorage, they must have a diameter of not less than 12.7 mm (1/2 in.) and must be spaced at not more than 2.4 m (7 ft. 10 in.) on centre.

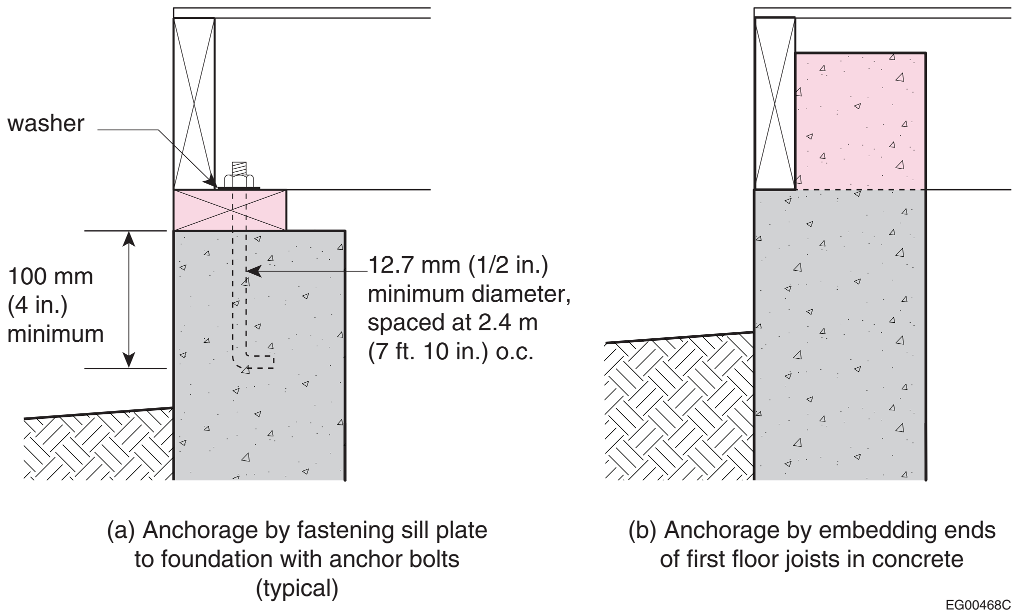


Figure 9.23.-9
Anchorage of building frames to foundation

For buildings with two or more floors supported by frame walls in areas where $S_a(0.2) \leq 0.70$ or 0.80 kPa (16 psf) ≤ HWP < 1.20 kPa (25 psf), anchorage must be provided by fastening the sill plate to the foundation with not less than two anchor bolts per braced wall panel (Figure 9.23.-10). The anchor bolts must have a diameter of not less than 12.7 mm (1/2 in.) and be spaced at not more than 1.7 m (5 ft. 7 in) on centre, or must have a diameter of not less than 15.9 mm (5/8 in.) and be spaced at not more than 2.4 m (7 ft. 10 in.) on centre. In either case, the anchor bolts must be located within 0.5 m (20 in.) of the end of the foundation.

For buildings supported by frame walls in areas where $0.70 < S_a(0.2) \leq 1.8$ and HWP ≤ 1.20 kPa (25 psf), anchorage must be provided by fastening the sill plate to the foundation with not less than two anchor bolts per braced wall panel. The anchor bolts must be located within 0.5 m (20 in.) of the end of the foundation, and sized and spaced in accordance with NBC Table 9.23.6.1.

Where $S_a(0.2) > 1.80$ or HWP ≥ 1.2 kPa (25 psf), NBC Part 4 must be used to design the anchorage of building frames.

9.23.6.2. Anchorage of Columns and Posts

This Article requires that columns and posts be anchored to resist uplift. Buildings are attached to the tops of columns in a manner that will keep the superstructure from sliding or being lifted up due to wind action. Exterior columns and posts need to be anchored to resist uplift and lateral movement.

Where columns or posts support balconies, decks or verandas, and where the distance from the ground to the underside of joists does not exceed 600 mm (2 ft.), the columns or posts shall be anchored to the foundation, or the supported joists or beams shall be directly anchored to the ground to resist uplift.

Anchorage is not required for balconies, decks and verandas that are no more than one storey in height, are no more than 55 m² (590 ft.²), do not support a roof load, and are not attached to another structure (unless it can be shown that differential movement will not adversely affect the other structure). See Guide 9.12.2.2., Minimum Depth of Foundations, Figure 9.12.-6.

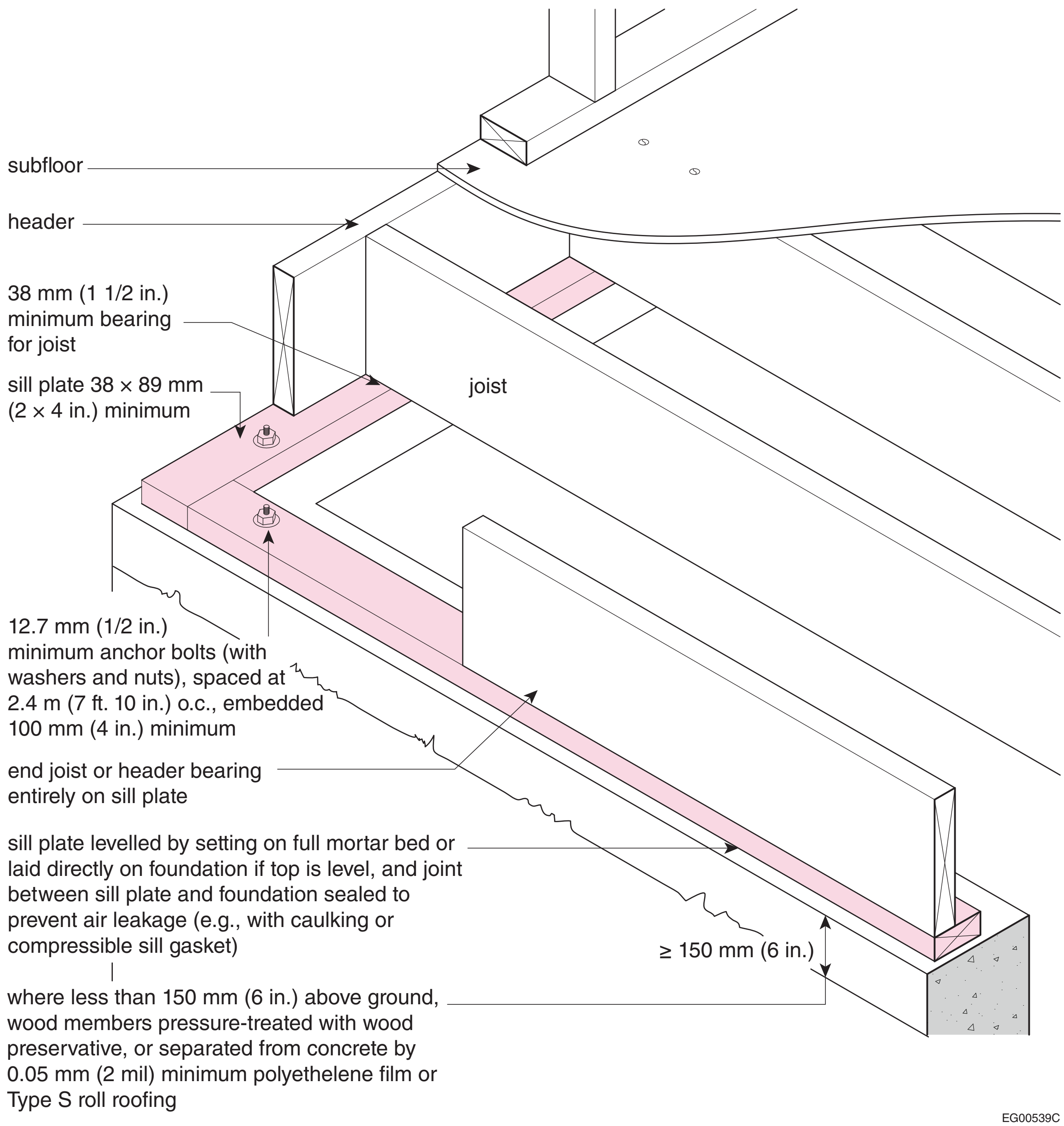


Figure 9.23.-10
Anchorage of building frames to foundation

9.23.6.3. Anchorage of Smaller Buildings

This Article requires anchorage for smaller buildings. Narrow buildings are particularly vulnerable to overturning forces due to wind action. The light weight of such buildings adds to this problem. Such buildings, therefore, require special anchorage provisions.

Single-storey buildings less than 4.3 m (14 ft.) wide can be anchored in accordance with the requirements in CSA Z240.10.1, "Site Preparation, Foundation and Anchorage of Manufactured Homes." These buildings are normally supported on piers spaced along the undersides of wood beams that support the floor system, so that traditional anchorage is not possible. Tie-down rods are, therefore, generally required near each corner to provide stability against wind forces, although CSA Z240.10.1 provides exemptions if it can be demonstrated through calculations that pier toppling and overturning will not occur. These rods are fastened to ground anchors to resist uplift. Various types of ground anchors may be used, including auger types, concrete blocks, or buried dead-men types.

9.23.7. Sill Plates

The primary purpose of sill plates is to provide a means for anchoring wood-frame floors to foundations, and to serve as a means for the attachment of the supported floor joists. Sill plates that sit on the foundation wall assist in the levelling of the floor system and in the transfer of floor loads to the foundation walls.

9.23.7.1. Size of Sill Plates

This Article indicates the minimum acceptable size of sill plates. Sill plates must have sufficient thickness to allow reasonable nail penetration to attach the joists to the sill plate. This is necessary to transfer the anchorage resistance from the sill plates to the floor joists they support. Sill plates must also have sufficient cross-sectional area to provide adequate strength between anchorage points to resist upward as well as lateral forces. Sill plates must also be wide enough to support the ends of the joists without crushing the wood, and allow for nailing the joists to the sill plates.

Sill plates supporting joists and headers must be at least 38 × 89 mm (2 × 4 in. nominal), and either set in a full mortar bed, or laid directly on the foundation, and then caulked or sealed with an acceptable gasket.

9.23.7.2. Levelling and Sealing of Sill Plates

This Article requires that sill plates be placed level with a seal to the foundation. The sill provides a firm, level base on which the floor framing can be supported. To restrict air leakage into the building at the junction between the sill plate and the foundation, it must be sealed in accordance with NBC Subsection 9.25.3. so that it is airtight.

9.23.8. Beams to Support Floors

9.23.8.1. Bearing for Beams

This Article sets a minimum length of even and level bearing for beams. Providing sufficient bearing area at beam supports avoids excessive crushing of beams (in the case of wood beams), or excessive stress in the supporting element. This ensures that loads are safely transferred from the beam to the supporting element. It also provides a sufficient length of bearing to avoid accidental dislodgment.

Wood or steel beams used in houses must bear at least 89 mm (3 1/2 in.), except as indicated in the notes for NBC Tables 9.23.4.2.-H to -K, which indicate the minimum bearing lengths for those beams.

9.23.8.2. Priming of Steel Beams

This Article requires that exterior steel beams be shop primed to limit rusting caused by exposure to the elements.

9.23.8.3. Built-up Wood Beams

This Article describes the requirements for the assembly and support of wood built-up beams. Wood beams, built up from several separate pieces of lumber, are to be assembled in a manner that allows the beam to support anticipated floor loads. This is provided for by locating the joints between butted pieces of lumber at the points of least bending stress, staggering the joints, and taking measures to develop continuity of the built-up beam over the column supports.

Three, four or five individual pieces of lumber that comprise a beam and that have not been suitably tied together will have less strength than if they were properly nailed together, so as to be continuous across intermediate column supports. If a beam is continuous across three or more supports, and carries a uniform load on each span, the maximum bending moments occur at the supports and near the centres of the spans. The stresses fall to zero at or near the end quarter points of the spans. The preferred location for joints, therefore, is near these points. Figures 9.23.-11 and 9.23.-12 illustrate the NBC requirements for nailing and splicing of built-up beams.

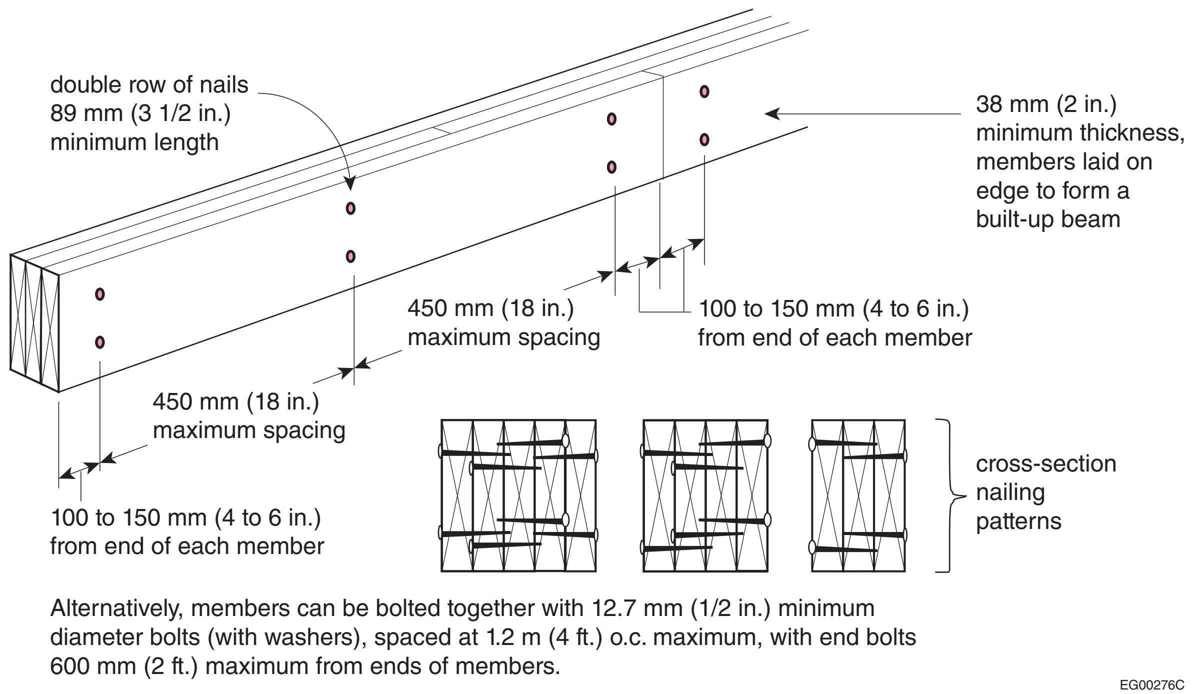


Figure 9.23.-11
Nailing of built-up beams

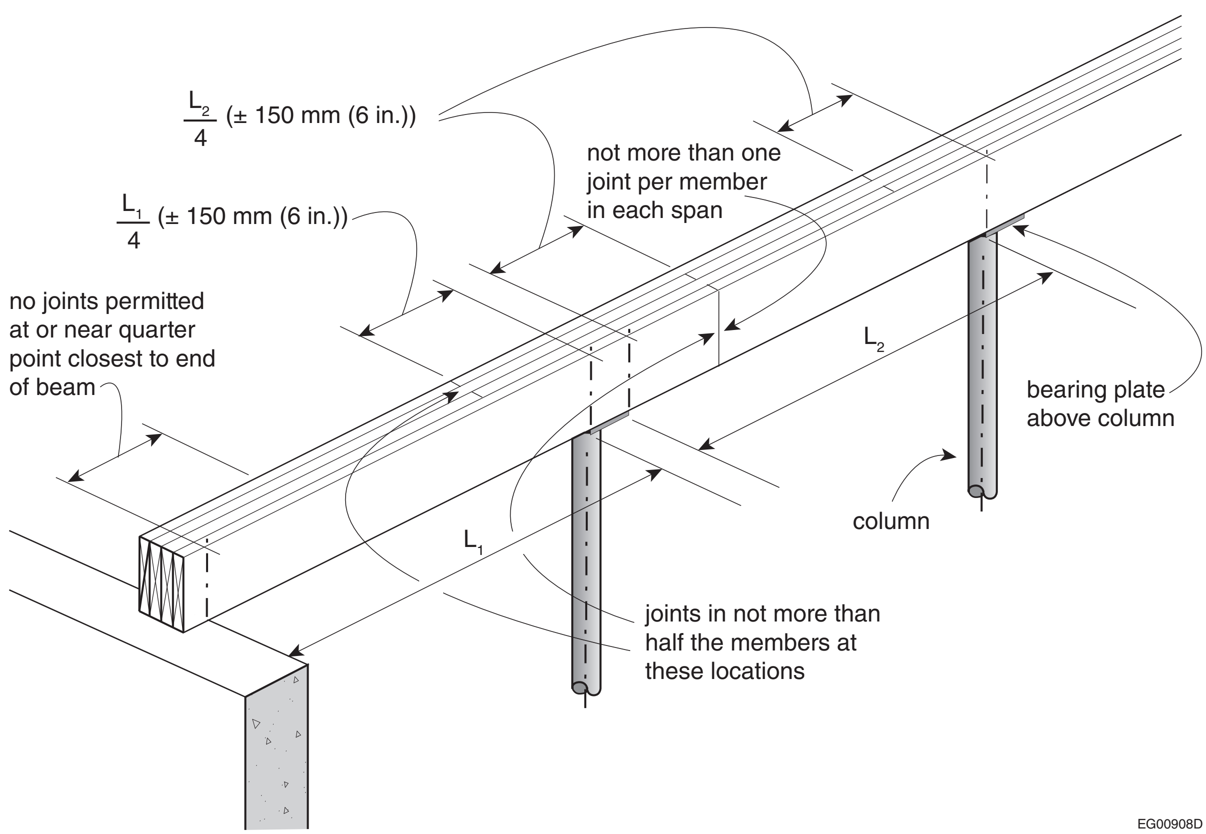


Figure 9.23.-12
Splicing of built-up beams

9.23.9. Floor Joists

9.23.9.1. End Bearing for Joists

This Article sets the minimum end bearing requirements for floor joists to provide sufficient bearing area under the individual joists to avoid undue crushing of the wood, and to permit adequate transfer of vertical loads. A second purpose is to provide a sufficient joist length to allow nailing of the joist to its support.

End bearings for joists are required to be at least 38 mm (1 1/2 in.), except when ribbon boards are used.

This exemption for joists supported on ribbon boards is rationalized on the basis that the joists are also face-nailed to the studs (Figure 9.23.-13). This helps to support the joists and makes it unnecessary to nail them to the ribbon boards. The ribbon board is notched into the wall studding with the joists nailed into the sides of the studs. The ribbon board must be at least 19 × 89 mm (1 × 4 in. nominal).

Where joists are supported by means of embedment into a concrete foundation, the joists must be treated or separated from the concrete according to NBC Article 9.23.2.2., as shown in Figure 9.23.-3.

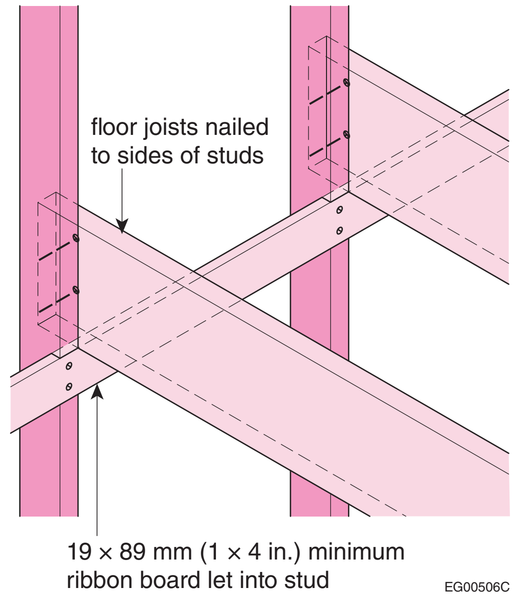


Figure 9.23.-13
Support of floor joists on ribbon boards

9.23.9.2. Joists Supported by Beams

This Article lists the requirements for securely supporting the ends of floor joists on steel or wooden beams in a manner that provides continuous support for the subflooring, and keeps the joist ends from twisting as the lumber dries. It also provides the requirements for accommodating the shrinkage of wood joists framed into the sides of steel beams without affecting the support for the subflooring in the vicinity of the beam.

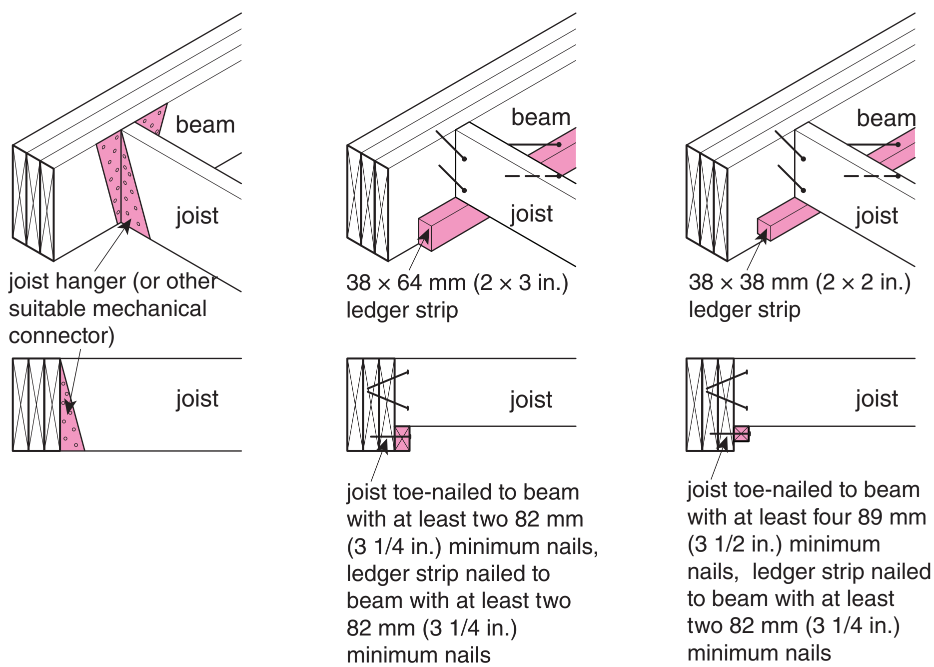


Figure 9.23.-14
Framing of floor joists into wood beams

Joists can be side mounted to wood beams with joist hangers, or they can bear on ledger strips that are nailed to the beam. Figure 9.23.-14 illustrates NBC requirements for joists that frame into the sides of wood beams. The side-mounted joist framing system allows for increased headroom beneath the beam and an unobstructed ceiling. This framing alternative, however, makes duct layout more difficult since there are no joist spaces above the beam in which to run ducts.

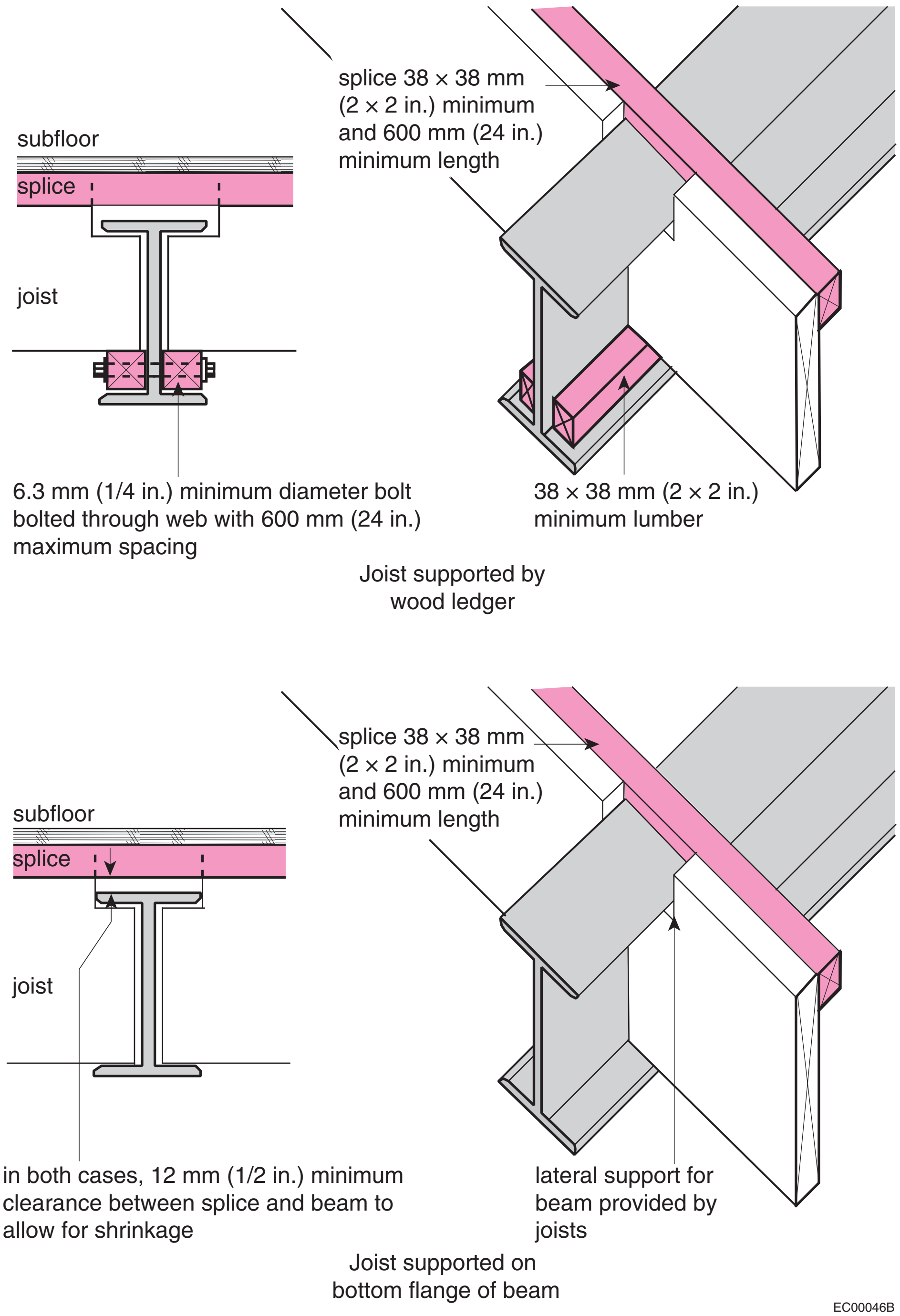
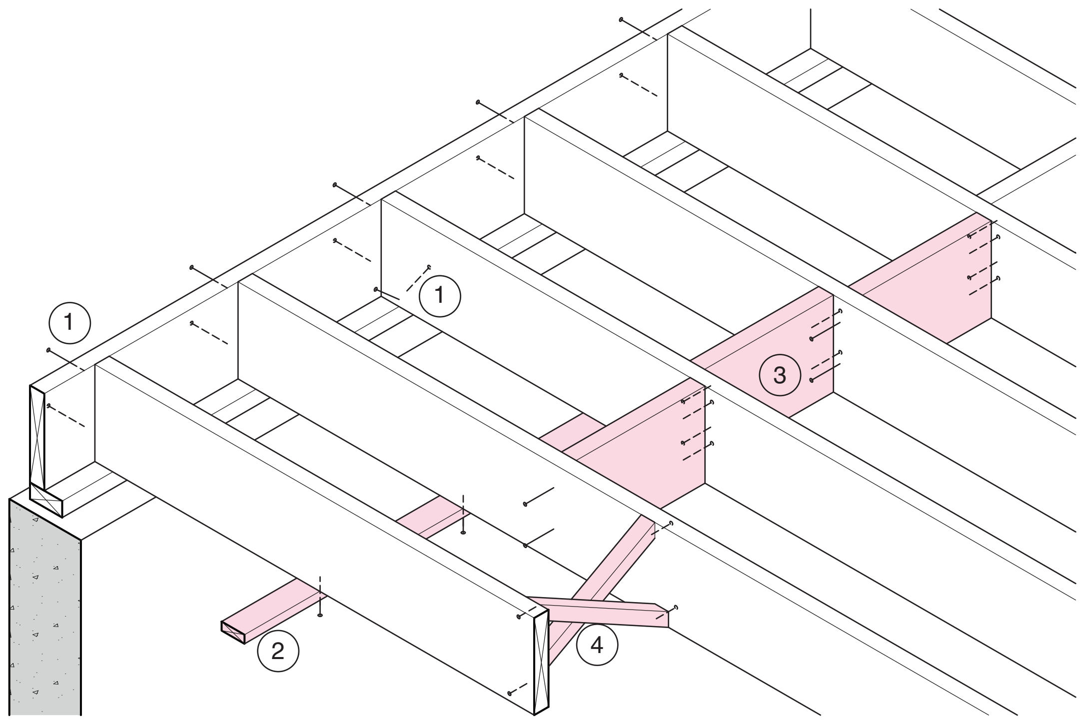


Figure 9.23.-15
Mounting of floor joists to steel beams

Joists may also be supported on wood strips bolted to the web near the bottom flange of the steel beam. Since the joists are often deeper than the beam, they project above it, leaving a gap above the beam between opposing joists. This is bridged by splices across the opposing joists. These splices must be installed with at least a 12 mm (1/2 in.) clearance to accommodate shrinkage. Figure 9.23.-15 also shows the provisions for joists that are mounted onto the sides of steel beams.

9.23.9.3. Restraint of Joist Bottoms

This Article requires that the bottom of joists be restrained from twisting. Figure 9.23.-16 shows the methods used to resist joist twisting. Bridging, strapping, or both bridging and strapping also increase stiffness and reduce the vibration of floor joists. Strapping is not required where furring strips or a panel-type ceiling finish is attached directly to the joists.



Options for restraining floor joists from twisting:
(1) end-nailing to header or toe-nailing to support,
(2) continuous 19 × 64 mm (1 × 3 in.) minimum strapping (not required if furring strips or panel-type ceiling finish attached directly to joists),
(3) 38 mm (1 1/2 in.) solid blocking, or
(4) 38 × 38 mm (2 × 2 in.) or 19 × 64 mm (1 × 3 in.) minimum cross-bridging.

EG00045C

Figure 9.23.-16
Restraint of floor joists from twisting

9.23.9.4. Strapping, Bridging, Furring, and Ceilings in Span Tables 9.23.4.2.-A and -B

This Article describes the installation of strapping, bridging and wood furring, which help provide a floor system that can support the anticipated loads, and will not seem springy. In addition to strength and stiffness requirements, the spans in the floor joist tables limit the amount of floor vibration. This is the result of extensive research on floor performance and acceptance. The procedure to quantify vibration effects was based on a concentrated load calculation and considered the composite action of the floor system.

The spans listed in NBC Table 9.23.4.2.-A make allowances for the composite effects of contributing structural elements, such as subflooring. They are provided for three basic floor systems: with strapping only, with bridging only, and with bridging and strapping.

The first category (strapping only) applies to continuous strapping (19 × 64 mm (1 × 3 in. nominal)) nailed to the underside of the joists and fastened at each end to the sill or header. Joists that support a furred ceiling or a ceiling made from panels such as gypsum board are considered to be in the this category and need no additional strapping.

The second category (bridging only) applies to joists with cross-bridging. This bridging is nailed in pairs between adjacent joists. This is more efficient in load sharing and results in slightly longer allowable spans.

The third category, combining bridging and strapping, is the most efficient in load sharing and permits even longer spans in many cases. The cross-bridging is located over the continuous strapping, creating a truss perpendicular to the joists (Figure 9.23.-17). Solid blocking can be substituted for cross-bridging in this case, and will have a similar effect. In all cases the strapping or bridging is located in rows perpendicular to the joists so that the distance between rows or from the end supports is 2.1 m (6 ft. 11 in.) or less.

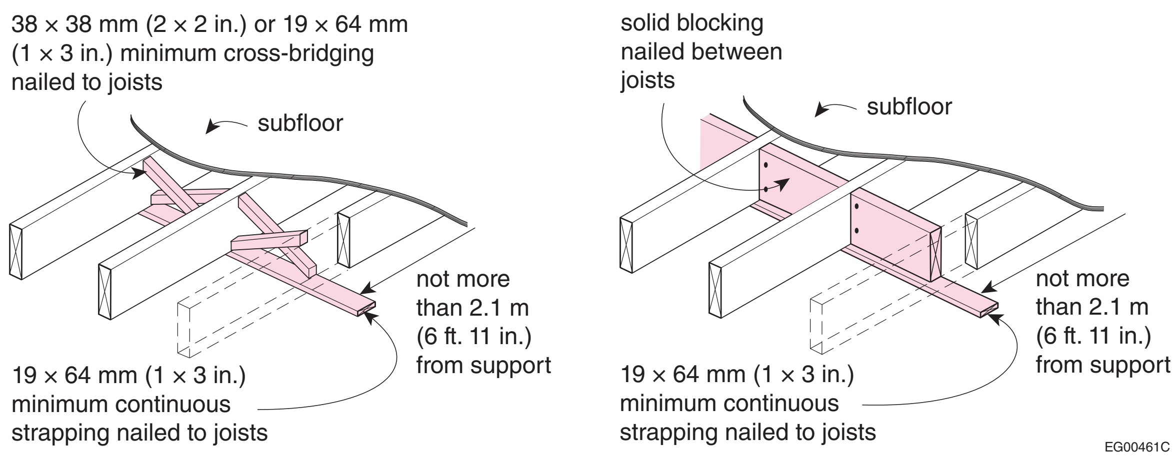


Figure 9.23.-17
Combined bridging and strapping

NBC 9.23.4.2.-B recognizes the composite action that is provided by either wood furring for ceiling finish being installed below the floor joists, or a concrete topping being used above the floor joists. In the case of the wood furring, it must consist of either 19 × 89 mm (1 × 4 in. nominal) boards at not more than 600 mm (24 in.) on centre, or 19 × 64 mm (1 × 3 in. nominal) boards at not more than 300 mm (12 in.) on centre. The concrete topping should be 30 to 51 mm (1 3/16 to 2 in.) of normal-weight concrete (not less than 20 MPa (3 000 psi)) placed directly on the subfloor. The use of either a lightweight concrete topping or a bond breaker between the concrete and the subfloor would limit the composite effect, and is not allowed when using NBC Table 9.23.4.2.-B. Where a lightweight concrete or a bond breaker is used, NBC Table 9.23.4.2.-A may be used.

Further load sharing can be gained if the subfloor is increased in thickness, since the subfloor assists in transferring the load from one joist to another. Gluing the subfloor to the top of the floor joists causes part of the load to be carried by the subfloor, which acts as a compression flange, thus strengthening the overall floor. The subfloor and joists act together to form an integral T-beam that can often eliminate or significantly reduce excessive bounce or vibration in a floor system. Gluing can also reduce floor creaking and squeaking.

The requirements in NBC Part 9 apply to factory-built and site-built structures, since the framing features of both are essentially the same. Certain practices that are intended to accommodate the field erection of factory-built modules, however, have been incorporated into the requirements of NBC Section 9.23., along with those that evolved in the manufactured home industry.

9.23.9.5. Header Joists

This Article lists the requirements for the size of header joists to provide header joists at floor openings that have sufficient strength to transfer vertical loads, including the loads from the supported tail joists, without excessive deflections. Floor openings must always be reinforced with doubled headers when the length of the header exceeds 1.2 m (4 ft.) (Figure 9.23.-18). Header joist sizes must be calculated when their length exceeds 3.2 m (10 ft. 6 in.)

9.23.9.6. Trimmer Joists

This Article indicates the minimum size of trimmer joists at floor openings to provide sufficient strength to transfer vertical loads, including the loads caused by the header joists, without excessive deflection.

Doubled trimmer joists are required when the header length exceeds 800 mm (31 1/2 in.) (Figure 9.23.-18). If the header length exceeds 2 m (6 ft. 7 in.), trimmer joists must be designed for the expected loads in accordance with NBC Part 4. Tail joists and header joists supported by the floor framing must be supported by joist hangers or nailed in accordance with NBC requirements.

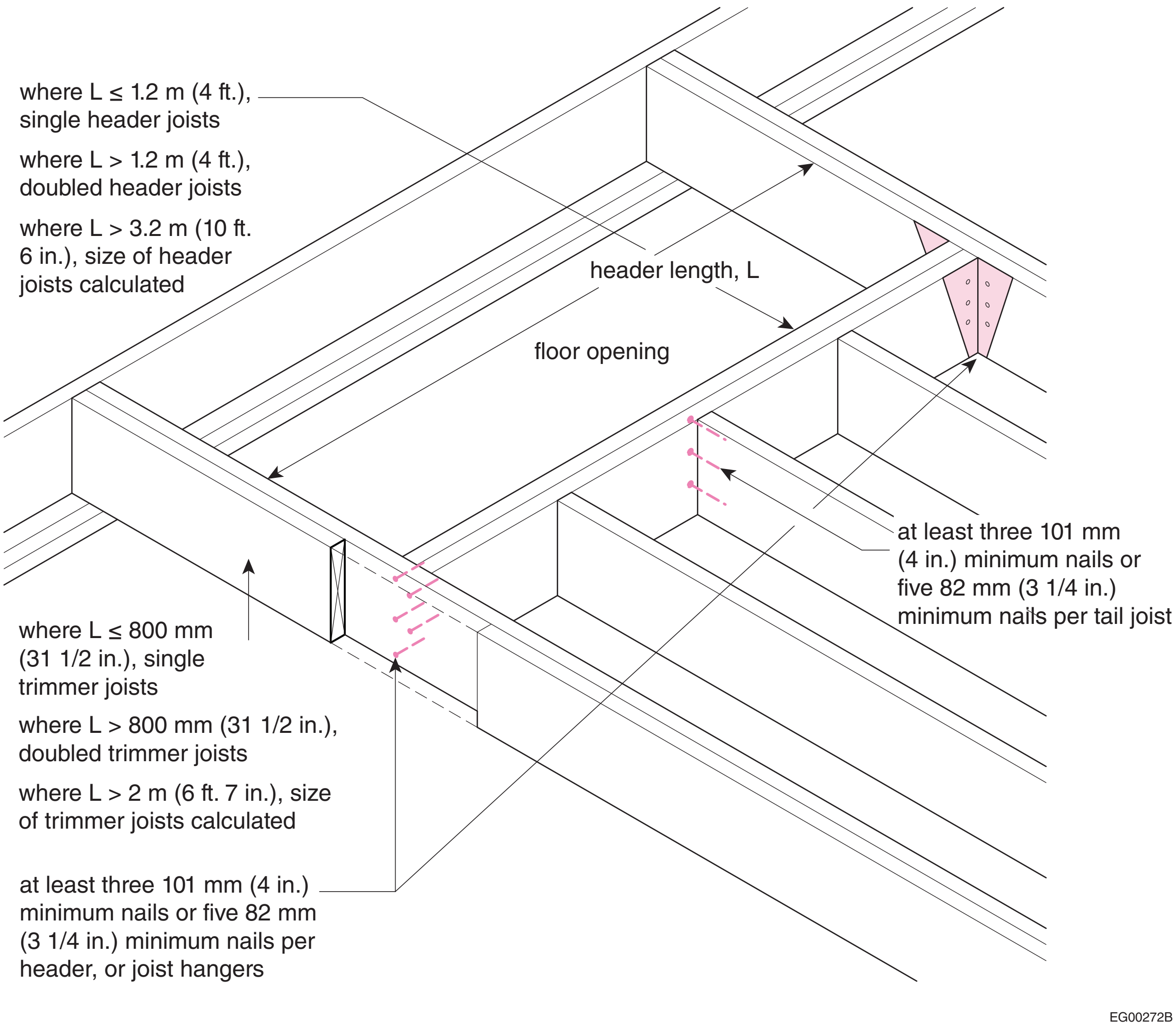


Figure 9.23.-18
Framing around floor openings

Table 9.23.-A shows the maximum header lengths for which single and double headers and trimmers can be used, as well as those for which calculations are required.

Table 9.23.-A
Types of Header and Trimmer Joists Required around Floor Openings

Header Length (L), m	Type of Header Joist Required	Type of Trimmer Joist Required
L ≤ 0.8	Single	Single
0.8 < L ≤ 1.2	Single	Double
1.2 < L ≤ 2	Double	Double
2 < L ≤ 3.2	Double	Size must be calculated
L > 3.2	Size must be calculated	Size must be calculated

9.23.9.7. Support of Tail and Header Joists

This Article indicates the requirements for the support of tail and header joists by using a joist hanger or nailing according to NBC Table 9.23.3.4. Fasteners used to connect the tail joists to the header joists and the header joists to the trimmer joists should have sufficient strength to adequately transfer vertical loads.

9.23.9.8. Support of Walls

This Article requires that support be provided to loadbearing and non-loadbearing walls in a manner that will not cause the floor framing to be overloaded or the deflection of the floor joists or subfloor to be excessive.

The extra weight of non-loadbearing interior walls is not considered sufficient to require the installation of additional joists. If, however, the walls are parallel to the joists and are not located directly over a joist, the extra weight may cause a subfloor to sag. In such cases, cross blocking (38 × 89 mm (2 × 4 in. nominal)) is installed at right angles beneath the wall at intervals of 1.2 m (4 ft.) to transfer the wall loads to the adjacent joists.

The support of non-loadbearing interior walls running parallel to floor joists is illustrated in Figure 9.23.-19. Non-loadbearing interior walls located at right angles to the floor joists are not restricted as to location.

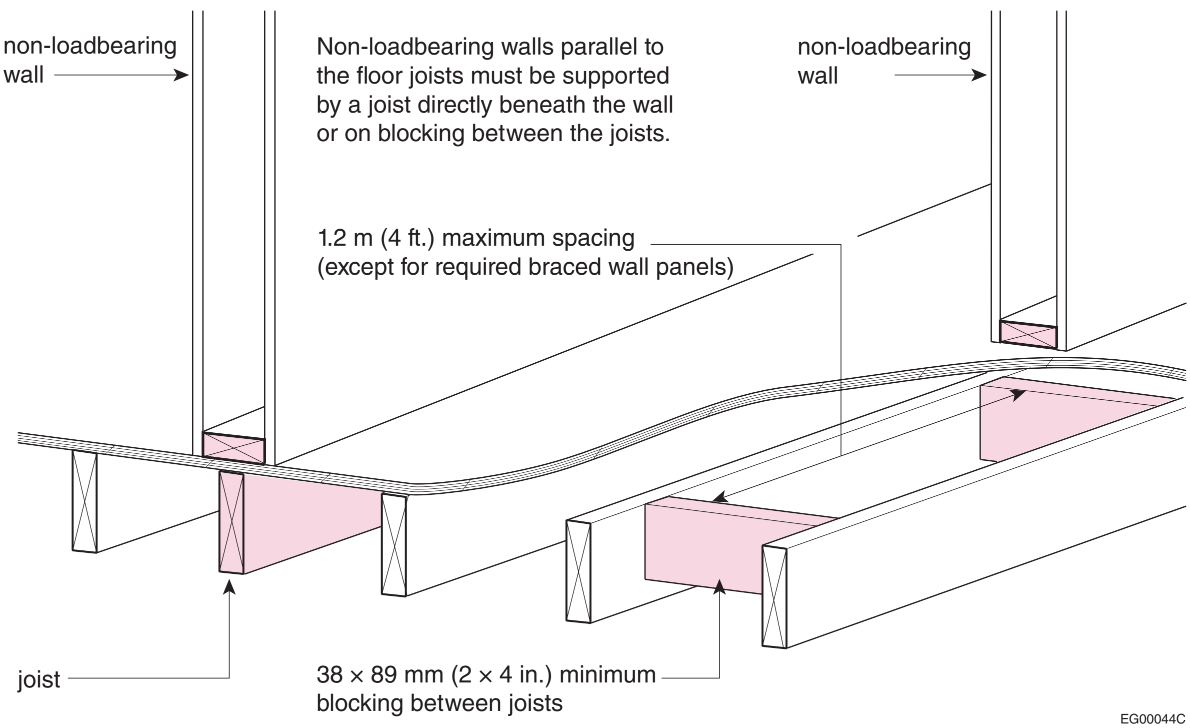


Figure 9.23.-19
Support of non-loadbearing walls parallel to floor joists

Loadbearing interior walls that carry no floor load and that are at right angles to floor joists must be no more than 900 mm (36 in.) from the joist support, such as a beam or loadbearing wall. If floor loads are present, the support can be no further than 600 mm (24 in.) from the loadbearing wall. Figure 9.23.-20 illustrates these cases.

Both loadbearing and non-loadbearing walls that must be braced wall panels in order to meet earthquake or high-wind requirements need to be supported by floor joists, blocking, or rim joists so that the required tie-down fastening can be provided (see NBC Subsection 9.23.13.).

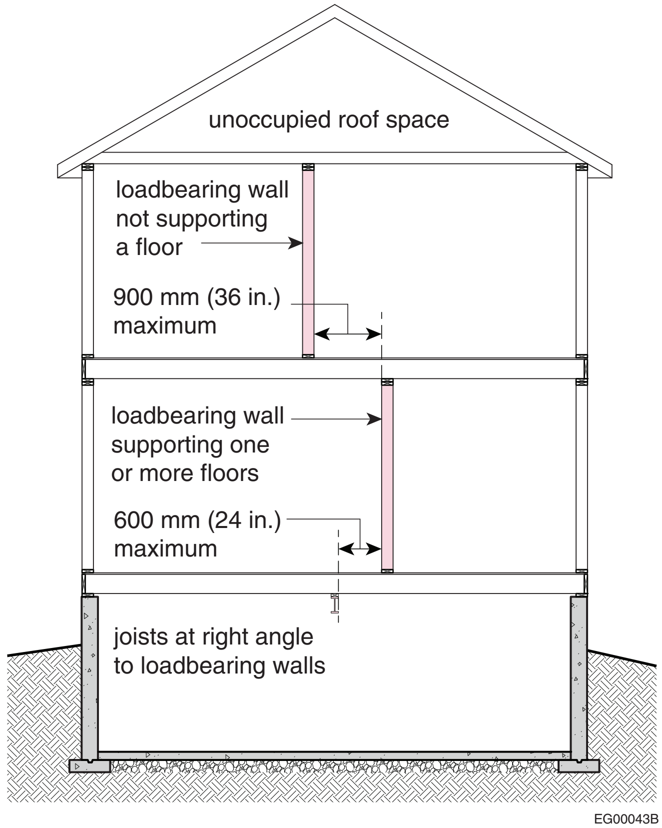


Figure 9.23.-20
Support of loadbearing interior walls at right angles to floor joists

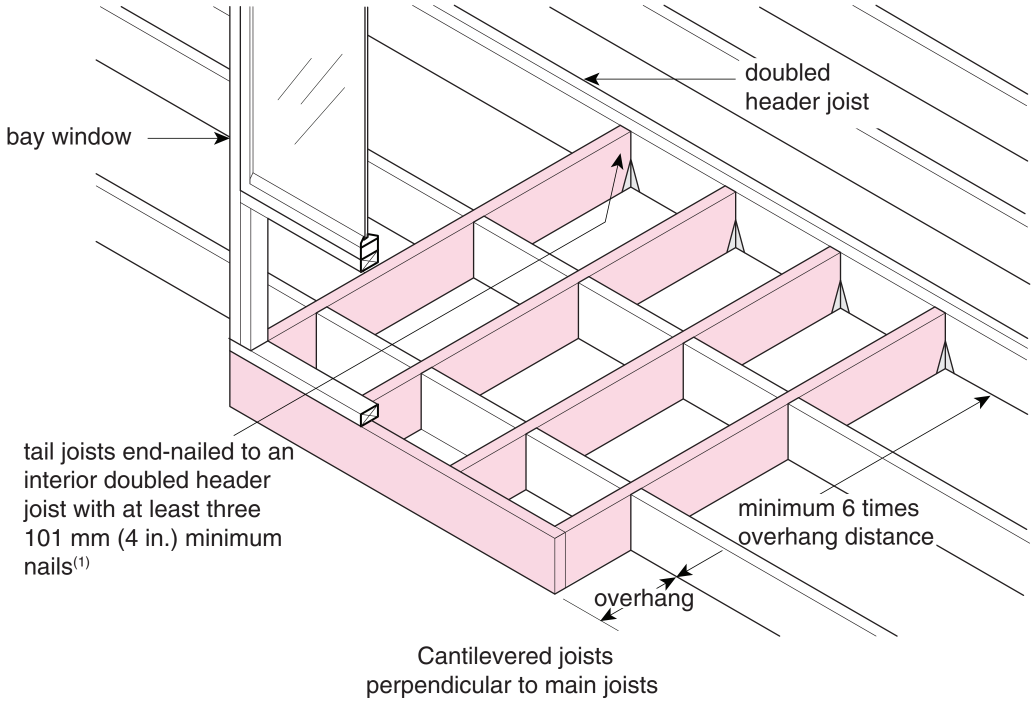
9.23.9.9. Cantilevered Floor Joists

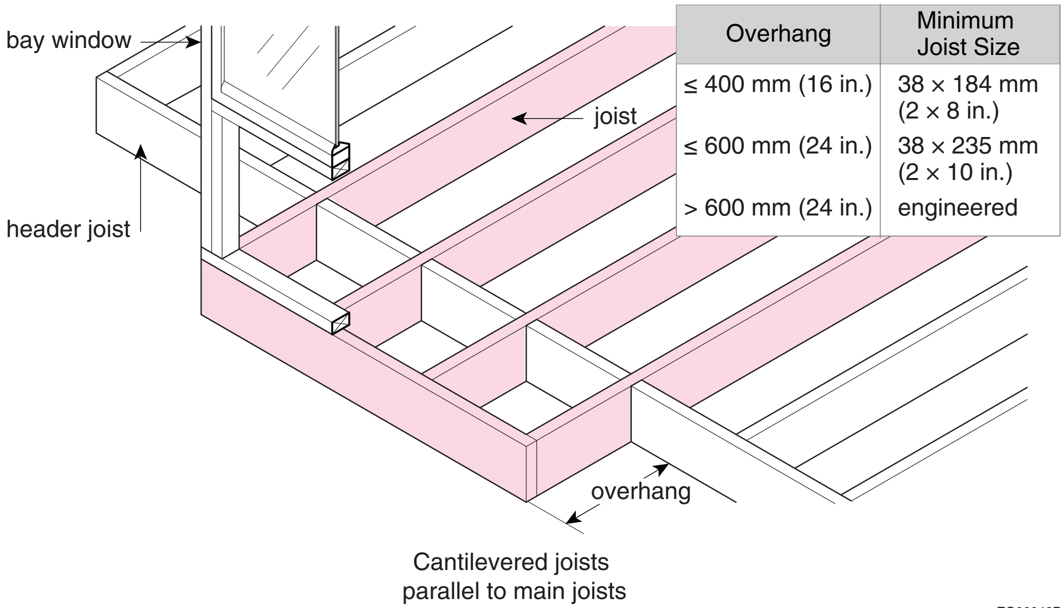
This Article lists the requirements for cantilevered floor joists. Floor joists that are cantilevered out beyond their supports should not be over-stressed or deflect excessively when the anticipated loads are applied, and should be attached at the opposite end in such a manner as to provide stability under the applied load.

When roof loads are supported on the cantilevered end of cantilevered floor joists, the opposite ends of the joists are subjected to an upward thrust. If all the joist framing runs in the same direction, the joists are normally carried back far enough so that the upward forces can be resisted by ordinary nailing. If, however, the cantilevered joists are perpendicular to the common floor joists, an excessive upward thrust may occur if the joists are fairly short. These joists are, therefore, required to be extended back to counterbalance the load on the cantilevered portion.

Floor joists may be cantilevered beyond their supports, provided that the cantilevered end does not support floor loads from above. They are, however, permitted to support roof loads. The amount that the floor joists can be cantilevered depends on the depth of the joists. The greater the depth, the greater the load that can be carried, hence the more cantilever that is permitted. The amount permitted to be cantilevered is based on experience rather than engineering analysis.

Floor joists supporting roof loads must not be cantilevered by more than 400 mm (16 in.) beyond their supports where 38 × 184 mm (2 × 8 in. nominal) joists are used, and not more than 600 mm (24 in.) where the joists are 38 × 235 mm (2 × 10 in. nominal) or larger (Figure 9.23.-21). Calculations must be made to design floor joists that support floor loads from other storeys.





Overhang	Minimum Joist Size
≤ 400 mm (16 in.)	38 × 184 mm (2 × 8 in.)
≤ 600 mm (24 in.)	38 × 235 mm (2 × 10 in.)
> 600 mm (24 in.)	engineered

Figure 9.23.-21
Cantilevered floor joists

Note to Figure 9.23.-21:

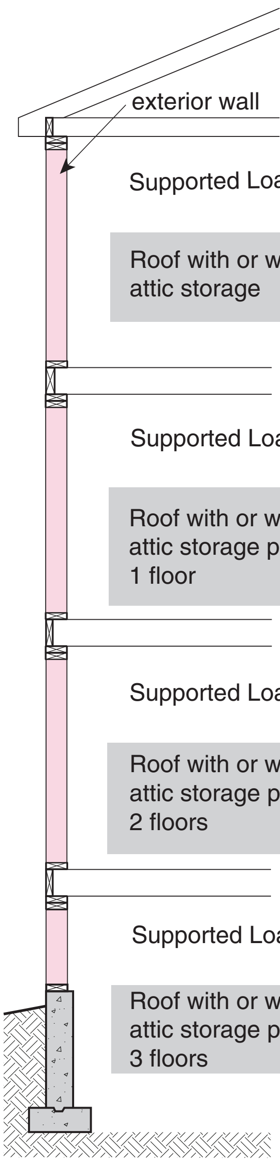
(1) Where cantilevered joists support floor loads from other storeys, calculations must be carried out to show that the design resistances of the cantilevered joists are not exceeded.

9.23.10. Wall Studs

Wall studs are the vertical framing members to which sheathing, cladding and interior finishes are attached. The studs support loads from the roof and/or other floors. They sit on a bottom wall plate and transfer the load to beams, other walls, or directly to the foundation.

9.23.10.1. Stud Size and Spacing

This Article refers to NBC Table 9.23.10.1. for acceptable stud size and spacing. This is to provide stud wall framing that has sufficient strength to support anticipated vertical loads due to occupancy, snow, rain and the weight of the structure, and sufficient transverse strength to withstand forces due to wind action. Studs also provide support and a base for the attachment of sheathing, cladding, and wall finish.



Supported Load	Minimum Stud Size	Maximum Stud Spacing	Maximum Unsupported Height
Roof with or without attic storage	38 × 64 mm (2 × 3 in.) 38 × 89 mm (2 × 4 in.)	400 mm (16 in.) 600 mm (24 in.)	2.4 m (7 ft. 10 in.) 3.0 m (9 ft. 10 in.)

Supported Load	Minimum Stud Size	Maximum Stud Spacing	Maximum Unsupported Height
Roof with or without attic storage plus 1 floor	38 × 89 mm (2 × 4 in.) 38 × 140 mm (2 × 6 in.)	400 mm (16 in.) 600 mm (24 in.)	3.0 m (9 ft. 10 in.) 3.0 m (9 ft. 10 in.)

Supported Load	Minimum Stud Size	Maximum Stud Spacing	Maximum Unsupported Height
Roof with or without attic storage plus 2 floors	38 × 89 mm (2 × 4 in.) 64 × 89 mm (3 × 4 in.) 38 × 140 mm (2 × 6 in.)	300 mm (12 in.) 400 mm (16 in.) 400 mm (16 in.)	3.0 m (9 ft. 10 in.) 3.0 m (9 ft. 10 in.) 3.6 m (11 ft. 10 in.)

Supported Load	Minimum Stud Size	Maximum Stud Spacing	Maximum Unsupported Height
Roof with or without attic storage plus 3 floors	38 × 140 mm (2 × 6 in.)	300 mm (12 in.)	1.8 m (5 ft. 11 in.)

EG00010B

Figure 9.23.-22
Minimum sizes, maximum spacings, and maximum unsupported heights for studs in exterior walls

The ability of wall studs to carry vertical loads depends on their depth, spacing and height. The tendency to buckle under vertical loads depends on the ratio of their thickness to their height. If the wider dimension is perpendicular to the wall face, the wall finish restrains the studs from buckling sideways, so that such walls can carry much greater vertical loads than if the studs are parallel to the wall. Unless the loads are very light, therefore, such as in the gable ends of attics, studs must be installed with their faces perpendicular to the wall surface.

The size and spacing of wood studs is determined by the loads that are supported, the unsupported height of the studs and the location of the wall (interior or exterior) and must conform to NBC Table 9.23.10.1. Figure 9.23.-22 shows the size, spacing and maximum unsupported height for wall studs in houses.

In order to provide additional space for insulation in exterior walls, 38 × 140 mm (2 × 6 in. nominal) studs have become common. Exterior walls are sometimes constructed with two rows of studs (either 38 × 64 mm (2 × 3 in. nominal) or 38 × 89 mm (2 × 4 in. nominal)), the spacing of which can be adjusted to accommodate any insulation thickness. Others incorporate vertical wall trusses to provide greater insulation space. Their use, however, is not sufficiently widespread to warrant special rules being developed for NBC purposes.

9.23.10.2. Bracing and Lateral Support

This Article indicates that loadbearing interior walls not finished in accordance with NBC Section 9.29. will require bracing and lateral support. This is to provide buildings that will have sufficient rigidity to resist lateral forces due to anticipated wind forces. It also keeps loadbearing studs in interior walls from buckling sideways under anticipated vertical loads.

Loadbearing studs must be supported laterally by cladding or blocking, and must be placed at right angles to the wall face. They must be continuous for the full storey height (except at openings). Finger-jointed studs manufactured to NLGA SPS-3, "Fingerjointed 'Vertical Stud Use Only' Lumber" can be used.

Where studs are used instead of columns and beams to support a floor over a basement, blocking must be installed at mid-wall height to keep the studs from buckling if they do not have a wall finish.

9.23.10.3. Orientation of Studs

This Article requires that studs be installed at a right angle to the wall face with some exceptions. This keeps loadbearing studs from being oriented in a wall in a way that would cause them to fail prematurely under anticipated vertical loading. An exemption for gable-end walls is justified on the basis that such walls are short and are lightly loaded. An exemption for loadbearing walls in bungalows is justified on the basis that additional loadbearing capacity is provided by structural sheathing, and the loads carried by such walls are relatively small.

9.23.10.4. Continuity of Studs

This Article requires that studs be continuous for the full storey height to avoid the use of joints in studs, since joints would significantly reduce the capacity of the studs to carry vertical or horizontal loads. An exemption for glued fingerjoints is justified on the basis that such joints can provide studs equivalent in strength to full-length studs.

9.23.10.5. Support for Cladding, Sheathing and Finishing Materials

This Article lists the requirements that pertain to the support of the edges of exterior sheathing and cladding materials at the corners of buildings so as to allow them to be fastened to resist the negative pressure due to wind action. A second purpose is to support the edges of interior wall finishes so they can be securely fastened in place to increase the overall stiffness of the building in resisting horizontal wind loads. Such supports are also intended to reduce the risk of damage to finishes resulting from accidental impact.

Corners and intersections must be designed to provide adequate support to the vertical edges of interior finishes, sheathing and cladding. Exterior corners must be framed with a minimum of two studs. Where the vertical edges of interior finishes are supported by blocking or furring, the maximum distance between supports is specified in NBC Article 9.29.5.3.

Where the edges of the gypsum board are supported by special clips or other devices spaced at suitable intervals, such intersections and corners can be framed using only two studs (Figure 9.23.-23).

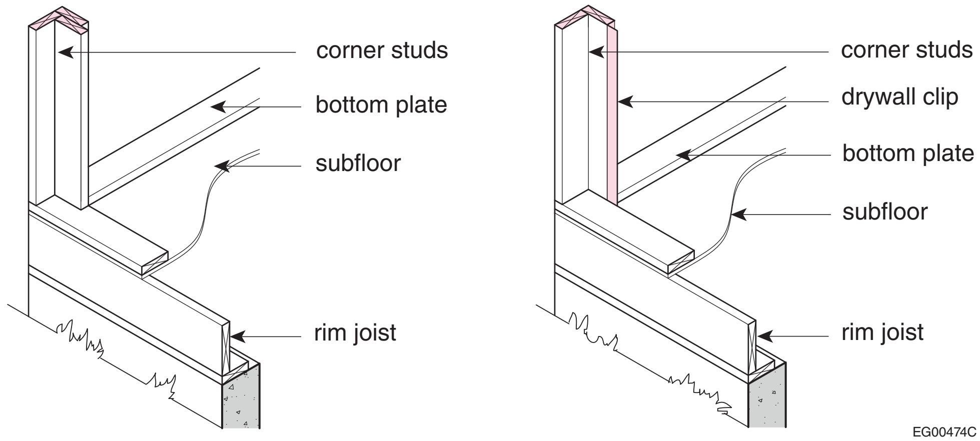


Figure 9.23.-23
Framing of intersections and corners

Sometimes a gap is left in the framing between an intersecting interior wall and the exterior wall to allow the gypsum board to be slipped between the two. This increases the air tightness of the exterior walls and reduces the possibility of condensation within the stud space. However, this is not a mandatory requirement.

9.23.10.6. Studs at Sides of Openings

This Article lists the requirements for the size of studs at the sides of openings to provide members at the sides of openings in walls that have sufficient strength to support the loads transmitted by lintels. Although single studs are permitted adjacent to openings in non-loadbearing interior walls, if the opening supports a heavy door, such as a solid core wood door, doubled studs are generally used to provide additional support.

In rated fire separations, doubled studs are required on either side of openings, regardless of whether the wall is loadbearing or non-loadbearing. Single studs are permitted on each side of an opening in a loadbearing or non-loadbearing interior or exterior wall, provided that the opening is less than the width of the required stud spacing, and that no two openings are located adjacent to each other (Figures 9.23.-24 and 9.23.-25).

Where a lintel spanning an opening is more than 3 m (10 ft.) long, three studs are required at each side of the opening, with two of them supporting the lintel and the third (outer) stud extending to the upper wall plates.

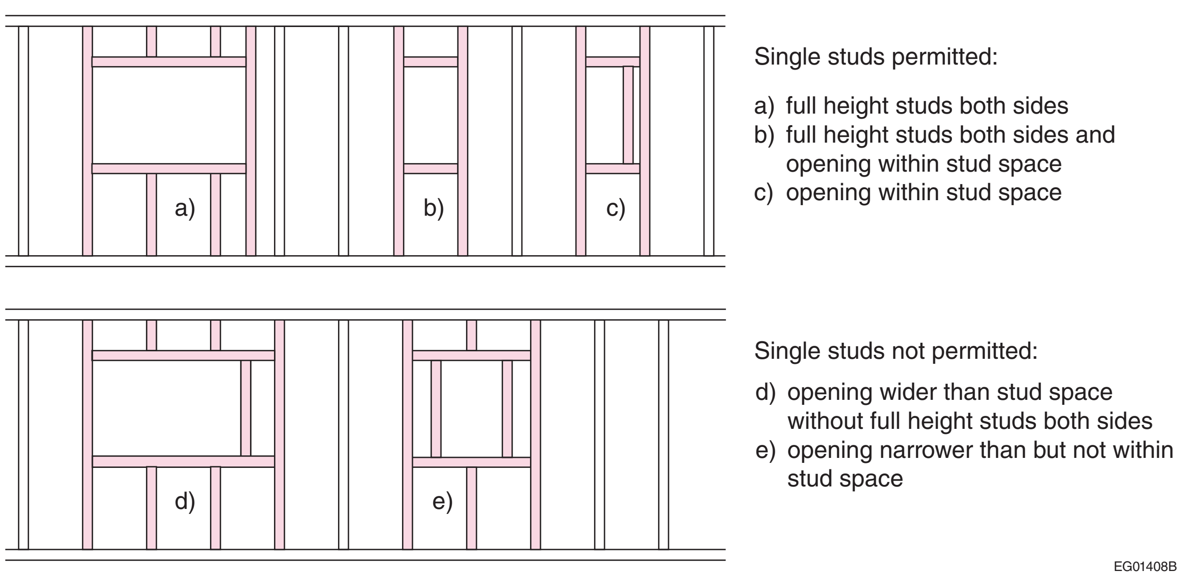


Figure 9.23.-24
Single studs on sides of openings in non-loadbearing interior walls not required to have a fire-resistance rating

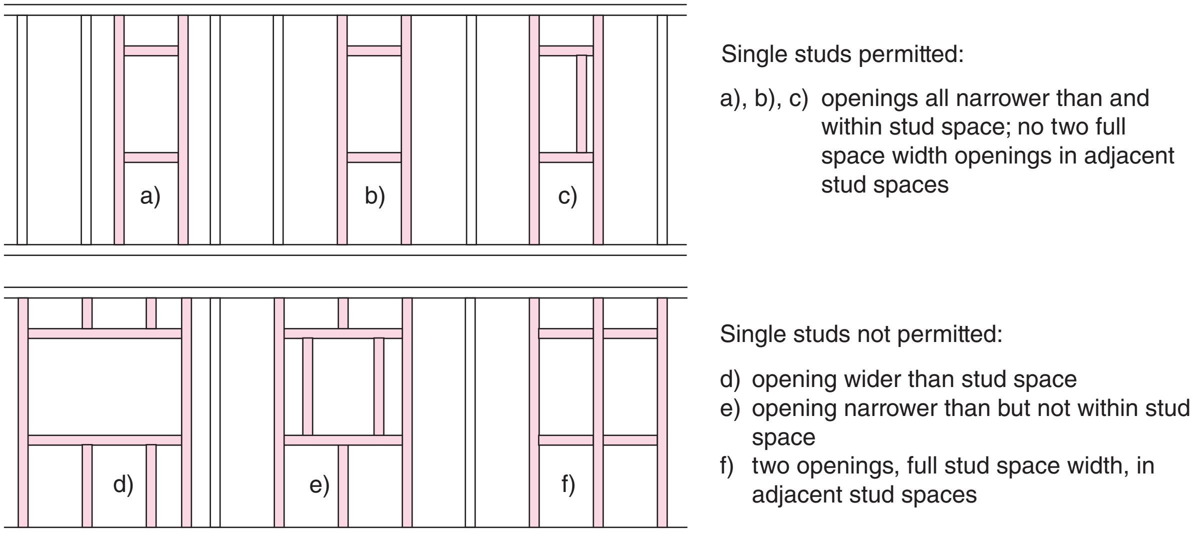


Figure 9.23.-25
Single studs on sides of openings in all other walls

Where window and door openings occur, the lintels above them must transfer the loads to adjacent studs. These studs, which are placed under each end of the lintel, are referred to as jack studs, and extend in one piece down to the bottom wall plate. Each is stiffened and supported by a second stud extending from the upper wall plates down to the lower wall plate (Figure 9.23.-26).

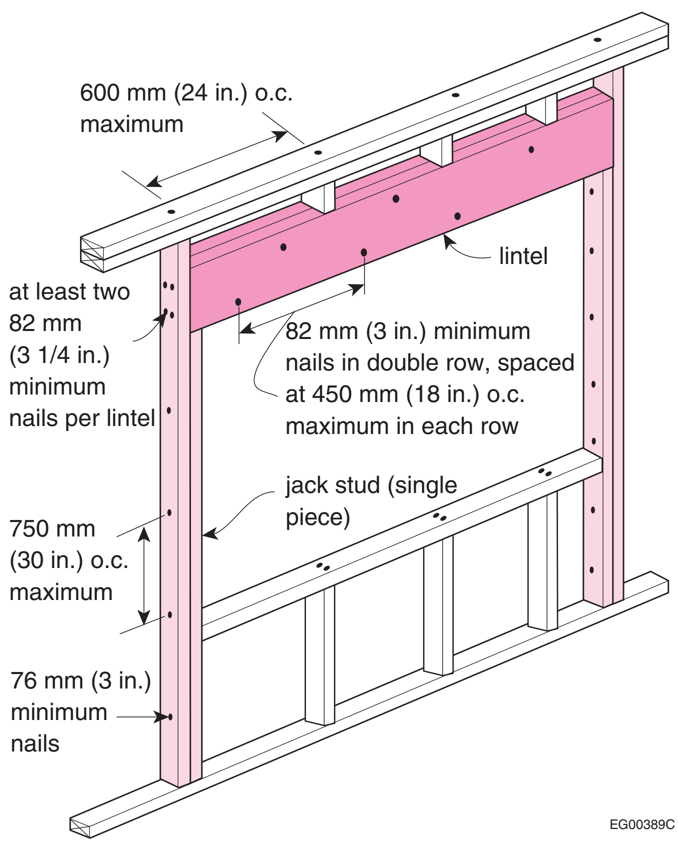


Figure 9.23.-26
Support of lintels

9.23.11. Wall Plates

Wall plates are used to align and anchor the studs, and tie them together to act as a unit.

9.23.11.1. Size of Wall Plates

This Article indicates the minimum allowable wall plate size, intended to ensure that wall plates are strong enough to resist lateral loads and vertical loads. Since they support the top and bottom edges of the sheathing and wall finish, and provide a base for their attachment, they must be the same width as the studs in standard framing configurations. Wall plates also transfer supported loads to wall studs, and from the studs to the floor joists below. They must have sufficient strength and stiffness to carry out this function without damage to the wall finish. Studs directly above joists, however, exert no bending load on a bottom plate, so the bottom plate can be reduced in thickness.

Normally, only one plate is provided at the bottom and two at the top. The wall plates at the top serve to stiffen the top of the wall and when suitably lapped at corners and intersections, tie the entire frame of the house together. They are also able to support the load from a framing member, such as a joist, rafter or roof truss that may fall between two studs, and transfer the load to the adjacent studs. The plate at the bottom, like those at the top, also keeps the studs in alignment and provides support for the bottom edge of the gypsum board.

In typical wood-frame construction, wall plates are the same width and thickness as the studs. However, sometimes studs wider than required by the NBC are used to accommodate more insulation. In these cases, the plates need be no wider than the required width of the studs.

9.23.11.2. Bottom Wall Plates

This Article requires that bottom wall plates not project more than one third the plate width over the support. Bottom wall plates are needed to anchor walls to the floor system on which they rest. Since such plates also transfer loads from the studs to the floor framing, they must be located over a support in such a manner that the wall will not become unstable under anticipated loads. The amount that they are permitted to be cantilevered beyond their support is therefore limited. A bottom plate is permitted to overhang a floor by up to one third of the plate width (Figure 9.23.-27).

The bottom wall plate may be reduced to a thickness of 19 mm (3/4 in.) if it is supported directly over the floor framing. This is another practice initially used by the manufactured home industry, and subsequently adopted in NBC Part 9.

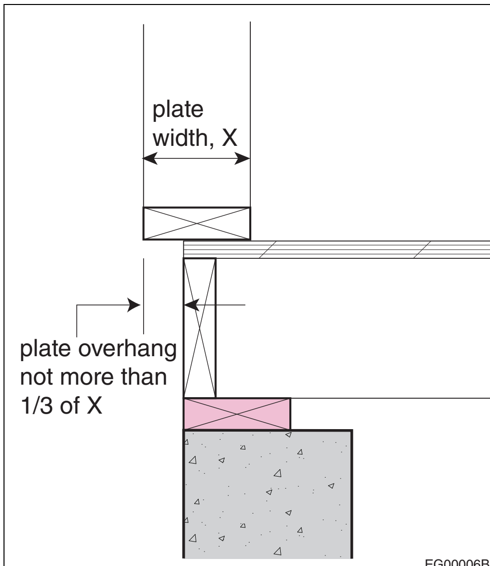


Figure 9.23.-27
Maximum overhang of wall plates

9.23.11.3. Top Plates

This Article requires top plates in loadbearing walls with some exceptions. This is to provide sufficient strength and stiffness to transfer supported loads to the studs without damage to the interior finish. Top plates for loadbearing walls are doubled unless supported members are within 50 mm (2 in.) of the supporting stud or where a lintel is provided since little bending load is carried by the plate.

Where joints occur in doubled top plates, they should be offset by at least one stud space in order to provide a reasonable tie across the joint. Figure 9.23.-28 shows this detail and other requirements for wall plates.

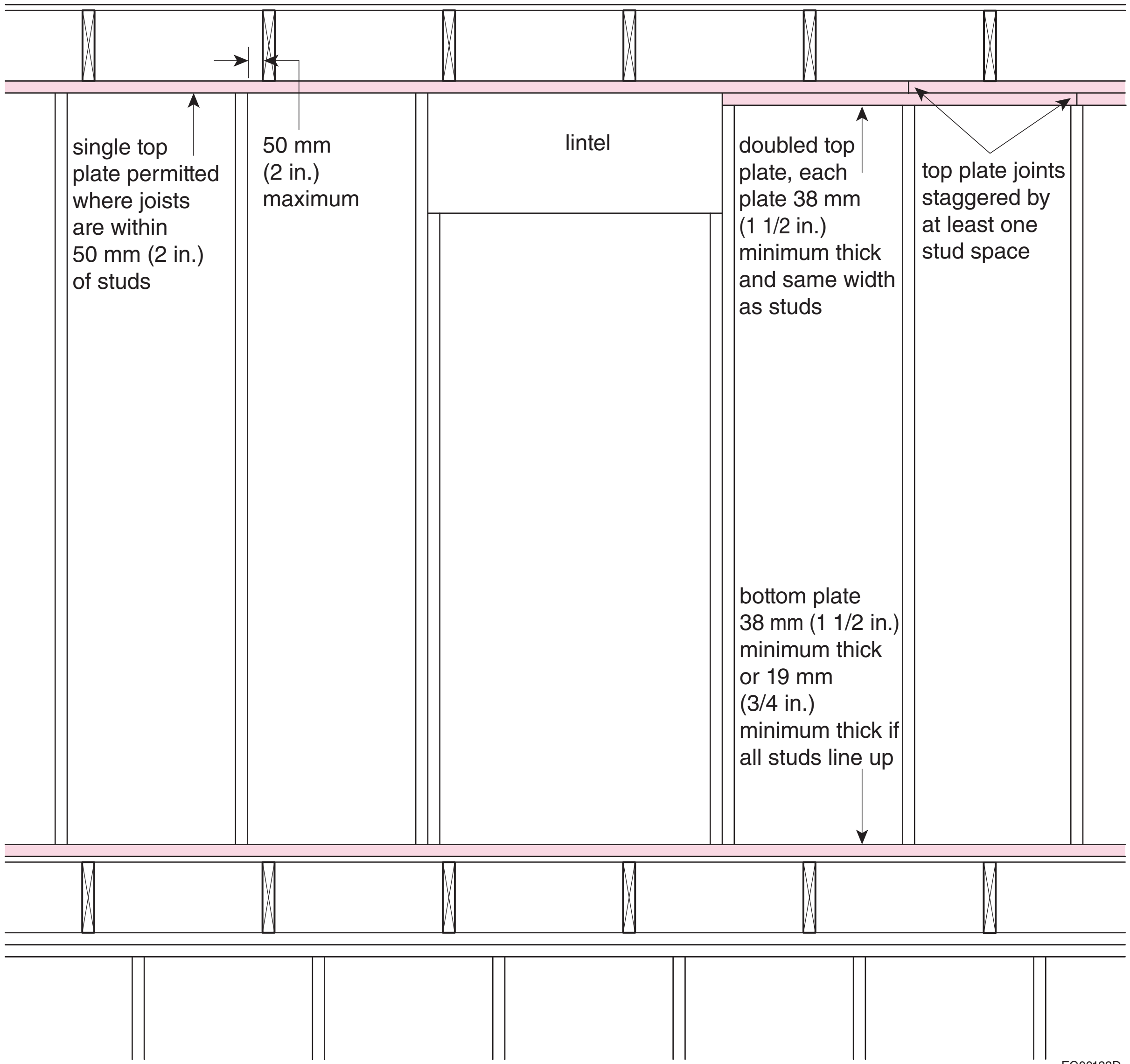


Figure 9.23.-28
Requirements for wall plates

Where wide openings are to be bridged by lintels, or if a reduced ceiling height is used, there may not be sufficient room above the lintel to provide the usual doubled plate. In such cases, only one top plate may be extended across the lintel to provide a suitable tie. The top plate must, of course, be supported throughout its length by the lintel. If there is no room to allow the top plates to extend across the framing, the wall plates may be terminated at the lintel if a metal strap or wood tie is provided across each end of the lintel (Figure 9.23.-29).

9.23.11.4. Joints in Top Plates

This Article requires that joints in the top plates of loadbearing walls be staggered, which is intended to ensure that the top plates effectively link the top ends of the wall studs so that they can act as a structural unit (see Figure 9.23.-30). This Article also requires that the top plates of loadbearing walls be lapped or otherwise tied at corners and intersecting walls, which is intended to ensure that walls are effectively joined to provide the building with additional stiffness and strength in resisting wind loads.

In areas where $0.70 < S_a(0.2) \leq 1.8$, an additional fastening requirement applies: doubled top plates in braced wall bands must be fastened on each side of a splice with 76 mm (3 in) long common steel wire nails or spiral nails in accordance with NBC Table 9.23.11.4.

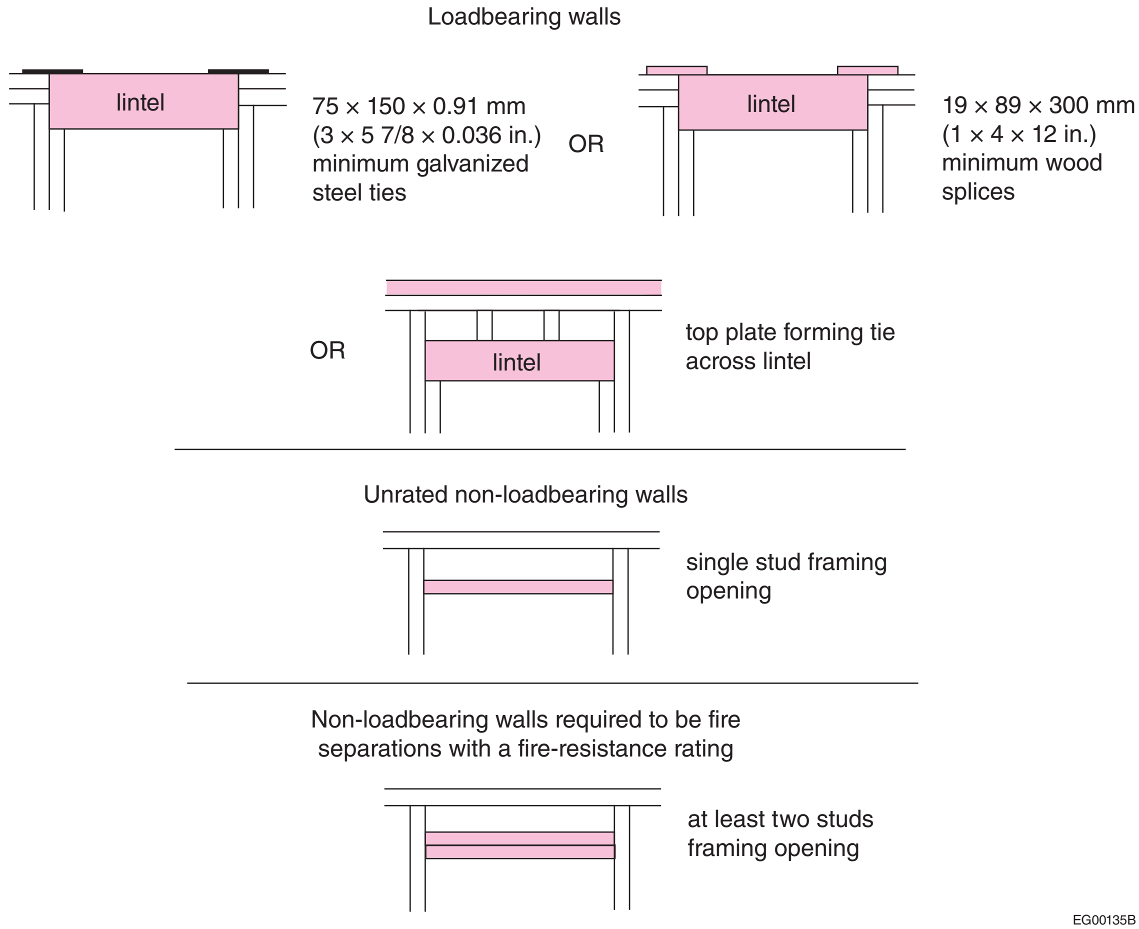


Figure 9.23.-29
Framing over openings

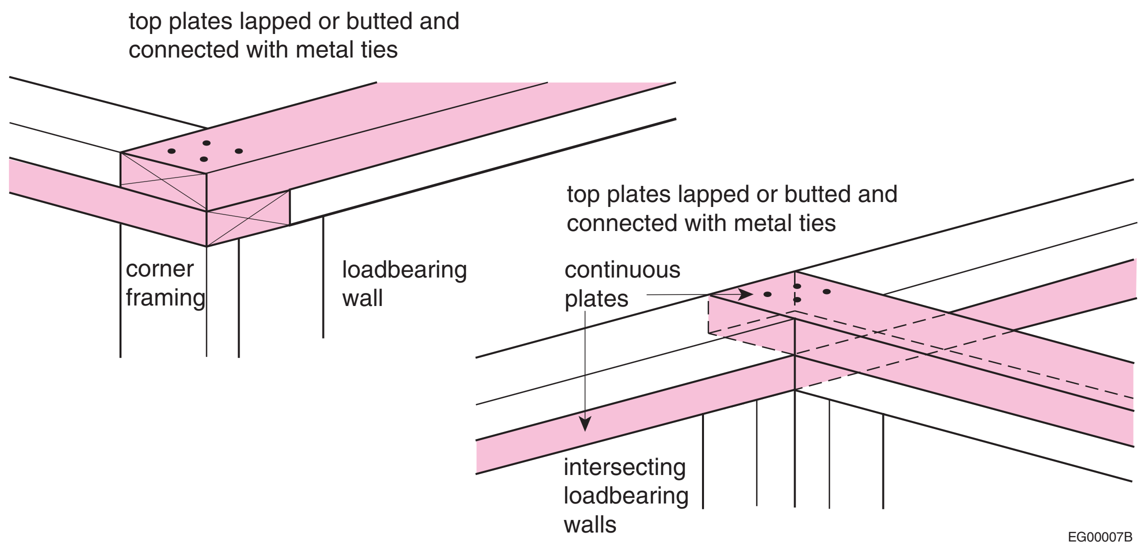


Figure 9.23.-30
Lapping of top plates in loadbearing walls at corners and intersecting walls

9.23.12. Framing over Openings

9.23.12.1. Openings in Non-Loadbearing Walls

This Article indicates the requirements that pertain to framing over openings in non-loadbearing walls. Openings in walls weaken their resistance to both vertical and lateral loads. The openings must be reinforced to avoid deformation or collapse. Additionally, framing provides a means for securing the top of the finish door frame to the rough wall framing. It also provides support to the lower edge of the wall finish over the opening, and provides a base for its attachment, as well as the attachment of the top door trim piece. In the case of walls required to provide a fire separation, the framing above the opening must also provide sufficient fire resistance above the opening to allow the closure to reach its required fire-resistance rating.

Where openings occur in non-loadbearing walls, these can be bridged by members with the same cross-sectional area as the studs. This includes interior walls beneath roof trusses and the gable end walls that do not support roof or floor loads. Where a frame wall acts as a rated fire separation (NBC Article 9.23.10.6.), however, the framing above the opening must be doubled (the same as required for the side members) (Figure 9.23.-31).

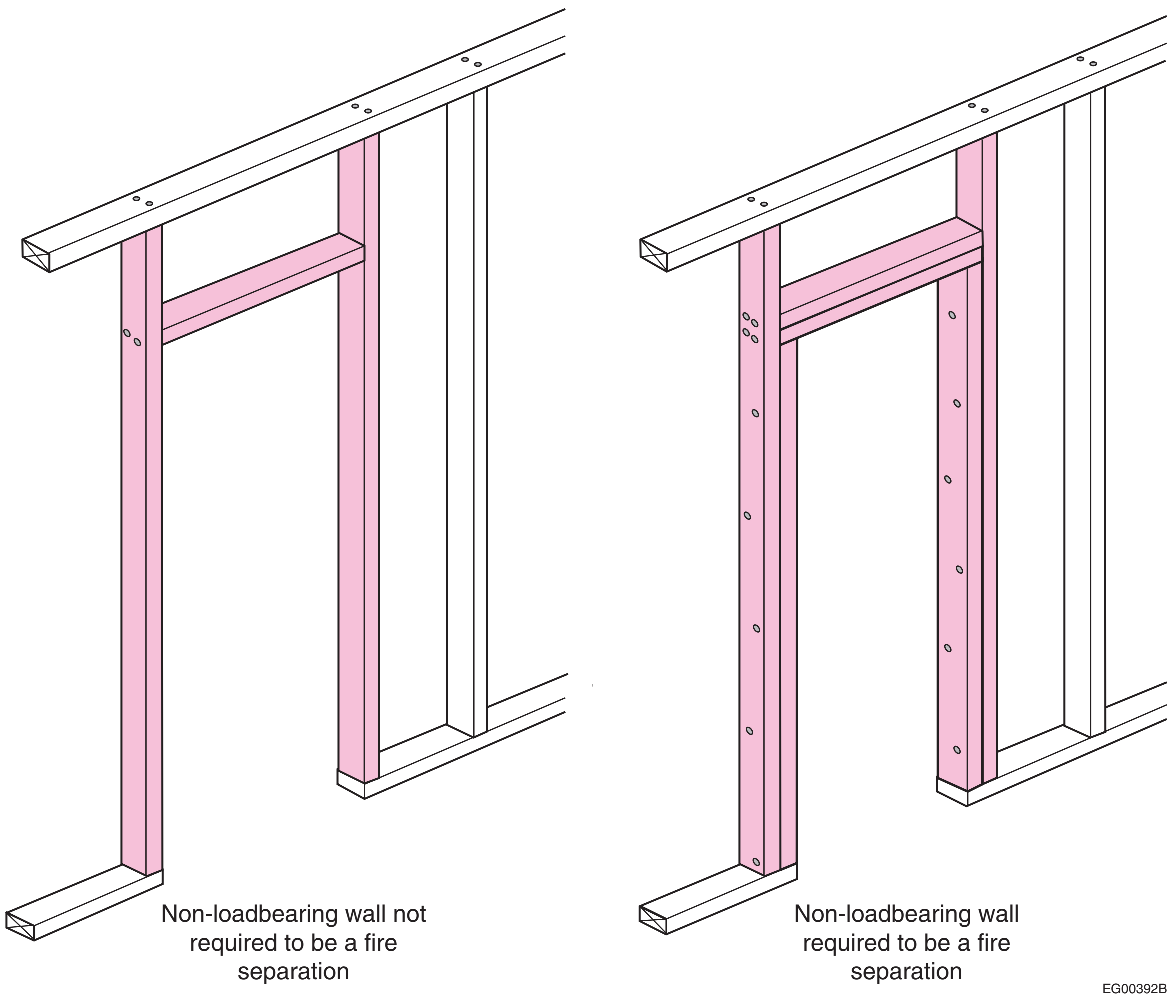


Figure 9.23.-31
Framing around openings in non-loadbearing walls

9.23.12.2. Openings in Loadbearing Walls

This Article indicates the requirements pertaining to openings in loadbearing walls, which are intended to ensure the transfer of anticipated loads above openings in stud walls to stud members located on each side of the opening (jamb studs).

Lintels are beam-like elements in walls that support wall loads across openings in the wall. Lintels in wood-frame walls are usually formed from two pieces of 38 mm (2 in. nominal) lumber nailed together with 82 mm (3 1/4 in.) nails spaced no more than 450 mm (18 in.) apart in two rows, as shown in Figure 9.23.-32. Lintel members can be separated by filler pieces. The depth of the lintel depends on the size of the opening, its location (interior or exterior), and the supported load.

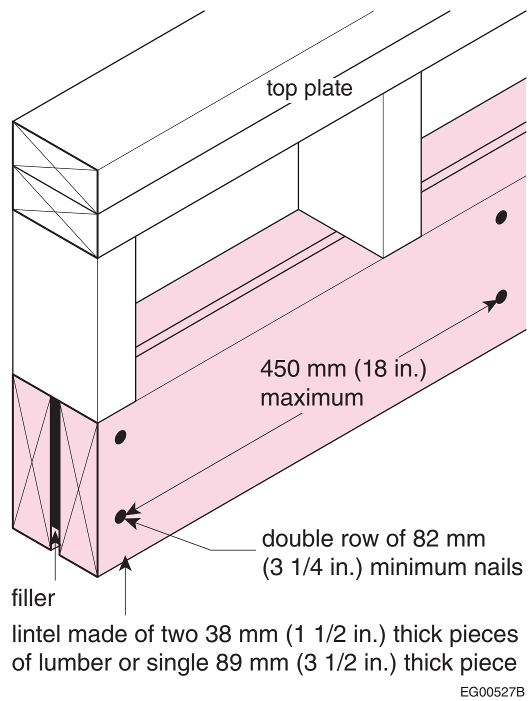


Figure 9.23.-32
Joining of lintel members

9.23.12.3. Lintel Spans and Sizes

This Article refers to NBC Span Tables for lintel spans and sizes to ensure that members have sufficient strength and stiffness to support anticipated vertical loads above wall openings, and transmit the loads to vertical framing members at the sides of the openings without damage to the cladding materials.

Lintel sizes can be selected from NBC Tables 9.23.4.2.-L and 9.23.12.3.-A to -D. NBC Part 4 must be used if the size of the opening exceeds the maximum allowable spans in these tables. These tables were calculated based on a maximum supported joist or rafter length of 4.9 m (16 ft.) and a maximum supported truss length of 9.8 m (32 ft.)

Lintels for exterior walls with 38 × 64 mm (2 × 3 in. nominal) studs intended to accommodate manufactured home wall framing are allowed. Since it is not possible to use two 38 mm (2 in. nominal) pieces of lumber in a 64 mm thick (2 1/2 in.) wall, lintels are permitted to be made from one piece of 38 mm (2 in. nominal) lumber and one piece of 19 mm (1 in. nominal) lumber. In order for the lintel to have at least the same strength as is required for lintels made from two pieces of 38 mm (2 in. nominal) lumber, the lintels are required to be 50 mm (2 in.) greater in depth, and their span is limited to 2.24 m (7 ft. 4 in.) in length.

Figure 9.23.-33 shows one common approach for providing a lintel over a basement window.

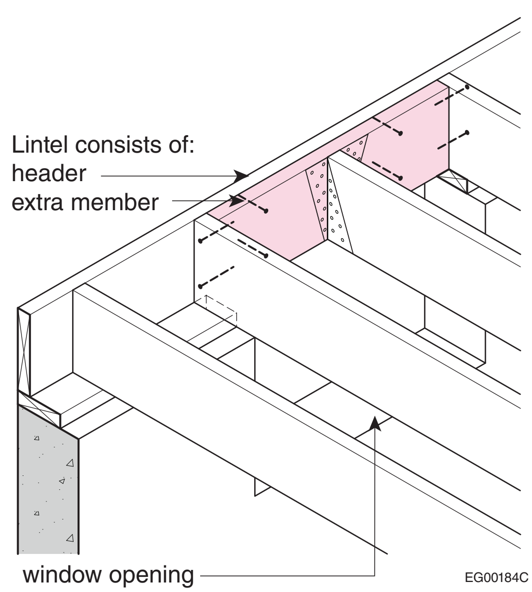


Figure 9.23.-33
Wood lintels over basement windows

Example 24 – Lintel Sizing

What size lintel is required to span a distance of 1.6 m and to support roof, ceiling and three storeys for a house being constructed in Port Elgin, Ontario? The specifications call for No. 1 Spruce–Pine–Fir to be used along with non-structural sheathing. The house is 6 m wide.

1. From NBC Table C-2 in Appendix C, the ground snow load and associated rain load is 2.8 and 0.4 kPa respectively.
2. Using the formula given in NBC Article 9.4.2.2., calculate the specified snow load, S

$$S = C_b S_s + S_r$$
$$S = (0.55 \times 2.8) + 0.4$$
$$S = 1.94\,\mathrm{kPa}$$

3. Using NBC Table 9.23.12.3.-C for No. 1 Spruce–Pine–Fir lintels and non-structural sheathing, and under the column for the 2.0 kPa specified snow load, it is determined that a 2-ply 38 × 235 mm (2 × 10 in. nominal) lintel that will span 1.62 m (5 ft. 3 in.) will meet the requirements.

9.23.13. Bracing to Resist Lateral Loads Due to Wind and Earthquake

Buildings must be strong enough to resist lateral forces due to anticipated lateral wind and earthquake loads. Resistance to wind and earthquake loads is provided by the roof, floor, and wall systems, as well as the connections between these systems.

In editions of the NBC prior to 2010, NBC Part 9 did not explicitly include prescriptive requirements for lateral resistance of Part 9 buildings. The requirements introduced in 2010 reflect the fact that house construction has changed. Older houses tended to have small rooms, meaning that there were lots of interior walls to provide rigidity. They also tended to have a moderate number and size of windows and doors, which left ample exterior wall area to add rigidity.

Newer buildings with open interior spaces and larger window and door openings have fewer interior walls and less exterior wall area. Therefore, depending on building location and design features, these buildings need some additional bracing to resist wind and earthquake loads. The new bracing provisions specify the minimum requirements for Part 9 buildings to resist lateral loads, and focus on required wall construction and the interconnection of wall, roof and floor systems.

General Background

Effect of Lateral Loads

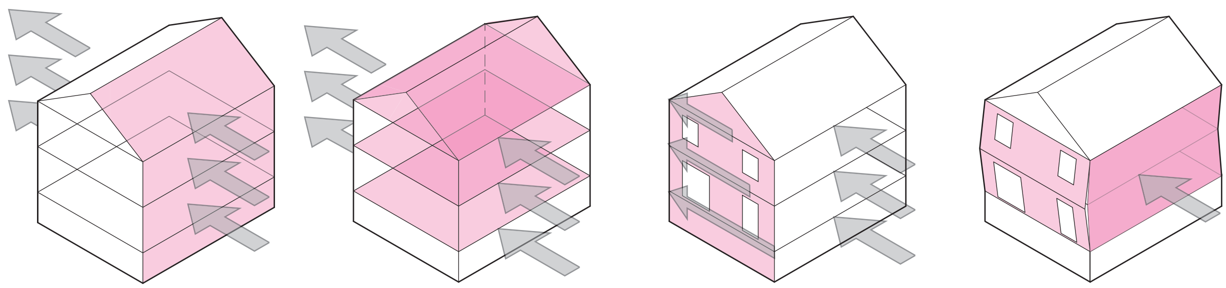
Figure 9.23.-34 shows how wind loads are transferred from storey to storey to the foundation by wall and floor assemblies.

In order to ensure that the lateral load path is capable of resisting the lateral loads, it is necessary to provide:
- walls that are strong enough to resist cumulative lateral loads,
- walls that are arranged and configured to allow load transfer between floors, and
- connections that are strong enough to transfer forces between roof, walls, floors and foundations.

Heavy building materials result in greater racking forces when a building is subjected to earthquake loads. Buildings with tile roofs or concrete topping on floors are more susceptible to damage in earthquakes. Loads accumulate from the top storey down, so lower storeys must be able to transfer more forces than do upper storeys.

Earthquakes subject buildings to lateral loads that are proportional to the mass of the building and its contents. For example, the lateral load on a building containing a concrete slab with a thickness of 150 mm (12 in.) is about 13 times larger than that on a building containing a typical wood-frame floor of the same thickness.

The design technique used to provide resistance to lateral loads will depend on whether the climatic data for a region establishes it as having low to moderate, high, or extreme wind or earthquake loads. It is more likely that an engineered solution will be required for a higher building, for a building with a complex shape, where heavier materials are used in the building, or where there are more openings in the lateral load restricting system. Regions of extreme exposure require engineered solutions.



a) Lateral wind loads create pressure and suction on the roof and walls perpendicular to the wind direction. Roof and wall framing members transfer the lateral forces to the roof and floor systems (or diaphragms).

b) Roof and floor systems (or diaphragms) transfer the lateral forces to the walls parallel to the wind direction.

c) Lateral forces accumulate in the parallel walls and are transferred down to the foundation.

d) Walls that are not strong enough to support the lateral loads may deform and fail.

EG01249B

Figure 9.23.-34
Resistance to lateral loads

Resistance to Lateral Loads

Buildings in different locations in Canada must be braced to resist lateral loads due to wind and earthquakes. NBC Appendix C provides the 1-in-50 hourly wind pressure (HWP) used to determine the severity of the wind load, and the seismic spectral response acceleration, $S_a(0.2)$, used to determine the severity of the loads expected from earthquakes for low-rise buildings in 679 locations in Canada.

These requirements are based on three levels of loads:

(1) Low to moderate: Buildings in this category can obtain required bracing simply by having exterior sheathing (NBC Subsection 9.23.17.), panel-type cladding (NBC Section 9.27.), or gypsum board finish (NBC Section 9.29.). Using more than one of these options will increase resistance.

Of the 679 locations identified in NBC Appendix C, 671 locations fall into this category for wind and 630 fall into this category for earthquake. This means that for most locations in Canada, bracing requirements can be met by using acceptable materials and fastening methods that have traditionally been required in NBC Part 9.

There remains the option of designing in accordance with NBC Subsection 9.23.13.4., NBC Part 4 or following good engineering practice,(5) as indicated in NBC Article 9.23.13.1.

(2) High: Buildings in this category require additional features to provide required resistance to lateral loads. NBC Articles 9.23.3.4. to 9.23.13.7. provide prescriptive solutions intended to provide strong portions of walls called "braced panels." These must meet requirements for location, spacing and construction.

There are limitations for using these prescriptive solutions based on building height, and whether the construction is comprised of heavy materials. Of all the locations identified in NBC Appendix C,

(5) "Engineering Guide for Wood Frame Construction" published by the CWC includes prescriptive as well as design solutions. It also contains alternative solutions and provides information on the applicability of the prescriptive structural requirements in NBC Part 9 to further assist designers and building officials in identifying appropriate design approach.

45 locations fall into this category for their $S_a(0.2)$ value. Most of these locations are in the coastal region of British Columbia, though four are in the lower St. Lawrence region of Quebec. There are five locations in the high wind category, which are situated in Newfoundland, Alberta and the Northwest Territories.

There remains the option of designing in accordance with NBC Part 4 or following good engineering practice.

(3) Extreme: Buildings in this category are required to be designed in accordance with NBC Part 4 or good engineering practice, as indicated in NBC Article 9.23.13.3.

Of all the locations identified in NBC Appendix C, only 3 locations fall into this category for their $S_a(0.2)$ value, and only 1 location for its HWP value.

