2020

ILLUSTRATED FIELD GUIDE TO THE MINNESOTA RESIDENTIAL CODE

• Administration • Construction • Radon • Energy

50 YEARS

THE STATE BUILDING CODE, 1972–2022

Celebrating 50 years of building safety in Minnesota

DEPARTMENT OF LABOR AND INDUSTRY

2020

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HOUSING FIRST MINNESOTA

BAM BUILDERS ASSOCIATION OF MINNESOTA

mn DEPARTMENT OF LABOR AND INDUSTRY

INTERNATIONAL CODE COUNCIL®

Illustrated Field Guide to the Minnesota Residential Code, 2020

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INTERNATIONAL CODE COUNCIL

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Contents

Introduction

Construction of residential buildings routinely consists of conventional practices, those tried-and-true methods that have performed well over the years and have long been recognized by the building code. With the introduction of new technology, materials, and methods, improved understanding of safe and healthy living environments, and innovation in dwelling designs, residential construction and the codes that regulate it have become increasingly complex. Such complexity is necessary to afford flexibility in design and construction.

The Illustrated Field Guide to the *Minnesota Residential Code,* 2020 was developed to address the need for an illustrated text explaining the basics of the residential code—those provisions essential to understanding the application of the code to the most commonly encountered building practices. The text is presented and organized in a user-friendly manner with an emphasis on technical accuracy and clear non-code language when possible. The content is directed to readers with a basic understanding of conventional dwelling construction but a less than complete knowledge of the *Minnesota Residential Code* (MRC).

Anyone involved in the design, construction, or inspection of residential buildings will benefit from this Guide. Beginning and experienced inspectors, contractors, home builders, architects, designers, home inspectors and apprenticing students will gain a fundamental understanding and practical application of the more frequently used provisions of the 2020 edition of the MRC. The content of the Illustrated Field Guide to the *Minnesota Residential Code,* 2020 is organized to correspond to the order of construction, beginning with sitework and foundations through completion of a safe, healthy and energy-efficient dwelling. The advantage of this format to the reader is that it pulls related information together from various sections of the MRC into one convenient location of the text and provides a familiar frame of reference to those with construction experience. The Guide explains the difference between "prescriptive" and "performance" requirements. Prescriptive structural design requirements to resist the forces of wind and snow are described and illustrated in an easy-to- understand way. Structural topics include conventional footings and foundations (including the fundamentals of soil capacity), conventional wood floor, wall and roof framing, and engineered wood products. Life-safety concerns are addressed with topics including means of egress, emergency escape, stairways, fall protection, smoke alarms, fire sprinklers and fire-resistant construction. The Guide also covers the minimum interior environmental conditions for a healthy living environment, weather protection and energy conservation measures.

This Guide does not intend to cover all provisions of the MRC or all of the accepted materials and methods of construction of residential buildings. Focusing in some detail on the most common conventional construction provisions affords an opportunity to fully understand the basics without exploring every variable and alternative. This is not to say that information not covered is any less important or valid. This Guide is best used as a companion to the MRC, which should be referenced for more complete information. Although not part of this Guide, the codes for mechanical, fuel-gas, plumbing and electrical are referenced in chapters 13, 14 & 15.

The Illustrated Field Guide to the *Minnesota Residential Code,* 2020 features full-color illustrations to assist the reader in visualizing the application of the code requirements. Practical examples, simplified tables and highlights of particularly useful information also aid in understanding the provisions and determining code compliance. References to the applicable sections of the 2020 edition of the MRC are helpful in locating the corresponding code language and related topics in the code. A glossary of code and construction terms clarifies the meaning of the technical provisions.

Preface

On July 1, 1972, the first State Building Code became effective in Minnesota, superseding the individual codes of cities, counties, and townships throughout the state. Obviously a lot has changed since then, including the size of the code book. However, the way we build houses has also changed and the code has had to adapt to keep pace with changes in technology and building materials that have touched virtually every aspect of house construction. The simplicity of how "we used to do things" is pretty much gone and been replaced with new methods, tools, fasteners, and engineered building materials that allow us to build bigger, stronger, and faster, in ways we couldn't imagine 50 years ago when a man last walked on the moon.

To commemorate the 50-year milestone anniversary, we are introducing this Illustrated Field Guide to the *Minnesota Residential Code,* 2020, a special illustrated version of the more common provisions contained in the *Minnesota Residential Code*. What makes this Guide unique are the illustrations and commentary that provide practical understanding of concepts that are difficult to communicate in the conventional code format. In this age of rapid technological advances, we wanted to see if 50 years later we could do a better job of helping others understand our codes, and ultimately, provide greater safety in our homes by creating a hybrid version that is part code and part explanation, something that could be understood by practitioners in construction and inspection. This is our attempt.

Scott McLellan,
Director/State Building Official
Construction Codes & Licensing Division
Minnesota Department of Labor and Industry

ACKNOWLEDGMENTS

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AIA, Vice President and Technical Director; Sandra Hyde, PE, Managing Director; Buddy Showalter, PE, Senior Staff Engineer; and Jerica Stacey, Energy Code Specialist, who all work in ICC's Product Development Group.