A summary of the requirements covering all three categories is shown in Table 9.23.-B.

Table 9.23.-B
Application of Lateral Load Requirements[1]

Applicable Requirements	Wind			Earthquake				
	Low to Moderate	High	Extreme	Low to Moderate	High	Extreme	High	Extreme
	HWP < 0.80 kPa	0.80 ≤ HWP < 1.20 kPa	HWP ≥ 1.20 kPa	$S_a(0.2) \le 0.70$	$0.70 < S_a(0.2) \le 1.8$	$S_a(0.2) > 1.8$	$0.70 < S_a(0.2) \le 1.8$	$S_a(0.2) > 1.8$
	All Construction			All Construction	Heavy Construction[2]		Light Construction	
Design requirements in NBC Article 9.23.16.2., NBC Section 9.27. and NBC Section 9.29.	✓[3]	n/a	n/a	✓	n/a	n/a	n/a	n/a
Bracing requirements in NBC Subsection 9.23.13.	✓	✓	n/a	✓	✓[4][5]	n/a	✓[5][6]	n/a
NBC Part 4 or CWC Guide	✓	✓	✓	✓	✓	✓	✓	✓

Notes to Table 9.23.B.:

(1) ✓ = requirements are applicable.
(2) Heavy construction refers to buildings with tile roofs, stucco walls or floors with concrete topping, or that are clad with directly applied heavyweight materials (see NBC Note A-9.23.13.2.(1)(a)(i)).
(3) Requirements apply to exterior walls only.
(4) Requirements apply where lowest exterior frame walls support not more than one floor.
(5) All constructions may include the support of a roof in addition to the stated number of floors.
(6) Requirements apply where lowest exterior frame walls support not more than two floors.

In addition to the requirements for bracing in NBC Subsection 9.23.13., additional requirements for resisting wind and earthquake loads in high wind and earthquake regions of Canada are found throughout NBC Part 9.

9.23.13.1. Requirements for Low to Moderate Wind and Seismic Forces

This Article indicates the range of wind and seismic forces that apply and the options for providing the required lateral resistance for low to moderate wind and seismic forces.

Required lateral resistance for buildings in areas with low to moderate exposure to wind and seismic forces can be provided by either exterior sheathing, panel-type cladding or panel-type interior finish, as shown in

Figure 9.23.-35. There are no requirements for the spacing or minimum dimension of braced wall panels in these buildings. Design under NBC Part 4 or in accordance with good engineering practice are other options.

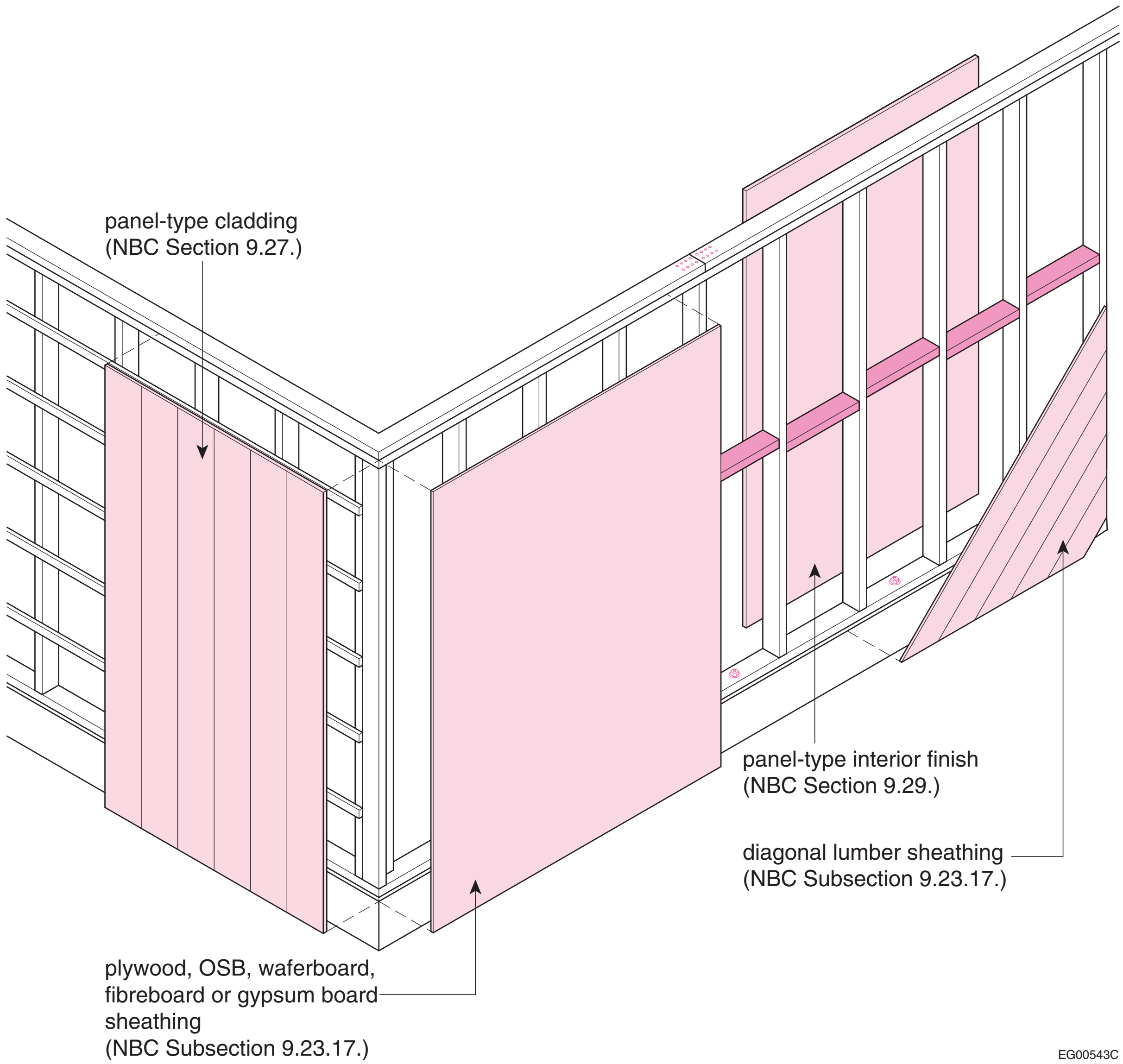


Figure 9.23.-35
Bracing methods for low to moderate wind and seismic forces

The NBC does not address the issue of bracing of a structure during construction. Until interior finishes or sheathing are installed, temporary bracing should be used.

9.23.13.2. Requirements for High Wind and Seismic Forces

This Article indicates the range of wind and seismic forces that apply and the options for providing the required lateral resistance for high wind and seismic forces. Additional measures are required to resist loads for high wind and earthquake forces. In addition to NBC Part 4 and engineering solutions, builders have the option of using strong wall segments called "braced wall panels."

In addition to the range of wind and seismic forces, this Article sets limits on the number of storeys of a building. The number of storeys is reduced for buildings of heavy construction (tile roofs or concrete topping on floors) (see NBC Table A-9.23.13.).

Braced wall panels must be located, spaced and constructed in accordance with NBC Articles 9.23.13.4. to 9.23.13.7. If a given wall is required to have a certain number of braced wall panels, it is optional to only provide the required panels, or to construct the entire wall using the same construction technique as for the braced wall panels.

Braced Wall Bands and Braced Wall Panels

The prescriptive wall bracing technique that can be used where applicable for regions of high wind and seismic forces uses the following terms that are defined in NBC Article 1.4.1.2. of Division A:

- braced wall band,
- braced wall panel, and
- rim joist.

9.23.13.3. Requirements for Extreme Wind and Seismic Forces

This Article indicates the range of wind and seismic forces that apply and the options for providing required lateral resistance for extreme wind and seismic forces.

In locations exposed to extreme wind and seismic forces, bracing to resist lateral loads must be designed in accordance with NBC Part 4 or good engineering practice, such as that provided in CWC 2014, "Engineering Guide for Wood Frame Construction."

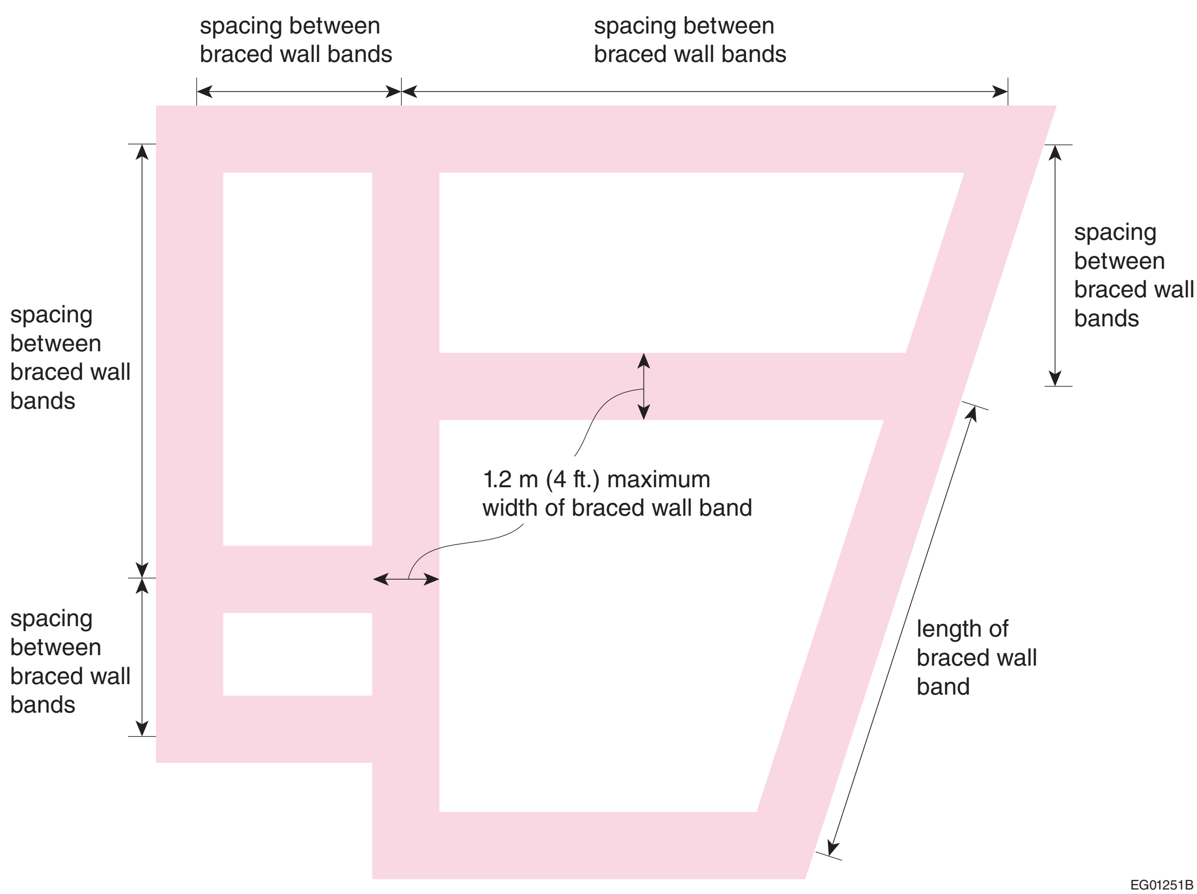


Figure 9.23.-36
Plan view of braced wall bands

9.23.13.4. Braced Wall Bands

This Article lists the required characteristics of braced wall bands and their location in a building where braced wall panels are used to provide lateral resistance in regions with high wind and seismic forces.

Bracing intended to resist lateral loads is provided by braced wall panels. These panels must be constructed within bands. A band is an imaginary, three dimensional space that extends through all the floors of a building. As exterior walls must provide bracing, the perimeter of the building must be located within the braced wall bands.

Interior bands may be required to respect the maximum spacing allowance between bands, as measured from centre-to-centre. Bands must start and finish at another band, so that their ends overlap (Figure 9.23.-36). Required braced wall panels can be offset within the 1.2 m (4 ft.) width of a band, and be distributed along the bands. The required spacing for braced wall panels is provided in NBC Table 9.23.13.5.

The provisions for braced wall bands allows for non-orthogonal (non-perpendicular) bands, and hence a non-orthogonal structural grid. Figure 9.23.-37 demonstrates the characteristics and positioning of braced wall panels for several building shapes.

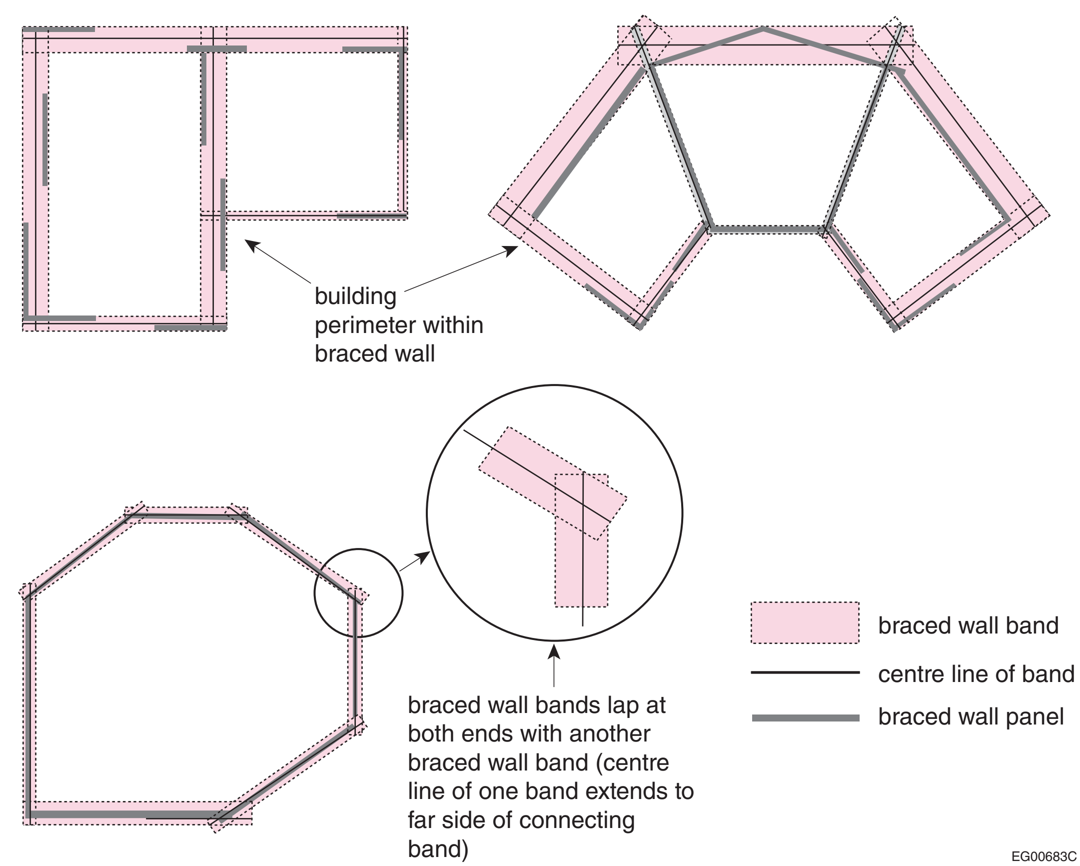


Figure 9.23.-37
Braced wall bands at building perimeters

To provide vertical continuity of bracing, a braced wall band must be located where there is a change in floor level greater than the depth of one floor joist in split-level buildings (Figure 9.23.-38).

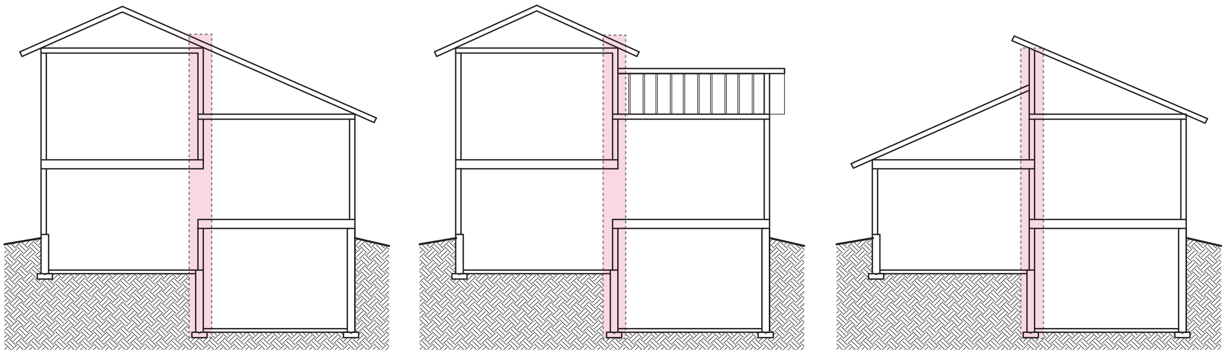


Figure 9.23.-38
Braced wall bands at changes in floor level in split-level buildings

9.23.13.5. Braced Wall Panels in Braced Wall Bands

This Article indicates the location, spacing, configuration, and dimensions for braced wall panels where they are used to provide required lateral resistance in regions exposed to high wind and seismic forces.

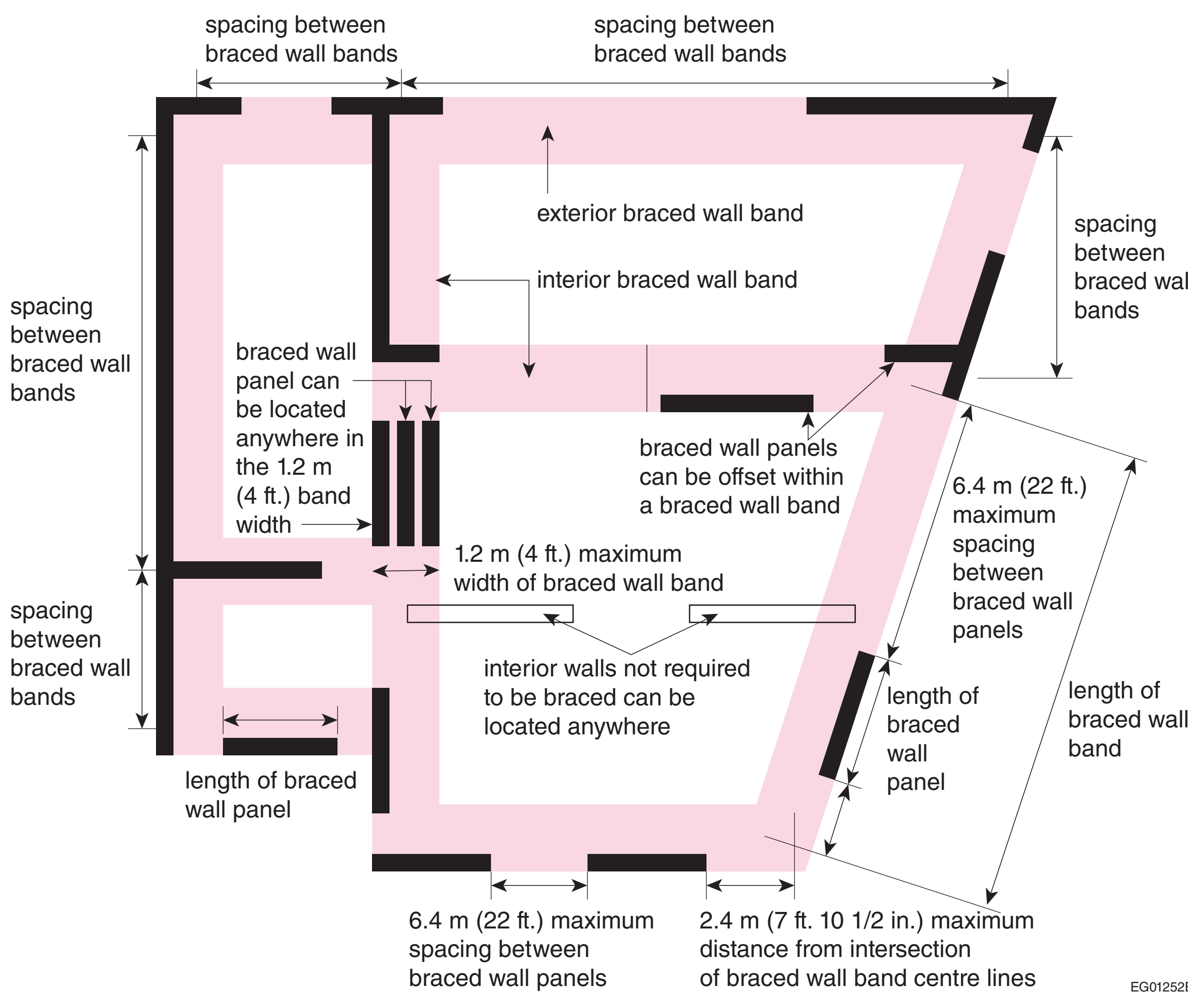


Figure 9.23.-39
Plan view of braced wall bands and panels

Figure 9.23.-39 shows a plan view of an arrangement of braced wall bands and braced wall panels. The requirements for bands and panels is provided in NBC Table 9.23.13.5. Interior braced wall bands will be selected to accommodate the architecture of the building while meeting the requirements for spacing of braced wall bands. Interior walls that do not form part of a braced wall band are not required to conform to NBC Article 9.23.13.5.

Figure 9.23.-40 shows an isometric view of the floor plan in Figure 9.23.-38. It shows that the braced panels can be offset laterally and longitudinally from panels on the floor below, but must fall within the braced band.

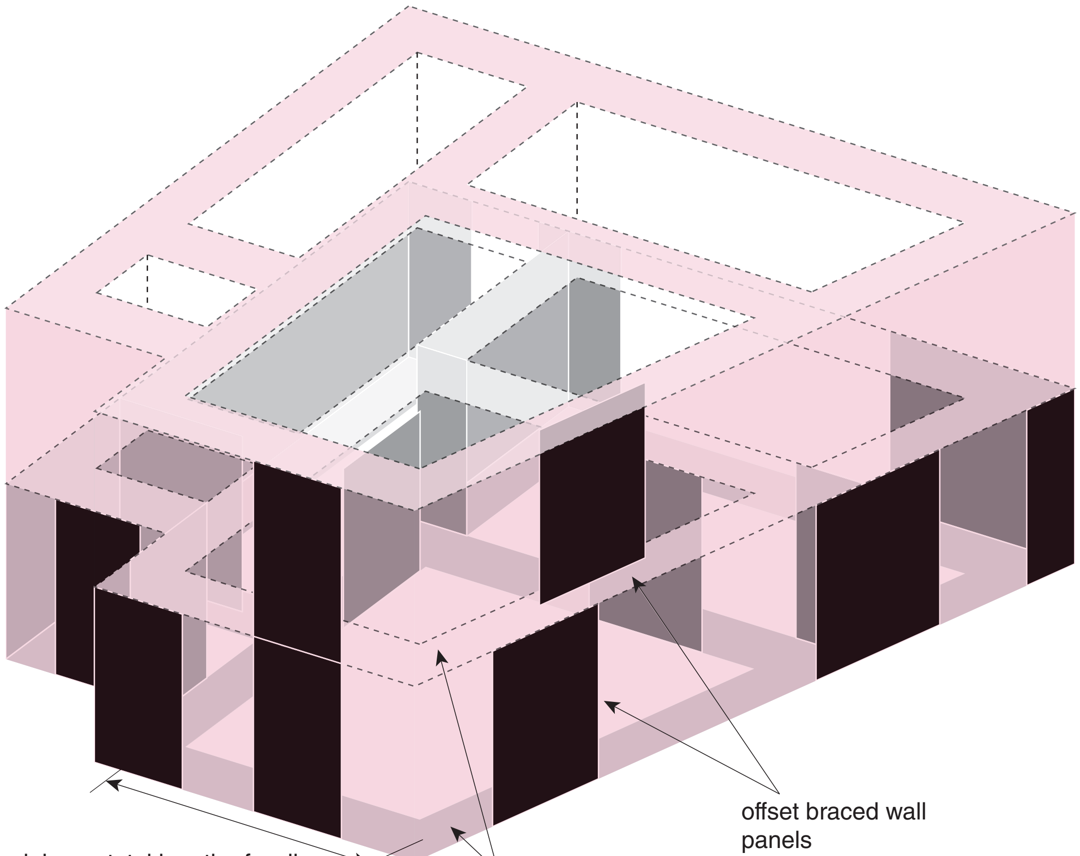


Figure 9.23.-40
Isometric view of braced wall bands and panels on two floors

In order to provide a continuous lateral load path, braced wall panels must be located within braced wall bands, and must extend from the top of the supporting foundation, slab or subfloor to the underside of the floor, ceiling or roof framing above. Figure 9.23.-41 shows a sectional view of braced wall bands showing the maximum allowable offset of 1.2 m (4 ft.).

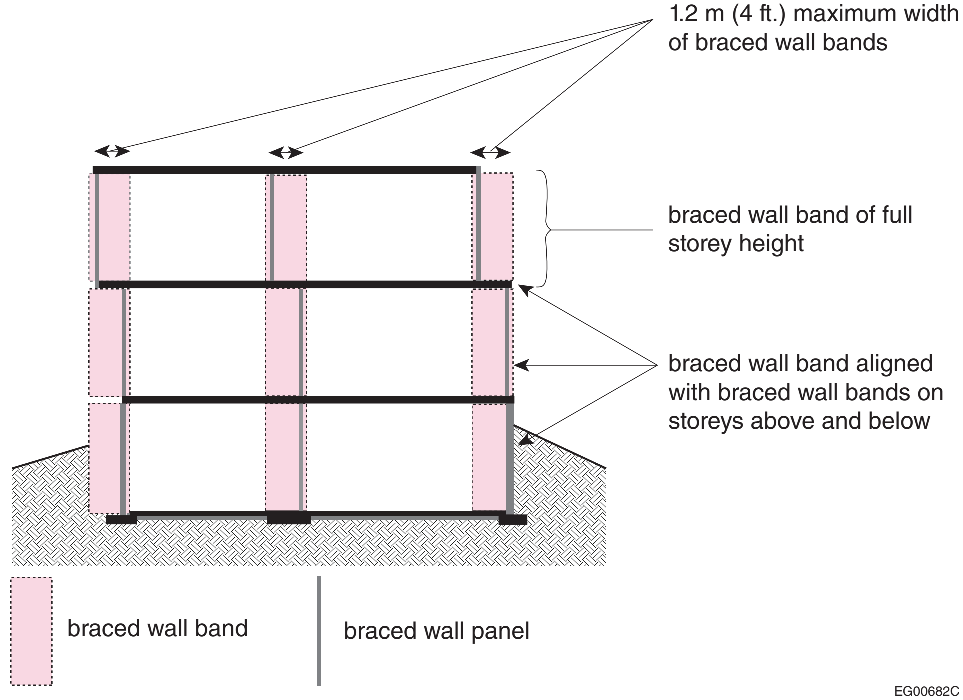


Figure 9.23.-41
Elevation view of braced wall bands and panels

Basements and Crawl Spaces

For basements or crawl spaces, perimeter concrete or masonry walls will provide significant lateral resistance compared to above-ground frame walls, where the foundation walls extend from the footings to the underside of the supported floor. For this reason, interior braced wall bands can be terminated at the floor above the basement or crawl space provided that the remaining braced wall bands are spaced not more than 15 m (49 ft.) on centre or 15 m (49 ft.) from a perimeter braced wall band.

Where the perimeter foundation walls in basements and crawl spaces extend from the footings to the underside of the supported floor, these walls perform the same function as braced wall bands with braced wall panels. All other braced wall bands in the basement or crawl space that align with bands with a wood-based bracing material on the upper floors need to be constructed with braced wall panels, which must be made of a wood-based bracing material, masonry or concrete (Figure 9.23.-42).

Porches

Many traditional house designs have incorporated enclosed porches where the enclosure is light construction and mostly glazed. More modern house designs sometimes incorporate solaria that are constructed outside the main structure of the building. Neither of these types of space have exterior wall area that could be constructed as braced wall panels. For this reason, the construction of these spaces is permitted provided that:

- they have limited depth from the main structure of the building;
- they do not support a floor; and
- the roof provides lateral resistance by being either contiguous with the roof of the rest of the building or fastened to the framing of the main structure.

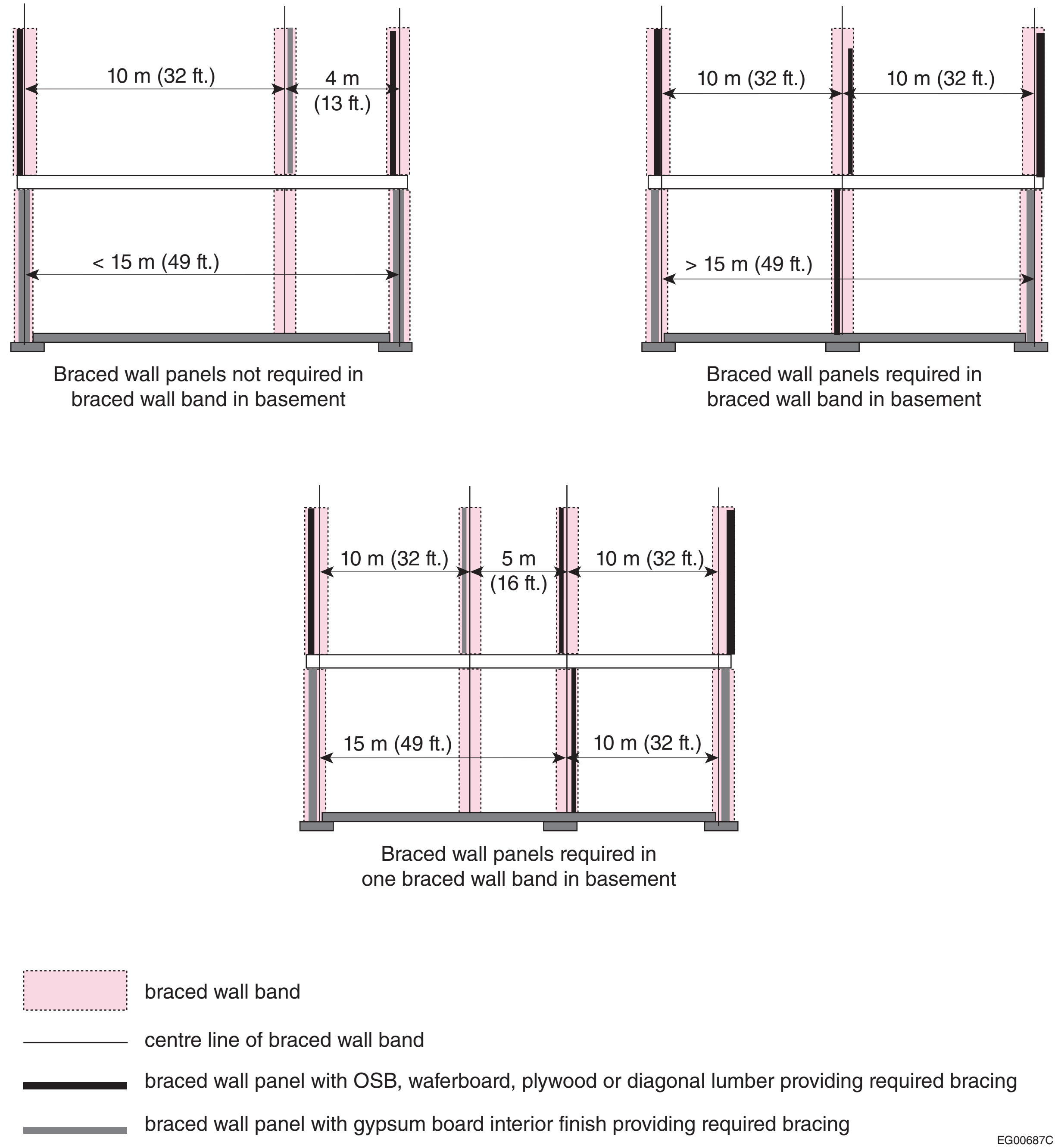


Figure 9.23.-42
Braced wall bands and panels in basements and crawl spaces

Figure 9.23.-43 and Figure 9.23.-44 show the methods for attaching porch roofs to exterior wall framing.

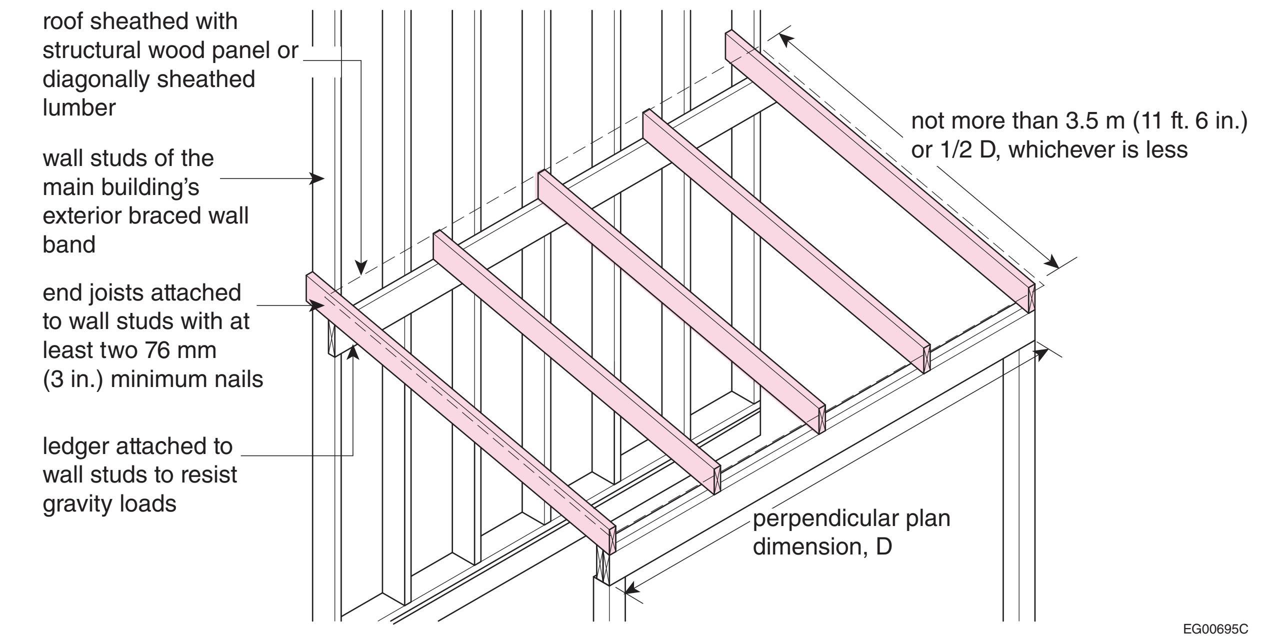


Figure 9.23.-43
Porch roof framing perpendicular to wall framing between floors

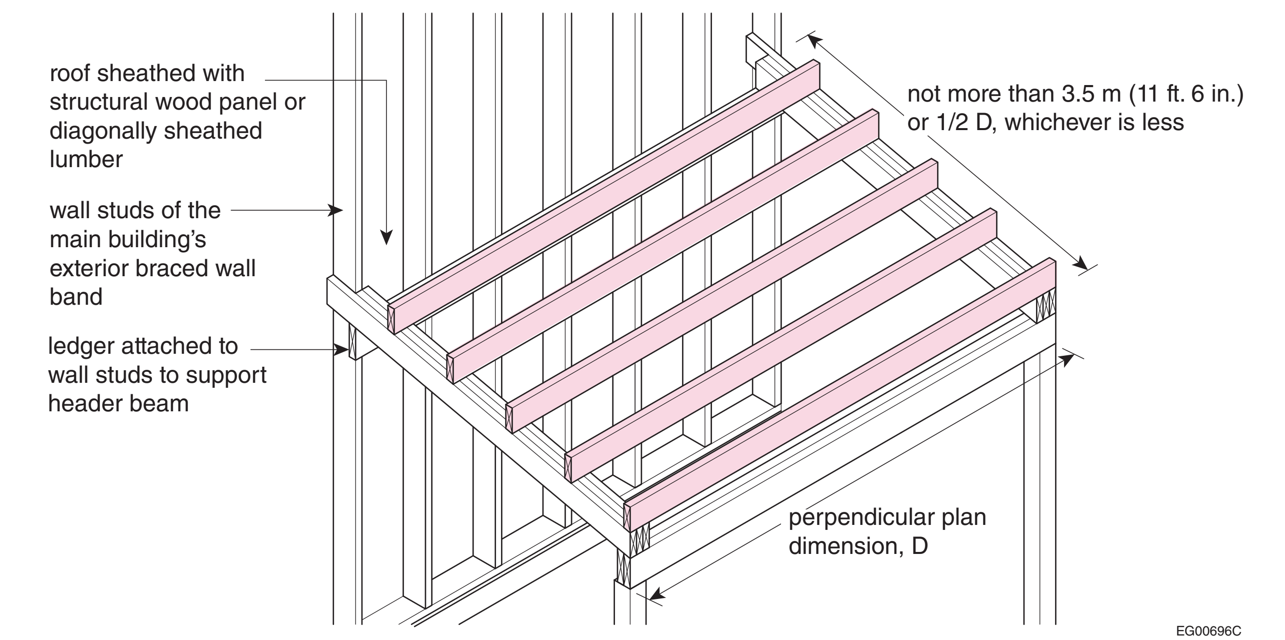


Figure 9.23.-44
Porch roof parallel to wall framing between floors

Garages

Requiring braced wall bands and braced wall panels on the front wall of a garage would result in a significant change to current construction conventions, and the need to widen the width to accommodate both garage doors and braced wall panels. Because people do not generally spend significant amount of time in garages or accessory buildings, and they do not sleep in these buildings or spaces, less stringent requirements are considered to be acceptable for these structures, provided that they do not support a floor. For these reasons, one-storey detached garages, one-storey accessory buildings and the front wall of a one-storey attached garage do not need to comply with NBC Table 9.23.13.5., provided that certain conditions are met.

Braced wall panels in the braced wall band at the front of an attached garage serving a single dwelling unit do not need to comply with NBC Table 9.23.13.5. provided that:

- the distance between the front and back walls of the garage does not exceed 7.6 m (24 ft. 11 in.);
- there is not more than one floor above the garage;
- not less than 50% of the length of the back wall is constructed of braced panels; and
- not less than 25% of the length of the side walls is constructed of braced panels.

These conditions are illustrated in Figure 9.23.-45.

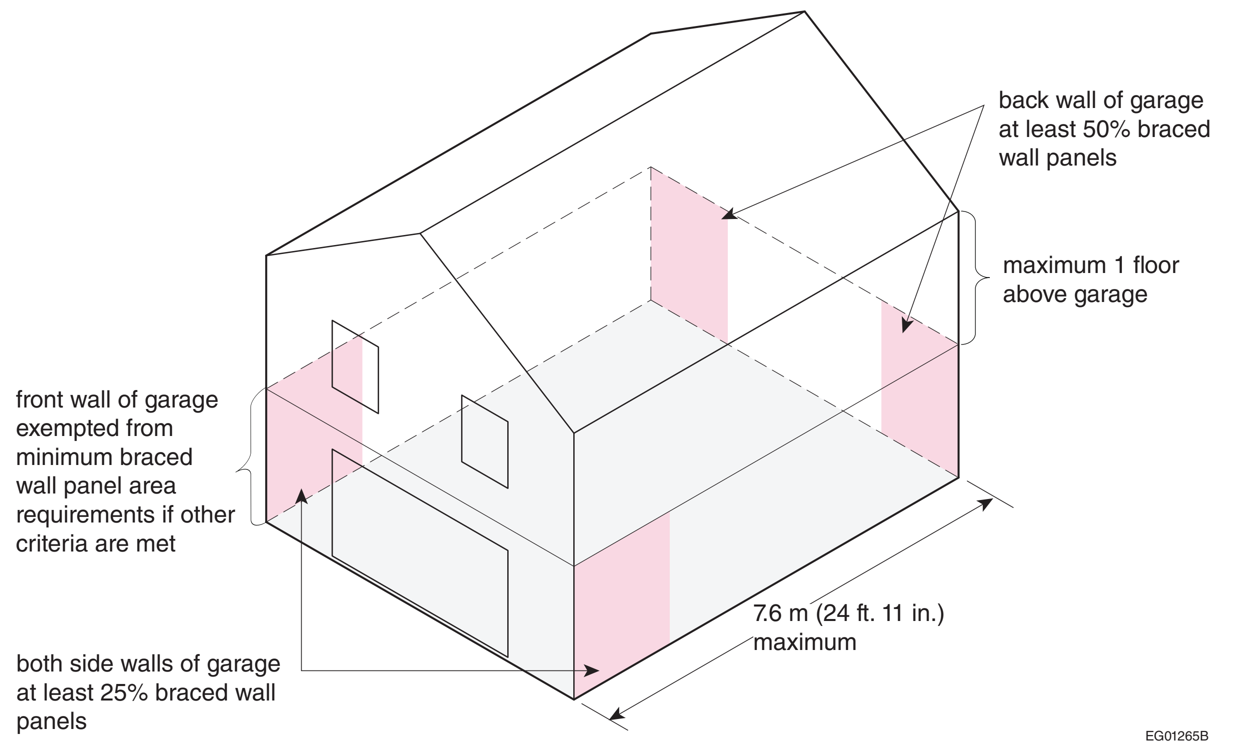


Figure 9.23.-45
Braced wall panels in attached garages serving a single dwelling unit

Where the walls of an attached garage support a floor above, and where the width of the garage is not increased to incorporate braced wall panels according to the preceding requirements, another approach must be used to provide the necessary lateral support.

Braced Wall Panels in Braced Wall Bands in Irregularly Shaped Buildings

Identifying adjacent braced wall bands and determining the spacing of braced wall panels and braced wall bands is not complicated where intersecting walls are perpendicular, but becomes more complicated where buildings have irregular shapes.

Where the plan is triangular, all braced wall bands intersect with the subject braced wall band. The prescriptive requirements in NBC Part 9 would, therefore, not apply to these cases, and the building should be designed according to NBC Part 4 for lateral load resistance.

Where the braced wall bands are not parallel, the adjacent band is identified as follows (using Figure 9.23.-46 as an example):

1. determine the midpoint of the centre line of the subject braced wall band (A);
2. project a perpendicular line from this midpoint (B); and
3. identify the first braced wall band encountered as the adjacent braced wall band (C); where the projected line encounters an intersection point between two braced wall bands, either wall band can be identified as the adjacent braced wall band.

The spacing of non-parallel braced wall bands is measured as the greatest distance between the centre lines of the bands.

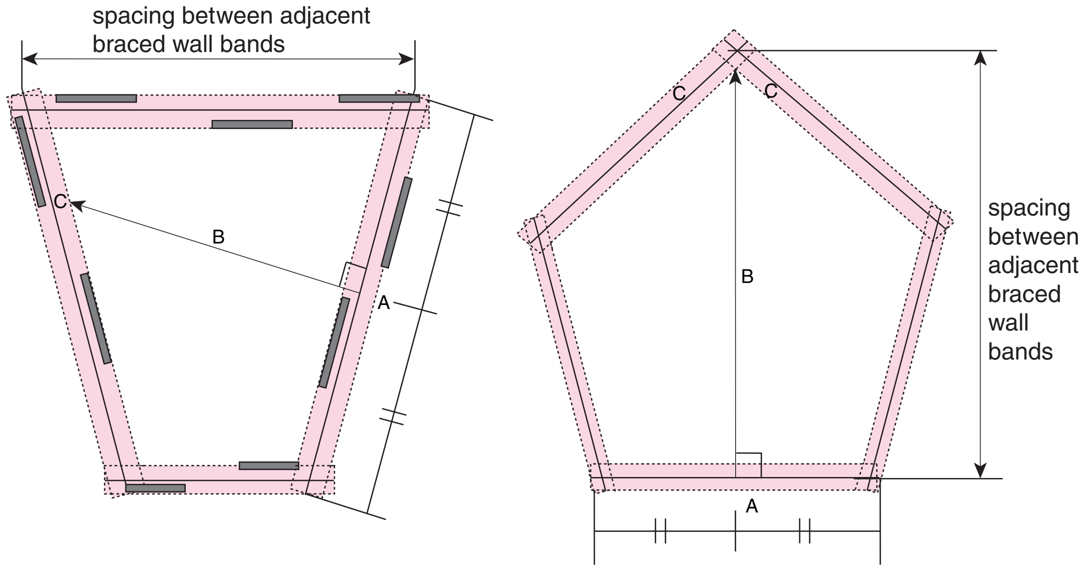


Figure 9.23.-46
Identification and spacing of adjacent non-parallel braced wall bands

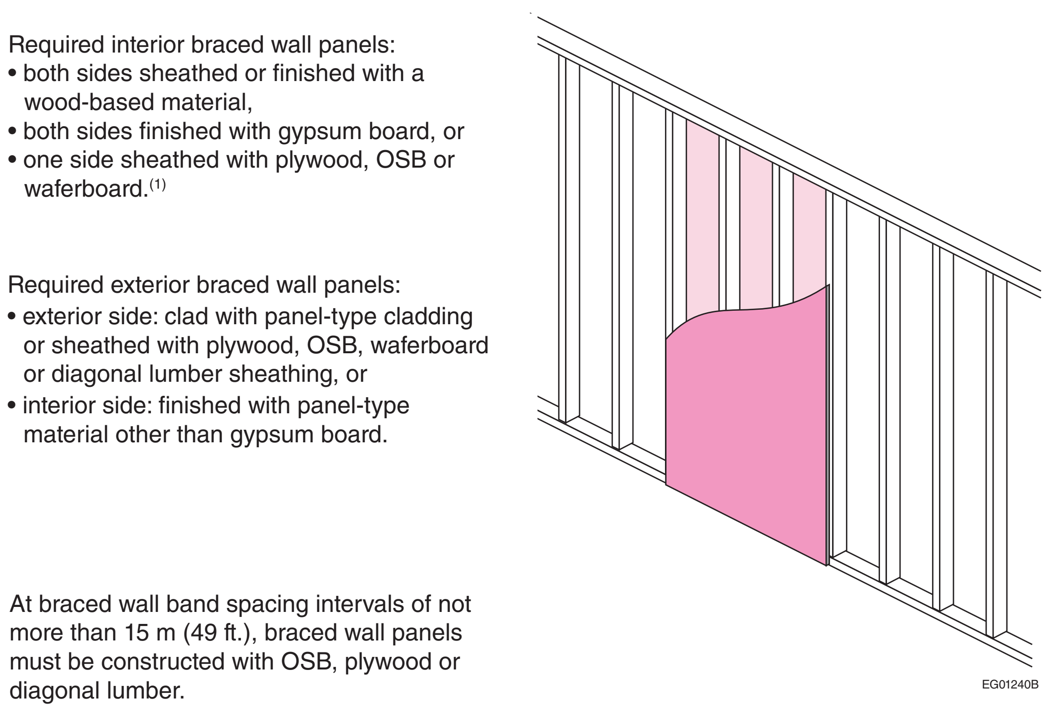


Figure 9.23.-47
Composition of braced wall panels

Note to Figure 9.23.-47:
(1) The maximum spacing of fasteners must be half of that shown in NBC Table 9.23.3.5.-B.

9.23.13.6. Materials in Braced Wall Panels

This Article indicates how braced wall panels are to be constructed when they are used to provide the required resistance to lateral loads in regions exposed to high wind and seismic forces.

The types of panels to be used for interior and exterior braced wall panels are provided in NBC Table 9.23.13.6. The requirements in NBC Table 9.23.13.6. are illustrated in Figure 9.23.-47.

Gypsum board braced wall panels

Braced wall panels constructed with gypsum board provide less resistance to lateral loads than panels constructed with OSB, waferboard, plywood or diagonal lumber. For this reason, the use of gypsum board for braced wall panels is limited to interior walls. The use of gypsum board is further limited for providing required lateral resistance because walls not more than 15 m (49 ft.) apart are required to be constructed with panels made of wood or wood-based sheathing (Figure 9.23.-48).

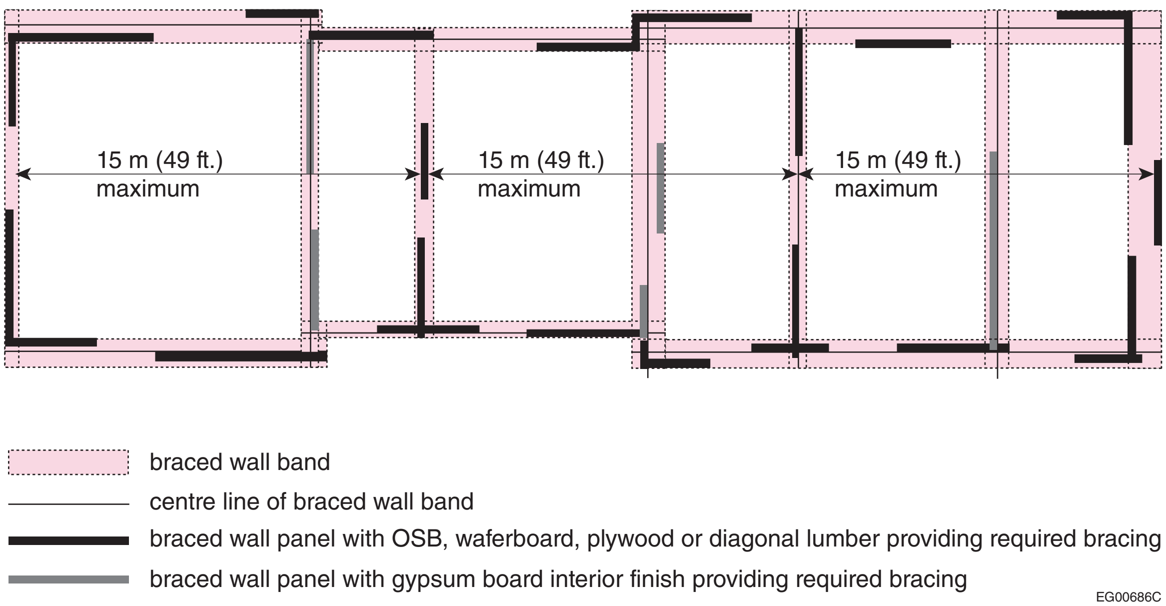


Figure 9.23.-48
Braced wall panels constructed of wood-based materials

9.23.13.7. Additional System Considerations

This Article lists additional options for the location of braced wall bands and braced wall panels when they are used to provide required resistance to lateral loads in regions that are exposed to high wind and seismic forces.

The clear direction provided in the 2010 NBC for ensuring adequate resistance to lateral loads for Part 9 buildings was developed to respect the architectural styles and features of modern buildings. It was not intended that the provisions of NBC Articles 9.23.13.1. to 9.23.13.6. would unnecessarily change architectural styles and common building designs. For this reason, the additional system requirements in NBC Article 9.23.13.7. were added to provide additional prescriptive solutions to allow typical Part 9 building designs to be structurally safe in seismic zones.

These additional considerations are trade-offs, rather than relaxations allowing current architectural styles to be retained without compromising structural safety. The trade-offs include:

- allowance for an up to 10.6 m (35 ft.) exterior wall setback on the top storey, provided that additional interior braced walls are provided, and the supporting structure for the setback wall is strengthened (Figure 9.23.-49),
- the maximum distance between required braced wall panels may be increased to 7.3 m (24 ft.), provided that all braced wall panels in all storeys of the braced wall band are at least 1.2 m (4 ft.) long,
- the spacing between the required braced wall bands may be increased from 7.6 to 10.6 m (24 to 35 ft.), where an interior wall band is added, and where that wall band is constructed with wood sheathed panels and extends to foundation, and
- the required length of braced wall panels in an exterior wall may be reduced where an interior wall band is added within 10.6 m (35 ft.) of the exterior, and where that wall band is constructed of wood sheathed panels and extends to the foundation.

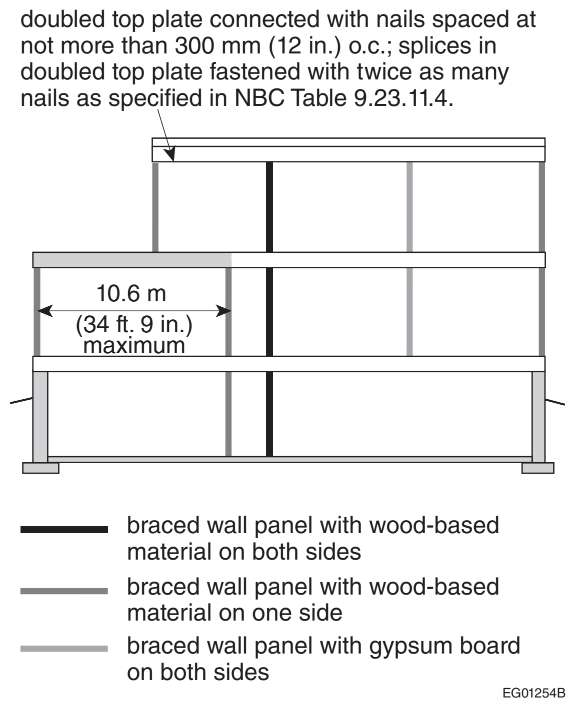


Figure 9.23.-49
Section view of a setback wall in the top storey of a building

9.23.14. Roof and Ceiling Framing

In the Span Tables (NBC Tables 9.23.4.2.-C to -G), the term "rafter" refers to a sloping wood member that supports the roof sheathing and encloses an attic space, but that does not support a ceiling. The term "roof joist" refers to a horizontal or sloping wood framing member that supports the roof sheathing and the ceiling finish, but that does not enclose an attic space. For information on the maximum spans for roof rafters, roof joists and ridge beams, see NBC Article 9.23.4.2. and its associated heading in this Guide.

Although most roofs are framed with roof trusses, conventional joist and rafter framing is still used, particularly where factory-made trusses are unavailable, or when the shape or design of the roof makes it more practical to use joists and rafters. Normally, each opposing pair of rafters meet at the ridge on a ridge board, which serves to align the tops of the rafters. Sometimes, for ease of assembly, two ridge boards are used, and the rafters on each side are nailed to the board before they are lifted into place. The ridge boards are then nailed to each other. Where only a single board is used, the rafters may be offset by their own thickness to allow them to be nailed to the ridge board from the opposite side. Where houses built as two sections are joined at the site, galvanized steel strips may be used to tie the framing together at the ridge at 1.2 m (4 ft.) intervals.

9.23.14.1. Continuity of Rafters and Joists

This Article requires that rafters and ceiling joists be continuous or be spliced. This ensures that rafters and joists will not be weakened by the presence of joints, so that they will be able to support anticipated roof loads. Rafters, as well as roof and ceiling joists, must be continuous across their spans. If splices are required, they must occur over vertical supports that extend to suitable bearing.

9.23.14.2. Framing around Openings

This Article indicates the requirements for double roof and ceiling framing members around openings to ensure that openings in roof framing do not compromise the strength of the roof. When openings are framed into roofs so that it is necessary to cut through rafter or joist members, the cut members must be supported on a header member, which in turn is fastened to the trimmer joists or rafters on each side of the opening. This imposes an extra load on the trimmer members and to avoid over-stressing them, they are doubled up on each side. If only one rafter or joist is cut, however, the additional load carried by the trimmer joists is considered to be tolerable and doubling is not necessary.

9.23.14.3. End Bearing Length

This Article requires a minimum bearing length to allow the ends of joists and rafters to be nailed to their supports without excessive wood splitting. A second purpose is to provide a sufficient area of wood to avoid excessive crushing of the fibres at the support. The end bearing of rafters and joists must be at least 38 mm (1 1/2 in.), and be shaped to bear evenly over the support, as illustrated in Figure 9.23.-50.

It is important that trusses be supported at their support points exactly the way they were intended in the design.

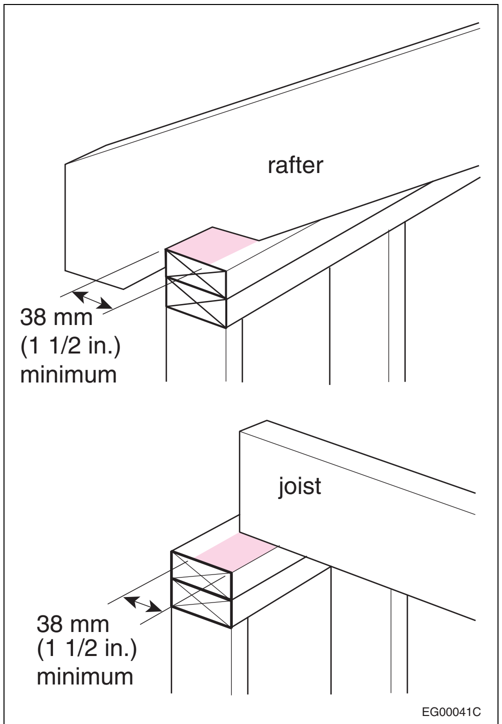


Figure 9.23.-50
End bearing of rafters and joists

9.23.14.4. Location and Attachment of Rafters

This Article provides the requirements that pertain to securing rafters at the peak. Rafters must be able to withstand uplift forces due to wind action, as well as the weight of snow and rainwater. Rafters must, therefore, be held together at the peak to resist wind action, and supported at the peak to carry the weight of snow and rain loads. If the rafters are directly opposite to each other, the horizontal rafter forces at the peak cancel each other. If the rafters are offset to an appreciable degree and depend on a ridge board to transfer the horizontal thrust to opposing rafters, the ridge board must be robust enough to prevent its deflection. For this reason, thin ridge boards are only permitted if the rafters are not significantly offset from one another.

9.23.14.5. Shaping of Rafters

This Article requires an even bearing surface at the lower ends of rafters to allow them to support anticipated roof loads without excessive crushing of the wood (see Figure 9.23.-50).

9.23.14.6. Hip and Valley Rafters

This Article indicates the minimum size of hip and valley rafters to ensure that they are able to support the jack rafters. Where two sloping roof surfaces intersect one another, they form a hip if the intersection forms an outside corner, or a valley where the intersection forms an inside corner. In the former case, the rafters are supported at their lower ends on the top wall plate, and are supported by a sloping hip rafter at their upper ends. In the latter case, the rafters are supported at the ridge at the top ends, and by a sloping valley rafter at the lower ends. The rafters supported by the hip or valley rafters are known as jack rafters.

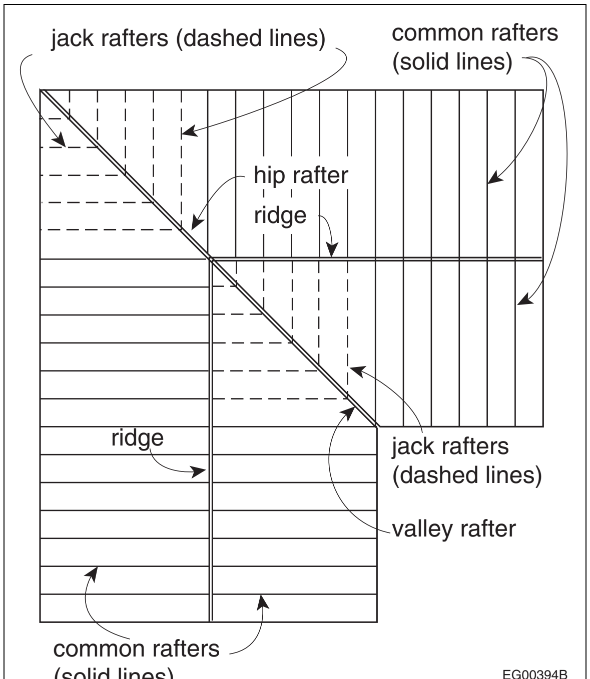


Figure 9.23.-51
Schematic plan view of rafters

For a hip roof, the sloping ridges, commonly called "hip rafters," support the jack rafters. The jack rafters are longest near the ridge and shortest near the eave. Since the hip rafters must partially support the load from these jack rafters, they are required to be at least 50 mm (2 in.) greater in depth than the other rafters (Figure 9.23.-51).

Similarly, when two sloping roof surfaces meet to form a valley, such as where the building has an 'L' or 'T' shape, the valley rafter at the convergence of the two slopes must support the jack rafters. In this case, the jack rafters are longest at the eaves, and get progressively shorter up the roof slope. The valley rafter is required to be at least 50 mm (2 in.) greater in depth than the other rafters, and must not be less than 38 mm (1 1/2 in.) thick.

9.23.14.7. Intermediate Support for Rafters and Joists

This Article describe the types of intermediate rafter supports that will permit a reduction in the length of span, so that smaller rafter sizes can be used. Because of the relatively high roof loads in many parts of Canada due to snow, rafters of typical sizes are only able to span a relatively short distance without over-stressing wood-framing.

Where stub walls are supported on the ceiling joists, the ceiling joist depth must be increased by at least 25 mm (1 in.) to provide additional strength. Where the roof slope is less than 1:4, the ceiling joists must be designed as roof joists.

When a joist and rafter roof is subjected to snow loads, the lower ends of the rafters tend to push outward. This outward movement can be resisted by using the ceiling joists to tie the bottom ends of the rafters together. The force necessary to resist the outward push of the rafters increases as the snow load increases. It also increases as the roof slope is lowered or if the span is increased. To act as effective ties, the ceiling joists must be nailed to each pair of opposing rafters, and to each other, with a sufficient number of nails to resist the outward forces.

Dwarf walls and struts can be used to reduce the span of roof joists and rafters. Where the roof slope is at least 1:3, ceiling joists and collar ties can also be used to reduce the effective span of the rafters. Collar ties act as compression members and not as ties when roof rafters are tied at the outer ends by ceiling joists. Joists that support roof loads from dwarf walls must be at least 25 mm (1 in.) deeper than normal ceiling joists. The NBC Span Tables for roof joists must be used to select joist sizes when the roof slope is 1:4 or less. Figure 9.23.-52 illustrates these requirements.

Collar ties and ceiling joists must be at least 38 × 89 mm (2 × 4 in. nominal) to be effective. In addition, if the ties are longer than 2.4 m (7 ft. 10 in.), they must be laterally supported near their centres by 19 × 89 mm (1 × 4 in. nominal) strapping applied at right angles to the ties to prevent buckling under snow loads.

Struts installed to reduce the span of rafters must be not less than 38 × 89 mm (2 × 4 in. nominal), and must be connected to loadbearing walls at an angle not less than 45° to the horizontal.

9.23.14.8. Ridge Support

This Article describes how the ridge must be supported adequately to control rafter or joist spread or how the lower ends of the rafters can be tied to control rafter spread. Sloping rafters and roof joists loaded with snow will spread outward at their bottom ends unless the ridge of the roof is adequately supported, or the ends of the rafters or joists are tied together. Tying is usually managed by nailing the rafters to the ceiling joists, and the ceiling joists to each other to complete the tie. At the lower slopes, however, the number of nails required becomes too great for this method to be practicable.

Although rafter-to-joist nailing requirements for snow loads of 2.0 kPa (42 psf) or more are specified in NBC Table 9.23.14.8., NBC Part 4 or good engineering practice should be used where snow loads are significantly greater than 2.0 kPa (42 psf). Likewise, where the table does not provide a value, NBC Part 4 or good engineering practice, such as that provided in CWC 2014, “Engineering Guide for Wood Frame Construction,” may be used.

Ridge support must be provided for all roofs with a slope less than 1:3. This ridge support can be either a loadbearing wall or a ridge beam. If the ridge beam is to be supported every 1.2 m (4 ft.) by 38 × 89 mm (2 × 4 in. nominal) vertical members, it may be constructed of not less than 38 × 140 mm (2 × 6 in. nominal) material. Otherwise, it must comply with NBC Table 9.23.4.2.-L.

Ridge support can be omitted in roofs with a slope of 1:3 or more, provided the lower ends of the rafters are secured to prevent outward movement. Tie rods or ceiling joists can be used for this purpose. Rafter-to-joist nailing must conform to NBC Table 9.23.14.8. if ridge support is to be omitted. Note that NBC Table 9.23.14.8. only applies where the lower ends of the rafters are tied; where raised ties are used, the connection requirements are higher (CWC 2014 provides requirements for raised ties).

9.23.14.9. Restraint of Joist Bottoms

This Article requires that roof joist bottoms be restrained to prevent joists from damaging interior finishes. Some roof joists have a tendency to twist as they dry. Since they are restrained on the top edge by the roof sheathing, the major joist movement occurs at the lower edge, causing nails to pull through ceiling finishes such as gypsum board. The requirements in this Article are intended to prevent such damage by restraining the lower end near the support. An exemption for plywood, OSB or waferboard ceilings is rationalized on the basis that such materials have sufficient strength to resist the twisting action.

Roof joists that support gypsum board ceilings must be restrained from twisting by furring, blocking, cross-bridging or strapping. This joist restraint is the same as that for floor joists (see Figure 9.23.-17).

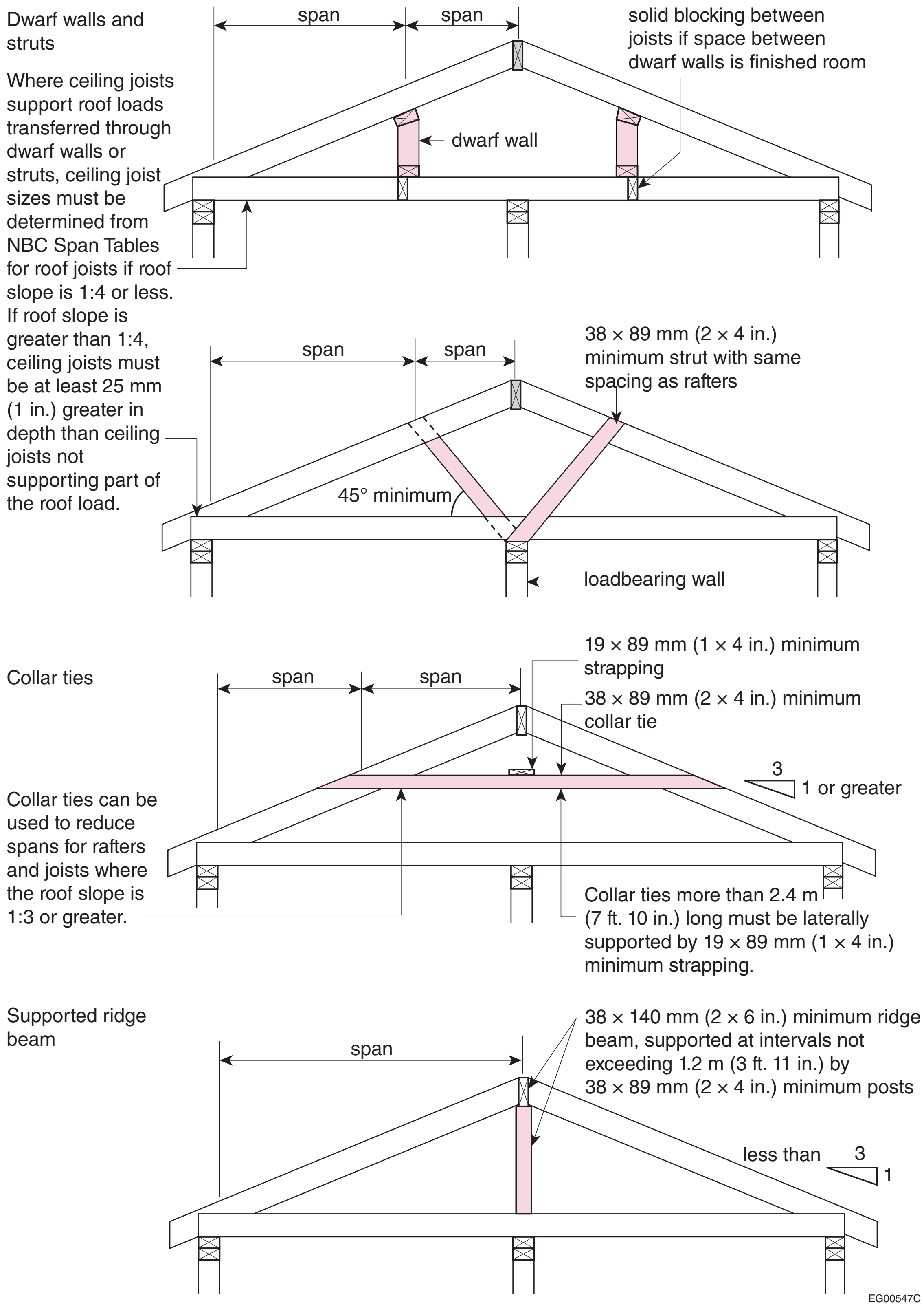


Figure 9.23.-52
Intermediate and ridge support for joists and rafters

9.23.14.10. Ceiling Joists Supporting Roof Load

This Article indicates the requirements for ceiling joists that support roof loads. When the intermediate support for rafters (such as dwarf walls) is supported by ceiling joists, the ceiling joists may become over-stressed as the rafters deflect under the snow load. Since the NBC Span Tables for ceiling joists do not allow for this type of load, the ceiling joists must be strengthened. The proportion of roof load transferred to the ceiling joists increases as the roof slope decreases, and appropriate compensating measures must be taken to increase the strength of the ceiling joists for different roof slopes to avoid over-stressing the joists.

9.23.14.11. Roof Trusses

This Article indicates the requirements for roof trusses to ensure that they will be capable of supporting anticipated roof and ceiling loads without collapsing, and without excessive deflections that may damage the ceiling finish or create objectionable sagging. Roof trusses have largely replaced joists and rafters in roofs. Trusses are available in a wide variety of geometries and are generally constructed to the designs developed by truss plate manufacturers or truss fabricators.

Allowable deflections for roof trusses are provided in NBC Table 9.23.14.11. It is important that trusses be supported at their support points exactly the way they were intended in the design. Trusses must be supported where the design specifies such support. Field modifications must not be made unless approved by the designer. Any alteration to the original design, including support location, cutting, or notching is not permitted unless it can be shown that the alteration is safe.

Roof trusses are very strong in their vertical position provided the top members are supported against buckling by the roof sheathing. In their horizontal position, however, they are very weak and can easily be damaged. Trusses should, therefore, always be lifted in their vertical position and transported vertically, unless they are fully supported.

NBC Article 9.23.14.11. requires that the connections used in wood roof trusses be designed in conformance with NBC Part 4. NBC Sentence 4.1.1.5.(2), which applies to all of NBC Part 4, requires that a designer be a specially trained and qualified person skilled in the work concerned. This has the effect of requiring that the trusses themselves be designed by professional engineers or architects. Although this is a departure from the usual practice in the NBC, it is appropriate, since wood roof trusses are complex structures that depend on a number of components (e.g., chord members, web members, cross-bracing, connectors) working together to function safely. This complexity precludes the standardization of truss design into tables comprehensive enough to satisfy the variety of roof designs required by the housing industry.

9.23.15. Subflooring

9.23.15.1. Subflooring Required

This Article indicates where subflooring is required. If finish flooring does not possess the required strength and stiffness to transfer expected floor loads to floor framing members, a subfloor must be provided. It must be able to withstand exposure to the elements if it is constructed on site, as well as wetting from floor cleaning, accidental water spills, and plumbing leaks that may occur during normal occupancy.

Subflooring provides the strength needed to support the finish flooring and anticipated floor loads. If, however, the finish flooring itself is able to support floor loads, the subfloor may be safely omitted, or reduced in thickness, depending on its strength contribution. Where wood strip flooring is laid perpendicular to the joists, for example, it can take all or part of the structural loads. The requirements for strip flooring used for structural purposes are described in NBC Section 9.30.

If the finish flooring is 19 mm (3/4 in.) matched wood laid perpendicular to the joists, plywood and OSB (O-2 grade) subflooring can be reduced to 12.5 mm (1/2 in.) for all joist spacings, while OSB (O-1 grade) and waferboard can be reduced to 12.7 mm (1/2 in.). Where a separate panel underlay is provided, or a concrete topping is used, the reduced thicknesses are also allowed but only up to 400 mm (16 in.) joist spacing.

Subfloors, however, are also used as working platforms for the rough carpentry work and other construction activities that might subject the finish floor to scarring or other damage. Weather can also inflict damage to finish floors if they are left unprotected. These practical considerations most often overrule potential material savings to be gained by omitting subfloors, which continue to be used in almost all wood-frame buildings. Subfloor support requirements are illustrated in Figure 9.23.-53.

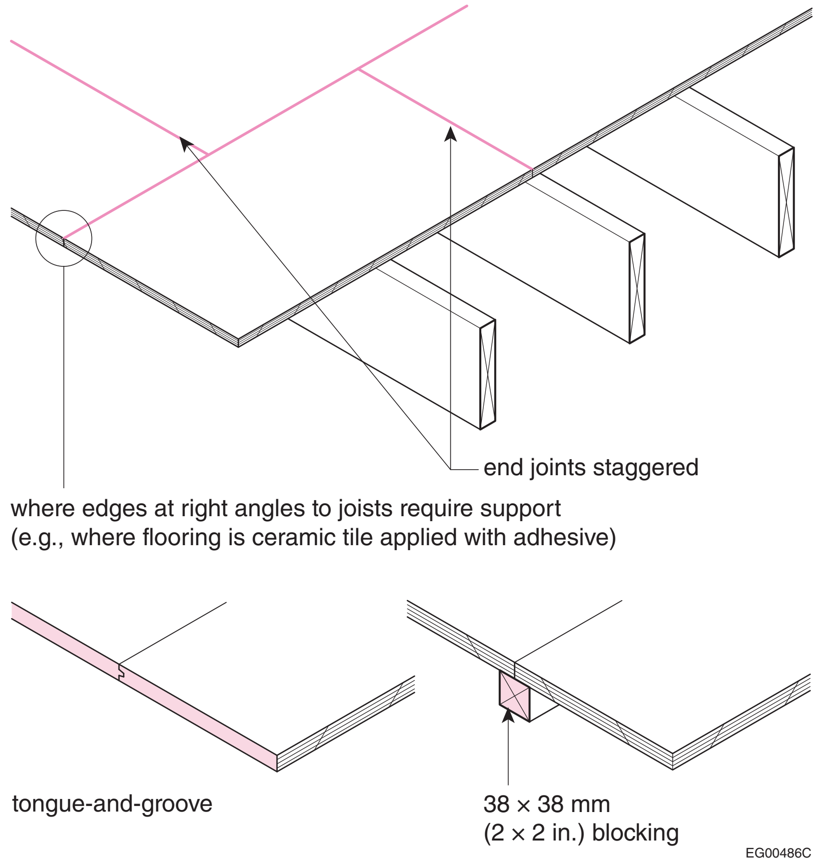


Figure 9.23.-53
Edge support requirements

9.23.15.2. Material Standards

This Article defines, through reference to standards, the characteristics needed for subflooring. CSA O325, "Construction Sheathing," applies to all wood-based panel products used for sheathing and subflooring. It establishes minimum bond durability, physical characteristics and structural performance criteria for each intended use. The essential element of the standard, however, is that the panel products are designated on the basis of their ability to meet the performance criteria specified for each application.

Panels evaluated by this standard are not designated by thickness. Instead, each is face-marked with a letter designation: F (for subfloors), W (for wall sheathing) or R (for roof sheathing). Subfloors are divided into two types: 1F designates a subfloor without a separate panel underlay, and 2F a subfloor for use with a separate underlay. Roof sheathings are also divided into two types: 1R is for roof sheathing with unsupported edges, and 2R is for roof sheathing with supported edges.

A number designating the maximum allowable spacing of the supports in inches follows the letter designation. For example, if an OSB or plywood panel is marked "2F 16," it means that the panel is intended for use as subflooring over joists spaced 16 in. (400 mm) apart, and that a separate panel underlay must be used with it. If a particular panel thickness is intended for more than one application, it can have additional designations marked on the panel.

Particleboard subflooring may only be used in factory-built floor systems that are not exposed to weather during construction. In areas that are exposed to wetting, such as kitchens, bathrooms and entrance ways, particleboard subflooring must have its upper surfaces and all edges sealed with an acceptable material.

Since not all panel products are evaluated against this performance standard, the existing standards for the individual products continue to be referenced. The tables showing the minimum allowable thicknesses for these products are also found in NBC Table 9.23.15.5.-A.

While waferboard is made from randomly oriented chips or “wafers,” OSB has its fibres generally oriented in the long dimension of the panel, giving it directional properties somewhat similar to those of plywood. This means OSB is considerably stronger in the direction of the fibres.

Products made to this standard are required to be face-marked with a letter R (for random), as in R-1 Grade Waferboard, or O (for oriented) as in O-1 Grade OSB. The OSB is made in two grades: O-1 and O-2. Type O-2 board has somewhat superior properties to O-1 board, and is made in the same thicknesses as plywood. The thicknesses of type O-1 and type R-1 are slightly different than type O-2, since they are based on a direct conversion of fractional inch dimensions rather than rationalized conversion as in the case of the O-2 board. In summary, as far as minimum thicknesses are concerned, plywood and O-2 OSB can be considered equal.

9.23.15.3. Edge Support

This Article requires that edge support be provided for subflooring. Finish flooring such as sheet vinyl, vinyl tile, ceramic tile and carpeting is not able to bridge across subfloor irregularities caused by differential deflection in adjoining sheets of subflooring. Such deflection occurs when one sheet is loaded near its edge and the second is not, and can damage finish flooring. To reduce this risk, the subfloor edges must be tongue-and-groove or blocking nailed between framing members must be placed beneath the joint to support the edges of the subfloor.

Floors with concrete toppings (without ceramic tiles) and floors to be finished with wood strip flooring at least 19 mm (3/4 in.) thick can use thinner subflooring (NBC Article 9.23.15.5.).

9.23.15.4. Direction of Installation

This Article indicates how panel subflooring is to be installed. Plywood is stronger and stiffer in the direction of the surface grain than it is across the grain. OSB fibres, which are oriented along the length of the sheet, are also stronger in this direction. For this reason, plywood and O-1, O-2 and R-1 grades of OSB subflooring need to be installed so that the direction of face orientation is at right angles to the joists and the panel ends parallel to the joists. Staggering joints, so that they do not occur in adjacent rows of panels along the length of any joist, also has an overall stiffening effect on the flooring and reduces the risk of cracks developing in the finish flooring above the joint in the subfloor if resilient flooring or ceramic tile is used.

9.23.15.5. Subfloor Thickness or Rating

This Article indicates the required minimum thickness or rating for subfloors to provide sufficient strength and stiffness in combination with other elements in the floor system to support the anticipated floor loads without causing excessive springiness, and to provide a base that will be compatible with the characteristics of the finish flooring. The subfloor required strength and stiffness depend on the other constituent elements of the assembly.

Certain types of flooring, such as adhesive-applied ceramic flooring, require a very rigid base to avoid subsequent glue-bond failures or damaged tiles. Wood strip flooring, on the other hand, can bridge surface irregularities and even contribute to the overall strength and stiffness of the floor. Panel-type underlay can also contribute to strength and stiffness, and mask surface irregularities in the subfloor. Refer to Guide 9.23.15.4., Direction of Installation, for information about rated panels for subflooring.

9.23.15.6. Annular Grooved Nails

This Article indicates where annular grooved nails are required. The nailing requirements for subfloors are contained and summarized in NBC Table 9.23.3.5.

When resilient flooring is to be directly applied over OSB, waferboard, particleboard or plywood subflooring, the subfloor must be fastened with annular grooved nails. Subfloors must be quite stiff to prevent cracking of ceramic tile flooring, if that flooring is installed directly to the subflooring with adhesive. For this reason, requirements for the support of such floors are more stringent than for other floors.

9.23.15.7. Lumber Subflooring

This Article indicates the requirements that pertain to lumber subflooring. Lumber subflooring is commonly laid in a diagonal pattern to permit wood strip flooring to be laid either parallel or at right angles to the joists. As the angle between the subflooring and the joists decreases, the effective span of each piece of lumber in the subfloor is increased, causing the floor to be springier. Therefore, a limit is placed on the minimum size of the angle between the joist and the subfloor.

The ends of individual pieces are supported to reduce the springiness of the subfloor. As the width of the subfloor boards is increased, the total potential movement due to shrinkage is also increased and can cause gaps between the flooring strips. The limit on board width is intended to reduce this problem. Requirements for lumber subflooring are illustrated in Figure 9.23.-54.

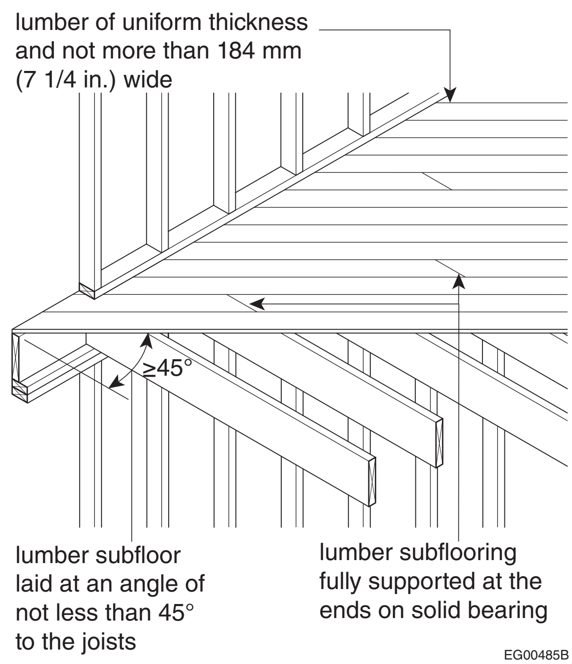


Figure 9.23.-54
Lumber subflooring requirements

9.23.16. Roof Sheathing

9.23.16.1. Required Roof Sheathing

This Article indicates the requirements that pertain to roof sheathing. Roof sheathing is used beneath roofing when the roofing does not have sufficient strength to support the expected roof loads. Such sheathing must be able to support the anticipated roof loads (including construction workers), as well as resist deterioration due to exposure to the weather during construction, occasional wetting from roof leaks, and cold-weather condensation.

Where the 1-in-50 hourly wind pressure (HWP) is equal to or greater than 0.8 kPa (16 psf), and the spectral response acceleration, $S_a(0.2)$, is less than or equal to 0.70, continuous lumber or panel-type roof sheathing is required to provide diaphragm action to resist lateral loads.

9.23.16.2. Material Standards

This Article indicates, through reference to standards, the required properties of roof sheathing. Roof sheathing that is not used as a walking deck must conform to NBC Tables 9.23.16.7.-A or 9.23.16.7.-B. If the sheathing is to be used as a walking deck, then the subfloor requirements in NBC Part 3 apply.

Although the traditional sheathing material has been lumber, most roofs are now built with plywood, OSB or waferboard. When board sheathing is used, it is laid so that the ends of all boards are supported and the joints in adjacent pieces are staggered to increase the overall rigidity of the roof.

Asphalt impregnated roof sheathing has been successfully used for constructing manufactured homes. Such roofs are also normally covered with a continuous sheet of aluminum or sheet steel roofing, which helps to support the load. This type of roof deck is acceptable provided the framing spacing is not greater than 400 mm (16 in.) and the edges between sheets are supported by blocking or framing. Tests demonstrated the structural adequacy of such an arrangement before this system was recognized in Part 9.

9.23.16.3. Direction of Installation

This Article indicates the direction in which wood panel sheathing is to be installed. Plywood is stronger and stiffer in the direction of the surface grain than it is across the grain. OSB fibres, which are oriented along the length of the sheet, are also stronger in this direction. The sheets must, therefore, be laid across the rafters or roof joists, and not parallel to them, to ensure that the roof surface will withstand the anticipated roof loads, including the weight of workers.

Plywood roof sheathing must be installed with the surface grain at right angles to the roof framing members. Similarly, OSB of O-1 and O-2 grades must be installed with face orientation at right angles to roof framing. Wood-based roof sheathing must be installed with at least a 2 mm (3/32 in.) gap between sheets. This space allows for swelling. When using panel-type sheathing requiring edge support, joints perpendicular to the roof ridge should be staggered.

Lumber roof sheathing must be installed diagonally where the seismic spectral response acceleration, $S_a(0.2)$, is greater than 0.70, but not greater than 1.2, and where the 1-in-50 hourly wind pressure (HWP) is equal to or greater than 0.8 kPa (16 psf), but less than 1.2 kPa (25 psf). Where the seismic spectral response acceleration,

$S_a(0.2)$, is greater than 1.2, or where the 1-in-50 hourly wind pressure (HWP) is equal to or greater than 1.2 kPa (25 psf), lumber roof sheathing must be designed in accordance with NBC Part 4.

9.23.16.4. Joints in Panel-Type Sheathing

This Article lists the requirements for joints in panel-type sheathing to avoid creating bulges in the roof sheathing should it become wet and expand. This is accomplished by controlling the direction of installation, staggering joints, and leaving a small gap between panels to permit expansion.

9.23.16.5. Lumber Roof Sheathing

This Article limits the width of lumber roof sheathing to minimize its shrinking and splitting. As lumber roof sheathing shrinks, the nails or staples fastening asphalt shingles are shifted to new positions. Small shifts in position can be accommodated by the roofing without showing noticeable effects on the roofing. For wider boards, the movement of the fasteners causes the asphalt shingles to bulge upward. Limiting the maximum width of roof boards is intended to reduce this problem.

For this reason, lumber roof sheathing cannot be more than 286 mm (11 in.) wide to limit moisture expansion and contraction, and to reduce shingle buckling. The ends of the lumber must be supported on solid framing with end joints staggered.

9.23.16.6. Edge Support

This Article requires that adequate edge support be provided for lumber roof sheathing. When two sheets of roof sheathing butt together without underlying support, one sheet will deflect relative to the other under weight. If the deflection is large enough, the roofing will be damaged and the roof will leak. If the sheathing is not sufficiently thick to avoid excessive differential deflection, the edges must be kept from moving relative to each other to avoid being damaged.

Support is usually provided by H clips designed to prevent differential movement between sheets. Blocking between the framing can also be used, but is usually more expensive. Tongued and grooved panel sheathing can also be used to provide this edge support, provided the material is thick enough to allow a tongued and grooved edge to be formed.

9.23.16.7. Thickness or Rating

This Article indicates the required thickness or rating for roof sheathing to provide sufficient strength for the roof deck to support the anticipated loads, including those due to snow and rain, as well as those from foot traffic. If the roofing itself contributes substantially to the strength of the roof, a somewhat weaker deck material can provide sufficient strength to support the anticipated loads. Where the surface is used as a walking deck, a stiffer surface than that provided for traditional roof decks is necessary to avoid excessive springiness.

Roof sheathing that is not used for a balcony deck or for pedestrian traffic can be much thinner than is required for subflooring. Although roofing can tolerate more differential movement between sheets than can finish flooring, it can still be damaged if the differential deflection between sheets is too great.

Refer to Guide 9.23.15.4., Direction of Installation, for information about rated subflooring panels.

9.23.17. Wall Sheathing

9.23.17.1. Required Sheathing

This Article describes the conditions under which wall sheathing is necessary. Whether or not it is needed depends on other wall components and how they are installed. Sheathing can add strength to resist wind loads and impact forces, and can be used as a nailing base to attach the cladding. Many claddings can be attached directly to the sheathing (if it has adequate nail-holding characteristics), or to furring or blocking at right angles to the studs. The cladding thickness or the furring size can, therefore, depend on whether or not sheathing is used.

Sheathing is required on exterior walls and gable ends when the exterior cladding requires either solid backing, or intermediate fastening between wall framing member supports.

In high wind and seismic areas, wall sheathing is required on exterior walls to provide lateral resistance. Where sheathing is not required to resist high seismic and wind loads, for the direct attachment of the cladding, or for providing additional support for the cladding or strapping, it can be removed entirely. However, sheathing is seldom removed because of the advantage it provides in allowing a building to be enclosed quickly and be protected from the weather. Where it is not required, but used only as a construction aid, the thickness limits in NBC Tables 9.23.17.2.-A and -B do not apply, and a builder can use whatever is most economical.

9.23.17.2. Thickness, Rating and Material Standards

This Article describes, through reference to standards, the thickness and other characteristics of various wall sheathings needed to provide sufficient strength and durability to justify a reduced thickness for certain claddings, or a reduced furring size. Sheathing can be exposed to rain during construction or to condensation in winter. It must therefore have sufficient water resistance to limit deterioration of its required strength resulting from such exposure.

Where wall sheathing is required for the purpose of complying with NBC Section 9.23., it must conform to NBC Table 9.23.17.2.-A or -B. The sheathing materials in NBC Table 9.23.17.2.-A may have a low air or vapour permeance, necessitating their compliance with NBC Article 9.25.5.2. (see NBC Article 9.25.5.1.). The flame-spread rating of gypsum board conforming to ASTM C 1396/C 1396M, "Gypsum Board," must be determined in accordance with CAN/ULC-S102, "Test for Surface Burning Characteristics of Building Materials and Assemblies."

If exterior cladding is attached directly to framing (or to furring strips nailed through the sheathing and into the framing), the type of sheathing used makes little difference as far as nail withdrawal resistance is concerned. If the cladding is directly attached to the sheathing, however, only lumber, plywood, OSB, or waferboard is considered to provide the appropriate resistance to nail withdrawal. The thickness required in these cases depends on the type of cladding to be supported (see NBC Article 9.27.5.1.).

If wall sheathing supports stucco reinforcement, the nails must support a considerable vertical load, and the sheathing is required to be thicker than if it supports plastic or aluminum siding or wood shingles. If it supports vertical wood siding, the nails must restrain the lumber against warping so that a greater sheathing thickness is necessary to develop the necessary nail withdrawal resistance.

9.23.17.3. Attachment of Cladding to Sheathing

This Article indicates that certain sheathing materials should not be used for the direct attachment of cladding because they are not considered to have sufficient fastener anchorage strength.

9.23.17.4. Lumber Sheathing

This Article provides the requirements for the installation of lumber wall sheathing to ensure that it will have sufficient stiffness to resist impact forces that might damage the cladding as a result of differential deflection between abutting sheathing boards. The ends of lumber wall sheathing must be supported by framing members or blocking. If lumber sheathing is required for bracing, the joints of the sheathing must be staggered.

9.23.17.5. Joints in Panel-Type Sheathing

This Article contains requirements for joints in panel-type sheathing to avoid creating bulges in the wall sheathing if it expands as a result of increased moisture content. The shape of a joint is critical to its ability to drain water. Tongue and groove, and lapped joints can shed water if oriented correctly. Butt joints can drain to either side, and so should not be used unless they are sealed. However, joint detailing requires attention not just to the shape of the joint but also to the materials that form the joint. For example, even if properly shaped, the joints in insulating sheathing with an integral sheathing membrane could not be expected to shed water if the insulating material absorbs water, unless the membrane extends through the joints.

The joints of panel-type wood-based sheathing must have a gap of not less than 2 mm (approximately 3/32 in.) between panel edges to allow for expansion of the panels with increasing moisture content.

9.23.17.6. Mansard Style Roofs

This Article indicates that the lower part of a mansard roof is a wall and needs to comply with NBC Articles 9.27.3.2. to 9.27.3.6. When the lower portion of a mansard or gambrel style roof is vented, the insulated part of the lower portion is subject to air leakage. Therefore, a sheathing membrane is required to restrict air leakage as it is for walls.

Section 9.24.
Sheet Steel Stud Wall Framing

Introduction

Steel studs are divided into two categories: those for non-loadbearing interior walls (which can have very thin metal thickness) and those for exterior walls (which are somewhat heavier). The height and thickness limits for interior studs were selected to be fairly representative of industry practice. The thickness requirements for studs in exterior non-loadbearing walls were designed to resist the anticipated wind forces on low rise construction in most regions. NBC Table 9.24.2.5. should not be used for determining the sizes of steel studs used in exterior walls of taller buildings outside the scope of NBC Part 9, because such buildings are subjected to higher wind pressures.

The ability of steel studs to support axial loads depends on the degree to which their flanges are laterally braced against buckling or twisting. Braced flanges were assumed for the calculation of lateral strength for wind resistance. This should be kept in mind when foamed plastic or glass fibreboard sheathing is used. The stiffening effect of these materials on the flanges is unknown and may in fact be negligible. Therefore, conventional sheathing or some other method of laterally bracing the flanges, such as transverse strapping, is recommended beneath insulating sheathings, unless the strength of the walls with insulated sheathings is established by tests or calculations.

Loadbearing steel studs can be used to construct Part 9 buildings, but they must be designed in conformance with NBC Part 4 (NBC Article 9.24.1.1.).

The Canadian Sheet Steel Building Institute (CSSBI) has a number of publications to assist designers and builders in using steel studs (www.cssbi.ca/).

9.24.1. General

9.24.1.1. Application

This Article indicates that NBC Section 9.24. applies only to sheet steel studs in non-loadbearing interior and exterior walls. Loadbearing sheet steel studs require structural calculations for proper usage. They can be used to construct Part 9 buildings, but they must be designed in conformance with Part 4.

9.24.1.2. Material Standards

This Article defines, through reference to a standard, the characteristics of steel studs that will enable them to fulfill their intended purpose. The standard is AISI S201, “North American Standard for Cold-Formed Steel Framing – Product Data.”

9.24.1.3. Metal Thickness

This Article clarifies that the steel thicknesses of studs in NBC Section 9.24. do not include the thicknesses of the protective coatings, which do not add to a stud’s strength. This reflects industry practice and avoids the error of overestimating stud strength in structural calculations.

9.24.1.4. Screws

This Article defines, through reference to standards, the characteristics of screws needed to attach gypsum board to steel studs to enable the wall assembly to fulfill its intended function.

9.24.1.5. Cladding, Sheathing and Interior Finish Required

This Article indicates the methods for attaching exterior cladding and interior finishes. Screws for the application of cladding, sheathing, or interior finish materials to steel studs, runners, and furring channels need to conform to standards referenced in NBC Articles 9.24.1.4. and 9.29.5.7.

Screws must penetrate not less than 10 mm (3/8 in.) through the metal and be spaced as required in the NBC.

9.24.2. Size of Framing

9.24.2.1. Size and Spacing of Studs in Interior Walls

This Article indicates the size and spacing requirements of studs for interior non-loadbearing walls. Interior walls provide framing for the support of interior wall finish materials. A second purpose is to provide walls with sufficient rigidity to withstand impact forces, including those resulting from the operation of doors, to avoid damage to the wall finish. Steel studs for interior non-loadbearing walls must conform to NBC Table 9.24.2.1.

The required size of steel studs depends on the ceiling height, stud spacing, metal thickness and location (non-loadbearing interior walls, exterior walls). Non-loadbearing interior wall studs are generally smaller and lighter than those for exterior walls because they are not required to resist wind pressures.

9.24.2.2. Thickness of Studs

This Article requires a minimum metal thickness of 0.46 mm (25 gauge) for steel studs to provide sufficient strength and stiffness.

9.24.2.3. Runners

This Article requires a minimum thickness for runners which provide a means for holding steel studs in alignment at the tops and bottoms of the studs, and a means for anchoring the wall assembly to the floor and ceiling. Runners must have a thickness not less than the thickness of the steel wall studs they support, and have at least 30 mm (1 3/16 in.) wide flanges. Runner members are U-shaped and are installed at the top and bottom of the studs to line them up and fix their position, much like the top and bottom plate in conventional wood-frame construction. Runners are also attached to the ends of the studs at the top and bottom of window and door openings. The runners are nailed or screwed to the ceiling and floor members at appropriate intervals to stabilize the wall against movement.

Such anchorage is more restrictive for outside walls because of the wind pressures to be resisted. Studs adjacent to window openings are required to be doubled or tripled, depending on the width of the opening, the same as is required for those adjacent to door openings.

9.24.2.4. Openings in Fire Separations

This Article provides the requirements that pertain to openings in fire separations. Fire doors subjected to fire on one side tend to warp. Since the doors are restrained by hinges and latches, this warping creates forces that are resisted by the door frame, which is in turn supported by the steel studs. Since the stud closest to door openings in the framing assists in stiffening the frame near the door, its spacing from the opening is also limited. Additionally, the framing must provide sufficient strength and stiffness to resist impact forces from the normal operations of the door without damaging the wall finish.

9.24.2.5. Size and Spacing of Studs in Exterior Walls

This Article refers to NBC Table 9.24.2.5. Walls must be of sufficient strength and stiffness to resist horizontal forces due to anticipated wind loads. While not explicitly stated in the NBC, steel framing on exterior walls should incorporate a detail that offers a thermal break between the interior and exterior of the wall.

9.24.3. Installation

The framing for steel studs follows the same general pattern as for wood studs, although two different types of members are used instead of one.

9.24.3.1. Installation of Runners

This Article indicates the requirements that pertain to the installation of runners, which provide a means for keeping the top and bottom ends of studs in alignment, and a means for anchoring the wall assembly to the floor and ceiling to resist wind loads and impact forces. A second purpose is to provide a means for supporting the studs beneath or above wall openings.

Runners must be attached at the floor and ceiling with 63 mm (2 1/2 in.) nails or 25 mm (1 in.) screws spaced no more than 300 mm (12 in.) on centre apart for exterior walls and no more than 600 mm (24 in.) on centre apart for interior walls, and within 50 mm (2 in.) of the ends of the runner.

9.24.3.2. Fire-Rated Walls

This Article lists the requirements that pertain to framing in fire-rated walls. When steel stud walls are subjected to fire, the studs increase in length. If the studs are restrained from expanding at the top and bottom, they may buckle and damage the continuity of the protecting gypsum board. To reduce this risk of failure in fire, a 12 mm (1/2 in.) clearance is required between the top of the studs and the runner in walls required to act as fire separations. The studs should not be firmly attached to the top runner since this would negate the effects of the clearance. The bottoms of the studs, however, should be fastened to the runner.

In walls required to be fire separations, a strip of gypsum board is required between the runners and the door frame, as shown in Figure 9.24.-1, to insulate the runners from fire exposure below.

The framing size and spacing for walls required to act as fire separations are the same as for any other wall if there are no openings through it. If there are openings, however, the required stud size for fire separations will depend on the widths of the openings. For example, if the opening span is not more than 1.2 m (4 ft.), at least 63 mm (2 1/2 in.) wide studs are required; however, if it is wider than 1.2 m (4 ft.), then 91 mm (3 5/8 in.) studs must be used and the steel thickness increased from 0.50 to 0.85 mm (25 to 21 gauge) for added rigidity. The maximum distance between the studs adjacent to the opening and the next stud is also regulated (see Figure 9.24.-1).

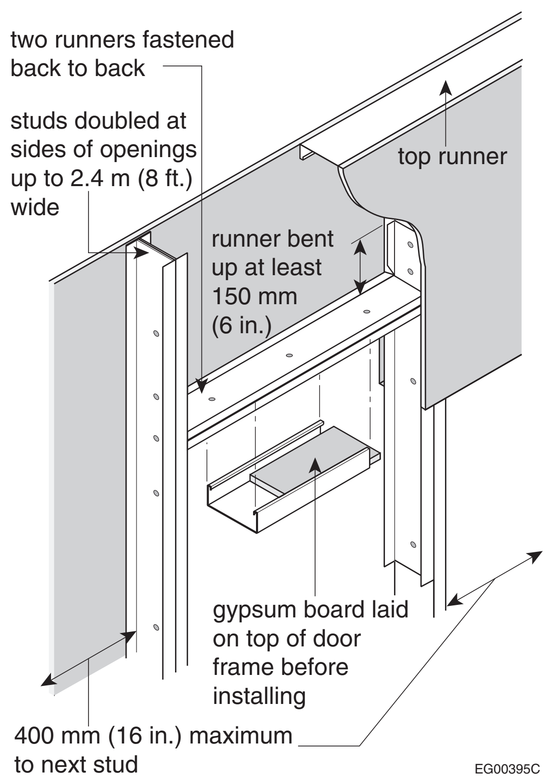


Figure 9.24.-1
Steel stud framing above an opening in a fire separation

9.24.3.3. Orientation of Studs

This Article requires that steel studs be installed at a right angle to the wall face and be continuous. This is to develop the necessary strength in walls to resist horizontal forces due to wind and/or impact forces. Wall studs are much stronger and stiffer with their webs perpendicular to the gypsum board than parallel to it. In addition, if the webs are parallel to the wall it would be impossible to attach the gypsum board to the flange members. Finally, studs that are spliced will not be as stiff and strong as those that are in one piece. Splicing is acceptable for steel studs provided that the splice is adequate for the intended use of the wall and the joints can provide strength equivalent to that of full length studs.

Steel studs, like wood studs, are installed with their widest face perpendicular to the wall surfaces for maximum stiffness, and are continuous for the full height of the wall except at openings. They are also arranged at corners and intersecting interior walls to support the edges of the gypsum board finish similar to wood studs. Usually, three studs are used at each such location.

9.24.3.4. Support for Cladding Materials

This Article requires that gypsum board edges that meet at wall corners and intersecting walls be supported to avoid damage to the gypsum board as a result of impact or wind forces in these locations.

9.24.3.5. Framing around Openings

This Article lists the requirements for framing studs to transfer loads around openings in steel framing. Wind forces on doors or windows are transferred to the jamb studs at the sides of the openings. If the opening for a door or window is more than a stud space in width, the jamb studs will not be strong enough, unless they are reinforced with additional studs. As the opening width is increased, a greater magnitude of load is transferred to the side studs, and more than one additional stud will be necessary to provide adequate stiffness.

At openings, studs must be doubled on each side of the opening and tripled if the opening is part of an exterior wall, and if that opening and is more than 2.4 m (7 ft. 10 in.) wide. The studs must be tied together to act as a unit. The ends of studs above and below openings are also tied to runners and attached to the studs at either side of the openings as illustrated in Figure 9.24.-2.

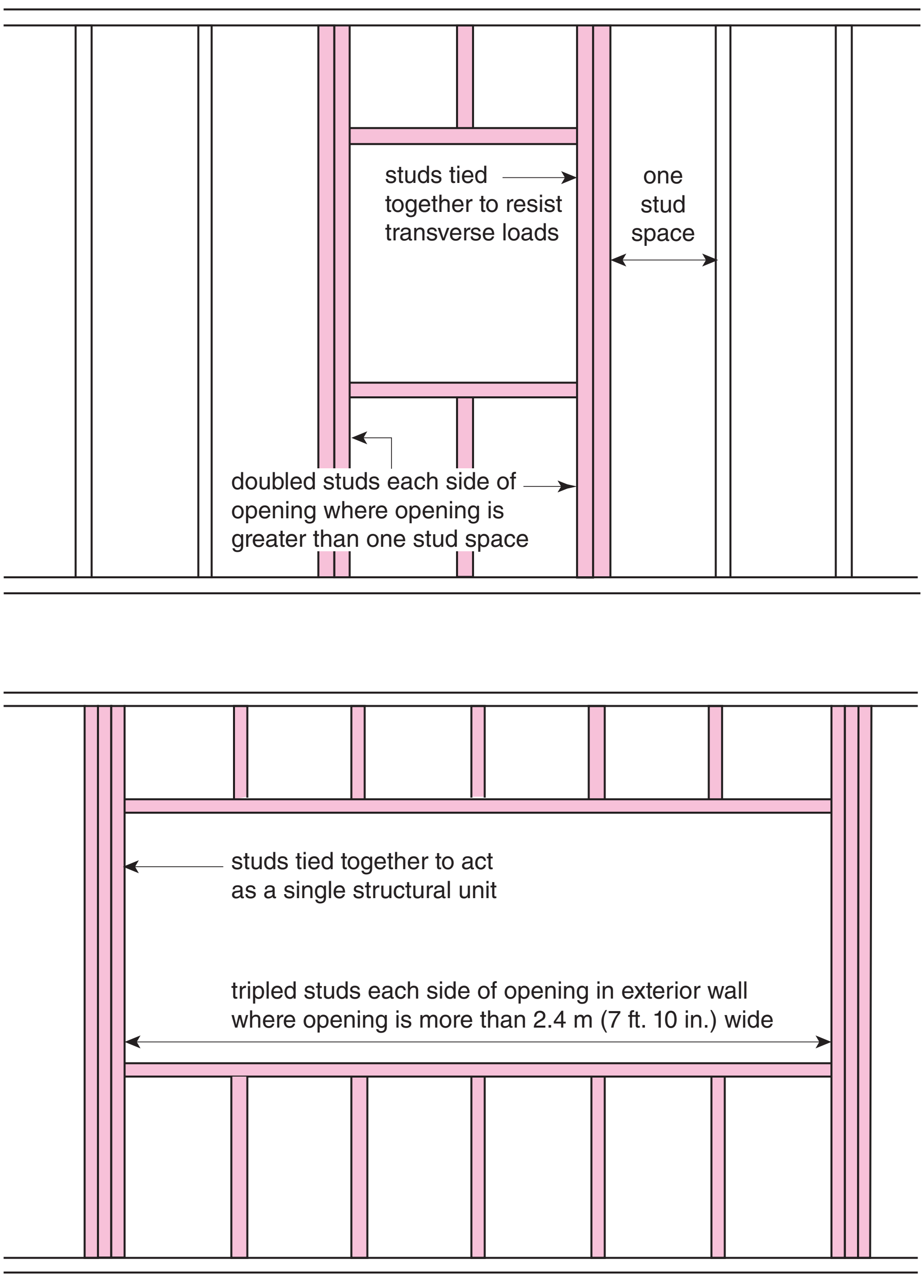


Figure 9.24.-2
Steel stud framing around openings

9.24.3.6. Attachment of Studs to Runners

This Article indicates how studs should be attached to runners to keep them in proper alignment during construction, as well as allow for their expansion in walls required to act as fire separations.

9.24.3.7. Openings for Fire Dampers

This Article indicates the requirements that pertain to openings for fire dampers. Wall framing around fire dampers must provide sufficient strength to support the dampers and, in the event of fire, retain them in their proper positions. Gypsum board between the wall framing and the fire damper protects the wall framing from excessive heat transmission from the fire damper casing to the wall framing. This is intended to reduce the distortion of the framing, which could cause the damper assembly to fail prematurely.

Where a fire damper is to be mounted in a steel stud wall, doubled studs are required adjacent to each side of the opening, while the top and bottom are framed in with runners. In this case, the opening is required to be lined with gypsum board to insulate the framing as shown in Figure 9.24.-3.

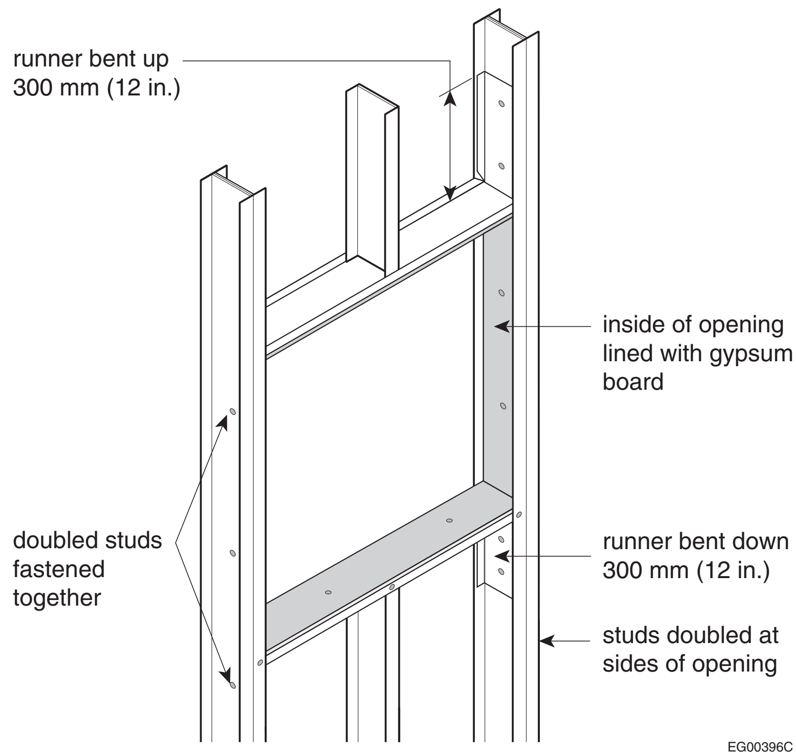


Figure 9.24.-3
Steel stud framing to accommodate a fire damper

Section 9.25. Heat Transfer, Air Leakage and Condensation Control

Introduction

The control of heat transfer, air leakage and condensation is important for occupant comfort and for minimizing building damage and deterioration. The air and vapour permeability of materials used in the building envelope assembly and their location are equally important. This Section is structured so that each of these issues is addressed separately.

9.25.1. General

9.25.1.1. Scope and Application

This Section addresses the transfer of heat, air and water vapour, as well as measures to control condensation. It applies to all occupancies covered by Part 9 buildings.

All walls, ceilings and floors separating conditioned space from unconditioned space, the exterior air, and the ground are required to have thermal insulation, an air barrier, and a vapour barrier. They must also conform to the requirements for the properties and location of low permeance materials (Figure 9.25.-1).

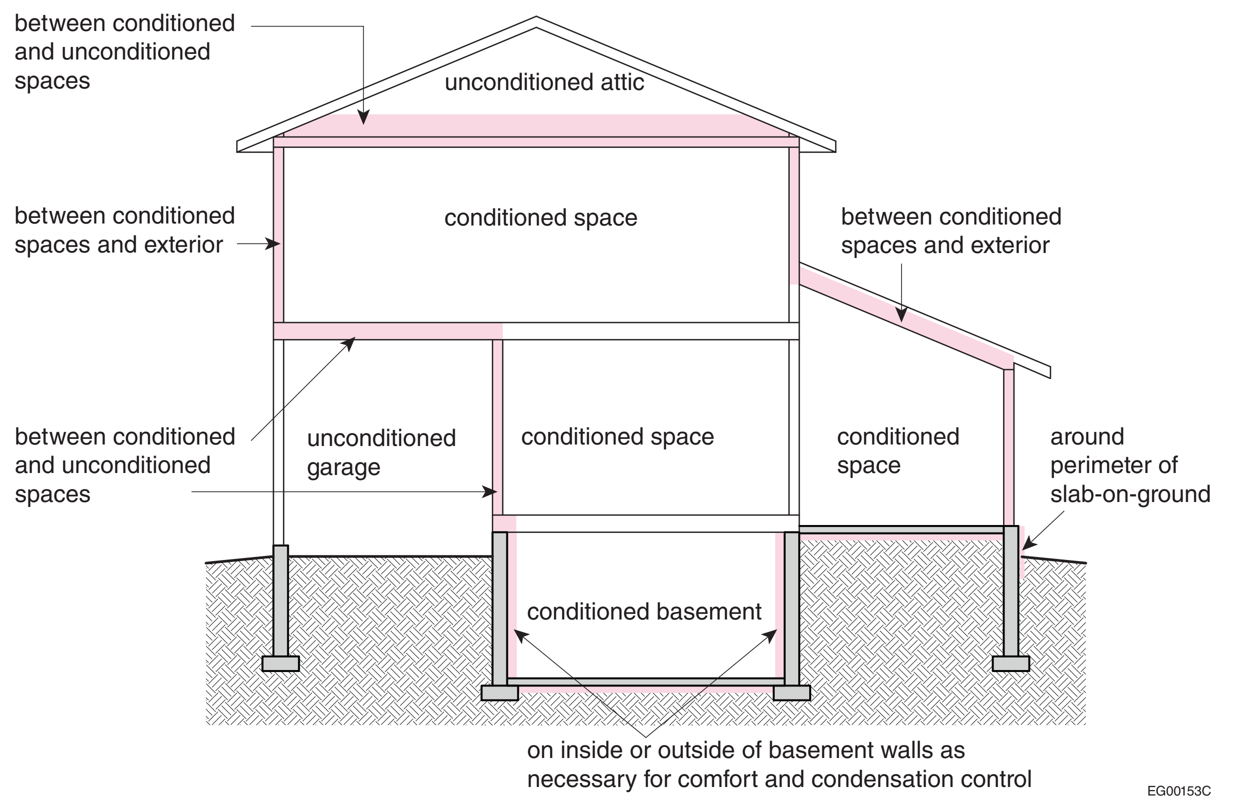


Figure 9.25.-1
Locations requiring an air barrier, a vapour barrier and thermal insulation

The insulation of heating and ventilating ducts is governed by the requirements of NBC Sections 9.32. and 9.33.

9.25.2. Thermal Insulation

Heat flows from high temperature to lower temperature by three distinct mechanisms: conduction, convection and radiation (Figure 9.25.-2). In buildings, all three mechanisms can occur, although only one or two may predominate in any particular situation. A fourth mechanism is the transfer of heat by mass transport (air or water), where the driving force is not a temperature differential but a pressure differential.

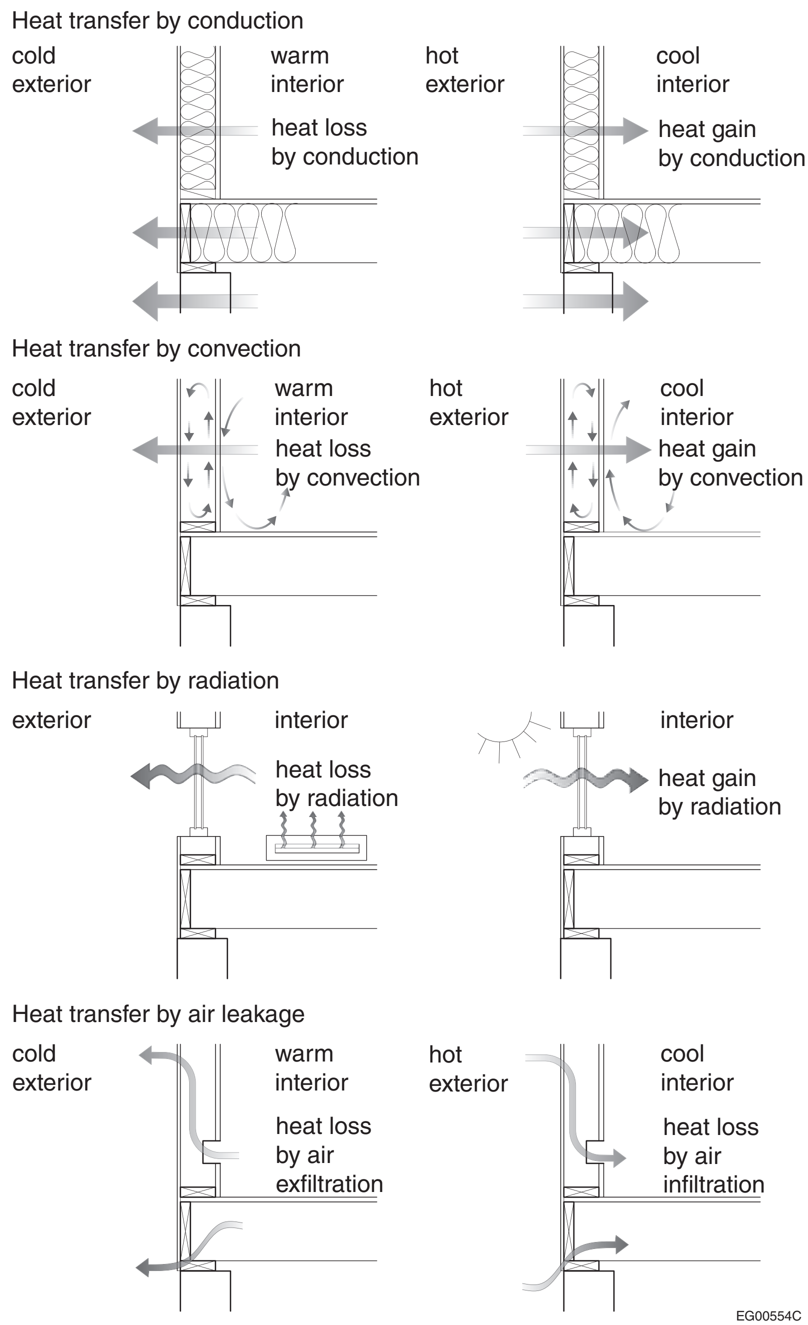


Figure 9.25.-2
Heat flow mechanisms

Conduction is initiated when molecules in one portion of a material are excited by the addition of heat. This molecular agitation (or heat) is passed along from the very agitated portions of the material (warm side) through the material toward the slower moving molecule in the material's colder parts. This is the way that most heat is transferred through solid materials such as wood or concrete. Materials have a wide range of thermal conducting properties. Materials such as metals are very good thermal conductors while others, such as insulation, have much lower conductivity. Still air is a very poor conductor and a good resistor to heat flow by conduction.

Convection is the transfer of heat through a liquid or gas due to the movement of the liquid or gas, which is caused by a change in density, which is itself caused by heating. Air or water adjacent to a heated surface is warmed by conduction. It becomes less dense and rises to a level where the heat is given up to a colder body. Cooler air or water moves in to replace the heated air or water. In an insulating material such as mineral wool, the air is trapped in such small pockets that convection currents are prevented.

Radiation occurs when a heated surface is adjacent to a medium such as air or water that facilitates the travel of infra red (heat) radiation. The radiation carries heat energy away from the heated body to other bodies that can 'see' the heat source. This is the way that radiant heating works, and is the principal mechanism of heat delivery from space heaters. Black, dull surfaces are efficient radiators, while shiny, bright faces such as aluminum foil are very poor radiators.

Heat loss by air mass transport (air leakage) occurs when a pressure difference exists from the interior of a building to the exterior side of a building and an opening exists that allows air to move from the high pressure side to the low pressure side. Interior air would then carry the heat energy to the exterior. The loss of heat through air leakage can be substantial.

9.25.2.1. Required Insulation

This Article requires that insulation provide sufficient thermal resistance in the building envelope to hinder moisture condensation on the inside surface in cold weather, and to provide thermal comfort for the occupants.

Insulation is required for all walls, ceilings and floors separating conditioned (heated) space from unconditioned (unheated) space, the exterior, or the ground, where the lack of insulation could lead to condensation on the warm side. While the NBC does not specify the insulation value required, it is specific about insulation location to minimize condensation to avoid the growth of mould (for health) or the deterioration of wall, roof or floor components (for safety). Cottages intended for use only in the summer and which, therefore, have no space heating appliances, would not be required to be insulated.

Insulation also has an influence on the comfort of the occupants and serves to reduce the heat losses from a building. Home buyers now have greater expectations regarding the level of a building's insulation, so that more significant levels of insulation are now required. In addition, some provincial, territorial and local authorities enforce minimum insulation levels through their building codes or through energy conservation regulations.

9.25.2.2. Insulation Materials

This Article defines, through reference to standards, the acceptable characteristics for thermal insulating materials to perform their intended functions in the building envelope. The referenced standards address mostly performance requirements at the time of manufacturing, while a few of the documents also contain guidance on certain applications.

In addition to the insulation materials being governed by standards referenced in NBC Article 9.25.2.2., there is a requirement that insulation in contact with the ground must be inert to the action of soil and water and possess insulating properties not significantly reduced by moisture.

With the exception of foamed plastics (NBC Article 9.10.17.10.), NBC Part 9 has no requirements for flame-spread ratings of insulation materials because they are seldom exposed in parts of buildings where fires are likely to start. Some insulating material standards referenced do include flame-spread ratings criteria, either because the manufacturer wishes to show that the product does not constitute a fire hazard, or because the product is regulated by authorities other than building authorities (e.g., Health Canada's Hazardous Products Act). However, the NBC cannot apply such requirements to some materials and not to others, so flame-spread rating requirements are excepted in referencing these standards.

9.25.2.3. Installation of Thermal Insulation

This Article indicates the installation requirements for thermal insulation to ensure that it fulfills its intended purpose without creating problems related to cold weather, such as condensation on interior surfaces and low thermal comfort for the occupants. It should be noted that air leakage can also lead to substantial heat loss in buildings. This is addressed in NBC Subsection 9.25.3.

In general, insulation must be installed to provide a reasonably uniform thermal resistance over the entire face of the insulated area. Insulation applied between furring or framing must extend the full width and length of these spaces. See NBC Note A-9.36.2.5.(2) for more information.

For thermal insulation to be effective, it must not be short-circuited by convective air flow through or around the material. Thermal insulation must be installed in full and continuous contact with the air barrier system. If low-density fibrous insulation is installed with an air space on both sides of the insulation, the temperature differential between the warm and cold sides will drive convective air flow around the insulation. If foam plastic insulation is spot-adhered to a back-up wall, or adhered in a grid pattern to an air-permeable substrate, and is not sealed at the joints and around the perimeter, air spaces between the insulation and the substrate will interconnect with spaces behind the cladding, and convective loops may contribute to increased heat loss. Moreover, air leakage paths may be created.

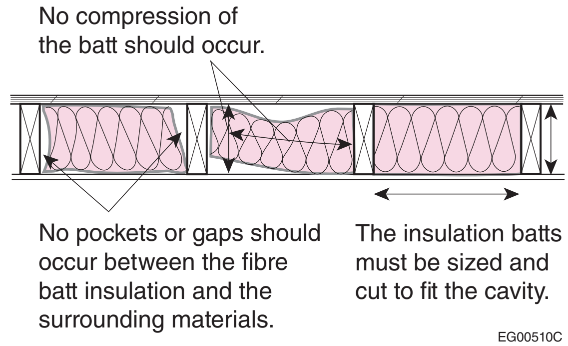


Figure 9.25.-3
Reducing convective air movement in cavities

Any temperature or air pressure differential across the insulation will lead to short-circuiting of the insulation by air flow. Unless the insulation also fulfills the function of the air barrier, which would require that it have low air permeance and be sealed at all joints, the insulation must be installed in full and continuous contact with the airtight element of the air barrier system or with another continuous component with low air permeance to reduce convective air movement in the cavity, as illustrated in Figure 9.25.-3. See NBC Table A-9.25.5.1.(1) for examples of low air permeance materials. Insulation must not be compressed to fit into a space.

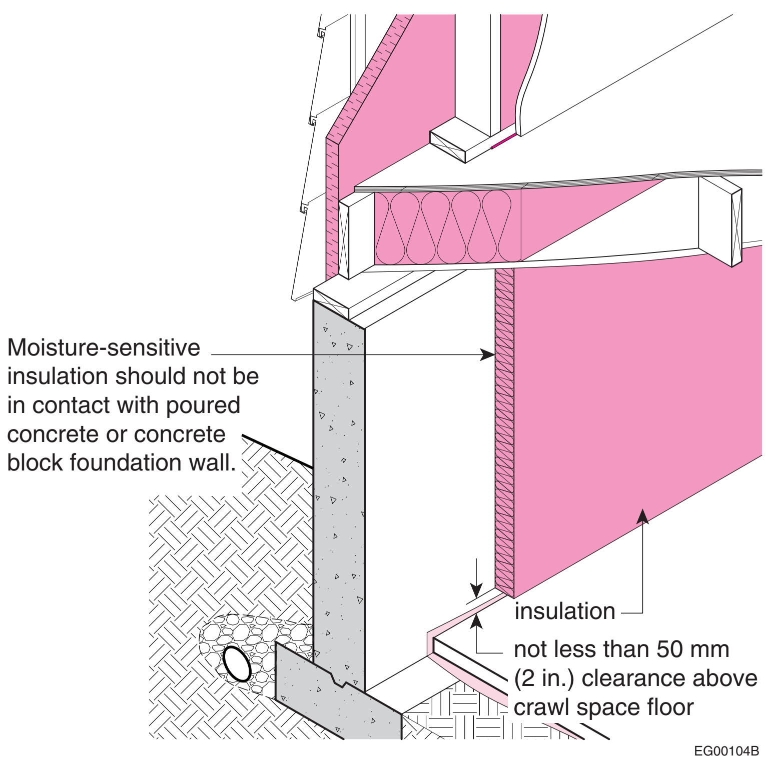


Figure 9.25.-4
Clearances in crawl spaces

Insulation materials that can be damaged by water and that are installed on the interior of foundation walls enclosing crawl spaces must be not less than 50 mm (2 in.) above the crawl space floor, as illustrated in Figure 9.25.-4.

Insulation around concrete slabs-on-ground must be located so that heat from the building is not restricted from reaching the ground beneath the perimeter of the footings, unless the footings extend below frost level, as illustrated in Figure 9.25.-5. Insulation placed underneath the slab can also fulfill the function of an air/soil gas barrier as long as any joints between panels are sealed.

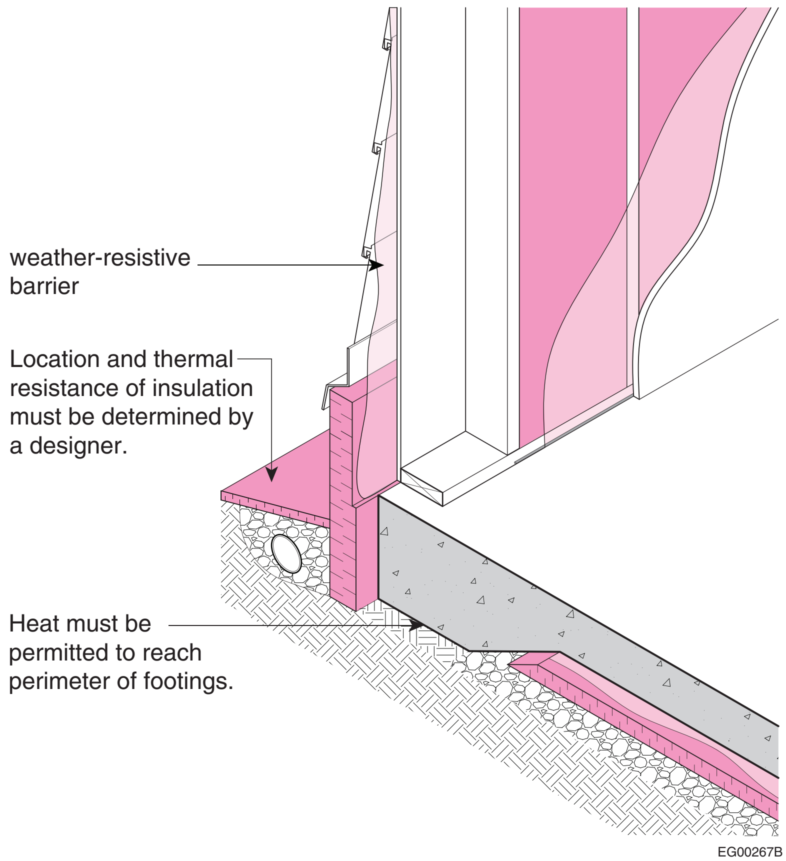


Figure 9.25.-5
Insulating slabs-on-ground

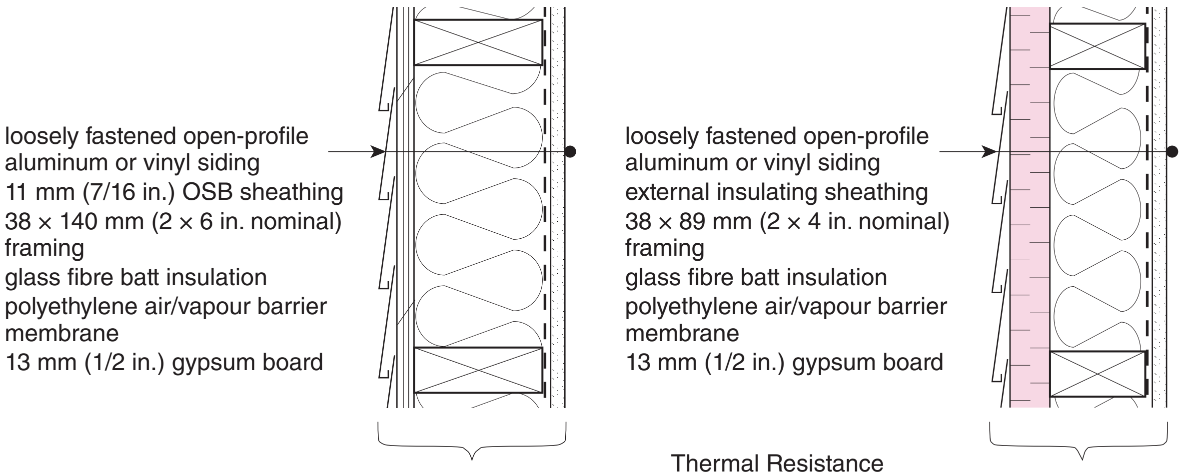
Where insulation is exposed to the weather and is subject to mechanical damage, it must be protected with not less than 6 mm (1/4 in.) cement board, 6 mm (1/4 in.) preservative-treated plywood, or 12 mm (1/2 in.) cement parging on wire lath applied to the exposed face and edge of the insulation. Insulation subject to mechanical damage must be protected by a covering such as gypsum board, plywood, particleboard, oriented strandboard (OSB), waferboard or hardboard. The top edge is normally protected by metal flashing if it is not already protected by the cladding.

Insulation in unfinished areas that may be occupied only periodically can be damaged unless it is protected by one of the interior finishes described in NBC Section 9.29. Insulation that is high enough above the floor to make damage unlikely does not have to be protected.

Insulation in factory-built buildings must be installed so that it will not become dislodged during transportation. When additional insulation is installed to upgrade the energy-efficiency of existing buildings, care is required to ensure that moisture problems are not introduced. Any openings in walls that could permit leakage of interior heated air into the wall cavity should be sealed. The inside surface should be coated with a low-permeability paint to reduce moisture transfer by diffusion. Finally, the exterior siding, flashing and caulking should be checked and repaired if necessary to prevent rain penetration.

Thermal Bridging

The installation of exterior insulating sheathing reduces thermal bridging—heat flow across solid framing members—because these more thermally conductive elements (studs) are covered by a less thermally conductive material (insulation), as shown in Figure 9.25.-6. This will make the interior surface temperature more uniform across the wall.



Thermal Resistance

RSI 3.52 (R20)	Nominal	RSI 3.43 (R19.4)
RSI 4.70 (R26.6)	Total nominal	RSI 4.48 (R25.4)
RSI 3.11 (R17.6)	Total effective(1)	RSI 3.40 (R19.2)

EG00546D

Figure 9.25.-6
Minimizing thermal bridging

Note to Figure 9.25.-6:
(1) Effective insulation values take into account the thermal transmittance of all materials used in the wall assembly, including the wood framing.

Where insulation is installed on the inside face of foundation walls, the portion below ground level must be protected to resist the entry of ground moisture and, in the case of cast-in-place concrete, construction moisture, unless the insulation itself acts as moisture protection. Similarly, high permeance insulation must also be protected from interior sources of moisture by a vapour barrier. As with other insulated assemblies, the basement wall must incorporate an air barrier system. All insulation installed on the interior of foundation walls must be installed in continuous contact with a low air permeance material to reduce air circulation in the assembly (Figure 9.25.-7).

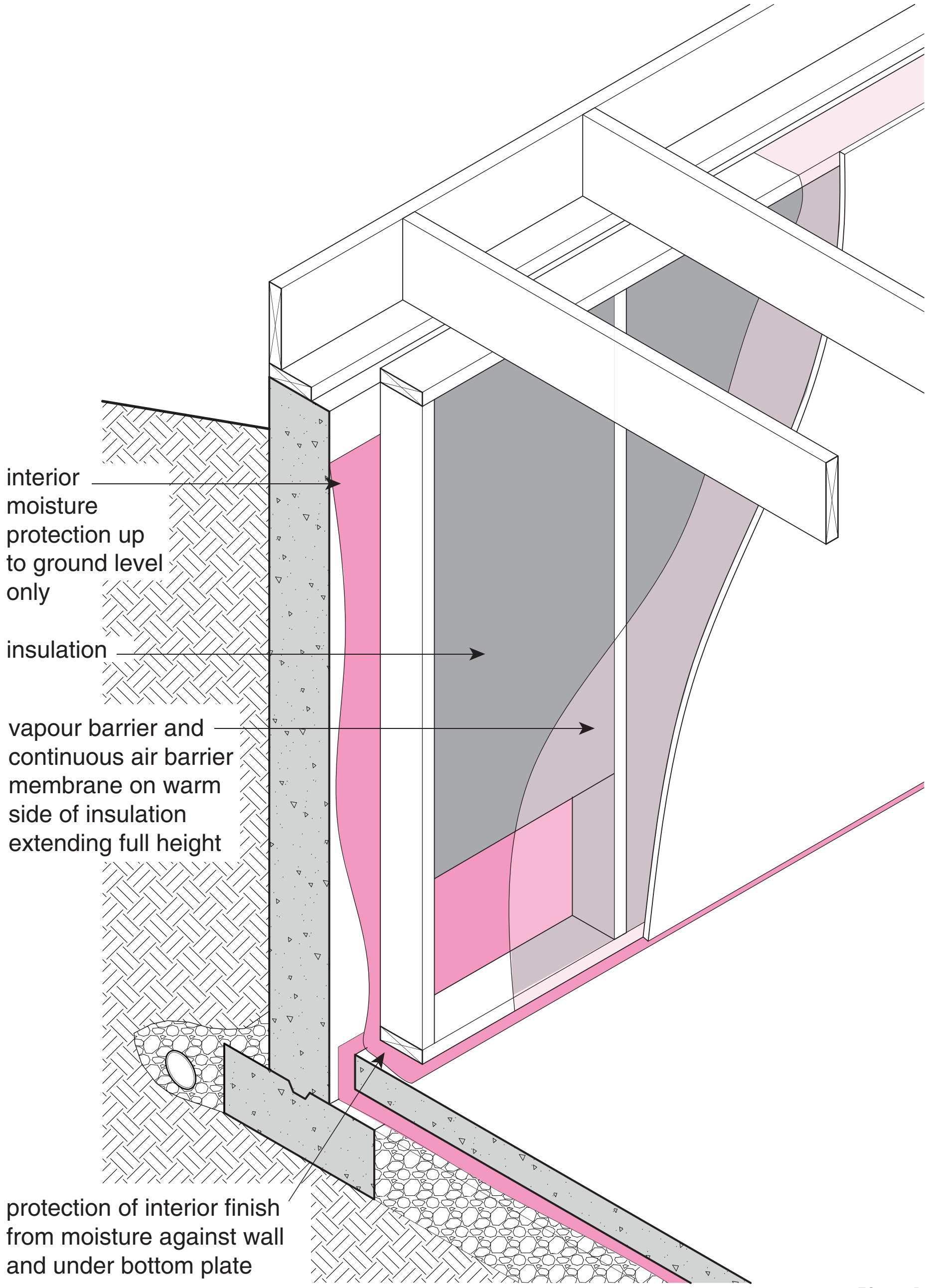


Figure 9.25.-7
Moisture protection for basement insulation

9.25.2.4. Installation of Loose-Fill Insulation

This Article lists the installation requirements for loose-fill insulation, so that it fulfills its intended function.

Ceilings and Attics

Loose-fill insulation is most commonly used on horizontal surfaces such as those found in attics. Such insulation can be used in sloping ceilings and in walls, subject to the limitations of the NBC. When loose-fill insulation is applied in attics where soffit venting is used, measures must be taken to prevent the insulation from blocking the soffit vents and to minimize the flow of cold air into the insulation near the soffit vents (see Figure 9.25.-8 and Guide 9.19., Roof Spaces).

Limited accessibility in attics sometimes makes it difficult to control the placement of loose-fill insulation. As a result, it may block the space between the roof sheathing and the wall plate and, by doing so, restrict ventilation. It may also spill over the top of the plate and block the soffit vents. Measures must be taken to prevent the insulation from blocking off soffit venting, and to prevent wind from entering the vents and either penetrating or displacing the insulation (see Guide 9.19., Roof Spaces).

Where loose-fill insulation is installed in an unconfined sloped space, such as an attic space over a sloped ceiling, the maximum slope permitted is 4.5:12 for mineral fibre or cellulose fibre insulation, and 2.5:12 for other types of insulation.

Walls

Loose-fill insulation can be installed in the wood-frame walls of new buildings above or below ground provided that:

- the density of the installed insulation is sufficient to preclude settlement,
- the material is installed behind a membrane that permits visual inspection,
- the material is installed in a manner that does not interfere with the installation of the interior finish, and
- no water is added to the insulation, unless it can be shown that the added water will not adversely affect the other materials in the assembly.

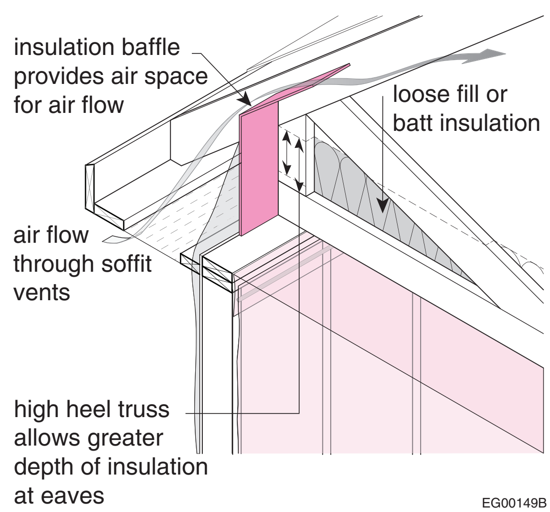


Figure 9.25.-8
Preventing blockage of soffit venting

Masonry Walls

Loose-fill insulation can be used between the outer and inner wythes of masonry cavity walls. However, the cavity wall construction prescribed by NBC Part 9 does not prevent the entry of precipitation into the cavity. For this reason, loose-fill insulation used in cavity walls must be water-repellent. A test for determining the water-repellency of loose-fill insulation suitable for installation in masonry cavity walls can be found in ASTM C 516, "Vermiculite Loose Fill Thermal Insulation."

9.25.2.5. Installation of Spray-Applied Polyurethane

This Article, through reference to a standard, indicates the installation requirements for spray-applied polyurethane, so that it will be able to fulfill its intended function without causing health risks for the occupants or the development of building-related problems.

Spray-applied polyurethane insulation must be installed in accordance with CAN/ULC-S705.2, "Thermal Insulation – Spray Applied Rigid Polyurethane Foam, Medium Density – Application." Spray-applied insulation is a two-part product mixed on-site during the installation process. The referenced standard also covers installation practices. Because spray-applied foam insulation is a site-mixed product, its installation has a direct impact on the performance of the finished insulation.

9.25.3. Air Barrier Systems

9.25.3.1. Required Barrier to Air Leakage

This Article indicates the requirements for an air barrier system to minimize air leakage into building assemblies and to reduce the ingress of soil gas. While room moisture that diffuses into wall, roof and floor assemblies can be effectively resisted by vapour barrier materials, moisture carried by air leakage, is harder to control and accounts for most condensation problems in building assemblies.

Air barrier systems installed in building envelope assemblies and in other environmental separators, such as walls between garages and dwelling units, are intended to reduce the leakage of moisture-laden air into exterior assemblies where it may condense and lead to structural deterioration and the growth of fungi. Air barrier systems also reduce the ingress of soil gas, reduce drafts of cold air, and help to maintain the effectiveness of air permeable insulation materials. Figure 9.25.-9 illustrates the locations that must be carefully considered when designing and installing the air barrier system.

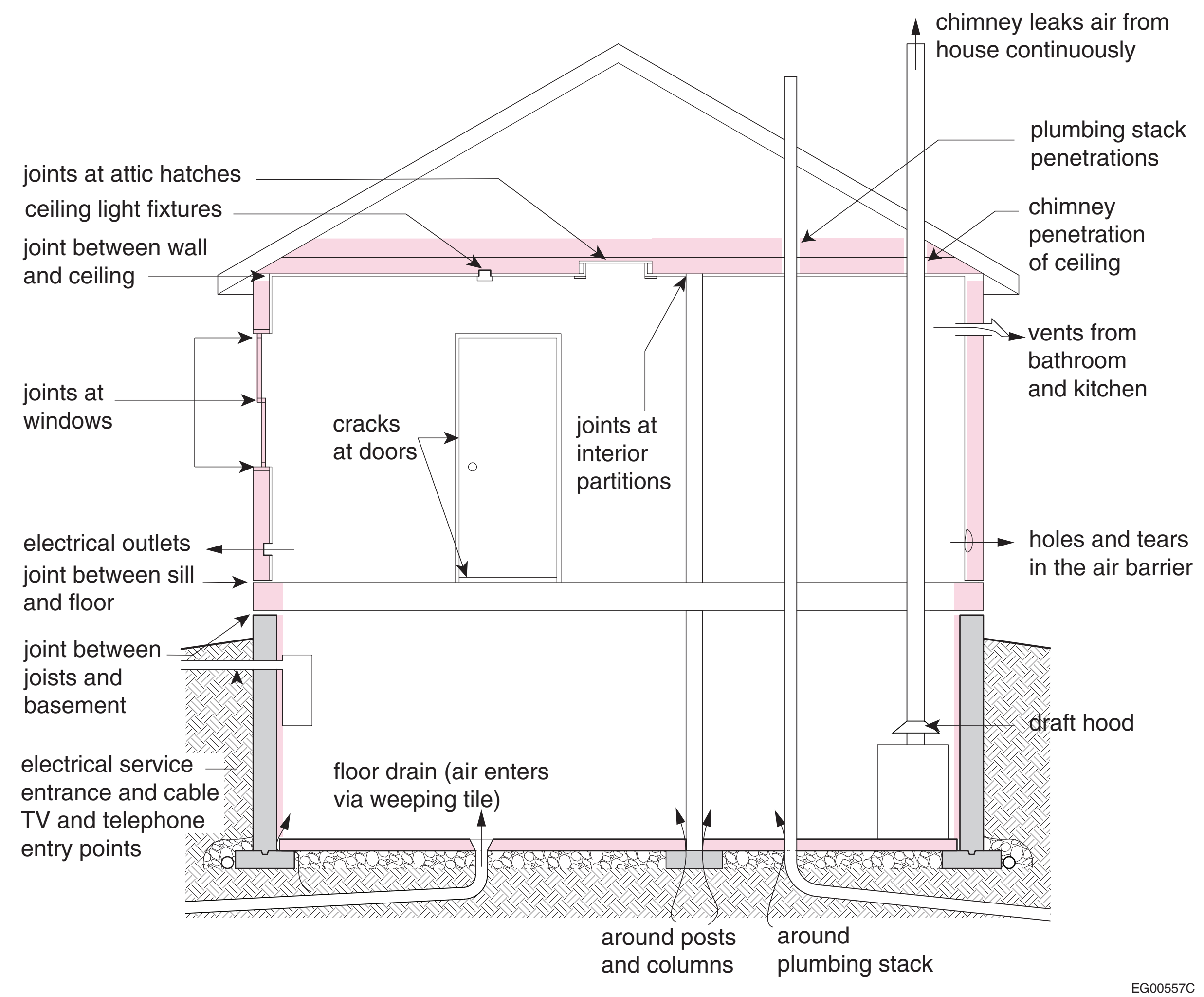


Figure 9.25.-9
Potential air leakage locations

Air Barrier Systems

Air leakage must at the least be controlled to a level where the occurrence of condensation is sufficiently rare or the quantities accumulated sufficiently small, and where drying is sufficiently rapid to avoid material deterioration and the growth of mould and fungi.

Although NBC Section 9.25. refers separately to vapour barriers and airtight elements in the air barrier system, both roles can be performed by the same product. The most common air barrier systems are sealed sheet polyethylene, sealed sheathing membrane, sealed gypsum board, and concrete. For conventional wood-frame construction, sheet polyethylene is often used as an air barrier, which also performs the role of the vapour barrier. Although concrete is considered an air barrier, sheet polyethylene is required below floor slabs to protect against soil gas ingress should cracks develop in the concrete floor slab.

While a vapour barrier should be continuous (without having to be sealed), an air barrier must be continuous, sealed, and structurally supported. This means that openings and penetrations in an air barrier system for items such as electrical boxes must be sealed to prevent air leakage. In cases where the same product performs the role of both the air barrier and the vapour barrier, the product must be continuous and be sealed.

While the location of a vapour barrier must be on the warm side of insulation in order to minimize the deposition of moisture, the location of an air barrier in a building assembly is not critical. It can restrict air leakage whether it is located near the outer surface of the assembly, near the inner surface, or at some intermediate location. However, if a material chosen to act as an airtight element in the air barrier system also has the characteristics of a vapour barrier (i.e., low permeability to water vapour), or is intended to perform the role of both the air barrier and the vapour barrier, its location must be chosen very carefully according to NBC Subsection 9.25.5. to minimize moisture problems.

Controlling Air Flow

Air flows into and out of a building whenever there is a hole and an air pressure difference across the hole. Air pressure difference can be induced by stack effect, wind, and mechanical systems. Stack effect is the result of warmer air being more buoyant than cooler air. As outside air is drawn into the house, it is warmed and rises, creating a positive pressure at the upper areas of the building envelope, and a negative pressure at the base.

Wind pressures will exert a positive pressure on the windward side of the building, driving air into the house, and a negative pressure on the downwind side of the house, drawing air out of the building.

Mechanically induced pressures are the result of the operation of exhaust fans, appliances, and heating equipment, all of which force air out of the building. The operation of this equipment induces a negative pressure on the inside of the building, drawing air into the house through holes in the envelope.

The combined effect of these pressures will draw air in through some elements of the building and force air out in other locations. Drafts caused by such leakage can result in occupant discomfort. The movement of warm, moisture-laden air through the envelope is a primary cause of condensation in concealed spaces and consequent building deterioration.

An effective air barrier system represents the primary line of defence against air leakage. Figure 9.25.-10 illustrates air pressure differentials and air flow.

9.25.3.2. Air Barrier System Properties

This Article outlines the properties an air barrier system must have to fulfill its function of limiting the movement of moisture via air leakage and limiting the infiltration of cold air.

There are a number of different ways air barrier systems can be constructed, and there are many products that can be used as effective air barrier materials. Materials that have been tested and are considered to have sufficiently low air permeance are listed in NBC Table A-9.25.5.1.(1).

Where a polyethylene sheet is used to provide airtightness in the air barrier system, it must conform to CAN/CGSB-51.34-M, “Vapour Barrier, Polyethylene Sheet for Use in Building Construction.” Materials that comply will have a reference to this standard printed on the polyethylene sheet.

Materials used to provide air leakage protection must together be capable of minimizing air transfer (low air permeance and continuity) under differential air pressure due to stack effect, the operation of mechanical systems, or wind (structural integrity). Due to the reversals of air pressure across building envelopes, it is important to select materials and design air barriers systems with adequate resistance to long-term fatigue. This means that flexible air barrier materials need structural support to withstand these loads effectively.

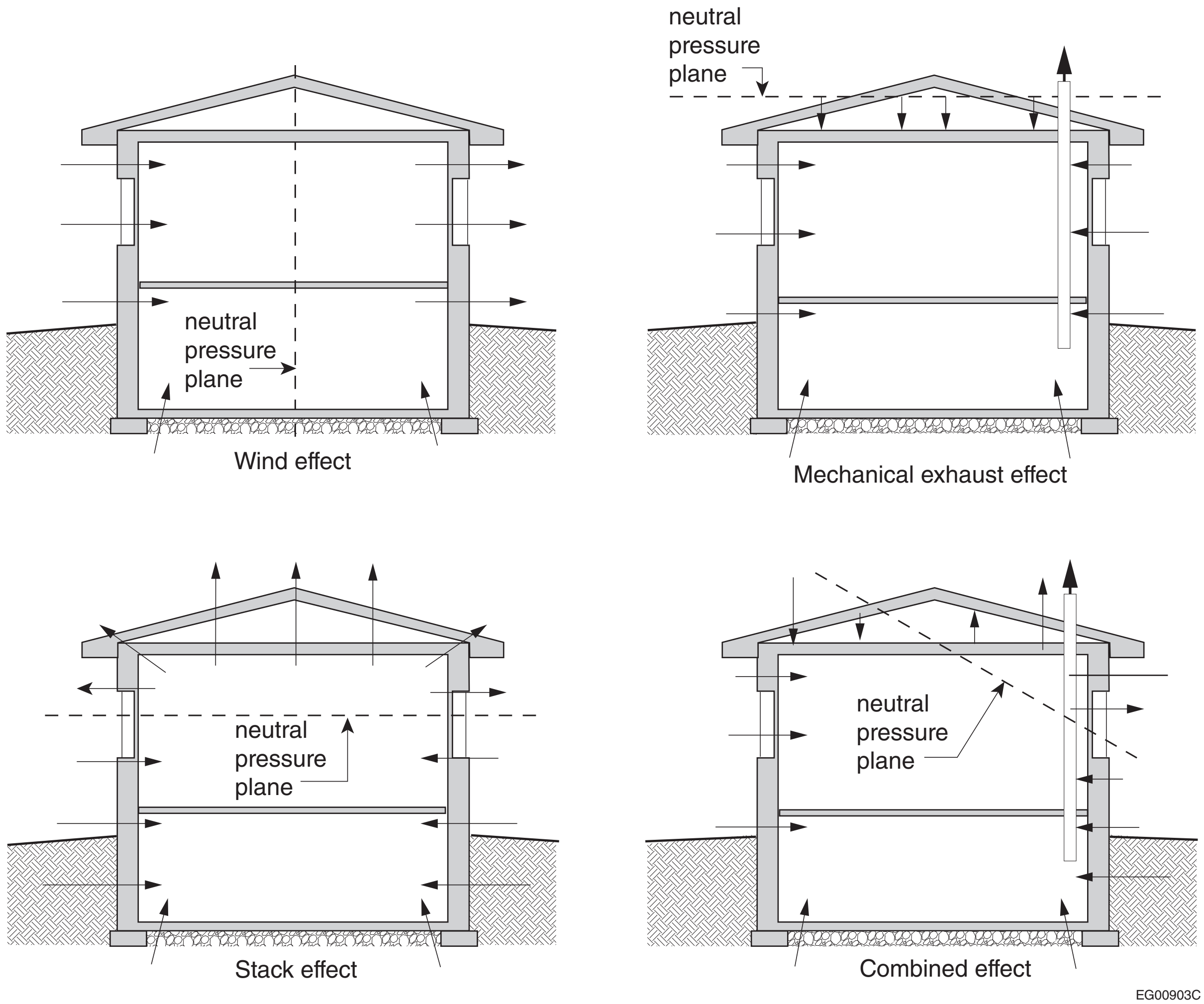


Figure 9.25.-10
Air pressure differentials and air flow

9.25.3.3. Continuity of the Air Barrier System

This Article lists the requirements that pertain to the continuity of the air barrier system. Any air leakage through or around an air barrier system reduces its effectiveness and raises the possibility of moisture-related or thermal problems.

Typically, an air barrier system consists of a number of different materials and components in a building. It is, therefore, of the utmost importance that the joints of adjacent materials are effectively sealed. For example, the polyethylene required under floor slabs could be wrapped around the slab edge and then sealed to the airtight drywall, or taped to a rigid foam board insulation before it is sealed or taped to another sheet of polyethylene at the intersection between the foundation wall and the first floor.

Joints in the air barrier system must be sealed. Where the air barrier system consists of flexible sheet material, all joints must be sealed or lapped at least 100 mm (4 in.) and mechanically clamped, such as between framing members, furring or blocking and rigid panels.

It is also important that the air barrier system continues where interior walls intersect with the exterior floor, wall or ceiling assemblies. Figures 9.25.-11 and 9.25.-12 provide a few examples of the installation details for the intersections and penetration of the air barrier membrane.

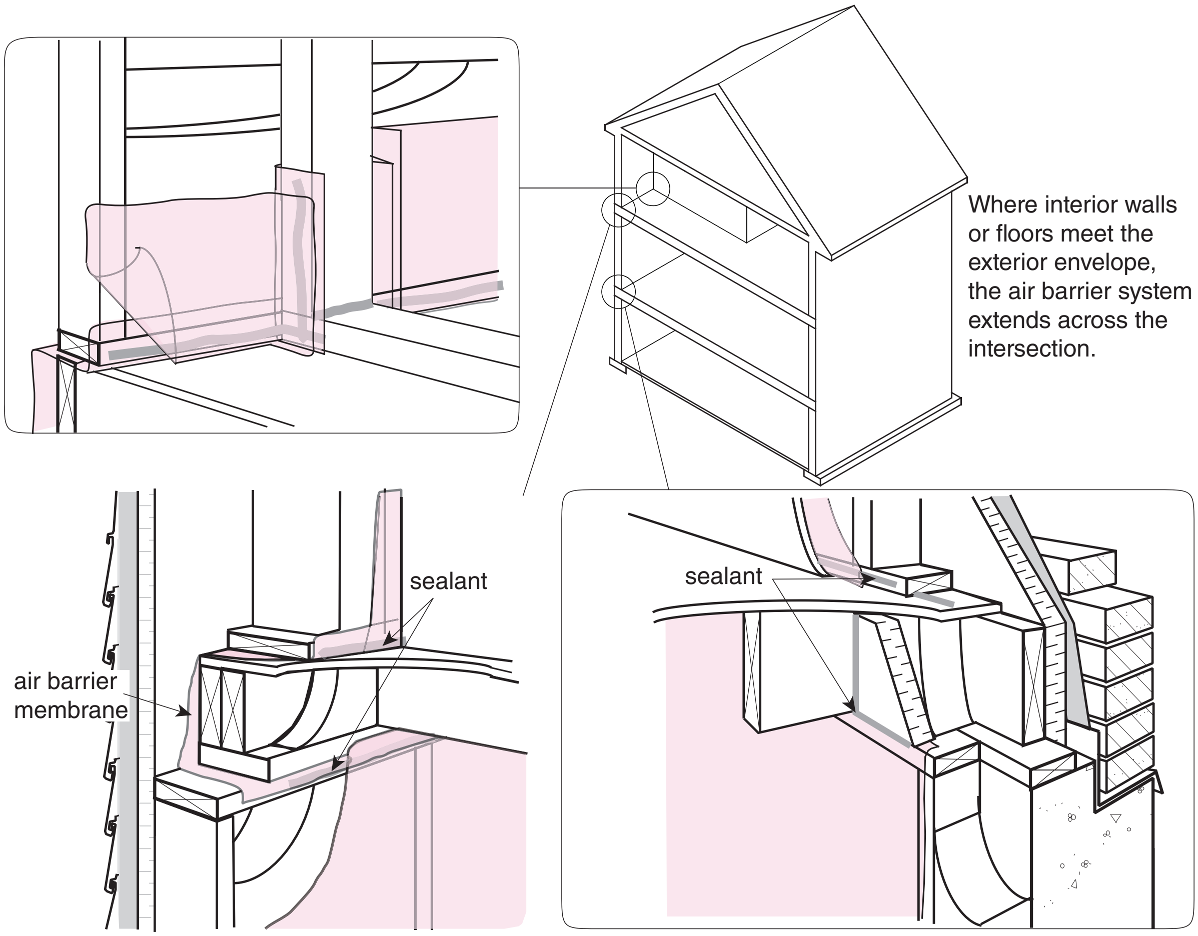
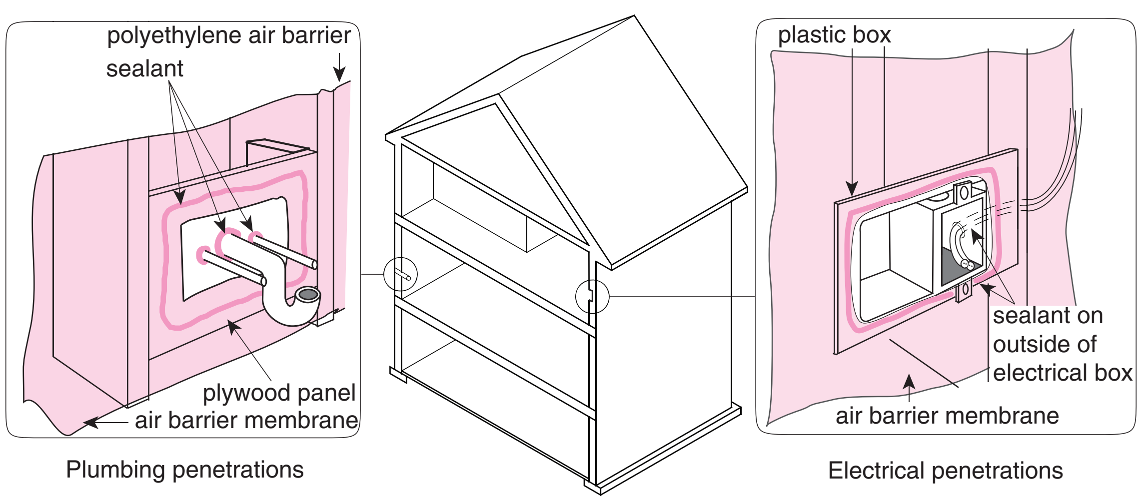


Figure 9.25.-11
Examples of air barrier system detailing at intersections



Penetrations of the air barrier system, such as those created by the installation of doors, windows, electrical wiring, electrical boxes, piping or ductwork, must be sealed to maintain the integrity of the system over the entire surface.

EG00286C

Figure 9.25.-12
Examples of air barrier system detailing at penetrations

For air barriers to be effective, all penetrations through the walls, floors and ceilings must be sealed. Examples of penetrations include below-grade electrical, water and sewer services, floor drains, sump-pump covers, attic hatches, and hollow metal and masonry columns. To protect buildings from the ingress of soil gases, the floor-on-ground must be sealed around columns (Figure 9.25.-13) and at its perimeter to the inner surface of walls using a flexible sealant.

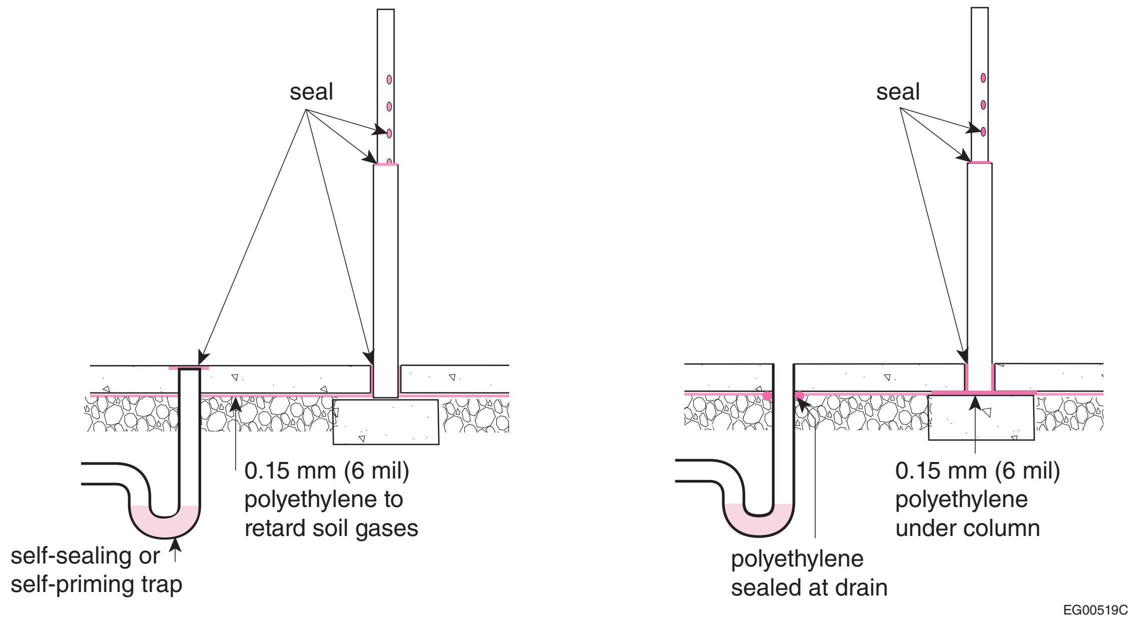


Figure 9.25.-13
Sealing floor penetrations in slabs-on-ground

Clearances between chimneys and gas vents penetrating assemblies requiring air barrier protection must be sealed with noncombustible material. It is extremely important to verify that only chimneys and gas vents certified for this type of installation are used, to avoid creating a fire hazard.

9.25.3.4. Air Leakage Control in Masonry Walls

This Article describes the measures required to minimize air leakage in hollow masonry construction. Cast-in-place foundation walls with exterior dampproofing provide resistance to air ingress from the ground (Figure 9.25.-14). Hollow masonry construction alone cannot provide adequate resistance to air ingress from the ground. Masonry walls, in addition to being parged and dampproofed, must include a course of solid units at the base of the walls, or be sealed with flashing material extending across the full width of the masonry at or below the level of the adjoining floor slab or ground cover.

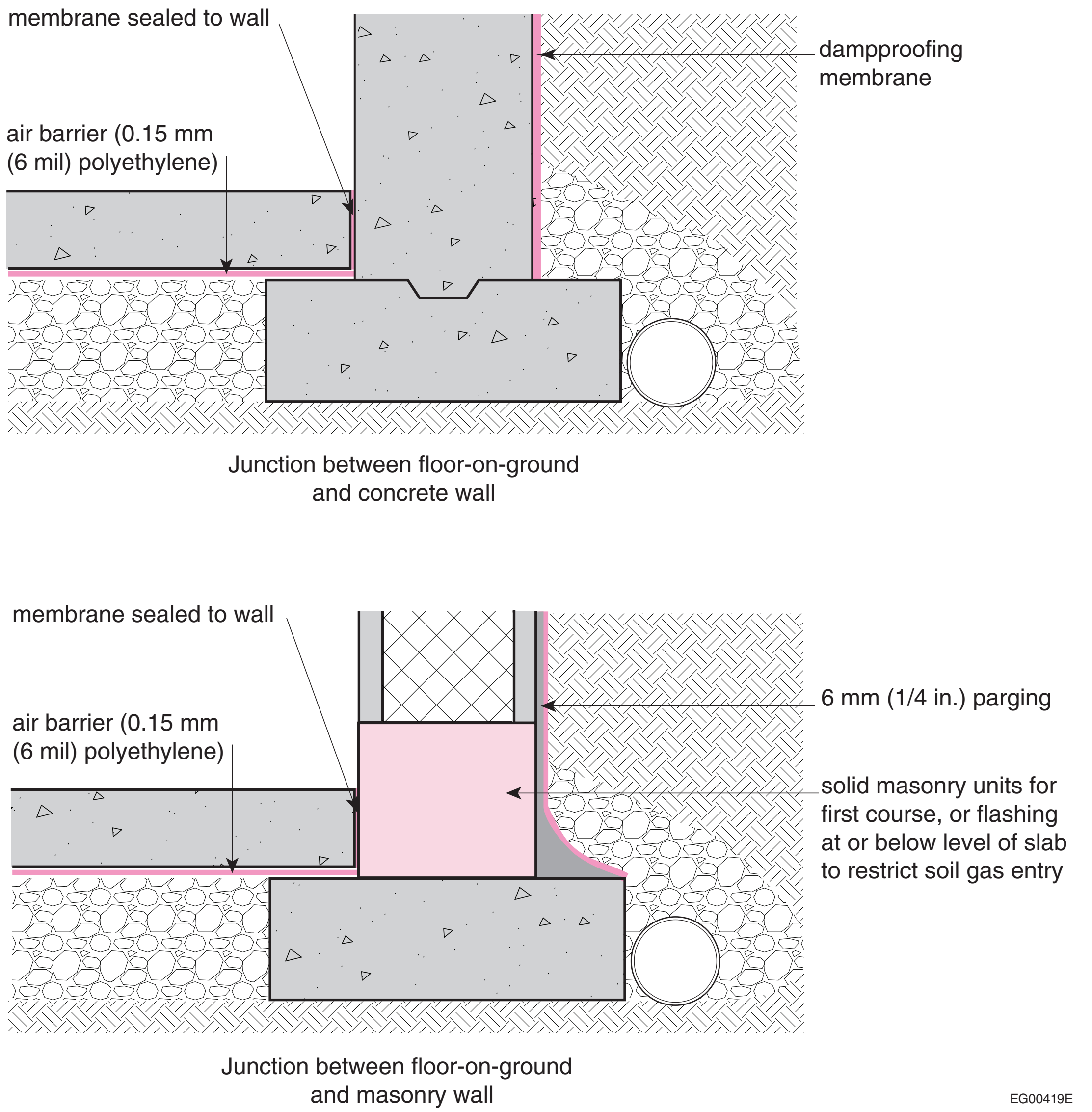


Figure 9.25.-14
Sealing the perimeter of floors-on-ground

9.25.3.5. Air Leakage Control in Underground Roofs

This Article describes the measures to control air leakage in underground roofs. Waterproofing systems for the roofs of underground structures need to be sealed to the air barriers in the walls so that the structure has resistance to air ingress from the ground, which could contain radon and other soil gases.

9.25.3.6. Air Barrier Systems in Floors-on-Ground

This Article describes the measures required to control air leakage in floors-on-ground. Floors-on-ground separating conditioned space from the ground must be constructed with an air barrier to reduce the potential for entry of radon or other soil gases. An effective air barrier system for floors-on-ground must:

- minimize concrete cracks,
- provide a barrier material under the floor, which in most cases, is accomplished by placing 0.15 mm (6 mil) polyethylene under the floor, and
- seal voids, joints and penetrations through walls, floors and underground roofs.

Materials used to provide a barrier to air ingress must conform to CAN/CGSB-51.34-M, “Vapour Barrier, Polyethylene Sheet for Use in Building Construction.”

Air barriers for slabs-on-ground can be installed either below the slab, or above the slab where a separate floor is installed over the slab. Where the sheet polyethylene barrier is installed prior to pouring of the slab, joints in the sheet must be lapped not less than 300 mm (12 in.). Where the barrier is installed over top of the slab, all joints must be sealed. The air barrier under a slab-on-ground could also consist of rigid insulation, which could be sealed or taped at the joints.

Bonding between the floor slabs and footings should be prevented, such as by the use of polyethylene film over the footing before the slab is cast. This allows the slab to pull away from the footing as it shrinks without causing it to crack and create leakage paths for radon and other gases. The required perimeter sealing allows for perimeter shrinkage by the use of non-hardening sealant where the slab meets the wall.

Floor drains must permit the drainage of water, while preventing the upward flow of air. The requirement can be satisfied with any of a number of proprietary devices that prevent air entry through floor drains. Some options are illustrated in Figure 9.25.-15. Some types of floor drains incorporate a trap that is connected to a nearby tap so that the trap is filled every time the tap is used. This is intended to prevent the entry of sewer gas, but would be equally effective against the entry of air.

Finishing Concrete Placed over Polyethylene

Finishing a concrete slab placed directly on sheet polyethylene requires special care because all bleed water must rise to the surface; none can escape to the ground below as in the case of a slab placed directly on ground. Because of this, finishing operations should be delayed until all excess water has evaporated.

The first step for limiting cracking in concrete slabs-on-ground required to be an air barrier to limit air leakage and soil gas ingress is to use a well-proportioned concrete mix that has a correct water to cement ratio. The less the total amount of water in a concrete mix, the less shrinkage and cracking that is likely to occur. The water/cementing materials ratio for slabs-on-ground should be no higher than 0.55. Admixtures can be used should additional workability be required for concrete placing.

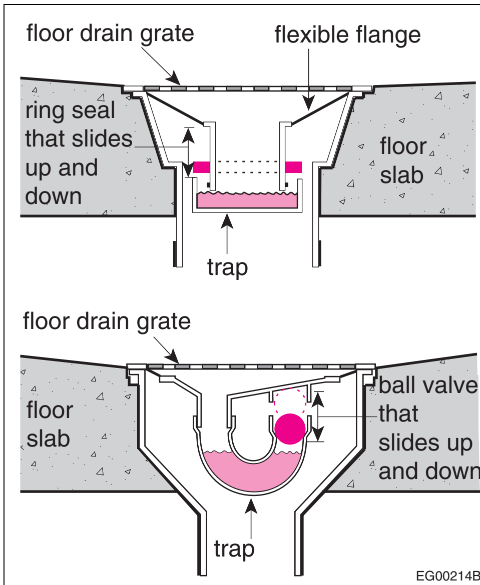


Figure 9.25.-15
Sealing floor drains in slabs-on-ground

9.25.4. Vapour Barriers

Vapour barriers are intended to control the diffusion of water vapour through insulated building assemblies. The amount of moisture penetrating insulated building assemblies by diffusion is significantly less than that by air leakage. Some vapour barrier membranes can function as air barrier membranes. Where separate materials serve the functions of airtight components of the air barrier system and vapour barrier, the vapour barrier should be continuous but, unlike an air barrier, does not need to be sealed.

9.25.4.1. Required Barrier to Vapour Diffusion

This Article requires that a vapour barrier be used to restrict the diffusion of moisture in room air into the building envelope where it could condense during cold weather and lead to a variety of moisture-related problems. The driving force for the diffusion of water vapour is the difference in absolute humidity (water vapour pressure) on each side of the barrier.

However, it is recognized that the majority of condensation problems in building assemblies are caused by air exfiltration, which air barriers are intended to resist. Vapour diffusion, which vapour barriers are intended to resist, is a much weaker mechanism that can easily be controlled by even the limited vapour resistance of many types of paint film.

All thermally insulated wall, ceiling and floor assemblies must be provided with a means to reduce the diffusion of water vapour from the interior into the wall, floor, attic or roof spaces. Any material that has a water vapour permeance no greater than 60 ng/(Pa·s·m^2) (1 perm) can fulfill the function of the vapour barrier.

Vapour barriers are required to be placed on the warm side of insulation, but in a different arrangement. Low permeance sheathing may also serve as the vapour barrier if it can be shown that the temperature of the interior surface of the sheathing will not fall below the dew point temperature at design conditions. This may be the case where exterior insulating sheathing is used with or without minimal insulation in the stud spaces (see Guide 9.25.5.2., Position of Low Permeance Materials).

If low permeance foamed plastic is the only thermal insulation in the building assembly, the temperature of the inner surface of this element will be close to the interior temperature, and no additional vapour barrier is needed. However, if low permeance thermal insulation is installed on the outside of an insulated frame wall, the temperature of the inner surface of the foam insulation might fall below the temperature at which saturation will occur. In this case, a separate element must be installed to provide the necessary diffusion protection.

9.25.4.2. Vapour Barrier Materials

This Article defines the characteristics that are necessary for a material to fulfill the function of a vapour barrier.

Vapour barriers must have a permeance of not more than 60 ng/(Pa·s·m^2) (1 perm) measured in accordance with ASTM E 96/E 96M, “Water Vapor Transmission of Materials,” using the dessicant method (dry cup). This requirement is based on the assumption that the building assembly is subjected to conditions that are considered normal for typical residential occupancies and business and personal services occupancies. However, where the intended use of an occupancy includes facilities or activities that will generate a substantial amount of moisture indoors during the heating season, such as swimming pools, greenhouses, laundromats, or continuously operated hot tubs or saunas, the building envelope assemblies have to demonstrate acceptable performance levels in accordance with the requirements in NBC Part 5.

There are many materials with a water vapour permeance of not more than 60 ng/(Pa·s·m^2) (1 perm), such as paints, rigid foam boards and sheet polyethylene. Where polyethylene sheet is used to perform the role of vapour barrier, it must conform to CAN/CGSB-51.34-M, “Vapour Barrier, Polyethylene Sheet for Use in Building Construction.”

Polyethylene sheet meeting this standard is required to have a degree of oxidation and ultraviolet (UV) resistance, as well as minimum tensile and elongation properties. The standard also calls for a minimum thickness of 0.15 mm (6 mil). Despite the name of the standard, it mostly addresses properties that are important when the polyethylene is used as an air barrier but less so when it is used as a vapour barrier. For example, resistance to tearing is important for air barriers, but less so for a vapour barrier. Vapour diffusion is only affected proportionally to the size of the tear. Only large torn areas would move significant amounts of water vapour, while even a small tear could contribute to a significant volume of air leakage depending on the air pressure difference across the tear.

Where foamed plastic is used as a vapour barrier, it is important that its permeance not exceed 60 ng/(Pa·s·m^2) (1 perm) at the thickness of the provided insulation.

Where a coating is applied to gypsum board to act as a vapour barrier, the permeance of the coating must be determined in accordance with CAN/CGSB-1.501-M, “Method for Permeance of Coated Wallboard.”

9.25.4.3. Installation of Vapour Barriers

This Article describes where and how vapour barriers must be installed to meet the purpose of NBC Article 9.25.4.1. without creating problems caused by condensation within the building envelope.

Vapour barriers must be installed to protect the entire surface of thermally insulated wall, ceiling and floor assemblies. Vapour barriers must be installed sufficiently close to the warm side of insulation to prevent condensation at design conditions. Vapour barriers may be installed between layers of insulation, provided that the surface temperature of the vapour barrier within the insulated assembly can be shown not to support condensation of the indoor air when the outside temperature is equal to the winter design temperature. This location is determined by calculation.

9.25.5. Properties and Position of Materials in the Building Envelope

The accumulation of moisture condensation in the building envelope is reduced by providing and properly locating air- and vapour-resisting materials within the building envelope. Air barrier systems are identified separately from vapour barriers because they control different transfer mechanisms. Air movement is the main driving force that moves moisture into building assemblies. This moisture can cause problems affecting the durability of the structure and indoor air quality.

There are many materials that can fulfill a number of building envelope functions at the same time; for example, some rigid foam board products can be used to fulfill the functions of insulation, air barrier and vapour barrier. However, the properties and location in the building envelope of such materials are critical to their performance.

It is important to note that the requirements of this Subsection apply in addition to those for air and vapour barriers and do not replace them. In the scientific analysis used to develop these requirements, a vapour barrier was assumed to be present on the interior side of the assembly.

9.25.5.1. General

This Article describes the materials to which NBC Article 9.25.5.2. applies. Materials with the combination of properties described in this Article include most plastics, such as polyethylene and vinyl, roofing and waterproofing membranes, some insulating sheathings, and sheet metal.

Limitations to the Application

The requirements in NBC Subsection 9.25.5. were developed for situations where the intended use of the interior space will not result in high moisture generation. This condition can generally be assumed to exist in all residential occupancies and in most business and personal services occupancies. See Guide 9.25.4.2., Vapour Barrier Materials.

Two types of materials are exempted from complying with NBC Sentence 9.25.5.1.(1):

(1) wood-based sheathing materials not more than 12.5 mm (1/2 in.) thick and complying with NBC Article 9.23.17.2.; and
(2) materials having a water vapour permeance of not less than 30 ng/(Pa·s·m^2) (0.5 perm) and a thermal resistance of not less than 0.7 (m^2·K)/W (R4), provided the heating degree-days of the building location are less than 6000.

Wood-based sheathing materials are exempted because of their demonstrated performance in the field (rather than the calculations used to prepare NBC Table 9.25.5.2.). This field performance reflects experience with both older constructions (with vapour barriers and limited thermal insulation), where heat loss facilitates the drying of any moisture that accumulates on the inside of the sheathing, and newer constructions (with vapour barriers that also serve as air barriers, and increased levels of thermal insulation), where heat loss is a less significant factor in drying.

Tests have shown that the water vapour permeance of OSB and plywood sheathing panels increases by 300% to 900% when the mean relative humidity increases from 25% to 75%. This result indicates that the water vapour permeance of wood-based panels in a wall in service can be much higher than that determined using the dry cup method in accordance with ASTM E 96/E 96M, "Water Vapor Transmission of Materials," which explains the ability of traditional wood-frame walls to dry outward as observed in field exposure studies.

Materials of the second type are exempted because research has shown that the condensation potential of assemblies with these materials as exterior insulation is comparable to that of reference assemblies without exterior insulation.

9.25.5.2. Position of Low Permeance Materials

This Article describes the permitted locations for low permeance materials. Low permeance materials must be properly located to control the movement and accumulation of moisture in the building envelope.

With the exception of materials with the characteristics outlined in NBC Sentences 9.25.5.1.(3) and (4), low permeance sheet and panel type materials incorporated into assemblies described in NBC Article 9.25.1.1. must be installed:

(a) on the warm face of the assembly (e.g., paint or polyethylene sheet) (Figure 9.25.-16),
(b) at a location between the warm and cold sides of the assembly where the ratio between the total thermal resistance of all materials outboard of the innermost impermeable surface of the material and the total thermal resistance of all materials inboard of that surface is not less than that required by NBC Table 9.25.5.2. (i.e., at a location within the assembly where the material will not cause the accumulation of condensation) (Figure 9.25.-17), or
(c) outboard of an air space that is vented to the outdoors (e.g., metal or vinyl cladding) (Figure 9.25.-16).

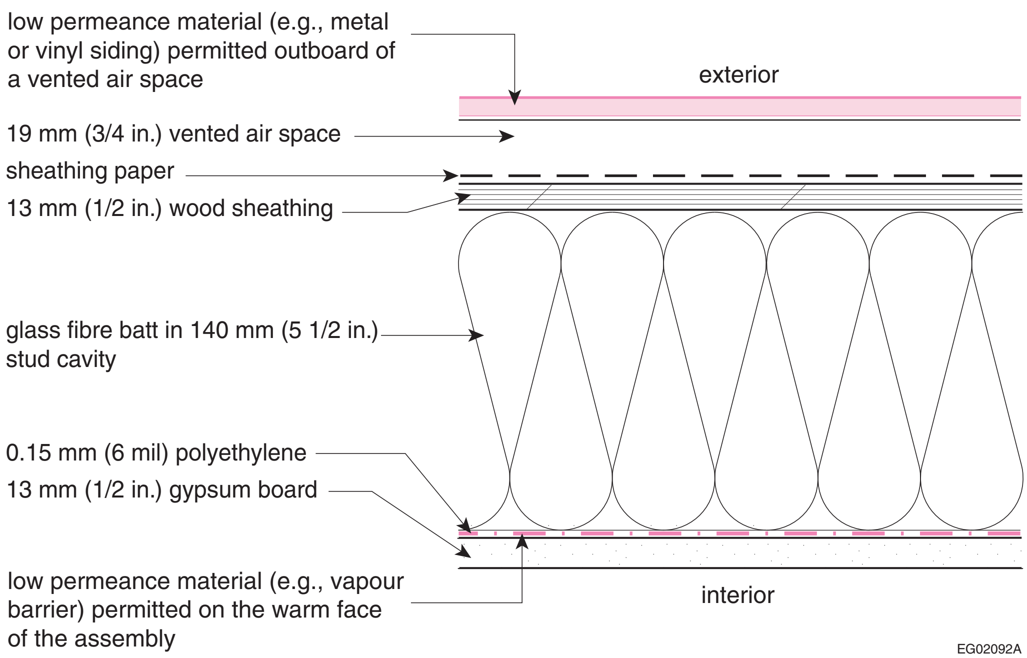


Figure 9.25.-16
Permitted locations of low permeance materials on the warm face of the assembly and outboard of a vented air space

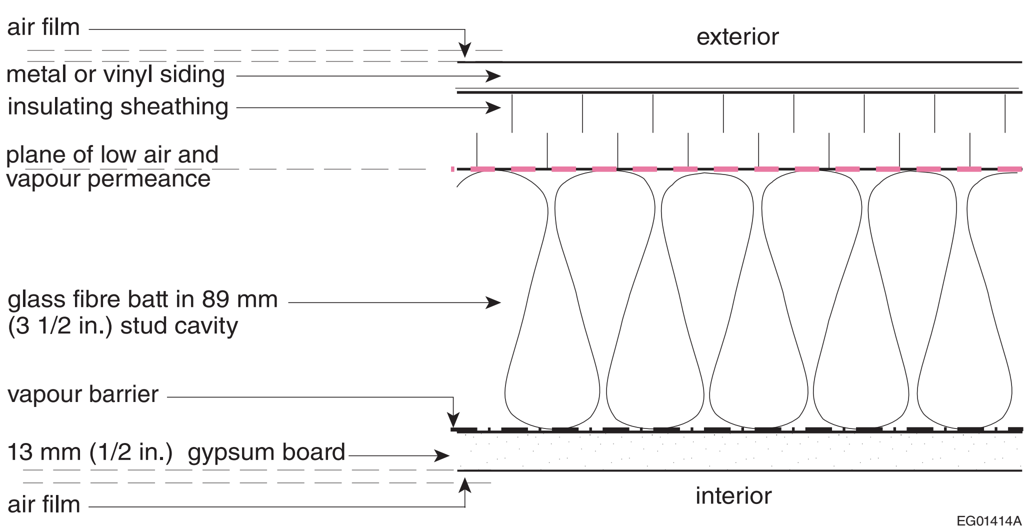


Figure 9.25.-17
Permitted location of a low permeance material between the warm and cold sides of the assembly where the material will not cause the accumulation of condensation

Positioning Low Air and Vapour Permeance Materials to Avoid Moisture Accumulation

The location of a material in a building assembly with low air permeance (air barrier) is generally not critical. The material can restrict the outward movement of indoor air whether it is located near the outer surface of the assembly, near the inner surface, or at some intermediate location. However, if that material also has low permeability to water vapour, its location must be chosen more carefully in order to avoid moisture accumulation.

If the low air and vapour permeance material is located where the temperature is below the dew point of the air at that location, water vapour will condense and accumulate as water or ice. This will reduce the humidity level and encourage the movement of more water vapour into the assembly. If the temperature remains below the dew point for any length of time, significant moisture could accumulate. When warmer weather returns, the presence of a material with low water vapour permeance can slow the drying of the accumulated moisture. Moisture that remains into warmer weather can cause the deterioration of surrounding materials.

Therefore, when a material with low air and vapour permeance is installed within an assembly, its position must be selected so that the ratio of the total outboard thermal resistance to the total inboard thermal resistance meets or exceeds the minimum value in NBC Table 9.25.5.2., which depends on the heating degree-days of the building location. How far toward the exterior of an assembly the material can be located depends on the amount of insulation on either side of the material and on the climate in the building location. In general, the more severe the climate, the more thermal insulation there should be outboard of the low permeance material.

The method of calculating the outboard to inboard thermal resistance (RSI) ratio is illustrated in Figure 9.25.-18. Comparing the RSI ratio for the wall assembly in the figure to those in NBC Table 9.25.5.2. indicates that this assembly would be acceptable in areas with Celsius degree-day values up to 7 999, such as Whitehorse, Fort McMurray, Yorkton, Flin Flon, Geraldton, Val-d'Or and Wabush (note that in areas with Celsius degree-day values of 6 000 or more, the building would require a heat recovery ventilator in accordance with NBC Article 9.36.2.6.). Degree-day values for various locations in Canada are provided in NBC Appendix C.

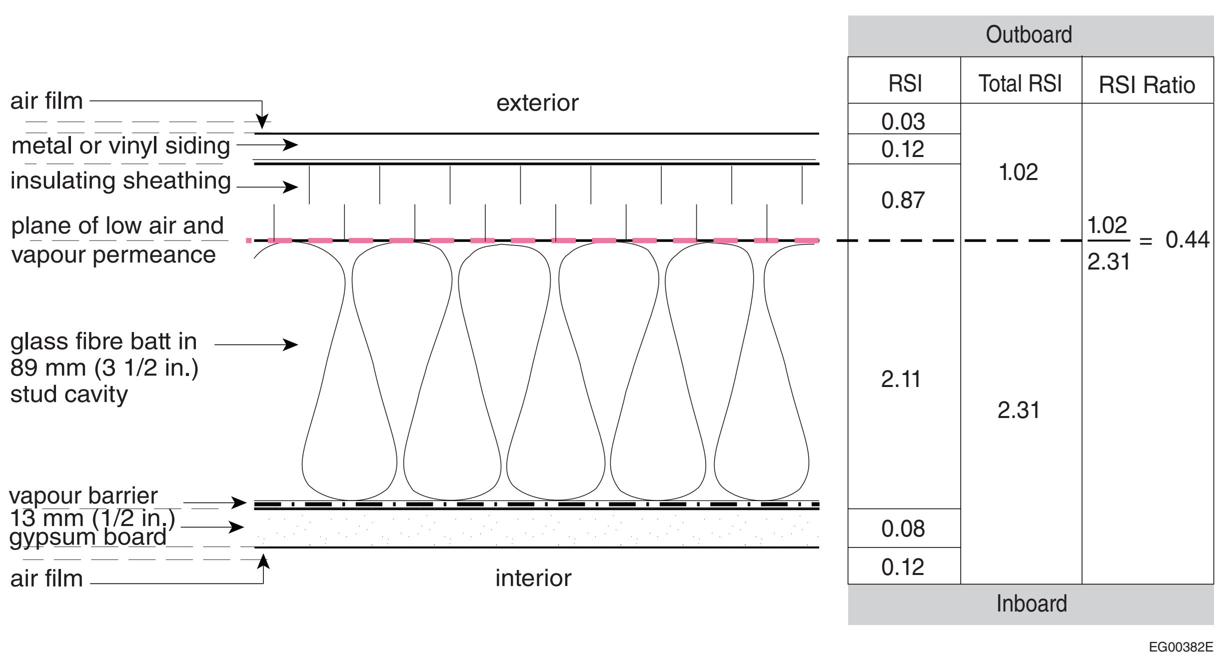


Figure 9.25.-18
Calculation of the outboard to inboard RSI ratio for a wall assembly with a low permeance material located within the assembly

A similar calculation would indicate that, for a similar assembly with a 140 mm (5 1/2 in.) stud cavity filled with an RSI 3.52 batt, the ratio would be 0.28. Thus, such a wall could be used in areas with Celsius degree-day values up to 4 999, such as Cranbrook, Lethbridge, Ottawa, Montréal, Fredericton, Sydney, Charlottetown and St. John's.

Cladding

Different cladding materials have different vapour permeances and different degrees of susceptibility to moisture deterioration. They are each installed in different ways that are more or less conducive to the release of moisture that may accumulate on the inner surface. Sheet or panel-type cladding materials, such as metal sheet, have a vapour permeance less than 60 ng/(Pa·s·m²) (1 perm). Sheet metal cladding that has lock seams also has low air leakage, and must, as a result, be installed outboard of a drained and vented air space. Assemblies clad with standard residential vinyl or metal strip siding do not require additional protection as the joints are not so tight as to prevent the dissipation of moisture.

Combined Vapour Barrier and Thermal Insulation

Low permeance foamed plastic insulation can be used as a combined vapour barrier and thermal insulation, provided it can be shown that the temperature on the interior surface of the insulation will not fall below the dew point. This condition may exist where the foamed plastic insulation is located on the interior side of the assembly or where it is the sole thermal insulation in the assembly. In these cases, the temperature of the interior surface of the foamed plastic insulation will be close to the interior temperature, and no additional vapour barrier is needed to control condensation due to vapour diffusion because the function of the vapour barrier is fulfilled by the insulation (Figure 9.25.-19). However, where low permeance foamed plastic insulation, such as insulating sheathing, is installed on the outside of an insulated frame wall, the temperature of the inner surface of the insulation may fall below the dew point. In this case, a separate vapour barrier must be installed on the warm side of the wall to provide the necessary vapour diffusion protection.

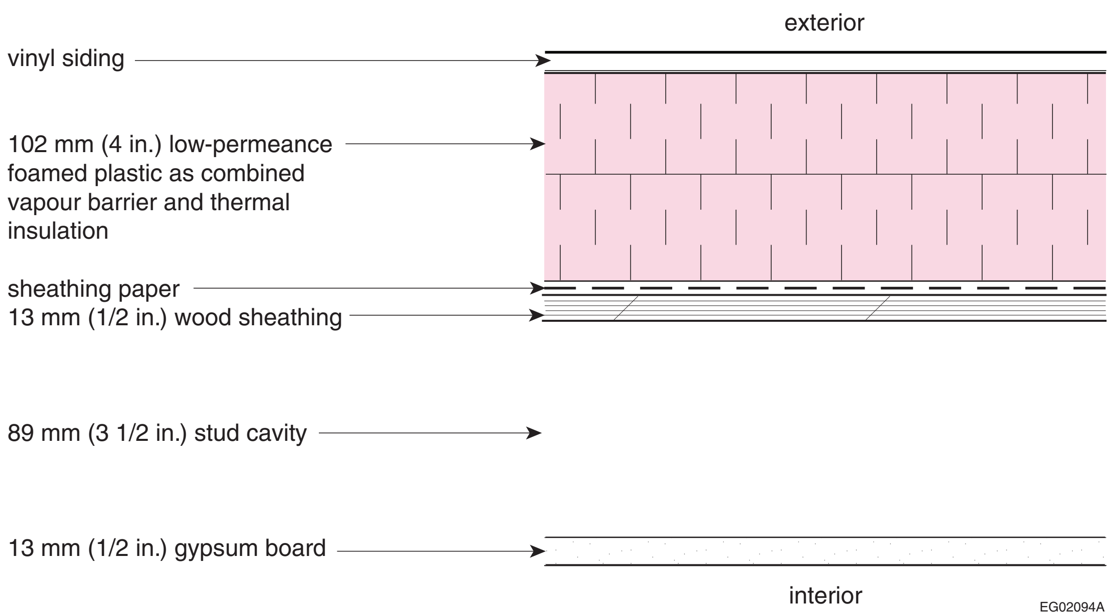


Figure 9.25.-19
Assembly with combined vapour barrier and thermal insulation

Combined Air and Vapour Barriers

In residential construction, the airtight element in the air barrier system is often sheet polyethylene, which also provides the required resistance to vapour diffusion and thereby also serves as the vapour barrier. In this case, the combined air/vapour barrier must be positioned sufficiently close to the warm side of the assembly so that its temperature remains above the dew point temperature at that location.

Section 9.26. Roofing

Introduction

The purpose of roofing is to keep rainwater and snow-melt from entering a roof space or attic. This is accomplished by means of roof coverings and flashings that are appropriate for the slope, exposure, and shape of a given roof.

9.26.1. General

9.26.1.1. Definitions

This Article defines the terms "roof" and "roofing."

A "roof" is defined as a sloped or near-horizontal assembly that protects the space beneath it. Platforms that effectively serve as roofs with respect to the accumulation or drainage of precipitation are also considered as roofs. For example, decks, balconies, exterior walkways and other exterior surfaces that do not allow precipitation to drain freely are considered as roofs. Water ponds on such surfaces, and wind can drive the ponded water up onto adjacent assemblies.

"Roofing" is defined as the primary covering for roofs.

9.26.1.2. Required Protection

This Article requires that roofs be protected with roofing, including flashing, installed so as to effectively shed water, prevent the ingress of water and moisture into building assemblies and occupied space, and minimize the ingress of water due to ice damming into building assemblies. Compliance with this requirement must be demonstrated by conforming to the remainder of NBC Subsection 9.26. or NBC Part 5.

Roofing must prevent rainwater and snow-melt from entering a roof space or attic. Since roofing is exposed to the weather, it must also be able to resist deterioration caused by exposure to the sun, water and air for a reasonable period of time, and to resist anticipated snow loads and uplift forces due to wind action.

9.26.1.3. Alternative Installation Methods

This Article describes, through reference to standards, methods of installing asphalt shingles that differ from those described in NBC Section 9.26.

9.26.2. Roofing Materials

9.26.2.1. Material Standards

This Article defines, through reference to various material standards, the required characteristics of various types of roofing materials.

9.26.2.2. Installation of Materials

This Article requires that the materials listed in NBC Tables 9.26.2.1.-A and 9.26.2.1.-B be installed in conformance with the manufacturer's written instructions.

9.26.2.3. Nails

This Article describes the required characteristics of nails for various applications. Nails and staples must be corrosion-resistant and comply with CSA B111, “Wire Nails, Spikes and Staples,” or ASTM F 1667, “Driven Fasteners: Nails, Spikes, and Staples.” Nails and staples that are used for wood shakes and shingles are required to be made of stainless steel, aluminum, or hot-dipped galvanized steel (nails only). Where shingles or shakes have been chemically treated with a preservative or a fire retardant, the fastener should be made of a material known to be compatible with the chemicals used in the treatment.

Table 9.26.-A outlines the sizing criteria for nails and staples. See also NBC Article 9.26.7.4.

Table 9.26.-A
Minimum Dimensions for Roofing Fasteners

Roofing Material	Minimum Dimension, mm (in.)					
	Nails			Staples[1]		
	Head Diameter	Shank Diameter	Length[2]	Crown Width	Thickness or Diameter	Length
Asphalt shingles	9.5 (3/8)	2.95 (1/8)	12 (1/2)	25 (1)[3]	1.6 (1/16)	19 (3/4)
Wood shingles or shakes[4]	4.8 (3/16)	2.0 (1/8)	12 (1/2)	9.5 (3/8)	1.6 (1/16)	29 (1 3/16)

Notes to Table 9.26.A.:

(1) Staples must be driven with the crown parallel to the eaves.
(2) Minimum penetration into roof sheathing.
(3) Staples with an 11 mm (7/16 in.) crown can be used, provided shingles are fastened with at least 6 staples (NBC Sentence 9.26.7.4.(2)).
(4) Nails used with wood shingles or shakes must be stainless steel, aluminum or hot-dipped galvanized; staples must be stainless steel or aluminum.

9.26.2.4. Staples

This Article defines the characteristics of staples required to meet the purposes of NBC Article 9.26.1.2. Staples can be subject to periodic wetting, and must therefore be able to resist deterioration for a reasonable time. See Table 9.26.-A for a summary of staple requirements, as well as Guide 9.26.7.4., Fasteners.

9.26.3. Slope of Roofed Surfaces

9.26.3.1. Slope

This Article indicates roofing materials suited for the slope so that the roof can effectively shed rainwater. The choice of roofing materials depends to a large extent on the roof slope and aesthetic preferences. Certain roofing materials do not provide a watertight surface and depend on a certain minimum slope to provide adequate water shedding.

Other types of roofing materials are intended to be essentially watertight, and may be used on much lower slopes. Built-up roofing, for example, which relies on several layers of material cemented in place and coated with a thick coating of waterproofing material, is permitted to be used for the lowest roof slopes.

NBC Table 9.26.3.1. lists the minimum and maximum roof slopes permitted for common roof types. Note that asphalt and gravel roofs, and coal tar and gravel roofs may be sloped less than 1:50 provided that roof drains are installed at the lowest point on the roof.

Complete watertightness is difficult to achieve, and there is always a risk of leakage. If water is allowed to pond on the roof surface, the leakage damage can be much more serious than if the roofs have positive drainage. The minimum slope that will reduce the risk of ponding is about 1:50 (NBC Table 9.26.3.1.). This is the minimum roof slope permitted for gravelled built-up roofing. If the roof surface is not protected by gravel, the surface will deteriorate more quickly and will be more prone to leaks. Therefore, built-up roofs without gravel are required to have a greater minimum slope (1:25).

Profiled metal roofing products may be installed at slopes lower than the minimum provided in NBC Table 9.26.3.1. if they are specifically designed for low-slope applications and are installed in accordance with manufacturers’ instructions.

Back-slopes on structures attached to buildings such as solid-surface decks, balconies and exterior walkways can cause water to move back toward adjacent walls. For this reason, the roofs on these types of structures must slope away from the building.

Selvage roofing and low slope asphalt shingles rely on a single band of cement to achieve watertightness. The risk of water leakage is, therefore, somewhat greater than for built-up roofing and an even greater minimum slope is required (1:6).

Although the NBC only makes explicit reference to built-up roofs, there is an increased use of pre-manufactured membranes that are installed in various ways. Some are heated as they are installed and are referred to as "torch-on" membranes. These often have a finish that incorporates a protective coat that does not require gravel.

Some of these products have been tested and are suited for use on slopes lower than those identified in NBC Table 9.26.3.1. The use of such systems not specifically described in the NBC falls under NBC Division A. The CCMC publishes evaluations for many of these systems.

Where the roofing relies solely on mechanical fastening for attachment to the roof deck, there is usually no maximum roof slope limit (although in practice, some types of roofing lend themselves better to steep-roof-slope application than do others).

When built-up roofing is used, the final waterproofing coat is applied as a liquid, which subsequently stiffens to provide an important element of the roof protection. During warmer weather, solar radiation heats the roof surface and makes the surface flood coat more plastic. If the roof surface is too steep, the material may begin to flow. This tendency is significantly greater with coal tar than with asphalt. To reduce this risk, a maximum slope limit of 1:25 is specified for coal tar and gravel built-up roofs. Built-up roofs without gravel, however, are less prone to flow down the surface and a higher slope is therefore permitted. With the steeper roof slopes, asphalt with a higher melting point is recommended.

9.26.4. Flashing at Intersections

9.26.4.1. Required Flashing at Intersections

This Article indicates the flashing that is required at intersections to keep rainwater and snow-melt from reaching the roof deck. Except where the omission of flashing will not adversely affect adjacent supported or supporting constructions, flashing is required at junctions between roofs and at roof/wall junctions, including platforms that effectively serve as roofs.

Drainage of water from decks and other platforms that effectively serve as roofs will be blocked by walls, and blocked or restricted by guards where significant lengths and heights of material are connected to the deck. Without proper flashing at such roof-wall junctions or roof-guard junctions, water will generally leak into the adjoining constructions and can penetrate into supporting constructions below. Exceptions include platforms where waterproof curbs of sufficient height are cast-in or where the deck and wall or guard are unit-formed. In these cases, the monolithic deck-wall or deck-guard junctions will minimize the likelihood of water ingress.

9.26.4.2. Materials

This Article defines, through reference to various material standards, the required characteristics for various types of roof flashing materials. The installation of flashing is intended to provide protection for joints, corners, and material intersections and to ensure the integrity of the roof as a water-shedding surface.

A variety of materials may be used for flashing (Table 9.26.-B) depending on whether or not the flashing will be exposed to the weather. When exposed, galvanized sheet steel is generally used; however, zinc, copper, aluminum and sheet lead flashing are used where greater life expectancy is desired.

Table 9.26.-B
Minimum Thicknesses for Sheet Metal Flashing Materials

Material	Minimum Thickness, mm (in.)
Sheet lead	1.73 (0.068)
Galvanized steel	0.33 (0.013)
Copper	0.33 (0.013)
Zinc	0.35 (0.014)
Aluminum	0.48 (0.019)

9.26.4.3. Valley Flashing

This Article indicates flashing requirements to keep rainwater and snow-melt from reaching the roof deck in the vicinity of a valley between two intersecting roof surfaces.

Where two roof surfaces intersect to form a valley or where a roof surface meets a wall or a chimney, the area of intersection must be flashed in a manner that will shed rainwater so that it will not leak under the roofing material. Valley flashing needs to be installed over continuous sheathing to avoid deformation or failure of the flashing under load.

With open valley flashing, the flashing is not exposed after the roofing has been installed. Short pieces of flashing are inter-weaved with the roofing as the roofing is installed. Closed valley flashing is not as watertight as continuous, open valley flashing. For this reason, closed valley flashing is not permitted with rigid shingles, such as wood shingles or shakes, on slopes of less than 1:1.2.

Flashing in an open valley, where the flashing is exposed, must be either sheet metal (at least 600 mm (24 in.) wide) or two layers of roll roofing. The first layer of roll roofing must be a layer of Type S smooth roll roofing or Type M mineral surfaced roofing (mineral surface down) at least 457 mm (18 in.) wide. The top layer must consist of mineral surfaced Type M in accordance with the sizing and attachment requirements illustrated in Figure 9.26.-1.

9.26.4.4. Intersection of Shingle Roofs and Masonry

This Article indicates flashing requirements to keep rainwater and snow-melt from reaching the roof deck or entering the building envelope at the juncture between a shingle roof and a masonry surface. Since differential vertical movement may occur between the masonry and roof surface, the flashing is counter flashed to accommodate this movement.

The intersection of shingle roofing and masonry, including chimneys and parapets, requires flashing. Figures 9.26.-2, 9.26.-3 and 9.26.-4 show a number of details with minimum dimensional requirements for flashing and counter flashing at the edge, top and bottom of a roof slope.

It is very important that a roof abutting a solid masonry wall is flashed to the inside up under the sheathing membrane to ensure that any moisture within the wall is shed out onto the top surface of the roof (Figure 9.26.-5).

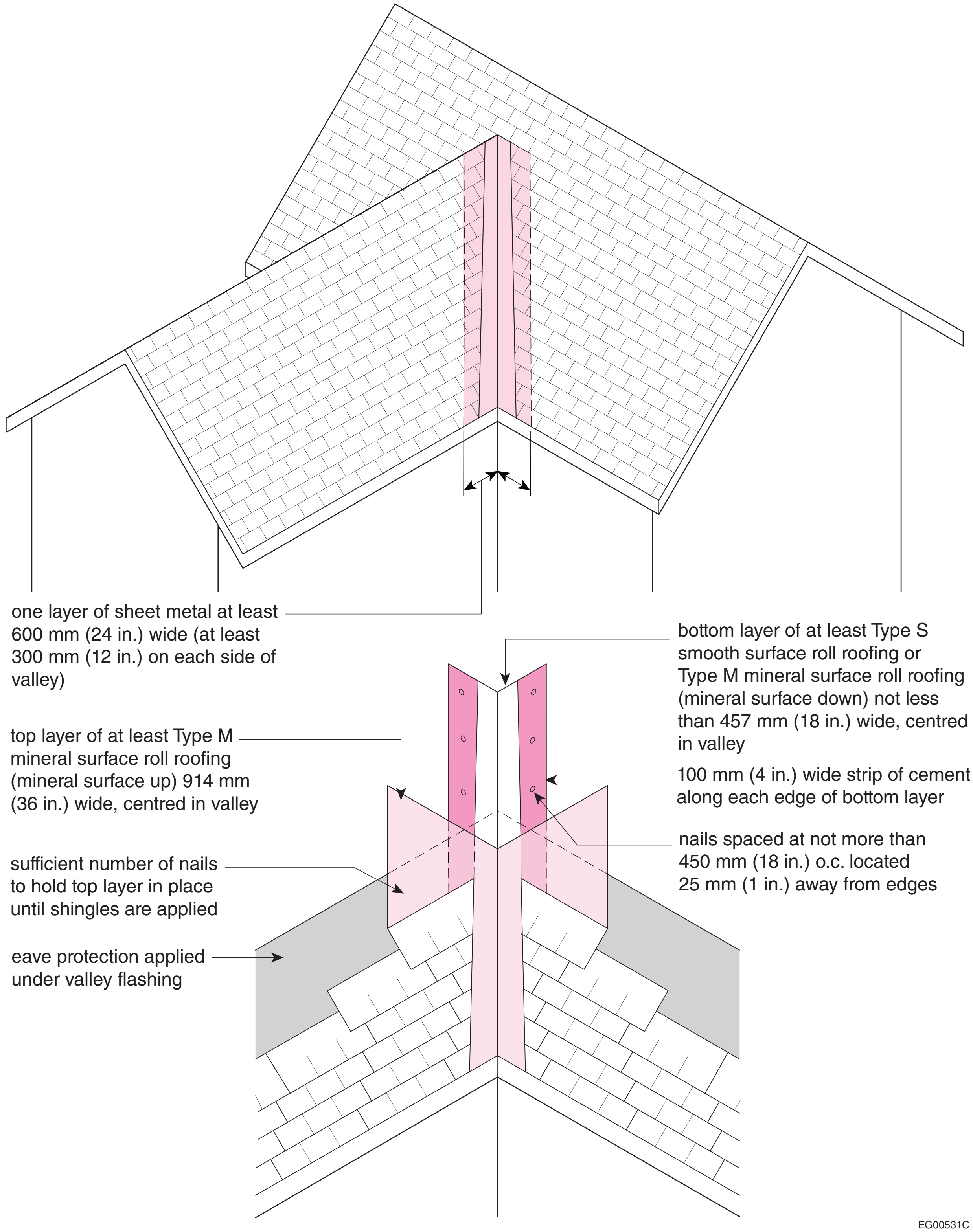


Figure 9.26.-1
Open valley flashing

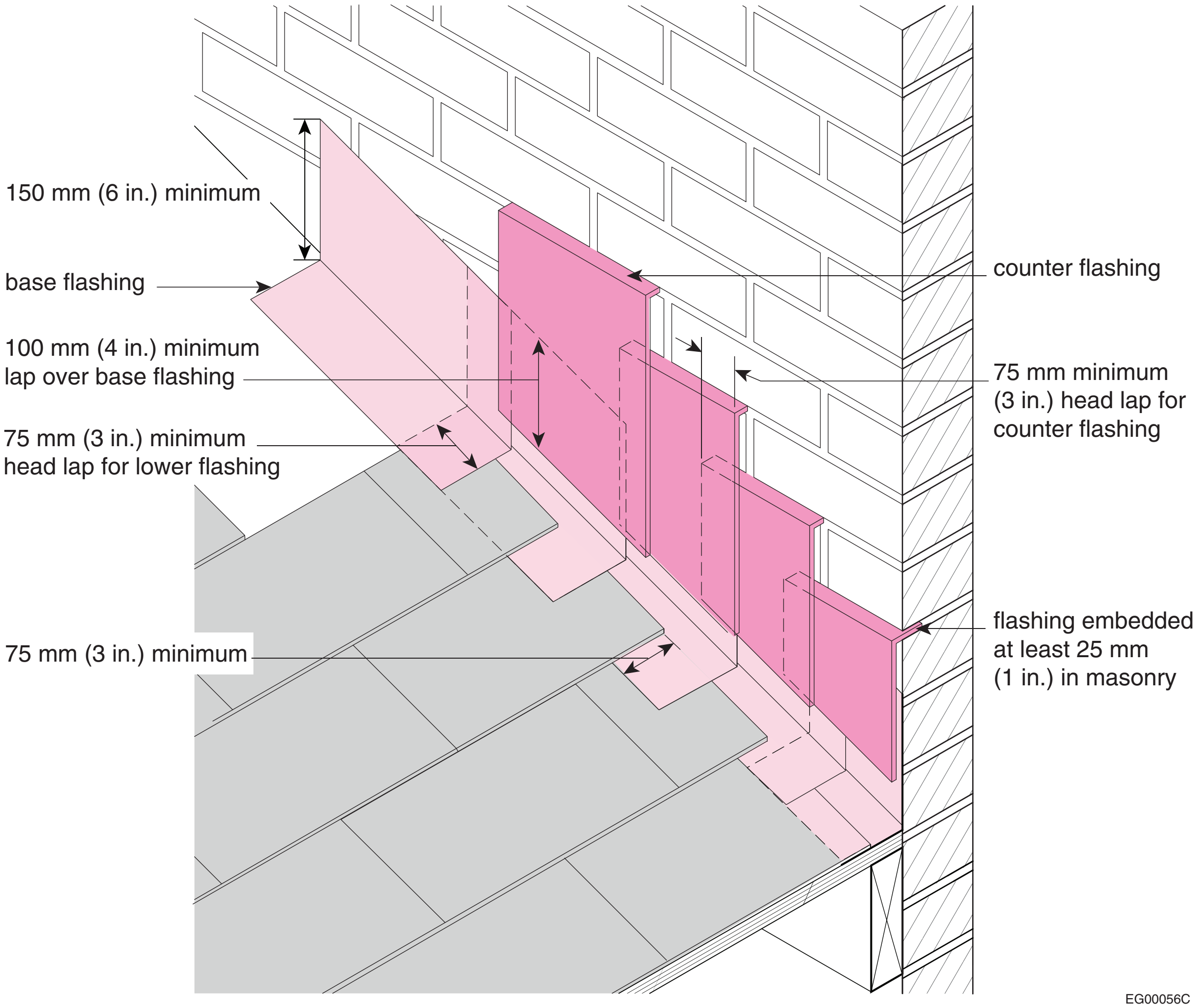


Figure 9.26.-2
Flashing to masonry at the edge of a roof slope

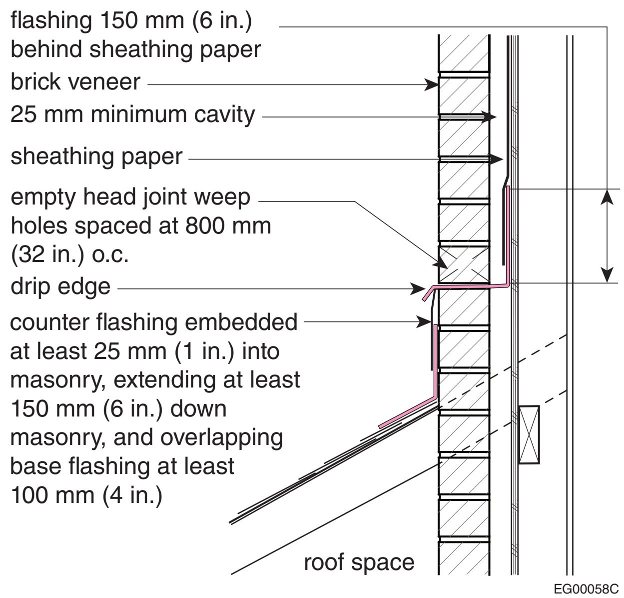


Figure 9.26.-3
Flashing to masonry at the top of a roof slope

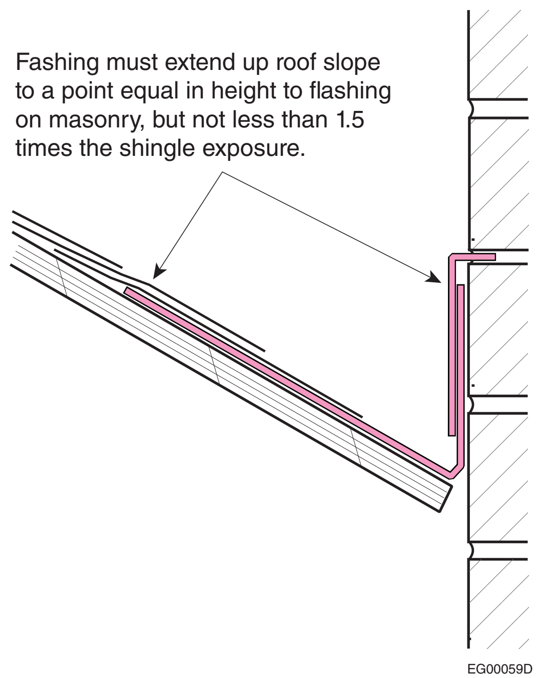


Figure 9.26.-4
Flashing to masonry at the bottom of a roof slope

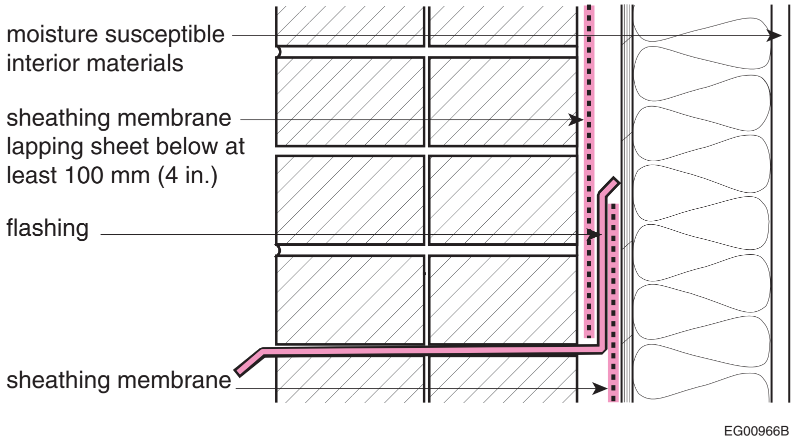


Figure 9.26.-5
Flashing through solid masonry wall

9.26.4.5. Intersection of Shingle Roofs and Walls other than Masonry

This Article indicates flashing requirements to keep rainwater and snow-melt from reaching the roof deck or entering the building envelope at the juncture between a shingled roof surface and a wood-frame wall with other than a masonry veneer exterior.

Where shingle roofs intersect with siding or stucco finish, the flashing must be installed up behind the sheathing membrane. Figure 9.26.-6 shows the required lapping of the flashing.

9.26.4.6. Intersection of Built-up Roofs and Masonry

This Article requires roofing membrane and counter flashing to keep rainwater and snow-melt from reaching the roof deck or entering the building envelope at the juncture between a built-up roof and a masonry surface. Since differential vertical movement may occur between the masonry and the built-up roof surface, counter flashing is used to accommodate such movement. The cant strip beneath the flashing at the juncture allows a gradual transition between the horizontal and vertical surfaces to facilitate mopping of the asphalt plies at the transition in order to obtain a watertight flashing.

The intersection of built-up roofs with masonry walls and chimneys must have a cant strip. The roofing material is then mopped over the strip and up the wall at least 150 mm (6 in.). Counter flashing must be embedded into the wall as shown in Figure 9.26.-7.

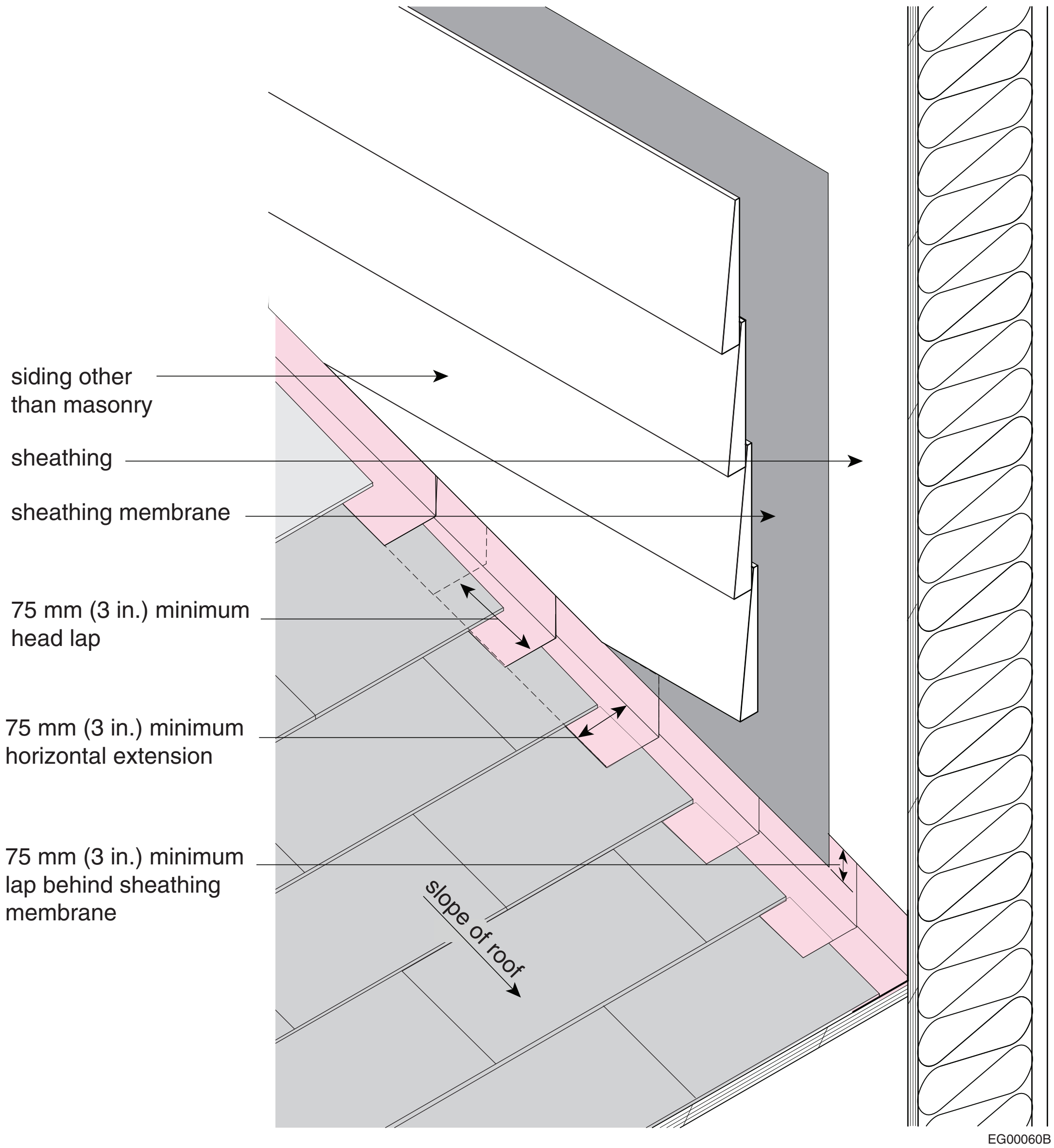


Figure 9.26.-6
Flashing a roof to a wall with siding

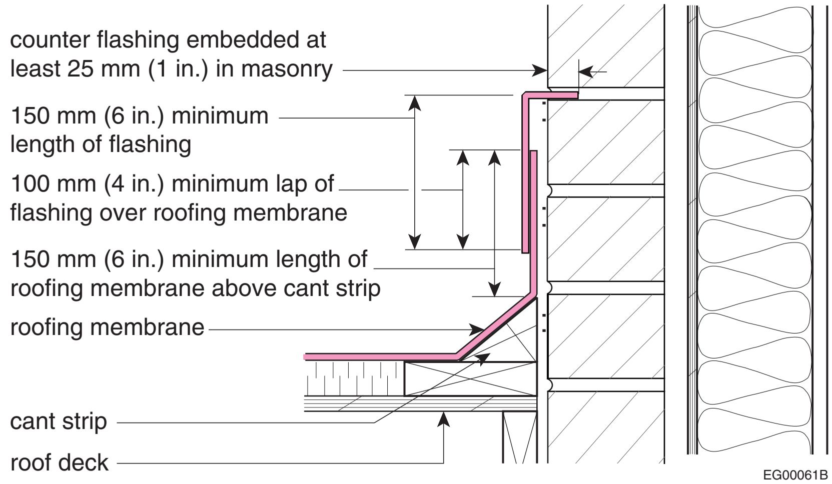


Figure 9.26.-7
Flashing built-up roof to masonry wall

9.26.4.7. Intersection of Built-up Roofs and Walls other than Masonry

This Article requires roofing membrane and flashing to keep rainwater and snow-melt from reaching the roof deck or entering the building envelope at the juncture between a built-up roof and a wood-frame wall unless it is clad with masonry veneer. Cant strips at the junctures are intended to facilitate mopping of the asphalt plies at the transition to form a watertight flashing.

Intersections of built-up roofs and siding or stucco finishes must be provided with a cant strip, and the bitumen must be mopped up onto the sheathing beneath the sheathing membrane at least 150 mm (6 in.) above the cant strip as shown in Figure 9.26.-8. Flashing for the edge of built-up roofs that do not abut walls is covered in Guide 9.26.11.10., Cant Strips.

9.26.4.8. Chimney Saddles

This Article requires chimney saddles to keep masonry work from becoming saturated (which could lead to damage from frost action) and to avoid the entry of snow-melt. The purpose of the saddle is to shed rainwater to either side of the chimney, rather than letting the water drain down directly to the chimney, where it might collect and eventually cause a leak.

The slope of the saddle is normally the same as the main roof slope. Saddles may be omitted for chimneys that are no wider than 750 mm (2 ft. 6 in.) or where the roof-chimney intersection is protected by sheet metal flashing that extends at least 1/6 of the chimney width up the chimney, but no less than 150 mm (6 in.). This flashing must then extend up the roof to the same elevation, but not less than 1.5 times the shingle exposure. Figure 9.26.-9 illustrates flashing for chimney saddles.

It is also possible to flash a chimney without a saddle if the sheet-metal flashing is carried far enough up the chimney (at least 1/6 the width of the chimney). The sheet metal is then carried up the roof slope to the same elevation. This allows a considerable simplification since the framing for the saddle is eliminated and the base flashing can be installed as a single flat sheet.

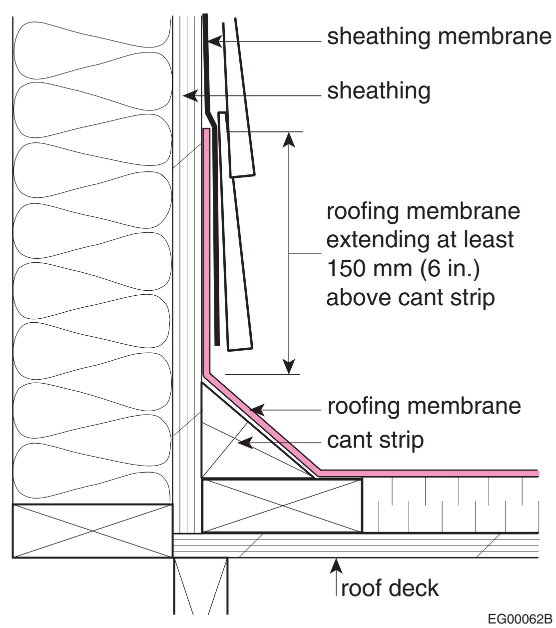


Figure 9.26.-8
Flashing built-up roof to wall with siding

The saddle is usually framed and sheathed as a miniature roof. It may be covered with roofing materials or with sheet metal. If covered with roofing materials, the flashing methods are the same as previously described for roof intersections. When a sheet-metal covering is used, the flashing is somewhat different. In such cases, joints in the flashing at the peak of the saddle and at the corners of the chimney have to be sealed (usually by soldering) to make them watertight before the counter flashing is installed.

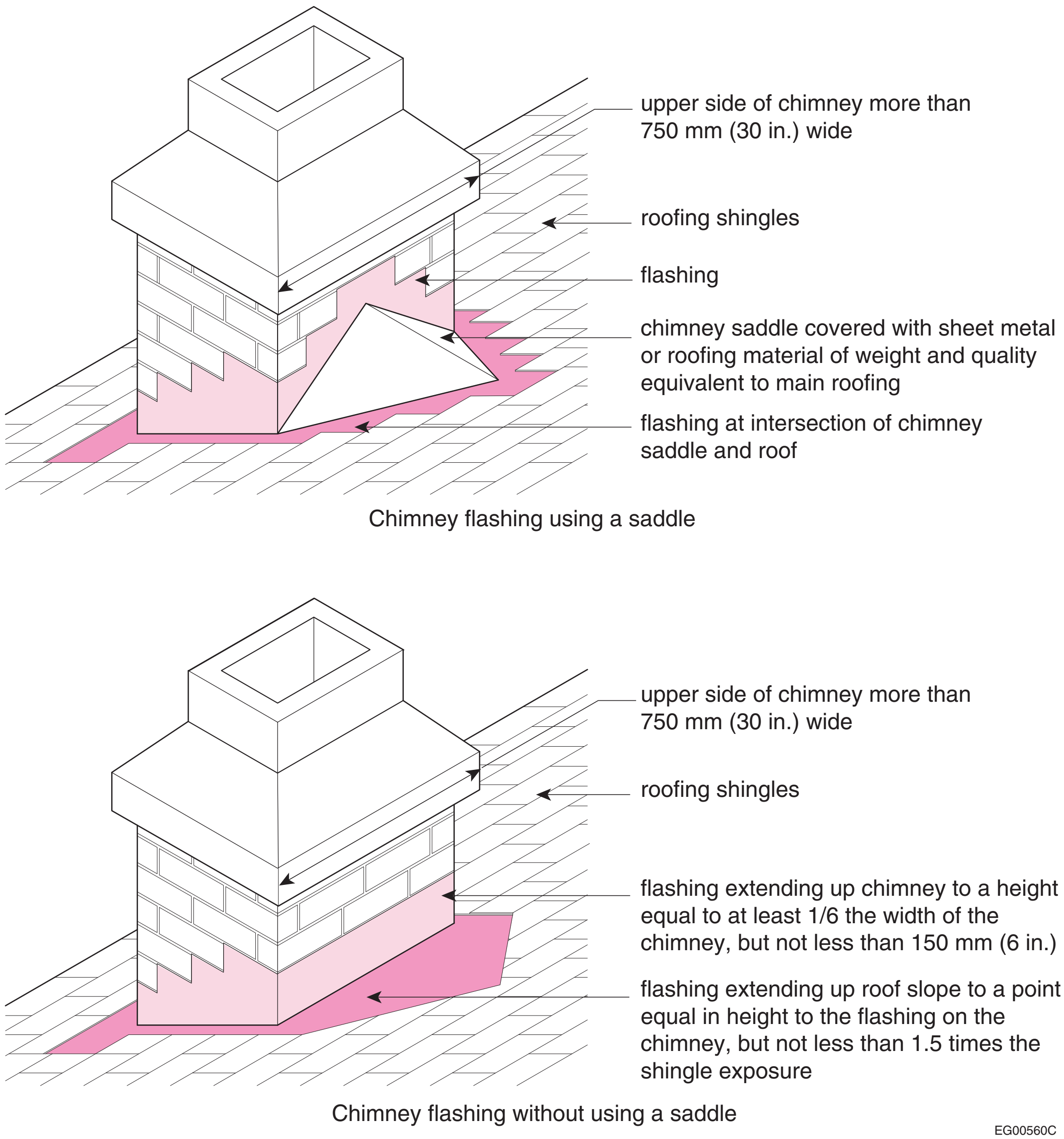


Figure 9.26.-9
Flashing a chimney with and without using a saddle

9.26.5. Eave Protection for Shingles and Shakes

9.26.5.1. Required Eave Protection

This Article requires eave protection to keep snow-melt from leaking into the finished areas of a building, where it could damage the ceiling, and from leaking onto ceiling insulation, which could reduce the insulation's thermal resistance.

Roofing systems that are not designed to be watertight, such as standard shingles, shakes, and tiles are subject to leakage from ice damming. This condition occurs most commonly during winter thaws, when temperatures are milder, or where there is significant snow build-up on the roof.

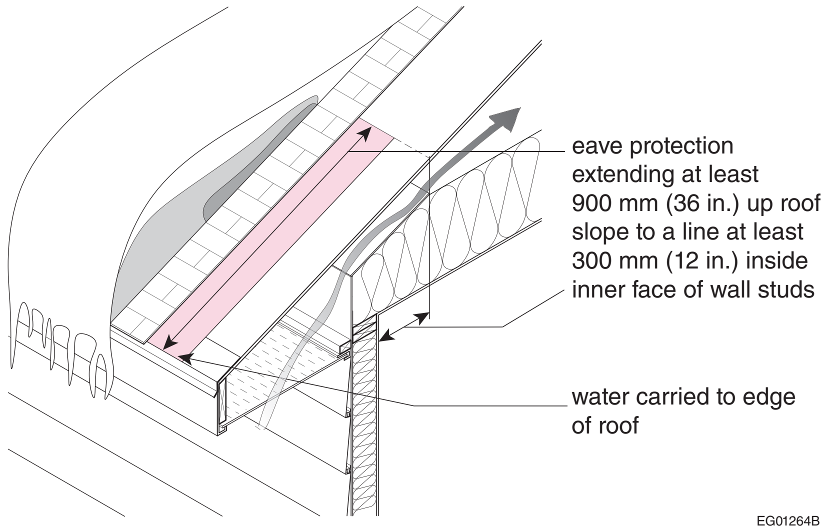


Figure 9.26.-10
Eave protection against ice damming

As the roof surface warms, the snow melts and runs down the roof slope, subsequently refreezing at the edge of the roof, where it builds up a ridge of ice. Ice damming can also be caused by heat loss into the attic space. Ice damming can result in a pool of meltwater that seeps back under the roof covering and leaks through the roof deck (Figure 9.26.-10). The condition is made worse by poor attic ventilation and inadequate ceiling insulation, both of which increase the temperature of the attic space and create an even warmer roof surface to melt the snow.

To reduce the risk of such leakage, eave protection is applied along the bottom edge of the roof to create a watertight membrane beneath the roofing. Where low-slope shingles are used, the courses of shingles are cemented together to form a waterproof membrane so that eave protection is unnecessary. Such protection is also considered unnecessary for unheated garages and carports (where ice damming is uncommon), or where a large roof overhang makes the distance between the fascia and the inside wall finish large enough to reduce the risk of damage to the inside finish.

Eave protection must comply with NBC Subsection 9.26.5. unless
- (a) the roof is over an unheated garage, carport or porch,
- (b) the roof extends more than 900 mm (3 ft.) from the interior wall face to the edge of the roof measured along the roof slope,
- (c) asphalt shingles are applied in conformance with the requirements for shingles on low slopes,
- (d) the roof slope is 1:1.5 or greater, or
- (e) the roof is in a region with 3 500 or fewer degree-days.

Eave protection should run from the edge of the roof to at least 900 mm (36 in.) (one roll width) up the slope and at least 300 mm (12 in.) inside the interior wall surface.

9.26.5.2. Materials

This Article defines the characteristics of materials that can be used as eave protection. Materials for use as eave protection can be
- (a) No. 15 asphalt-saturated felt laid in two plies lapped at least 480 mm (19 in.) and cemented together with lap cement,
- (b) Type M or S roll roofing lapped at least 100 mm (4 in.) and cemented together with lap cement,
- (c) glass fibre or polyester fibre coated base sheets, or
- (d) self-sealing composite membranes coated with a modified bituminous material.

9.26.6. Underlay beneath Shingles

9.26.6.1. Materials

This Article describes the materials to be used when an underlay is required. Underlay has traditionally been used beneath shingles as a second line of defence against rainwater leakage. Experience has shown that underlay is not necessary for modern asphalt shingles.

It is common roofing practice to place an underlay beneath asphalt shingles over the entire roof, but this is not an NBC requirement. Breather-type underlay is required under wood shingles and shakes and must be

(a) an asphalt-saturated sheathing paper of at least 0.195 kg/m^2 (4 lb./100 ft.^{2}), or
(b) No. 15 plain or perforated asphalt-saturated felt.

9.26.6.2. Installation

This Article indicates installation requirements to ensure underlay is installed in a manner that will allow it to shed water and protect a roof from water that might leak pass by the shingles.

When underlay is used, it should be laid parallel to the eaves and lapped to shed water. Polyethylene film is not permitted as an underlay because it is extremely slippery to work on, can be dangerous for workers, and can allow build up of moisture under the plastic that can lead to structural deterioration.

9.26.7. Asphalt Shingles on Slopes of 1 in 3 or Greater

9.26.7.1. Coverage

This Article requires that shingles have sufficient overlap to allow them to shed water effectively in order to meet the requirements of NBC Article 9.26.1.2.

Roofs with a slope of 1:3 or greater require shingles to provide double coverage that is to be at least two layers thick over the entire roof surface not including cutouts. Head laps must be a minimum of 50 mm (2 in.) (Figure 9.26.-11).

9.26.7.2. Starter Strip

This Article requires the installation of a starter strip to avoid water leakage through the cutouts between the shingle tabs in the bottom course of shingles.

A starting strip is first installed along the eaves, extending beyond the edge of the deck (as shown in Figure 9.26.-11) to form a drip edge. The starting strip commonly consists of a row of asphalt shingles, mineral side up, with the tabs pointing up the roof slope. Mineral-surfaced roll roofing can also act as the starting strip if it is at least Type M and is at least 300 mm (12 in.) wide.

9.26.7.3. Head Lap

This Article requires that a minimum head lap be provided to avoid water leakage above the cutouts between shingle tabs. Shingles are lapped to provide double coverage over the roof.

9.26.7.4. Fasteners

This Article lists the requirements for fasteners which should be installed in a manner that allows them to resist uplift forces that result from wind action. No fewer than four fasteners must be provided for every 1 m (3 ft. 3 in.) of shingle width when conventional strip shingles are used. Where staples with an 11 mm (3/8 in.) crown are used, six staples are required.

Fasteners must be located within 25 mm (1 in.) to 40 mm (1 1/2 in.) of each end of the shingle and at least 12 mm (1/2 in.) away from any cutaways or cutouts.

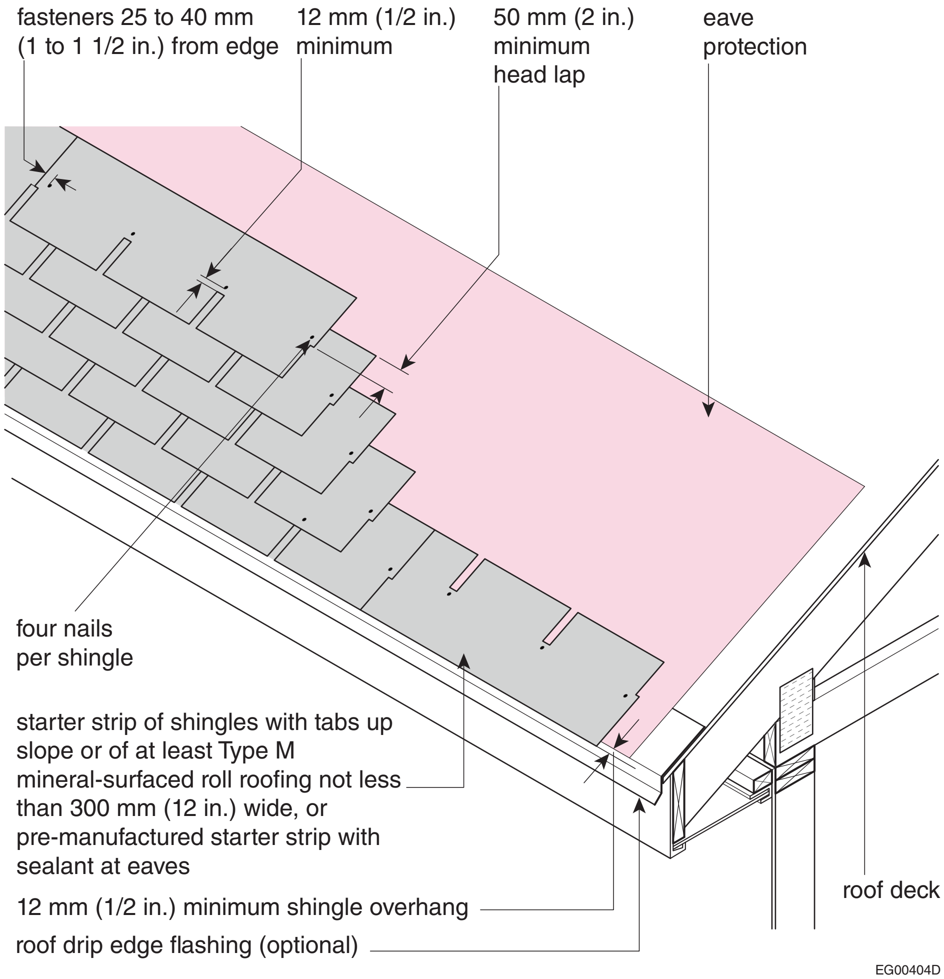


Figure 9.26.-11
Asphalt shingles on slopes of 1:3 or greater

9.26.7.5. Securing of Tabs

This Article requires that shingle tabs be secured to avoid damage to shingles resulting from wind action that lifts and breaks the shingle tabs. All shingle tabs must be secured with spots of plastic cement not greater than 25 mm (1 in.) in diameter under the centre of each tab, unless the shingles are of the self-sealing type. Shingles incorporating interlocking features or that are of a type other than strip shingles require an evaluation to determine alternate attachment methods.

9.26.7.6. Hips and Ridges

This Article lists requirements for the protection of shingles at hips and ridges from water leakage, and to fasten the protection in such a manner as to resist uplift due to wind forces. Shingles at hips and ridges must extend at least 100 mm (4 in.) on both sides of the centre line and must be lapped at least 150 mm (6 in.) to ensure a tight fit edge that will not be dislodged by wind. Shingles on ridges and hips must be fastened within 25 mm (1 in.) of the edges and the exposure line of the butt end of the next higher course of shingles.

9.26.7.7. Eave Protection

This Article refers to the requirements of NBC Subsection 9.26.5., which are intended to keep snow-melt from leaking into the finished areas of a building, where it could damage the ceiling, and from leaking onto ceiling insulation, which could reduce the insulation’s thermal resistance.

9.26.7.8. Flashing

This Article refers to the requirements of NBC Subsection 9.26.4., which are intended to keep rainwater and snow-melt from reaching the roof deck or entering the building envelope at intersections.

9.26.8. Asphalt Shingles on Slopes of less than 1 in 3

9.26.8.1. Coverage

This Article presents the thickness requirements for roof slopes that are less than 1:3, which are intended to provide sufficient overlap between courses of asphalt shingles, that when cemented together, will provide a continuous waterproofing membrane that keeps water from entering beneath each course of shingles into the space below.

Double-coverage asphalt shingles shown in Figure 9.26.-12 do not provide sufficient protection when the roof slope is less than 1:3. Experience has shown that such roofs are more prone to leaks when subjected to wind-blown rain. They are also subject to a greater risk of roof leakage from ice damming, since the water is backed up the roof slope for a greater distance.

Except for the first two courses, asphalt shingles applied to roofs on a slope of less than 1:3 are required to provide triple coverage; that is, be at least three layers thick over the entire roof, not including cutouts (Figure 9.26.-12).

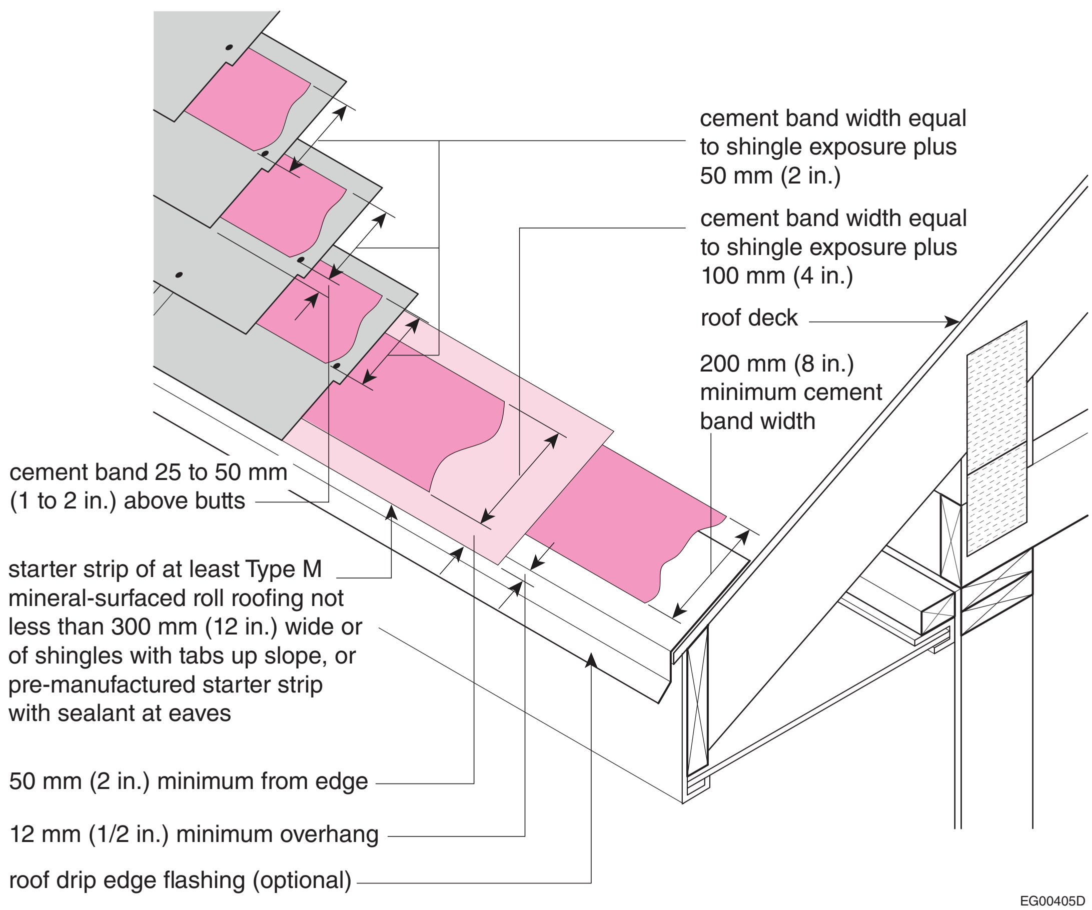


Figure 9.26.-12
Asphalt shingles on slopes of less than 1:3

9.26.8.2. Starter Strip

This Article requires that a starter strip be installed to avoid water leakage through the cutouts between the shingle tabs in the bottom course of shingles. Lower slopes require an application procedure that will provide a watertight surface. Special low-slope shingles are used that provide triple coverage of shingles over most of the surface. A starter strip, similar to that used for double-coverage shingles, is first attached to the roof deck by a band of cement. The first course of shingles is then cemented to the starter strip by a band of roofing cement and each subsequent course cemented to the preceding course (see Figure 9.26.-12).

Fastening for individual shingles follows the same pattern as shown for double coverage shingles in Figure 9.26.-11. Normal shingles can also be used on low-slope roofs, but a special installation technique is required to achieve the necessary degree of watertightness. This technique is described in CAN3-A123.52-M, "Asphalt Shingle Application on Roof Slopes 1:6 to Less Than 1:3."

9.26.8.3. Securing of Tabs

This Article requires that shingle tabs be secured to avoid damage to shingles caused by wind action that could lift and breaks the tabs. The first course of shingles must be secured to the starter strip with a band of cement the width of the shingle exposure plus 100 mm (4 in.).

9.26.8.4. Securing of Shingle Courses

This Article presents the securing requirements for sealing each course of shingles to the adjacent course in such a manner that the roofing will form a continuous waterproof membrane that keeps water from entering beneath each course into the space below. Shingle tabs are secured with a cold application of cement of 0.5 L/m^2 (1 gal./100 ft.^{2}) or a hot application of asphalt of 1 kg/m^2 (0.21 lb./ft.^{2}).

9.26.8.5. Hips and Ridges

This Article requires additional protection for the hips and ridges of a roof so that water will not be able to leak underneath the courses of the protecting shingles. A second purpose is to attach the protecting shingles to resist uplift forces resulting from wind action, with fasteners located so they are protected from wetting.

Hips and ridges are finished by folding over individual shingle tabs usually cut from the strip shingles the same as for double coverage shingles. These are also applied to provide triple coverage, with each course being cemented with a band of cement and nailed so that the nail heads are protected by the cement. To prevent roof stains, the roofing cement on the hip and ridge shingles is kept 25 mm (1 in.) or so above the butt of the overlying shingle. Shingles applied on hips and ridges must be at least 300 mm (12 in.) wide and provide triple coverage.

9.26.8.6. Flashing

This Article requires flashing to keep snow-melt from leaking into the finished areas of a building, where it could damage the ceiling, and from leaking onto ceiling insulation, which could reduce the insulation's thermal resistance, in accordance with NBC Subsection 9.26.4.

9.26.8.7. Fastening

This Article requires fastening shingles so they will resist uplift forces that result from wind action. Over time, roofing will shrink away from nail or staple shanks, and leakage will occur if the nails are exposed to rain. Fasteners are, therefore, located so that they are protected from such wetting in accordance with NBC Article 9.26.7.4.

9.26.9. Wood Roof Shingles

Wood roof shingles have a long history of use in Canada. Being a natural product, characteristics such as loose knots and knot holes must be taken into consideration by specifying a good-quality grade of shingle.

9.26.9.1. Decking

This Article indicates the requirements for decking to provide structural support for wood shingles to support anticipated snow loads and the weight of workers. A second purpose is to provide a means for the attachment of the shingles to resist wind uplift.

Wood shingles may be laid on a continuous deck, the same as other types of roofing, or the decking may consist of spaced boards. The spacing of the boards depends on the shingle exposure. If the allowable exposure were 190 mm (7 1/2 in.), for example, the spacing centre to centre of the boards would also have to be 190 mm (7 1/2 in.). Spaced decking is sometimes preferred in wet climates since it allows the shingles to dry out more quickly than continuous decking.

9.26.9.2. Grade

This Article indicates the acceptable lumber grades and species for wood roof shingles to provide a means for controlling defects in shingles so that they will be able to shed rainwater without leaking. Western red cedar shingles must be of No. 2 grade or better. Eastern white cedar shingles must not be less than B (clear) grade.

9.26.9.3. Size

This Article indicates the minimum length and acceptable width range for wood roof shingles. The minimum permitted length of shingles corresponds to the minimum length recognized in standards that define the defects permitted in each grade. The maximum width limit is intended to restrict the extent of random splitting that could occur when the shingles dry. The minimum width limit is intended to avoid the use of shingles that are too small to provide sufficient coverage over joints and natural defects in the under-courses.

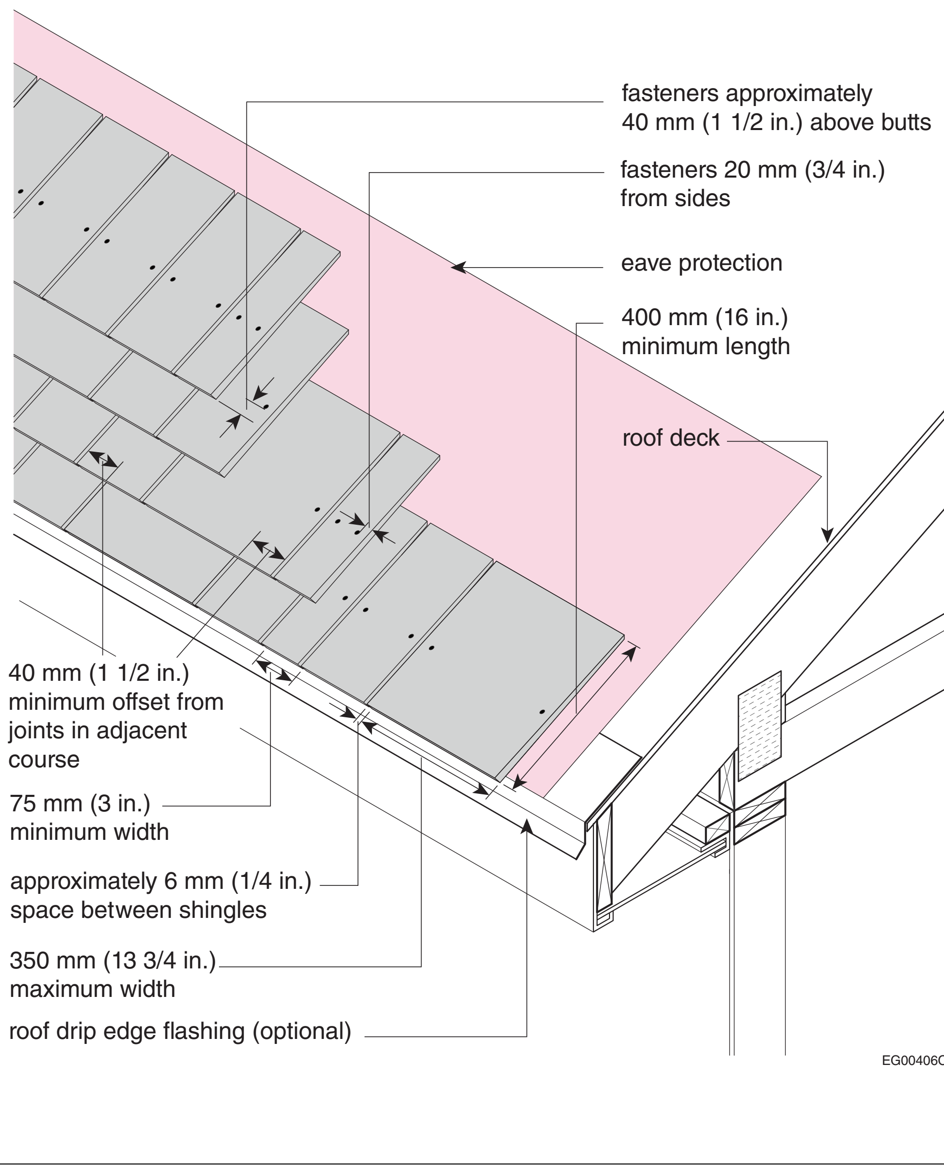


Figure 9.26.-13
Wood shingles

Wood shingles come in random widths, and this must also be considered in their placement if they are to shed water effectively. If shingles are too wide, they will eventually crack as the shingles dry. They may also swell excessively and buckle. If shingles are too narrow, on the other hand, it is not possible to lay them without the risk of insufficient side laps in adjacent and alternate courses. Provision for swelling is made by providing a gap between shingles.

The size of wood shingles and requirements for fasteners must conform to Figure 9.26.-13. The exposure for the shingles must comply with NBC Table 9.26.9.6.

Shingle grades also affect the allowable exposure, since these determine the location of allowable defects. Should loose knots or knotholes in the underlying shingles coincide with the joints in the exposed shingles, leakage may occur. Lower-grade shingles are, therefore, required to have less exposure than are higher-grade shingles.

Finally, the amount of allowable exposure depends on the roof slope. There is a greater risk of rain leakage in lower slopes (i.e., 1:3 to 1:4) than in higher slopes. Obviously, the more layers of shingles at any location, the less risk of through leaks. Lower slopes are, therefore, not permitted to have as much exposure as are steeper slopes (i.e., greater than 1:3).

9.26.9.4. Spacing and Joints

This Article requires spacing between adjacent shingles to allow for swelling when the shingles get wet. If laid too tightly, wood shingles could buckle upward when wet, which could cause the nails to lift. The purpose of offsetting joints in adjacent courses is that there will be sufficient overlap of shingles in adjacent courses to avoid leakage through the roofing.

9.26.9.5. Fastening

This Article indicates that fasteners are required to attach shingles to the roof deck to resist uplift due to wind action. As the roofing weathers, the gap between the shingle and fastener shank will widen and allow leaking. Fasteners are therefore protected from the weather by locating them beneath the overlying shingle courses.

9.26.9.6. Exposure

This Article refers to the requirements of NBC Table 9.26.9.6. for roof shingle exposure to provide sufficient overlapping of the shingles to enable them to shed water effectively without leakage occurring because of through-leakage paths.

9.26.9.7. Flashing

This Article refers to the requirements of NBC Subsection 9.26.4. for flashing to keep snow-melt from leaking into the finished areas of a building, where it could damage the ceiling, and from leaking onto ceiling insulation, which could reduce the insulation's thermal resistance.

9.26.9.8. Eave Protection

This Article refers to the requirements of NBC Subsection 9.26.5. for eave protection to keep snow-melt from leaking into the finished areas of a building, where it could damage the ceiling, and from leaking onto ceiling insulation, which could reduce the insulation's thermal resistance.

9.26.10. Cedar Roof Shakes

Unlike wood shingles that are manufactured by sawing, cedar roof shakes are produced by splitting the wood along the grain and providing a more textured appearance.

9.26.10.1. Size and Thickness

This Article indicates the minimum acceptable length, thickness and width range for cedar roof shakes. The minimum length limit for shakes is the minimum length recognized for cedar roof shakes in standards that define the defects permitted in each grade. The maximum width limit is intended to restrict the extent of random splitting that results from shrinkage. The minimum width limit is intended to avoid the use of shakes that are too small to provide sufficient coverage to protect joints and other defects in the under-courses. The minimum thickness limit is intended to provide sufficient wood to provide reasonable durability from weathering. The maximum thickness limit is intended to avoid excessive unevenness in the decking, which could encourage the entry of wind-blown snow and rain.

Handsplit wood shakes are available in two lengths and, like shingles, their allowable butt exposure depends on their length. Unlike shingles, however, shakes are required to have a paper or felt underlay. This underlay is not installed in the same manner as are other roof coverings. If eave protection is not provided because of the steepness of the slope or because of the mild climate, a strip of breather-type underlay is installed along the eaves (900 mm (36 in.) wide). A strip of breather-type underlay about half as wide is then laid along each hip and ridge. After each shake course is laid, another strip of breather-type underlay (450 mm (18 in.) wide) is laid parallel to the eave for a distance equal to twice the shake exposure above the bottom edge of the shakes, as shown in Figure 9.26.-14.

Shakes tend to be relatively uneven in thickness (10 to 30 mm (3/8 to 1 1/4 in.)) so that when courses are lapped, open voids are created on the roof surface that can allow the entry of wind-blown rain and snow. Dimensional and maximum exposure requirements for handsplit shakes are shown in Figure 9.26.-14.

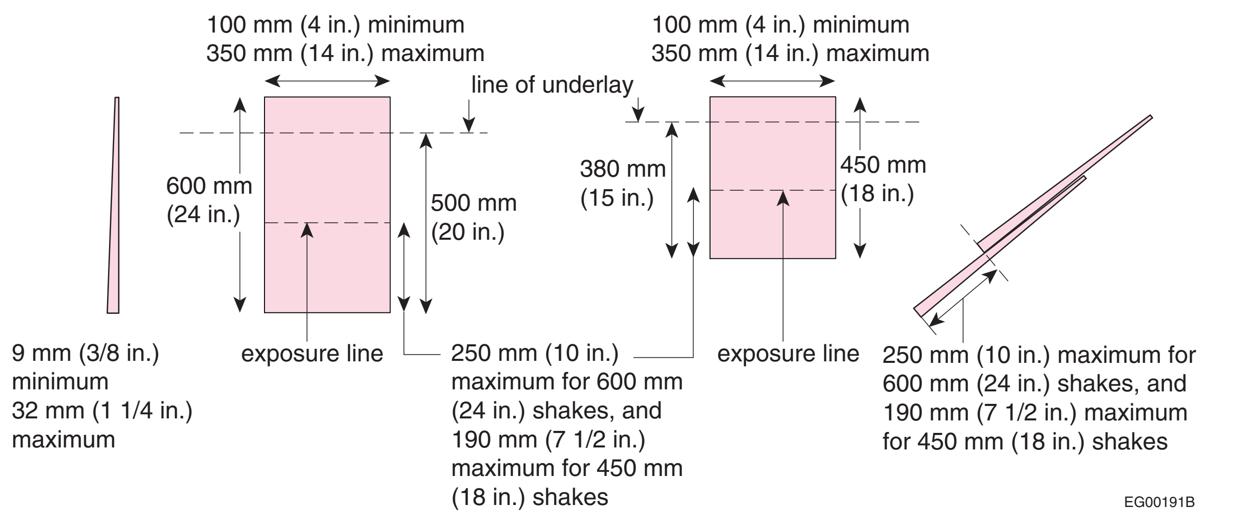


Figure 9.26.-14
Sizing of cedar roof shakes

9.26.10.2. Underlay

This Article requires an underlay where eave protection is not provided to intercept wind-blown snow and rain that gains entry due to the unevenness between shakes, and to redirect any water to the exterior of the roof. A strip of interlay material at least 450 mm (18 in.) wide must be provided between each course of shakes as shown in Figure 9.26.-15. These interlaid strips must be lapped at least 150 mm (6 in.) on ridges and hips to prevent any penetration of rain water due to ice damming or wind-driven rain.

9.26.10.3. Spacing and Joints

This Article indicates the required spacing and separation between joints for cedar roof shakes. Spacing between adjacent shakes allows for swelling when the shakes get wet. If laid too close, the shakes may buckle upward when wet, causing the nails to lift. Offsetting joints in adjacent courses avoids through leakage paths through the roofing. The required spacing and offsetting of joints and the fastening of shakes is shown in Figure 9.26.-15.

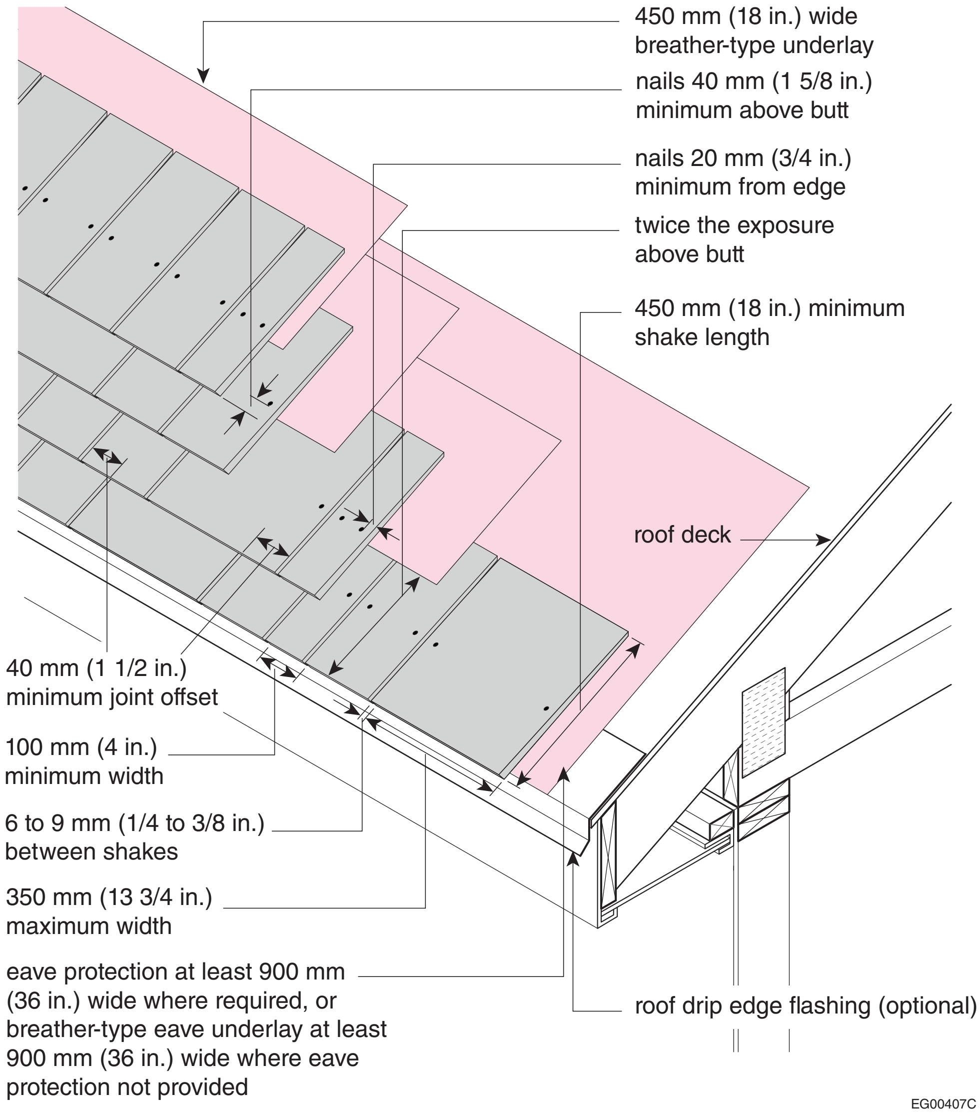


Figure 9.26.-15
Application of cedar roof shakes

9.26.10.4. Fastening

This Article indicates fastening requirements to attach shingles to the roof deck so that they will resist uplift due to wind action. As the roofing weathers, the gap between the shingle and fastener shank will widen and allow leaking. Fasteners are therefore protected from the weather by locating them beneath the overlying shingle courses.

9.26.10.5. Exposure

This Article limits exposure to provide sufficient overlapping of the shingles to enable them to shed water effectively without leakage occurring because of through leakage paths.

9.26.10.6. Flashing

This Article refers to the requirements of NBC Subsection 9.26.4. for flashing required to keep snow-melt from leaking into the finished areas of a building, where it could damage the ceiling, and from leaking onto ceiling insulation, which could reduce the insulation's thermal resistance.

9.26.10.7. Eave Protection

This Article refers to the requirements contained in NBC Subsection 9.26.5. for eave protection to keep snow-melt from leaking into the finished areas of a building, where it could damage the ceiling, and from leaking onto ceiling insulation, which could reduce the insulation's thermal resistance.

9.26.10.8. Grade

This Article indicates the minimum grade for shakes to provide a means for controlling defects in shingles so that they will be able to shed rainwater without leaking.

9.26.11. Built-Up Roofs

The effectiveness of a built-up roofing system depends on the conditions under which it is laid and on the workmanship or skill of the applicators. If the roofing is laid while it is raining or snowing, moisture can be trapped in the roofing system, which may lead to blisters and other defects in hot weather.

9.26.11.1. Quantity of Materials

This Article requires a minimum amount of bituminous material to avoid the entry of rainwater and snow-melt through a built-up roofing system over the tops, and to the deck below by providing sufficient bitumen between the plies of the roofing felt to make the roofing perform as a continuous waterproof membrane.

When hot bitumen (asphalt or coal tar) is used, each layer of felt must be laid while the bitumen is hot enough for adhesion. However, if the bitumen is allowed to become too hot, its properties can be adversely affected and accidental fires during construction may result. A sufficient amount of bitumen must be mopped on so that a solid uniform film is created between plies (insufficient bitumen has been responsible for many premature roof failures). Wrinkles in the felt will allow channels for water leakage so that, as each layer of felt is applied, it must be broomed flat as it is rolled out. This also ensures more complete adhesion between plies.

The quantities of bitumen used for built-up roofs must conform to NBC Table 9.26.11.1. Coal tar and asphalt products must not be used together. All bitumen felts must be at least No. 15 weight or better.

Aggregate that is used for surfacing must be clean, dry, and durable, and it may be either gravel, crushed stone, or air-cooled blast furnace slag from 6 mm (1/4 in.) to 15 mm (5/8 in.) in size. At least 15 kg (33 lb.) of gravel or crushed stone or 10 kg (22 lb.) of slag must be used to cover a 1 m^2 (10.76 $ft.^2$) area.

9.26.11.2. Coal-Tar and Asphalt Products

This Article prohibits using coal-tar and asphalt products together in built-up roof construction. Asphalt and coal-tar products sometimes interact with one another to adversely affect the properties of both. The use of incompatible materials can lead to premature failure of a roofing system.

9.26.11.3. Roof Felts

This Article requires a minimum weight for roofing felts. Roofing felts used in built-up roofs serve as reinforcing for the bitumen layers that provide the prime waterproofing components. Roofing felt is also used to keep the bitumen from leaking through the roof deck into the roof space.

9.26.11.4. Aggregate Surfacing

This Article indicates the required properties and quantities for aggregate surfacing. The asphalt or coal tar between the layers and the flood coat on top provide the waterproofing, while the layers of roofing felt provide the reinforcing for the waterproofing and allow it to withstand the shrinkage effects that occur with aging or with temperature changes.

Aggregate surfaces applied to the flood coat shield the cement from the harmful effects of solar radiation, and reduce the temperature of the roofing systems in summer. They also act as ballast in resisting wind uplift. The aggregate can consist of a variety of materials, although gravel and crushed stone are the most common. If the material is too fine, it will blow off, and if it is too coarse, an excessive weight of aggregate may be required to ensure adequate coverage of the surface without leaving voids to expose the flood coat. Steeper slopes encourage the flood coat to flow or the aggregate to be blown off the roof, so the maximum slope is less than that permitted for built-up roofs without aggregate.

9.26.11.5. Flashing

This Article refers to the requirements of NBC Subsection 9.26.4. for flashing to keep snow-melt from leaking into the finished areas of a building where it could damage the ceiling, and from leaking onto ceiling insulation, which could reduce the insulation's thermal resistance.

9.26.11.6. Number of Layers

This Article requires that built-up roofing have a minimum of three layers of roofing felt. Built-up roofing relies on the watertightness provided by using several layers of roofing felts, with each cemented to the underlying base and to each other with a layer of asphalt or coal-tar cement. These are coated overall with a relatively thick layer of similar cement (flood coat). Since coal tar and asphalt products are not compatible, a system that uses asphalt-based roofing felts should also use asphalt for cementing the felts and for the flood coats.

Built-up roofs must have at least three continuous layers of felt mopped down with bitumen. Felt must be laid free of any wrinkles and rolled directly onto the hot bitumen so that the felt is completely coated such that no two layers of felt touch each other directly. Rolls must overlap to guarantee each individual layer is continuous.

9.26.11.7. Installation of Layers

This Article lists the installation requirements for built-up roofing, which are intended to keep water from leaking through or past each ply of roofing felt in a built-up roof. A continuous layer of bitumen is required between each ply, ensuring that there is a complete adhesion between plies.

9.26.11.8. Roofing over Wood-Based Sheathing

This Article requires a base layer of felt over wood-based sheathing to keep bitumen from leaking through the wood roof deck into the space below where it could cause stains.

When built-up roofing is laid over a wood deck, precautions have to be taken to prevent the asphalt or coal tar from dripping through, where it could damage a ceiling below. This can be achieved by the use of a layer of dry-laid roofing felt (Figure 9.26.-16) suitably lapped at the joints, or, in the case of plywood, oriented strandboard (OSB) or waferboard decking, the joints may be taped before a bitumen prime-coat is applied to the deck.

9.26.11.9. Attachment to Decking

This Article requires that roofing be securely attached to decking to avoid the uplifting of roofing and roof insulation resulting from wind action. Roofing applied to decking or insulation must be secured before any felt or bitumen is applied.

Unless there is sufficient ballast to resist wind forces, the roofing must depend on mechanical fastening or direct adhesion to the deck to hold it in place. Where it is applied over an insulation board, therefore, the board must be attached to the deck, either by adhesives or mechanical fastening, before the felt is adhered to the insulation.

9.26.11.10. Cant Strips

This Article requires that a cant strip be provided at the edges of roofs to keep aggregate on top of built-up roofing from falling off the edge of the roof. Cant strips must be provided at the edges of all roofs unless a gravel stop is installed. At least two layers of roofing membrane must extend up over the edge of the cant strip and be suitably flashed with a drip as shown in Figure 9.26.-17; or a gravel stop must be installed. Other flashing requirements can be found in Guide 9.26.4., Flashing at Intersections.

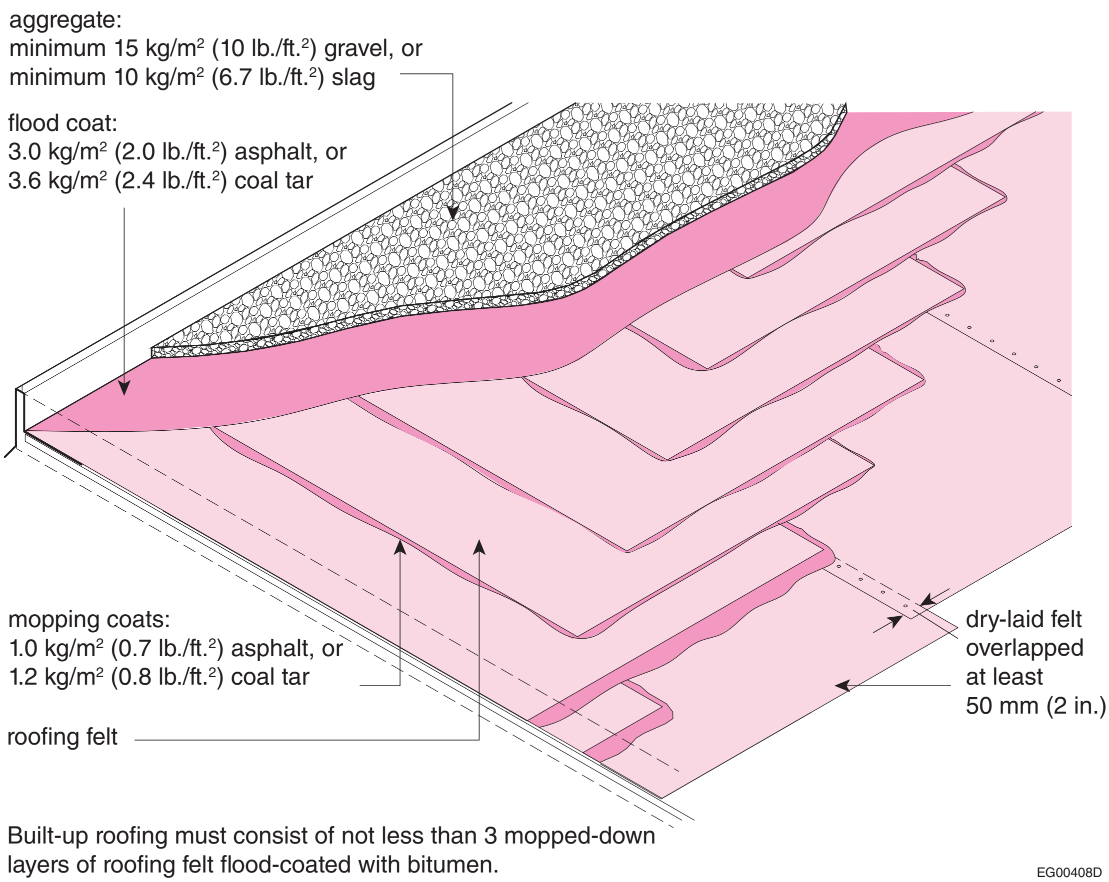


Figure 9.26.-16
Built-up roofing on wood-based sheathing

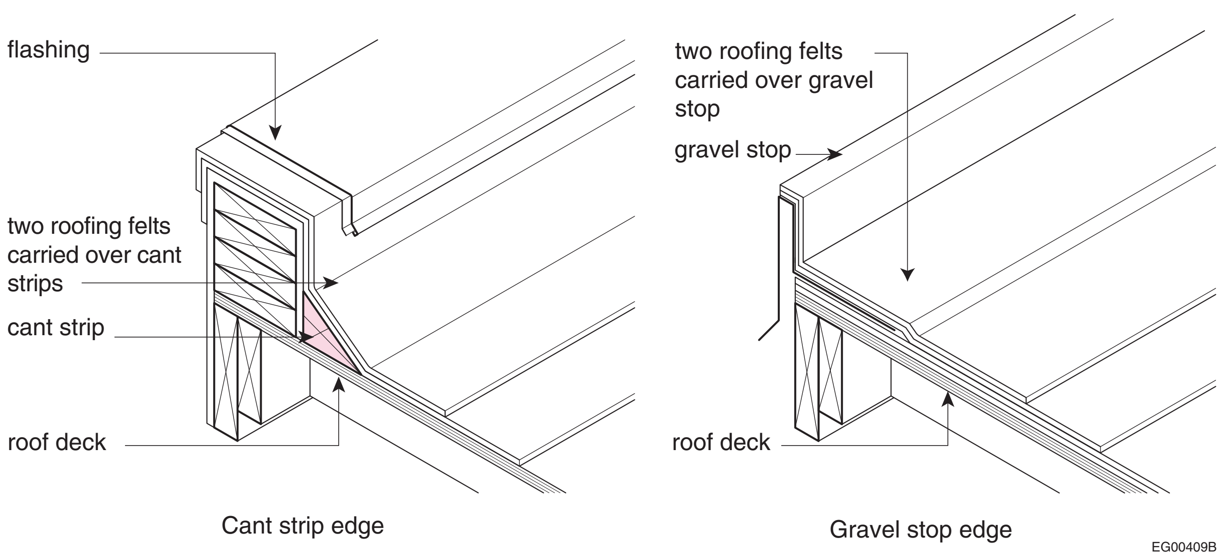


Figure 9.26.-17
Built-up roof edges

9.26.12. Selvage Roofing

9.26.12.1. Coverage

This Article requires double coverage for selvage roofing (roll roofing) to keep water from leaking past the juncture between each sheet of roofing to the roof deck. The double coverage allows the cementing area between layers to be sufficiently large to provide a good water seal between sheets so that the roofing can be used on low slopes without the risk of leakage due to ice damming. Each portion of roll roofing is overlapped by the succeeding course to obtain double coverage.

9.26.12.2. Joints

This Article requires that plies of selvage roofing (roll roofing) be cemented together creating a watertight joint to keep water from leaking past the juncture between each sheet of roofing to the roof deck.

9.26.13. Sheet Metal Roofing

9.26.13.1. Thickness

This Article indicates the minimum required thickness for different materials of sheet metal roofing so it will have sufficient corrosion-resistance to give the roofing a reasonable life expectancy. A second purpose is to provide the roofing with sufficient strength to support anticipated roof loads when it is installed over purlins or discontinuous roof decking. Where sheet metal roofing is not supported by roof decking, but spans between spaced supports, the panels need to be designed to support specified live loads for roofs.

9.26.13.2. Support

This Article indicates that panels of sheet metal roofing must be designed to span between spaced supports unless supported by roof decking.

9.26.14. Glass Reinforced Polyester Roofing

9.26.14.1. Support

This Article requires that glass reinforced polyester roofing be designed with sufficient strength to support anticipated live roof loads when it is installed over purlins or discontinuous decking.

9.26.15. Hot Applied Rubberized Asphalt Roofing

9.26.15.1. Installation

This Article, through reference to a standard, requires that hot applied rubberized asphalt roofing be installed so as to provide a continuous waterproof membrane.

9.26.16. Polyvinyl Chloride Sheet Roofing

9.26.16.1. Installation

This Article, through reference to a standard, requires that polyvinyl chloride sheet roofing be installed so as to provide a continuous waterproof membrane.

9.26.17. Concrete Roof Tiles

9.26.17.1. Installation

This Article requires, through reference to a standard, that concrete roofing tiles be installed so as to shed water effectively and avoid the entry of water caused by ice dams. A second purpose is that such roofing be attached to the roof in such a manner as to resist uplift from wind action. Where concrete roof tiles are to be installed, the dead load imposed by this material should be considered in determining the minimum sizes and maximum spans of the supporting roof members.

9.26.18. Roof Drains and Downspouts

9.26.18.1. Roof Drains

This Article refers to the requirements of NBC Part 7, and requires roof drains to lead roof drainage water to the building sewer in such a manner as to not create problems such as wet basements.

9.26.18.2. Downspouts

This Article indicates requirements for downspouts to direct roof drainage water away from the foundation so that it will not contribute to basement wall leakage, and in such a manner as to not cause soil erosion.

Section 9.27. Cladding

Introduction

Cladding (sometimes referred to as siding) includes the various exterior wall-covering materials that rely on attachment to the sheathing or framing for support. It includes materials applied as horizontal or vertical strips, panels, shingles or shakes. Cladding may be made from lumber, plywood, hardboard, oriented strandboard (OSB), waferboard, asphalt, vinyl, aluminum, steel, fibreglass-reinforced polyester, masonry or stucco. Cladding also includes the flashing, the soffit and the trim. Although stucco and masonry veneer are covered in separate sections, there are common performance expectations listed in NBC Subsection 9.27.2., as well as common requirements for flashing, sealing and the attachment of cladding in NBC Subsections 9.27.3. to 9.27.5. These requirements apply to all cladding systems.

The general purpose of all cladding materials is to shed rain, minimize water from entering the structure, and prevent the entry of water into interior space. Each type of finish requires specific accessories such as trim, sealants, supporting materials, flashing, and fasteners. Cladding must be designed and constructed to fulfill the following functions:

- deflect snow and rain, even under wind;
- allow for the drainage or dissipation of any moisture from behind the exterior finish;
- protect back-up materials in the wall assembly from mechanical damage and ultraviolet (UV) deterioration; and
- provide reasonable durability.

9.27.1. Application

9.27.1.1. General

This Article lists the types of cladding materials covered in NBC Section 9.27. Systems other than those listed or not installed in accordance with NBC Section 9.27. must comply with NBC Part 5. The Article also lists in detail the applicable requirements for common cladding materials and substrates, including those outside of NBC Section 9.27. For example, it clarifies that the requirements in NBC Section 9.20. apply to masonry veneer walls, and that the requirements in NBC Section 9.28. apply to stucco walls in addition to the relevant common Subsections on required protection, sealants and flashing. For all cladding and substrates, this Article provides design to NBC Part 5 as an option. For cladding types or substrates that are not explicitly listed, such as insulating concrete form (ICF) walls, this Article requires design to NBC Part 5.

9.27.2. Required Protection from Precipitation

Exterior walls must be designed to prevent precipitation from entering the wall assembly and from entering the living space. Total prevention of precipitation ingress behind the cladding and into the assembly is difficult to achieve and may not be absolutely necessary. However, it is necessary to limit precipitation ingress into the structure and living space and to ensure that wall cavities have the ability to dry rapidly.

9.27.2.1. Minimizing and Preventing Ingress and Damage

This Article identifies the performance expectations for cladding. Cladding protects exterior walls from the entry of rain and snow into the wall assembly. Such leakage can result in a variety of moisture-related problems ranging from wood decay to paint peeling. Cladding must also provide sufficient strength to resist wind action, and in some wall designs acts as an air barrier in restricting air leakage. Since cladding is exposed to the weather, it must resist degradation from cycles of wetting and drying as well as freezing and thawing.

Cladding is also expected to resist the effects of mechanical impact and ultraviolet radiation. This Article describes that cladding is exempted from the requirements, where it is otherwise protected from precipitation, such as by large roof overhangs or where it can be shown that precipitation ingress will not adversely affect occupant health or safety, which could be the case in buildings that are essentially open to the outside and where water entry into the structure or occupied space will not create any damage or deterioration.

The qualitative performance requirements listed in NBC Article 9.27.2.1. are intended to govern all other requirements in NBC Section 9.27., which means that even prescriptive requirements for specific cladding systems in NBC Subsections 9.27.6. to 9.27.12. are only acceptable if the performance requirements are satisfied.

9.27.2.2. Minimum Protection from Precipitation Ingress

This Article indicates the minimum requirements for protection from precipitation ingress, which are based on occupancy. It also clarifies where a first and second plane of protection is required and in which cases a capillary break is required. The NBC provides clear direction aimed to achieve long-term performance of wall assemblies by ensuring any precipitation into the wall cavity could escape and allow the cavity to dry. The direction given is intended to meet the minimum requirements. Designers must take any additional measures dictated by local good practices and conditions.

In areas where the possibility of precipitation ingress is high and the opportunity for drying is low, exterior walls must have first and second planes of protection separated by a capillary break. This configuration is commonly called a rainscreen. Figure 9.27.-1 shows several ways of constructing rainscreen assemblies.

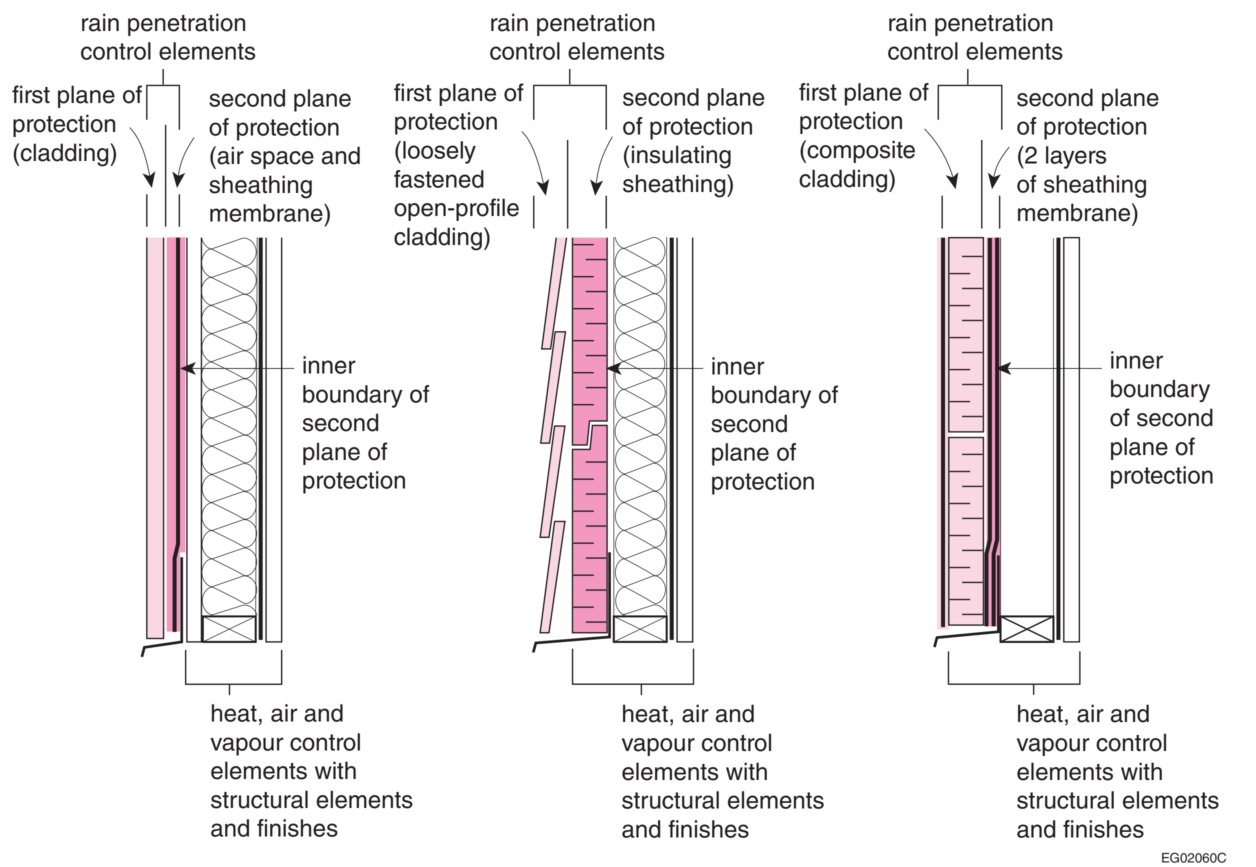


Figure 9.27.-1
Examples of rainscreen assemblies

NBC Sentence 9.27.2.2.(1) states that the following is deemed to act as a capillary break:

(a) a drained and vented air space not less than 10 mm (7/16 in.) deep behind the cladding, over the full height and width of the wall;
(b) an open drainage material not less than 10 mm (7/16 in.) thick and with a cross-sectional area not less than 80% open, installed between the cladding and the backing, over the full height and width of the wall;
(c) a typical cladding (e.g., horizontal metal or vinyl siding without contoured insulated backing) that is loosely fastened to the backing and that provides (by design) an air space that is continuous for the full width of the component, not less than 10 mm (7/16 in.) deep at the bottom of the component, and not less than 6 mm (1/4 in.) deep over not less than 90 mm (3 1/2 in.) for every 230 mm (9 in.) of exposed height of the component;
(d) a typical masonry cavity wall or masonry veneer wall constructed according to NBC Section 9.20.; or
(e) an exterior insulation finish system that conforms to NBC Subsection 9.27.13.

The main functions of the capillary break are:

- dissipating water effectively to the exterior, and
- promoting drying through evaporation, venting and reduced air pressure difference.

In order to be effective, a capillary break must be provided over the full height and width of a wall except where openings, such as windows and doors, or service penetrations, such as pipes, ducts as well as electrical outlets, and flashings are present. Where furring is used to provide the 10 mm (7/16 in.) air space, the furring must not cover more than 20% of the wall area.

For houses and other residential occupancies, and where exterior walls are not otherwise protected from rain and snow, a first and second plane of protection is required. The first plane of protection is typically the outermost layer, for example, siding or stucco, and the second plane of protection is typically a sheathing membrane or insulating sheathing.

Where a building of any other occupancy is located in high moisture areas in Canada, a capillary break is required. The potential for a high risk of moisture accumulation in the exterior wall assembly is indicated by the moisture index (MI) value, which is listed for each of the 650 Canadian locations in NBC Appendix C. Where the MI value in a specific location is greater than 1.0 in cold climates and greater than 0.9 in mild climates, exterior walls in a building of any occupancy need to be protected with a cladding system featuring a first and second plane of protection as well as a capillary break.

There are, however, some exceptions to this rule. For example, where it can be shown that omitting the capillary break will not adversely affect the performance of the building assemblies, the building is an accessory building, or the wall is constructed of non-moisture-sensitive materials, and intersecting or supported floors are also constructed of non-moisture-sensitive materials, or is constructed as a mass wall of sufficient thickness to minimize the transfer of moisture to the interior, a capillary break is not required.

Moisture Index

The MI is an indicator of the moisture load imposed on a building by the climate and is used in NBC Part 9 to define the minimum levels of protection from precipitation to be provided by cladding assemblies on exterior walls. MI values are a single number indicator used to determine the appropriate levels of protection from precipitation. Although weather conditions can vary markedly within a relatively small geographical area, the MI values provided in Table C-2 of NBC Appendix C give a good indication of the average conditions within a particular region. Some caution should, however, be exercised when applying them to a locality that is outside the region where the weather station is located.

The MI is calculated from a wetting index (WI) and a drying index (DI). The WI quantitatively defines the rainwater load on a wall, taking into consideration wind speed, wind direction, and rainfall, along with factors that can affect exposure, such as nearby buildings, vegetation and topography. The WI is based on annual rainfall and is normalized based on 1 000 mm (40 in.). The DI is based on temperature and relative humidity, which define the drying capacity of ambient air.

The relationship between WI and DI that correctly defines moisture loading on a wall is not known. The MI values provided in Table C-2 of NBC Appendix C are based on the root mean square values of WI and DI, with those values equally weighted. This is illustrated in Figure C-1 in NBC Appendix C. The resultant MI values are sufficiently consistent with industry's understanding of climate severity with respect to moisture loading as to allow limits to be identified for the purpose of specifying where additional protection from precipitation is required.

9.27.2.3. First and Second Planes of Protection

This Article describes the functions of the first and second planes of protection. The concept of a first and second plane of protection is based on research on rainscreen assemblies. In the context of the NBC, the first plane should be designed and constructed to deflect virtually all of the precipitation load. The primary functions of the first plane are as follows:

- reducing the moisture load on the cladding,
- minimizing the number and size of holes in the cladding, and
- managing the driving forces across the cladding.

The first plane of protection consists of the cladding itself, flashing (NBC Articles 9.27.3.7. and 9.27.3.8.), fasteners (NBC Subsection 9.27.5.), sealants (NBC Subsection 9.27.4.), and accessories such as trim or caps if they are part of the cladding system.

The main functions of the second plane of protection are as follows:

- intercepting any water that has penetrated the first plane, and
- dissipating those relatively small quantities of incidental water to the exterior.

The second plane of protection consists of the sheathing material and flashing (NBC Articles 9.27.3.7. and 9.27.3.8.) and accessories such as sealants or tapes if they are part of the sheathing installation design. The NBC does not define the term flashing. The term can be understood to mean both rigid metal flashing leading to the exterior of the cladding system, and flexible self-adhered membranes used to protect rough openings, but not leading to the exterior. In many assemblies, the air barrier system, which plays a role in controlling precipitation ingress due to air pressure difference, is also protected from the elements by the second plane of protection or, as in some cases, the sheathing membrane also fulfills the function of the air barrier.

Additionally, NBC Article 9.27.2.3. requires that both the first and second planes of protection maintain their protection at all wall penetrations created by the installation of components and services such as windows, doors, ventilation ducts, piping, wiring and electrical outlets, and at the interface with other wall assemblies. These penetrations and interfaces at openings are traditionally where most cladding systems develop problems over their lifetime.

9.27.2.4. Protection of Cladding from Moisture

This Article requires that cladding be protected from moisture to avoid the deterioration of wood-based cladding resulting from backsplash from rain or contact with melting snow. Cladding materials that are subject to decay or other damage by excessive moisture exposure (such as untreated wood-based materials) must not be installed within 200 mm (8 in.) of the finished grade or within 50 mm (2 in.) of the finished roof surface.

9.27.3. Second Plane of Protection

9.27.3.1. Elements of the Second Plane of Protection

This Article indicates the expected performance of the second plane of protection (drainage, dissipation, continuity across joints, junctions and penetrations), describes its components, and clarifies the application of the Articles in NBC Subsection 9.27.3.

Except for exterior insulation finish systems conforming to 9.27.13., the second plane of protection shall consist of a drainage plane from a suitable material serving as the inner boundary to precipitation ingress, such as a sheathing membrane. The membrane must provide continuous protection at wall penetrations created by doors, windows and services, as well as at junctions with other wall assemblies or materials.

The sheathing membrane forms part of a second line of defence against the entry of rainwater. It can, in some cases, also provide resistance to air infiltration. Since there is a possibility that some moisture may condense in the wall space in winter, the sheathing membrane must be capable of allowing any trapped moisture to escape before the start of wood decay.

9.27.3.2. Sheathing Membrane Material Standard

This Article describes, through reference to a standard, the characteristics necessary for sheathing membranes to fulfill their intended functions. Sheathing membranes must conform to CAN/CGSB-51.32-M, “Sheathing, Membrane, Breather Type.”

Common breather-type sheathing membranes are made of asphalt-saturated felt, building paper, and products referred to as house wrap. Sheathing membranes are not waterproof and will, after long-term exposure to wetting and drying, allow some water to penetrate to the sheathing or framing.

Some sheathing membrane products can also fulfill the function of an air barrier system. In addition to the continuity at penetrations, joints and junctions, fulfilling this function would also trigger requirements for structural support and airtightness at high wind pressures.

9.27.3.3. Required Sheathing Membrane and Installation

This Article specifies how to correctly install a single sheathing membrane intended to provide part of a second line of defence against rainwater and wind entry into the building walls, and lists three additional means of providing a second plane of protection.

Unless sealed rigid insulating sheathing is used or the cladding is faced sealed, at least one layer of sheathing membrane must be installed beneath strip or panel siding, shakes, shingles, stucco or masonry veneer.

The requirement that tar-saturated building paper not be used under stucco has been removed from the NBC because this results in an appearance problem which cannot, as such, be linked to NBC objectives. It remains good practice to avoid such problems, and this can be done by using asphalt-impregnated sheathing paper.

Sheathing membranes must be lapped at least 100 mm (4 in.) and, if applied horizontally, the upper sheets must overlap the lower sheets.

9.27.3.4. Insulating Sheathing in lieu of Sheathing Membrane

This Article describes how insulating sheathing needs to be installed in order to fulfill the function of the second plane of protection where no sheathing membrane is used. Sheathing membrane is not required when rigid exterior insulating sheathing with sealed joints faces the second plane of protection.

In general, the shape of cladding joints is critical to its ability to drain water. Since any material forming the inner boundary of the second plane of protection will have to drain water occasionally, it is important to note that tongue and groove, and lapped joints can shed water if oriented correctly. However, butt joints can drain to either side, and so should not be used unless they are sealed. The detailing of joints requires attention, not just to the shape of the joint, but also to the materials that form the joint. For example, even if properly shaped, the joints in insulating sheathing with an integral sheathing membrane could not be expected to shed water if the insulating material absorbs water, unless the membrane extends through the joints.

9.27.3.5. Sheathing Membranes in lieu of Sheathing

This Article describes how a sheathing membrane needs to be installed in order to fulfill the function of the second plane of protection where no sheathing is used.

The sheathing in a wall works together with the sheathing membrane to provide part of a second line of defence against the entry of any rainwater and wind that bypasses exterior cladding. When sheathing is not used, the sheathing membrane alone is not an adequate second plane of protection. A second layer of membrane is, therefore, required to compensate for the lack of sheathing. The membrane must be attached with sufficient fasteners to keep it tight to the framing for airtightness. If the sheathing is not needed for structural reasons, it merely acts as a back-up for the membrane and its thickness is relatively unimportant.

The joints in the sheathing membrane must be supported by framing beneath. The membrane must be nailed with roofing nails or staples spaced not more than 150 mm (6 in.) apart along the edges of the outer layer of sheathing membrane.

9.27.3.6. Face Sealed Cladding

This Article describes the necessary installation requirements for face sealed cladding assemblies where no sheathing membrane is provided. Sheathing membrane is not required where it can be demonstrated that the first plane of protection, the cladding, is face sealed so that it is at least as impervious to air and water penetration as sheathing membrane, and that its jointing system results in joints that are at least as impervious to air and water penetration as the material itself.

Certain types of cladding consisting of very large sheets or panels with well-sealed joints will perform in this way, eliminating the need for a sheathing membrane. This is true of the metal cladding with lock-seamed joints sometimes used on manufactured housing.

Metal or vinyl siding applied in narrow strips does not qualify as being faced sealed. It does not act as a substitute for sheathing membrane since it incorporates provisions for venting the wall cavity, and has many loosely fitted joints which cannot be counted on to prevent the entry of wind and rain. Furthermore, certain types of sheathing systems can perform the function of the sheathing membrane.

Cladding such as plywood, hardboard, OSB and waferboard can provide weathertight joints where all edges are directly supported by framing, where the vertical joints are covered with battens and where vertical or horizontal joints are sealed, ship-lapped or otherwise matched to provide weathertight joints.

9.27.3.7. Flashing Materials

This Article lists the acceptable flashing materials and their minimum required thickness.

9.27.3.8. Flashing Installation

This Article indicates where flashing is required in the cladding system and where flashing is required at the head of window and door openings. It also lists the required dimensions of flashing and where flashing is required at the sill of windows and doors. The flashing requirements for masonry veneer walls are listed in NBC Subsection 9.20.13.

Flashing is required between every horizontal intersection of different exterior finishes, except where the upper finish laps over top of the lower finish by at least 25 mm (1 in.). Flashing is also required where there is a change in substrate and the substrates differ sufficiently for stresses to be concentrated along the junction (Figure 9.27.-2), as might apply with stucco cladding.

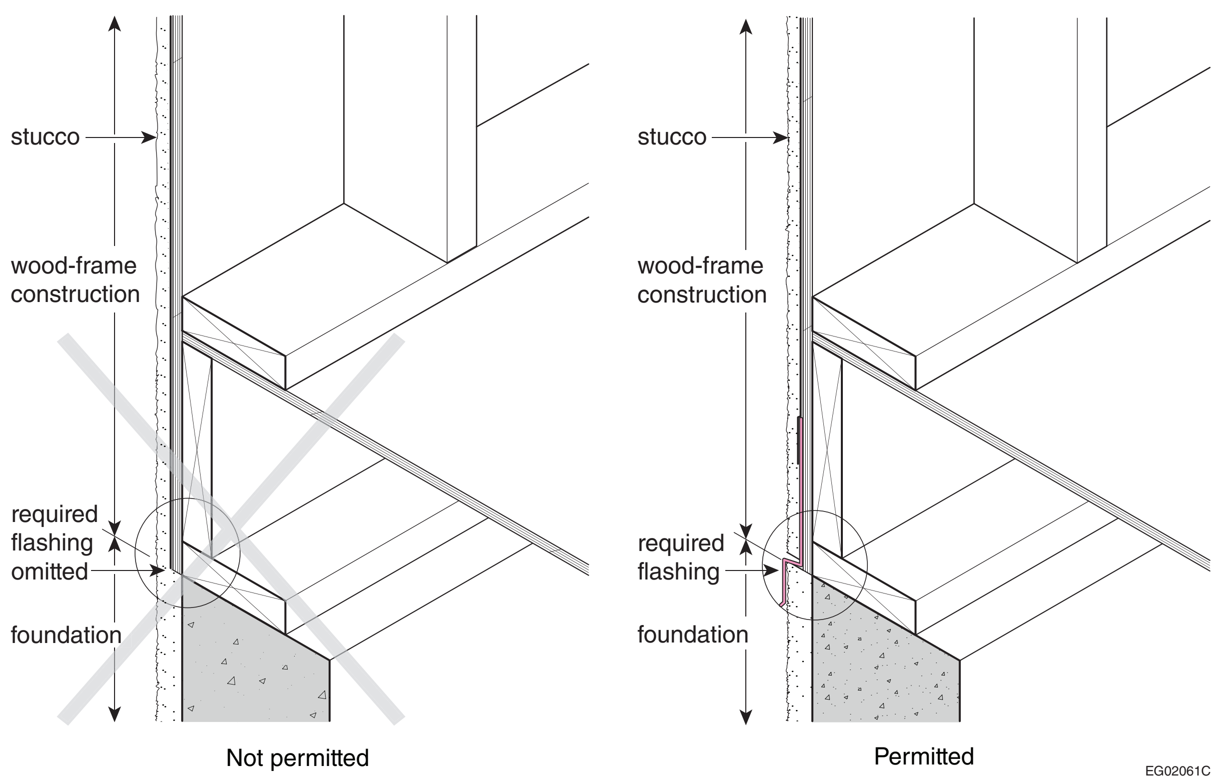


Figure 9.27.-2
Flashing at changes in substrate

Flashing is installed as part of the second plane of protection to minimize the entry of rainwater at the junctures of different cladding materials or over the heads of openings where the cladding is not shielded from rain by a sufficient roof overhang, but is mostly necessary to drain rain or meltwater that has penetrated the cladding.

NBC Sentence 9.27.3.8.(2) lists three cases where flashing is not required. In the first scenario, the upper cladding fulfills the function of the joint protection by providing an overlap of more than 25 mm (1 in.). In the second case the flashing requirements are waived where the cladding is installed outboard of a drained and vented air space (vinyl, masonry, strapping or mesh), and where the horizontal detail is constructed to minimize the ingress of water into that air space. This scenario also applies to stucco where the joint is finished with an expansion-contraction strip.

The angle at which rain strikes the face of the wall depends on the wind velocity. In high winds, rain is assumed to travel 4 m (12 ft.) horizontally for each metre of vertical drop.

Flashing needs to have upstands to prevent water from going up and over a flashing, and horizontal offsets to direct water away from the building face (Figure 9.27.-3).

Flashing is required over the top of window and door openings if the distance from the top of the opening to the underside of the eave is more than one quarter of the width of the eave projection (Figures 9.27.-4 and 9.27.-5). Flashing extends up behind the sheathing membrane, slopes at least 6% toward the exterior, extends beyond the trim to form a drip edge, and is fitted with a dam at both ends to keep water from entering the wall cavity (NBC Article 9.27.3.8.).

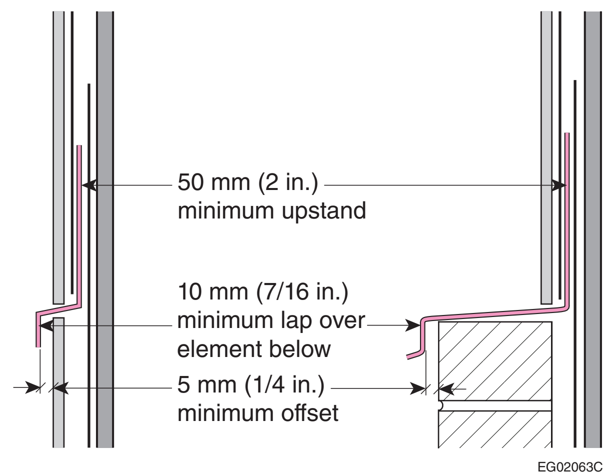


Figure 9.27.-3
Examples of flashing configurations

Where the opening has a curved top, the vertical distance from the bottom of the eave to the trim over the opening that determines whether flashing is required is measured from the eave to the point where the trim becomes vertical (NBC Note A-9.27.3.8.(3)).

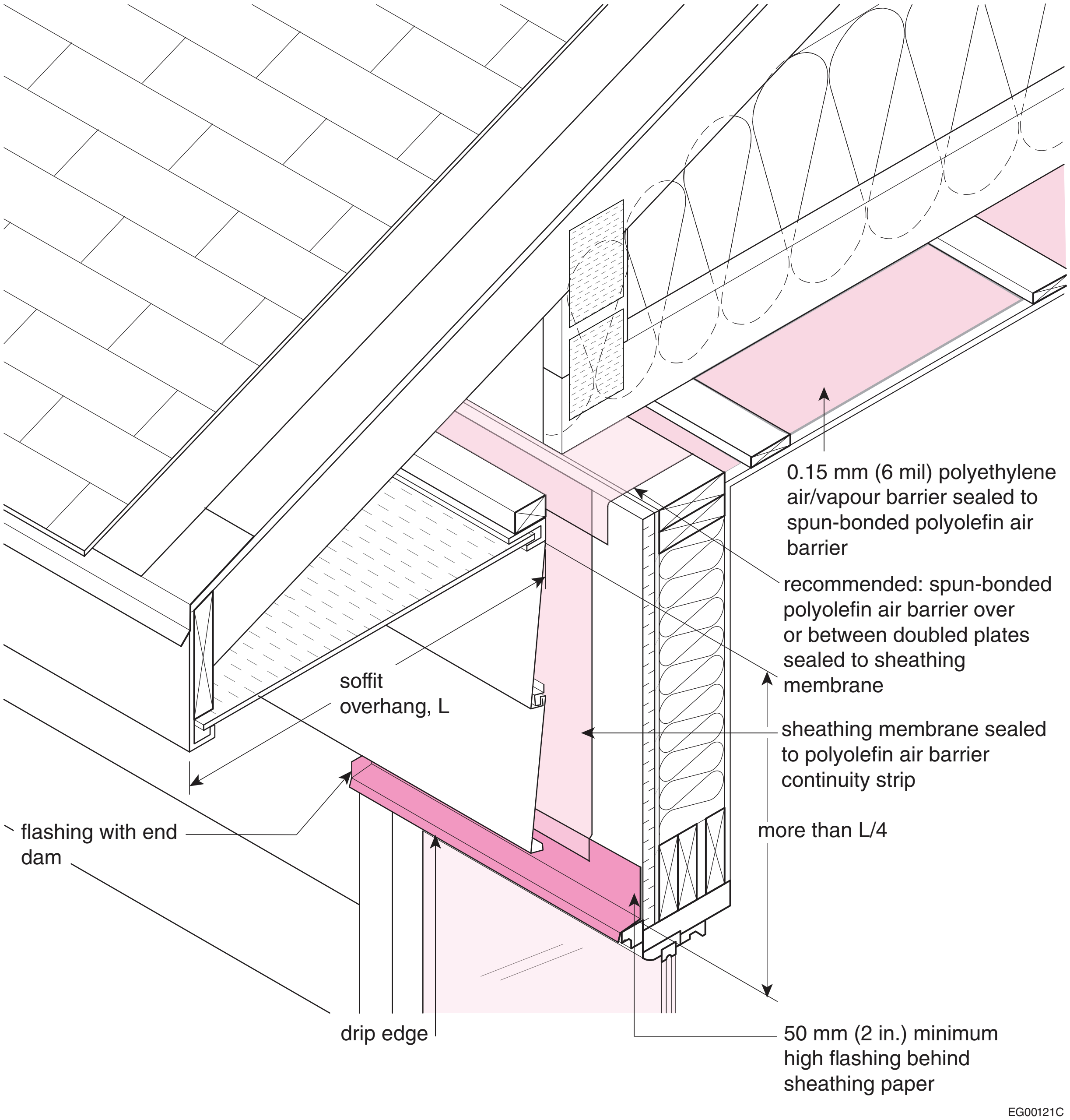


Figure 9.27.-4
Head flashing over window and door openings

Self-flashing sills that slope away from a window, extend beyond the cladding and are provided with a drip notch to prevent water from moving back along the underside of the sill into the cavity may be used in lieu of flashing. Flashing may be omitted under non-jointed masonry window sills where these slope downward and are provided with a drip at least 25 mm (1 in.) from the wall surface (Figure 9.27.-6).

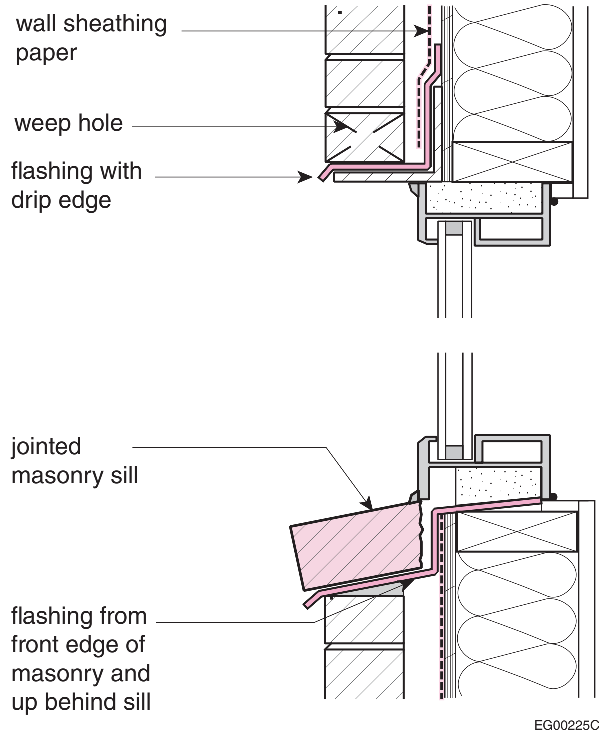


Figure 9.27.-5
Flashing over and under openings

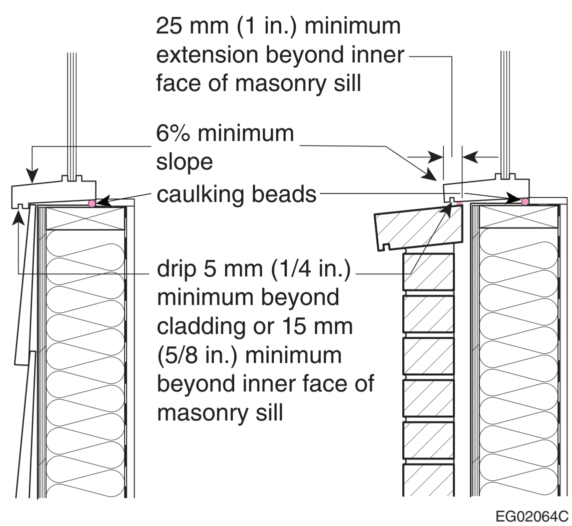


Figure 9.27.-6
Examples of self-flashing sills

9.27.4. Sealants

The NBC requires that sealant be applied at any location through which rain or snow would be able to penetrate into the back-up assembly. Sealant must not only be waterproof but must also be able to resist shrinkage and deterioration from solar exposure.

9.27.4.1. Required Sealants

This Article identifies the locations where caulking is required in order to resist the entry of water into the walls. These locations are at the junctions between cladding materials and window and door trim, and between different cladding materials where they are not lapped or flashed to shed water effectively.

Vertical joints between different cladding materials must be sealed and/or lapped to ensure that rain and snow cannot penetrate the wall assembly. Vinyl siding is subject to considerably greater expansion and contraction due to temperature changes than are other sidings. It should not be restrained by sealants in such a way that buckling may result. Instead, the siding is normally lapped to allow such movement while remaining rain-tight.

9.27.4.2. Materials

This Article defines, through reference to various material standards, the characteristics of different types of sealants and backer rod materials that are required to provide durable seals. Since sealants (caulking) are exposed to the weather, the referenced standards address issues such as the resistance of sealant materials to degrading resulting from solar radiation and periodic wetting and drying cycles. Since the protected joint or junction may be subject to some movement caused by changes in temperature or moisture content of the cladding materials, or building movement, the sealant must remain pliable and retain its adhering qualities for a reasonable time. It must also be compatible with the protected surfaces.

Many sealant joint failures result from improper joint preparation or installation in temperatures that do not respect manufacturers' recommendations. In addition to manufacturers' guidelines, ASTM standards on joint design and use of sealants are referenced in NBC Note A-9.27.4.2.(1), and describe several considerations for applying sealants.

In many cases, the use of backer rods conforming to ASTM C 1330, "Cylindrical Sealant Backing for Use with Cold Liquid-Applied Sealants," would be required to prevent adhesion of the sealant to the backing.

9.27.5. Attachment of Cladding

Cladding is usually attached directly to framing members, furring members or to blocking between the framing members.

9.27.5.1. Attachment

This Article describes the acceptable methods for attaching cladding materials to the building in such a manner as to support their weights, effectively resist the effects of wind action and provide sufficient restraining force to resist the warping of the cladding when lumber siding is used.

Vertical lumber and stucco lath or reinforcing may be directly attached to lumber, plywood, OSB and waferboard sheathing. Soft or friable sheathing materials, such as fibreboard, insulating sheathing and gypsum sheathing, do not provide sufficient nail-holding strength to allow their use for direct attachment of cladding. The minimum sheathing thickness for direct cladding attachment depends on the type of cladding.

Table 9.27.-A summarizes the types of acceptable sheathing materials and their required minimum thicknesses. Vertical wood cladding may warp when subjected to wetting and drying, and this must be resisted by nailing. For this reason, vertical metal or vinyl cladding or shingles and shakes must be supported.

Table 9.27.-A
Sheathing Requirements for Cladding Materials

Cladding Material	Minimum Sheathing Thickness or Lath Size, mm (in.)				
	Sheathing Material				
	Lumber	Plywood	Waferboard	OSB	Wood Lath
Vertical lumber, or stucco lath or reinforcing	14.3 (5/8)	12.5 (1/2)	12.5 (1/2)	12.5 (1/2)	n/a
Vertical metal siding or vinyl siding	14.3 (5/8)	7.5 (1/4)	7.5 (1/4)	7.5 (1/4)	n/a
Wood shingles or shakes	14.3 (5/8)	7.5 (1/4)	7.5 (1/4)	7.5 (1/4)	38 × 9.5 (1 1/2 × 3/8)
Fibre-cement shingles	n/a	n/a	n/a	n/a	89 × 9.5 (3 1/2 × 3/8)

9.27.5.2. Blocking

This Article indicates the minimum size and requirements for blocking as a means for the attachment of cladding. Although blocking between framing members is permitted to be relatively small (38 × 38 mm (2 × 2 in. nominal)), it is usually more practical to use the same size of lumber used for the stud in order to reduce splitting and provide a more solid base for nailing. The maximum vertical spacing for blocking is the same as the maximum stud spacing (600 mm (24 in.) on centre).

Blocking and furring used for the attachment of cladding must be at least as large as the sizes shown in Table 9.27.-B.

Table 9.27.-B
Minimum Sizes of Furring and Blocking for the Attachment of Cladding

Material	Minimum Size, mm (in.)
Furring applied over sheathing(1)	19 × 38 (1 × 2 nominal)
Furring applied without sheathing to supports spaced not more than 400 mm (16 in.) on centre(2)	19 × 64 (1 × 3 nominal)
Furring applied without sheathing to supports spaced not more than 600 mm (24 in.) on centre(2)	19 × 89 (1 × 4 nominal)
Blocking in wall framing(3)	38 × 38 (2 × 2 nominal)

Notes to Table 9.27.B.:
(1) Does not apply to wood laths in Table 9.27.-A.
(2) Support spacing determined by cladding attachment requirements.
(3) Blocking specifically intended to support cladding.

9.27.5.3. Furring

This Article provides the requirements for the attachment of cladding through furring. When furring is used, it is applied over the sheathing paper so that the paper is pressed against the sheathing for maximum airtightness. The minimum width of furring must be increased if it is not supported by sheathing. When sheathing is not provided, the minimum width required depends on the spacing between the furring strips. Furring may be applied horizontally, vertically, or diagonally, depending on the type of cladding used.

9.27.5.4. Size and Spacing of Fasteners

This Article provides the minimum dimensions of fasteners that are adequate for the attachment of cladding. Fastener size and spacing must comply with NBC Table 9.27.5.4. to ensure a minimum standard for proper installation.

The spacing of the fasteners coincides with the spacing of the supporting members. The fastener spacing for panel-type cladding is the same as is required for panel-type sheathing (150 mm (6 in.) along edges and 300 mm (12 in.) along other supports).

9.27.5.5. Fastener Materials

This Article contains the requirements intended to minimize corrosion. Fasteners for cladding are subject to periodic exposure to moisture. They must be able to resist corrosion and not be in contact with other metals that result in deterioration due to galvanic action.

9.27.5.6. Expansion and Contraction

This Article makes allowance for the movement of cladding to reduce the likelihood of buckling. Cladding materials expand and contract with changes in temperature. In wood-based cladding, this movement is relatively small and can be accommodated by the nailing. In the case of aluminum and plastic claddings, however, the movement is greater, and unless allowance is made to permit such movement, the cladding will tend to buckle and take on a wavy appearance in warmer weather.

Fasteners for metal and vinyl siding must be installed in a manner that allows the siding to expand and contract freely without damaging the fasteners or the siding (Figure 9.27.-7). Therefore, fasteners should not be driven so tightly as to prevent this movement.

9.27.5.7. Penetration of Fasteners

This Article requires sufficient fastener withdrawal resistance to resist the effects of wind action on cladding materials, and sufficient length of bearing for the fastener to support the weight of the cladding. Fasteners must be long enough to penetrate the furring or sheathing (if directly attached to it) or at least 25 mm (1 in.) into the furring or blocking.

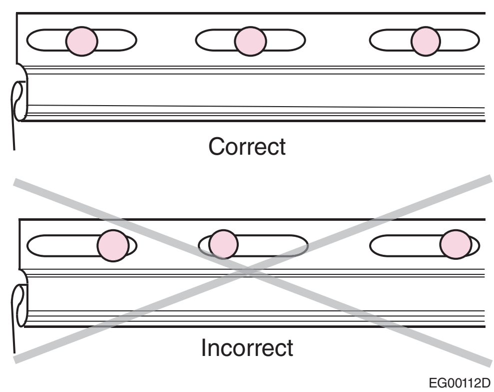


Figure 9.27.-7
Installation of metal or vinyl siding to permit expansion and contraction

9.27.6. Lumber Siding

Lumber siding is a traditional cladding material that has shown very good performance over a long period of time in most Canadian climates, including wet climates. The requirements in this Subsection address most of the installation requirements that pertain to lumber siding. In addition to the prescriptive requirements in NBC Subsection 9.27.6., the general requirements in NBC Subsections 9.27.1. to 9.27.5. must be met.

9.27.6.1. Materials

This Article lists the requirements for lumber siding materials which must be sound and free of knot holes, loose knots, through checks, or splits, in order to ensure they can provide a siding surface that will shed water effectively.

9.27.6.2. Thickness and Width

This Article sets the minimum required thickness and width for siding to reduce the risk of developing checks and splits to a reasonable level, and to provide a surface that is relatively free from warping. Lumber siding swells and shrinks with changes in moisture content. This can cause splits to occur over time because of the shrinkage stresses created in the wood fibres. The wider the member, the greater the shrinkage, and the greater the risk of developing splits in the siding. Similarly, as the thickness of lumber is decreased, there is an increasing tendency for it to warp with changes in moisture content.

Lumber siding is available in a wide variety of shapes and patterns and may be applied horizontally, vertically or diagonally. It may be bevelled and lapped or ship-lapped to shed water when applied horizontally or diagonally. Required widths and thicknesses for lumber siding are shown in Figure 9.27.-8.

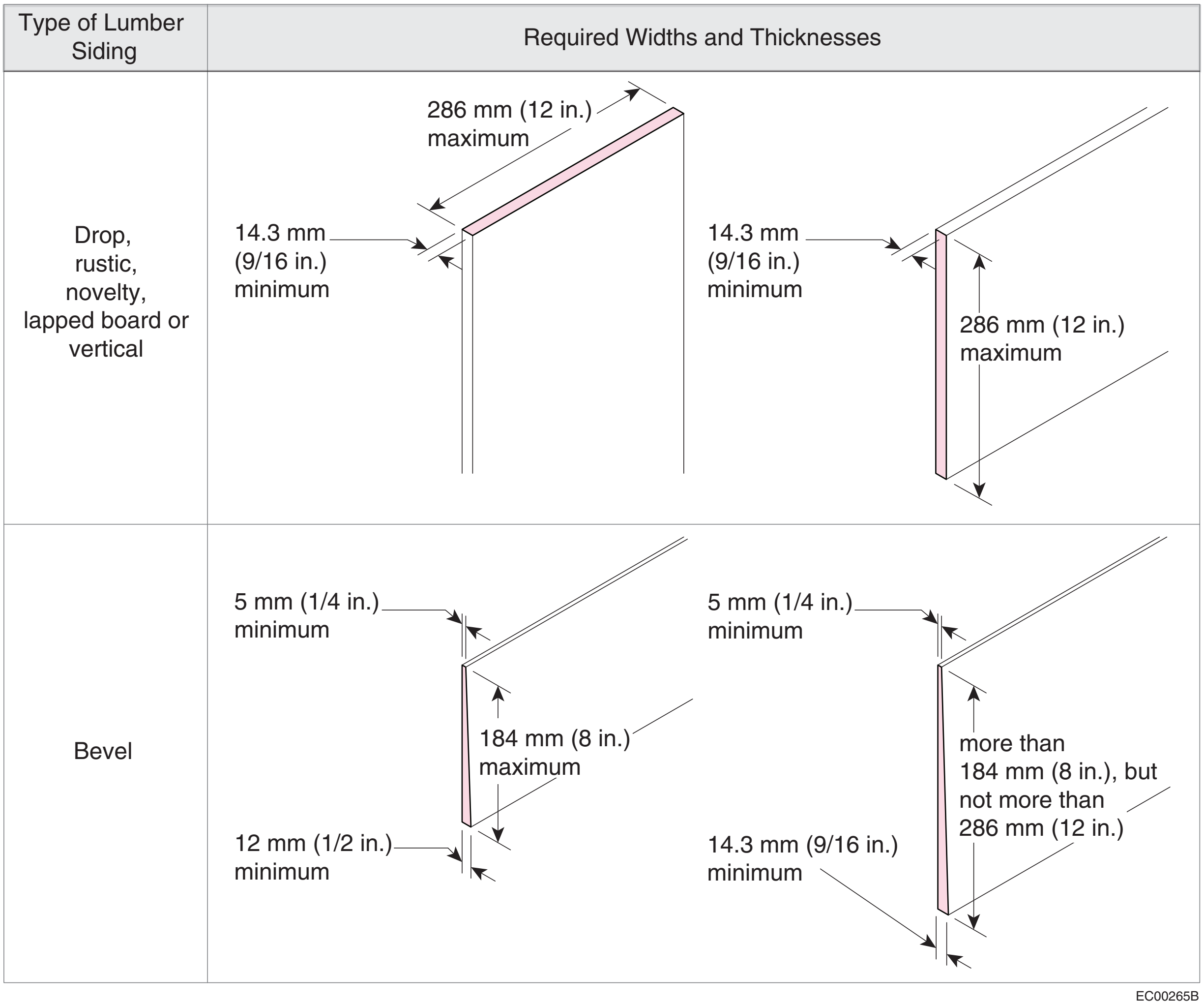


Figure 9.27.-8
Required widths and thicknesses for lumber siding

9.27.6.3. Joints

This Article indicates the requirements for lumber siding joints and overlap to allow lumber siding to accommodate changes in its moisture content without creating cracks between siding members that would cause the entry of rainwater.

When applied vertically, wood siding may have tongued and grooved or ship-lapped edges. It may also have squared edges if applied as board-on-board. The amount of overlap provided by the edge matching must be sufficient to allow shrinkage to occur without exposing the joint to water penetration. This varies with the width of the piece and with the type of siding. The amount of overlap provided to prevent rain leakage is based on traditional practices and tends to be somewhat arbitrary.

Bevelled siding requires more than 2.5 times the overlap of shiplap siding (25 mm (1 in.) versus 9.5 mm (3/8 in.)). Vertical battens, on the other hand, require only half as much overlap as bevelled siding. In no instance, however, should the amount of overlap be less than 1/16 of the width of the siding.

All joints in lumber siding should be installed to prevent the entry of rain and snow by lapping lumber pieces, matching joints (tongue and groove), or using vertical battens. Minimum lapping widths are shown in Figure 9.27.-9.

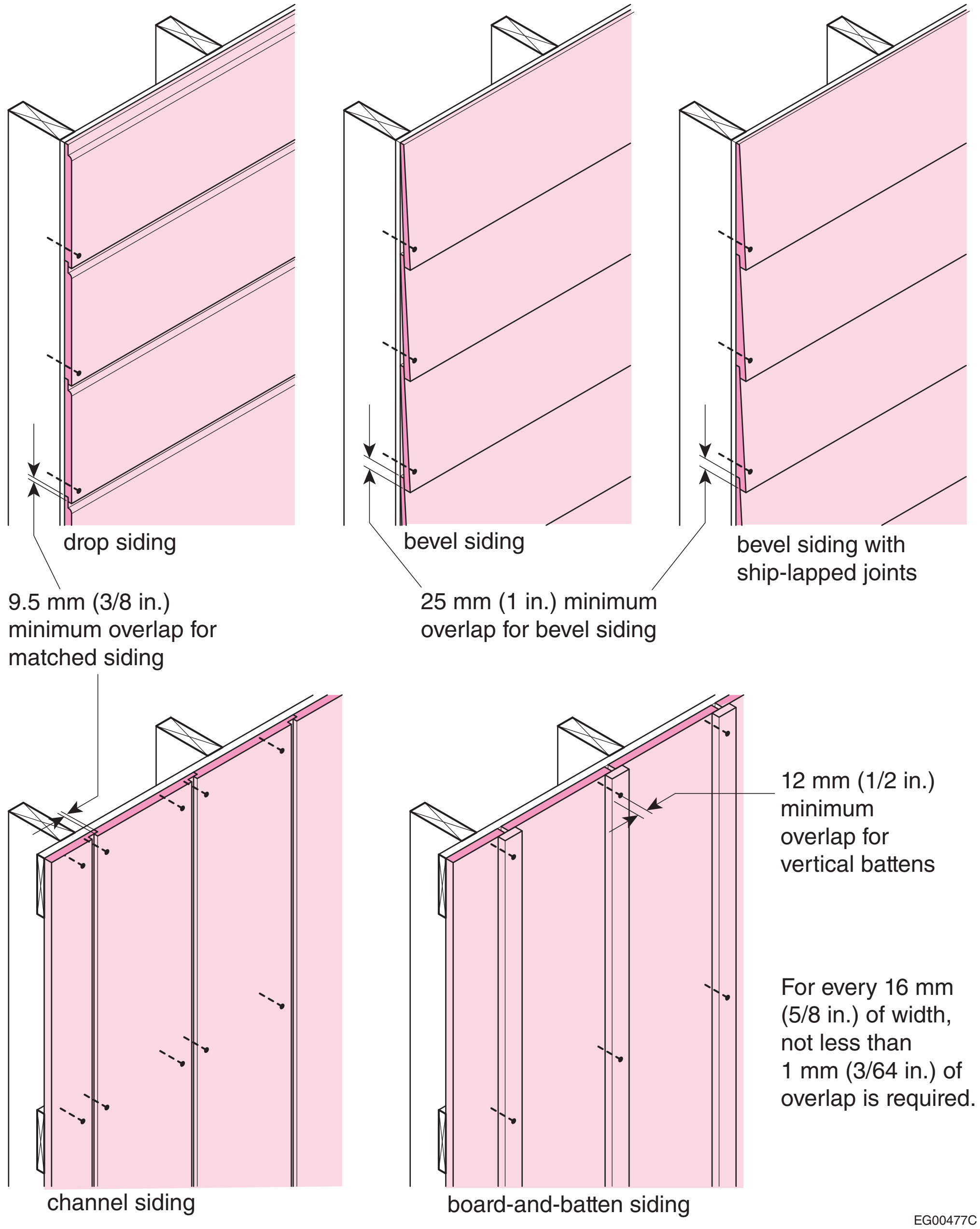


Figure 9.27.-9
Lapping requirements for lumber siding

If siding is overlapped, the fasteners should be located so that the siding can shrink or swell, as individual pieces, without being restrained by the fasteners. If nailing interconnects the siding, splitting may occur as the siding dries. This is important with bevelled, board-on-board and board-and-batten siding (Figure 9.27.-10).

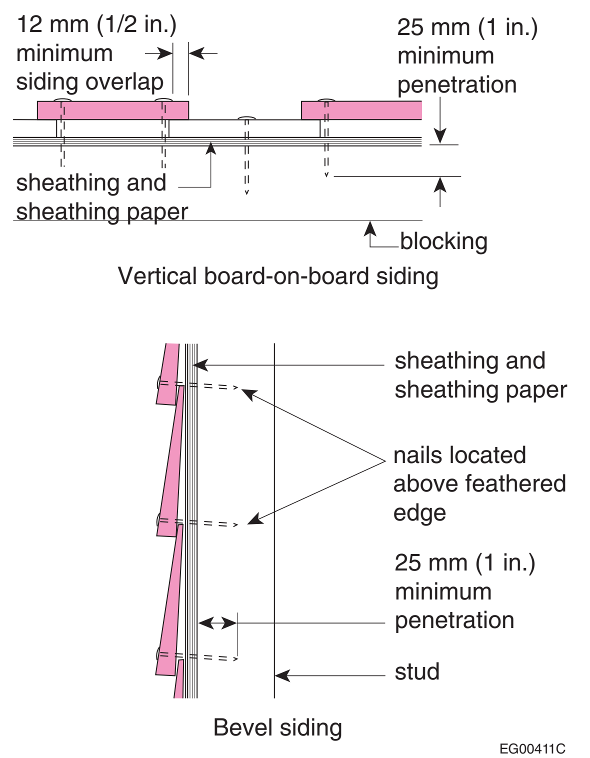


Figure 9.27.-10
Nail location to minimize siding splitting

9.27.7. Wood Shingles and Shakes

Wood shingles and shakes have shown very good performance over a long period of time in most Canadian climates, including wet climates. The requirements in this Subsection address most of the installation requirements that pertain to wood shingles and shakes. In addition to the prescriptive requirements in NBC Subsection 9.27.7., the general requirements in NBC Subsections 9.27.1. to 9.27.5. must be met.

9.27.7.1. Materials

This Article references the standards and acceptable grades for wood shingle and shake materials. All wood shingles and shakes are required to comply with the requirements shown in Table 9.27.-C, and with CSA O118.1, "Western Red Cedar Shakes and Shingles," or CSA O118.2, "Eastern White Cedar Shingles."

Table 9.27.-C
Minimum Grades for Wood Shingles and Shakes

Type of Wood	Type of Cladding	Minimum Grade
Western red cedar	Shakes	No. 1
	Shingles	No. 2
	Shingles for lower course of double-course application	No. 3
Eastern white cedar	Shingles	B (clear)
	Shingles for lower course of double-course application	C

9.27.7.2. Width

This Article indicates the range of widths acceptable for shingles and shakes to reduce the risk of splitting as the shingles dry and to avoid the use of shingles that are too small to provide sufficient lap over joints and other defects in the under-courses. In the traditional single-course pattern (Figure 9.27.-11), the shingles or shakes are applied so that the nail heads are hidden. In the double-course pattern, the shingle exposure is greater but the nail heads are exposed.

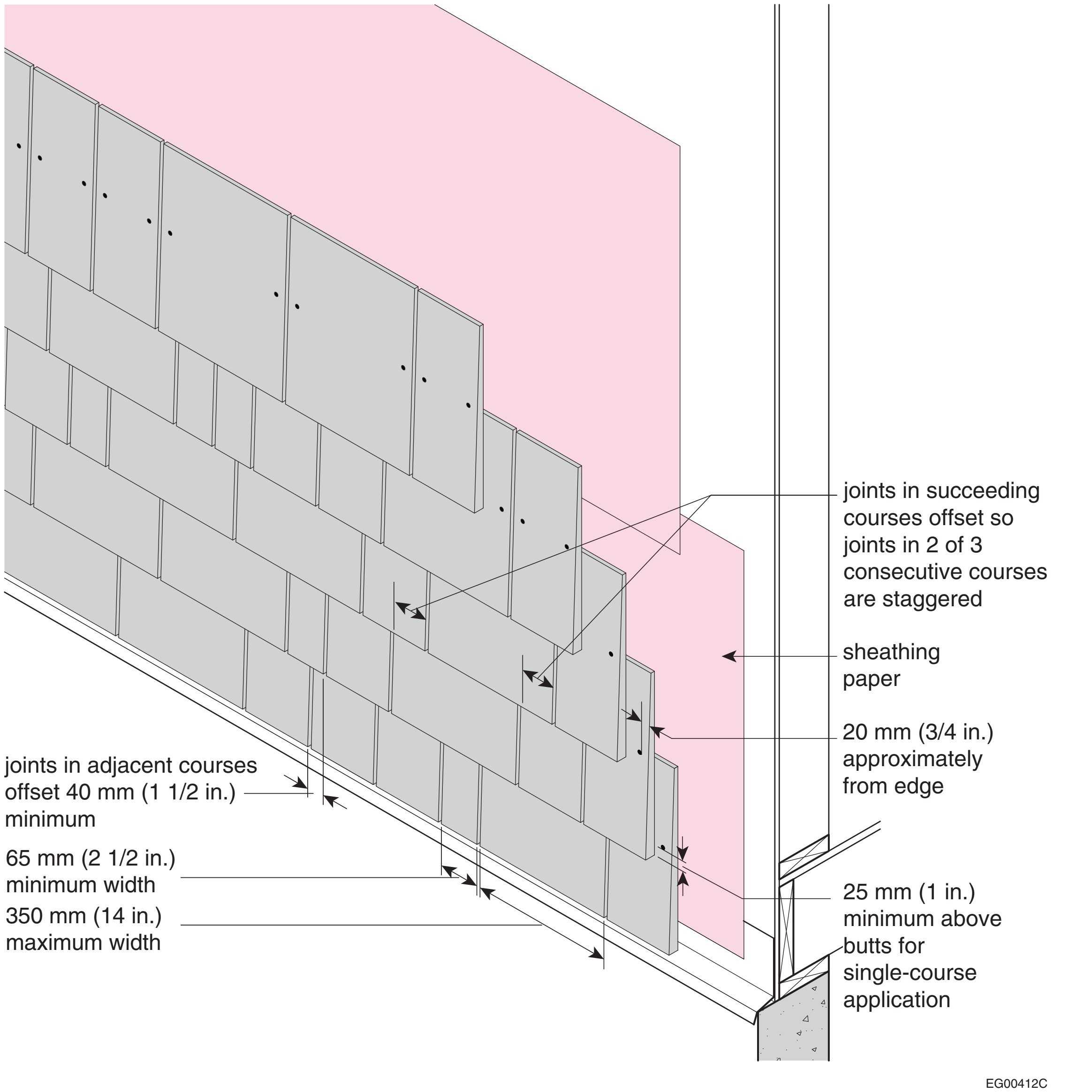


Figure 9.27.-11
Single-course application of wood shingles and shakes

When laid in a double-course style (Figure 9.27.-12), the butts of the under-course rest on top of a lath furring strip, while the top course is nailed to the lath. This allows the use of sheathing materials that cannot provide sufficient nail-holding power for direct fastening. When applied without furring (over a base that allows for direct fastening), the same general pattern is used as that shown in Figure 9.27.-12, although in this case the outer course is applied with the butts only 12 mm (7/16 in.) below the butts of the under-course.

9.27.7.3. Fasteners

This Article indicates the fastening requirements to ensure wood shingles and shakes are attached to a wall in such a manner as to resist the effects of wind action and to support their weight. Since fasteners provide an opportunity for rainwater leakage, they are located so that they are not exposed to rainwater.

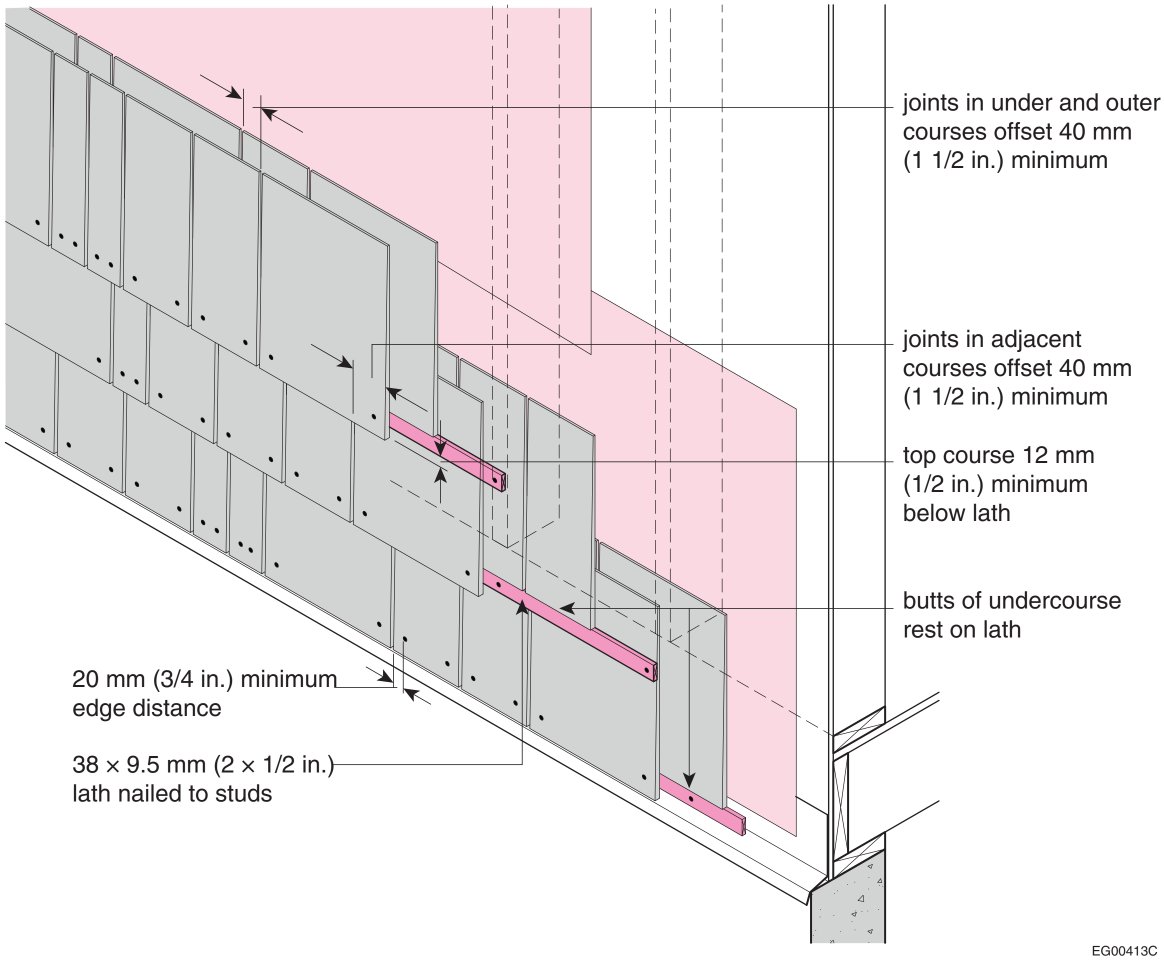


Figure 9.27.-12
Double-course application of shingles and shakes using lath

9.27.7.4. Offsetting of Joints

This Article describes the required lapping of shingles over the joints in the under-courses to avoid the entry of rainwater into the wall.

The same general requirements for the offsetting of joints in adjacent and alternate courses that apply to shingles and shakes on roofs also apply to walls. The allowable exposure on walls is somewhat greater, since the vertical orientation sheds rain more effectively. Shingles and shakes are available in three lengths and, as with roof shingles, the amount of allowable exposure depends on their lengths. Exposure also depends on whether the shingles or shakes are applied in a single- or double-course pattern.

The offsetting of shakes and shingles in single-course applications must be such that any two of three successive courses are staggered at least 40 mm (1 1/2 in.) (see Figure 9.27.-11). A double-course application requires that joints be staggered at least 40 mm (1 1/2 in.) between outer courses and under-courses, as well as between successive courses (see Figure 9.27.-12).

9.27.7.5. Fastening to Lath

This Article provides a method for attaching shingle and shake claddings that will resist the effects of wind action, and support the weight of the cladding.

When lath is used in a double-course application, the butt ends of the under-course must bear on the top edge of the lath. Nailing of the outer course must penetrate the lath.

9.27.7.6. Exposure and Thickness

This Article requires sufficient overlapping of shingles to enable them to shed rainwater effectively and avoid the entry of rainwater into the wall. A second purpose is to provide a sufficient thickness of material to provide a reasonable life expectancy as the shingle erodes from weathering.

The allowable exposure of shakes and shingles is provided in NBC Table 9.27.7.6. If wood lath is used, it must be spaced according to the allowable exposure.

9.27.8. Plywood

Plywood cladding is available in a variety of forms. It may be used as plain large panels with squared edges, or patterned to simulate vertical board-on-board or board-and-batten siding with shiplap edges. Plywood may also be applied as horizontal strips to resemble bevelled siding. In addition to the prescriptive requirements in NBC Subsection 9.27.8., the general requirements in NBC Subsections 9.27.1. to 9.27.5. must be met.

9.27.8.1. Material Standards

This Article defines, through reference to various standards, the characteristics needed for plywood cladding to meet the purposes of NBC Article 9.27.2.1.

Exterior plywood cladding must comply with the standards listed in the NBC. The thickness of exterior plywood must conform to the values shown in NBC Table 9.27.8.2. For grooved or textured plywood, thickness is measured at the point of least thickness. It is important to check that all edges are sealed with a primer or shellac to protect the inner plies from exposure.

9.27.8.2. Thickness

This Article requires a minimum thickness for plywood cladding to ensure adequate strength and stiffness to resist forces due to wind action as well as impact loads that may occur. A second purpose is to provide sufficient thickness to allow for the erosion of the plywood over time due to weathering.

The thickness required for plywood and OSB cladding depends on how it is supported, and the direction of the wood fibres relative to the supports. When sheathing supports such cladding, only a minimum thickness is required (6 mm (1/4 in.)) to ensure reasonable durability to weathering. If the cladding spans between framing or furring supports, however, its thickness depends on the spacing of those supports, as well as on the direction of the grain in the face-plies. Since plywood is stronger in the direction of the surface grain, its thickness can be less than if the cladding is applied at right angles to the supports.

9.27.8.3. Edge Treatment

This Article requires that the edges of plywood be treated to restrict the entry of water. This can lead to paint peeling and eventual delamination of the plies near the edges.

All plywood edges should be sealed to reduce water absorption and swelling. If plywood is painted, continued weathering eventually causes surface cracks in the paint film. The surface plies tend to compress across the grain during periods of wetness, and shrink during periods of dryness. This action eventually causes the paint film to fail unless a bonded substrate is applied to the surface of the plywood before it is painted. Penetrating stains can also be used, and while these do not prevent surface cracks from appearing in the plywood, they are usually less noticeable.

9.27.8.4. Panel Cladding

This Article indicates the requirements to provide adequate support at the edges of the plywood sheets to enable the cladding to withstand wind and impact forces.

Plywood panels used for wall cladding must have all their edges supported. All panels and butted ends of lapped strips are required to be spaced apart.

Panels must have their vertical joints protected from the rain, such as by vertical wood strips (battens) or by the use of ship-lapped joints. Although sealant is permitted as an alternative, such joints do not usually have as great a life expectancy and may require periodic inspection and maintenance for ongoing effectiveness. To allow for expansion, a small gap, at least 2 mm (3/32 in.), is required between sheets (Figure 9.27.-13).

Horizontal joints must be lapped at least 25 mm (1 in.) or, for panels, flashed. Vertical joints between siding strips must be sealed. Note that plywood more than 12.5 mm (1/2 in.) thick must be installed outboard of a vented air space (see NBC Articles 9.25.5.1. and 9.25.5.2.).

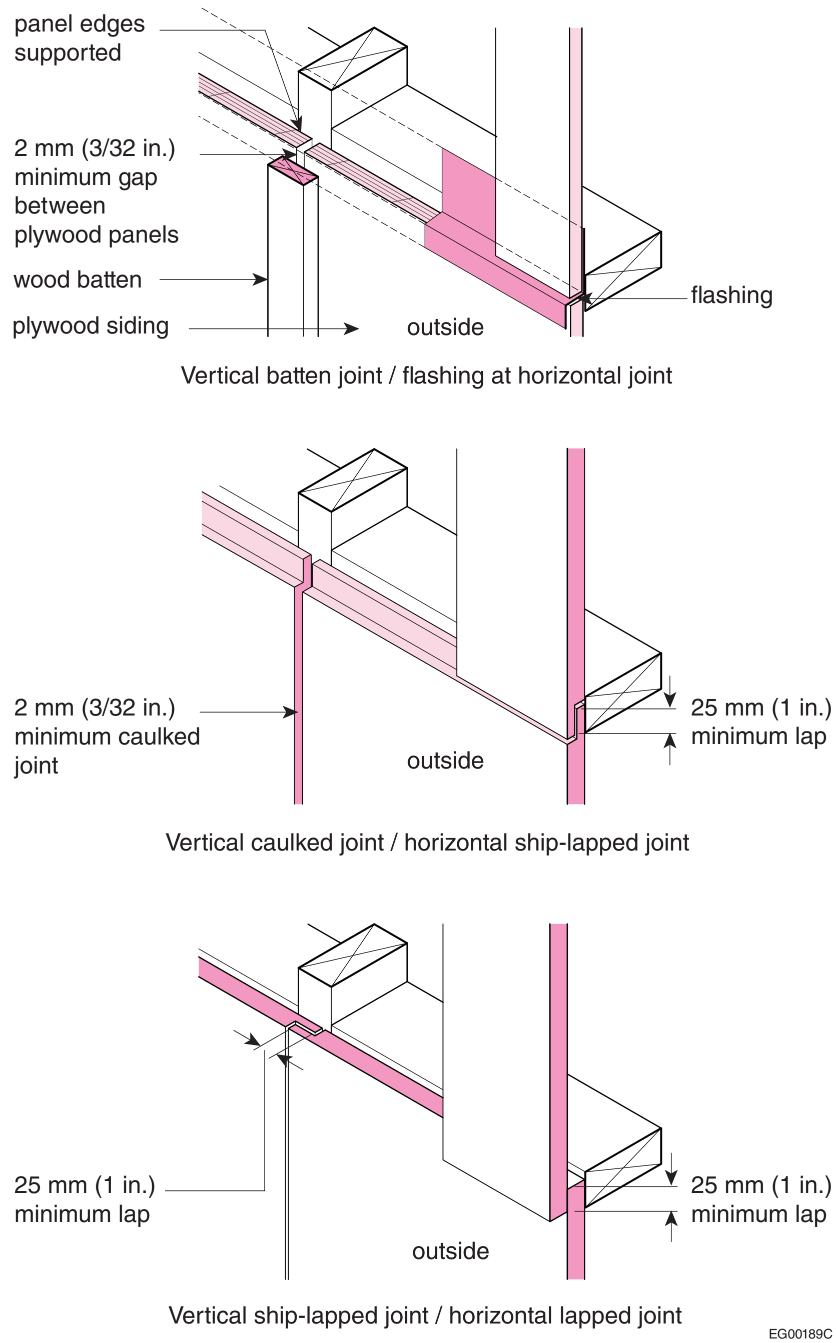


Figure 9.27.-13
Horizontal and vertical joint requirements for plywood cladding

9.27.8.5. Lapped Strip Siding

This Article indicates the requirements for lapped strip siding. Horizontal lapping provides support at the edges of strip plywood siding to withstand impact forces and to keep the edges in alignment where they butt together. A second purpose is to provide a sufficient overlap for the siding to shed water effectively. The butt joints are designed to allow the plywood to expand without buckling while still maintaining watertightness.

Plywood strip siding applied without sheathing requires that wedges fit in snugly between the framing and the boards at vertical butt joints and corners (Figure 9.27.-14).

9.27.9. Hardboard

Hardboard siding is a cladding material installed either vertically or horizontally. In addition to the prescriptive requirements in NBC Subsection 9.27.9., the general requirements in NBC Subsections 9.27.1. to 9.27.5. must be met.

9.27.9.1. Material Standards

This Article defines, through reference to standards, the required characteristics of hardboard cladding. Hardboard cladding, like plywood cladding, is available either in panel form or as horizontal strips. The CGSB standard that regulates the manufacturing of hardboard, CAN/CGSB-11.3-M, "Hardboard," recognizes five different types. Type 1, "Standard Hardboard," is the most dense.

Type 2, "Tempered Hardboard," is similar to Type 1, except that it is treated with oil blends and oxidizing resins, which give improved properties of stiffness, strength, surface hardness and water resistance. Type 3, "Service Hardboard," and Type 4, "Tempered Service Hardboard," have lower strength properties and greater water absorption characteristics than do Types 1 and 2. They are not intended for use as cladding materials.

Type 5, "Exterior Cladding," although less dense than Types 1 and 2, is usually thicker and specifically designed as cladding material. It can be manufactured with various embossed patterns or with plain surfaces.

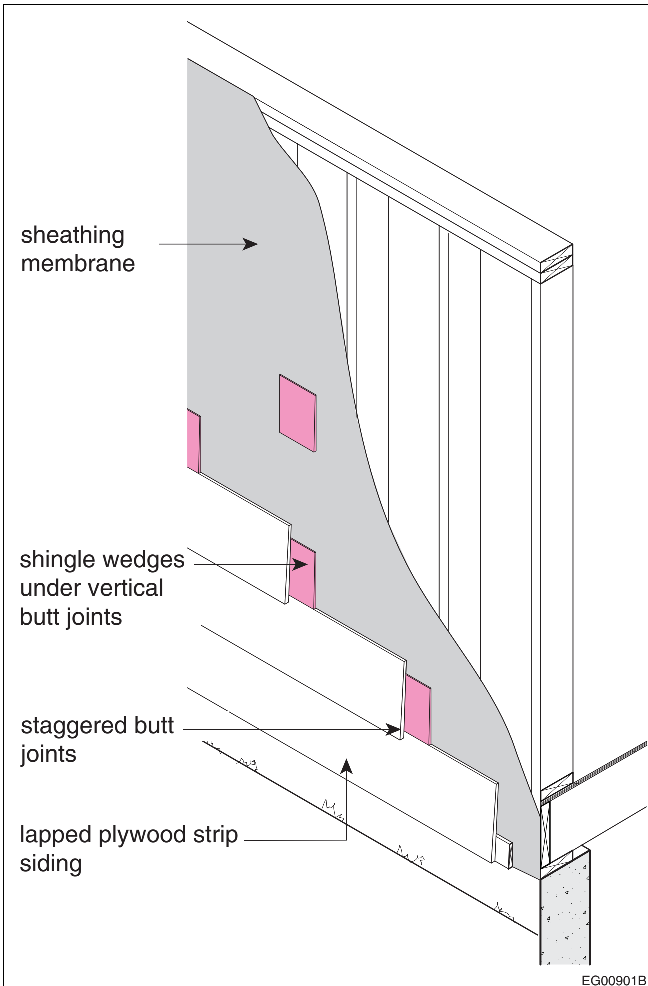


Figure 9.27.-14
Lapped plywood strip siding applied without sheathing

9.27.9.2. Thickness

This Article sets a minimum thickness to provide hardboard cladding with adequate strength and stiffness to resist forces due to wind action as well as impact loads that may occur.

The minimum thickness of hardboard exterior finishing must comply with values listed in Table 9.27.-D. Grooves deeper than 1.5 mm (1/16 in.) may be used in thicker cladding provided they do not reduce the thickness to less than the required thickness minus 1.5 mm (1/16 in.). Thus, for Type 1 or 2 cladding, grooves must not reduce the thickness to less than 4.5 mm (3/16 in.) or 6 mm (1/4 in.), depending on the method of support, or to less than 7.5 mm (5/16 in.) for Type 5 material.

Table 9.27.-D
Minimum Thicknesses for Hardboard

Type of Hardboard	Type of Support	Minimum Thickness of Hardboard,(1) mm (in.)
Type 1 or 2	Sheathing providing continuous support	6.0 (1/4)
	Furring or framing members spaced at not more than 400 mm (16 in.) on centre	7.5 (5/16)
Type 5	Sheathing providing continuous support	9.0 (3/8)
	Furring or framing members spaced at not more than 400 mm (16 in.) on centre	9.0 (3/8)

Table 9.27.-D (Continued)

Notes to Table 9.27.D.:

(1) Where hardboard cladding is grooved, the grooves must not extend more than 1.5 mm (1/16 in.) into the minimum required thickness (NBC Sentence 9.27.9.2.(3)).

Because of the lower strength characteristics of Type 5 hardboard, the minimum thickness permitted for cladding is greater than that required for Types 1 or 2 (9 mm (3/8 in.) versus 6 mm (1/4 in.)), when applied directly to sheathing. Grooves or embossing are permitted to extend 1.5 mm (1/16 in.) into the minimum required thickness.

Although hardboard readily accepts surface paint treatments, the majority of hardboard claddings used are factory-finished. Any cuts made on site should not be left unsealed because moisture may deform the material.

9.27.9.3. Panel Cladding

This Article lists the requirements for the edges and joints in panel cladding to provide adequate support and enable the cladding to withstand wind and impact forces.

9.27.9.4. Lapped Strip Siding

This Article indicates the requirements for joints and lapping in panel cladding. This is to provide adequate support at the edges of lapped strip hardboard cladding to withstand impact forces, and to keep the edges in alignment where they butt together. A second purpose is to provide a sufficient overlap for the siding to shed water effectively.

Shrinkage and swelling due to changes in moisture content are substantially greater for hardboard than for plywood. Because of this, a larger gap (5 mm (3/16 in.)) is required between panels or at the ends of horizontal strip cladding. In addition, a clearance is required between the cladding and any door or window frames (3 mm (1/8 in.)) to provide for expansion. These clearance gaps should be sealed or protected with a batten or moulding.

Horizontal lapped hardboard strips must be lapped at least 1 mm (1/32 in.) for every 16 mm (5/8 in.) of strip width and a minimum of 9.5 mm (3/8 in.) for matched strips and 25 mm (1 in.) for normal lapped boards.

9.27.9.5. Clearance

This Article requires a minimum clearance between hardboard cladding and door and window frames. This is to allow hardboard cladding to expand at window and door openings without causing it to buckle. Hardboard panels must follow the same installation requirements as plywood as shown in Figure 9.27.-13 except that the edges must be spaced at least 3 mm (1/8 in.).

9.27.10. OSB and Waferboard

Although OSB and waferboard are sometimes used as cladding for cottages, camps, farm buildings, accessory buildings and temporary buildings, they are seldom used as cladding for principal residences. In addition to the prescriptive requirements in NBC Subsection 9.27.10., the general requirements in NBC Subsections 9.27.1. to 9.27.5. must be met.

9.27.10.1. Material Standard

This Article defines, through reference to a standard, the characteristics needed for OSB and waferboard to meet the purposes of NBC Article 9.27.2.1. All OSB and waferboard exterior finishes must conform to CSA O437.0, “OSB and Waferboard.”

9.27.10.2. Thickness

This Article requires a minimum thickness to enable OSB and waferboard cladding to have adequate strength and stiffness to resist forces due to wind action as well as impact loads that may occur. A second purpose is to provide sufficient thickness to allow for the erosion of the OSB and waferboard over time due to weathering. The thicknesses required for waferboard and O-1 grade OSB are slightly greater than those required for plywood and O-2 grade OSB. In general, however, the same joint treatment specified for plywood applies to OSB and waferboard.

OSB and waferboard thicknesses for cladding are listed in Table 9.27.-E.

Table 9.27.-E
Minimum Thicknesses for OSB and Waferboard

Material	Minimum Thickness, mm (in.)		
	Applied directly to sheathing	Applied to supports spaced at not more than 400 mm (16 in.)	Applied to supports spaced at not more than 600 mm (24 in.)
O-1 grade OSB or R-1 grade waferboard	7.9 (5/16)	9.5 (3/8)	12.7 (1/2)
O-2 grade OSB			
face orientation parallel to supports	6 (1/4)	8 (5/16)	11 (7/16)
face orientation perpendicular to supports	6 (1/4)	6 (1/4)	8 (5/16)

9.27.10.3. Panel Cladding

This Article lists the requirements for edges in panel cladding to provide adequate support and enable the cladding to withstand wind and impact forces. An additional purpose is to restrict the entry of water into the edges of the board. This can lead to paint peeling and swelling of the board at the edges. Exterior finished boards must have all edges primed (or sealed) and supported.

Boards that are lapped must be lapped with at least a 25 mm (1 in.) overlap. Horizontal flush joints must be flashed in the same manner as plywood and hardboard. Vertical joints must be caulked, or protected with battens or suitable mouldings.

9.27.10.4. Clearance

This Article requires a minimum clearance to allow OSB and waferboard cladding to expand at window and door openings without causing it to buckle. OSB and waferboard cladding must have a 3 mm (1/8 in.) space between all edges and between the cladding and door or window frames.

9.27.11. Metal

Metal is a common cladding material. In addition to the prescriptive requirements in NBC Subsection 9.27.11., the general requirements in NBC Subsections 9.27.1. to 9.27.5. must be met. Some types of metal cladding are installed to become very air and vapour tight. In this case, the requirements in NBC Subsection 9.25.5. are triggered and such cladding would need to be installed outside of a vented air space (see NBC Clause 9.25.5.2.(1)(c)).

9.27.11.1. Material Standards

This Article defines, through reference to standards, the required characteristics of metal cladding. Metal claddings are available in strips designed for vertical and horizontal applications. Sheet aluminum cladding is also used in manufactured home construction. Each system has its appropriate accessory pieces for corners, finishing strips, flashing and trim, which have become part of standard trade practices.

Table 9.27.-F identifies requirements for steel and aluminum siding. The installation of siding must be done in accordance with NBC Article 9.27.3.8. and NBC Subsections 9.27.4. and 9.27.5. The standards governing metal and aluminum siding materials are listed in Table 9.27.-F.

Table 9.27.-F
Minimum Thicknesses for Steel and Aluminum Siding

Material	Minimum Thickness, mm (mil)	Applicable Standard
Horizontal or vertical strip steel siding (including flashing and trim accessories)	n/a	CAN/CGSB-93.4
Steel sheet cladding	0.3 (12)	CAN/CGSB-93.3-M
Horizontal or vertical strip aluminum siding	n/a	CAN/CGSB-93.2-M
Aluminum sheet cladding		
not supported by backing or sheathing	0.58 (23)	CAN/CGSB-93.1-M
supported by backing or sheathing	0.46 (18)	CAN/CGSB-93.1-M

Metal cladding is somewhat more prone to damage from impact, so a greater metal thickness is required when it is used without a protecting backer board. If the cladding is flat against the sheathing, the increased thickness is not required. Manufacturers usually provide installation instructions that are included with every package of material, so these should also be checked on site.

Additional information on the installation of factory manufactured claddings can be found in a number of available installation standards.(6)(7)(8) These, however, are not referenced as mandatory standards in NBC Part 9.

9.27.12. Vinyl Siding

Vinyl is a common cladding material. In addition to the prescriptive requirements in NBC Subsection 9.27.12., the general requirements in NBC Subsections 9.27.1. to 9.27.5. must be met. Some types of vinyl cladding are installed to become very air and vapour tight. In this case, the requirements in NBC Subsection 9.25.5. are triggered and such cladding would need to be installed outside of a vented air space (see NBC Clause 9.25.5.2.(1)(c)).

9.27.12.1. Material Standard

This Article defines, through reference to a standard, the required characteristics of vinyl siding. Vinyl siding must conform to CAN/CGSB-41.24, “Rigid Vinyl Siding, Soffits and Fascia.”

9.27.12.2. Attachment

This Article refers to the requirements of NBC Subsection 9.27.5. for the attachment of vinyl siding. Cladding materials are attached to the building in such a manner as to support their weights and effectively resist the effects of wind action. A second purpose is to provide sufficient restraining force to resist warping of the cladding when lumber siding is used. The installation of siding must accommodate expansion and contraction of the material as illustrated in Figure 9.27.-7.

9.27.13. Exterior Insulation Finish Systems

Exterior insulation finish systems (EIFSs) are common cladding systems. Such systems must meet the general requirements for cladding in NBC Subsections 9.27.1. to 9.27.5., in addition to the prescriptive requirements for EIFSs in this Subsection.

9.27.13.1. Application

This Article states that NBC Subsection 9.27.13. applies to EIFSs that are covered in the scope of CAN/ULC-S716.1, “Exterior Insulation and Finish Systems (EIFS) – Materials and Systems,” and that have

(6) CAN/CGSB-41.33-M87, Installation of Rigid Vinyl Residential Siding, Soffits and Fascia, Canadian General Standards Board, Ottawa.

(7) CAN/CGSB-11.6-M87, Installation of Exterior Hardboard Cladding, Canadian General Standards Board, Ottawa.

(8) CAN/CGSB-93.5-92, Installation of Metal Residential Siding, Soffits and Fascia, Canadian General Standards Board, Ottawa.

a geometrically defined drainage cavity (i.e., a pre-shaped backing board, as explained in NBC Note A-9.27.13.1.(1)) with a minimum cavity depth of 10 mm (3/8 in.) and an open area equal to not less than 13% of the area of the full-size EIFS panel. The cavity requirements for such EIFSs (which are used together with a water-resistive barrier that is more robust than a typical sheathing membrane) balance the need for drainage with the need to minimize thermal losses through the cavity and the need to address construction tolerances.

EIFSs that are not covered by NBC Subsection 9.27.13. must be designed according to NBC Part 5.

9.27.13.2. Materials

This Article states that the materials used in EIFSs must conform to CAN/ULC-S716.1, "Exterior Insulation and Finish Systems (EIFS) – Materials and Systems," and that the substrate on which the EIFS is installed must be compatible with the particular system and must comply with structural requirements for sheathing materials in NBC Section 9.23. NBC Note A-9.27.13.2.(2)(a) lists substrates that are generally considered to be acceptable for EIFSs; however, individual substrates may not be compatible with some systems.

9.27.13.3. Design and Installation

This Article states that the design and installation of EIFSs must comply with CAN/ULC-S716.2, "Exterior Insulation Finish Systems (EIFS) – Installation of EIFS Components and Water Resistive Barrier," and CAN/ULC-S716.3, "Exterior Insulation Finish Systems (EIFS) – Design Application." In addition to adhering to these standards, builders, designers and installers should follow the EIFS manufacturer's installation instructions.

Section 9.28.
Stucco

Introduction

Stucco is a Portland cement mortar material applied to the surface of any building or structure to form a hard and durable covering for the exterior walls. Stucco is a cladding and must conform to NBC Subsections 9.27.1. to 9.27.5. It is not a face-sealed exterior cladding system, so it is critical that the sheathing membrane and flashings be installed carefully. Through-the-wall penetrations, such as windows, doors and vents, must be flashed in such a way as to allow integration with the sheathing membrane and stucco accessories, so that any water that penetrates the stucco will be directed to the exterior. Parging should not be confused with stucco. Information on parging of foundations is found in NBC Subsection 9.15.6.

9.28.1. General

Stucco can be applied as a weathering surface either to masonry or to wood-frame construction. Normally, stucco is applied over a reinforcing lath or mesh, although it can also be applied directly to sound, clean masonry if it is sufficiently rough to provide good adhesion.

The requirement that tar-saturated building paper not be used under stucco has been removed from the NBC because this results in an appearance problem, which cannot, as such, be linked to NBC objectives. It remains good practice to avoid such problems (see NBC Article 9.27.3.3.).

Additional information about stucco is available in the "NBC Portland Cement Plaster (Stucco) Manual," published by the Portland Cement Association.

9.28.1.1. Sheathing beneath Stucco

This Article requires sheathing beneath stucco to provide a firm base over which an even coat of stucco can be applied with sufficient pressure to fully embed the lath or reinforcing. While there are a number of construction advantages in using sheathing, it is not necessary for the purpose of providing additional strength to the stucco in resisting horizontal forces. Reinforced stucco is much stiffer than are common sheet-type sheathings, and therefore takes most of such loads. Sheathing may be omitted if horizontal reinforcing wires are provided to support the stucco lath or reinforcing during the application of stucco so that the metal can be fully embedded. Paper-backed welded wire lath also allows the metal to be fully embedded in the stucco, making sheathing unnecessary.

Sheathing is required behind stucco except as noted in NBC Article 9.28.4.2. Where sheathing is installed, it must be of a minimum thickness, conforming to the values listed in NBC Subsection 9.23.17. However, in high wind and seismic areas, sheathing is required (see NBC Subsection 9.23.13.).

9.28.1.2. Lath and Reinforcing

This Article requires stucco lathe or reinforcing to provide a good bond for stucco and minimize cracking. Both stucco lath and reinforcing provide a means for securing stucco, supporting its weight, and reducing the size of shrinkage cracks. Stucco lath or stucco reinforcement must be used for the attachment of stucco to wood-frame walls.

Stucco lath must be used to attach stucco to soft burned tile or brick. Lath is required when a masonry substrate is not sound and clean. When stucco is applied to masonry chimneys, reinforcing is necessary to reduce the risk of stucco cracks as a result of thermal expansion of the masonry.

9.28.1.3. Concrete Masonry Units

This Article limits the application of stucco finish over concrete masonry units less than a month old to minimize the cracking of stucco applied over masonry units. Masonry units that have not been cured by the autoclave process (i.e., steam cured) shrink after manufacture due to the occurrence of continuing drying and curing. If stucco is applied over such units too soon after manufacture, shrinkage cracks may result.

9.28.1.4. Clearance over Ground Level

This Article requires that a minimum clearance be provided between stucco and the ground. Stucco applied over wood-frame construction that is too close to the ground will expose the sheathing and framing to ground moisture and back splash from rain. This could lead to an eventual deterioration or decay of the sheathing and framing. Stucco must be at least 200 mm (8 in.) above the ground when applied over frame construction.

9.28.1.5. Flashing and Caulking

This Article requires flashing and caulking to avoid the entry of rainwater. Flashing and caulking, where required, must conform to NBC Subsections 9.27.3. and 9.27.4.

Although the requirements that pertain to flashing and caulking for stucco are similar to those that apply to cladding materials (described in NBC Section 9.27.), when aluminum flashing is used with stucco, it must be protected by a membrane or coating to keep it from coming in contact with the stucco. Otherwise, the cementitious materials in the stucco will corrode the aluminum.

9.28.2. Stucco Materials

The NBC does not address stucco accessories. The stucco industry recommends that all stucco trims and accessories be fabricated of 0.51 mm (24 gauge) galvanized steel, zinc, extruded aluminum or polyvinyl chloride (PVC). Plaster stops and casing beads should be 18.5 mm (3/4 in.).

9.28.2.1. Portland Cement

This Article, through reference to a standard, describes the characteristics of Portland cement that has the necessary properties to produce stucco that will perform all its required functions. Since stucco performs the same function as siding, comparable provisions have the same purposes as described for siding.

9.28.2.2. Aggregate

This Article indicates the requirements for stucco aggregate to enable the production of stucco that will perform all its required functions. If aggregate is not well graded, it will require an excessive amount of Portland cement to provide durable stucco that will resist rainwater and cycles of freezing and thawing.

Stucco aggregate for mixing must be clean, properly graded, free of any significant contaminating material, and graded in accordance with the values listed in NBC Table 9.28.2.2. The aggregate can be either natural sand, sand manufactured from crushed stone, gravel, or air-cooled blast furnace slag.

9.28.2.3. Water

This Article requires mix water that will provide stucco to fulfill the function of an exterior cladding. Dirty water can cause stucco to deteriorate prematurely.

9.28.3. Fasteners

9.28.3.1. Materials

This Article requires that fasteners used to attach metal lath or reinforcing be corrosion-resistant. Since stucco fasteners are subject to wetting even though they are covered by stucco, they must be corrosion-resistant. Aluminum is not used because it reacts with Portland cement in the stucco, which shortens the life expectancy of the fasteners.

9.28.3.2. Nails and Staples

This Article lists fastener requirements for the attachment of metal lath or reinforcing that will support the weight of the stucco and resist wind loads. Wall stucco is partly self-supporting, so the withdrawal resistance required for walls (i.e., fastener penetration) is less than for stucco applied to soffits or carport ceilings (Table 9.28.-A).

Table 9.28.-A
Minimum Dimensions for Fasteners Used to Attach Stucco Lath or Reinforcing

Type of Fastener	Minimum Shaft Diameter or Thickness, mm (in.)	Minimum Head Diameter, mm (in.)	Minimum Penetration into Vertical Framing, mm (in.)	Minimum Length on Horizontal Surfaces, mm (in.)
Nails	3.2 (1/8)	11.1 (7/16)	25 (1)	38 (1/2)
Staples	1.98 (1/8)	n/a	25 (1)	n/a

Stucco wall lath or reinforcing is normally attached to wood framing members with galvanized roofing nails or staples that penetrate at least 25 mm (1 in.) into the framing. Although it is preferable to attach the reinforcing to the framing to reduce the risk of stucco cracks, direct attachment to oriented strandboard (OSB), waferboard, plywood or lumber sheathing is also permitted if the sheathing is thick enough (see NBC Article 9.27.5.1.) to provide adequate nail strength to support the weight of the stucco. However, there is little or no advantage in such a direct attachment.

9.28.4. Stucco Lath

9.28.4.1. Materials

This Article indicates the materials used for stucco lath and reinforcing that will have a reasonable life expectancy when embedded in stucco. Stucco reinforcement or lath for walls consists of two basic types: wire mesh (welded or woven) and expanded metal mesh. The latter is manufactured from flat sheets of metal slit into a pattern that allows the sheets to be stretched into a mesh with diamond-shaped holes.

Both wire mesh (welded or woven) and expanded metal mesh are required to be corrosion-resistant. While galvanizing is preferred, paint coatings are also permitted in the case of expanded metal mesh, provided the coating is designed to be corrosion-resistant and completely covers the mesh.

Rib lath or expanded metal mesh must be copper-alloy steel that is either painted with corrosion-resistant paint or galvanized. Woven and welded wire mesh must be galvanized. Stucco lath materials must conform to the required properties listed in NBC Table 9.28.4.3. Stucco lath must be spaced at least 6 mm (1/4 in.) from backing materials with self-furring devices.

9.28.4.2. No Sheathing Required

This Article provides alternative means of supporting stucco lath and reinforcing when sheathing is not used. Sheathing must be provided beneath stucco applied over wood-frame walls (NBC Article 9.28.1.1.), unless a 1.19 mm (1/16 in.) diameter galvanized wire is applied horizontally to the framing with a vertical spacing of not more than 150 mm (6 in.), or paper-backed welded wire lath is installed.

9.28.4.3. Stucco Lath Specifications

This Article indicates the specifications for stucco lath and reinforcing that will have sufficient strength to resist stucco cracking due to shrinkage, and to resist horizontal forces due to wind and impact loads. In the case of horizontal applications (i.e., soffits and ceilings), the stucco rib lath provides additional strength to support the weight of the stucco between fasteners. The requirements for lath are listed in NBC Table 9.28.4.3.

Expanded metal stucco mesh is made from thicker metal than is gypsum plaster lath (used for ornamental interior applications compared to exterior stucco), and has much more corrosion resistance. The latter should, therefore, not be substituted in stucco applications.

For horizontal applications such as carport ceilings, wire mesh reinforcing is not suitable for spanning between supports given its lack of stiffness. So-called rib lath is usually used for this purpose. Such lath is stiffened by a series of ribs that allow it to support the wet stucco without significant sagging.

9.28.4.4. Self-Furring Devices

This Article requires that stucco lath be held away at least 6 mm (1/4 in.) from its backing so that the stucco can flow around the mesh or reinforcing to completely embed it. This helps to provide additional corrosion protection for the lath as well as strength for the stucco.

9.28.4.5. Application of Stucco Lath

This Article describes the application requirements for stucco lath intended to reduce the likelihood of stucco cracks developing over the joints between stucco lath. Stucco lath must be attached lengthwise across framing, and joints in the lath must be lapped at least 50 mm (2 in.). Laps must be staggered between lath courses and be located over framing members. External corners must be reinforced as shown in Figure 9.28.-1. In addition, corner beads are commonly used at the outside corners to provide a ground for the stucco depth, and to ensure that the corner is straight and true. In wet or salty climates, it is good practice to use a corner bead with a PVC nose to prevent corrosion.

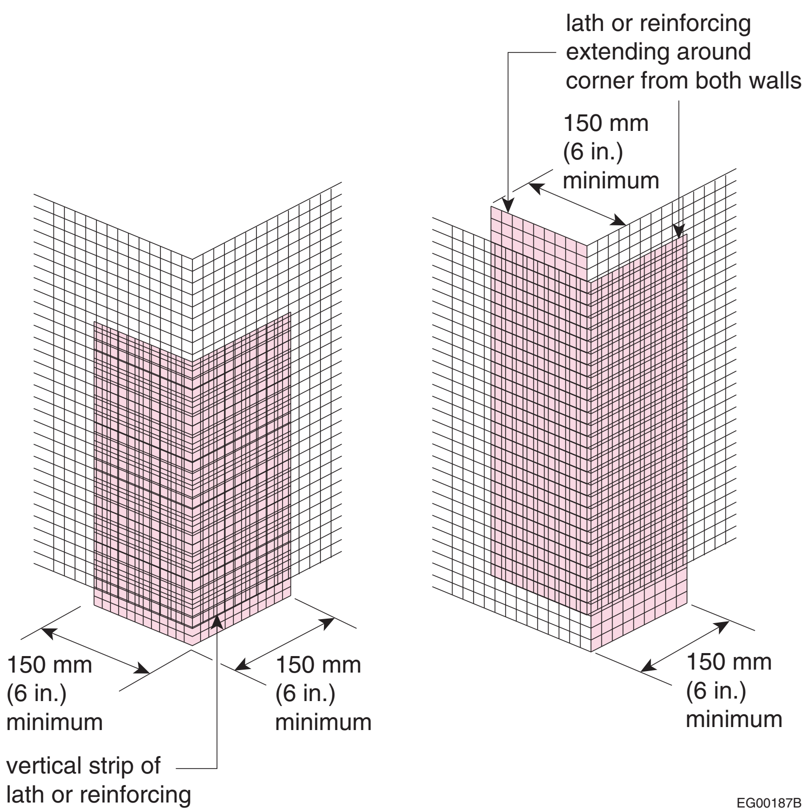


Figure 9.28.-1
Reinforcing external corners of stucco lath

9.28.4.6. Fastening

This Article contains the fastening requirements for stucco lath to provide sufficient fasteners to attach stucco lath to the building to support the weight of the stucco and to resist wind forces. Requirements for fastening of metal lath to structures are the same as for other claddings (see NBC Subsection 9.27.5.). Fastener spacing requirements are provided in Table 9.28.-B. In all assemblies, stucco lath must have at least 20 fasteners for every 1 m^2 (10 $ft.^2$) if a different nailing or stapling pattern is used from the one shown.

Table 9.28.-B
Maximum Spacings for Fasteners Used to Attach Stucco Lath

Location	Maximum Horizontal Spacing or Maximum Spacing Between Framing Members, mm (in.)	Maximum Vertical Spacing or Maximum Spacing Along Framing Members, mm (in.)
Vertical surface(1)	100 (4)	600 (24)
	150 (6)	400 (16)
Horizontal surface	400 (16)	150 (6)
	600 (24)	100 (4)

Notes to Table 9.28.B.:
(1) Other nailing patterns are permitted, provided there are at least 20 nails or staples per 1 m^2 (10 $ft.^2$) of wall surface.

9.28.5. Stucco Mixes

The same general principles for good concrete or mortar also apply to stucco. The aggregate must be clean and well graded, and the mix water free of materials that will have a detrimental effect on the stucco. Like concrete and mortar, stucco must be kept from freezing until it has sufficiently set to prevent damage.

9.28.5.1. Mixes

This Article lists the stucco mix requirements to provide stucco with adequate strength and durability. The materials required to make a sound stucco mix must be carefully selected. Portland cement is the most common cement used, although other cements such as masonry cement are acceptable.

Stucco materials must be mixed using the proportions provided in NBC Table 9.28.5.1. Any pigment added to the stucco must consist of pure mineral oxides that will not react with sunlight, lime or cement. Pigment must not exceed 6% of the Portland cement by weight. All stucco materials must be thoroughly mixed before and after adding water. Stucco must be applied within three hours of the initial mixing.

Stucco mixes are generally weaker than typical mortar mixes and consist of a mixture of Portland cement, masonry cement (or lime), and aggregate. The proportions can vary, but they are commonly in the range of one part Portland cement, one part masonry cement (or lime), and 3.25 to 4 parts of aggregate by volume (NBC Table 9.28.5.1.). Excessive proportions of water can have a negative impact on the ability of stucco to resist cracking. It is generally best to keep the water content as low as practicable for workability.

The aggregate is a critical component of the stucco mix. Sand must be washed, be the correct size, and not have a significant amount of fines material. Very fine sand can be a source of cracking in the base coats. Clay fines can also be a source of cracking, since they will swell when wet and shrink during drying.

The use of admixtures must be appropriate to the materials. Some admixtures are used to make the stucco mix more plastic and trowelable, and can reduce water content. However, soap is not an acceptable additive, because it will counteract the cement hydration process needed for curing of the stucco.

9.28.5.2. Pigments

This Article prohibits the use of pigments that may adversely affect the strength or durability of the stucco. A second purpose is to avoid the use of pigments that will not be colour fast.

9.28.5.3. Mixing

This Article indicates the mixing requirements for stucco, and states the time interval after which mixed stucco should not be used.

9.28.6. Stucco Application

Various types of final coats may be used to achieve different decorative effects. Where so-called stone dash or dry stone finish is used, it is thrown or pressed into the second coat while the coat is still plastic. If a wet third coat is used, the second coat is also lightly scratched and allowed to set before the final coat is applied.

An alternate technique endorsed by the stucco industry is the double back method, whereby the second coat is applied shortly after the first coat is firm enough to support the second application. This method ensures that a significant amount of moisture stays in the material for a longer time to enhance curing. Either method is acceptable.

9.28.6.1. Low Temperature Conditions

This Article sets minimum temperature requirements for the application and curing of stucco to keep it from freezing during the curing period. If stucco freezes before it sets, its strength and durability will be compromised.

The large surface area of stucco in relation to its volume makes it very vulnerable to damage from freezing. Stucco must be kept above 10°C (50°F) during its application, and for at least 48 h after its application to prevent subsequent frost damage.

9.28.6.2. Number of Coats and Total Thickness

This Article requires a minimum number of coats and a minimum thickness for stucco to minimize the risk of cracking, as well as ensure the lath is embedded. Stucco is applied in several coats to reduce the risk of shrinkage cracks extending from the surface to the base material. As one coat dries and shrinks, some cracks will occur in the stucco. These are covered in succeeding coats. Any new cracks that occur would seldom coincide with those in the previous coat. The total minimum thickness is to provide for sufficient material to embed the lath and protect it from the weather, which will in turn ensure it has a reasonable life expectancy.

Stucco must be applied with at least two base coats and one finish coat or stone dash, which will result in a total thickness of not less than 15 mm (5/8 in.) from the face level of the lath or the masonry, as shown in Figure 9.28.-2.

9.28.6.3. First Coat

This Article requires that the first coat of stucco have a minimum thickness so that it completely embeds the lath or reinforcing, and creates a surface that will provide a sufficient bond for the second coat.

Even though stucco is reinforced, minute cracks will develop in the stucco as it dries and shrinks. To reduce the risk of through cracks, the stucco is applied in three coats. The first coat fully embeds the lath and is scratched or roughened to provide a bond with the second coat. It must be at least 6 mm (1/4 in.) thick from the face of the lath or masonry.

9.28.6.4. Second Coat

This Article requires a second coat to strengthen the stucco and provide a solid base for the application of the finish coat.

The second coat must be at least 6 mm (1/4 in.) thick and lightly roughened to guarantee good adhesion for the final coat, unless the finish coat is stone dash, in which case the second coat may be smooth finished. Once the initial set has taken place, the second coat should be floated to densify the surface and increase the water resistance of the material. To enhance the proper curing of the base coats, they should be wet-cured for a number of days to ensure that moisture stays in the material to allow for complete hydration of the Portland cement.

9.28.6.5. Finish Coat

This Article requires a finish coat that will resist the entry of rainwater and the effects of freezing and thawing cycles. The finish coat must be at least 3 mm (1/8 in.) thick. The second coat must be dampened, but not soaked, before the final coat is applied. For a stone dash finish, the stones must be partially embedded in the second coat before it starts to set.

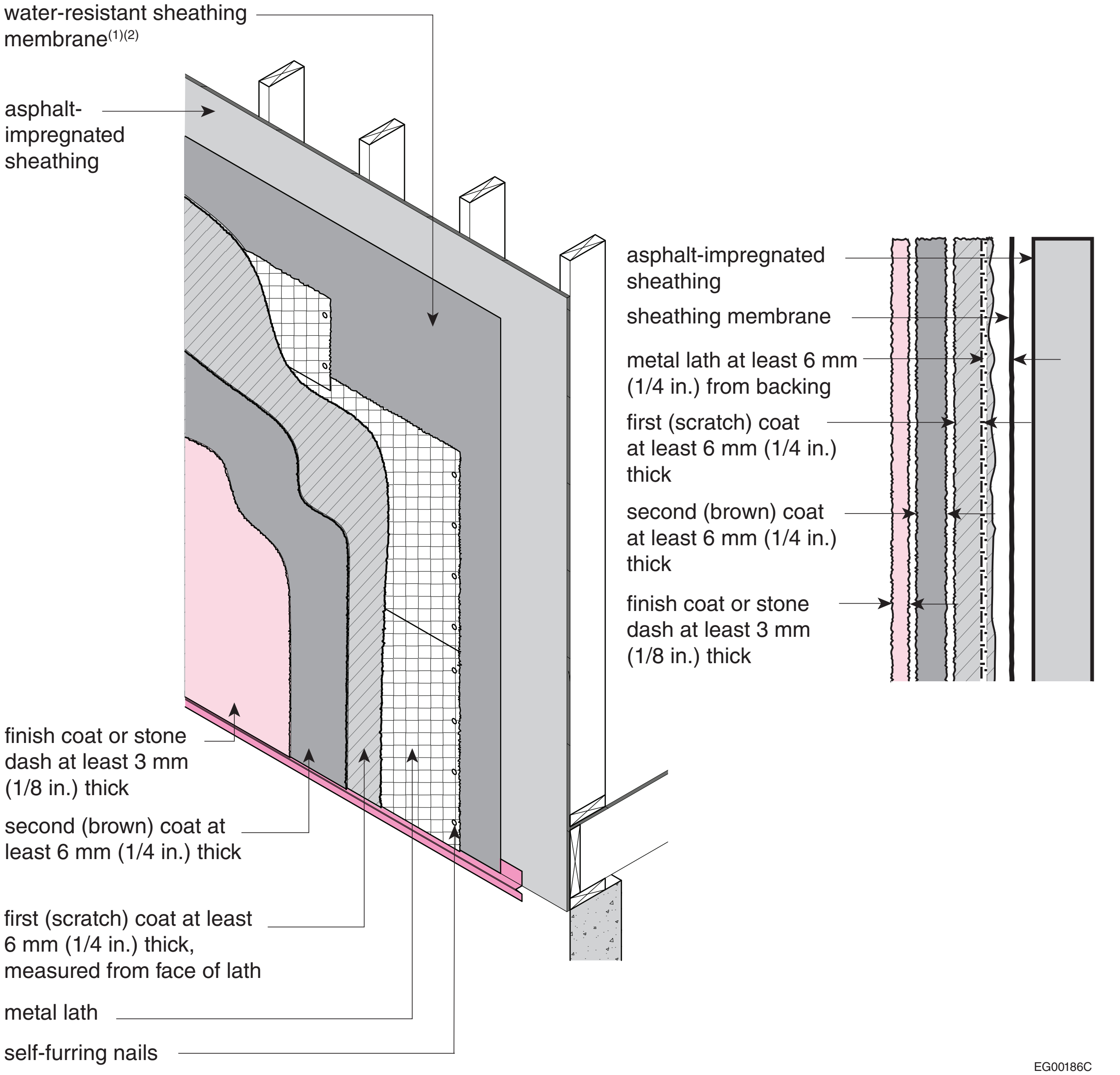


Figure 9.28.-2
Stucco application

Notes to Figure 9.28.-2:

(1) Tar-saturated felts or papers must not be used beneath stucco.
(2) Some CCMC evaluations for sheathing membranes require a 10 mm (13/32 in.) air space.

Section 9.29. Interior Wall and Ceiling Finishes

Introduction

Wall and ceiling finishes provide some ability to resist horizontal forces and provide attractive interior surfaces. Interior finishes can also be an important element in an assembly required to provide fire or sound resistance. They are expected to be reasonably durable and able to resist impact forces that might occur as a result of occupancy. Finally, because interior finishes play an important role in the speed of fire propagation in a building, their flame-spread ratings must be within reasonable limits, to allow occupants time to escape and give firefighters a chance to control the extent of damage.

9.29.1. General

9.29.1.1. Fire Protection and Sound Control

This Article indicates that wall or ceiling finishes need to comply with fire safety and sound resistance requirements contained in NBC Sections 9.10. and 9.11.

Although interior finishes are generally considered to be essentially decorative, they do in fact fulfill other useful functions, and their properties can significantly influence health and safety in buildings.

The flame-spread properties of wall and ceiling surfaces, for example, determine the rate of fire travel within compartments, and directly affect life safety in all occupancies. Finishes also act as an important component in many assemblies required to provide fire resistance. Finishes can also act as thermal protection for cellular plastic insulation, thereby extending the time before flashover in fire. In assemblies required to provide sound resistance, the interior finish can play a significant role in determining the sound transmission class (STC) rating. It can play an important structural role as well by providing rigidity to resist wind forces. Finishes can also contribute to the lateral stability required to resist wind and seismic loads.

The ability of gypsum board to retard the passage of heat, smoke and flame, and to perform the role of an airtight barrier when it has been designed to do so, is directly related to the quality of the joints.

Another factor that affects the ability of joints in interior finishes to deter the passage of fire, smoke and sound is truss uplift. Figure 9.29.-1 shows ways of minimizing damage from truss movement.

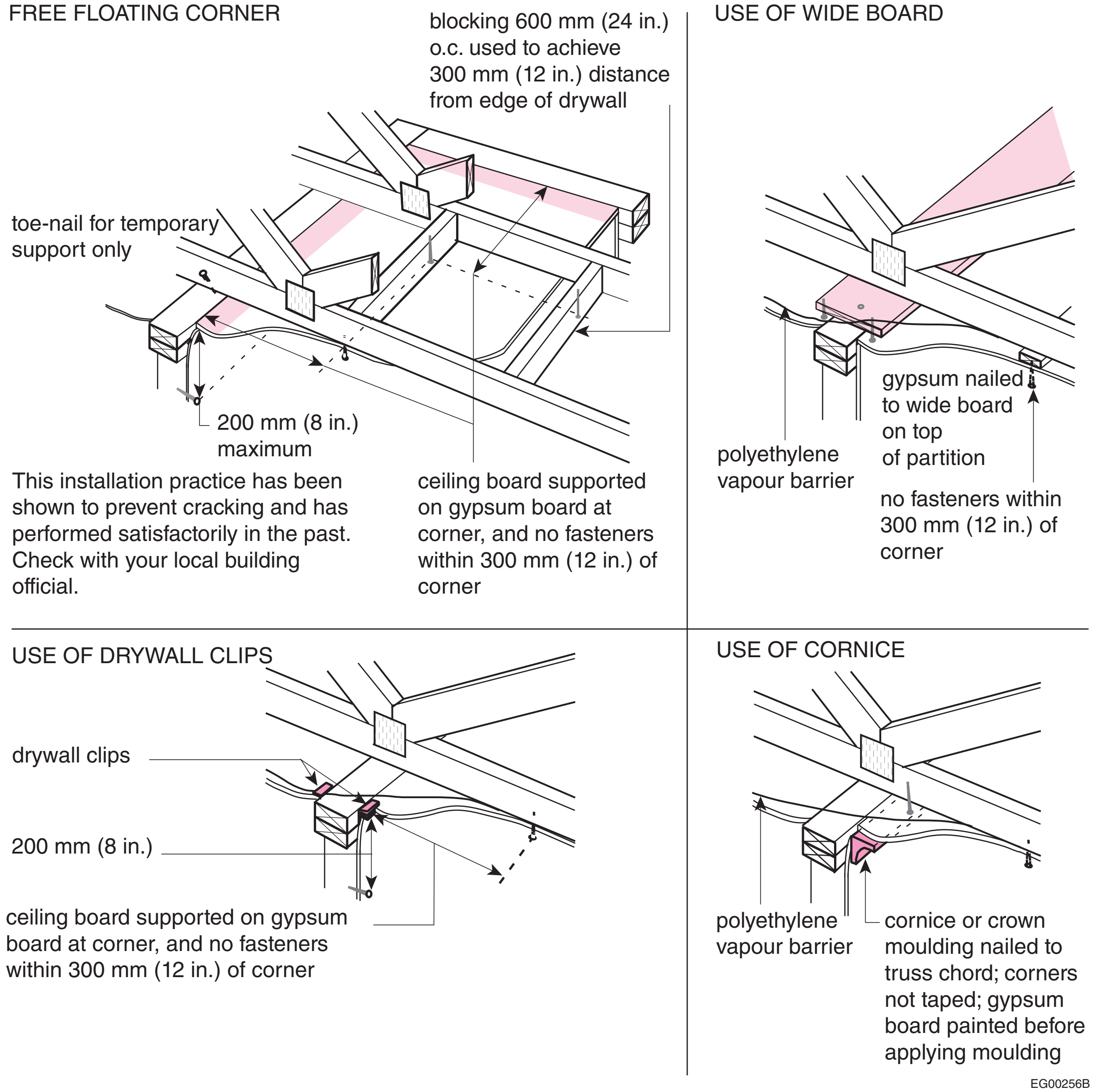


Figure 9.29.-1
Minimizing the effects of truss uplift

9.29.2. Waterproof Wall Finish

Certain wall surfaces are subjected to periodic wetting from shower spray or splashing, and must therefore be protected with finishes that will not deteriorate or absorb water. Such finishes can consist of tiles of various composition, sheet vinyl, tempered hardboard, plastic laminates or linoleum. Showers and bathtub units may be designed with moulded plastic enclosures that require no additional protection.

9.29.2.1. Where Required

This Article lists the requirements for waterproof wall finish to provide a reasonably durable wall finish that will not deteriorate from frequent exposure to water splash in showers and around bathtubs.

Shower stalls must have waterproof wall finish to at least 1.8 m (5 ft. 11 in.) above the floor. Waterproof finishes must be provided to at least 1.2 m (4 ft.) above the top of a bathtub rim that has a shower nozzle, and to at least 400 mm (16 in.) above one that does not (Figure 9.29.-2).

9.29.2.2. Materials

This Article describes a number of wall finishes that will meet the requirements for waterproof finishes. Materials that may be used for waterproof finishes include ceramic, plastic or metal tile, sheet vinyl, tempered hardboard, laminated thermosetting decorative sheets, or linoleum.

Ceramic tile is the most common waterproof finish (see NBC Subsection 9.29.10.). When used in wood-frame construction, it is normally applied to a moisture-resistant backing with a waterproof adhesive. A special grade of gypsum board is manufactured for this purpose. The joints in the tile are pointed with special tile mortar to provide a seal against water entry. The mortar used for this purpose should be relatively non-porous and firmly tooled into the joints to reduce the risk of water accumulation behind the tile. This is particularly important if the shower is to be used frequently.

The joint between the tile and the bathtub must be sealed with a sealant compound designed for this purpose. This is specially formulated to resist moisture and mildew growth. Ceramic wall tile can be set in mortar applied to metal lath over framing, or directly to mortar over masonry.

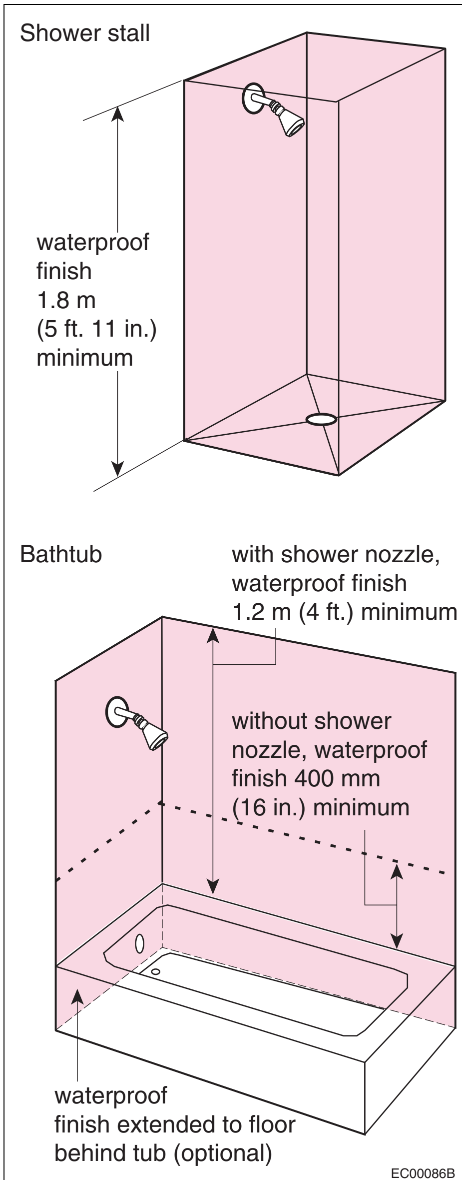


Figure 9.29.-2
Minimum height of waterproof finish

9.29.3. Wood Furring

A wall or ceiling finish always looks better when it appears plane and even. Furring can help achieve this where wall or ceiling members are slightly out of line.

9.29.3.1. Size and Spacing of Furring

This Article indicates the required size and spacing of furring. Wood furring is often used over existing wall surfaces, or over solid surfaces such as masonry, to provide an even and more accommodating surface for the attachment of new wall finishes. Wood furring is also applied directly to framing to reduce the support spacing or to change the orientation of panels in applying wall and ceiling finishes.

The prime function of furring is to provide an attachment base for the wall or ceiling finish. Furring must have sufficient thickness to give fasteners adequate withdrawal resistance to support the weight of the finish, and provide sufficient stiffness for the application of nails or staples. This is the main reason for increasing the size of strapping when the distance between supports is increased.

9.29.3.2. Fastening

This Article requires fastening the furring to the framing so that it can support the weight of the finish and resist twisting of the furring as it dries. Wood furring is fastened with at least 51 mm (2 in.) nails to the framing or to wood blocks formed into concrete or laid into masonry joints. NBC Table 9.29.3.1. specifies the minimum size and maximum spacing of furring.

9.29.4. Plastering

Although lath and plaster was the most common interior finish for many years, its use has declined steadily since the introduction of gypsum board. While still used occasionally, it is mainly confined to localized areas or to the renovation of heritage buildings.

9.29.4.1. Application

This Article describes, through reference to CSA A82.30-M, “Interior Furring, Lathing and Gypsum Plastering,” lath and plaster finishes that will provide a durable interior finish.

9.29.5. Gypsum Board Finish (Taped Joints)

Gypsum board is the most widely used wall and ceiling finish in Canada.

9.29.5.1. Application

This Article limits the applicability of this Subsection to single layers of gypsum board to wood furring or framing using nails or screws. While single-layer gypsum board is by far the more common method of application, double-layer applications may also be used to achieve greater fire or sound ratings, increased strength, or a reduced incidence of nail popping. Single-layer systems may also be applied with adhesives in combination with fasteners to reduce nail popping. Since these methods are not nearly as common as the single layer, mechanical fastening method, they are not covered directly in NBC Section 9.29. Instead, reference is made to CSA A82.31-M, “Gypsum Board Application” (NBC Sentence 9.29.5.1.(2)).

9.29.5.2. Materials

This Article describes, through reference to standards, the characteristics of gypsum board that will provide a suitable wall or ceiling finish.

9.29.5.3. Maximum Spacing of Supports

This Article indicates the maximum spacing of supports for the attachment of gypsum board to ensure that supports are spaced sufficiently close together to avoid objectionable sagging of the ceiling finish between supports, as well as any excessive flexing of the wall finish when subjected to impact forces. The required spacing of supports for gypsum board is shown in NBC Table 9.29.5.3.

Gypsum board is fairly weak in bending, and depends on the paper facing to provide much of the strength required to resist bending. The paper facing, however, loses much of its strength at elevated moisture levels, as does the gypsum core. The application of a stippled ceiling, or prolonged excessive humidities, can therefore contribute to sagging. The situation can also be aggravated if the board is required to support a significant weight of insulation.

The paper facing has considerably more strength in the long dimension of the board than across it. Ceiling boards applied at right angles to the supports are, therefore, permitted to span longer distances between supports. NBC Table 9.29.5.3. takes into account the directional strength of the board and whether or not the board is to have a painted or water-based texture finish.

NBC Table 9.29.5.3. identifies gypsum board that resists sagging (ASTM C 1396/C 1396M, “Gypsum Board”). It is specifically designed for installation on ceilings where water-based textures are used. Its properties allow 12.7 mm (1/2 in.) panels to be supported at 600 mm (24 in.) on centre.

9.29.5.4. Support of Insulation

This Article indicates the minimum thickness for gypsum board ceiling finish that supports the weight of insulation to avoid excessive sagging of the board between supports. Gypsum board that supports insulation must be at least 12.7 mm (1/2 in.) thick. To reduce the risk of sagging, builders may wish to increase ceiling board thickness if larger depths of insulation are supported, or if it is not practicable to decrease humidity levels in the house when drywall is being finished.

9.29.5.5. Length of Fasteners

This Article requires sufficient fastener length to avoid the premature failure of a building assembly in accordance with its required fire resistance. Minimum fastener penetration is intended to provide fasteners with sufficient withdrawal resistance under service loads. When exposed to fire, wood members char and their ability to hold fasteners decreases.

Also, fasteners for wall and ceiling finishes will conduct heat into the support members, causing charring around the fasteners. This causes the fasteners to lose their withdrawal resistance. The longer the wood members or the fasteners are subjected to fire, the greater will be the depth of char. Therefore, fastener length is adjusted for the required fire-resistance duration. Since walls are partially self-supporting, the depth of fastener penetration is not as important as it is with ceilings.

The length of fasteners must conform to NBC Table 9.29.5.5. An exception for fire-rated walls can be made where fire tests show that the length of fastener is adequate to obtain the fire rating.

Nail Popping

While gypsum board is generally free from major problems, one persistent annoyance has been the incidence of nail popping. This is caused by the fact that wood shrinks, while fasteners do not. This creates a gap between the gypsum board and its supports (Figure 9.29.-3). Subsequent pressure on the gypsum board causes the nail heads to push through (or pop) the cementitious covering. This condition most commonly occurs in the area of the board where the nail heads are not protected by joint-reinforcing tape or wall trim.

Wood shrinkage is the main cause of nail popping in drywall finishes. As wood dries it tends to shrink. Most shrinkage takes place during the first heating season. Longer nails tend to pop further than do short nails. Smooth nails tend to pop more than do screws. The first preventative measure is to use wood framing with a moisture content not exceeding 19% at the time of installation (NBC Article 9.3.2.5.).

Ring shank nails resist pull-out much more effectively than do plain shank nails, and this allows the use of shorter nails than would otherwise be the case to reduce the risk of nail popping. Nails that are 31 mm (1 1/4 in.) long with annular rings are considered appropriate for this application.

Screws and double nailing can be used to pull boards flush with framing and further reduce the likelihood of nail pop-out. The use of adhesives and resilient furring are becoming alternatives to conventional drywall installation.

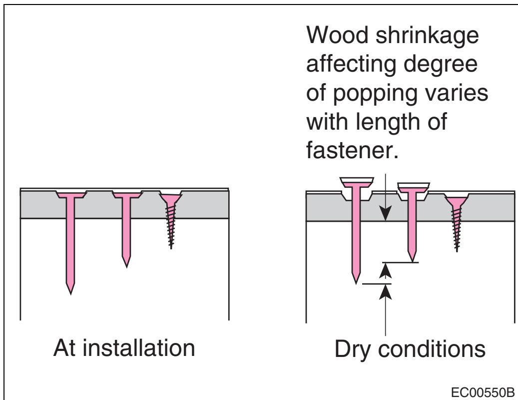


Figure 9.29.-3
Nail pops and fastener length

The use of so-called "double nailing" is also aimed at reducing nail popping. In this method of fastening, the nails are spaced in pairs about 50 mm (2 in.) from each other, so that the nails in each pair are about 30 mm (1 3/16 in.) apart. The first nail in each pair is intended to snug the board to the support, while the second nail is to ensure tight contact.

9.29.5.6. Nails

This Article defines, through reference to standards, the characteristics of nails to be used for the attachment of gypsum board. Nails must comply with either CSA B111, "Wire Nails, Spikes and Staples," or with ASTM F 1667, "Driven Fasteners: Nails, Spikes, and Staples."

9.29.5.7. Screws

This Article defines, through reference to a standard, the characteristics of screws to be used for the attachment of gypsum board.

Screws must conform to ASTM C 1002, "Steel Self-Piercing Tapping Screws for the Application of Gypsum Panel Products or Metal Plaster Bases to Wood Studs or Steel Studs." This specification covers steel self-piercing tapping screws for use in fastening gypsum panel products and metal plaster bases to cold-formed steel studs and wood framing members, and for fastening gypsum panel products to gypsum board. Steel screws covered by this specification are of four types of thread configurations:
(1) Type G, course-pitch high-thread self-piercing screws for fastening gypsum board to gypsum board,
(2) Type S, fine-thread screws for fastening gypsum board to cold-formed steel members,
(3) Type W, course-thread screws for fastening gypsum board to wood framing members, and
(4) Type A, course-pitch tapping screws for fastening metal plaster bases to wood or cold-formed steel.

9.29.5.8. Spacing of Nails

This Article requires a sufficient number of nails to support the weight of the finish and provide a suitable interior finish. Nails must not puncture the finish paper. Spacing of nails for single layer applications must be not more than 180 mm (7 in.) on centre for ceilings and not more than 200 mm (8 in.) on centre for vertical wall frames. Nails may be spaced in pairs about 50 mm (2 in.) apart at 300 mm (12 in.) on centre for walls and ceilings (Figure 9.29.-4).

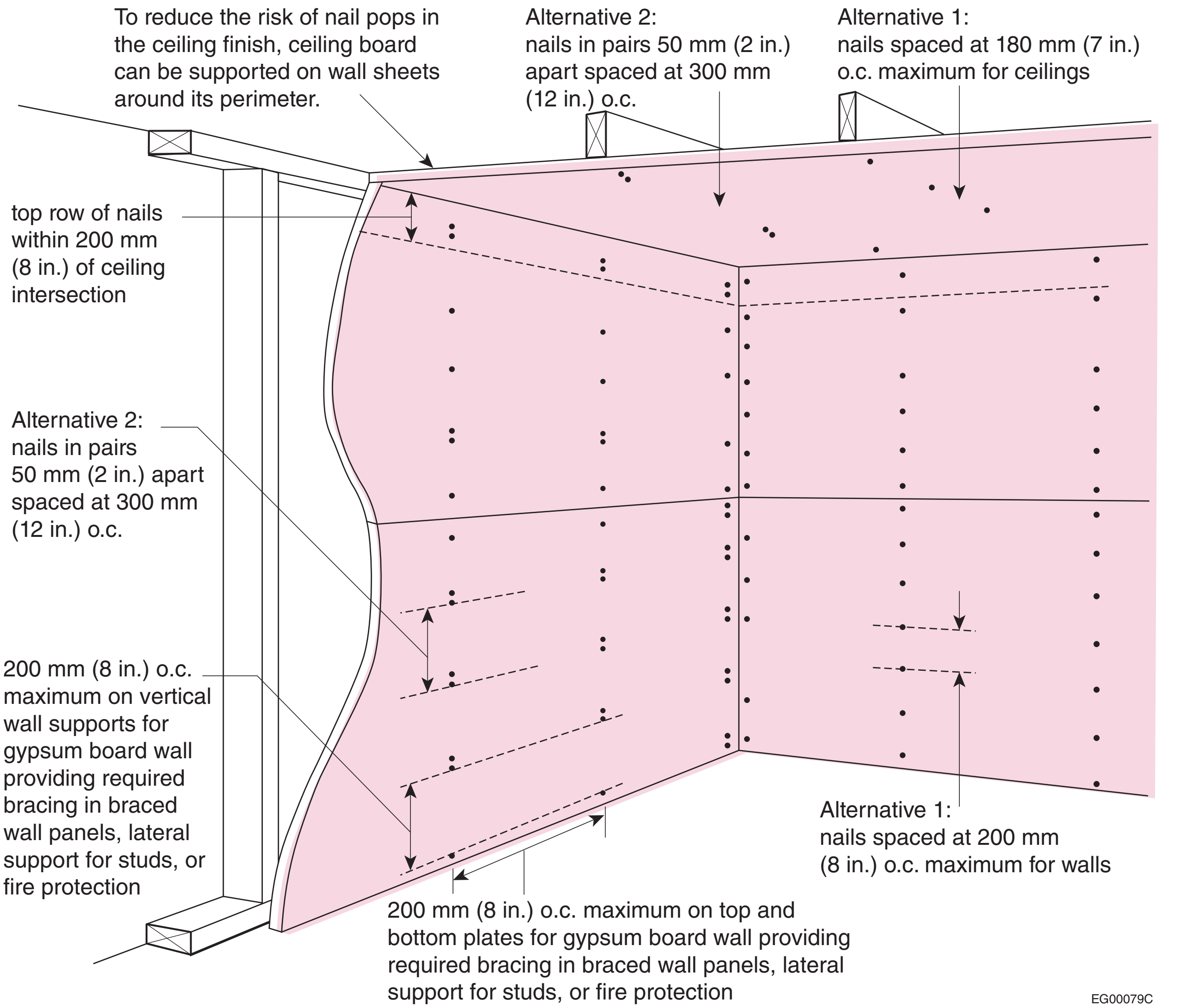


Figure 9.29.-4
Nail spacing for gypsum board

Single-layer gypsum board walls that provide required bracing for braced wall panels, lateral stability for studs, or fire protection require closer nailing patterns. Nails must be provided along the top and bottom plates. The spacing of these nails and those attaching gypsum board to vertical supports must not be more than 200 mm (8 in.) on centre.

Ceiling sheets may be supported on the wall sheets around the ceiling perimeter to eliminate corner nails. The nails along the top row on a wall must be placed at not more than 200 mm (8 in.) from the intersection of the ceiling and wall. This system of nailing is intended to create a floating corner and to reduce the risk of nail popping through the ceiling finish at this location, caused by the weight of the floor or roof assembly above it pushing the nail heads through the finish after wood shrinkage has taken place. At other locations, nails must not be less than 10 mm (3/8 in.) from the edge of a gypsum board.

9.29.5.9. Spacing of Screws

This Article requires a sufficient number of screws to support the weight of the finish and provide a suitable interior finish. The use of drywall screws can minimize nail popping because they are even shorter than annular grooved nails in non-fire-rated assemblies. They can also be installed at wider spacings and with less damage to the paper face while still providing a tight contact with the support.

Screws must be spaced not more than 300 mm (12 in.) on centre apart along supports, except they may be 400 mm (16 in.) on centre apart where vertical supports are spaced not more than 400 mm (16 in.) on centre. Note that screws should also be at least 10 mm (3/8 in.) from the edge of the board and should penetrate the board face without puncturing the surface paper.

Single-layer gypsum board walls that are required to provide bracing for braced wall panels, lateral stability for studs, or fire protection require closer fastening patterns. Screws must be provided along the top and bottom plates. The spacing of these screws and those attaching gypsum board to vertical supports must not be more than 300 mm (12 in.) on centre, except where a fire-resistance rating is provided by means of an assembly from NBC Table 9.10.3.1.-A.

9.29.5.10. Low Temperature Conditions

This Article requires that sufficient heat be provided to allow the gypsum compound to dry before subsequent freezing can occur, so that the joints will be capable of performing their required functions. Heat must be provided, when necessary, to maintain a temperature of at least 10°C (50°F) 48 h before taping and after finishing.

9.29.6. Plywood Finish

Plywood is sometimes used for interior finishes. These finishes are combustible and generally have a higher flame-spread rating than gypsum board. The thinner the board, the higher the rating tends to be, particularly in thicknesses below 12 mm (1/2 in.).

9.29.6.1. Thickness

This Article indicates the minimum required thickness for plywood finish to ensure that supports for the attachment of plywood wall and ceiling finishes are spaced sufficiently close together to avoid objectionable sagging of the ceiling finishes, and excessive flexing of the wall finishes when subjected to impact forces. If blocking is provided at mid-wall height, the wall panels are considerably stiffened, allowing the use of thinner wall finish. If applied to a continuous backing, the plywood serves a decorative function and no minimum thickness is required. Plywood thickness must conform to NBC Table 9.29.6.1.

9.29.6.2. Grooved Plywood

This Article indicates the allowable depth of grooves for grooved plywood. Thinner plywoods of the type used for wall finish can be seriously weakened if the decorative face grooves extend through the first ply. Such plywood can easily fail under modest impact forces if the grooves do not coincide with the supporting members. Since thinner plywoods are much stronger in their long direction, such deep grooves are permitted if the plywood is applied perpendicular to the supports and its thickness increased to compensate for the depth of the groove into the inner plies.

Grooved plywood finished for interior use must not have its grooves extend through the face ply or the plies beneath it, unless the groove is supported by furring or framing (Figure 9.29.-5).

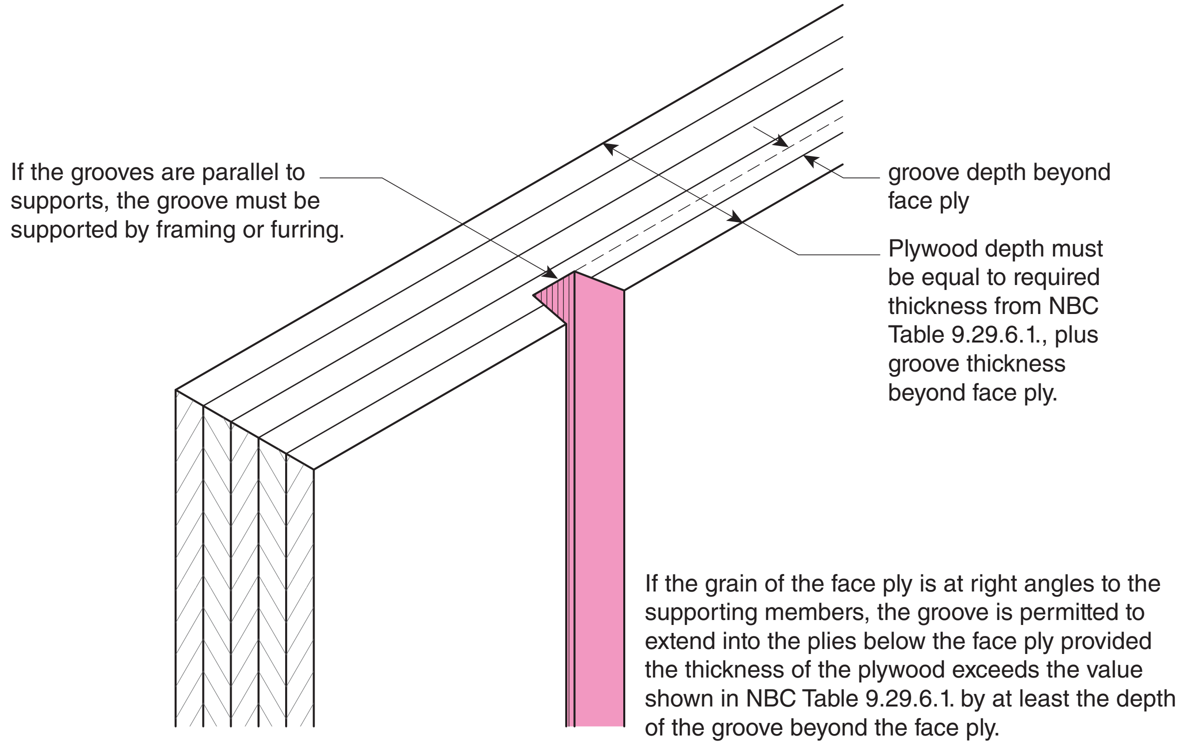


Figure 9.29.-5
Grooved plywood

9.29.6.3. Nails and Staples

This Article requires a sufficient number of fasteners of adequate size to support the weight of plywood interior finish. Plywood finishes must be nailed with finishing or casing nails at least 38 mm (1 1/2 in.) long, spaced not more than 150 mm (6 in.) on centre along the edges, and 300 mm (12 in.) on centre along intermediate supports. Plywood may be stapled provided that fasteners offer equivalent performance.

Where structural plywood meeting CSA O325, "Construction Sheathing," is used on interior surfaces to provide required bracing in braced wall panels (NBC Subsection 9.23.13.), the plywood needs to be fastened in accordance with fastening requirements for sheathing stated in NBC Article 9.23.3.5.

9.29.6.4. Edge Support

This Article requires that plywood edges be supported to avoid excessive flexing and damage to the interior wall and ceiling finish resulting from impact forces. Furring, blocking or framing support must be provided for all edges and joints in plywood finishes.

9.29.7. Hardboard Finish

Hardboard is sometimes used for interior finishes. It is combustible and generally has a higher flame-spread rating than does gypsum board. This must be considered when using hardboard as an interior finish.

9.29.7.1. Material Standard

This Article describes, through reference to a standard, the characteristics of hardboard that will provide a suitable wall or ceiling finish.

9.29.7.2. Thickness

This Article indicates the minimum required thickness for hardboard based on support conditions to ensure that supports for the attachment of hardboard wall and ceiling finishes are spaced sufficiently close together to avoid objectionable sagging of the ceiling finishes, and excessive flexing of the wall finishes when subjected to impact forces. If blocking is provided at mid-wall height, the wall panels are considerably stiffened, allowing the use of thinner wall finishes. If applied to a continuous backing, the hardboard serves only a decorative function and no minimum thickness is required.

Hardboard must be at least 3 mm (1/8 in.) thick when it is supported on continuous backing, 6 mm (1/4 in.) thick when supported on framing not greater than 400 mm (16 in.) on centre, and 9 mm (3/8 in.) thick when supported on framing not greater than 600 mm (24 in.) on centre.

9.29.7.3. Nails

This Article requires a sufficient number of fasteners of adequate size to support the weight of the hardboard finish. Hardboard finishes must be nailed with finishing or casing nails at least 38 mm (1 1/2 in.) long, spaced not more than 150 mm (6 in.) on centre along the edges, and 300 mm (12 in.) on centre along intermediate supports.

9.29.7.4. Edge Support

This Article requires that hardboard edges be supported to avoid excessive flexing and damage to the interior wall and ceiling finish resulting from impact forces. As with plywood, support must be provided for all edges and joints in hardboard finishes.

9.29.8. Insulating Fibreboard Finish

Few fibreboard wall finishes are currently used in new houses. It is now mainly used for ceiling finishes, usually as tiles or in relatively small panels. Such material, unless suitably treated, can have high flame-spread ratings. Evidence of its flame-spread properties should, therefore, be determined before it is used.

9.29.8.1. Material Standard

This Article describes, through reference to a standard, the characteristics of insulating fibreboard.

9.29.8.2. Thickness

This Article indicates the minimum required thickness for insulating fibreboard to ensure that supports for the attachment of insulating fibreboard ceiling finishes are spaced sufficiently close together to avoid objectionable sagging of the ceiling finishes, and excessive flexing of the wall finishes when subjected to impact forces. If blocking is provided at mid-wall height, the wall panels are considerably stiffened, allowing the use of thinner wall finishes. If applied to a continuous backing, the insulating fibreboard serves only a decorative function and no minimum thickness is required.

Sheets must be at least 11.1 mm (7/16 in.) thick when supports are not more than 400 mm (16 in.) on centre. Fibreboard tile must be at least 12.7 mm (1/2 in.) thick when supports are not more than 400 mm (16 in.) on centre.

9.29.8.3. Nails

This Article requires a sufficient number of fasteners of adequate size to support the weight of the insulating fibreboard finish. Nailing of fibreboard sheets requires 2.6 mm (3/32 in.) shank diameter casing nails or finishing nails that penetrate supports at least 20 mm (13/16 in.). Nails must be spaced not more than 100 mm (4 in.) on centre along edge supports and not more than 200 mm (8 in.) on centre along intermediate supports.

9.29.8.4. Edge Support

This Article requires that fibreboard edges be supported to avoid excessive flexing and damage to the ceiling finish resulting from impact forces. All edges must be supported by framing, furring, or blocking.

9.29.9. Particleboard, OSB or Waferboard Finish

Particleboard, OSB or waferboard are sometimes used for interior finishes in utility rooms or garages. Particleboard, oriented strandboard (OSB) or waferboard finishes are combustible and generally have a higher flame-spread rating than does gypsum board. The thinner the board, the higher the rating tends to be, particularly in thicknesses below 12 mm (1/2 in.). Such board, therefore, should be identified in a manner to indicate its flame-spread rating in order to establish its acceptability.

Particleboard finishes must conform to ANSI A208.1, “Particleboard.” Waferboard and OSB finishes must conform to CSA O325, “Construction Sheathing,” or CSA O437.0, “OSB and Waferboard.”

9.29.9.1. Material Standard

This Article describes, through reference to standards, the characteristics of particleboard, OSB and waferboard that will provide a suitable wall or ceiling finish. OSB conforming to CSA O325, “Construction Sheathing,” needs to have at least the following panel marks:

- W16 on supports not more than 400 mm (16 in.),
- W24 on supports not more than 600 mm (24 in.), and
- W16 on supports not more than 600 mm (24 in.) where blocking is provided at mid-wall height.

9.29.9.2. Minimum Thickness

This Article indicates the minimum thickness to ensure the attachment of particleboard, OSB or waferboard is adequate to prevent sagging when it is used as a ceiling finish, and excessive flexing when it is used as a wall finish. If there is no mid-height blocking between studs, then OSB grade O-1, grade R-1 waferboard and all particleboard must be at least:

- 6.35 mm (1/4 in.) thick on supports spaced not more than 400 mm (16 in.) on centre,
- 9.5 mm (3/8 in.) thick on supports spaced not more than 600 mm (24 in.) on centre, and
- 6.35 mm (1/4 in.) thick on supports spaced not more than 600 mm (24 in.) on centre where blocking support is provided at mid-wall height.

OSB grade O-2 must conform to the requirements shown for plywood in NBC Table 9.29.6.1., except that the boards may be of any thickness when supported by continuous backing.

9.29.9.3. Nails

This Article requires a sufficient number of fasteners of adequate size to support the weight of the particleboard, OSB or waferboard finish. Nailing of particleboard, OSB or waferboard finishes requires finishing or casing nails at least 38 mm (1 1/2 in.) long spaced not more than 150 mm (6 in.) on centre along the edges and 300 mm (12 in.) on centre along intermediate supports. All edges of these boards must be continuously supported with furring, framing, or blocking.

9.29.9.4. Edge Support

This Article requires edge support to avoid excessive flexing and damage to the interior wall and ceiling finish resulting from impact forces. All edges must be supported by framing, furring, or blocking.

9.29.10. Wall Tile Finish

9.29.10.1. Tile Application

This Article describes how ceramic or plastic tile wall finish must be applied.

9.29.10.2. Mortar Base

This Article describes how a mortar base used to adhere ceramic wall tile must be applied. Ceramic wall tile can be set in a mortar base or fixed with an adhesive. A mortar base of cementitious material must consist of 4 parts of Portland cement to not more than 1 part lime by volume. Sand aggregate must be at least 3 parts and not more than 5 parts for 1 part of the cement/lime mixture by volume. The mortar must be applied to metal lath or masonry. The tiles must be pre-soaked and applied firmly so that mortar will fill the joints between the tiles so they can be easily tooled to a flush finish (Figure 9.29.-6).

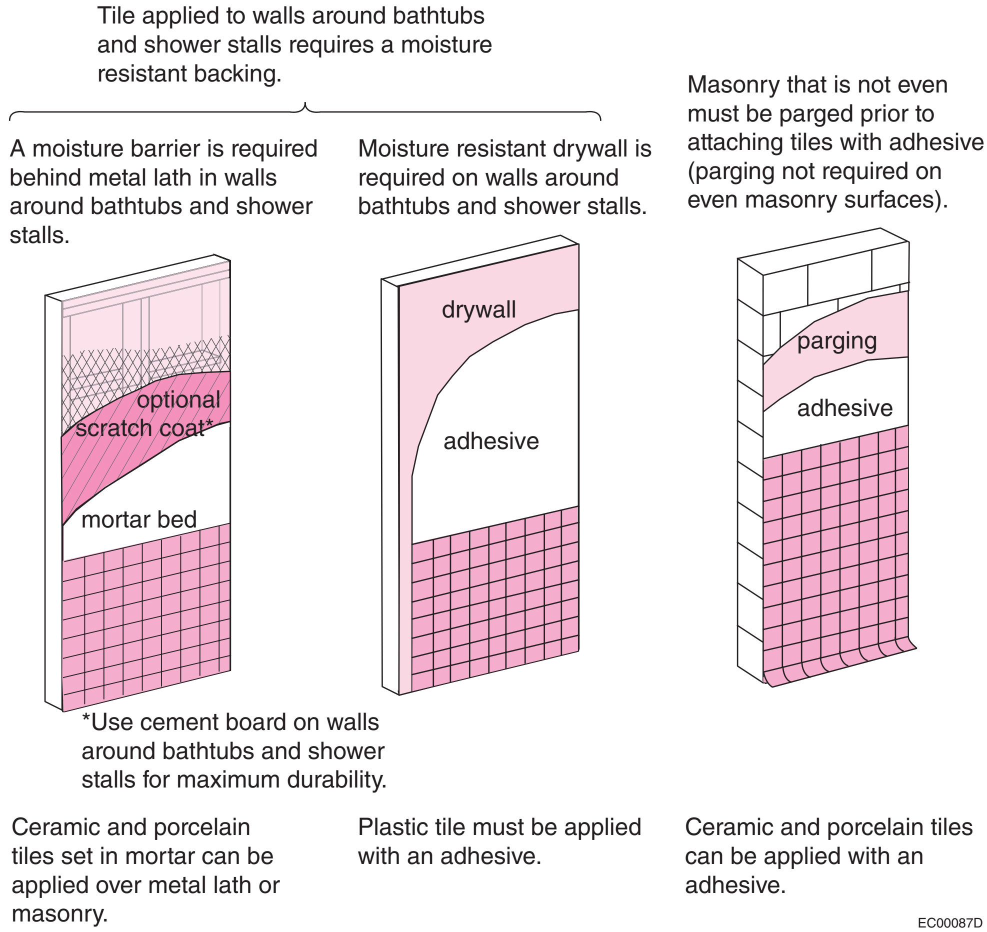


Figure 9.29.-6
Setting ceramic tile

9.29.10.3. Adhesives

This Article describes how adhesive used to install plastic or ceramic wall tile should be applied. Plastic tile must be applied with an adhesive. When applied with an adhesive, ceramic and plastic tiles must be applied to the finish or brown coat of trowelled plaster, to gypsum board, or to masonry, provided that it is even Figure 9.29.-6.

9.29.10.4. Moisture-Resistant Backing

This Article outlines the requirements for moisture-resistant backing. When tiled walls are subjected to splash water, there is a risk of some leakage through the tile joints and where the tile meets the bathtub or fixture. The base material can, therefore, be damaged over time unless it is made of water-resistant material or has been appropriately treated to repel water. For this reason, ceramic and plastic tile applied to walls around bathtubs and shower stalls is required to have a water-resistant backing.

9.29.10.5. Joints between Tiles and Bathtub

This Article requires, through reference to a standard, sealing to prevent water damage from leaks. Experience has shown that the junction between the wall tiles and the bathtub has been the source of numerous problems ranging from mildew to severe wall damage. Joints between bathtubs and tiles must be caulked and sealed using materials that conform to CAN/CGSB-19.22-M, "Mildew-Resistant Sealing Compound for Tubs and Tiles." Figure 9.29.-7 shows examples of sealing around shower pans and bathtub rims.

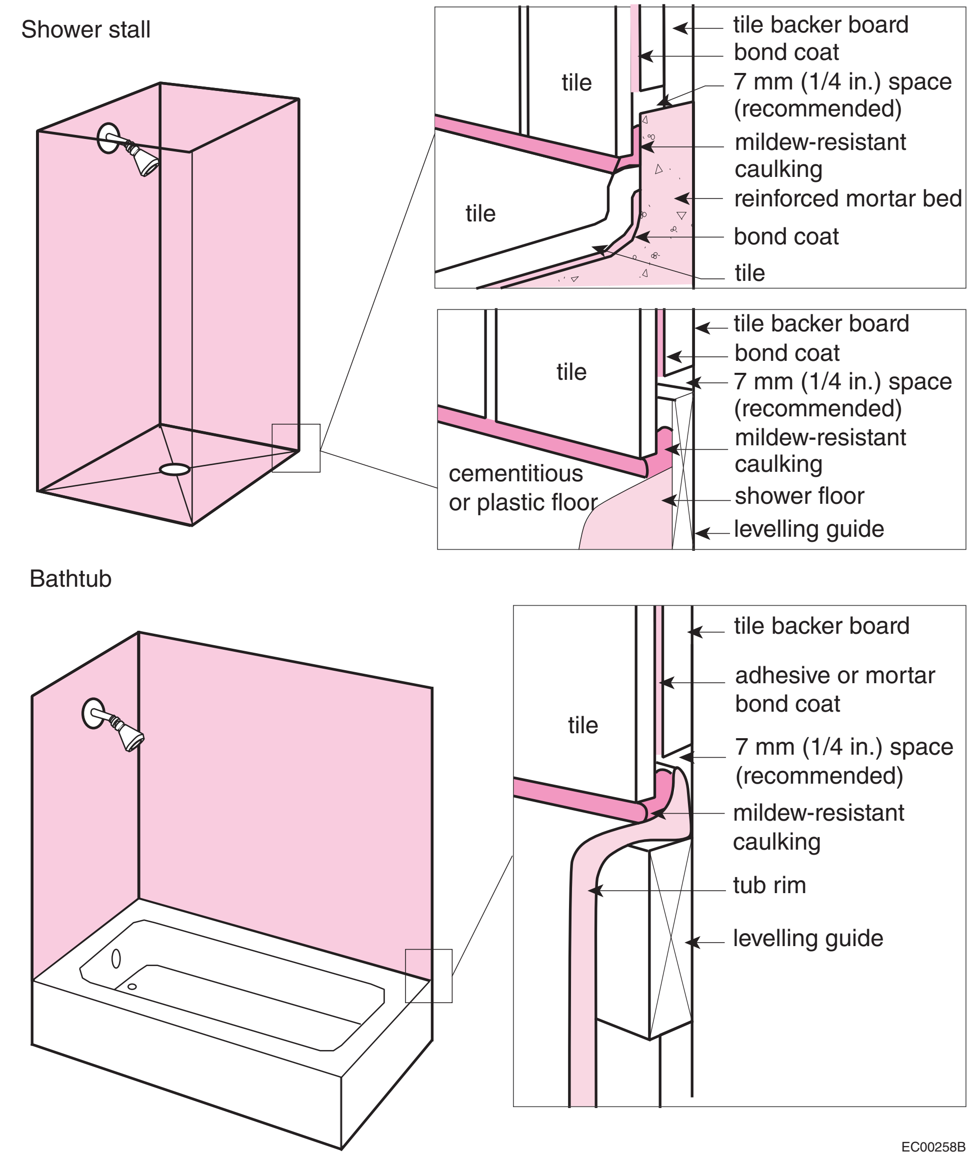


Figure 9.29.-7
Sealing joints between tile and tub or shower

Section 9.30. Flooring

Introduction

Finished flooring provides the wearing surface needed for the occupancy in which it is located. Its characteristics and functions, therefore, depend on the nature of the occupancy, and the design of the floor system. The type of finish flooring permitted depends on the use of the floor, and the base over which it is applied. In some areas of buildings, water and other substances may frequently be splashed or spilled onto the floor, in which case finish flooring and subflooring should be able to withstand periodic wetting without being damaged. It must be safe for occupants by being even. It must not be slippery and not emit harmful chemicals. Finished flooring may also contribute to structural support in the case of wood flooring, depending on the design of the floor.

9.30.1. General

9.30.1.1. Required Finished Flooring

This Article indicates the requirements for finish flooring in all residential occupancies.

9.30.1.2. Water Resistance

This Article requires floors with a high resistance to deterioration from moisture and with characteristics that facilitate cleaning in areas that are subject to water splash or food preparation. Where absorbent or permeable flooring materials are used, they should be installed in such a way that they can be conveniently removed periodically for cleaning or replacement, i.e., they should not be glued or nailed down.

If the subfloor is a type that is susceptible to moisture damage (this includes virtually all of the wood-based subfloor materials used in wood-frame construction), it must be protected by an impermeable membrane with a water permeance of not more than 18 ng/(Pa·s·m^2) (0.3 perms) placed between the finish flooring and the subfloor. The minimum degree of impermeability required could be provided by such materials as polyethylene, aluminum foil, and most single-ply roofing membranes (e.g., ethylene propylene diene terpolymer (EPDM) and polyvinyl chloride (PVC)).

9.30.1.3. Sleepers

This Article requires that lumber for wood sleepers supported on concrete resting on the ground be pressure-treated. Such sleepers may be subjected to water from leaky basements, surface condensation on concrete during warm weather, moisture migration from the ground (if the slab has not been effectively dampproofed), and water from the drying of the concrete during construction.

Sleepers supporting flooring on concrete must be at least 19 × 38 mm (1 × 2 in. nominal) and treated with a wood preservative. They create an air space beneath the subfloor (or the finish floor if no subfloor is used), and prevent direct contact with the concrete surface. Although this reduces the risk of water contact, floors in such areas can still be exposed to high relative humidities. This can increase the moisture content of the flooring and cause it to expand. In severe cases, the flooring may buckle upwards during sustained humid periods.

9.30.1.4. Finish Quality

This Article requires that floor surfaces have a smooth and even surface that will not create a tripping hazard or lead to injuries resulting from splinters.

9.30.2. Panel-Type Underlay

9.30.2.1. Required Underlay

This Article lists the types of flooring where an underlay is required to provide an even, stable base suitable for the type of floor finish to be applied. If lumber subflooring or panel-type subflooring whose edges are unsupported is installed, a separate panel-type underlay must be provided (Figure 9.30.-1) if the finish flooring consists of the following:

- ceramic tile (laid over lumber subflooring),
- resilient flooring,
- parquet flooring,
- felted-synthetic-fibre floor covering, or
- carpeting.

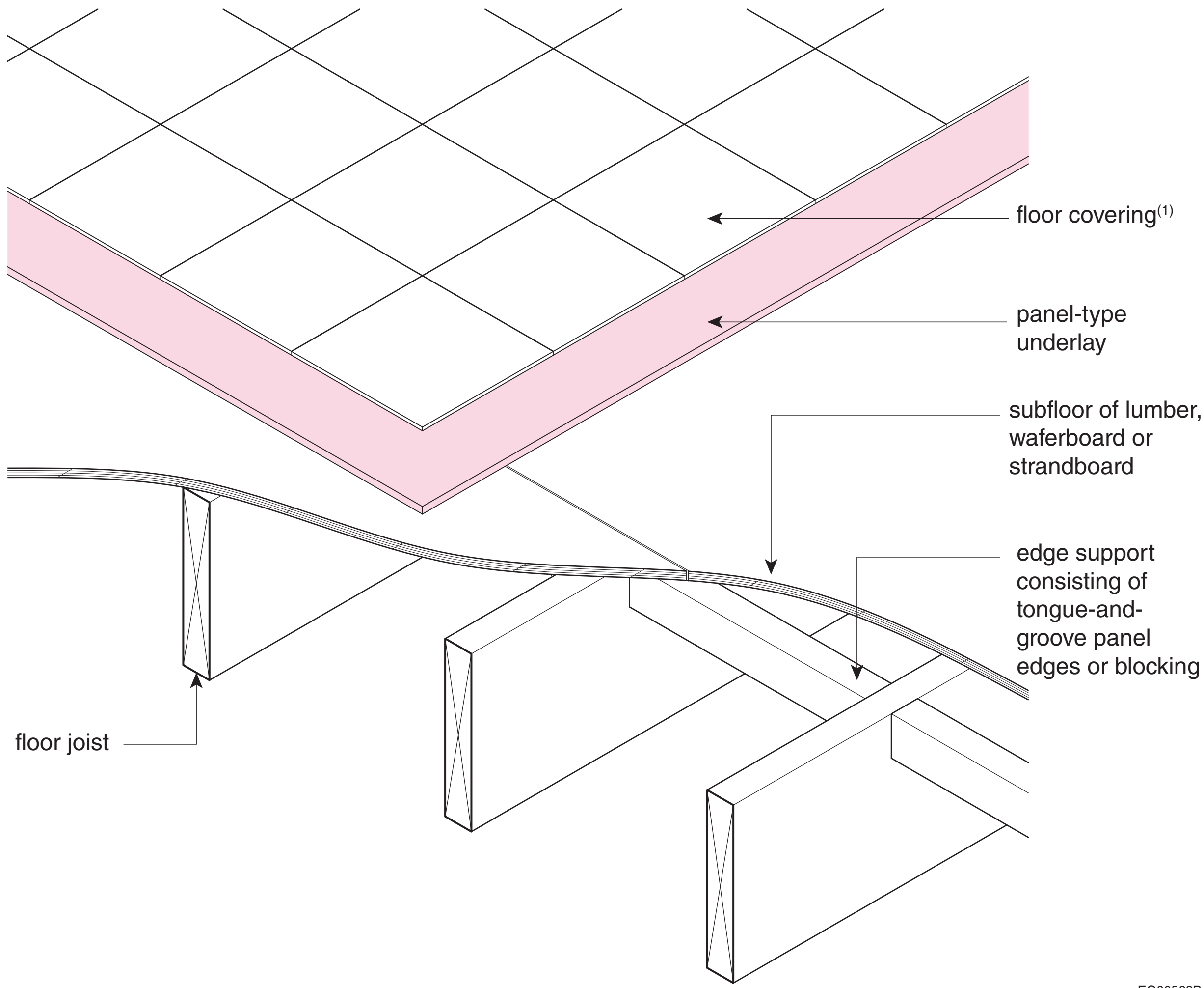


Figure 9.30.-1
Panel-type underlay for flooring

Note to Figure 9.30.-1:
(1) See NBC Article 9.30.2.1. for types of flooring requiring a panel-type underlay.

Panel-type underlay evens out subfloor irregularities, and bridges over subfloor joints that are subject to differential deflection when one side of the joint is loaded. Since strip flooring is able to do this as well, it does not require underlay where the strips are installed across the joists. However, because underlay is a safe and convenient working surface, the cost savings from omitting it may be outweighed by other cost factors.

If strip flooring is parallel to lumber subflooring, any shrinkage of the lumber subfloor will cause cracks to open in the wood strip floor finish, making underlay necessary.

9.30.2.2. Materials and Thickness

This Article defines, through reference to standards, the characteristics required for panel-type underlay to fulfill its required functions.

Table 9.30.-A summarizes the underlay requirements for various types of finish flooring. Where adhesive-applied ceramic tile flooring is used, a separate panel-type underlay must be provided. When panel-type subflooring is used, all edges must be supported.

Table 9.30.-A
Panel-Type Underlays

Finish Flooring	Subflooring	Underlay	NBC Reference
Resilient, parquet, carpeting, or felted-synthetic-fibre floor covering	Lumber, or panel-type with unsupported edges	Required	9.30.2.1.(1) and (2)
Resilient, parquet, carpeting, or felted-synthetic-fibre floor covering	Panel-type with all edges supported or concrete	Not required	n/a
Ceramic tile, set in mortar bed	Lumber	Required	9.30.2.1.(1)
Ceramic tile, set in mortar bed	All types, except lumber	Not required	n/a
Ceramic tile, adhesive-applied	All types	Required	9.30.2.1.(3)
Wood strip flooring, laid parallel to lumber subflooring	Lumber	Required	9.30.3.2.(1)
Wood strip flooring, laid at right angles to joists	None	Not required	9.30.3.2.(2)

Panel-type underlay must be at least 6 mm (1/4 in.) thick, except when the finish flooring consists of ceramic tile. The underlay must be at least 11 mm (7/16 in.) thick if the subfloor supports are spaced more than 300 mm (12 in.) on centre apart. Underlay must conform to the appropriate standards referenced in NBC Article 9.30.2.2.

9.30.2.3. Fastening

This Article describes how panel-type underlay must be attached to the subfloor. Panel-type underlay must be fastened to the subfloor with staples, annular grooved flooring nails, or spiral nails, spaced not more than 150 mm (6 in.) on centre on the edges, and 200 mm (8 in.) on centre in both directions on the panel interior face. Annular ring or spiral nails reduce the incidence of nail popping and floor squeaking, and are therefore specified in lieu of common nails.

Adhesive-fastened ceramic tile and resilient flooring are particularly sensitive to defects in the supporting base, so all holes and open defects must be filled before the tile is laid.

Nails for 6 mm (1/4 in.) thick underlay must be at least 19 mm (3/4 in.) long and nails for 7.9 mm (5/16 in.) thick underlay must be at least 22 mm (7/8 in.) long.

Staples for underlay must have a shank diameter of at least 1.2 mm (1/16 in.) with a crown width of at least 4.7 mm (3/16 in.) and must be at least 22 mm (7/8 in.) long for 6 mm (1/4 in.) thick underlay, and 28 mm (1 1/8 in.) long for 7.9 mm (5/16 in.) and 9.5 mm (3/8 in.) thick underlays.

9.30.2.4. Joints Offset

This Article requires a minimum offset for joints in panel-underlay. If joints in panel-type underlay coincide with the joints in panel-type subflooring, the underlay will not be able to control differential deflection if one side of the joint is loaded, and damage to the floor finish may result.

To mask the effect of the differential movement between subfloor panels, the joints of the underlay must be staggered at least 200 mm (8 in.) from the joints of the plywood, waferboard, or oriented strandboard subflooring. Surface defects such as holes must be filled and patched where used with resilient flooring or ceramic tiles applied with an adhesive.

Telegraphing of Underlay

Telegraphing of joints in the underlay through resilient flooring can be annoying and costly to repair. Underlay panels are susceptible to dimensional change when exposed to moisture. Panels swell when they absorb moisture, which causes ridging at seams. Underlay materials must reach an equilibrium with the temperature and moisture conditions expected in the house before they are installed (Figure 9.30.-2).

9.30.2.5. Surface Defects

This Article requires that holes and defects in panel-type underlay be filled so they will not damage finish flooring such as vinyl, linoleum, or adhesive-applied ceramic tile when a concentrated load is applied above the defect.

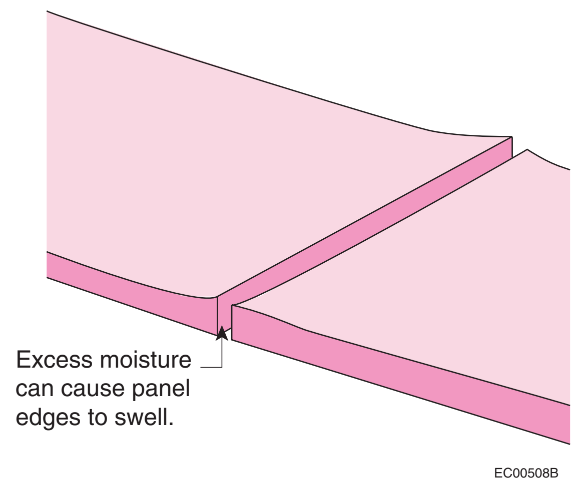


Figure 9.30.-2
Minimizing telegraphing of underlay

9.30.3. Wood Strip Flooring

Wood strip flooring is manufactured in an assortment of sizes, species, and grades. A variety of species of lumber can be used for strip flooring: oak, maple, and to a lesser extent, birch, beech and vertical-grain Douglas fir have been more commonly used for interior floors because of their wear-resistance and availability. The lengths are generally random, and edges and ends are usually tongued and grooved. The strips are slightly wider at the top to ensure a flush fit, and are normally grooved on the underside to increase dimensional stability. Wood strip flooring may be factory finished or finished in place after installation.

While not specifically required, it is considered good practice to store wood strip and parquet flooring in the area in which it is to be used until it reaches its equilibrium moisture level before laying. It should also be laid so that some expansion can take place around the perimeter of the floor. Usually about 10 to 15 mm (3/8 to 5/8 in.) clearance is provided and is concealed with mouldings at the base of the walls.

Exterior flooring not fully protected by a canopy or other shelter is subject to deterioration from prolonged wetting due to rain and snow-melt. Although not specifically required by the NBC, the life expectancy of such flooring can be extended by promoting rapid drying between periods of rain. This is accomplished by laying the flooring with spaces between individual strips to allow water to drain and air to circulate. Wood preservative treatments can also extend the life of exposed wood floors. Surface treatments such as paint coatings, however, do not provide as long-lasting protection as pressure treatment with leach-resistant preservatives.

9.30.3.1. Thickness

This Article requires a minimum thickness to provide adequate strength and stiffness for the flooring system when wood strip flooring acts as a structural member. A second purpose is to provide sufficient wood thickness to allow for surface wear resulting from occupant use and subsequent re-sanding and refinishing.

Wood strip flooring must have a thickness that conforms to NBC Table 9.30.3.1. Unless an underlay is provided, strips must not be laid parallel to lumber subflooring. If no subfloor is provided, strips must be laid perpendicular to joist direction so that end joints are staggered on supports, or are staggered and end matched. End matching requires that no two adjoining strips break their joints within the same joist space, and that each strip be supported by at least two joists.

9.30.3.2. Strip Direction and End Joints

This Article indicates requirements for wood strip flooring to keep cracks from opening between adjacent strips of flooring as a result of shrinkage in the subflooring. A second purpose is to limit differential movement between the butted ends of strips when a concentrated load is applied to one of the strips. Staggering the end joints, and making the strips continuous over two or more supports, provides additional stiffness in the strip flooring.

Most interior floors are built with subfloors as a construction convenience; subfloors are therefore usually installed even when they are not required. Where wood strip flooring is laid without a subfloor, the end joints of the strips have to be matched (i.e., tongued and grooved) if the joints are not located over joists. To ensure adequate strength, the joints between the supports must be spaced so that they do not occur in adjacent strips in the same joist space, and each strip must be long enough to bear on at least two joists (Figure 9.30.-3).

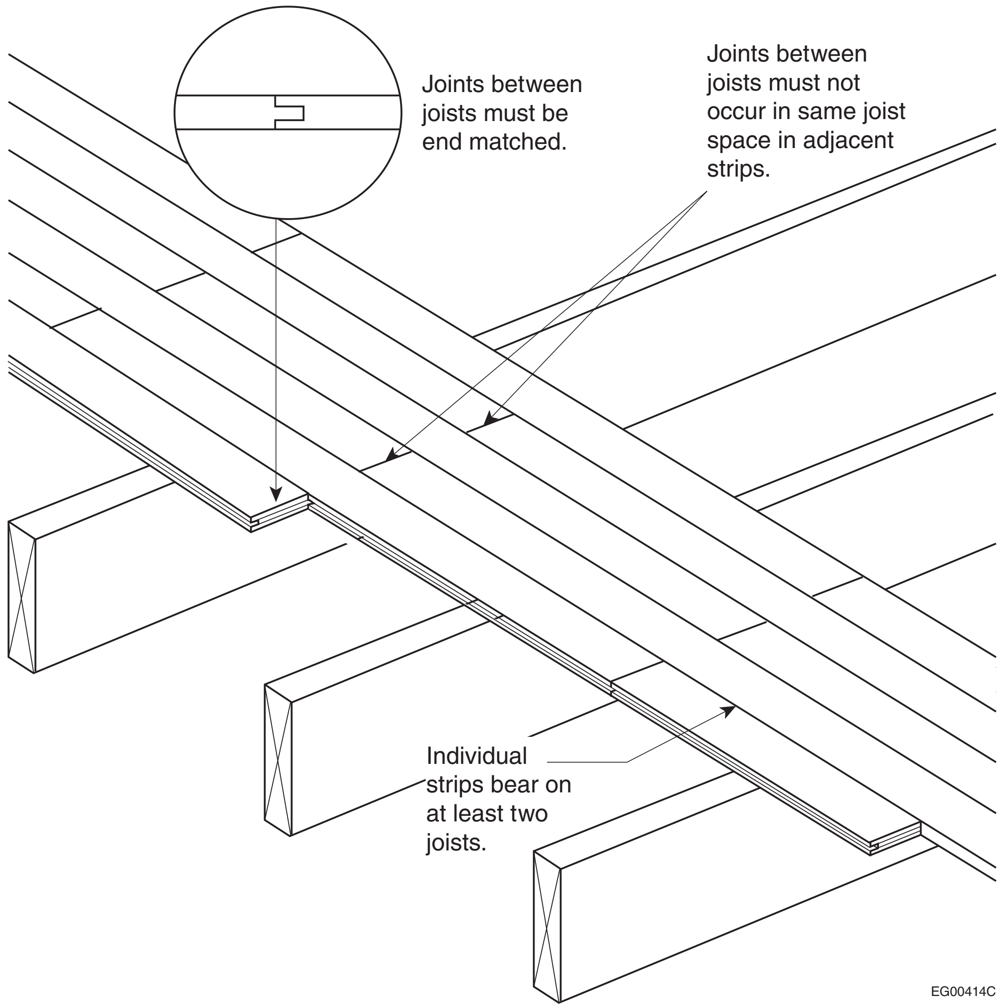


Figure 9.30.-3
Location of joints in wood flooring laid without a subfloor

9.30.3.3. Nailing

This Article indicates nailing requirements to attach firmly wood strip flooring to its base so that the strips can resist warpage or the floor can resist buckling resulting from a seasonal increase in the moisture content of the wood. Since nail heads tend to rise as the wood shrinks, they are countersunk to prevent them from creating a hazard, and the holes are filled to improve their appearance.

Nailing of wood strip flooring requires either toe-nailing or face-nailing with at least one nail per strip in accordance with the length and spacing requirements of NBC Table 9.30.3.3., except that face nailed strips more than 25 mm (1 in.) in width must have at least two nails per strip. All face nailed strips must be countersunk and the resulting holes filled with an appropriate filler. Staples may be used for wood strip flooring that is not greater than 7.9 mm (5/16 in.) thick, provided that the staples are at least 29 mm (1 1/8 in.) long with a shank diameter of at least 1.19 mm (1/16 in.) and 4.7 mm (3/16 in.) wide crowns. Refer to Figure 9.30.-4 for proper nailing and installation practices for wood strip flooring.

9.30.3.4. Staples

This Article permits the use of staples to attach firmly wood strip flooring to its base, so that the strips can resist warpage or the floor can resist buckling resulting from a seasonal increase in the moisture content of the wood.

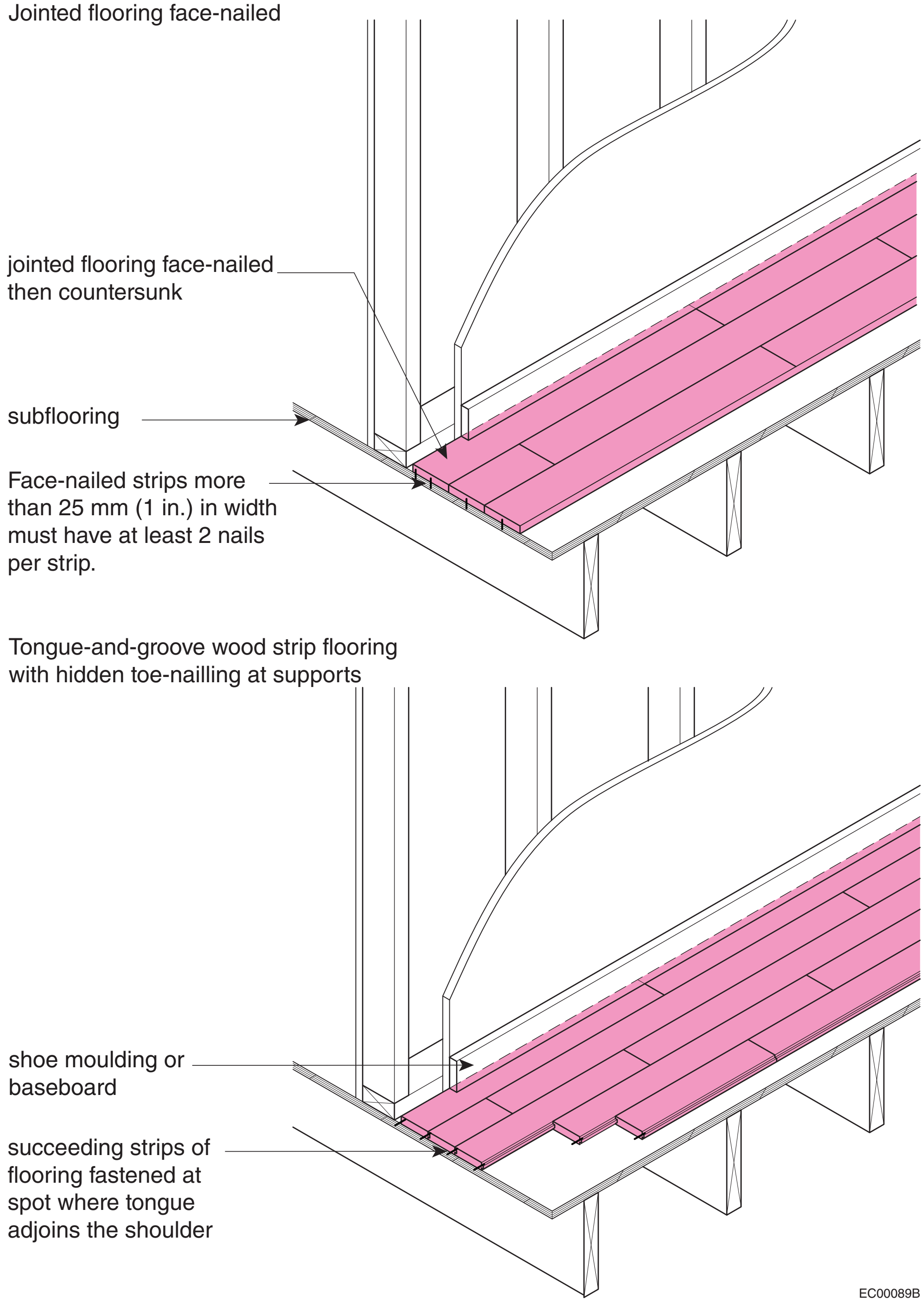


Figure 9.30.-4
Installation and nailing of wood strip flooring to a subfloor

9.30.4. Parquet Flooring

Parquet flooring, made from short thin pieces of hardwood, allows for a more efficient utilization of wood. Parquet flooring is made in tile form and attached to a backing material so that it can be laid with an adhesive, similar to resilient flooring. The parquet blocks may be designed to be finished after being laid or may have a factory-applied finish that requires no additional on-site treatment. Parquet flooring is most generally 7.9 mm (5/16 in.) thick. Thicker varieties are often used in complicated patterns where strength and rigidity are important.

9.30.4.1. Adhesive

This Article requires that adhesive for parquet flooring be suitable for the application. This is to ensure that parquet flooring is adequately attached to the supporting base by an adhesive that will be compatible with the surfaces to be joined, and will resist any upward movement of the parquet that may occur as a result of buckling caused by swelling of the parquet.

9.30.5. Resilient Flooring

Although resilient flooring can be made from a variety of materials, vinyl-based flooring is by far the most popular. Asphalt tile, popular about 40 years ago, is no longer produced. Linoleum, which once replaced asphalt, has in turn been largely replaced by various types of vinyl floor coverings.

9.30.5.1. Materials

This Article indicates the appropriate materials (including adhesives) for resilient flooring applied to floors-on-grade. Resilient flooring used on concrete floors supported on ground must be any of the following: asphalt, rubber, vinyl composite, unbacked vinyl, or vinyl with inorganic backing. The adhesive for the types of permitted flooring must be waterproof and alkali-resistant.

Resilient flooring may be laid over concrete and wood substrates. Special care should be taken in removing any bumps and lumps that would show through the finish and potentially damage it.

9.30.6. Ceramic Tile

9.30.6.1. Substrate

This Article indicates the substrate requirements to provide a base for ceramic tile that will provide adequate support for the tile and will not contribute to its premature failure.

Ceramic tile may be laid either directly on a concrete, plywood or oriented strandboard (OSB) base with an adhesive, or in a mortar bed about 30 mm (1 3/16 in.) thick over a concrete or wood-frame floor. A typical mortar mix contains 1 part of Portland cement and 0.25 part lime to approximately 4 to 6 parts of sand (by volume). A number of manufacturers have prepackaged mortar mixes formulated for various subfloor conditions.

Ceramic tile applied to a wood floor with an adhesive is particularly sensitive to deflection. Where ceramic tile is applied to a panel-type subfloor with an adhesive, the edges of the subfloor must be supported to increase its stiffness, and the joints must be offset as shown in Figure 9.30.-5.

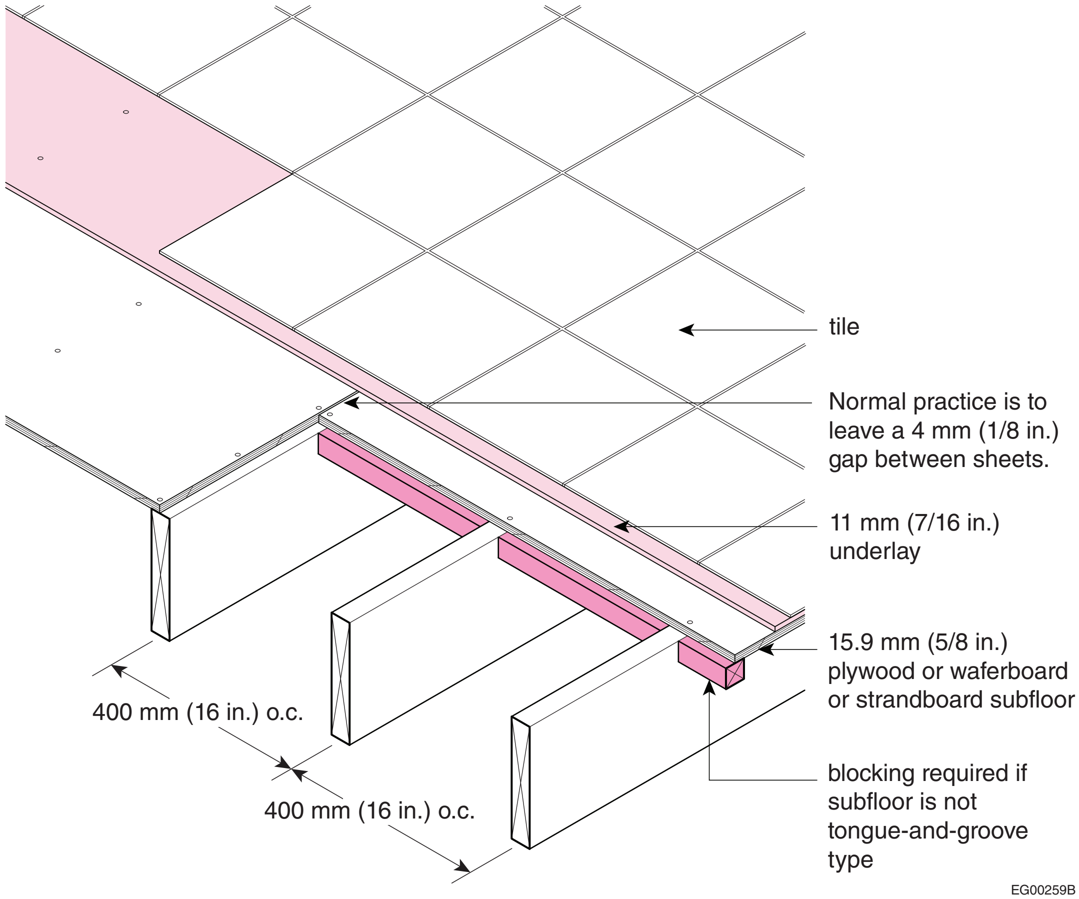


Figure 9.30.-5
Reinforcing of subflooring supporting ceramic tile flooring

Section 9.31. Plumbing Facilities

Introduction

The requirements for plumbing facilities in NBC Section 9.31. address the distribution and connection of water, sewage and wastewater systems in dwelling units. These are intended to maintain reasonable sanitation conditions.

9.31.1. Scope

9.31.1.1. Application

This Article informs NBC users that NBC Section 9.31. applies to plumbing facilities in dwelling units, and that requirements in NBC Part 3 apply to occupancies that are not dwelling units. In occupancies other than dwelling units, plumbing facilities, grab bars, floor drains, and floor and wall finishes around urinals need to conform to NBC Subsection 3.7.2. Barrier-free plumbing facilities need to be designed in accordance with NBC Section 3.8. Medical gas piping systems need to be designed in accordance with NBC Subsection 3.7.3.

9.31.2. General

9.31.2.1. General

This Article refers to the requirements of the National Plumbing Code of Canada 2010 (NPC) that pertain to water distribution systems, plumbing fixtures, and rainwater collectors, as well as to the drain, waste and vent piping that service them, such that they will not create a health hazard or a nuisance to the occupants they serve.

9.31.2.2. Corrosion Protection

This Article requires protecting metal piping from coming in contact with potentially corrosive material that might reduce the service life of the piping.

9.31.2.3. Grab Bars

This Article indicates that when grab bars are used in conjunction with plumbing fixtures, they must be capable of supporting a load of not less than 1.3 kN (239 lbf) applied horizontally or vertically that results from the user of the fixtures.

9.31.3. Water Supply and Distribution

9.31.3.1. Required Water Supply

This Article requires that each dwelling unit be provided with water that is fit to drink.

9.31.3.2. Required Connections

This Article requires plumbing fixtures that can provide an appropriate level of sanitation where the dwelling unit has a piped water supply. Houses that have a piped water supply distribution system must have piping for hot and cold water connected to every kitchen sink, lavatory, bathtub, shower, slop sink and laundry area. Piping for cold water must be run to every water closet and hose bib.

9.31.4. Required Facilities

9.31.4.1. Required Fixtures

This Article requires a basic level of sanitation in dwelling units where a piped water supply is available by providing essential plumbing facilities necessary for sanitary food preparation, dish washing, personal washing, and sewage disposal.

Not every house is connected to a piped-in, potable water supply, either because of groundwater pollution or the unsuitable nature of the water supply. Houses are permitted to be without piped water, provided that an alternative source is available to provide suitable drinking water. In such cases, the only practical alternative may be to transport potable water to the dwelling unit. Such cases are relatively rare but, when they occur, the requirements for providing fixtures for sanitary purposes are waived. Where a piped water supply is available, however, a kitchen sink, a lavatory, a water closet, and either a bathtub or a shower must be provided. In addition, each dwelling unit with these facilities must have a piped hot water supply so that each sink, lavatory, bathtub or shower is connected to both the hot and cold water lines.

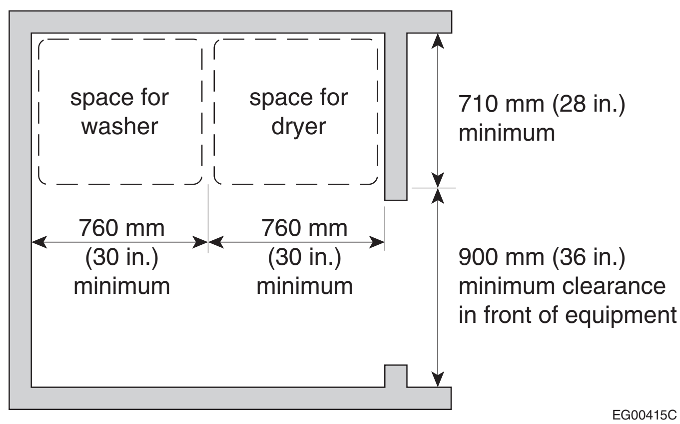


Figure 9.31.-1
Suggested minimum dimensions for laundry areas

Neither laundry facilities nor space for laundry equipment is required by the NBC. Where these are provided, it is only reasonable that sufficient clearance be provided to allow for their convenient use. Similarly, the Code does not specify minimum areas for bathrooms (Figures 9.31.-1 and 9.31.-2).

9.31.4.2. Hot Water Supply

This Article requires basic levels of sanitation in dwelling units by providing a supply of hot water to service the basic plumbing facilities used for washing, laundering or food preparation. Bathrooms, water-closet rooms or laundry areas above grade must have a minimum ceiling height of 2.1 m (6 ft. 11 in.) in any area where a person would normally be in a standing position. See NBC Subsection 9.5.3. for specific requirements.

9.31.4.3. Floor Drains

This Article requires floor drains to facilitate the disposal of water in basements that may result from groundwater leakage, plumbing or equipment leakage. House basements may be subject to periodic water leaks as a result of flooding conditions or severe storms. They are, therefore, required to have floor drains, unless it is not possible to drain the water by gravity to a sewer, ditch or dry well without the use of pumps.

Garbage rooms and incinerator rooms in apartment buildings are subject to fouling by accidental garbage spills and must occasionally be hosed down for sanitary reasons. To facilitate this practice, floor drains are required to be installed to dispose of the wash water. Boiler rooms are subject to water leaks from bleeding the lines, as well as other accidental water discharges. They are also required to have floor drains to dispose of such water.

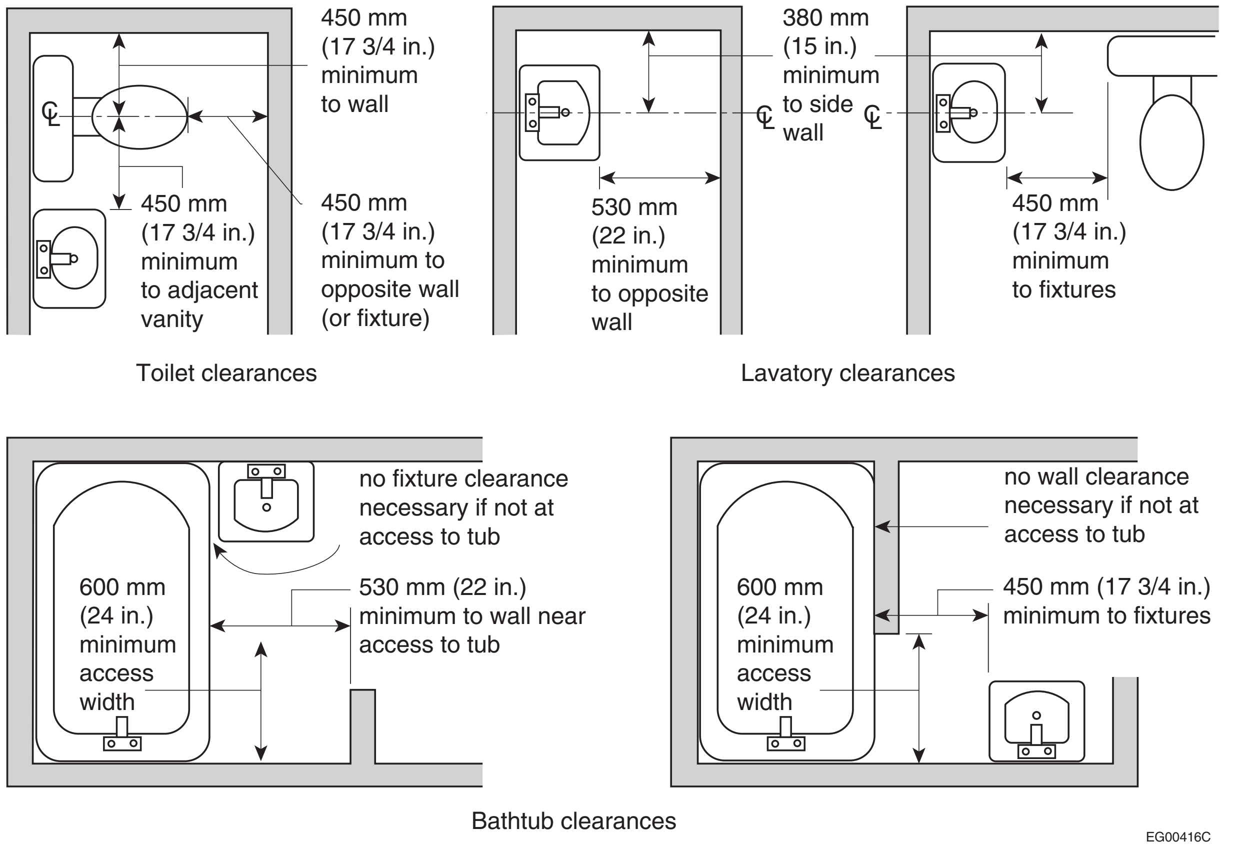


Figure 9.31.-2
Suggested minimum clearances for bathroom fixtures

9.31.5. Sewage Disposal

9.31.5.1. Building Sewer

This Article requires a basic level of sanitation in dwelling units by disposing, to the building sewer, the waste from every plumbing fixture.

Provincial, territorial and municipal authorities have local requirements for private disposal systems, and regulate where they are permitted to be installed. Such systems, if not designed and installed in conformance with accepted practices, taking into account local soil and drainage conditions, can create a major health hazard for the building occupants as well as the neighbourhood. It is important, therefore, that local building and health authorities be consulted at an early stage of design.

If a house is constructed on a lot that has access to a sanitary sewer, its plumbing fixtures must be connected to a plumbing drainage system that leads to the sewer. If there is no access to a sewer system, the fixtures must drain to an appropriate private sewage disposal system, such as a septic tank. This applies only if there is a piped water supply.

9.31.5.2. Discharge of Sewage

This Article requires a basic level of sanitation in dwelling units by providing for the sanitary disposal of waste from the building.

9.31.6. Service Water Heating Facilities

9.31.6.1. Hot Water Supply

This Article requires that water supply be hot enough and in sufficient quantity as required in NBC Article 9.31.4.2., but not so hot as to cause serious accidental burn injury.

Equipment must be capable of heating an adequate supply of water to at least 45°C (113°F), but not more than 60°C (140°F). Service water heaters must conform to appropriate provincial or territorial requirements or, in their absence, to the NPC.

9.31.6.2. Equipment and Installation

This Article, through reference to standards, requires that service water heaters be designed and installed so that they will not cause an undue risk of fire, explosion, or electric shock. Also, they must not expose the occupants to a health risk from the products of combustion.

Water heaters could pose a hazard if toppled in an earthquake. Exposure to earthquake risk is expressed in terms of the spectral response acceleration, $S_a(0.2)$ (NBC Table C-3 of Appendix C). Where a building is located in an area where the spectral response acceleration, $S_a(0.2)$, is greater than 0.55, service water heaters must be attached to the building structure to prevent their toppling over and breaking a gas line. Figure 9.31.-3 illustrates one method of securing a water heater to the floor joists above.

9.31.6.3. Corrosion-Resistant Coating

This Article requires that steel service water heaters be coated to ensure a reasonable service life. Storage tanks for domestic water heaters fabricated from corrosion-susceptible materials such as steel must be coated with zinc, vitreous enamel (glass lined), hydraulic cement, or other corrosion-resistant material. This requirement is intended to prevent corrosion in order to extend the life of the tank.

9.31.6.4. Fuel-Burning Heaters

This Article indicates that fuel-burning service water heaters must be connected to a chimney flue, as described in NBC Section 9.21. This is to vent the products of combustion to the exterior so they will not create a health hazard to the occupants.

9.31.6.5. Heating Coils

This Article disallows the use of hot water heating coils installed in a flue or a furnace combustion chamber because they could heat the water above its boiling point and create dangerous pressures in the water system.
Such a practice can lead to scalding temperatures at the taps, rupture of the coils when solder melts, and even rupture of the hot water tank itself from excessive pressure.

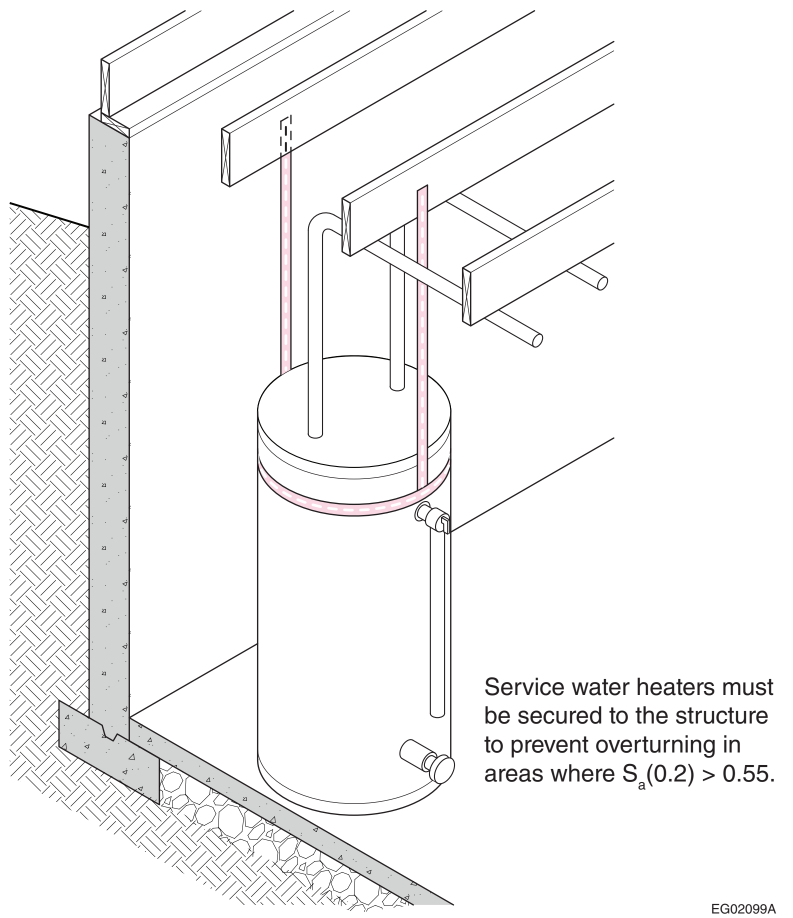


Figure 9.31.-3
Securement of service water heaters

Section 9.32. Ventilation

Introduction

The purpose of ventilation is to maintain healthy indoor conditions for the occupants. Ventilation for occupants must not be confused with ventilation requirements for the structure. Ventilation requirements for unheated crawl spaces and attic spaces are dealt with in NBC Sections 9.18. and 9.19., respectively. Ventilation for occupancy must also not be confused with combustion air requirements for combustion equipment, which is part of the heating system, and is dealt with in NBC Section 9.33.

Mechanical ventilation requirements in the NBC have evolved since its 1980 edition from a simple requirement that exhaust fans be incorporated in electrically heated houses, to a requirement that all houses have mechanical ventilation systems capable of exchanging the indoor air for outdoor air at a specified rate of air changes per hour in the editions of 1985 and 1990. NBC 1995 addressed not only the overall air change rate created by the mechanical ventilation system, but also the need to ensure that the outdoor air brought into the house by the system be distributed throughout the house.

In the NBC 2005, additional provisions were included with the following goals in mind:
- provisions that are easier to understand,
- reduced probability that outdoor air distributed through a forced-air heating system will be cool enough to cause premature deterioration of the furnace heat exchanger, and
- reduced probability that the ventilation system will cause excessive depressurization of the dwelling unit.

In terms of mechanical ventilation, the NBC 2005 required that the normal principal ventilation fan rate be determined by a bedroom count. The bedroom count acts as a surrogate for the occupancy level of the dwelling. This low flow rate was still required to be capable of continuous operation.

The NBC 2005 also required supplemental exhaust fans in bathrooms, water-closet rooms and kitchens. However, it also offered the option to provide the supplemental exhaust capacity through the principal ventilation fan. This option could be used if the principal ventilation fan could be operated at a high flow rate. The NBC 2005 retained the requirement for balanced exhaust and supply airflows by provision of outdoor air supply, air except in specific circumstances where exhaust only ventilation systems were permitted.

9.32.1. General

9.32.1.1. Application

This Article informs NBC users of the application of NBC Section 9.32., and directs them to other applicable ventilation requirements in other Parts of the NBC.

NBC Section 9.32. applies only to self-contained residential systems serving a single dwelling unit. The design of ventilation systems for all other buildings covered by NBC Part 9 must conform to NBC Part 6. Mechanical systems serving more than one dwelling unit are considered too complex to be included in NBC Part 9 and are required to be designed in conformance with NBC Part 6. However, the ventilation systems for individual dwelling units in multi-unit dwelling buildings can meet the requirements in NBC Part 9 if each unit's system is self-contained.

Small parking garages associated with residential buildings are considered adequately ventilated by normal air leakage and do not require mechanical ventilation systems. If they are designed to contain more than four motor vehicles, however, they must be ventilated in conformance with NBC Part 6.

9.32.1.2. Required Ventilation

This Article requires a sufficient rate of air change in dwelling units for the purpose of maintaining healthy conditions for occupants on a year-round basis. A second purpose is to avoid the excessive build-up of moisture, odors and other contaminants, during the time when the dwelling unit's heating system would normally be in operation with the windows closed.

Every residential occupancy must be ventilated by natural means or by a mechanical ventilation system during the non-heating season.

Heating season ventilation systems serving single dwelling units that are supplied with electricity and a heating system may be designed in accordance with NBC Subsection 9.32.3. or the requirements of NBC Part 6. All residential occupancies with electricity and a heating system, except for single dwelling units, are required to have ventilation systems designed in accordance with NBC Part 6.

Houses with a Secondary Suite

In houses that contain a secondary suite, exits, public corridors and ancillary spaces that are not within dwelling units are not required to have heating season ventilation. However, ancillary spaces must be ventilated with make-up air if they contain exhaust devices.

The control of smoke transfer between dwelling units in a house with a secondary suite, or between the dwelling units and other spaces in the house, is a critical safety issue. Although providing a second ventilation system to serve the two dwelling units is expensive, and potentially difficult in an existing building, it is necessary to achieve a minimum acceptable level of fire safety. Alternative solutions to providing separate ventilation systems for the dwelling units must address smoke control.

Although smoke dampers restrict the spread of smoke by automatically closing in the event of a fire, their installation in a ventilation system that serves both dwelling units in a house with a secondary suite is not considered to be a workable solution because they are very expensive, require regular inspection and maintenance, and must be reset after every activation.

The provision of a ventilation system for the purpose of maintaining acceptable indoor air quality is a critical health issue. However, NBC Sentence 9.32.1.2.(3) allows exits and public corridors in houses with a secondary suite to be unventilated. Lack of active ventilation of these spaces is considered acceptable because occupants do not spend long periods of time there and because exits are naturally ventilated to a certain degree when doors are opened. Considering the cost of installing separate ventilation systems, NBC Sentence 9.32.1.2.(4) also exempts ancillary spaces in houses with a secondary suite from the requirement to be ventilated, provided that makeup air is supplied in accordance with NBC Article 9.32.3.8.

9.32.1.3. Venting of Laundry-Drying Equipment

This Article requires that exhaust ducts and vents connected to laundry-drying equipment discharge directly to the outdoors. This requirement is intended to reduce the level of particulates and the level of humidity in the indoor building environment, which improves the indoor air quality. Furthermore, the reduced level of particulates decreases the fire hazard level of the building, and the reduced level of humidity decreases the rate of deterioration of the building assembly.

Exhaust ducts connected to laundry-drying equipment must be independent of other exhaust ducts, accessible for cleaning, and constructed of a smooth corrosion-resistant material (Figure 9.32.-1). These requirements do not apply to the flexible ducts that are often used to connect the equipment to the rigid exhaust duct.

Multiple installations of laundry-drying equipment (e.g., in the common laundry room of a multi-unit residential building) are permitted to be vented collectively, provided that certain conditions are met. The ventilation system must be connected to a common exhaust duct that is vented by one central exhaust fan and incorporates one central lint trap, and must include an interlock to activate the central exhaust fan when laundry-drying equipment is in use (Figure 9.32.-1). The system must also be provided with make-up air where required by NBC Article 9.32.3.8.

The venting of a common exhaust duct by a central exhaust fan creates a continuous negative pressure in the plenum, preventing any backdraft or short-circuiting of the exhaust air to non-operating drying equipment and reducing the risk of fire associated with lint build-up.

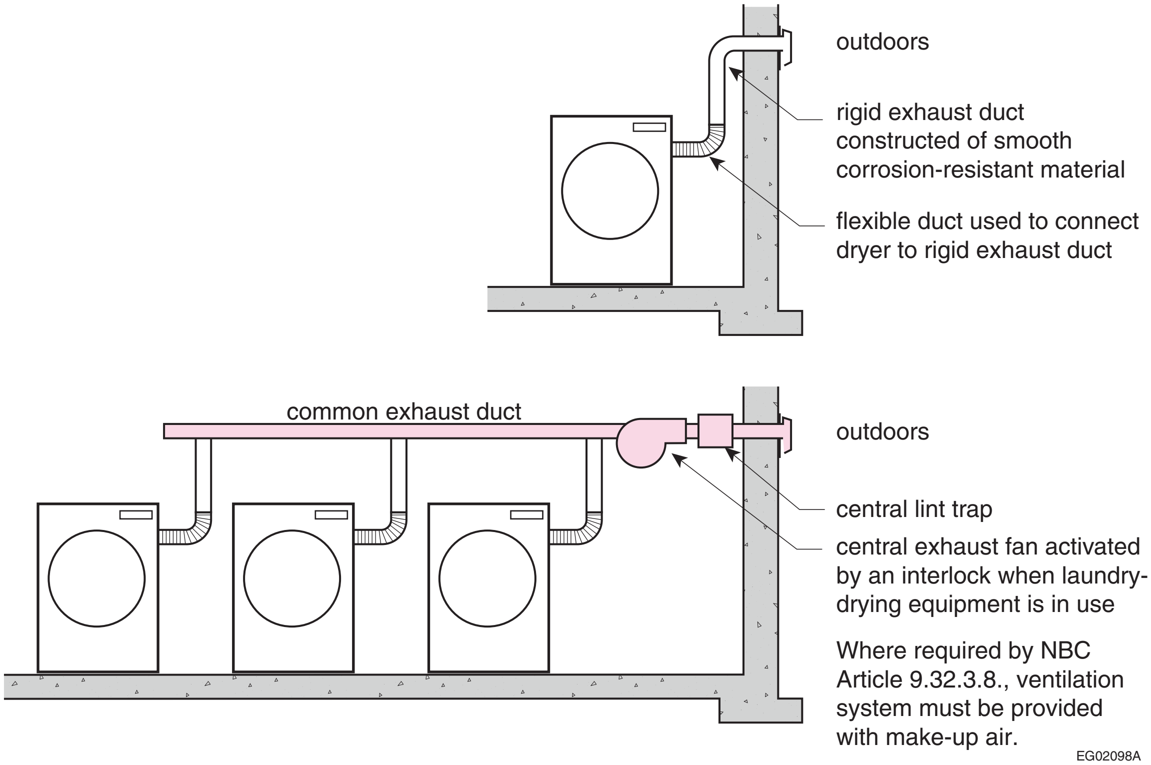


Figure 9.32.-1
Typical and collective venting of laundry-drying equipment

9.32.2. Non-Heating-Season Ventilation

9.32.2.1. Required Ventilation

This Article requires that sufficient ventilation be provided during the non-heating season using either natural ventilation or mechanical ventilation (to meet the requirements of NBC Article 9.32.1.2.). This will also maintain indoor air quality and avoid excessive build-up of heat in dwelling units that may result from lack of air change during this period.

Rooms or spaces may be ventilated during the non-heating season by natural means or by a mechanical ventilation system.

9.32.2.2. Non-Heating-Season Natural Ventilation

This Article requires sufficient ventilation area to the exterior for individual rooms and spaces within dwelling units during periods when the heating system would not be in operation (the non-heating season). Effective natural ventilation depends on factors such as siting, house design, and weather conditions.

Rooms and spaces that are ventilated by natural means must have unobstructed openable ventilation areas to the outdoors. Where a vestibule opens off a living or dining room, ventilation to the outdoors may be through the vestibule.

NBC Table 9.32.2.2. identifies the areas that are required for natural ventilation. It should be noted that openings other than windows must also provide protection from the weather and from insects. As well, screening must be made of rustproof material. The NBC no longer specifies a minimum window area per room for reasons of aesthetics and psychological well-being, but a minimum window area is required where outdoor air is provided by means of natural ventilation.

9.32.2.3. Non-Heating-Season Mechanical Ventilation

Where natural means (windows, screen doors, etc.) are not used for ventilation during the non-heating season, as in the case of a house using mechanical cooling in hot, humid conditions, mechanical ventilation must be provided at a rate conforming with NBC Table 9.32.2.3. If the room or space is not mechanically cooled, then mechanical ventilation must be provided at the rate of one air change per hour according to NBC Sentence 9.32.2.3.(3).

Guidance on the design and installation of non-heating season mechanical ventilation systems is also provided in ASHRAE Handbooks and Standards, the HRAI Digest, the Hydronics Institute Manuals and SMACNA manuals.

9.32.3. Heating-Season Mechanical Ventilation

9.32.3.1. Required Ventilation

This Article requires that a system of mechanical ventilation be provided for rooms and spaces within dwelling units during periods when the heating system would normally be in operation with the windows closed. While natural ventilation, in the form of openable windows, can provide ventilation during the warm periods of the year, every house with electrical power must be provided with a mechanical system for heating season ventilation.

The NBC requires mechanical ventilation systems in all residential buildings. Every dwelling unit supplied with electrical power must be provided with a mechanical ventilation system complying with:
- CAN/CSA-F326-M, “Residential Mechanical Ventilation Systems,” or
- for dwelling units with no more than five bedrooms, prescriptive systems as described in NBC Subsection 9.32.3., which provides a prescriptive compliance method that is loosely based on CAN/CSA-F326-M.

CAN/CSA-F326-M is a comprehensive performance standard. It gives experienced ventilation system designers the flexibility to design a variety of residential ventilation systems that satisfy those requirements.

The prescriptively described systems in NBC Subsection 9.32.3. are intended to provide a level of performance approaching that provided by systems complying with CAN/CSA-F326-M. They are included in the NBC for use by those less experienced in ventilation system design. Code users who do not find these prescriptively described systems satisfactory for their purposes, or who find them too restrictive, are free to use any other type of ventilation system that satisfies the performance requirements of CAN/CSA-F326-M.

All mechanical ventilation systems need to have at least a principal ventilation system, exhaust capacity, and protection against depressurization. These and other desirable features can be summarized as follows:

- A principal ventilation system capable of continuously ventilating at a rate governed by the number of bedrooms: The system must include an exhaust fan and a means for introducing, tempering, and distributing outdoor replacement air (exhaust-only systems introduce air by infiltration, and acceptable levels of tempering are assumed to occur as infiltration air mixes with conditioned house air).
- Exhaust from all bathrooms and kitchens: This can be provided in whole or in part by the principal ventilation system exhaust fan, or by supplemental exhaust fans.
- Protection against depressurization and air pollutants: Measures must be taken to minimize exposure to combustion products and contaminated air from attached garages. Make-up air may be required for exhaust fans, heat recovery units and energy recovery units that have exhaust-only defrost, clothes dryers, central vacuums, range hoods and other cooktop and oven exhaust devices.
- Make-up air systems for exhaust devices: These are required if fuel-fired space and/or water heating devices are not direct-vented or mechanically vented.
- Carbon monoxide alarms in specific locations: This is a requirement in all dwelling units that contain fuel-burning appliances or have attached garages.
- Fans that comply with airflow and sone (noise) ratings: Fans with less than 1 m (3 ft. 3 in.) of duct between them and surfaces of living spaces must meet the following sound rating requirements:
  (a) 2.0 sones or less if they are rated in accordance with CAN/CSA-C260-M, “Rating the Performance of Residential Mechanical Ventilating Equipment,” or 2.5 sones or less if rated in accordance with HVI Publication 915, “Loudness Testing and Rating Procedure,” for principal ventilation fans, and

(b) 2.5 sones or less if they are rated in accordance with CAN/CSA-C260-M, or 3.5 sones or less if rated in accordance with HVI Publication 915, for supplemental fans installed in bathrooms.

Achieving the required distribution of outdoor air is simple in houses with forced-air heating systems, because the heating ducts do double duty as ventilating ducts. In houses without forced-air heating, such as those with baseboard or radiant heat, it is necessary to install a system of ducts to distribute the outdoor air to each bedroom, to each storey without a bedroom, and if there is no storey without a bedroom, to the principal living area.

9.32.3.2. Design and Installation

This Article requires that a mechanical ventilation system be installed to fulfill its intended purpose, and not create a fire, health or shock risk for occupants.

Aspects of mechanical ventilation systems not described in NBC Subsection 9.32.3. must be designed and installed in accordance with the following:
- good practice, such as described in the ASHRAE Handbooks and Standards, the HRAI Digest, the Hydronics Institute Manuals, and the SMACNA manuals,
- manufacturers' installation requirements, unless they conflict with the requirements of the NBC,
- the requirement that vibration isolation be provided for equipment to prevent noise and vibration transfer to occupied spaces,
- the requirement that acceptable air flow regulating dampers be installed where required,
- the requirement that equipment be accessible for inspection and maintenance, and
- the special requirements that apply to equipment installed in unheated spaces.

9.32.3.3. Principal Ventilation System

This Article requires that the principal ventilation system be installed to fulfill its intended purpose, and not create a fire, health or shock risk for occupants.

The principal ventilation system exhausts stale indoor air, supplies outdoor air, and distributes this outdoor air to specific locations throughout the house for the purpose of maintaining acceptable indoor air quality. Each ventilation system has four main components:
(1) outdoor air supply,
(2) distribution of air,
(3) controls, and
(4) indoor air exhaust.

The operation of the principal ventilation fan exchanges indoor air for outdoor air. Its operation is linked with a means of introducing and distributing outdoor air to the dwelling unit at approximately the same rate at which the indoor air is exhausted, except as permitted by NBC Article 9.32.3.6. The principal ventilation fan must be capable of exhausting air from the dwelling unit to the outdoors. Though actual usage will be determined by the occupants, the fan must be capable of continuous operation. As there is no standard method of testing and designating fans for continuous use, such a designation is not a mandatory requirement at this time. Supplemental exhaust fans, such as kitchen cooktop hoods and bathroom fans, provide more ventilation at point of source when needed.

Several configurations are possible for principal ventilation systems (see NBC Figures A-9.32.3.3.-A to -F and A-9.32.3.6.). Even for these prescriptive solutions, a significant degree of flexibility is available.

Outdoor Air Supply

Outdoor air is brought into a house either through a dedicated outdoor air supply duct to the return duct of the forced air system or, in exhaust-only systems permitted under NBC Article 9.32.3.6. by leaks through the building envelope.

Where the kitchen or a bathroom is chosen as the location for the air intake of the principal ventilation fan, the intake must be positioned high enough to capture contaminants, warm moist air and hot gases, which tend to rise and stratify near the ceiling. These restrictions prevent the use of a cooktop exhaust or hood fan as the principal ventilation fan.

Distribution of Air

There are two approaches to ensuring air is distributed to all parts of the house:
(1) in forced air heating systems, the furnace circulation fan moves the air through heating distribution ducts, and
(2) in non-forced air heating systems, a supply fan circulates air through dedicated ventilation distribution ducts.

The principal ventilation fan operates at a rate known as the "normal operating exhaust capacity." This rate is intended to be suitable for use on a continuous basis at any time that an ongoing, background level of ventilation is needed (e.g., the late fall or early spring when air leakage driven by wind and inside/outside temperature differences is lowest but it is too cold to rely on open windows).

The normal operating exhaust capacity is typically about 0.3 air change per hour. This rate is recommended by many experts for healthy indoor conditions and is obtained by the use of the principal ventilation system plus the supplementary fans.

Though actual operation will be determined by the occupants, the fan should be capable of continuous operation. The principal exhaust fan is intended to provide a relatively low level of ventilation in a manner that allows it to run continuously, quietly, and be energy-efficient.

The capacity of the principal ventilation fan is determined on the basis of the number of bedrooms in the house (see NBC Table 9.32.3.3.) rather than on the basis of some fraction of the house volume, as in previous editions of the NBC. This is because the amount of ventilation required is related to the activities of people, and the number of people in the house is usually related to the number of bedrooms rather than to the size of the house. It should be emphasized that this air change rate refers to the installed capacity of the system, not to the rate of ventilation that is actually used in the house.

In many households, ventilating even at the background rate would provide more ventilation than required, resulting in unnecessarily high heating bills and perhaps excessively low indoor relative humidity. Thus, although a system with the minimum capacity must be installed, it can incorporate controls that allow the system to be used at less than its full capacity most of the time.

A maximum is set for the capacity of the principal ventilation fan because, if it were to be much larger than the ventilation needs of the household, it might never be used. The principal ventilation fan is intended to provide a relatively low level of ventilation such that it can be run continuously without too much noise and without serious energy penalty. If the installed capacity exceeds the minimum by a large margin and the fan flow cannot be reduced, there is an increased probability that the fan will not be used at all, thus defeating the purpose of having it in the first place. NBC Sentence 9.32.3.3.(2), therefore, places limits on oversizing.

Controls

The principal ventilation fan must incorporate controls that allow it to be turned off. There are four main types of controls used in residential applications:

(1) Manual on-off switch: This is the simplest form of control but, while acceptable, it is not the best means of maintaining indoor air quality. Occupants may turn the system off without understanding the importance of proper ventilation and forget to turn it back on, or they may turn it off to reduce noise or on the assumption that this will reduce heating bills.

(2) Dehumidistat: A dehumidistat automatically activates the ventilation system in response to rising humidity. Humidity is often the main reason why ventilation is required, but not always. Depending on the activities of the occupants and the relative strengths of other sources of pollutants and humidity, the amount of ventilation required to control humidity may not be enough to control other pollutants.

(3) Carbon dioxide sensor: Ventilation systems in large buildings are sometimes controlled by carbon dioxide (CO_2) sensors, and this technology is just beginning to become available on a residential scale. Increasing CO_2 concentration is usually a good indication of decreasing air quality. But even this form of control may not be satisfactory in cases where there are unusual pollutants, such as those generated by certain hobbies.

(4) Periodic cycling control: Devices are available that cause the furnace circulation fan to operate at user-set intervals if the thermostat does not call for heat. If such a device were wired so that it turned on the principal ventilation fan as well as the furnace circulation fan, it would satisfy the requirements

of NBC Article 9.32.3.4. However, if it were wired to only operate the furnace circulation fan in a system designed to NBC Article 9.32.3.4., at times the principal ventilation fan would operate without the furnace circulation fan. Since such systems rely on the furnace circulation fan drawing in outdoor air to balance the exhaust flow through the principal ventilation fan, this would result in the exhaust flow not being balanced and the dwelling being depressurized. This configuration would therefore not be acceptable but would be acceptable for a system designed in accordance with NBC Article 9.32.3.6.

The purpose of the requirement to locate the controls in the living area is to have them easily accessible to the occupants, rather than in a little used room or unfinished basement, for example. Installers should consider marking the manual switch with an icon depicting a fan as well as the words “Ventilation Fan.”

9.32.3.4. Ventilation Systems Used in Conjunction with Forced Air Heating Systems

This Article requires that a means for supplying outside air to a dwelling unit be provided by using a forced air system or furnace blower and duct system to distribute ventilation air. In dwelling units that utilize non-forced air heating systems, such as in-floor heating systems, there may be a forced air cooling system that can be used to distribute ventilation air. The blower operation is coupled with the exhaust fan required for general ventilation to avoid excessive pressurization within the dwelling unit, which may create moisture problems within the building envelope. The outdoor air intake is connected to the return air plenum of the forced air system in such a manner as to keep excessively cold air from reaching the heat exchanger and creating corrosion problems due to condensation.

Coupling a ventilation system with a forced air heating system to provide the necessary distribution of outdoor air is relatively simple. A duct brings air from outdoors to the heating system’s return air plenum (Figure 9.32.-2). This outdoor air can be either drawn in by the suction of the furnace fan on the return air plenum, or by the use of a supply air fan used to draw air into the duct and blow it into the return air plenum. This system tempers the outdoor air before it reaches occupied areas of the house by mixing it with return air in the furnace’s return air plenum. The furnace must be wired so that whenever the required ventilation fan controller activates the principal ventilation fan at the normal operating exhaust capacity (NBC Table 9.32.3.3.), the forced air blower is automatically activated to distribute the outdoor air. The outdoor air is supplied at the same rate as the principal exhaust fan to provide balanced (± 10%) exhaust and supply. The intent of the balanced supply and exhaust is to avoid excessive pressurization or depressurization within the dwelling unit when the principal ventilation system is operated. Since this is the most common and possibly continuous ventilation mode, the home will operate in a balanced mode the majority of the time. It reduces the probability of pressurization, which might create moisture problems within the building envelope, as well as depressurization, which could increase soil gas inflow and possibly cause combustion appliance spillage.

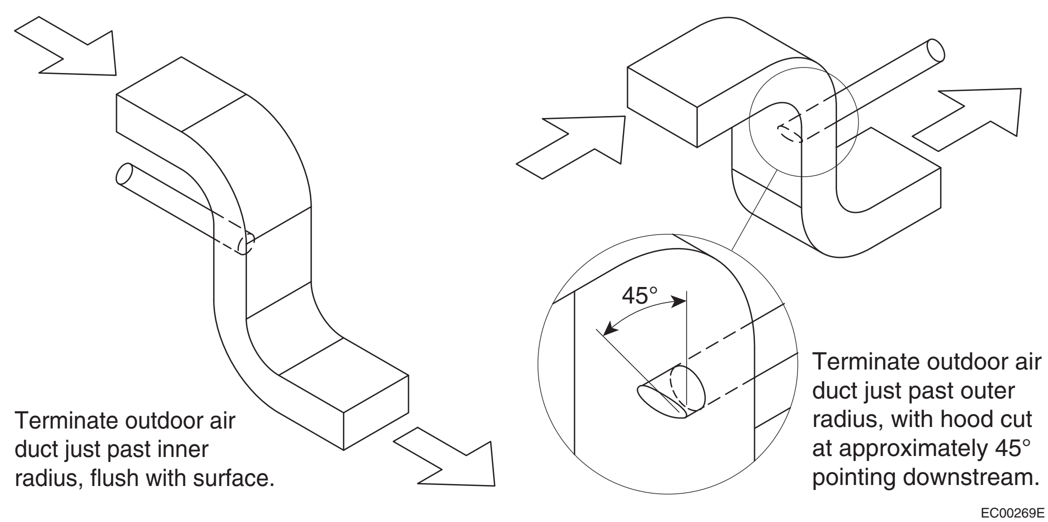


Figure 9.32.-2
Connection of outdoor air duct to return air plenum

This outdoor air duct must not be considered to provide combustion and/or dilution air to fuel-burning appliances.

Figure 9.32.-3 illustrates a possible configuration of a mechanical ventilation system coupled with a forced air heating system.

When the operating capacity of a principal ventilation fan exceeds the values in NBC Table 9.32.3.4. return air entering the furnace combustion chamber must be tempered so that its temperature is at least 15°C (60°F) or as specified by the furnace manufacturer.

Where no auxiliary supply fan is installed, the furnace fan also drives the flow of outdoor air in through the outdoor air duct. Use of an auxiliary supply fan allows the size of the outdoor air supply duct to be reduced. This system tempers the outdoor air before it reaches occupied areas of the house by mixing it with return air in the furnace's return air plenum.

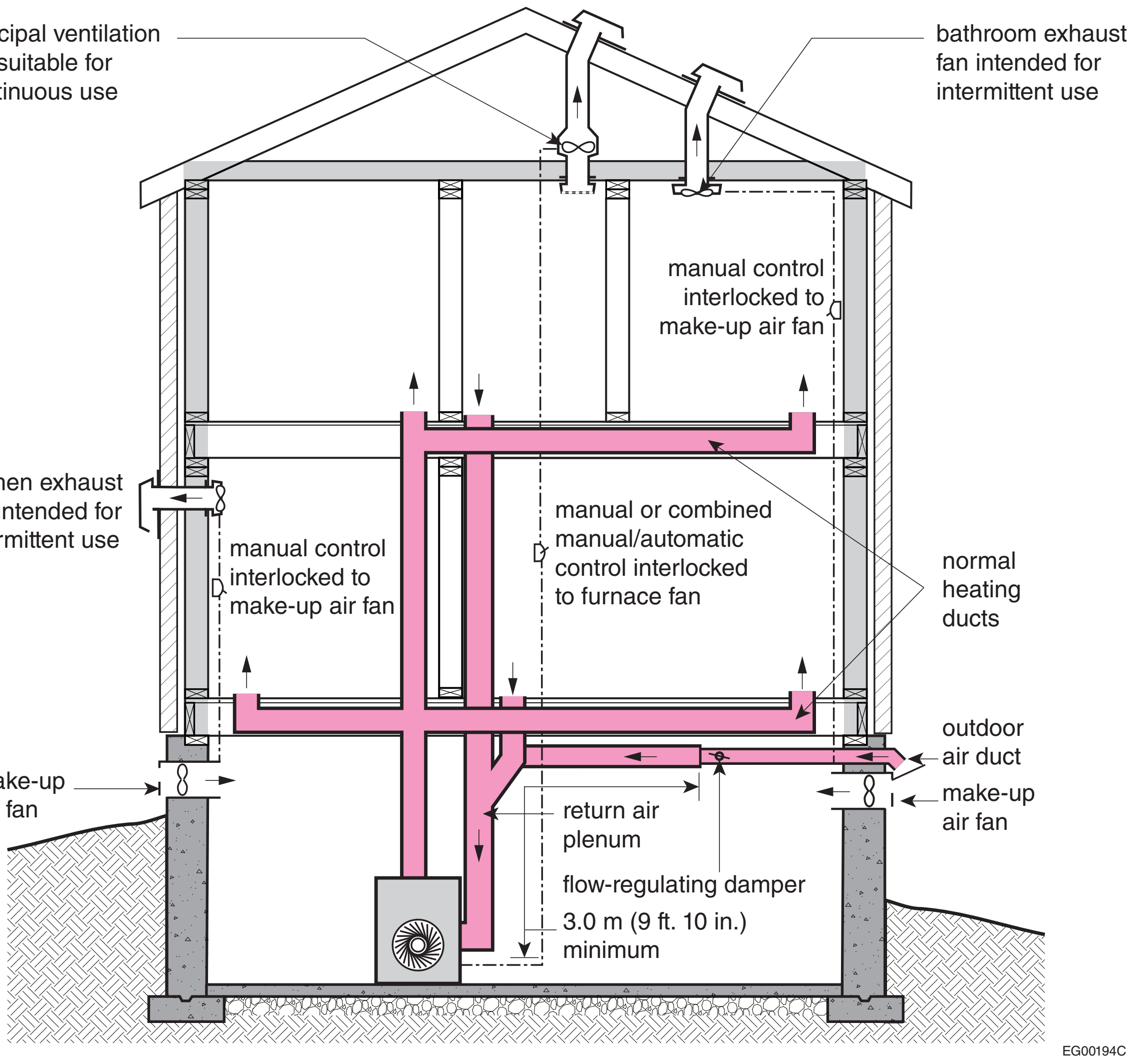


Figure 9.32.-3
Possible configuration of a mechanical ventilation system coupled with a forced air heating system

It is important that thorough mixing occur before the cold air reaches the furnace's heat exchanger, otherwise condensation could reduce the service life of the heat exchanger. The outside air must not be connected upstream of any return air branch. The outdoor air supply duct must be installed not less than 3 m (9 ft. 10 in.) upstream of the plenum connection to the furnace as measured along the length of the duct, or through an acceptable mixing device installed in the return air plenum.

Where a supply fan is used, it must be designated by the manufacturer as being capable of handling untempered outdoor air. This outdoor air duct must not be considered to provide combustion and/or dilution air to fuel-burning appliances.

Two factors determine if condensation is likely to occur in the furnace heat exchanger, the mixing ratio of cold outdoor air to return air, and the ability of the introduced air to completely mix with the return air and result in an even mixed air temperature across the entire return airflow that enters the furnace. A table provides a means of determining the mixed air temperature of the combined house return air and the outdoor air. Based on the outdoor design temperature and the furnace blower airflow, if the normal operating capacity of a principal ventilation fan exceeds the values in NBC Table 9.32.3.4., return air entering the furnace combustion chamber heat exchanger must be tempered so that its temperature is at least 15°C (60°F), or as specified by the furnace manufacturer. In some cases, it will not be possible to use the forced air system to circulate the outdoor air unless additional heating devices are used to temper the outdoor air before it reaches the furnace heat exchanger. This may be the case, for example, in a highly insulated house with a small furnace that is located in a colder region.

To use NBC Table 9.32.3.4., the furnace airflow may be determined by measuring the return airflow or by using the furnace manufacturers fan charts that provide airflow rates at specified external static pressures. If there are no outdoor airflows listed in NBC Table 9.32.3.4. for a particular January 2.5% outdoor design temperature and furnace airflow, the allowable outdoor airflow exceeds the maximum principal ventilation fan required flow.

If the return air is not tempered, an alternative is to design the mechanical ventilation system to meet CAN/CSA-F326-M, "Residential Mechanical Ventilation Systems," or design a system in accordance with NBC Article 9.32.3.5.

Even if the volume of outdoor air is acceptable, based on NBC Table 9.32.3.4., it is important that complete mixing occur before the cold air reaches the furnace's heat exchanger, otherwise cold spots could occur within the furnace heat exchanger, resulting in condensation and corrosion. To aid mixing, the outdoor air supply duct must be connected not less than 3 m (9 ft. 10 in.) upstream of the plenum connection to the furnace as measured along the length of the duct. Where an outdoor supply fan is not used, the furnace fan suction is used to draw in the outdoor air, and the outdoor air duct must be connected between the furnace return air plenum connection and the last return air branch. If these requirements cannot be met, the outdoor air must be introduced into the return air plenum or duct through an acceptable mixing device.

The maximum outdoor airflow permitted by NBC Table 9.32.3.4. must equal or exceed the normal operating exhaust capacity of the principal ventilation fan, as determined in accordance with NBC Sentence 9.32.3.3.(2); otherwise, there is an increased possibility that the mixed airflow over the furnace heat exchanger in cold weather will be colder than what the heat exchanger can tolerate. No values are listed in NBC Table 9.32.3.4. when the maximum flow permitted exceeds the maximum capacity found in NBC Table 9.32.3.3., since no higher outdoor airflow is required to match the flow of the principal ventilation fan.

NBC Sentence 9.32.3.3.(9) is intended to avoid having the principal ventilation fan exhaust the outdoor air brought in through the outdoor air supply duct before it is circulated to the dwelling. The design of some advanced integrated mechanical systems is such that some portion of the outdoor air is exhausted before being circulated, but this is taken into account in the design of the system and the total amount of outdoor air brought in is adjusted accordingly. This provision is not intended to preclude the use of such systems.

The duct bringing outdoor air to the furnace return air plenum must be equipped with a damper (see NBC Sentence 9.32.3.4.(6)) that is adjusted (see NBC Sentence 9.32.3.4.(10)) to balance the outdoor airflow with the flow through the principal ventilation fan and ensure that the actual incoming airflow is limited to the allowable maximum flow. It is recommended, but not mandatory, that a motorized damper also be installed in this duct and that it be wired to be fully open when the principal ventilation fan is operating and fully closed when the principal ventilation fan is not operating. This damper will allow ventilation to occur only when the occupants have called for it by turning the ventilation fan switch to the "on" position. The absence of such a damper can lead to unwanted ventilation, which can result, in turn, in excessive dryness and increased heating costs in winter, and increased loading on air-conditioning equipment in the summer.

For the ventilation system coupled to a forced air heating system, the normal heating distribution ducts are used to circulate the outdoor air. The furnace must be wired so that whenever the principal exhaust fan is started, the furnace fan automatically starts. Outdoor air is brought into the heating system's return air plenum upstream of the connection to the furnace.

9.32.3.5. Ventilation Systems Not Used in Conjunction with Forced Air Heating Systems

This Article requires that a means for supplying and distributing outside air to a dwelling unit be provided by using a separate mechanical air distribution system.

If there is no forced air system, or for some reason the forced air system is not used to distribute the outdoor air, then a special air distribution system must be installed. Many dwellings with hydronic or electric unitary (baseboard) or in-floor heating systems will need to use this type of ventilation distribution system. In addition, some manufacturers of solid-fuel-heating appliances do not permit the forced air fan to be controlled by any device that is not part of their system. Therefore, the type of interconnections required in NBC Article 9.32.3.4. are not permitted.

These special distributions systems only handle ventilation air. They do not handle heating distribution air. Therefore, smaller ducts can generally be used and the supply fan may be significantly smaller, and use less energy than a normal furnace circulation fan. NBC Sentences 9.32.3.5.(2) to (7) require that the supply fan operate at the same time and at the same rate as the principal ventilation fan in order to avoid either pressurizing or depressurizing the house. Pressurizing the house can lead to interstitial condensation within the building envelope. Depressurization can lead to the spillage of combustion products from heating equipment and increased entry of soil gas. A flow regulating damper in the outdoor supply air duct allows the airflows of the supply air to be balanced with the exhaust flow of the principal ventilation fan.

Figure 9.32.-4 illustrates a possible configuration of a mechanical ventilation system that is not coupled with a forced air heating system.

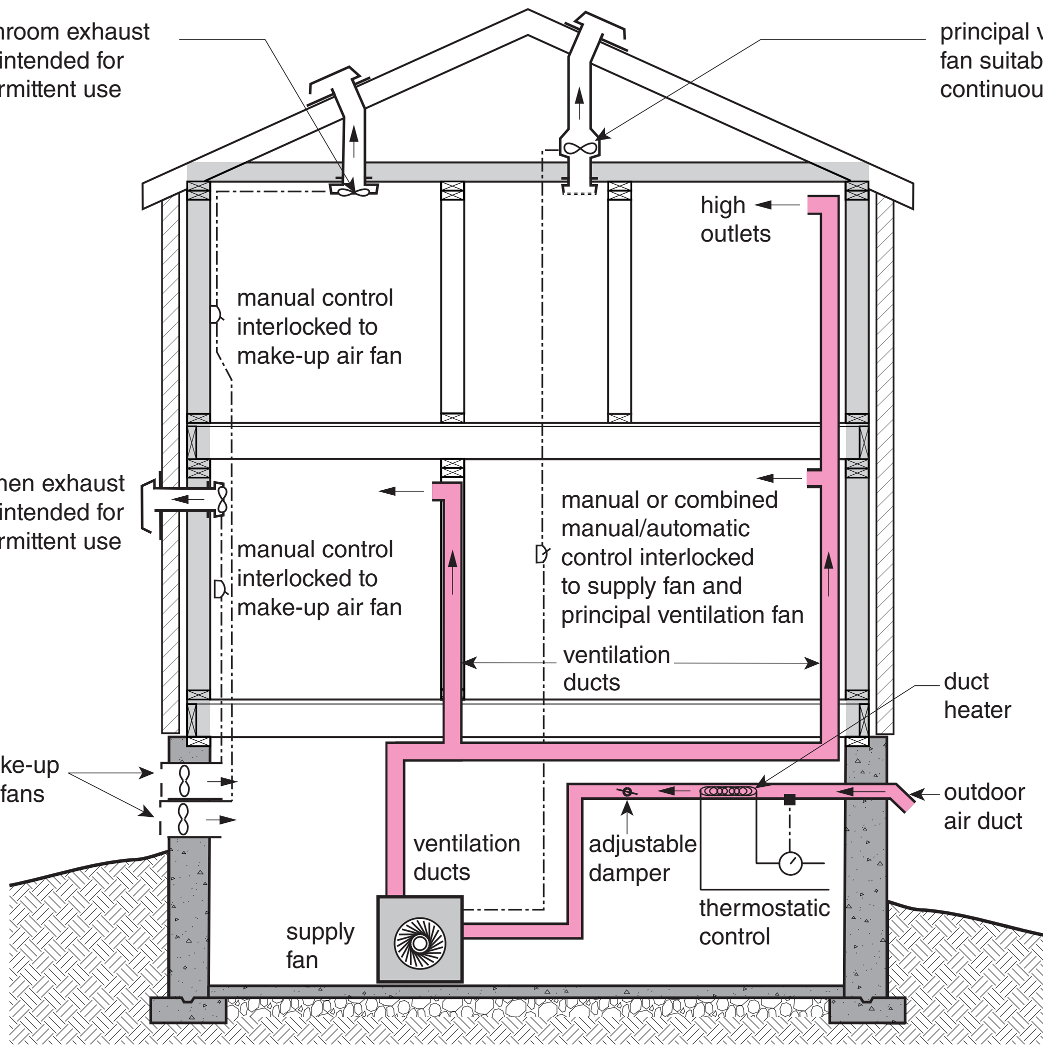


Figure 9.32.-4
Possible configuration of a mechanical ventilation system not coupled with a forced air heating system

A ventilation system that is not used in conjunction with a forced air heating system requires that the outdoor air be tempered before being circulated to the occupied areas of the house (see NBC Sentence 9.32.3.5.(8)).

Tempering can be accomplished by passing the outdoor air over some type of heating element or by mixing it with indoor air. The latter approach is more complex, since it requires that the ratio between the outdoor air and indoor air ducts or openings be neither too large nor too small. It was judged to be too complex to include within the context of these prescriptive requirements. Therefore, where tempering by mixing with indoor air is chosen, the system must be designed in accordance with CAN/CSA-F326-M, "Residential Mechanical Ventilation Systems."

Whereas a duct system associated with a forced air heating system would have ducts leading to almost all rooms, the requirements for these ventilation systems are more limited (see NBC Sentences 9.32.3.5.(10) to (14)). The most important point is that outdoor air must be provided to each bedroom; people often spend long periods of time in the bedroom with the door closed. It is also required that at least one duct lead to every storey, including the basement. In houses where there is no storey without a bedroom (e.g., bungalows with no basement), a duct must lead to the principal living area. Where there is more than one area that could be considered a living area, at least one such area must be designated as the principal living area.

There is also the alternative of locating one of the exhaust air intakes for the principal ventilation fan in the principal living area, rather than supplying outdoor air directly to it. With this arrangement, the outdoor air passes through the principal living area on its way to the exhaust fan. However, this arrangement will be less effective if only a small portion of the exhaust is withdrawn from the principal living area. For this reason, there is a limitation of two other exhaust air intakes for the principal ventilation fan (see NBC Sentence 9.32.3.5.(11)).

The outdoor air must be tempered to 12°C (54°F) before being circulated to the occupied areas of the house. This can be accomplished by using a heat recovery ventilator, a heating element, or by mixing outdoor air with indoor air. The mixed air is more complicated because it requires careful design and balance of the airflows between the outdoor air and indoor air ducts. This approach was judged to be too complex to deal with in the context of prescriptively described requirements, so where tempering by mixing with indoor air is chosen, the system must be designed in accordance with CAN/CSA-F326-M.

All branch supply ducts that are not fitted with diffusers with adjustable balance stops must be supplied with dampers that are accessible, can be adjusted, can be fixed in their adjusted position, and that include a device to indicate the position of the dampers.

The air supply outlets through which outdoor air is delivered to the rooms must be located at least 2 m (6 ft. 7 in.) above the floor and must be designed to promote diffusion across the ceiling. Provision must be made for the free flow of air to all rooms by leaving gaps beneath doors, using louvered doors, or installing grilles in doors.

9.32.3.6. Exhaust-Only Ventilation Systems

This Article requires that a means for supplying the necessary ventilation be provided without any specific provisions for the dedicated supply of outdoor air. Such a system is significantly simpler in that the concern about air that is colder than acceptable coming in contact with the furnace heat exchanger is eliminated.

A ventilation system that exhausts air to the exterior without any provision for a dedicated supply of outdoor air will depressurize the house and may cause problems with spillage-susceptible fuel-fired appliances. Therefore, exhaust-only systems are only permitted in single dwellings that have no solid-fuel-burning appliances, no fireplaces that are not a direct-vent type, and no other fuel-fired space- or water-heating appliances unless these appliances are mechanically vented or direct-vented types. There is still a possibility that these exhaust-only systems could increase the likelihood of drawing fumes from garages or soil gases into living spaces.

In a house with a very airtight building envelope, it may be difficult for the principal ventilation fan to achieve its full rated flow capacity due to high levels of house depressurization. Therefore, fans used as the principal ventilation fan in an exhaust-only ventilation system are required to have their flow rated at a higher static pressure.

If a house does not incorporate any dedicated supply of outdoor air, the air extracted by the principal ventilation fan will be replaced by outdoor air leaking in through the building envelope. The house will be depressurized by the operation of the principal ventilation fan, and the negative internal pressure will draw outdoor air inside through any available opening. This could increase the likelihood of drawing fumes from garages or soil gases into living spaces.

This need not be of concern if the house does not incorporate any spillage-susceptible combustion equipment. Such a system is significantly simpler in that the concern about too-cold air contacting the furnace heat exchanger is eliminated. However, there is no control over where the outdoor air enters the dwelling. Thus, it is required that houses using this system have an air distribution system so that, no matter where the outdoor air comes in, it will be mixed with the indoor air, and circulated throughout the house. A forced air heating system complying with NBC Section 9.33. satisfies the criteria for the air distribution system. An exhaust-only system circulates air from the house and intakes some outdoor air through openings in the building envelope. This means the air that is circulated has only a proportion of outdoor air. For this reason, an exhaust-only system is required to have a circulating fan at least five times the capacity of a principal ventilation exhaust fan. This circulation fan must be activated whenever the principal ventilation fan is operating, or it must be on a control that allows the occupants to set timed operating intervals.

9.32.3.7. Supplemental Exhaust

This Article requires that adequate exhausting be provided from the areas of a dwelling with potentially high humidity or heavy odours.

Each kitchen must have an exhaust fan with a minimum capacity of 50 L/s (100 cfm), and each bathroom at least 25 L/s (50 cfm), unless exhaust is provided by the principal ventilation fan according to specific requirements.

Each kitchen must have a supplemental exhaust fan unless the principal ventilation fan exhausts air only from the kitchen. Even if the principal ventilation fan exhausts air from the kitchen and any other room, a kitchen supplemental fan is not required if the principal fan can be operated from a control in the kitchen at a rate that is at least 2.5 times the normal operating exhaust capacity indicated in NBC Table 9.32.3.3.

Except for supplemental exhaust fans serving cooktops, supplementary kitchen fans or intakes for a supplemental fan must be installed in the ceiling or at least 2 m (6 ft. 7 in.) above the floor. This is the same requirement as for the intakes of principal ventilation fans located in kitchens, bathrooms or water-closet rooms and, as such, means that kitchen range hoods can never be used as a principal ventilation fan.

Supplemental exhaust fans must be provided with a manual switch located in the room served by the fan. Where a supplemental fan is controlled by a dehumidistat, or by some other automatic control in addition to the manual switch, the manual switch must be capable of activating the fan, regardless of the setting of the automatic control. Where the principal ventilation fan exhausts air from the kitchen, bathroom or water-closet rooms, the required room control must be wired so that the fan can be activated from both the central ventilation fan switch and the switch in the room.

9.32.3.8. Protection Against Depressurization

This Article intends to avoid contamination of indoor air from soil gases or the products of combustion intended to be vented to the exterior, due to excessive building depressurization caused by the operation of mechanical exhaust devices.

When an exhaust device extracts air from a house and there are no provisions for the introduction of outdoor air, such as by means of an outdoor air duct, and no supply fans are operating simultaneously, the exhausted air will automatically be replaced by outside air that has infiltrated through the house's building envelope. The rate of inward leakage will automatically equal the rate of outward extraction; otherwise, the house would eventually implode. The instant the exhaust device is turned on, the house pressure is lowered and the inside/outside pressure difference drives outside air in through any leaks it can find.

Even if the house is made more airtight, the inward leakage will equal the outward fan flow. However, because there are fewer and/or smaller leakage sites in an airtight house, it will take a larger inside/outside pressure difference to drive the same amount of air through the remaining leakage sites.

It is possible that the exhaust device will no longer be able to achieve its rated flow when operating against a very high inside/outside pressure difference. However, in this case, the inward flow will also decrease and will still be in equilibrium with the outward flow, but now at a higher inside/outside pressure difference than in a leakier house.

An exhaust device not operated in conjunction with a supply fan will always depressurize a house to some extent—even a leaky house. But it will depressurize a tight house more than it will depressurize a leaky house. And, of course, an exhaust device with a higher capacity will depressurize a house more than a device with a smaller capacity.

Any dwelling that contains solid-fuel-burning space- or fuel-fired water-heating appliances that is not direct-vented or mechanically vented is required to have protection against depressurization through the provision of make-up air, unless all other appliances are direct-vented or mechanically vented.

For houses with a fuel-fired heating appliance or fuel-fired water heater that is not mechanically vented or direct-vented that contains a secondary suite, ancillary spaces that are not part of a dwelling unit but have an exhaust device need to have protection against depressurization.

Any mechanical air exhausting device, other than the principal exhaust fan, is required to be provided with outdoor make-up air that is not less than the exhaust capacity of the device it serves, and not more than 10% greater. A mechanical air exhausting device that serves a subfloor depressurization system for reducing the risk of radon ingress is not required to be provided with outdoor make-up air.

Spillage of Combustion Products

Depressurization of the house by the ventilation system or other exhaust devices can cause the spillage of combustion products from certain types of combustion appliances. The types of appliances that are susceptible to pressure-induced spillage can generally be identified by the fact that they are vented through a natural draft chimney rather than through an arrangement that uses a fan to draw the products of combustion out of the house.

Examples include gas furnaces and water heaters with a draft hood, and oil furnaces with barometric dampers. Appliances such as gas furnaces and water heaters that are mechanically vented or direct-vented do not generally require make-up air. Sealed combustion oil furnaces, which are commonly used in modern manufactured homes, are more resistant to spillage and openings. However, as oil-fired appliances are not certified as being direct-vented by the appropriate certifying agency, they are often still considered to be spillage-susceptible.

Almost all gas or solid-fuel fireplaces are spillage-susceptible, even those with so called airtight glass doors and outside combustion air intakes, since most airtight doors are not really airtight. Gas fireplaces that are certified as direct-vented are considered to be in the same spillage resistant class as other direct-vented gas appliances. Certain types of gas combustion appliances, such as cooking appliances and decorative appliances, are not required to be vented. Their operation will not be significantly affected by depressurization of the house.

Terms used in gas appliance standards to describe categories of spillage-resistant appliances include “direct-vented,” “mechanically vented” and “side-wall-vented.”

The NBC addresses the potential for spillage from combustion appliances with requirements for make-up air and carbon monoxide alarms.

Make-up Air Requirements

Depressurization caused by the principal ventilation system itself is not an issue with balanced systems (i.e., non-exhaust-only systems). However, the operation of other exhaust devices, such as those for stove-top barbecues, clothes dryer and cooktop exhausts or range hoods can cause depressurization. Therefore, in a house with spillage-susceptible appliances, any such exhaust devices, including the required supplemental exhaust fans, must be provided with make-up air (see NBC Sentence 9.32.3.8.(2)).

In the past, the NBC and other codes and standards have tended to rely on the passive supply of make-up air through make-up air openings. This is no longer considered to be a reliable approach in the context of a simple, prescriptively described system without sophisticated controls on depressurization. Therefore, the make-up air must be provided by a supply fan that is automatically activated whenever the exhaust device that requires the make-up air is activated (see NBC Sentences 9.32.3.8.(2) and (3)).

Protection against depressurization through the provision of make-up air is required for any dwelling unit that has a fuel-fired space or water heater that is not direct-vented or mechanically vented. The need to provide make-up air can be avoided by avoiding the use of spillage-susceptible combustion equipment.

Make-up air is heated by introducing it into an unoccupied area of the dwelling, or by raising its temperature to at least 12°C (54°F) before it is introduced into occupied areas or into a supply duct. Where the outdoor air is not heated upstream of the supply fan, the fan must be designed for the handling of unheated outdoor air.

Carbon Monoxide Alarm Requirements for Solid-Fuel-Burning Appliances

Even at a relatively low level of depressurization, solid-fuel-burning appliances can spill products of combustion into the house, especially when operating in their die down or smouldering stages. In the absence of more sophisticated design and installation controls to prevent such levels of depressurization (such as those mentioned in CAN/CSA-F326-M, "Residential Mechanical Ventilation Systems"), the only available safeguard is to require the installation of a carbon monoxide (CO) alarm in any room incorporating a solid-fuel-burning device (see NBC Sentence 9.32.3.9.(3)). Where this is not acceptable, the prescriptively described alternatives must be abandoned and a system fully complying with CAN/CSA-F326-M must be designed.

One advantage of solid-fuel-burning devices is that their spillage is readily detected by a carbon monoxide alarm (which is not true of gas- or oil-burning devices). Therefore, where this is the only type of spillage-susceptible combustion device present, one has the choice of not providing make-up air for exhaust devices (see NBC Sentence 9.32.3.8.(6)). The carbon monoxide alarm required by NBC Sentence 9.32.3.9.(3) will warn occupants when depressurization is causing spillage.

Each room containing a solid-fuel-burning appliance such as a wood stove or fireplace is required to have a carbon monoxide alarm located at a height recommended by the manufacturer. The carbon monoxide alarm must conform to CAN/CSA-6.19, "Residential Carbon Monoxide Alarming Devices."

9.32.3.9. Carbon Monoxide Alarms

This Article indicates where carbon monoxide alarms are required. Carbon monoxide (CO) is a colourless, odourless gas that can build up to lethal concentrations in an enclosed space without the occupants being aware of it. Thus, where an enclosed space incorporates or is near a potential source of CO, it is prudent to provide some means of detecting and warning building occupants of its presence.

Dwelling units have two common potential sources of CO: fuel-fired space- or water-heating equipment within the dwelling unit or in adjacent spaces within the building, and attached storage garages. Most fuel-fired heating appliances do not normally produce CO and, even if they do, it is normally conveyed outside the building by the appliance's venting system. Nevertheless, appliances can malfunction and venting systems can fail. Therefore, the provision of appropriately placed CO alarms in the dwelling unit is a relatively low-cost back-up safety measure.

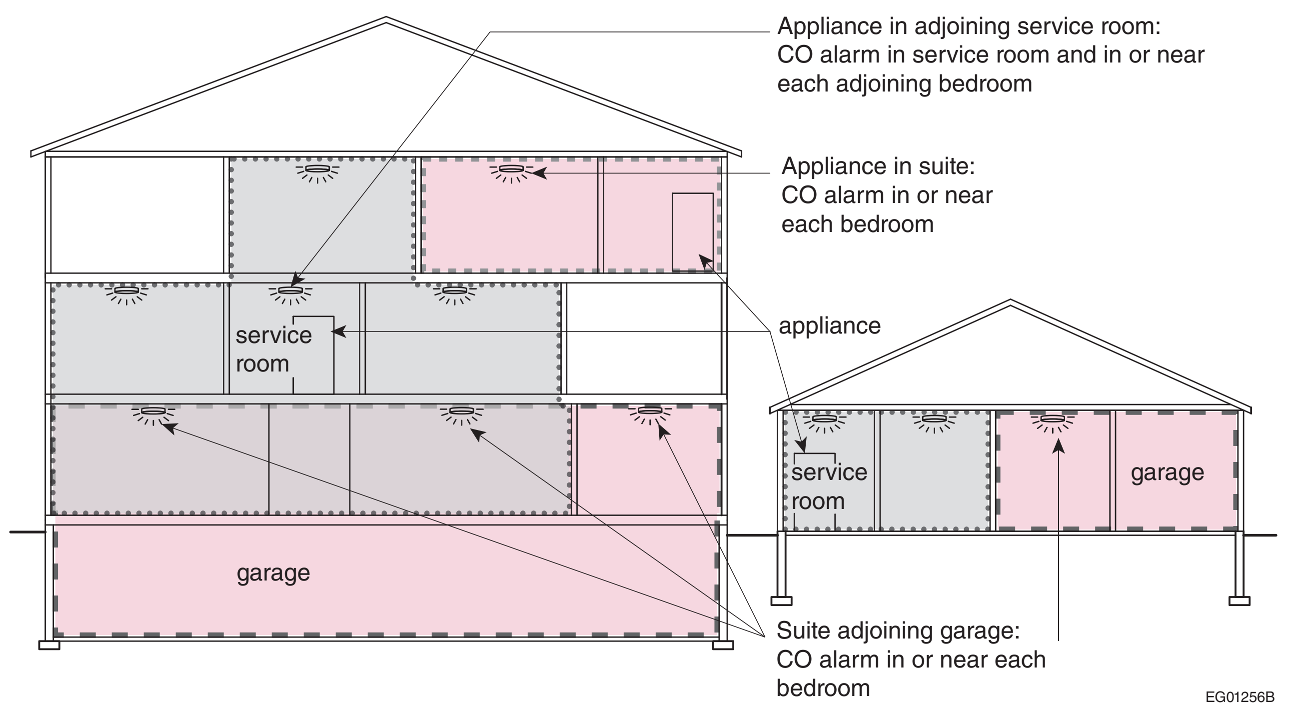


Figure 9.32.-5
Locations of carbon monoxide alarms

Similarly, although NBC Article 9.10.9.16. requires that the walls and floor/ceiling assemblies separating attached garages from dwelling units incorporate an air barrier system, there have been several instances of CO from garages being drawn into houses, which indicates that a fully gas-tight barrier is difficult to achieve. The entry of CO is increased if the dwelling unit is depressurized in relation to the garage. This can readily occur due to the operation of exhaust equipment or simply due to the stack effect created by heating the dwelling unit. Again, CO alarms in the dwelling unit provide a relatively low-cost back-up safety measure.

Buildings with residential occupancies that contain fuel-burning appliances or a storage garage are required to have alarms warning of high carbon monoxide concentration (Figure 9.32.-5).

Where a fuel-burning appliance is installed in a suite of residential occupancy, a carbon monoxide alarm is required either in every bedroom or outside each bedroom within 5 m (16 ft.) of the bedroom doors.

Where a fuel-burning appliance is installed in a service room that is not in a suite of residential occupancy, a carbon monoxide alarm is required in the service room, and either in every bedroom or outside each bedroom within 5 m (16 ft.) of the bedroom doors of all suites that share a common wall or floor/ceiling assembly with the service room.

Every suite of residential occupancy that shares a wall or floor/ceiling assembly with a storage garage or with a crawl space or attic that abuts a storage garage is required to have carbon monoxide alarms in every bedroom or outside each bedroom within 5 m (16 ft.) of the bedroom doors

Carbon monoxide alarms must conform to CAN/CSA-6.19, "Residential Carbon Monoxide Alarming Devices." They must be installed and mechanically fixed at a height recommended by the manufacturer and, if powered by a dwelling unit's electrical system, have no disconnect switch located between the alarm and the circuit's overload protection device.

Required carbon monoxide alarms installed in houses with a secondary suite are required to be interconnected so that if one alarm is activated, the others will sound.

Each room containing a solid-fuel-burning appliance is required to have a carbon monoxide alarm installed at the manufacturer's recommended height.

Battery-operated carbon monoxide alarms are permitted, but they must be mechanically fixed to a surface.

9.32.3.10. Fans

This Article provides a standard means for rating the air-moving capacity and sound rating of fans, blowers and other ventilating equipment. A second purpose is to restrict the level of noise generation of air-moving equipment so that it does not cause undue annoyance to the occupants. Air flow capacity ratings must be based on a static pressure differential as indicated in NBC Table 9.32.3.10.-A.

Heat recovery ventilators used to provide one or more of the required fans must be rated in accordance with CAN/CSA-C439, "Rating the Performance of Heat/Energy-Recovery Ventilators."

The principal ventilation fan is intended to be capable of running for long periods. Even the supplemental exhaust fans may be used for significant periods. Therefore, all fans that are mounted such that their sound is likely to intrude on the household, other than kitchen exhaust fans, are required to have reasonably low sound ratings so that building occupants will not turn them off before the need for ventilation has been met.

With the exception of fans in heat recovery ventilators, capacity and sound ratings for principal and supplementary exhaust fans must be determined in accordance with CAN/CSA-C260-M, "Rating the Performance of Residential Mechanical Ventilating Equipment," or HVI Publication 916, "Airflow Test Procedure," and HVI Publication 915, "Loudness Testing and Rating Procedure."

Except for heat recovery ventilators, supply and exhaust fans required to make up part or all of the total ventilation capacity must have a sound rating not greater than that specified in NBC Table 9.32.3.10.-B.

9.32.3.11. Ducts

This Article requires that ducts used for ventilation use acceptable materials and sizes, and meet installation standards to enable them to carry the required airflow without creating a fire hazard, or causing condensation problems.

NBC Table 9.32.3.11.-A is based on the data listed in Table 9, “Friction Chart for Round Ducts,” Chapter 32, ASHRAE Handbook of Fundamentals 1997. The allowable duct lengths listed in the Table have been calculated assuming the equivalent lengths of ducts are four times their physical lengths. The static pressure offset to account for building pressures is 10 Pa (0.21 psf). Using NBC Table 9.32.3.11.-A will generally result in very conservatively sized (i.e., larger) ducts compared to what would be achieved using the normal duct design procedures referenced in NBC Subsection 9.33.4.

Except for exhaust ducts for cooktop hoods and cooktop fans, dedicated ventilation system ducts can be made of combustible materials. Exhaust ducts must end outdoors, and not in an attic or roof space, because venting into such spaces will lead to large amounts of condensation in the space, which may eventually lead to serious structural damage.

Ducts need to be sized carefully to minimize airflow resistance. Flex ducts should be kept as straight as possible. When exhaust ducts pass through unheated spaces, moisture in the ducts can condense and run back into the house, where it may damage the finishes. To reduce this risk, ducts must be insulated, the duct material must be waterproof to withstand occasional wetting, and the joints must be airtight to prevent the transfer of moisture into the concealed spaces through which they pass. All joints and seams that are not airtight must be sealed with appropriate tape or duct mastic compound.

Similarly, where supply ducts carry outdoor air through a heated area (such as outdoor air into the return air side of the furnace plenum), room air may be cooled below its dew point temperature and condense on the outside surface of the ducts. These ducts must be insulated to prevent this.

Exhaust ducts must not discharge into heated or unheated enclosed spaces. Discharge into attics or soffit spaces is not permitted. Where an exhaust duct passes through an unheated space, it must be insulated to at least RSI 0.5 (R 2.8). Outdoor air supply ducts that pass through heated space must also be insulated to at least RSI 0.5 (R 2.8).

All exhaust intakes located within 3 m (10 ft.) horizontally of a cooktop are required to be fitted with a grease filter at the air intake end. A kitchen exhaust duct must be provided with a filter at the intake or it must be accessible for cleaning. Cooktop hood ductwork must be made of noncombustible material and lead directly to the outdoors with no connection to other exhaust fans or ducts.

Ductwork must be permanently supported or clipped to prevent sagging. Ductwork connected to supply or exhaust fans must be airtight at its joints. Where rectangular ducts are used in place of round ducts, the rectangular sizes considered to provide the same capacity as the round ducts in NBC Table 9.32.3.11.-A are provided in NBC Table 9.32.3.11.-B.

9.32.3.12. Heat Recovery Ventilators

This Article provides guidance whenever heat recovery equipment is installed to provide some or all of the required ventilation airflow. While not required by the NBC, heat recovery ventilators (HRVs) represent an increasingly popular means of ventilating houses, both those with or without forced air heating.

Enthalpy recovery ventilators (ERVs) are a type of heat recovery ventilator and must therefore comply with the same requirements as heat recovery ventilators. HRVs must be installed so that supply and exhaust flows are balanced. The lower flow rate must never be less than 90% of the greater flow rate unless specifically recommended by the manufacturer of the HRV. Two HRVs must not be connected in parallel air flow to a common downstream supply duct or exhaust duct, unless specifically recommended by the manufacturer.

Manufacturers’ recommendations for the installation, including balancing, start-up procedures and airflow determination, must be followed and the two air streams must be balanced within 10% of each other. Manufacturers’ instructions must be followed carefully when installing ventilation equipment in unheated spaces to avoid condensation of moisture on fans and motors and freezing of the condensate drains.

The free flow of condensate must be provided in accordance with the manufacturer’s instructions or, when not available, by a minimum 12.5 mm (1/2 in.) diameter pipe pitched in the direction of flow and complete with a trap or condensate pump. The condensate line must drain to the dwelling unit’s drain, waste and vent system, and thus cannot be drained into the ground under the foundation or to the exterior.

Where an HRV is connected to a forced air heating system, the supply side of the HRV must be connected directly to the return side of the furnace. One configuration is illustrated in Figure 9.32.-6.

Figure 9.32.-7 illustrates a possible configuration of a ventilation system using an HRV that is not coupled to a forced air heating system.

Fans and heat recovery ventilators must be installed according to manufacturer's instructions. All dampers that are intended to regulate flow must be adjustable and accessible without requiring the removal of fans, motors or insulating materials, and without the need for specialized tools. All ventilation equipment must be accessible for inspection, maintenance, repair and cleaning.

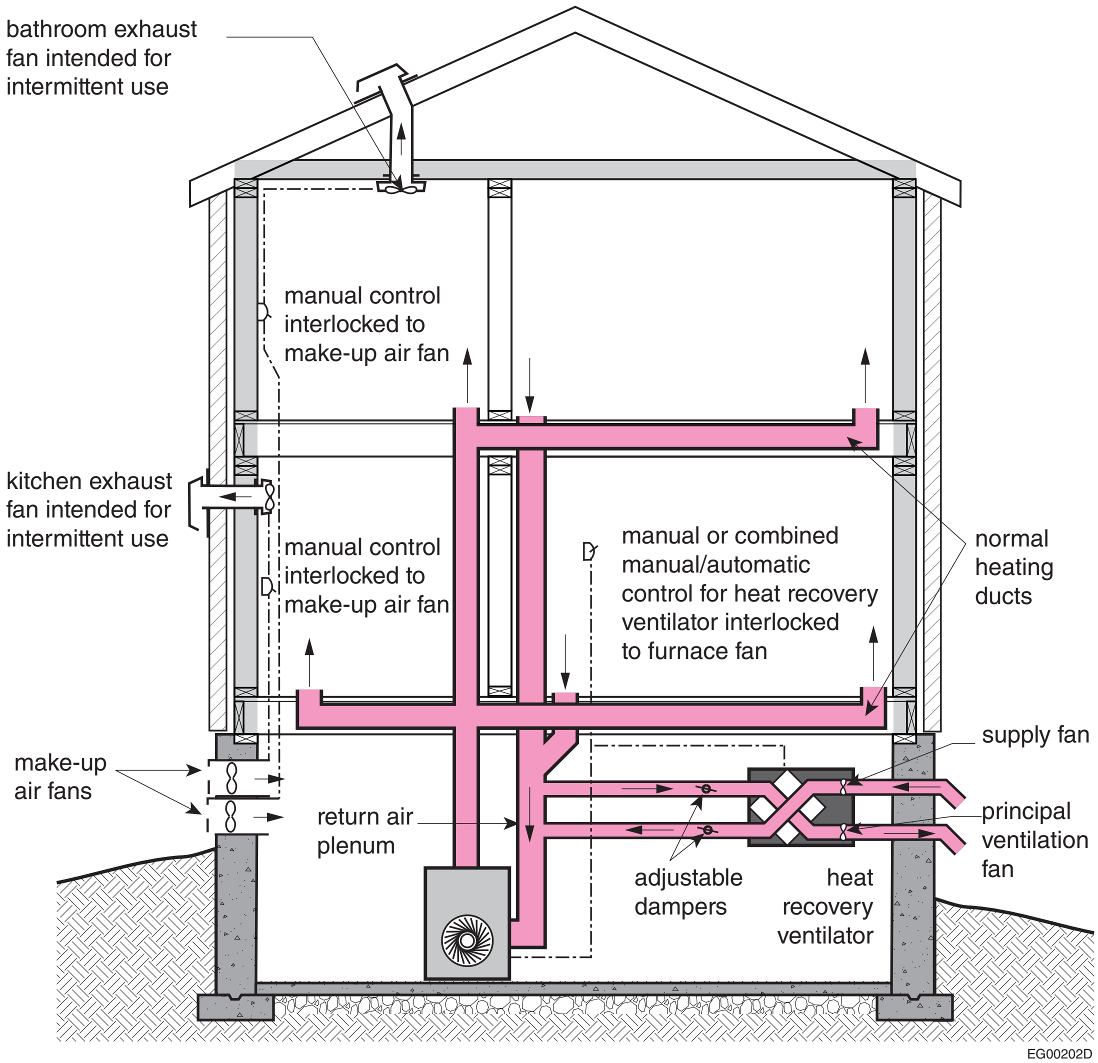


Figure 9.32.-6
Possible configuration of a ventilation system using a heat recovery ventilator coupled with a forced air heating system

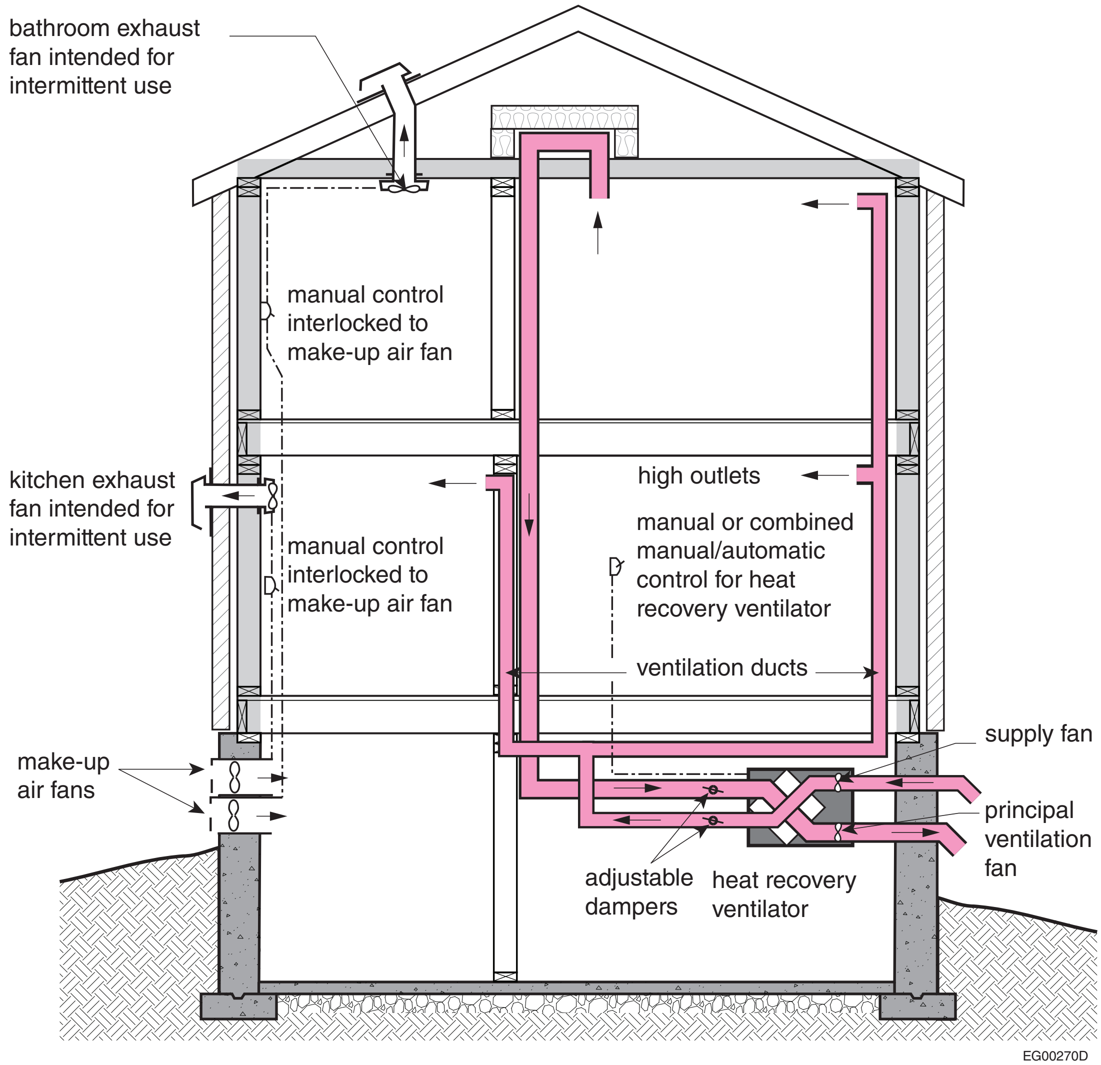


Figure 9.32.-7
Possible configuration of a ventilation system using a heat recovery ventilator not coupled with a forced air heating system

9.32.3.13. Outdoor Intake and Exhaust Openings

This Article provides guidance on the location, design and installation of outdoor intake and exhaust openings.

Care must be taken to situate intake openings to avoid the contamination of incoming ventilation air. Intake openings should not be located where they may be subject to contamination from automobile exhausts, garbage, or exhaust openings. Intake openings must be located no closer than 900 mm (36 in.) from sources of contamination, including gas vents or oil fill pipes, or from other exhaust openings.

Intakes must be located at least 450 mm (18 in.) from the ground or the local expected depth of snow accumulation, whichever is greater. They must be labelled for easy identification from the exterior of the house. Figure 9.32.-8 illustrates the requirements and recommendations for intake and exhaust openings.

Exhaust outlets must be located a minimum of 100 mm (4 in.) above the finished grade level.

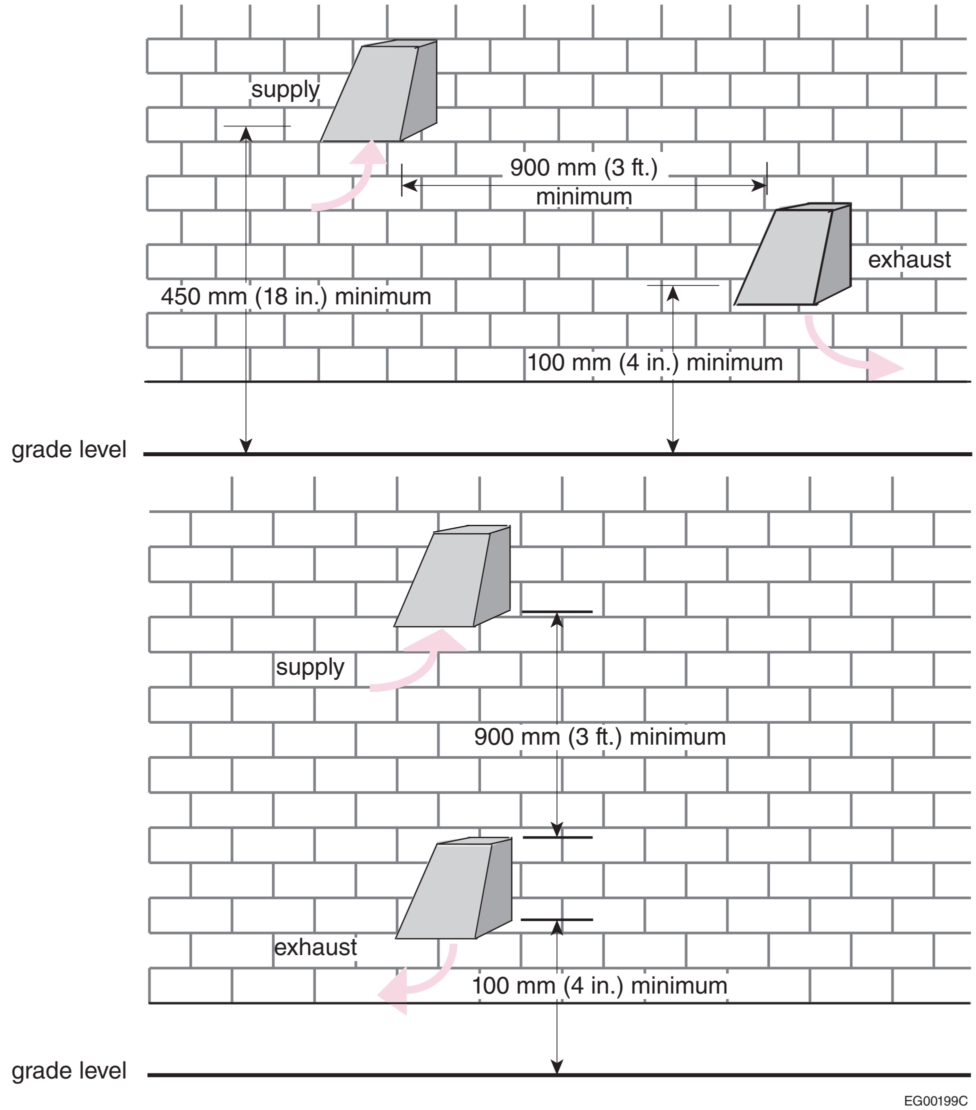


Figure 9.32.-8
Recommendations for intake and exhaust openings

Screens or grilles must be installed to prevent the entry of insects and animals. The area required depends on the mesh size as indicated in NBC Table 9.32.3.13. Screens, grilles and filters in intake and exhaust opening must be removable for cleaning without the need for special tools. Exhaust outlets, other than for heat recovery ventilators, must be equipped with backdraft dampers. If the backdraft damper is not installed at the building envelope, a screen must be located at the building envelope to protect the opening from the entry of animals.

All ventilation openings must be at least equal to the cross-sectional area of the duct served. All openings must be protected from precipitation by the use of louvers, weather cowls or other suitable protection, with all screens and grilles made of corrosion-resistant material.

Section 9.33. Heating and Air-conditioning

Introduction

This Section deals with heating and air-conditioning systems intended to condition spaces in single dwellings and houses with a secondary suite, including their common spaces, to make the temperature comfortable for occupants. All space conditioning systems have three basic components: a source of warmed or cooled air, a means of distributing the air to the rooms being heated or cooled, and a control used to regulate the system (e.g., thermostat).

Both heating and air conditioning work on the principle that heat always moves from a warm object to a cooler one, just as water flows from a higher to a lower level. Furnaces and heaters put heat into the air to make your home warmer; air conditioners remove heat to make your home cooler.

The integration of mechanical system functions to combine heating, cooling and ventilation requirements is becoming increasingly common. Whether employing an integrated mechanical system or a number of conventional, separate systems to heat, cool and ventilate the dwelling, consideration should be given to the layout of equipment, ducts and piping.

9.33.1. General

9.33.1.1. Application

This Article describes the limited application of NBC Section 9.33. and refers users to other Parts of the NBC for heating requirements beyond the application of Section 9.33.

NBC Section 9.33. applies to heating and air-conditioning systems for single dwellings. It also applies to radiant heating systems in a house with a secondary suite, including their common spaces. Systems for other occupancies must conform to the requirements of NBC Part 6.

So that combustion products generated in one suite in a house with a secondary suite cannot be transferred to another via ducts, the duct distribution systems serving one of the dwelling units in a house with a secondary suite cannot be directly interconnected with other parts of the house.

9.33.2. Required Heating Systems

9.33.2.1. Required Heating Systems

This Article requires that all residential buildings continually occupied in winter months be equipped with heating systems.

9.33.3. Design Temperatures

9.33.3.1. Indoor Design Temperatures

This Article requires that a minimum temperature level be maintained in residential occupancies that will provide reasonable health and comfort for the occupants.

Space heating systems must be adequately sized to deliver enough heat to maintain minimum inside temperatures throughout the coldest part of the year. The distribution of heat to ensure that minimum temperatures may be obtained in all rooms or habitable spaces is required to satisfy comfort requirements. This means a heating system must be capable of maintaining minimum indoor temperatures when the outdoor temperature is at the winter design temperature (see NBC Article 9.33.3.2.).

The minimum indoor design temperatures are 22°C (72°F) in all living spaces, 18°C (64°F) in unfinished basements and in common spaces serving houses with a secondary suite end, and 15°C (59°F) in heated crawl spaces. Figure 9.33.-1 shows the heating system indoor design temperatures required in the NBC.

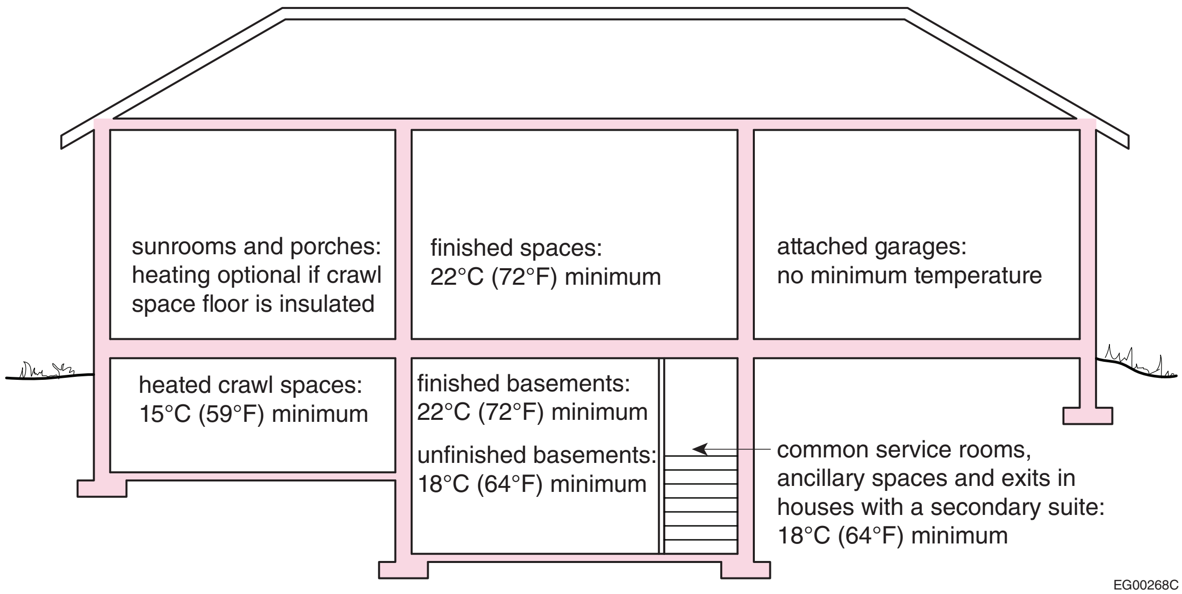


Figure 9.33.-1
Indoor design temperatures

9.33.3.2. Outdoor Design Temperatures

This Article describes the outdoor design temperatures that must be used in determining the maximum heat loss from a building for the purpose of determining the necessary heating capacity of equipment.

The required capacity of heating systems is based on the 2.5% January design temperatures as described in NBC Table C-2 of Appendix C. The design of heating systems can be based on the 2.5% January temperature rather than on the coldest January temperature. This is acceptable because it is deemed that buildings, based on their mass, have the ability to store heat and maintain indoor air temperatures during the short periods of time when the outdoor January minimum temperature occurs. It is calculated that the 2.5% January temperature would usually only be exceeded for 18.6 hours in a day (likely at night). During this period, the interior design temperature of 22°C (72°F) may not be met (as the furnace cannot meet the load) but will likely remain in the ASHRAE comfort zone. Otherwise, a significantly larger heating system would be required.

9.33.4. General Requirements for Heating and Air-conditioning Systems

9.33.4.1. Design of Heating and Air-conditioning Systems

This Article requires that heating and air-conditioning systems be designed and installed in such a manner as to fulfill their intended functions without creating a significant fire, shock, explosion or health risk. Where there are no provincial, territorial or municipal regulations, heating and air-conditioning systems must be designed, constructed and installed in accordance with good engineering practice, such as those described in ASHRAE Handbooks and Standards, the HRAI Digest, the Hydronics Institute Manuals, and the SMACNA Manuals.

The capacity of the heating system must be determined by the calculations set out in CSA F280, "Determining the Required Capacity of Residential Space Heating and Cooling Appliances." The design of heating and air-conditioning systems must take heat loss (or gain), the thermal resistance of the enclosing building envelope, the outdoor and indoor design temperatures, and air infiltration and ventilation loads into account.

9.33.4.2. Installation of Hydronic Heating Systems

This Article requires that hydronic heating systems safely meet the requirements for indoor design temperature. Since hydronic systems often operate at higher temperatures than do forced warm air systems, exposed portions of the hydronic system where people may come in contact with the components must not exceed 70°C (160°F).

The installation of a hydronic heating system needs to comply with applicable provincial or territorial regulations or municipal bylaws or, in the absence of such regulations or bylaws, with CSA B214, "Installation Code for Hydronic Heating Systems."

9.33.4.3 Heating System Control

This Article requires that individual controls for a heating system be provided to regulate indoor design temperatures for the occupant of a secondary suite.

Where a single heating system serves a house with a secondary suite, individual temperature controls need to be provided for each dwelling unit served by the system so that occupants can control the temperatures in their own suites. For fire safety reasons, single heating systems in houses with a secondary suite must not be comprised of shared ductwork, so this Article applies only to electric, fuel-fired or unitary heaters and hydronic heating systems. The controls for shared spaces may be located in those spaces or in one of the suites. Otherwise, independent heating systems with their own temperature controls are required.

9.33.4.4. Access

This Article requires that access be provided for the inspection, maintenance and repair of all components of a heating or air-conditioning system.

9.33.4.5. Protection from Freezing

This Article requires that heating or air-conditioning equipment in an unheated space be protected from freezing.

9.33.4.6 Expansion, Contraction and System Pressure

This Article requires that heating and cooling systems be designed to allow for thermal expansion and to maintain system pressure within the allowable pressure limits.

9.33.4.7. Structural Movement

This Article requires that mechanical systems and equipment, including ductwork and piping, be designed to avoid damage resulting from movement of the building structure, which could create unsafe or unhealthy conditions for the occupants.

The risk of damage from an earthquake is expressed in terms of spectral response acceleration values (NBC Table C-3 of Appendix C). Heating or air-conditioning equipment with fuel or power connections located in areas where the spectral response acceleration, $S_a(0.2)$, is greater than 0.55 are required to be secured to resist overturning and displacement.

9.33.4.8. Asbestos

This Article prohibits the use of asbestos in air distribution systems or equipment to keep asbestos fibres from entering the air supply or return systems, where they would create a health threat to the building occupants.

9.33.4.9. Contaminant Transfer

This Article prohibits ducting for heating systems from bringing contaminated air into habitable spaces. Ducts for heating systems serving a garage and ducts passing through a garage must be designed so that contaminated air from the garage cannot be brought into habitable space. This means that the duct located in or passing through the garage, the penetration of the duct through the building assembly separating the garage from the rest of the building, and heating appliances located in the garage must be airtight.

9.33.5. Heating and Air-conditioning Appliances and Equipment

9.33.5.1. Capacity of Heating Appliances

This Article intends to ensure that heating equipment that serves a single dwelling unit is capable of providing indoor design temperatures. The capacity of the heating system must be determined by the calculations set out in CSA F280, "Determining the Required Capacity of Residential Space Heating and Cooling Appliances." In order to perform these calculations, an indoor design temperature (NBC Article 9.33.3.1.) and an outdoor design temperature (2.5% January temperature, NBC Table C-2 of Appendix C) are required.

Heating demands should be determined on a room-by-room basis, so that the heating supplied to each space is appropriate for the heat loss from that space. From these calculations, the total capacity of the heating system and the size of air distribution ducts are determined (or in the case of hot water and electric baseboard systems, the radiator or heater capacity in each room).

In addition, each type of central heating or cooling system requires a specialized knowledge of installation procedures to reduce the risk of accidental fires, explosions, electrical shock, asphyxiation and other hazards that may occur with improper installation. The proper design and installation of central systems, therefore, requires specialized knowledge, not only of the requirements in the NBC itself, but also of the various installation CSA standards pertaining to oil, gas, wood and electrical appliances.

Heating system design must conform to good engineering practices. Engineering and industry associations and system suppliers have developed design approaches. A number of these are referenced in NBC Article 9.33.4.1.

To obtain greater economies and versatility, arrangements are sometimes devised to interconnect systems that burn solid fuel with those that burn gas or oil, or that use electricity. For example, water lines from hot water, oil or gas systems may be passed through the fire chamber of an appliance that burns solid fuel to preheat the hot water, or the fire chamber may be used to preheat air for a forced warm air system burning oil or gas or using electrical heating. These arrangements can lead to unsafe temperatures and may even create explosion hazards if the system is not installed with appropriate temperature and pressure controls, and are not permitted without approval from appropriate authorities.

9.33.5.2. Appliance Installation Standards

This Article requires, through reference to standards, that heating and air-conditioning equipment be installed in such a manner as to fulfill its intended functions without creating a fire, shock or explosion hazard, or lead to conditions that will have a detrimental effect on the health of the building occupants. In the absence or provincial, territorial or municipal standards, a number of appliance standards are listed for various fuel and equipment types.

9.33.5.3. Design, Construction and Installation Standard for Solid-Fuel-Burning Appliances

This Article requires, through reference to a standard, that solid-fuel-burning appliances be designed and installed so as to fulfill their intended functions without creating a fire or health hazard to the building occupants. The installation of solid-fuel-burning stoves, cooktops and space heaters, including requirements for combustion air, is governed by CSA B365, "Installation Code for Solid-Fuel-Burning Appliances and Equipment."

CSA B365 covers installation issues such as accessibility, air for combustion and ventilation, chimney and venting, mounting and floor protection, wall and ceiling clearances, installation of ducts, pipes, thimbles and manifolds, and control and safety devices. Through reference to other standards, it also covers design and construction issues. It requires that stoves, cooktops, central furnaces and other space heaters be designed and built in conformity with the relevant referenced standard.

The standard requires that the installation instructions intended for the appliance contain certain basic information, including the size and type of chimney connection, type of floor protection required, the size and type of chimney to which the appliance is to be connected, installation clearances, the type of fuel to be used, general operation and maintenance instructions (including chimney cleaning), and other relevant safety instructions. These installation instructions are used by the certifying agency in evaluating the suitability of the appliances when they undergo laboratory testing. Where there is a difference between the installation instructions and those in the general installation standard, the instructions govern. In effect, the installation instructions form part of the certification and should be met.

9.33.5.4. Fireplaces

This Article refers to NBC Section 9.22. for the design and construction of fireplaces.

9.33.6. Air Duct Systems

9.33.6.1. Application

This Article informs NBC users of the limited application of NBC Subsection 9.33.6., and advises them that other Parts of the NBC apply to air duct systems beyond this application. NBC Subsection 9.33.6. applies to the design, construction and installation of air duct distribution systems in which the rated heat input does not exceed 120 kW (400 000 Btu). NBC Part 6 and NBC Subsection 3.6.5. must be used for higher capacity furnaces.

Combustion Air

The operation of a fuel-burning (naturally aspirating or atmospherically vented) appliance removes air from the house, creating a slight negative pressure inside. In certain cases, the natural flow of air up a chimney can be reversed or can be inadequate to remove all the products of combustion, leading to a danger of carbon monoxide poisoning or long-term health problems for the occupants.

Newer houses are generally more airtight than older ones because of improved construction practices, including tighter windows, weatherstripping and sealant. This fact increases the probability that infiltration will not be able to supply enough air to compensate for simultaneous operation of exhaust fans, fireplaces, clothes dryers, furnaces and space heaters.

Therefore, it is necessary to introduce outside air to the space containing the fuel-burning appliance unless it is a sealed combustion appliance with its own air supply. Information regarding combustion air requirements for various types of appliances can be found in the installation standards referenced in NBC Article 9.33.5.2. In the case of solid-fuel-burning stoves, cooktops and space heaters, CSA B365, “Installation Code for Solid-Fuel-Burning Appliances and Equipment,” suggests that the minimum size of openings be determined by trial and error to accommodate the flue characteristics, the firing rate and the building characteristics. The combustion air opening is recommended by the standard to be 0.5 times the flue collar area.

9.33.6.2. Materials in Air Duct Systems

This Article requires that ducts for air-handling systems, including duct connectors and associated fittings, have the necessary properties to fulfill their intended function without creating a fire hazard or conditions detrimental to the health of the building occupants.

The spread of fire is a major concern for ducts and associated fittings. Ducts and associated fittings must be made of noncombustible materials. An exception is made for systems where the air temperature will not exceed 120°C (250°F). Effectively, this means only return air plenums.

Heating ducts, duct connectors, associated fittings and plenums must be constructed of steel, aluminum alloy, copper or appropriate noncombustible material. Ducts, such as those made from mineral wool, that contain only limited amounts of combustible material may also be used provided their flame-spread and smoke characteristics are within acceptable limits, and their use is restricted to prescribed limits. Ducts that convey only ventilation air are not subject to these restrictions. This Section also prescribes requirements for duct connectors, sealants, tapes, linings and insulation in the air duct system.

Materials in the air duct system that might be subject to excessive moisture must be corrosion-resistant and have no appreciable loss of strength when wet. The use of stud or joist spaces as ducts for return air has been common practice for a long time and has demonstrated safe and adequate performance. For this reason, ducts that are part of a return air system and that are contained entirely within a dwelling unit do not need to be noncombustible.

Foamed plastic insulation may not be used in ducts because of the concern of fire spread through the ducts. Foamed plastics have poor flame-spread characteristics.

9.33.6.3. Tape

This Article requires, through reference to a standard, acceptable tape for sealing duct joints that will not create a fire hazard by facilitating the spread of fire along its surface.

9.33.6.4. Coverings, Linings, Adhesives and Insulation

This Article ensures that air ducts (including plenums) and their coverings, linings, insulation and adhesives will not facilitate the spread of fire along the ducts and will not generate excessive amounts of smoke in the event of a fire. It also ensures that these components will not ignite when they are near sources of high temperatures and that they will be able to preserve the integrity of any fire separation through which the ducts pass. Interference of lining materials with the operation of dampers or fire block flaps has to be prevented.

In general, foamed plastic insulation must not be used as part of an air duct or for insulating an air duct. However, as illustrated in Figure 9.33.-2, foamed plastic insulation conforming to NBC Article 9.25.2.2. can be used to insulate a galvanized steel, stainless steel or aluminum air duct, provided the insulation applied to supply ductwork has a clearance of at least 3 m (9 ft. 10 in.) from the furnace bonnet, the temperature within the ductwork where the insulation is installed does not exceed 50°C (122°F), the duct joints are taped with a product conforming to NBC Sentence 9.33.6.3.(1), return air plenums are separated from the insulation, and the insulation is protected in accordance with NBC Clause 9.33.6.4.(6)(e) (see also NBC Article 9.10.17.10.).

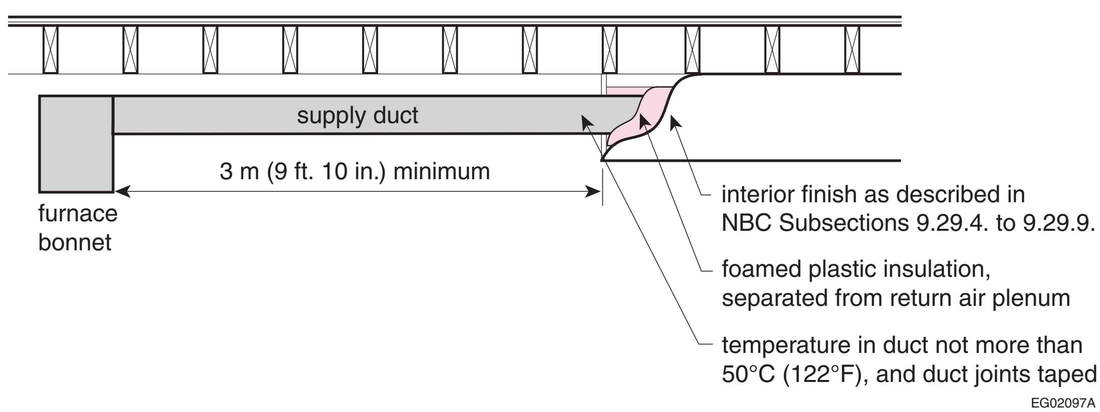


Figure 9.33.-2
Insulation of a galvanized steel, stainless steel or aluminum air duct with foamed plastic insulation conforming to NBC Article 9.25.2.2.

9.33.6.5. Galvanized Steel or Aluminum Supply Ducts

This Article requires that metal ducts have adequate strength to resist being damaged and sufficient metal thickness to provide a reasonable degree of durability. It also requires that the associated duct fittings provide reasonable strength to resist disengagement at the joints, provide reasonable airtightness, and facilitate the smooth flow of air at changes of direction of the ducts. The last is important to reduce pressure losses due to air turbulence in the ducts, as well as to reduce the noise level.

NBC Table 9.33.6.5. identifies the required minimum thickness of galvanized steel or aluminum supply ducts. The required thickness also applies to fittings for ducts.

9.33.6.6. Construction of Ducts and Plenums

This Article provides the requirements for ducts and plenums. To achieve reasonable efficiency in air distribution, ductwork, including joints, must be substantially airtight with no unnecessary openings cut into the ducts. If larger ducts are not stiffened by creases, they tend to move abruptly inward or outward with changes in air pressure or temperature, and reverberate causing noise in the duct system.

Spaces between the ductwork and the surrounding construction can create pathways for fire spread unless the spaces are fire blocked. Ducts have to be securely supported to avoid sagging and to keep them in alignment. The use of S and drive cleats not only reduces air leakage but also makes the joints resistant to dislodgment resulting from accidental impact forces.

Duct systems must have no openings other than those required for the proper operation and maintenance of the system. Air duct systems serving garages must not be interconnected to other parts of the dwelling. Joints in round ducts must be tight-fitting and lapped not less than 25 mm (1 in.). Rectangular ducts are fastened together with S and drive cleats or equivalent mechanical connections.

9.33.6.7. Installation of Ducts and Plenums

This Article establishes installation requirements for ductwork and plenums serving a garage. These could allow dangerous exhaust gases and gasoline fumes to enter the living areas if both living and garage areas are served by a common system.

Trunk supply ducts should not be nailed directly to wooden members because such connections do not provide sufficient support strength for the ducts, or allow for their expansion. Unless ductwork that passes through unheated spaces is made airtight, substantial quantities of moisture may be carried into such spaces, leading to moisture-related problems.

Combustible underground ducts are kept away from furnace plenums to avoid ignition. Since underground ducts are subjected to ground moisture, to avoid premature failure they must be able to resist the deteriorating effects of a damp environment, and be made watertight to control the entry of groundwater into the heating system and consequent problems related to excessive humidity. Direct drainage of underground ducts to a sewage system could allow sewer gases to enter the living areas and is therefore not allowed.

Joints in ducts passing through unheated spaces are taped or sealed throughout their length to prevent air leakage.

9.33.6.8. Clearances of Ducts and Plenums

This Article requires that ducts not expose adjacent combustible materials to temperatures that could eventually cause ignition. Figure 9.33.-3 illustrates required clearances between plenums and combustible materials, based on required plenum clearances called for in the relevant installation standards referenced in the NBC Article 9.33.5.2.

9.33.6.9. Adjustable Dampers and Balance Stops

This Article intends to facilitate the adjustment of the warm air supply to each heating outlet, so that the comfort level throughout the dwelling unit can be maximized. Warm-air supply outlets in finished areas are provided with diffusers and adjustable openings. All branch supply ducts not fitted with diffusers with adjustable balance stops must be supplied with adjustable dampers and fitted with devices to indicate the position of the damper.

9.33.6.10. Warm-Air Supply Outlets and Return Inlets – General

This Article contains requirements intended to keep large foreign objects from being dropped into the ductwork, which could restrict the flow of air or create a potential fire hazard. It also intends to avoid the use of grillwork that could create a fire hazard by facilitating flame-spread travel.

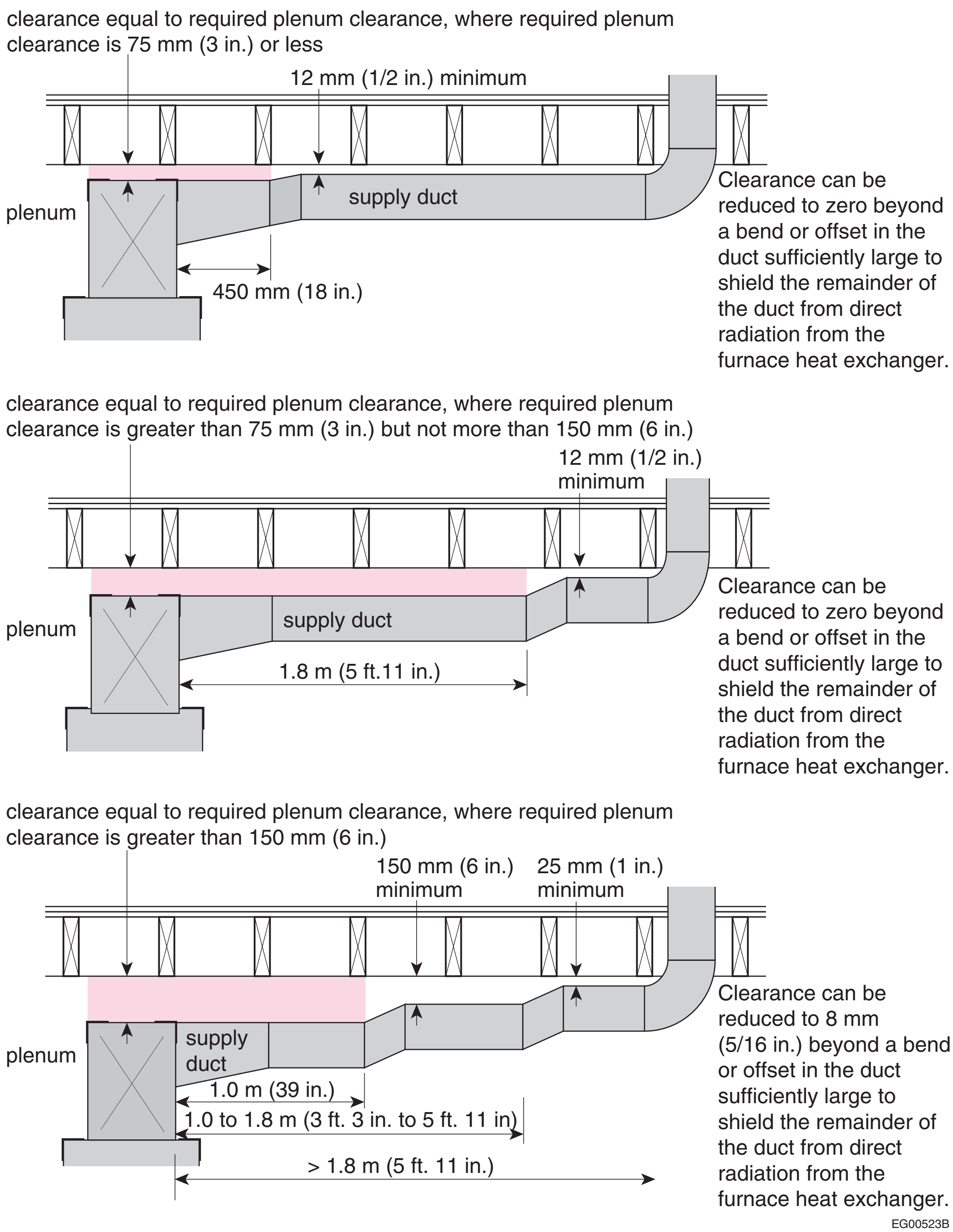


Figure 9.33.-3
Required clearances from combustible material for plenums

9.33.6.11. Warm-Air Supply Outlets

This Article contains requirements intended to ensure that warm air is distributed from a furnace throughout a dwelling unit in a manner that will provide a reasonable level of comfort in all parts of the dwelling unit. A second purpose is to ensure that the warm air temperature will be kept sufficiently low to avoid accidental burns from contact with the registers.

At least one warm-air supply outlet is provided in each finished room that is adjacent to unheated space. Outlets should be located so as to bathe with warm air at least one exterior wall or window in a room, except where this requirement is not practical in kitchens, bathrooms or utility rooms.

Where a heating system is also designed to provide ventilation air, ceiling outlets or outlets located high on interior walls are permitted to be installed provided that the outlets are designed accordingly and are provided with diffusers.

At least one warm-air supply outlet is required for each 40 m² (430 ft.²) of floor surface area in unfinished basements. The outlet must be located to provide adequate distribution throughout the basement. At least one warm-air supply outlet is required for each 80 m² (860 ft.²) of floor surface area in heated crawl spaces. The location must be such that there is adequate distribution of warm air throughout the crawl space.

The combined capacity of warm-air supply outlets must be at least equal to the design heat loss from the area they serve. Individual outlets must not exceed 3 kW (10 000 Btu) per outlet. The temperature of the supply air at the warm-air supply outlet must not exceed 70°C (160 °F).

Warm-air supply outlets are required for each finished area that is located adjacent to an unheated space. The general requirement is that heat be directed against cold surfaces. Outlets are normally located against outside walls and under windows, which represent the coldest surfaces in an outside wall. However, where the outlets are also used to distribute conditioned ventilation air, it may be more appropriate to locate the outlets in the ceiling or high on interior walls, provided the outlets are fitted with appropriately designed diffusers.

Experience has shown that in very energy-efficient houses that are airtight, with high insulation levels and high-performance windows, the locations of heating registers is not as critical, providing that the capacity and layout of these registers are carefully considered.

9.33.6.12. Return-Air Inlets

This Article requires that a reasonable recirculation of air from each storey and from each room in a dwelling unit. This facilitates the introduction of heated air in sufficient quantities to provide an adequate comfort level in each room. If return-air inlets are located in the same enclosed room or crawl space that provides furnace combustion air, the burner may be starved for oxygen and produce carbon monoxide. This carbon monoxide, along with other products of combustion, could find its way into the air system through the return-air inlet and create a serious threat to building occupants.

9.33.6.13. Return-Air System

This Article contains requirements intended to avoid the installation of return-air systems in a manner that will cause a risk of ignition, facilitate the spread of fire, or create a health risk by drawing the products of combustion into the return-air system. A second purpose is to ensure that the return-air system has sufficient capacity to handle the entire air supply. If undersized, the furnace will not operate at full capacity or top efficiency. If a common return duct has outlets on more than one floor, it will be difficult to balance the system to provide an adequate comfort level in all rooms.

It is common practice to introduce outdoor air into a house by means of an outdoor air duct connected to the return air plenum of a forced-air furnace. This is an effective method and is a component of one method of satisfying the mechanical ventilation requirements of NBC Subsection 9.32.3. However, some caution is required. If the proportion of cold outside to warm return air is too high, the resulting mixed air temperature could lead to excessive condensation in the furnace heat exchanger and possible premature failure of the heat exchanger. CAN/CSA-F326-M, "Residential Mechanical Ventilation Systems," requires that this mixed air temperature not be below 15.5°C (60°F) when the outdoor temperature is at the January 2.5% value. It is also important that the outdoor air and the return air mix thoroughly before reaching the heat exchanger (see NBC Article 9.32.3.4.).

Return-air systems must be designed to handle the entire air supply. At least one return-air intake duct must be provided for each floor, except for unfinished areas or where the floor level adjacent to a floor with a return-air duct is less than 900 mm (36 in.) above or below that level. A vertical return-air duct is only permitted to have openings on one floor. Provision is made for the return of air from all rooms by leaving gaps beneath doors, using louvered doors or by installing return air ducts and intakes. Spaces between studs or joists used as return ducts must be separated from the unused portion of such spaces by tight-fitting metal stops or wood blocking.

Return-air ducts and intakes must not be located in an enclosed room or crawl space that provides combustion air to a furnace. The return-air system must be designed to ensure that negative pressures from the circulating fan do not affect the furnace combustion air supply, and that combustion products are not drawn, through joints or openings in the furnace or flue pipe, back into the dwelling.

Where any part of the return-air duct is exposed to radiation from the furnace heat exchanger, the ducting above or within 600 mm (24 in.) of the furnace casing must be noncombustible. Return ducts serving solid-fuel-fired appliances are constructed of noncombustible material. Combustible return ducts are lined with noncombustible material below floor registers, at the bottom of vertical ducts and under furnaces having a bottom return.

9.33.6.14. Filters and Odour Removal Equipment

This Article contains requirements for different types of air filters. It references a standard for combustibility and smoke-produced characteristics of air filters and requires de-energizing the electrical circuit when the electrostatic type air filter is changed or the furnace is not in operation. Another purpose is to protect occupants from dust accumulation from adsorption-type filters and to provide access for reactivating the filter material.

9.33.7. Radiators and Convectors

9.33.7.1. Recessed Radiators and Convectors

This Article contains requirements intended to avoid the ignition of the wall surface adjacent to a radiator or convector after long-term exposure to the heat it produces.

9.33.7.2. Surface Temperature

This Article contains requirements intended to avoid accidental skin burns resulting from contact with a radiator. The exposed surface temperature of a steam or hot water radiator must not exceed 70°C (158°F), unless precautions are taken to prevent human contact. Every steam or hot water radiator and convector located in a recessed or concealed space, or attached to the face of a wall of combustible construction, must be provided with a noncombustible lining or backing.

9.33.8. Piping for Heating and Cooling Systems

9.33.8.1. Piping Materials and Installation

This Article contains requirements intended to avoid the rupture of steam and hot water piping resulting from excessive temperature or pressure of the heating medium. A second purpose is to avoid excessive stress in the piping and its supporting structure resulting from thermal expansion of the piping.

9.33.8.2. Insulation and Coverings

This Article requires that insulation and coverings on steam and hot water piping be serviceable at the operating temperature of the system, and do not create a fire or smoke hazard as a result of ignition, facilitate the spread of fire along their surfaces, or deteriorate in the presence of moisture. A second purpose is to avoid skin burns from accidental contact with the piping.

9.33.8.3. Clearances

This Article contains requirements intended to avoid the ignition of combustible material adjacent to steam and hot water piping resulting from long-term exposure to heat. Requirements for the installation, insulation and clearances relating to steam and hot water piping are provided in NBC Table 9.33.8.3.

No clearance is required between piping and combustible construction as long as the design temperature for the steam or water is less than 95°C (204°F).

9.33.8.4. Protection

This Article contains requirements intended to avoid the ignition of combustible material adjacent to steam and hot water piping resulting from long-term exposure to heat.

9.33.9. Refrigerating Systems and Equipment for Air-conditioning

9.33.9.1. Cooling Units

This Article contains requirements intended to ensure that, where heating and cooling systems share a common duct network, the systems will be installed so that the operating temperatures of one system will not adversely affect the equipment of the other system.

Where a cooling unit is combined with a fuel-fired furnace in the same duct system, the cooling unit must be installed in parallel with the furnace, upstream of a furnace designed for such application, or downstream of the furnace provided the cooling unit is designed to prevent excessive temperature or pressure in the refrigeration system.

9.33.10. Chimneys and Venting Equipment

9.33.10.1. Requirement for Venting

This Article intends to ensure that the products of combustion from fuel-fired heating equipment are vented to the exterior in a manner that will not create a fire or health risk to building occupants. Except for factory-built and masonry or concrete chimneys, the products of combustion from oil-, gas-, and solid-fuel-burning appliances including stoves, cooktops, and space heaters must be vented in conformance with the standards listed in NBC Articles 9.33.5.2. and 9.33.5.3.

9.33.10.2. Factory-Built Chimneys

This Article defines, through reference to a standard, the characteristics for factory-built chimneys that will provide safe operation.

Solid-fuel-burning appliances have a tendency to create creosote and soot deposits that can lead to chimney fires. Experience has shown that standard-duty prefabricated metal chimneys are not able to withstand severe fires without sustaining damage or even failing completely. Factory-built chimneys serving solid-fuel-burning appliances and their installation must comply with CAN/ULC-S629-M, “650°C Factory-Built Chimneys.” Certain solid-fuel-burning appliances may be connected to factory-built chimneys other than those specified in CAN/ULC-S629-M if tests show that the use of such a chimney will provide an equivalent level of safety (see NBC Article 9.33.5.3.).

9.33.10.3. Masonry or Concrete Chimneys

This Article refers to NBC Section 9.21. for the design and construction of masonry or concrete chimneys.

Section 9.34.
Electrical Facilities

Introduction

Each province has enacted electrical regulations based on the CSA's Canadian Electrical Code. It regulates the installation of electrical services for the purpose of reducing hazards due to electrical shock and fire. Therefore, the electrical requirements in NBC Part 9 are limited in scope, and generally do not regulate similar aspects of electrical installations, unless there is a practical reason for doing so.

For example, the Canadian Electrical Code contains comprehensive requirements for controlling fire hazards related to the use of recessed lighting fixtures. These fixtures are also regulated by NBC Part 9 (NBC Article 9.34.1.4.). This is done because of problems that may arise when insulation is applied to existing buildings. A recessed fixture, for example, may be quite satisfactory in an uninsulated ceiling, but could be a fire hazard if covered with insulation. A fire hazard could, therefore, result without any new electrical work being carried out (and hence no electrical inspection). Including this requirement in NBC Part 9 allows general building inspection to control the hazard when a building permit is required for retrofitting.

Generally, the electrical requirements in NBC Part 9 relate to the provision of lighting outlets. The justification for such requirements is accident prevention.

9.34.1. General

9.34.1.1. Standard for Electrical Installations

This Article requires that electrical systems be designed and installed so that they will not create a fire or shock hazard and will provide a reasonable level of convenience for building occupants.

Electrical installations, including the service capacity of the installation and the number and distribution of circuits and receptacles, have to meet the requirements of the appropriate provincial, territorial or municipal legislation or, in the absence of such legislation, must conform to CSA C22.1, "Canadian Electrical Code, Part I."

9.34.1.2. Required Facilities

This Article requires that if electrical services are available, the building must be provided with required electrical facilities.

9.34.1.3. Location of Equipment in Public Areas

This Article contains requirements intended to reduce the risk of unauthorized tampering or interference with the operation of electrical services or equipment in public areas.

9.34.1.4. Recessed Lighting Fixtures

This Article contains requirements intended to reduce the risk of ignition of combustible material adjacent to a recessed lighting fixture resulting from overheating of the fixture. Recessed lighting fixtures must not be located in insulated ceilings unless the fixtures are designed for this type of installation.

9.34.1.5. Wiring and Cables

This Article contains requirements intended to reduce the risk of fire propagation along electrical wiring. Given that data cables may be added to buildings without removing the old ones, optical fibre cables and electrical wires and cables installed in buildings of combustible construction must not convey flame or continue to burn for more than one min when tested in accordance with CSA C22.2 No. 0.3, "Test Methods for Electrical Wires and Cables," (FT1 rating). An FT rating is based upon temperature rise criteria and flame occurrence on the unexposed surface. Otherwise, the cables and wires must be enclosed in noncombustible raceways, masonry walls, concrete slabs or be totally enclosed in non-metallic raceways as specified in NBC Clause 3.1.5.20.(1)(b).

Concealed floor or ceiling spaces used for voice, sound or data transmission (except for wires and cables used for fire or security alarms, radio, and television) that have combustible insulation or jackets must conform with NBC Article 3.6.4.3. This means that FT6-rated cables should be used in plenums in buildings of noncombustible construction and cables with at least an FT4 rating should be used in plenums in buildings of combustible construction.

9.34.2. Lighting Outlets

The Canadian Electrical Code contains requirements relating to lighting that are similar to those in the NBC. The Electrical Code requirements, however, apply only to residential occupancies, whereas many of the requirements in the NBC apply to all Part 9 buildings. Code users must, therefore, be careful to ensure that all applicable provisions of the NBC are followed, irrespective of the limitations in the Electrical Code.

9.34.2.1. Lighting of Entrances

This Article contains requirements intended to reduce the risk of accidental falls and missteps at the entrance to a building, and to reduce the risk of forced entry. An additional purpose is to provide a reasonable level of convenience for the occupant. An exterior lighting outlet with fixture controlled by a wall switch located within the building must be provided at every entrance.

9.34.2.2. Outlets in Dwelling Units

This Article contains requirements intended to reduce the risk of accidents in dwelling units by providing a light switch at the entrance to a room. A second purpose is to provide a reasonable level of convenience for the occupant.

The spacing of electrical wall receptacles was at one time regulated by requirements in this Section; it was also regulated by the Canadian Electrical Code. Although attempts were made to keep the two sets of requirements consistent, differences inevitably arose, which led to enforcement problems. Since the maximum spacing of receptacles is considered to be justified on the premise of discouraging the need for extension cords and the overloading of electrical outlets, the requirements of the Canadian Electrical Code were considered to be more appropriate.

The requirements for receptacle spacing in the Canadian Electrical Code are similar to those that once formed part of NBC Section 9.34., with a few exceptions. In the habitable areas in dwelling units, such as the living room, dining room, recreation room and den, the receptacles must be spaced so that no point along a usable wall space is more than 1.8 m (6 ft.) from a receptacle (i.e., 3.6 m (12 ft.) apart). This is to permit lamps, fans, and other electrical appliances to be operated from any part of such spaces without the need for extension cords. A usable wall space is considered to be a portion of wall at least 900 mm (12 in.) long where a table or a lamp could normally be placed; however, it does not include the area occupied by a doorway, fireplace or a floor-length window.

A lighting outlet with fixture controlled by a wall switch must be provided in kitchens, bedrooms, living rooms, utility rooms, laundry rooms, dining rooms, bathrooms, water-closet rooms, vestibules and hallways. Fixtures can be omitted in bedrooms and living rooms, provided these rooms have a receptacle installed that is controlled by a wall switch.

In addition, a lighting outlet with fixture must be provided for an attached, built-in or detached garage or carport. Where the fixture is ceiling-mounted above an area normally occupied by a parked car, these outlets must be controlled by a wall switch near the doorway; otherwise, a switched lampholder may be used. Where a carport is illuminated by a light at the entrance to a dwelling unit, additional carport lighting is not required.

Hallways require wall receptacles for cleaning purposes. These must be spaced so that no point along the base of the wall is more than 4.5 m (15 ft.) from a receptacle. Kitchens, being areas of potentially heavy electrical use, have special requirements for receptacles. In addition to separate receptacles for the refrigerator, electric stove, and the kitchen-dining areas (for toasters and coffee makers), the counter work area is required to have sufficient receptacles so that no point along the counter wall is more than 900 mm (3 ft.) from a receptacle. The area occupied by the kitchen sink or work surfaces less than 300 mm (1 ft.) long is excluded.

9.34.2.3. Stairways

This Article contains requirements that are intended to reduce the risk of accidental falls and missteps on stairs by requiring stairways to be lit, and by having control switches at the top and bottom of the stairway (except for short stairway runs). An exemption to omit the stairway switch at the foot of stairways serving an unfinished basement that has no other exit is rationalized on the basis that the stairway is likely to be illuminated whenever the basement is occupied, because the only access to the basement is past the light switch at the top of the stairs.

All stairways must be provided with a light. In general, three-way wall switches located at the head and foot of every stairway must be provided to control the light for stairways with four or more risers in dwelling units and houses with a secondary suite, including their common spaces. However, stairway lighting for basements that do not contain finished space or lead to an outside entrance or built-in garage may be controlled by a single switch located at the head of stairs. In addition, unfinished basements must be provided with at least one lighting fixture for each 30 m^2 (320 $ft.^2$) (or fraction thereof) of floor area; these fixtures may be controlled by the same switch that controls the basement stair light.

9.34.2.4. Basements

This Article contains requirements that are intended to reduce the risk of accidents due to bumping into or tripping over objects in basements by having at least one basement light (the light closest to the stair) controlled by the switch at the head of the stair, and providing sufficient additional lighting to illuminate the entire basement.

9.34.2.5. Storage Rooms

This Article contains requirements that are intended to reduce the risk of accidental falls due to bumping into or tripping over objects in storage rooms. A second purpose is to provide a reasonable level of convenience for the occupant.

9.34.2.6. Garages and Carports

This Article contains requirements intended to reduce the risk of accidental falls or missteps in a garage or carport area.

9.34.2.7. Public and Service Areas

This Article contains requirements that are intended to provide a sufficient level of electric lighting in public areas to avoid accidental falls or missteps, facilitate the speed of egress, and reduce the risk of vandalism. All public areas are required to be provided with sufficient outlets so that every portion is illuminated. These areas include halls, storage rooms, service rooms, laundry areas, garages, washrooms, corridors, stairways and recreation rooms. Although the level of illumination is specified in lux units, this can only be established by the use of a light meter.

An equivalent listing of incandescent lighting intensity based on watts per square metre of floor area is also provided to allow for the calculation of the required capacity of lighting circuits (most energy-efficient fluorescent and compact fluorescent lights are sold with information on the equivalent incandescent bulb wattage). This can also be used as a check on whether or not the installed lighting is adequate if no light meter is available. This is a difficult requirement to enforce, however, since light bulbs can be changed to alter lighting levels, and there is no control in the replacement of burned-out bulbs.

In apartment buildings, a receptacle is required for each 10 m (33 ft.) of public corridor or stair. (These requirements from the Canadian Electrical Code for receptacles are provided solely for information, since the verification of such facilities now rests with the electrical inspector, rather than the building inspector.)

9.34.3. Emergency Lighting

9.34.3.1. Criteria for Emergency Lighting

This Article reminds NBC users that requirements for emergency lighting (to facilitate egress in the event of power failure) are located in NBC Subsection 9.9.12.

Section 9.35. Garages and Carports

Introduction

This Section applies to garages and carports serving not more than one dwelling unit. Built-in or attached garages and carports are considered to be part of the dwelling unit to which they are attached, and therefore have essentially the same structural requirements. This also applies to garages that are separated from a house by a breezeway. These are considered to be attached rather than detached because they share a common roof structure. Certain relaxations from the NBC requirements are permitted for detached garages and service sheds.

9.35.1. Scope

9.35.1.1. Application

This Article describes the limited application of NBC Section 9.35. The requirements of NBC Section 9.35. apply to all garages and carports serving not more than one dwelling unit. Garage and carport construction must conform with the requirements that are applicable to houses except as provided in this Section.

9.35.1.2. Construction Requirements

This Article indicates that the requirements for other buildings in NBC Part 9 also apply to garages and carports, except where NBC Subsection 9.35. provides exemptions. The requirements in NBC Section 9.35. are additional to the other requirements in NBC Part 9. The primary considerations for garages and carports are structural safety and, in the case of attached or connected garages and carports, their influence on the safety and integrity of the main dwelling.

The major requirements for carports and garages covered elsewhere in NBC Part 9 are:

- NBC Article 9.10.13.15.: A main safety concern for attached garages is the prevention of carbon monoxide from automobile exhaust entering the dwelling. It is essential to ensure that the walls and ceilings separating the dwelling from the garage are suitably sealed to prevent leakage. Doors between dwelling units and garages that are built onto the house must be closely fitted and weatherstripped to prevent fumes from gasoline and automobile exhaust leaking into the house (see Guide 9.10.13.15., Doors between Garages and Dwelling Units). A door from a bedroom or a room intended for sleeping cannot open into a garage.
- NBC Article 9.10.13.16.: Doors between a dwelling unit and an attached garage must be provided with a self-closing device.
- NBC Subsections 9.10.14. and 9.10.15.: Attached and unattached garages that ignite can be a threat to an adjacent building. For this reason, the requirements for spatial separation and construction of exposing building faces generally apply.

9.35.2. General

9.35.2.1. Carport Considered to be a Garage

This Article differentiates between a garage and a carport, based on the degree of enclosure. This affects the application of certain requirements such as those in NBC Articles 9.10.13.15. and 9.10.13.16., as well as those for spatial separation.

Carports have different degrees of enclosure, ranging from being entirely open, to being totally enclosed, except for the doorway. Since certain requirements apply only to garages and not to carports, it is important to make a distinction between the two. For example, garages are required to have certain features to prevent them from exposing the remainder of the building to exhaust fumes, but carports are considered to be vented, and therefore do not. For the purpose of determining the requirements that do or do not apply, a parking structure is considered to be a garage if more than 60% of its perimeter wall area is enclosed (Figure 9.35.-1).

9.35.2.2. Garage Floor

This Article contains requirements intended to ensure that drainage, to the exterior, of snow-melt from parked vehicles is provided, and to discourage the entry of drainage water from outside. A second purpose of these requirements is to encourage the movement, towards the exterior, of gases that are heavier than air.

The floors of one-, two- and three-vehicle garages are required to slope to the exterior if the adjacent spaces in the building are less than 50 mm (2 in.) above the garage floor, or an airtight curb or partition at least 50 mm (2 in.) above the garage floor needs to be provided between the garage and the adjacent space.

Sources of ignition, such as electrical wiring and appliances, can set off an explosion in the presence of gases or vapours such as those that can be released in garages. Where a garage can accommodate more than three vehicles, and where wiring is installed within 50 mm (2 in.) of the garage floor, the Canadian Electrical Code should be consulted, as it specifies more stringent criteria for wiring.

The capacity of a garage is based on standard-size passenger vehicles such as cars, minivans and sport utility vehicles, and half-ton trucks. In a typical configuration, the capacity of a garage would be defined by width of the garage doors, generally single or double width, which correlates to the number of parking bays.

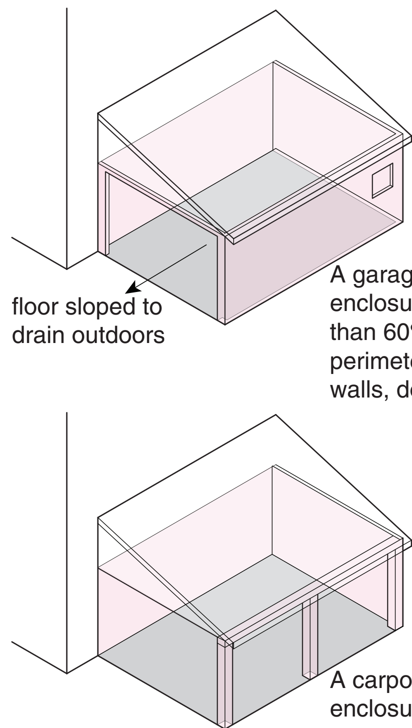


Figure 9.35.-1
Definition of garage and carport

In many constructions, floor areas adjacent to the garage are either above the garage floor level or separated from it by a foundation wall. Where the foundation wall is cast-in-place concrete and rises at least 50 mm (2 in.) above the garage floor, it can serve as the airtight curb. Where the foundation wall is masonry block or preservative-treated wood, extra measures may be needed to provide airtightness. In many cases, the construction will be required to be airtight to conform with NBC Article 9.25.3.1. and in any case, must comply with NBC Sentences 9.10.9.16.(4) and (5).

Where the space adjacent to the garage is at the same level as the garage, a 50 mm (2 in.) curb or partition is not needed if the wall is airtight and does not have a connecting door. Where there is a connecting door, it must be raised at least 50 mm (2 in.) off the floor or be installed so it closes against the curb.

In some cases, access to a basement is via a stair from a garage. In such cases, a curb must be installed at the edge of the garage floor area and must be sealed to the foundation wall, curb or partition between the garage and adjacent spaces (Figure 9.35.-2).

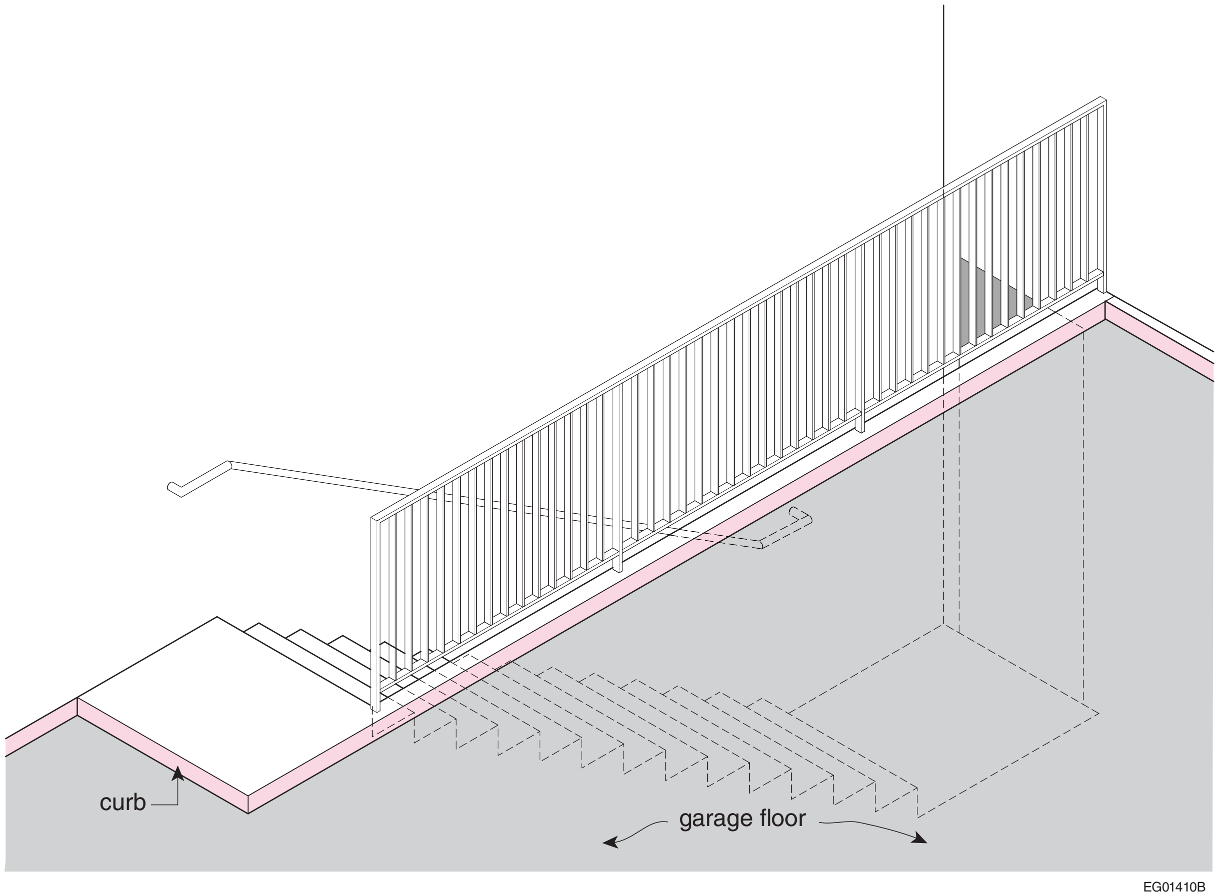


Figure 9.35.-2
Curb around garage floor at stairs

9.35.3. Foundations

An attached or built-in garage/carport shares part of the foundation with the remainder of the house, and is integrally connected by other wall, roof or floor/ceiling assemblies as well. Differential movement between the foundation for the garage (or carport) and the remainder of the building can, therefore, lead to structural damage to one of the other portions.

9.35.3.1. Foundation Required

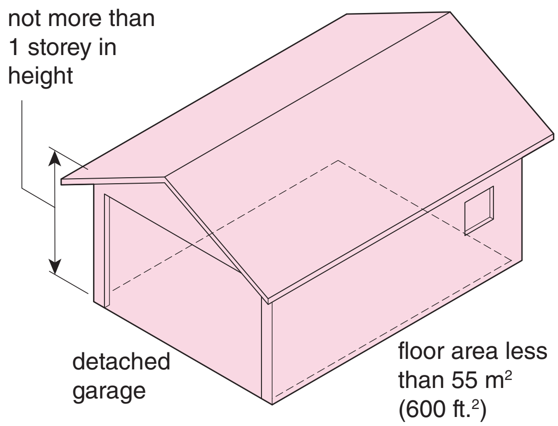
This Article contains requirements intended to provide a solid support for garages and carports, and avoid excessive movement of the superstructure that might cause structural damage, or hinder the operation of the garage door. If a garage is completely detached, however, its foundation movement has no effect on the house.

Foundation depths for attached unheated garages or carports must conform to the requirements of NBC Subsection 9.12.2. Foundations for garages and carports must conform to the requirements of NBC Section 9.15., except as described in NBC Article 9.35.3.3.

Concrete floors for garages or carports must be supported on undisturbed soil. The concrete used for garage and carport floors is required to have a minimum 28-day compressive strength of 32 MPa (4 640 psi) and 5 to 8% air entrainment (NBC Article 9.3.1.6.).

Foundations supporting garage walls are required to be continuous beneath all doors. This is to reduce the risk of frost heaving beneath doors, which could damage the hardware or make them impossible to close.

Detached garages of less than 55 m^2 (600 ft.^{2}) floor area and not more than one storey in height that are not of masonry or masonry veneer construction are permitted to be supported on wood mud sills or a 100 mm (4 in.) thick concrete floor slab (Figure 9.35.-3).



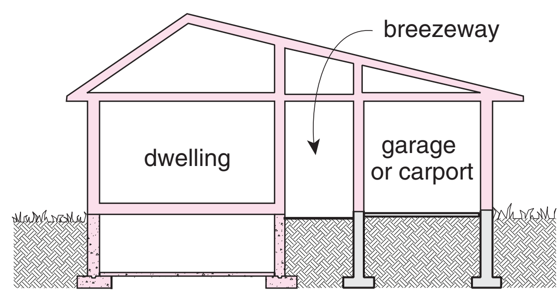
Small detached garages that are not of masonry or masonry veneer construction can be supported on wood mud sills or a 100 mm (4 in.) thick concrete floor slab.

Figure 9.35.-3
Support of small detached garages

9.35.3.2. Protection from Damage due to Soil Movement

This Article contains requirements intended to avoid structural damage to the superstructure due to differential movement between a house and a carport or garage attached directly to it or by a breezeway.

Clay soils shrink in volume as they dry. This can happen on a seasonal basis or as a result of prolonged drought. The effect of such drying varies with the depth of the soil. If the foundation beneath the house is significantly deeper than the foundation beneath the garage or carport, differential foundation movement may occur, particularly during periods of prolonged dry weather. To reduce this risk, the foundation beneath the garage or carport must be extended down to approximately the same depth as the house foundation if the two are connected by a breezeway or common roof system (Figure 9.35.-4).



In clay-type soils, foundations of garages and carports connected to a dwelling unit directly or by a breezeway must be at approximately the same depth as the main building foundation.

EG00098B

Figure 9.35.-4
Full-depth foundations for attached garages and carports in clay-type soils

Carports and most garages are unheated and are, therefore, more liable to frost heaving than are the heated portions. Consequently, it is important that portions of the foundations in the unheated portions extend below the level of frost damage (NBC Table 9.12.2.2.). This requires fairly deep excavation in the case of a built-in garage whose floor level is near the same level as the basement.

Where foundation walls or piers receive little or no heat from the remainder of the building, they can be subjected to heaving as a result of soil freezing to the sides of the foundation, so that uplift damage can occur, even though the footing itself is below frost level. This is more likely to occur in wet and poorly drained soils. Under such conditions, heaving can be reduced or prevented if the foundation is suitably reinforced by tension steel to resist the uplift forces, or if the foundation has adequate drainage to the bottom of the footing and is backfilled with coarse, granular soil or crushed rock to within a foot or so of the ground surface. The penetration of frost can be reduced by the installation of insulation in appropriate areas.

Where concrete slab foundations are used, the house slab must be isolated from the garage or breezeway portion by a construction joint so that cracks will not be transmitted from the garage to the house slab.

9.35.3.3. Drainage

This Article exempts small detached garages (with a floor area of less than 55 m² (600 ft.²) and a height of less than one storey) that are not of masonry or masonry veneer construction from the foundation drainage requirements in NBC Section 9.14. where the finished ground level is at or near the elevation of the garage floor and the ground slopes away from the building (Figure 9.35.-5). This exemption is rationalized on the basis that such buildings can withstand considerable movement without sustaining damage to the superstructure and that the collapse of such buildings poses little threat of injury because they are generally not occupied by people for any significant length of time.

Detached garages meeting the following conditions are exempt from the foundation drainage requirements in NBC Section 9.14.:

- garage has a floor area of less than 55 m² (600 ft.²),
- garage is not more than 1 storey in height,
- garage is not of masonry or masonry veneer construction,
- finished ground level is at or near garage floor level, and
- ground slopes away from the building.

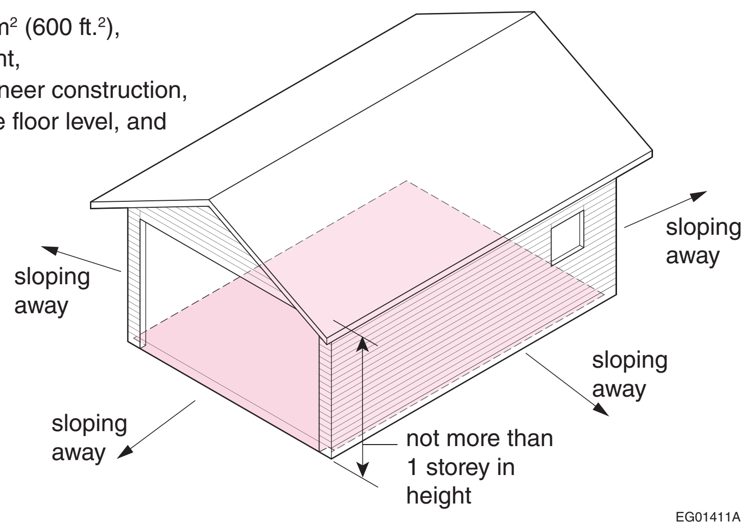


Figure 9.35.-5
Exemption of small detached garages from foundation drainage requirements

9.35.3.4. Column Piers

This Article contains requirements intended to prevent the lower ends of columns from being subjected to wetting from drainage water and snow-melt. This wetting can lead to decay in the case of wood columns, and corrosion in the case of metal. An additional purpose is to provide sufficient area at the base of the pier to avoid overloading of the soil when the columns support a roof load.

Column piers may be used to support carport columns provided they extend a minimum of 150 mm (6 in.) above ground level and project not less than 25 mm (1 in.) beyond the base of the column. Piers must be not less than 190 × 190 mm (7 1/2 × 7 1/2 in.). Figure 9.35.-6 summarizes these requirements.

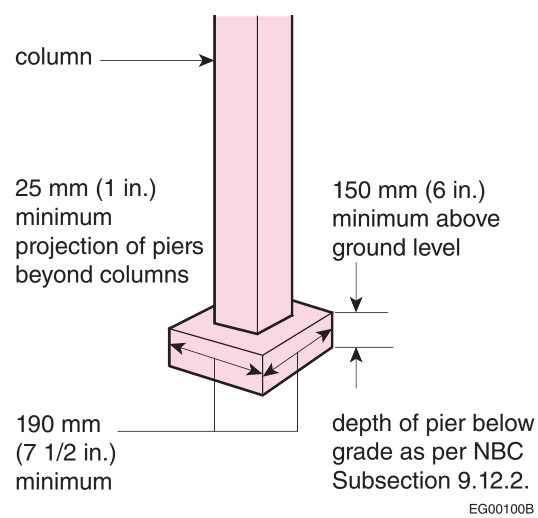


Figure 9.35.-6
Column piers for carports

9.35.4. Walls and Columns

9.35.4.1. Interior Finish

This Article exempts garages from the requirements for interior finish. This is rationalized on the basis that the space is unoccupied, and that such finish is not necessary aesthetically.

9.35.4.2. Columns

This Article allows wooden carport columns to be smaller than those used in basements to support the basement beam.

The requirements for columns described in NBC Section 9.17. apply to carport columns as well, except that in the case of wood columns, the size can be reduced to 89 × 89 mm (4 × 4 in. nominal). Carports are usually framed so that half of the roof load is carried by the house foundation and half by the columns. Since carports are relatively narrow, the load carried by such columns is considerably less than the theoretical load carried by basement columns.

9.35.4.3. Anchorage

This Article contains requirements intended to keep garages or carports from being moved as a result of wind action. Open structures such as carports can be subjected to considerable uplift forces from wind and lateral forces from earthquakes or impact. This makes it necessary to have adequate attachments to the piers as well as the roof structure. Where wooden columns are used, a steel saddle is commonly embedded in the top of the pier and bolted or spiked to the column. Where steel columns are used, anchor bolts to fasten the column bearing plate can be embedded in the piers.

Figure 9.35.-7 shows two methods for anchoring small garages.

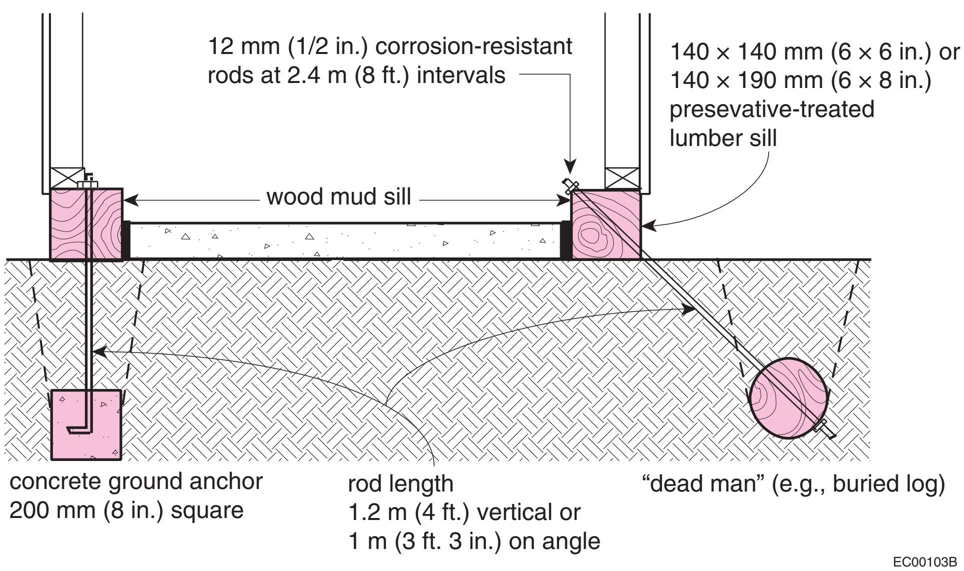


Figure 9.35.-7
Support and anchorage of small garages on wood mud sills

Figure 9.35.-8 shows two methods for anchoring carport columns.

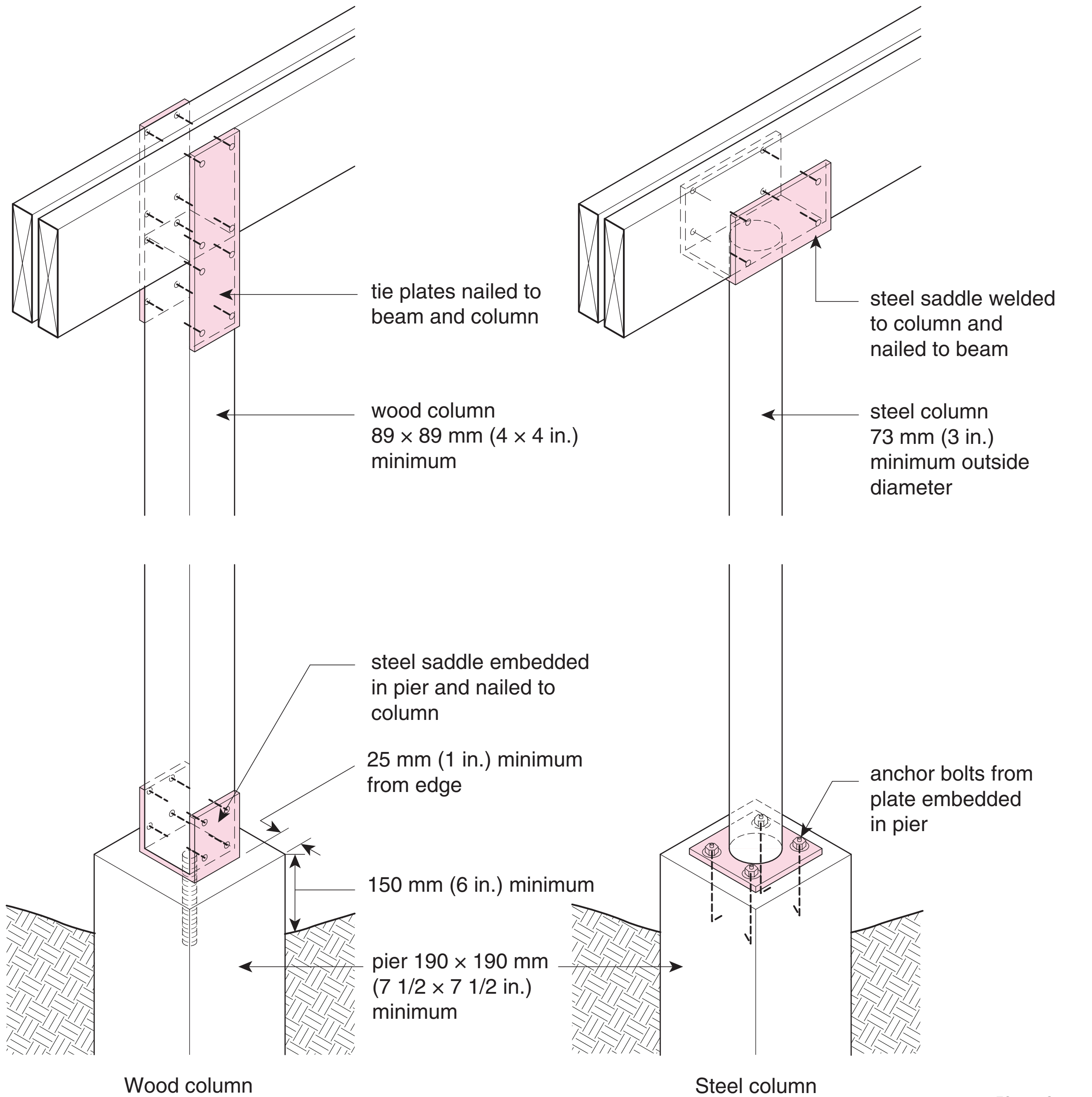


Figure 9.35.-8
Anchorage of carport columns

Section 9.36. Energy Efficiency

Introduction

The energy efficiency provisions in the NBC Part 9 deal with the construction of the building envelope, the sizing and selection of HVAC and water heating equipment, as well as the energy performance compliance for housing.

9.36.1. General

9.36.1.1. Scope

This Article describes the scope of the requirements in NBC Section 9.36., which is the reduction of energy used by the building as a result of the design and construction of the building envelope assemblies, as well as the design and construction or specification of systems and equipment used for heating, ventilation, air-conditioning and service water heating.

Calculating the energy requirements of a building normally includes aspects such as heat loss through the building envelope, duct work, and storage tanks, as well as the energy used by inefficient equipment, and the building's ventilation equipment. In the context of this Section, however, the calculation does not take into account the energy generated on site through renewable energy sources (i.e., solar, wind power, geothermal, etc.) and does not include requirements for energy-efficient selection of lighting sources or electrically powered equipment.

9.36.1.2. Definitions

This Article contains a number of definitions specific to NBC Section 9.36., such as "common space," "overall thermal transmittance," "effective thermal resistance," and "fenestration."

Common Space

The term "common space" is important in relation to the performance path of a building. NBC Subsection 9.36.5. was developed assuming that a maximum of 20% of the floor area of the conditioned space of a building is not part of a dwelling unit. The accuracy of common computer simulation programs might suffer when larger common spaces are modeled. Common spaces are typically hallways, staircases and entrances, but can also include common living space, such as community kitchens or lounges.

Overall Thermal Transmittance and Effective Thermal Resistance

These two terms are defined in NBC Section 9.36. because they are used in a number of different ways in the relevant literature and regulations. The RSI value (effective thermal resistance) is the main metric used for characterizing building envelope assemblies and components in NBC Subsection 9.36.2., while the U-value (overall thermal transmittance) is used for this purpose in the National Energy Code of Canada for Buildings 2015 (NECB).

Fenestration

The term "fenestration" is defined because the simple trade-off method (NBC Article 9.36.2.11.) and the performance path (NBC Subsection 9.36.5.) introduce options that are based on the amount of fenestration in a building relative to the gross wall area. The term is also defined in the same way in the NECB.

9.36.1.3. Compliance and Application

This Article describes the various compliance options (prescriptive, performance and compliance with the NECB) available depending on the size of the building, and the occupancy being proposed for its use (Figure 9.36.-1).

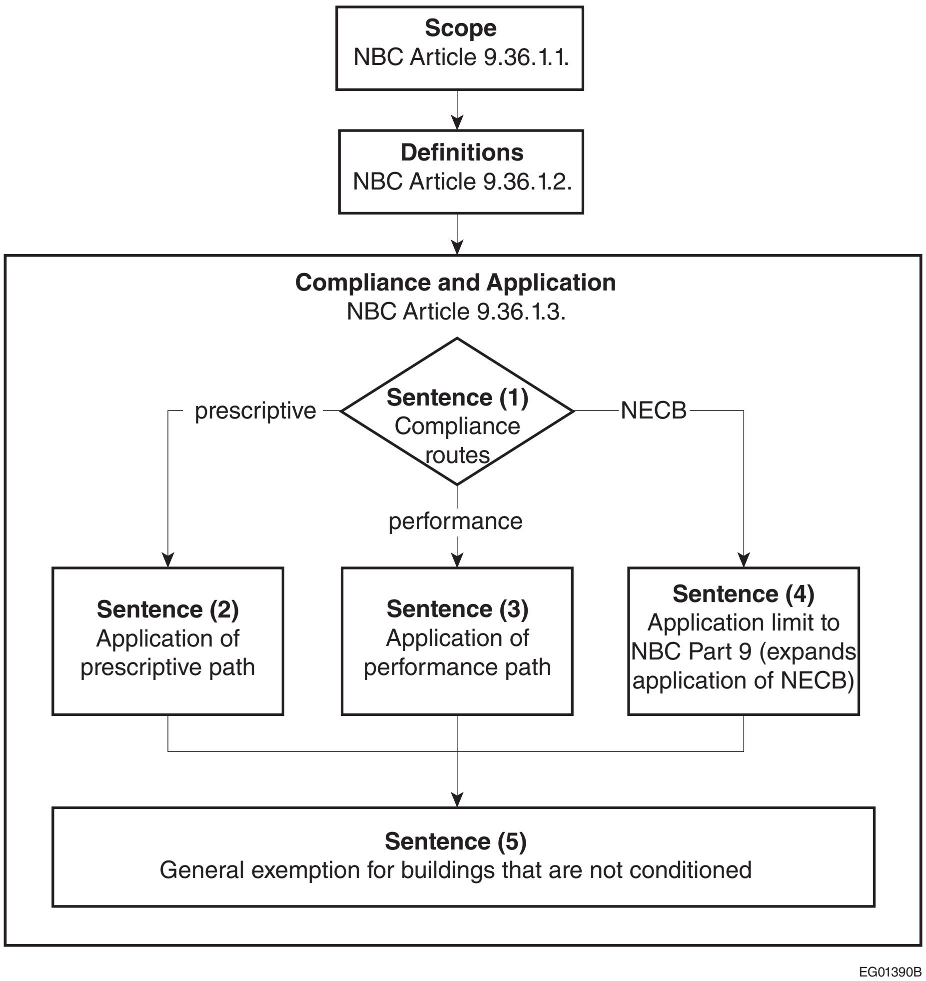


Figure 9.36.-1
Application of energy efficiency requirements in NBC Section 9.36.

The application of the performance path in NBC Subsection 9.36.5. is limited to houses, houses with secondary suites and multi-unit residential buildings. The maximum size of common spaces is also limited to 20% of the total floor area, because larger purely Part 9 residential buildings are known to use about 15% for hallways, staircases, vestibules, and other common spaces. The 20% limit is somewhat flexible, as the percentage of common space floor area per building area often increases with small to medium multi-unit residential spaces. Unheated garages, crawl spaces, vertical service shafts, and elevator shafts are not considered common spaces.

While the performance path is limited to Part 9 residential buildings, the prescriptive path (NBC Subsections 9.36.2. to 9.36.4.) applies to buildings of residential occupancy, to buildings containing business and personal services, mercantile or low-hazard industrial occupancies (Part 9 non-residential occupancies), as well as to buildings containing a mix of these two occupancy types.

The application of the prescriptive path also includes small, non-residential occupancies, which occupy no more than 300 m^2 (3 230 ft.^{2}) of floor area. Otherwise, these buildings would be required to comply with the NECB, including its lighting and electrical requirements. The 300 m^2 (3 230 ft.^{2}) size limit for non-residential spaces in any Part 9 building ensures that the energy use for lighting and electrical power remains sufficiently similar to the energy use for lighting and electrical power of dwelling units. This does not address medium-hazard industrial occupancies (F2), as such occupancies and their intended uses may have sufficiently different lighting and electrical use profiles. It is important to note that the 300 m² (3 230 ft.²) limit refers to floor area, while the 600 m² (6 500 ft.²) limit for the application of NBC Part 9 refers to building area. Both terms are defined in the NBC. A typical case that fits under this limit are live and work projects, where apartment units are situated over small business suites. This type of building is assumed to be sufficiently "house-like" so that the requirements of NBC Part 9 remain adequate.

9.36.2. Building Envelope

NBC Subsection 9.36.2. addresses the loss of energy due to heat transfer and air leakage through the building materials, components and assemblies, including their interfaces, forming part of a building envelope where it separates conditioned space from unconditioned space, the exterior air or the ground.

9.36.2.1. Scope and Application

This Article establishes the scope and limitations for the energy efficiency requirements of building envelopes. It also specifies that walls and floors between a conditioned space and a garage must always be airtight and insulated whether or not such a garage is heated because, even if a residential garage is kept unheated, it may nonetheless be equipped with space-heating equipment.

These requirements apply in conjunction and in addition to the requirements that pertain to the thermal characteristics in other Sections of NBC Part 9, such as NBC Sections 9.7. and 9.25. For example, building envelope designs using exterior insulating sheathing have to comply with NBC Table 9.25.5.2.

9.36.2.2. Determination of Thermal Characteristics of Materials, Components and Assemblies

This Article requires that consistent testing methods be used to determine the thermal characteristics of materials, components and assemblies. The measurement methods, and in some cases calculation methods, are those used to establish the material data provided in NBC Note A-9.36.2.4. Any new materials requiring evaluation must be tested using the same methods to ensure consistent R-values and U-values.

9.36.2.3. Calculation of Ceiling, Wall, Fenestration and Door Areas

This Article describes the rules for calculating the areas of walls and windows. The fenestration and door area to gross wall area ratio (FDWR) is needed to determine various application limits. For example, it is needed to determine whether or not one of the simple trade-off options described in NBC Article 9.36.2.11. is applicable. Another example is the application of the performance path, wherein the FDWR of the reference house depends on the calculation of the FDWR of the proposed house.

The procedure for calculating the areas of exterior walls and roofs are intended to be consistent with those for calculating the interior surface area of these same assemblies. This is important if the requirements for simulation tools, such as HOT2000—a tool requiring interior measurement and commonly used for the performance path—are to be consistent with those using exterior measurements.

9.36.2.4. Calculation of Effective Thermal Resistance of Assemblies

This Article contains the basic requirements and limitations pertaining to the calculation of thermal resistance and overall transmittance values.

The requirements for walls, ceilings and floors (above and below ground) are stated in effective thermal resistance values. The term "effective" refers to the comprehensiveness of the requirements, which take into account the contributions from all portions of an assembly, including the heat flow through the stud and through the insulation.

Guidance on the correct procedure for calculating the effective thermal resistance values is provided in NBC Note A-9.36.2.4. which also contains the thermal characteristics of common building materials and a few simple look-up tables to confirm the compliance of common constructions.

Additional information is provided in NRCan's tables for calculating the effective thermal resistance of opaque assemblies (www.nrcan.gc.ca/energy/efficiency/housing/new-homes/energy-star/14176). The CWC also has a free online calculator at www.EffectiveR.ca.

Minor penetrations, such as pipes or ducts, can be disregarded when calculating the thermal resistance of assemblies.

There is a 2% exemption based on gross wall area for major penetrations through any building envelope assembly. However, major structural penetrations, such as projecting slabs, constitute a significant portion of the 2% allowable exclusion. Where such large penetrations exist, calculation and analysis of the heat loss through these penetrations should be performed. Capturing the energy loss through construction featuring only occasional beams or joists is less critical to the overall energy performance of a building.

R-Values and U-Values

Requirements for opaque materials and assemblies are expressed in thermal resistance, or minimum effective thermal resistance values, which are referred to as “RSI.” RSI is measured in $(m^2{\cdot}K)/W$, and is defined as the reciprocal of the overall thermal transmittance (U or USI).

The requirements for windows and doors are expressed in maximum thermal transmittance or maximum Energy Rating values, while requirements for skylights are expressed only in U-values. U-values are referred to with the acronym “U,” and are measured in $W/(m^2{\cdot}K)$.

The term “R-value,” or the simple prefix “R,” should be understood to mean the imperial equivalent of the RSI. The imperial R is measured in $(h{\cdot}ft.^2{\cdot}°F)/Btu$ and can be converted into the metric RSI by dividing it by 5.678 (RSI = R/5.678). Where R is used in NBC Section 9.36., it is for information purposes only. The legally binding requirement is, in all cases, the metric RSI value.

The RSI values are calculated using the isothermal planes method, which is a simple addition to the resistance of each layer. In order for this to work for a framed assembly, the resistance of the frame/cavity portion needs to be established before it can be added to all the other material layers in the assembly. A number of calculation examples and look-up tables have been developed to assist builders, designers and officials in determining the RSI values of assemblies.

Climate Zones

The requirements for building envelope assemblies and components are defined by climate zone. The climate zones are determined according to heating degree-day (HDD) zones of 1 000 HDD, which are identical to the ranges and divisions used in the NBC, the NECB, and international standards related to energy efficiency in buildings.

Effect of Pressure-Equalized Rainscreen on the Thermal Resistance of Walls

It has been a known principle of building science for a long time that any thermal resistance outside of a vented air space cannot be counted when calculating the thermal resistance of an assembly, regardless of whether it is a wall or a roof assembly. This principle is well described in “Building Science for a Cold Climate.”[9] However, the thermal resistance of cladding systems installed without air space can certainly be counted.

During the development of the Model National Energy Code of Canada for Houses 1997 (MNECH), the air in the space behind brick veneer or other cladding systems on furring strips on low-rise buildings was considered sufficiently still, and therefore included in the thermal resistance calculations, such as in the calculation example for the steel-frame assembly in NBC Note A-9.36.2.4.(1). However, for roofing assemblies—a typical attic for example—the science did not support this approach at the time. This is why a footnote was added to NBC Table A-9.36.2.4.(1)-D, limiting the scope of the rule which states that the vented air spaces of roofing assemblies not be counted.

The difference in the thermal resistance value of an assembly could become quite significant depending on whether or not the cladding portion outside of a vented air space was counted. The issue is, therefore, currently being investigated by CCMC and NRC’s building envelope research group, especially as it pertains to EIFS cladding systems, which have the insulation outside the vented and drained air space. Essentially, if cladding systems are required to equalize the pressure behind them for the purpose of draining water (rainscreen principle), they would normally be considered as vented air space, irrespective of whether EIFS or brick veneer is installed in front of it.

(9) N.B. Hutcheon and G.O.P. Handegord, Building Science for a Cold Climate, National Research Council of Canada, Ottawa, 1983.

While this decision may have been made in 1997 for brick veneer, other cladding systems (such as EIFS) may not benefit in the same manner until new research information confirms the quantitative reduction of the thermal resistance of cladding and insulation installed outside of vented air spaces.

9.36.2.5. Continuity of Insulation

This Article addresses thermal bridging, provides the principles of continuous insulation at typical building junctions and details exemptions from these requirements (e.g., structural elements partly penetrating the plane of thermal resistance). The NBC does not require the insulation of every thermal bridge, but instead minimizes the effect of the most significant and most common building details that are known to create heat loss through thermal bridging.

The reason for requiring continuous insulation across entire assemblies is to ensure that the required assemblies in NBC Articles 9.36.2.6. and 9.36.2.8. perform consistently. As well, the requirements reflect assumptions made when considering the whole house energy performance in the performance path.

One exception to this requirement applies when the horizontal portion on top of a foundation wall that supports masonry veneer is permitted to interrupt the insulation. This is deemed acceptable because this construction method has certain advantages. It has a positive effect on the thermal mass storage through the interior surface of a foundation wall.

Another exception to this requirement applies when construction detail renders continuous insulation particularly difficult, and where the resulting installation offers nonetheless an acceptable performance (e.g., where an insulated floor meets a foundation wall insulated at the exterior).

Normally, overlapping insulation is avoided by a design that allows continuous insulation. Where it cannot be avoided, NBC Article 9.36.2.5. requires that such an overlap be situated where two planes of insulation are separated by an uninsulated assembly, such as a foundation wall.

The requirements for continuous insulation do not apply across the integral perimeter footing of a slab-on-grade because NBC Sentence 9.25.2.3.(5) specifically requires that this construction permit heat to flow to the footing, to keep the ground from freezing, where the footing is above the frost line.

Interrupted insulation in party walls between dwelling units is often the cause of heat loss and air leakage. NBC Article 9.36.2.5. deals only with the issue of heat loss. The continuity of the air barrier is addressed in NBC Article 9.36.2.10. The requirements in NBC Article 9.36.2.5. are intended to reduce the thermal bridging created by internal walls (often concrete or masonry) completely penetrating exterior insulated walls.

Masonry fireplaces and flues are known to introduce large surfaces that constitute one thermal bridge. The requirements address the minimum required insulation of masonry fireplaces and flues while allowing options to use masonry fireplace as an exterior design feature.

9.36.2.6. Thermal Characteristics of Above-ground Opaque Building Assemblies

This Article sets the minimum thermal characteristics of assemblies that are above-grade and do not come into contact with the ground. It also introduces a number of Notes and exceptions to these requirements. The Notes clarify which nominal insulation levels in various construction techniques meet the requirements for the effective thermal resistance of building envelope assemblies in various climate zones.

The approach to require minimum effective RSI values rather than individual nominal insulation levels based on each construction method was continued from the MNECH because there are many common wood and metal framing configurations, in addition to concrete and masonry based constructions. Each of these requires different nominal insulation values in order to achieve similar effective thermal resistances. In addition, the effective thermal resistance is the exact reciprocal of the U-value used in the NECB for all building envelope assemblies and components, which makes conversion from requirements in the NECB and in NBC Part 9 consistent and very simple.

The required RSI values for the selected assemblies were developed from values and assemblies in the MNECH and by considering the values in the NECB. A review of current practice as well as many provincial energy efficiency regulations led to the values required in this Article.

The required RSI values are provided in two separate tables, one specific to the use of a heat recovery ventilator (HRV), which represents considerable energy savings, and the other based on mechanical ventilation without heat recovery.

Distinct minimum RSI values for above-ground assemblies have been attributed to six climate zones in order to achieve a reasonable increase from current construction practice (R20 in 2 × 6 in. nominal (38 × 140 mm) framing at 16 in. (400 mm) on centre). Each of these has been determined in light of common framing sizes (2 × 6 in. nominal (38 × 140 mm) and 2 × 4 in. nominal (38 × 89 mm) at common spacings of 16 in. (400 mm), 19.2 in. (488 mm) and 24 in. (600 mm) on centre).

NBC Sentence 9.36.2.6.(3) explicitly addresses the attic insulation level at the perimeter under sloped roofs where it is not as easy to insulate as effectively as at the centre of the attic without incurring the considerable cost of raising the truss heel or changing the pitch of the roof. The required values for the two criteria (1 200 mm (48 in.) and nominal RSI 3.52 (R20) at the eaves) have been determined carefully, and are intended to include constructions with the most common roof slopes and insulation types. For low-sloped roofs, the simple trade-off path (NBC Article 9.36.2.11.) provides some flexibility.

NBC Sentence 9.36.2.6.(3) does not address the difference in energy performance caused by different roof shapes and attic geometries, which can significantly impact the overall insulation value.

NBC Sentence 9.36.2.6.(4) clarifies that shafts for skylights are to be treated as above-grade walls and not as a continuation of the ceiling below the attic space. This effectively permits the construction of skylight shafts.

9.36.2.7. Thermal Characteristics of Fenestration, Doors and Skylights

This Article sets the required thermal characteristics of fenestration, doors and skylights, including access hatches and vehicular access (garage) doors. A number of Notes discuss the construction features of windows and doors that typically achieve the required values and explain the concept of Energy Ratings. This Article also contains the requirements for site-built windows and doors for which U-values and Energy Ratings are not available.

Because the energy performance of windows, doors and skylights is critical to energy-efficient construction, the thermal characteristics of these fenestration components have been set relatively high.

NBC Section 9.36. does not establish a maximum amount of fenestration per wall, which is common in other building energy regulations. Instead, NBC Article 9.36.2.7. sets the maximum, fairly stringent values for fenestration components, which are in line with the 2010 ENERGY STAR requirements.

The required minimum U-values assume moderate solar gain for each window and glazed door, a mix of picture and sash windows, which have different energy performance, and fenestration area to gross wall area ratios ranging between 8% and 25%.

An exception for one entrance door allows the inclusion of decorative or historic entrance doors without considerable difficulty, while a prescriptive solution for site-built windows recognizes that it is onerous and costly to test site-built, custom windows in a laboratory.

9.36.2.8. Thermal Characteristics of Building Assemblies Below-Grade or in Contact with the Ground

This Article sets the minimum thermal characteristics for below-grade assemblies, and introduces a number of exceptions to these requirements. NBC Note A-9.36.2.8.(1) provides tables of common insulation products used in various construction techniques that meet the requirements for the effective thermal resistance of building envelope assemblies.

The requirements in this Article and the tables in NBC Note A-9.36.2.8.(1) were developed using the same process and considerations as those in NBC Article 9.36.2.6.

Specific minimum RSI values for below-ground assemblies have been attributed to six climate zones in order to achieve reasonable increase from current construction practice (R12 on the interior – full height). Each of these were determined in light of common framing sizes 2 × 6 (38 × 140 mm) and 2 × 4 in. nominal (38 × 89 mm) at common spacing of 24 in. (600 mm) on centre).

The above-ground portion of a foundation wall can be insulated to the reduced levels of the foundation wall rather than having to comply with the more stringent level required for above-grade walls. This relaxation applies where the top of a foundation wall is less than 600 mm (24 in.) on average per wall above the adjoining ground level.

Generally, insulation under heated floors is only required on the perimeter along the outside wall for about 1 200 mm (48 in.) inwards, and where only portions of floors are heated, because the full insulation of normal basement slabs was determined to be more costly than savings achieved through installation of insulation under the slab over the lifetime of the building.

Slabs do not have to be insulated at the perimeter, where the foundation wall insulation is placed on the outside and extends down to the level of the bottom of the floor. This arrangement achieves acceptable performance and is far cheaper.

According to building science principles, below-ground assemblies are generally less insulated than above-ground assemblies because of the more moderate expected temperature differences from the ground to the interior (ΔT = 15°C (59°F)) as compared to the expected temperature differences between the outside air and the interior (ΔT = 50°C (122°F)). Because under-slab insulation is exposed to even smaller temperature differences, the required insulation levels are less than those for below-ground walls, unless the slabs are heated.

NBC Article 9.36.2.8. uses the expression "slab-on-grade with an integral footing" where the slab is the loadbearing element. This construction requires a structural design that conforms to NBC Part 4, but its required insulation values are provided in NBC Section 9.36.

9.36.2.9. Airtightness

Air leakage has a significant impact on the energy performance of housing and small buildings, and is a major source of heat loss. This Article provides the requirements that are intended to limit the unwanted air leakage from heated houses or buildings. These requirements apply in addition to the minimum requirements already addressed in NBC Section 9.25.

Compliance through Testing

Rather than following the prescriptive requirements in NBC Article 9.36.2.10., compliance can also be demonstrated by installing an air barrier assembly that qualifies under CAN/ULC-S742, "Air Barrier Assemblies – Specification." Such an air barrier assembly would need to be connected with adjacent assemblies according to the manufacturer's instructions. The test report for the air barrier assembly should be accompanied by specific instructions as to the construction of the joints and junctions between adjacent assemblies which make up the continuous air barrier system.

Another testing option exists through ASTM E 2357, "Determining Air Leakage of Air Barrier Assemblies." While this testing option also deals with assemblies, the primary air barrier material is not required to comply with CAN/ULC-S741, "Air Barrier Materials – Specification." This option was primarily intended for traditional construction methods that are known to perform and be durable, such as a concrete block wall construction finished with two coats of paint. This testing option is only to be used where the air barrier is installed on the warm side of the thermal insulation of the opaque building assembly (and is protected from UV exposure and temperature variations) and where the building will not be subjected to sustained wind loads calculated based on a 1-in-50 hourly wind pressure exceeding 0.65 kPa (14 psf).

9.36.2.10. Construction of Air Barrier Details

This Article requires airtight construction of typical junctions, joints and penetrations that are known to cause air leakage. These requirements are similar in nature to those in NBC Subsection 9.25.3., but are provided in this Article in more detail.

The difference between the requirements in NBC Subsection 9.25.3. and NBC Section 9.36. is that the minimum requirements in Subsection 9.25.3. are intended to ensure that buildings are healthy and safe, and that they are free from mould and protected from premature deterioration, which may result from a lack of airtightness. The requirements that pertain to energy efficiency in NBC Articles 9.36.2.9. and 9.36.2.10. are intended to achieve a higher level of performance. More attention to detail is necessary to close all the joints, junctions and penetrations that can occur in a building.

There are a number of approaches to seal a building from air leakage. The requirements are worded to allow most, if not all approaches to be used. Sometimes a mix of approaches is necessary to succeed.

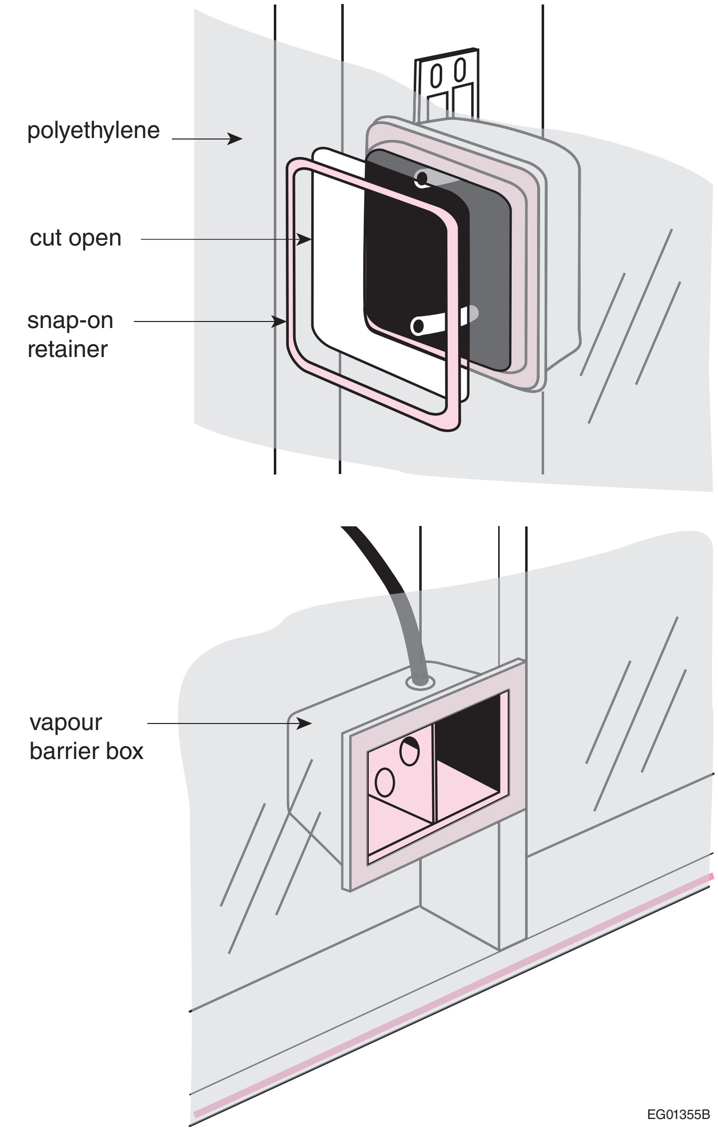


Figure 9.36.-2
Electrical boxes – surrounds or plastic outlet boxes

Electrical Boxes – Surrounds or Plastic Outlet Boxes

For example, rigid polyethylene surrounds work well with conventional metal outlet boxes while plastic airtight outlet boxes can replace conventional metal boxes. Plastic outlet boxes are often the same size as metal boxes, but provide greater airtightness using conventional installation practices (Figure 9.36.-2).

The entrance of the wire should be sealed in either case, and the wall air barrier material should be sealed to the box (or the surround). Some plastic outlet boxes come with a snap-on retainer provided by the manufacturer for this purpose.

Continuity at the Joints of Assemblies

Continuity of the air barrier using the airtight-drywall approach can be maintained at the header by installing sealant or gaskets (Figures 9.36.-3 and 9.36.-4).

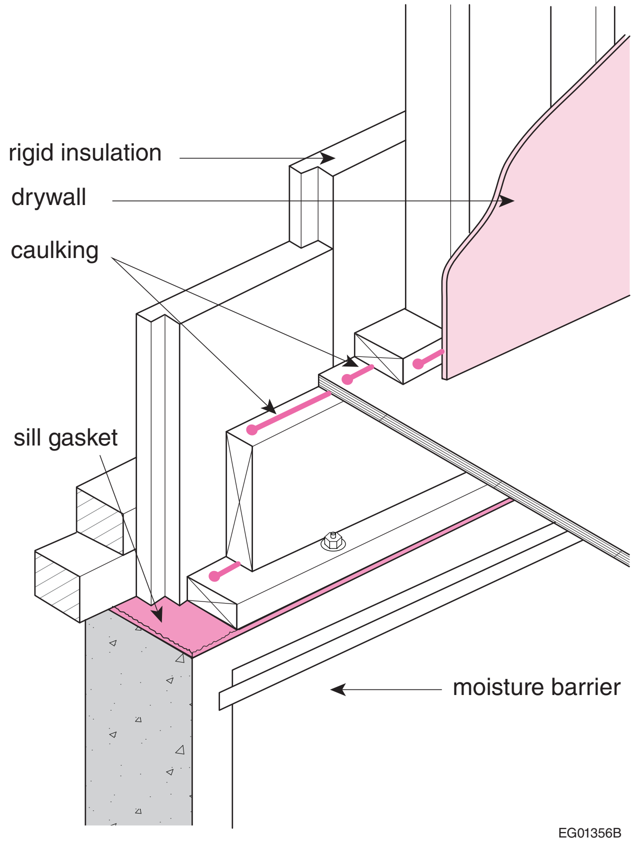


Figure 9.36.-3
Continuity at the joints of assemblies – airtight drywall approach

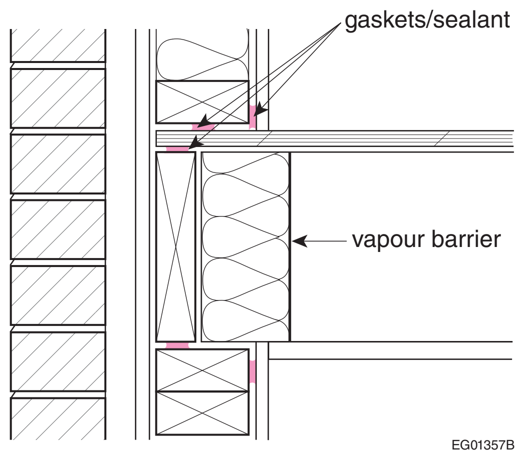


Figure 9.36.-4
Continuity of air barrier maintained by sealant or gaskets

In the polyethylene approach, maintaining the arrangement of materials in a frame wall through the header area is complicated by the need to install structurally supported polyethylene between floor joists. For this reason, the approach using polyethylene should switch from the vapour-tight interior polyethylene approach to the approach using a vapour permeable air barrier material (house wrap) at the exterior of the header and continue the vapour-tight polyethylene on the interior side of the header assembly (Figure 9.36.-5).

Where exterior sheathing is the airtight element, the sheathing must be sealed to the foundation wall.

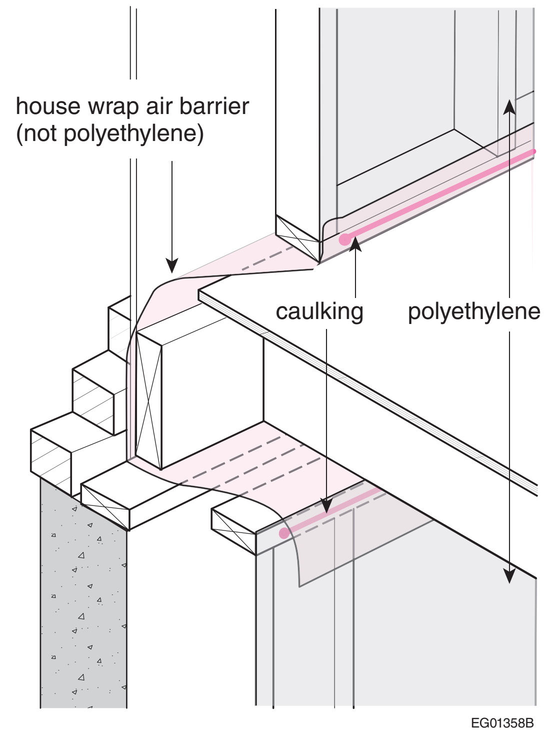


Figure 9.36.-5
Continuity at the joints of assemblies – polyethylene approach

Airtightness at Cantilevered Floors

The air sealing of cantilevered floors includes several junctions:

- from the wall above to the rim joist,
- from the rim joist to the floor, and
- from the floor to the wall below.

For each of the assemblies there are a number of possible elements that may fulfill the function of the air barrier. For example, the airtight element of the cantilevered floor could be the subfloor, the ceiling finish below (such as in the garage), or spray foam between the joists.

For the wall above and below, it could be the interior finish or exterior sheathing, or the sheet air barrier material or spray foam. The construction of a continuous air barrier around a cantilevered floor, therefore, needs to be carefully considered.

Interior Wall Details

This junction is not critical where the plane of airtightness is on the exterior of the building envelope. One method is to allow the air barrier/drywall to pass between the interior and exterior walls and remain continuous. In this case, either adequate clearance needs to be provided to allow the drywall to be slipped between the interior and exterior wall framing, or the exterior walls need to be finished with drywall and air barrier prior to framing the interior intersecting walls (Figure 9.36.-6).

Another way to provide continuity behind interior walls is to provide blocking so that the drywall or air barrier material can be sealed to a backing.

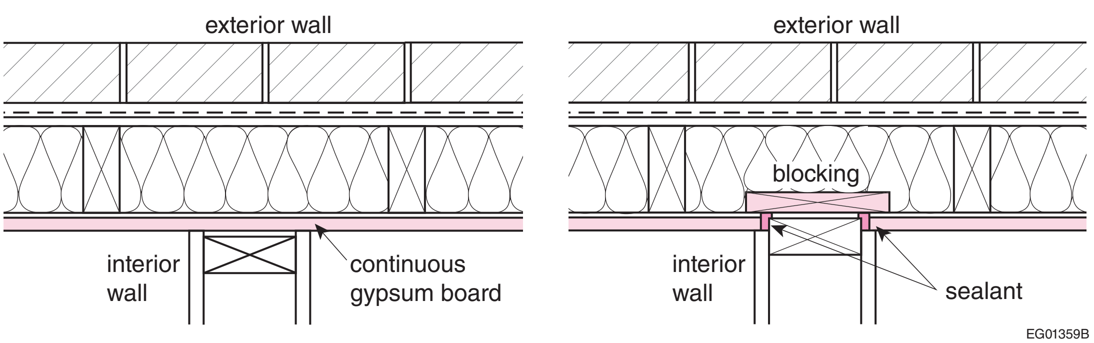


Figure 9.36.-6
Interior wall details

Knee Wall

Knee walls in the attic are a special case of interior walls. Where the air barrier approach relies on an interior air barrier (often the drywall or polyethylene sheet), continuity needs to be created from the ceiling finish below the knee wall across the joist space to the interior finish of the knee wall. This can be achieved by lumber or rigid foam blocking and sealing any gaps, or by sealing the entire cavity with a suitable thickness of spray foam (Figure 9.36.-7).

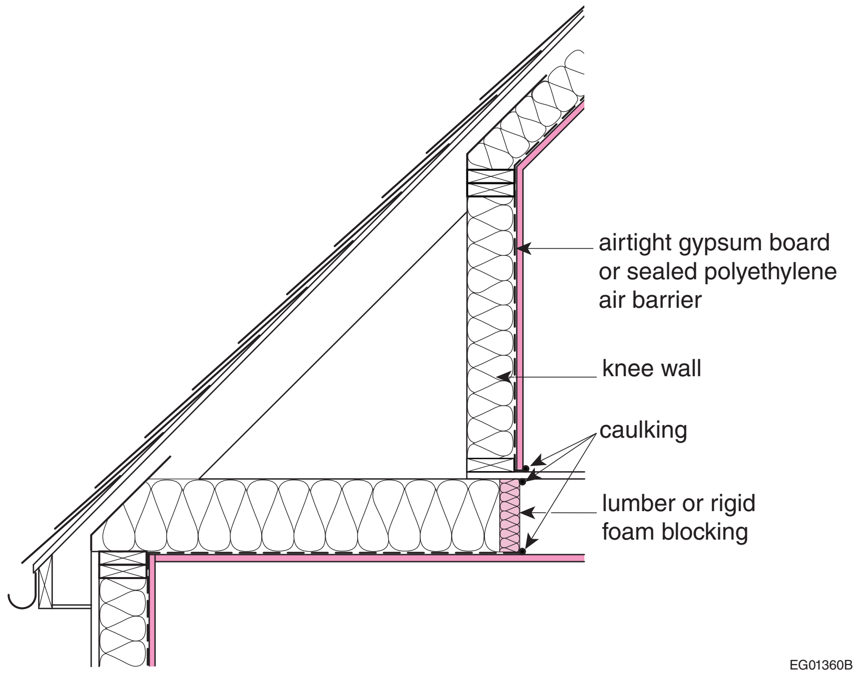


Figure 9.36.-7
Air barrier continuity at knee wall

Chimney Air Barrier Detailing

Zero clearance units allow the unit and flue to be installed inside the building envelope without compromising the integrity of the air barrier system in the walls. The sole detailing concern is the penetration through the airtight element in the ceiling.

Where exterior walls and ceilings are intersected by masonry chimneys or fireplaces, the continuity of the air barrier system is broken, and as a result requires careful detailing and construction (Figures 9.36.-8 and 9.36.-9).

For both zero-clearance and masonry fireplaces, the construction must comply with fire safety requirements in the NBC, allowing adequate clearance from combustible materials (see NBC Sections 9.21. and 9.22.).

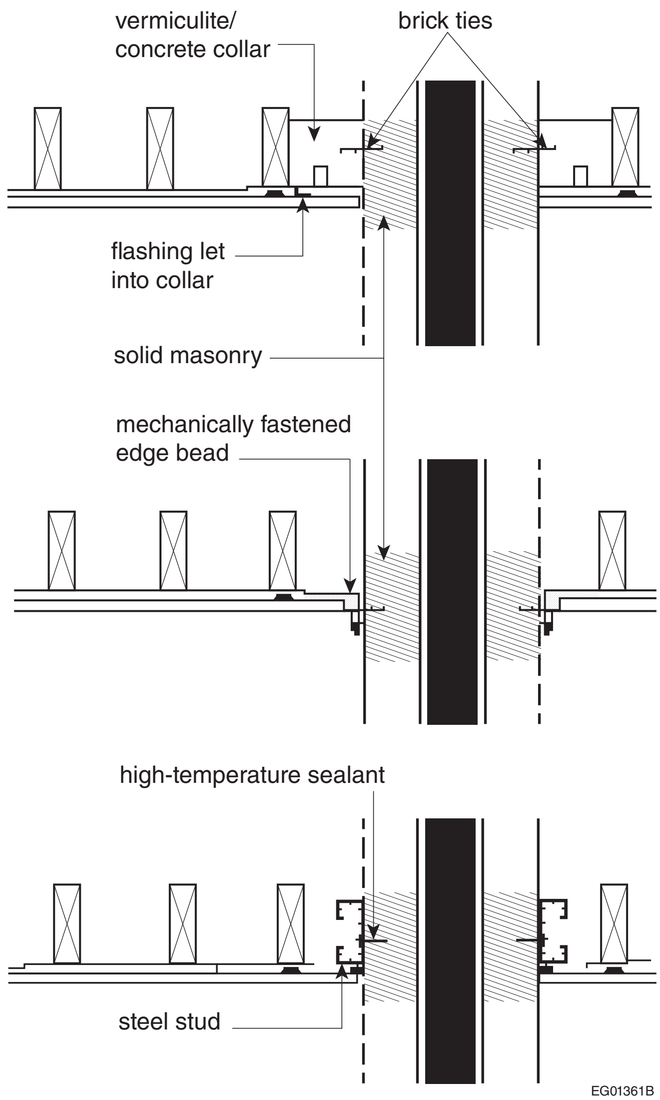


Figure 9.36.-8
Chimney air barrier detailing

Sealing Duct Penetrations

NBC Article 9.32.3.11. already requires that the joints in all ventilation system ducting be sealed with mastic, metal foil duct tape or the manufacturer's specified sealants.

NBC Sentence 9.36.2.10.(14) requires that any penetrations made by ducts through ceilings or walls be sealed with appropriate sealant materials and techniques. Mechanical fastening of the duct at the penetration may further reduce the likelihood of air leakage through the penetration.

Plumbing Vent Stack Pipes

Plumbing vent stack pipes must be sealed where they penetrate the wall top plates.

The air sealing approach for plumbing vent stack pipes should take into consideration shrinking and expansion at the sealant location. Where clearances from the vent stack pipe to the top plate are small, a flexible caulking can bridge the gap. More frequently, the penetration is larger and a plywood collar would be required to span the gaps and provide backing for any sealant.

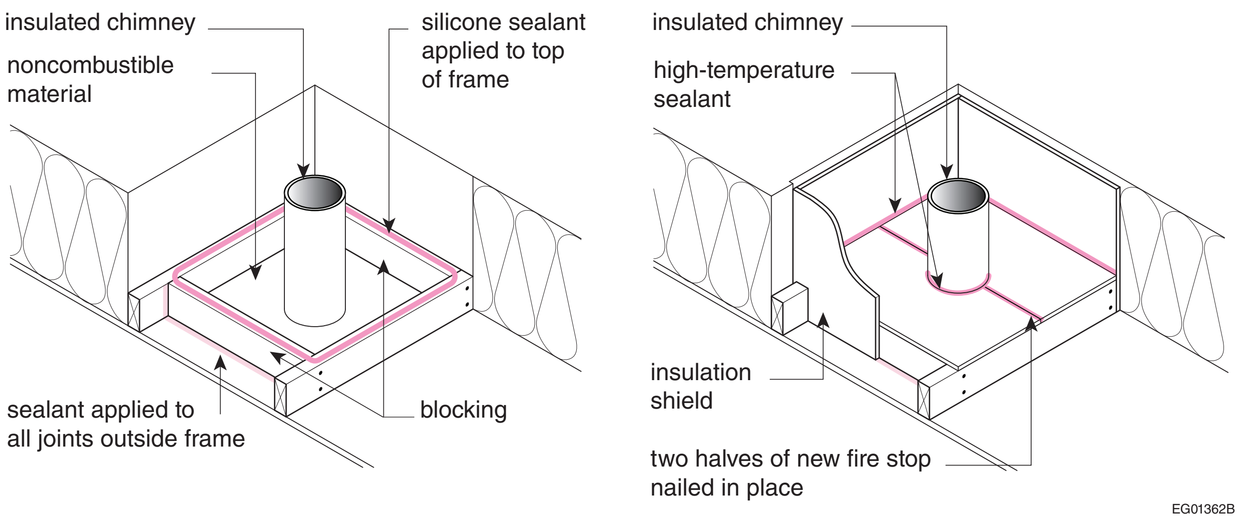


Figure 9.36.-9
Chimney air barrier detailing

A neoprene rubber gasket or roof jack, sealed and mechanically fastened to the top plate can also be used to provide a flexible air seal, accommodating movement in the vent stack pipe (Figure 9.36.-10).

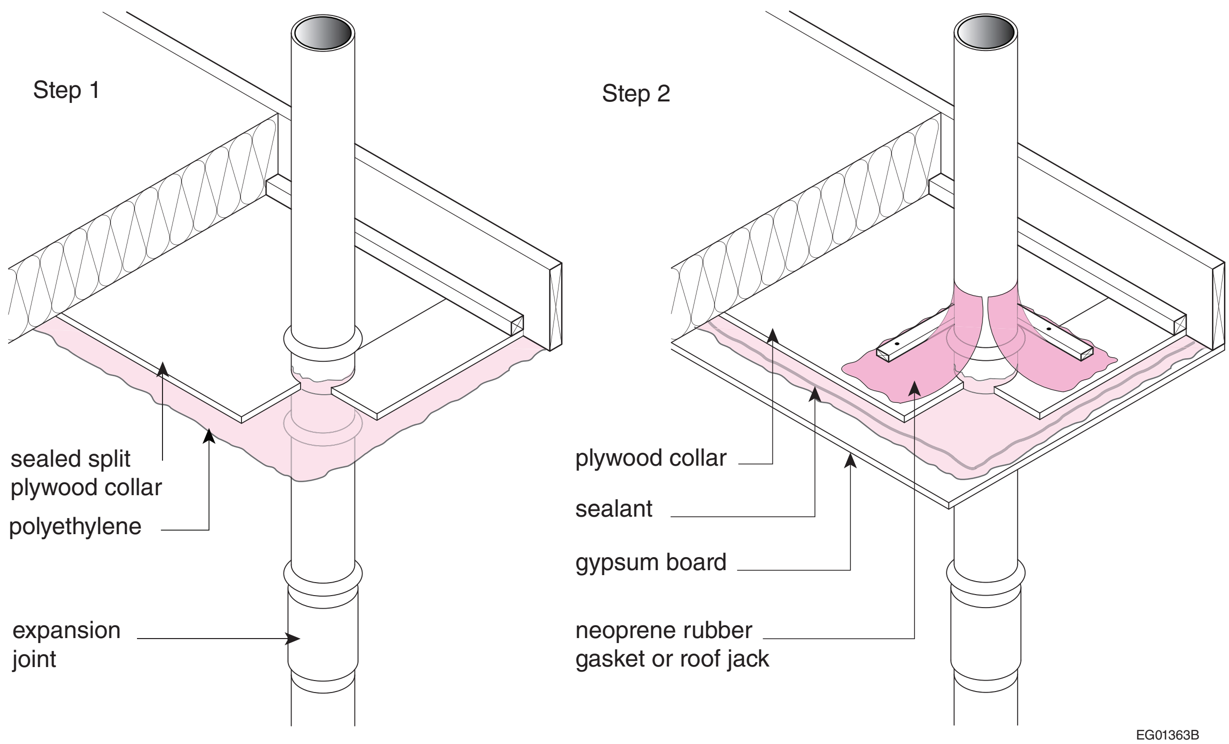


Figure 9.36.-10
Plumbing vent stack pipes

Party Wall Airtightness

While an assembly that separates conditioned space from unconditioned space requires an air barrier system (NBC Subsection 9.25.3.), an air barrier is not required for party walls. In addition, the construction of party walls often creates hollow spaces within it and spans from the basement to the uppermost storey creating a chimney effect drawing air from adjacent spaces.

Therefore, it is extremely important to seal any penetration through the party wall and every penetration that may be created by junctions of the party wall with intersecting floors or walls. Any reduction of air flow within the party wall, which may result from introducing blocking or foam sealant at every storey, will also reduce the air leakage (Figure 9.36.-11).

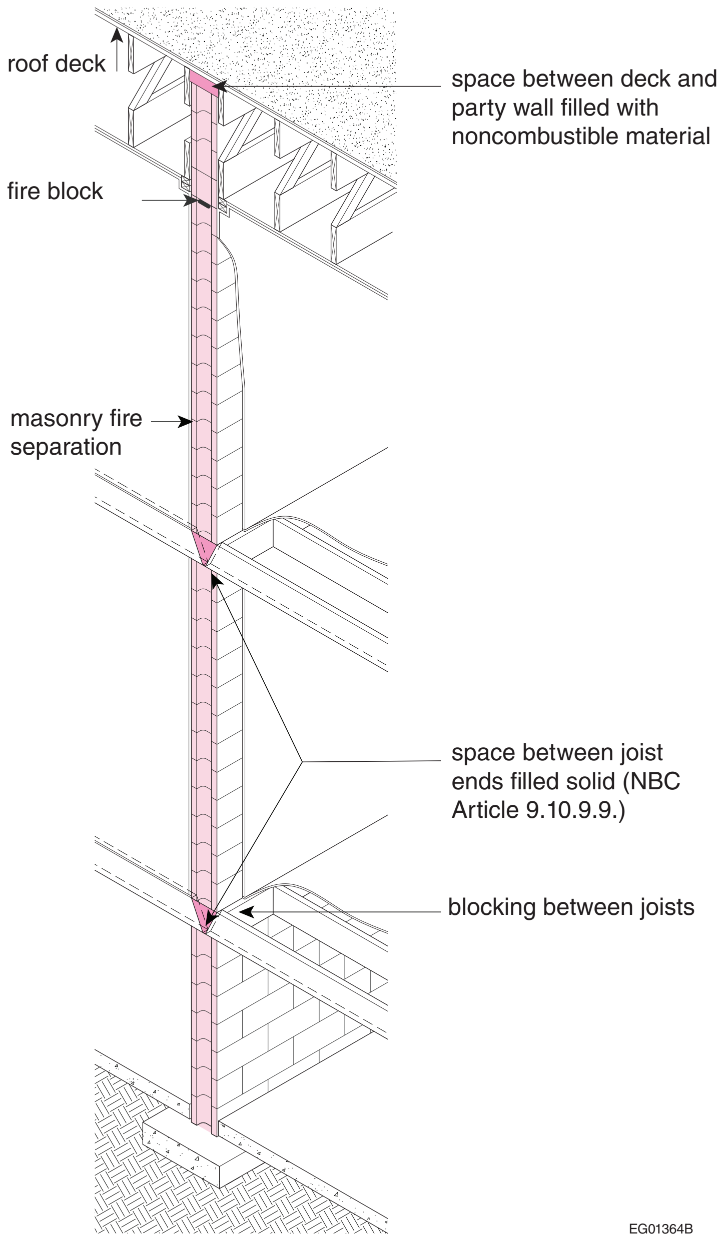


Figure 9.36.-11
Party wall airtightness

Air Sealing the Top of an Insulating Concrete Form Wall

Many insulating concrete form (ICF) walls use concrete as the plane of airtightness. In this case, where the top of an ICF wall meets a ceiling with an interior air barrier, the air barrier of the ceiling must be sealed to the concrete within the ICF wall in order to maintain continuity. Sealing it to the foam alone is not sufficient.

9.36.2.11. Trade-off Options for Above-ground Building Envelope Components and Assemblies

This Article contains three simple trade-off options to afford some flexibility in the construction and design of energy-efficient features in the building envelope. These methods permit builders/designers to reduce the effective thermal resistance of one or more assemblies below the minimum requirements, as long as the equivalent of the total area and required effective thermal resistance for that assembly are provided elsewhere. The simple trade-off methods only apply to above-ground assemblies and have strict limitations.

Trading Performance of Opaque Areas

This Article contains a trade-off option that applies where a designer wants to reduce the R-value of one building envelope area by increasing the R-value of another area to achieve the same total energy loss through the combined total area. The sum of the areas of each of the traded (reduced and increased) components must remain the same. There are limits on by how much a thermal resistance value can be reduced.

Trading Window Performance

This Article contains a trade-off option that applies where a designer wants to increase the U-value of one or more windows but reduce the U-value of others to achieve the same total energy loss through the combined total area of all windows. The sum of the areas of all traded (reduced and increased) components must remain the same. The U-values or Energy Ratings for windows, doors or skylights must be converted into R-values first. Conversion formulas are provided. This method is limited to the trading of windows in the same geographic orientation.

Trading Window Area for Reduced Attic Insulation

This Article contains a simple trade-off option for single-section factory-constructed buildings that are subject to transportation height limitations. The trade-off is provided to avoid unnecessary performance modeling costs. This method is limited to lower ceiling heights and lower FDWRs that are typical for factory-constructed buildings. The option is unlikely to be applied to site-constructed buildings or to factory-constructed buildings that are not subject to stringent transportation height restrictions because low ceilings are not the preferred choice, and the cost of cutting framing and interior finish panel products to size would exceed the cost of meeting the prescriptive attic and floor insulation levels.

The method is limited to houses with a FDWR of less than 15%, which use less energy due to fewer windows compared with the reference FDWR of 17%. The heat loss saved by reduced area of windows creates an energy credit, which can then be traded against specific reduction in RSI value in the attic where, due to often typical low roof slope, it is impossible to install the required insulation level.

9.36.3. HVAC Requirements

9.36.3.1. Scope and Application

This Article establishes the scope and limitations for the requirements on energy-efficient heating, ventilating and air-conditioning equipment, as well as its related components and systems. NBC Subsection 9.36.3. addresses the efficient use of energy by HVAC systems.

The requirements apply to typical HVAC systems that are found in houses and some small Part 9 non-residential buildings. Any building that uses HVAC systems or equipment that is not addressed within NBC Subsection 9.36.3. must be designed and constructed in accordance with the energy efficiency requirements of the NECB.

9.36.3.2. Equipment and Ducts

This Article cross-references NBC Sections 9.32. and 9.33. for the sizing of HVAC equipment and the design and installation of ducts. It requires that HVAC systems serving single dwelling units be sized in accordance with CSA F280, "Determining the Required Capacity of Residential Space Heating and Cooling Appliances."

The level of sealing that ducts require is equivalent to SMACNA's Class A sealing, which is the sealing of all joints. The materials listed are the acceptable means of sealing the joints. Fabric-backed tapes with rubber adhesives are not to be used as recommended by SMACNA. The sealing and insulating of the ducts is to minimize condensation, which affects the efficiency and durability of the equipment, as well as the health of the occupants.

The alternate requirements for insulation on ducts installed under floors and over unheated spaces is applicable to certain cases where, due to the limited space or transportation limitations set on single-section factory-constructed houses, it may not be possible to cover the ducts with insulation equivalent to the levels of the exterior walls. The alternate requirements allow for the insulation on the underside of ducts to be reduced and the insulation on the sides to be increased. The resulting performance is expected to be the same.

NBC Table A-9.36.3.2.(5) provides users with a selection of insulation values needed on the sides of ducts based on the RSI requirements for the exterior walls, the underside insulation level and the width of the duct.

9.36.3.3. Air Intake and Outlet Dampers

This Article describes when a damper is required to reduce the uncontrolled ingress of cold outside air from entering the building, which reduces the energy that would be required to heat the cold air. NBC Sentence 9.36.3.3.(1) applies to exhaust fan openings and exhaust vents from naturally vented appliances. NBC Sentence 9.36.3.3.(2) applies to all air intake openings where the appliance is not intended to run continuously.

The term "damper" is not intended to include flow-regulating or balancing dampers. The Article contains exceptions from the requirements where

- other regulations do not permit dampers,
- the climate is so mild that the energy loss is negligible, and
- HRVs are installed.

9.36.3.4. Piping for Heating and Cooling Systems

This Article cross-references NBC Subsection 9.33.8. for the design and installation of piping for heating and cooling systems.

This Article also specifies the location of pipes and requires that pipes which are installed outside the plane of insulation be adequately insulated, reducing the amount of energy that is needed to condition the pipes.

9.36.3.5. Equipment for Heating and Air-conditioning Systems

This Article requires that all equipment be installed in a conditioned space unless it is specifically designed for unconditioned spaces by the manufacturer. An example of this would be typical air-conditioning units for houses.

9.36.3.6. Temperature Controls

This Article requires that thermostats for electric heaters have a certain level of performance, and that simultaneous heating and cooling be prevented.

NBC Sentence 9.36.3.6.(1) requires that a thermostat activate the heating system when the temperature of the zone drops by at least 0.5°C (0.9°F) while in heating mode. This is intended to prevent overheating.

NBC Sentence 9.36.3.6.(4) prevents the cooling system from activating when the temperature set-point is lowered during the heating mode. It also prevents the heating system from activating when the temperature set-point is raised during the cooling mode. This allows the temperature of the zone to adjust naturally until the set-point temperature is reached.

NBC Sentence 9.36.3.6.(5) requires that the heating of each zone be adjusted by independent dampers, valves or switches. An example of this could be a damper on a floor register that can be closed to reduce the amount of heat entering the room, without affecting other parts of the house that may require more heat.

NBC Sentences 9.36.3.6.(6) and (7) apply to controls for heat pump systems. The controls are intended to ensure that there is no excess use of energy by supplementary heating systems when the heat they produce is not required.

9.36.3.7. Humidification

This Article requires humidification devices that are part of an HVAC system to be equipped with an automatic control device to maintain the humidity levels in the space.

9.36.3.8. Heat Recovery from Dehumidification in Spaces with an Indoor Pool or Hot Tub

This Article addresses heat loss in hot tubs and sets requirements where heat recovery ventilation is used as a means for the dehumidification of indoor pool areas.

9.36.3.9. Heat Recovery from Ventilation Systems

Even though HRVs are not mandatory in the NBC, this Article adds efficiency requirements for such equipment where it is installed. There is a large variety of HRVs on the market, with a wide spectrum of efficiencies. This Article sets out testing requirements in light of the exterior temperature at the building location. The testing requirements cover a large number of HRVs already on the market.

9.36.3.10. Equipment Efficiency

This Article provides a table with the proposed minimum efficiency values for various types of heating and cooling equipment that are typically installed in housing and small buildings, along with the appropriate performance standards to which the equipment must conform.

Other than federal, provincial and territorial energy efficiency acts and regulations, which only address the type of equipment that can be traded across international, provincial and territorial borders, there is no listing of minimum efficiency values for typical equipment.

The table shows various types of equipment with different capacities. The values and ratings were chosen based on equipment and related minimum efficiencies found in the MNECH, the NECB, other energy efficiency acts and regulations, and the applicable standards for typical equipment in housing and small buildings. In some cases, after a review of current industry practices (industry sales figures), the proposed efficiency ratings were increased where it could be shown that the cost and availability of the equipment were acceptable. Some of the required efficiency ratings are based on anticipated efficiency improvements in the energy efficiency acts and regulations and revisions to standards.

The table lists the most common types of equipment. It will therefore be up to the authority having jurisdiction to decide under which conditions unlisted equipment may be used. Minimum values set out in the energy efficiency acts and regulations govern and were the values in these acts and regulations to change in mid-Code cycle, those new values would take precedence.

Unit and packaged equipment, such as combination and integrated mechanical systems are typically comprised of several different pieces of smaller equipment. The efficiency of the whole unit may therefore be based on each of the individual component efficiencies as provided by the component manufacturer.

Natural gas and propane fireplaces or stoves are currently not listed with minimum performance requirements in the table. The standard according to which these types of equipment are tested is currently under revision to update test procedures for performance measures and to define what is considered a decorative piece of equipment. The general understanding is that if this decorative equipment is used, the principal heating source may not have to operate as frequently. However, being classified as decorative should not mean that the equipment can be so inefficient that it may end up using more energy than the principal equipment. The Article, therefore, requires that all gas and propane fireplaces or stoves must be direct-vent (sealed) and cannot have a standing pilot light.

9.36.3.11. Solar Thermal Systems

The NBC is silent on the use of renewable energy technologies; its requirements do not give credit where solar thermal equipment is used, and do not also create a barrier to its use.

As the use of renewable energy technologies becomes more popular and installation or performance standards become available, these standards could be listed within the prescriptive path as an acceptable solution.

The current NPC addresses solar thermal equipment and lists the appropriate standards for their installation. As the review of updated standards is ongoing, referring to the NPC eliminates duplicating the review of the updated standards.

9.36.4. Service Water Heating Systems

NBC Subsection 9.36.4. addresses the selection and installation of service water heating systems and the efficient use of energy by service water heating systems.

9.36.4.1. Scope and Application

This Article establishes the scope and limitations for the requirements pertaining to energy-efficient service water heating equipment and related components and systems.

The requirements apply to service water heating systems that are typically installed in houses and small Part 9 buildings. Any building that employs service water heating systems or equipment that is not addressed within NBC Subsection 9.36.3. must be designed and constructed in accordance with the energy efficiency requirements of the NECB.

9.36.4.2. Equipment Efficiency

This Article provides a table with the proposed minimum efficiency values for various types of service water heating equipment that are typically installed in housing and small buildings, along with the appropriate performance standards to which the equipment must conform.

Further information on the development of the ratings is provided in Guide 9.36.3.10., Equipment Efficiency.

9.36.4.3. Solar Domestic Hot Water Systems

This Article addresses the installation of solar domestic hot water systems by referencing the NPC and requires that storage tanks be installed in a conditioned space.

Further information on how solar domestic hot water systems are addressed by the NBC are provided in Guide 9.36.3.11., Solar Thermal Systems.

9.36.4.4. Piping

This Article provides the requirements for the energy-efficient construction and design of piping for service water heating systems. Covering the first 2 m (6 ft. 7 in.) of outlet piping with insulation provides a simple method to reduce the heat loss through the pipes, which results in decreasing the amount of energy required to heat the water. The Article also includes minimum insulation requirements for recirculation lines.

The requirements target periods of standby, where the water is not being used, and a substantial amount of heat loss from the pipes occurs directly adjacent to the tank. Insulating this portion of the pipes can reduce the heat loss at these locations.

9.36.4.5. Controls

This Article requires that a hot water tank have a temperature control device that allows the user to adjust the temperature of the hot water as desired, within the acceptable health and safety range.

9.36.4.6. Indoor Swimming Pool Equipment Controls

This Article requires a means to automatically or manually switch off swimming pool pumps or heaters when their operation is not required. This saves the energy that would have been used to heat the water or run the pump to circulate the water. It may be necessary to operate the pump in order to filter the water enough to prevent the build-up of harmful bacteria and algae or to prevent the temperature of the water to drop too low. Manufacturers' requirements for pump use should be followed.

9.36.5. Energy Performance Compliance

The performance compliance path follows the concept of establishing the energy performance of houses by comparing a proposed house to a reference house that is assumed to be built according to prescriptive code requirements. This performance compliance approach is consistent with the objective-based code approach of demonstrating a similar performance level regardless of the path used. The same concept is used for the performance path for buildings in the NECB.

9.36.5.1. Scope and Application

This Article links the application of NBC Subsection 9.36.5. to the application of the prescriptive requirements described in NBC Subsection 9.36.1., and limits the scope for the performance path option to houses, houses with secondary suites, and buildings that contain only dwelling units and common spaces where the common spaces occupy no more than 20% of the total floor area of the building.

The reason for permitting only buildings of purely residential occupancy to be modeled is that the models currently on the market may not be able to deal with non-residential occupancies adequately. Likewise, it is not known how well energy modeling software for larger non-residential buildings performs when modeling small buildings.

In addition, the loads and equipment used in dwelling units are well understood, and are less variable and more energy-efficient. Therefore, they can be calculated with acceptable accuracy. Similarly, simple common spaces such as hallways and vestibules typically have no special equipment or highly variable loads, and their energy use can also be calculated with acceptable accuracy.

Larger purely Part 9 residential buildings are known to use about 15% of the total floor area for hallways, staircases, vestibules and other small supporting common spaces. Placing a 20% limit on common spaces allows a margin to ensure smaller multi-unit residential buildings are not restricted from using the performance path.

9.36.5.2. Definitions

NBC Article 9.36.5.2. defines a number of terms used throughout NBC Subsection 9.36.5. The reason for defining the terms "reference house," "house energy target," "principal ventilation rate," and "annual energy consumption" is that they have no dictionary definitions and because the common meaning of these terms may be inappropriate to their use in NBC Subsection 9.36.5. Such a misunderstanding could make the requirements, in which these terms appear, difficult to enforce, as well as make for inconsistent energy use calculations for houses and buildings.

The term "house" is used in this Article and throughout NBC Subsection 9.36.5. intentionally. It is meant to include residential buildings, in contradiction to the term "building," given the relation of the latter with the terms "building energy target," "reference building," and "proposed building," which are used to refer to much larger buildings in the NECB.

The term "principal ventilation rate" was defined as the rate established in NBC Article 9.32.3.3. because Article 9.32.3.3. and CAN/CSA-F326-M, "Residential Mechanical Ventilation Systems," are acceptable solutions for the provision of ventilation in NBC Section 9.32. despite their slight differences. It was necessary to select one of the two as the reference method.

9.36.5.3. Compliance

This Article establishes the requirements to which the energy performance calculation procedure must conform.

The performance path compares the simulated energy used by a proposed house design to the energy used by a reference house that is identical to the proposed house, but designed to meet the prescriptive provisions of the NBC. If the simulation shows that the proposed house uses the same amount of energy or less than the reference house, it is deemed to comply with the NBC. Fundamentally, the performance path requires that two sets of calculation be performed; one for the proposed house, and the other for the reference house.

The performance path provides greater flexibility in the design and specification of building components affecting energy use, and allows a designer to comply with the energy efficiency requirements by using more energy-efficient building design features that are not prescriptively addressed in the NBC, such as benefiting from the orientation of glazing to minimize solar gains.

Additional reporting requirements are provided in NBC Division C to standardize what a compliance report should contain. These administrative requirements only apply to demonstrating compliance with NBC Subsection 9.36.5.

9.36.5.4. Calculation Methods

This Article defines the portion of the calculation method that is common to both the reference and proposed houses. The Article also includes a list of calculation rules as well as default parameters and values for input into simulation tools. For example, it provides guidance on how computer models use climatic and location-specific data, how heat transfer through the building envelope needs to be calculated, and how the performance of HVAC and service water heating equipment has to be modeled.

No particular software tools are prescribed, leaving the choice up to the user. The development of the performance path was, however, based on the default values and calculation procedures used in the NRCan HOT2000 program. NRCan may provide guidance for HOT2000 users on how to use HOT2000 for code compliance using the performance path in NBC Part 9. The calculations of both the proposed house and the reference house must use the same tool, except where an exception for differences in building components or energy efficiency features are explicitly provided in NBC Subsection 9.36.5.

The annual energy consumption for space heating, ventilation, and service water heating systems is based on primary equipment used, which is understood as the equipment that is required to meet the space conditioning load of the house. Redundant or back-up equipment can, therefore, be excluded from the calculation, provided it is equipped with controls.

Factors are provided to account for the heat gains produced by occupants, lighting and miscellaneous equipment. These are represented by a set of standard internal gains that are intended to compensate for the variability of occupant-driven behaviour from the calculation procedure. The scale factors applied to the load schedule are meant to account for the different occupant-driven loads observed in different types of residential buildings, and are based on the standard operating conditions used in the NRCan EnerGuide Rating System. The hourly load profile was derived from the average of three simulated Canadian residential electrical load profiles developed by International Energy Agency, Energy Conservation in Buildings and Community Systems Programme (IEA-ECBCS) Annex 42, while the magnitudes of the loads and factors correspond with those used in NRCan's EnerGuide Rating System for New Homes.

9.36.5.5. Climatic Data

This Article describes the general requirements for the use of climatic data in the energy use simulation for both the reference and proposed houses.

The NBC requires the use of climatic data measured at a time interval no greater than one hour for one year (8 760 hours) based on the average of at least 10 years of measured data collected at the weather station nearest to the region in which the proposed house is located. Climatic data sources include the Canadian Weather Year for Energy Calculations (CWEC) and the Canadian Weather Energy and Engineering Data Sets (CWEEDS).

9.36.5.6. Building Envelope Calculations

This Article provides the requirements that pertain to the building envelope calculation methods that are common to both the reference and proposed houses. It specifies which building elements and related properties need to be included in the calculations.

Credits may be applied to the calculation of the thermal mass and thermally active building assemblies, but locks the ratio of transparent and opaque portions of windows and doors at the same value for both the reference and proposed houses. The benefit of exterior shading can only be applied to the calculations of solar heat gain of windows and glazed doors. No shading benefits can be assumed for skylights or opaque building assemblies.

9.36.5.7. HVAC System Calculations

This Article defines the requirements that pertain to the calculation methods that are common to both the reference and proposed houses for the heating, ventilating, and air conditioning, where installed, of houses. It specifies which systems and what relevant performance data need to be included in the calculations.

A credit may be used in calculating the performance of ventilation, but the time period during which the ventilation equipment is assumed to be operating must be equal for both the reference and proposed houses. This requirement ensures that minimum ventilation is provided.

The calculation method does not allow the internal temperature to exceed 25°C (77°F) during the heating season. This maximum temperature set-point (5.5°C (9.9°F) above 20°C (68°F)) is based on an NRC research study[10]

(10) S.A. Barakat and D.M. Saunder, The Utilization of Internal Heat Gains, Vol. 92(1A), pp. 103–115, National Research Council of Canada, Ottawa, 1986.

and requires that the calculation for both the proposed and reference houses treats internal temperature rise in a consistent manner. The calculation may, however, model excess heat as if it escaped through windows.

Credit for reducing heat loss through piping is permitted, but the calculation needs to be applied consistently to both models for the reference and proposed houses. As well, a credit for better performing HRVs may be granted as long as the performance data is based on two data test points in accordance with the prescriptive requirements.

9.36.5.8. Service Water Heating System Calculations

This Article defines the requirements that pertain to the service water heating equipment calculation methods common to both the reference and proposed houses. It specifies supply cold water temperatures depending on the climatic region in which the house is situated, and also sets the service water delivery temperature at 55°C (131°F).

The energy model calculations must take into account a load distribution schedule. NBC Table 9.36.5.8. was derived from the default values used in HOT2000, and based on data of typical houses through studies by NRCan.

9.36.5.9. General Requirements for Modeling the Proposed House

This Article requires that the calculations use the construction features described in drawings and specifications for the proposed house. NBC Note A-9.36.5.9.(1) contains a list of components that would typically be expected to be reflected in the calculations.

9.36.5.10. Modeling Building Envelope of Proposed House

This Article provides the requirements that pertain to the energy model calculations in order to ensure that building envelope characteristics for the proposed house design are consistent. Default values are provided for certain criteria to simplify the calculations, and keep them consistent with the calculations used for the reference house.

With respect to foundation orientation, the construction of the actual house may be within 22.5° of the orientation used in the energy model calculations of the proposed house. This tolerance allows slight variations in site conditions that would otherwise prevent the actual house from being constructed and complying as shown in the permit drawings.

An assumed airtightness value for the building may be used in the calculation procedure. A measured value, obtained through a fan depressurization (blower door) test, can also be used.

Default values for airtightness have been determined by using the average measured airtightness from houses across Canada. It was determined that if a house was built using the existing code in that jurisdiction, the average airtightness observed by NRCan, calculated on the basis of thousands of sample houses, was 3.2 air changes per hour. Based on this value, it was determined that if the house was built according to the requirements of NBC Articles 9.36.2.9. and 9.36.2.10., a default value of 2.5 air changes per hour can be used.

Where airtightness is measured, a design value shall be assigned for use in the calculation procedure until the actual airtightness has been measured. Where measured airtightness is used in the calculation procedure, it shall be determined according to CAN/CGSB-149.10-M, "Determination of the Airtightness of Building Envelopes by the Fan Depressurization Method," either as the test method is written, or using the as-operated procedure in which some intentional openings in the building envelope are left unsealed during the test.

The following is a list of components that typically require no special preparation or sealing, and are left in the intended operating configuration for the as-operated blower door test:
- fuel-fired furnace and/or stove flues,
- furnace combustion air intakes,
- ventilation air intakes,
- fuel-fired hot water system flues,
- air to air heat exchangers designed to operate continuously, and
- intake and exhaust openings.

Where the as-operated test method is used, the resulting airtightness value should be adjusted in the energy model calculations to isolate and remove the effect of air leakage through flues.

The airtightness should be measured at a time in construction where the air barrier is complete, and the drywall is installed, but repairs could still be made should the house not reach the desired airtightness used in the energy model calculations.

9.36.5.11. Modeling HVAC System of Proposed House

This Article provides the requirements that pertain to the energy model calculations in order to ensure that the heating, ventilation, and air conditioning characteristics for the proposed house design are consistent with the calculations. Default values are provided for certain criteria to simplify the calculations and ensure consistency with the values used for the reference house.

The provisions in this Article deal with various types of heating/cooling equipment. The provisions only apply where such equipment is used.

The principal ventilation rate is consistent with the requirements of NBC Section 9.32., and is based on the number of bedrooms in the proposed house.

The part-load performance of the equipment in the proposed house is being kept the same as the reference house requirements for the same type of equipment. Using the actual manufacturer's data for part-load performance is also an option.

Where an HRV is installed in the proposed house, the calculations only account for the recovery of sensible heat but not the latent heat (humidity). This still allows an energy efficiency credit for better HRV heat recovery performance, but does not give credit for potential additional savings from energy recovery ventilators (ERVs).

For circulation fan flow rates and power requirements, several provisions are provided depending on the type of equipment that may be installed. The provisions provide options for determining rates for different scenarios.

9.36.5.12. Modeling Service Water Heating System of Proposed House

This Article provides the requirements that pertain to the energy model calculations in order to ensure that the service water heating characteristics of the proposed house design are consistent with the calculations. Default values are provided for certain criteria to simplify the calculations and ensure consistency with the criteria used for the reference house.

Drain-water heat recovery systems may be used in the energy model calculations, with certain default values listed. The Article requires that the drain-water heat recovery system be modeled on the exact configuration in which it will be installed. Variations in the installation configuration may undermine the intended benefit of the system in the energy model calculations and in reality.

9.36.5.13. General Requirements for Modeling the Reference House

This Article requires that the modeling assumptions for the reference house conform to the prescriptive requirements for the floor area, heated volume and the number and types of rooms of the proposed house.

9.36.5.14. Modeling Building Envelope of Reference House

This Article requires that the energy model calculations be consistent with the building envelope characteristics of the reference house design.

Default values are provided for certain criteria and are based on common house construction according to the prescriptive requirements of the NBC. Airtightness values are set at 2.5 air changes per hour to recognize that a house is built according to the air barrier details described in NBC Article 9.36.2.10.

Where there is no HRV, the default values to be used for the effective thermal resistance and overall thermal transmittance are those found in the tables of NBC Subsection 9.36.2.

The calculations assume that the total area of the fenestration and the doors is evenly distributed around all sides of the house. This has no negative effect on the model as the proposed house design has the actual placement of the fenestration and doors on each side, but is modeled as rotating the house in all four orientations. The effect of the placement of the fenestration and doors is therefore averaged out for the final calculation.

There is no limit for the fenestration and door area to gross wall area ratio (FDWR) in the prescriptive path. However, in the performance path, the proposed house uses the actual FDWR according to its design and the reference house uses a value between 17% to 22% (Figure 9.36.-12). Data collected from existing houses with one or two dwelling units in Canada show that the majority of housing has a FDWR in this range.

For multi-unit residential buildings, the FDWR can be determined in more than one manner. If the FDWR is based on measuring the interior area of the exterior assemblies, the set FDWR for the reference house can be set in the same manner as for houses with one or two dwelling units. If the FDWR for the proposed house is measured using all the interior wall areas, including interior walls separating suites, the FDWR of the reference house follows that of the proposed house up to 40%.

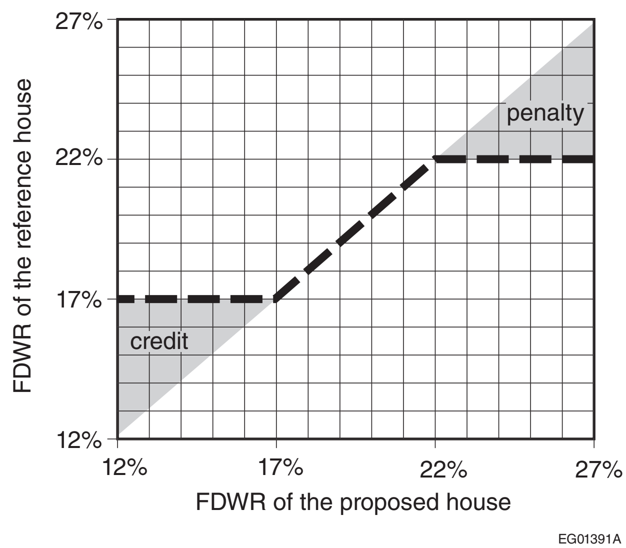


Figure 9.36.-12
FDWR of the reference house depending on the FDWR of the proposed house

9.36.5.15. Modeling HVAC System of Reference House

This Article requires that the energy model calculations be consistent with the heating, ventilation, and air conditioning characteristics of the reference house design. Default values are provided for certain criteria to simplify the calculations, and to ensure they are consistent with those used for the proposed house.

The Article requires that equipment be designed according to NBC Article 9.33.5.1., using CSA F280, "Determining the Required Capacity of Residential Space Heating and Cooling Appliances." It is important that the equipment not be oversized as this may have a negative effect on the energy model calculations.

For the reference house, an HRV is not assumed, except where the presence of an indoor pool or spa requires dehumidification in NBC Sentence 9.36.3.8.(1) and an HRV is installed to perform this function. As a result, the installation of an HRV in the proposed house would generally constitute an additional benefit.

For the equipment part-load performance requirements, the user can find pre-determined values in the NBC Tables 9.36.5.15.-A to -C, depending on the type of equipment. These factors are derived from the HOT2000 model tool, but values in other software tools for part-load performance are also acceptable.

The performance of the HVAC equipment used in the reference house should match the type of equipment used in the proposed house design. The base efficiency levels for the reference house equipment are as listed in NBC Table 9.36.3.10. Any increase in performance of the proposed house equipment constitutes an additional benefit. Where the table does not have the type of equipment used in the proposed house design, the default for the reference house is set as a 92% gas warm-air furnace.

9.36.5.16. Modeling Service Water Heating System of Reference House

This Article requires that the energy model calculations be consistent with the service water heating characteristics of the reference house design. Default values are provided for certain criteria to simplify the calculations and to ensure the criteria are consistent with those used for the proposed house.

Wherever possible, the energy source of the equipment used in the reference house is the same as that used in the proposed house, and is set to the minimum performance efficiency found in NBC Table 9.36.4.2. NBC Table 9.36.5.16. provides the required capacities that are to be used where the proposed house has a tankless water heater. When the equipment used in the proposed house is not listed in NBC Table 9.36.4.2., the base default equipment of the reference house should be modeled as a gas-fired storage type water heater.

Appendix A
Symbols and Other Abbreviations

Table A-1

Symbol or Abbreviation	Meaning
Btu	British thermal units
cm	centimetre(s)
°	degree(s)
°C	degree(s) Celsius
°F	degree(s) Fahrenheit
FDWR	fenestration and door area to gross wall area ratio
ft.	foot (feet)
g	gram(s)
h	hour(s)
HDD	heating degree-day(s)
HRV	heat recovery ventilator
HVAC	heating, ventilating and air-conditioning
ICF	insulating concrete form
in.	inch(es)
kg	kilogram(s)
kN	kilonewton(s)
kPa	kilopascal(s)
kW	kilowatt(s)
L	litre(s)
lb.	pound(s)
m	metre(s)
M	metric nomenclature for reinforcing bars
max.	maximum
min.	minimum
min	minute(s)
MJ	megajoule(s)
mm	millimetre(s)
MPa	megapascal(s)
N	newton(s)
n/a	not applicable
ng	nanogram(s)
No.	number(s)
OSB	oriented strandboard
Pa	pascal(s)

Table A-1 (Continued)

Symbol or Abbreviation	Meaning
psf	pounds per square foot
psi	pounds per square inch
R	thermal resistance (imperial unit)
RSI	thermal resistance (SI unit)
s	second(s)
W	watt(s)
%	percent
U	overall thermal transmittance

Appendix B
Abbreviations of Proper Names

Table B-1

Abbreviation	Organization
AISI	American Iron and Steel Institute (www.steel.org)
ANSI	American National Standards Institute (www.ansi.org)
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers (www.ashrae.org)
ASTM	American Society for Testing and Materials International (www.astm.org)
CAN	National Standard of Canada designation (The number or name following the CAN designation represents the agency under whose auspices the standard is issued. CAN3 designates CSA, and CAN4 designates ULC.)
CCBFC	Canadian Commission on Building and Fire Codes (www.nrc-cnrc.gc.ca/eng/solutions/advisory/codes_centre_index.html)
CCMC	Canadian Construction Materials Centre (www.nrc-cnrc.gc.ca/eng/solutions/advisory/ccmc_index.html)
CGSB	Canadian General Standards Board (www.tpsgc-pwgsc.gc.ca/ongc-cgsb/index-eng.html)
CLSAB	Canadian Lumber Standards Accreditation Board (www.clsab.ca)
CMHC	Canada Mortgage and Housing Corporation (www.cmhc.ca)
CSA	CSA Group (www.csagroup.org)
CSSBI	Canadian Sheet Steel Building Institute (www.cssbi.ca/)
CWC	Canadian Wood Council (www.cwc.ca)
HRAI	Heating, Refrigeration and Air Conditioning Institute of Canada (www.hrai.ca)
HVI	Home Ventilating Institute (www.hvi.org)
MNECH	Model National Energy Code of Canada for Houses 1997 (see CCBFC)
NBC	National Building Code of Canada 2015 (see CCBFC)
NECB	National Energy Code of Canada for Buildings 2015 (see CCBFC)
NFPA	National Fire Protection Association (www.nfpa.org)
NLGA	National Lumber Grades Authority (www.nlga.org)
NPC	National Plumbing Code of Canada 2015 (see CCBFC)
NRC	National Research Council of Canada (www.nrc-cnrc.gc.ca)
NRCan	Natural Resources Canada (www.nrcan.gc.ca)
SMACNA	Sheet Metal and Air Conditioning Contractors' National Association (www.smacna.org)
ULC	ULC Standards (Underwriters Laboratories of Canada) (canada.ul.com/ulcstandards)

Conversion Factors

SI Unit	Imperial Unit	To convert SI unit to imperial unit, multiply by
Temperature		
°C	°F	1.8 and add 32
Length		
mm	in.	0.03937
cm	in.	0.3937
m	ft.	3.281
Area		
mm^2	in.^{2}	0.00155
cm^2	in.^{2}	0.155
m^2	ft.^{2}	10.76
Mass		
kg	lb.	2.205
Volume		
cm^3	in.^{3}	0.061
m^3	ft.^{3}	35.31
L	gal. (imp.)	0.22
L	gal. (US)	0.2642
Density		
kg/m^3	lb./ft.^{3}	0.06243
Flow		
L/s	ft.^{3}/min (cfm)	2.11889
L/min	ft.^{3}/min (cfm)	0.0353
m^3/h	ft.^{3}/min (cfm)	0.5886
Permeance		
ng/(Pa·s·m^2)	perms	0.0174
Power		
W	Btu/h	3.413
Heat Flux		
W/m^2	Btu/(h·ft.^{2})	0.317
Overall Thermal Transmittance (U)		
W/(m^2·K)	Btu/(h·ft.^{2}·°F)	0.17612
Thermal Resistance		
(m^2·K)/W (RSI)	(h·ft.^{2}·°F)/Btu (R)	5.678
Thermal Conductivity		
W/(m·K)	(Btu·in.)/(h·ft.^{2}·°F)	6.93347
W/(m·K)	(Btu·ft.)/(h·ft.^{2}·°F)	0.5777
Pressure		
Pa	in. of water	0.004014
kPa	lbf./in.^{2} (psi)	0.145
kPa	lbf./ft.^{2} (psf)	20.88
Energy		
MJ	kWh	0.278
J	Btu	0.0009478
Force		
N	lbf.	0.2248
kN	lbf.	224.81
Loading		
kN/m	lbf./ft.	68.52