We are grateful for the technical staff of DLI (& CCLD) staff who without their expert input and vision for clear communication, this would not have been possible, including Richard Lockrem, Construction Code Rep & Residential Building Code Specialist; Chad Payment, Construction Code Rep & Technology/Education Specialist; Amanda Spuckler, Management Analyst & Technical Specialist; Daniel Kelsey, PE, Structural Specialist; Steven Shold, Construction Code Rep & Energy Code Specialist; Lyndy Logan, Management Analyst & Technical Support Specialist; and Chris Thompson, Communications & Graphics Specialist.

ABOUT THE INTERNATIONAL CODE COUNCIL®

The International Code Council is the leading global source of model codes and standards and building safety solutions that include product evaluation, accreditation, technology, codification, training and certification. The Code Council's codes, standards and solutions are used to ensure safe, affordable and sustainable communities and buildings worldwide. The International Code Council family of solutions includes the ICC Evaluation Service, the International Accreditation Service, General Code, S. K. Ghosh Associates, NTA Inc., Progressive Engineering Inc., ICC Community Development Solutions and the Alliance for National & Community Resilience. The Code Council is the largest international association of building safety professionals and is the trusted source of model codes and standards, establishing the baseline for building safety globally and creating a level playing field for designers, builders and manufacturers.

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About the Department of Labor and Industry

The Department of Labor and Industry ensures Minnesota's work and living environments are equitable, healthy and safe. The agency oversees the state's programs for apprenticeship, construction codes and licensing, dual-training pipeline, occupational safety and health, wage and hour standards, workers' compensation, and youth skills training programs.

The Construction Codes and Licensing Division (CCLD) provides for regulation and enforcement of construction-related health and safety codes and licensing laws in new and existing structures. It promulgates and administers the accessibility, boiler, building, electrical, elevator, energy, fuel gas, high-pressure piping, manufactured structures, mechanical, plumbing and residential codes. It licenses boiler operators, electricians, electrical and technology system contractors, elevator constructors, high-pressure-piping pipefitters, manufactured home installers, plumbers, plumbing contractors, power limited technicians, residential building contractors, remodelers and roofers. It also certifies building officials.

About the Builders Association of Minnesota

Since 1974, the Builders Association of Minnesota (BAM) has represented members and their businesses at the Minnesota State Capitol, before regulatory agencies and before the state's courts of law. BAM – as the largest statewide association – is a collaboration of all 11 local associations across our state in addition to At-Large Members in St. Cloud. We push for common sense laws that will benefit our members and our industry and strive to protect our industry from harmful legislation, regulation and litigation.

About Housing First Minnesota

Housing First Minnesota got its start in the late 1930s by a small group of builders. Their goal was to increase the professionalism and quality of the homebuilding industry. Over the years, the association has grown to include builders, remodelers, sub-contractors, suppliers and other professionals who support the building industry. Members subscribe to a defined code of ethics, and all our builders conform to minimum Performance Standards for construction and business practices. All builder and remodeler members are licensed through the state of Minnesota and must comply with the rules, regulations and continuing education requirements set by state statute.

About the Association of Minnesota Building Officials

The Association of Minnesota Building Officials (AMBO) is a non-profit organization representing individuals and municipalities with no financial interest in the content of construction regulations. Our interest is affordable public safety in the built environment and the efficient administration of construction codes.

PART 1

Code Administration

CHAPTER

1

Introduction to the Minnesota State Building Code

Building codes, in the broadest sense, are the various sets of regulations related to the construction, alteration, maintenance and use of buildings and structures. Sometimes collectively called construction codes, the separate volumes include not only structural considerations, but provisions for fire and life safety, energy conservation and systems for heating, cooling, plumbing and electrical utilities. These codes serve primarily to protect the safety and welfare of the building occupants and the public. One in a family of coordinated and compatible construction codes, the *Minnesota Residential Code* (MRC) combines many of the building elements necessary for the construction of one- and two-family dwellings and townhouses into a single volume. Providing design flexibility, the MRC references companion Minnesota codes for elements of construction outside the scope of the MRC.

For 50 years, the Minnesota State Building Code has been the standard by which buildings have been constructed to provide our citizens with safe, energy efficient and accessible buildings. From the many buildings built during those years, no one will know the countless lives saved from fire, structural collapse and hazardous materials; the injuries prevented from falls, shattered glass and electric shock; or the prevention of damage to buildings from roof ice, frost heave or water leakage. In addition, many hundreds of buildings are now fully accessible and usable for our family members and friends with disabilities while much less fossil fuel has had to be burned to heat and cool these same buildings.

Because one of the most important roles of government is to protect its citizens, it is the State of Minnesota's responsibility to help ensure this occurs in the construction of buildings. It is our hope that this illustrated Guide will further help to achieve that purpose in the construction and renovation of housing.

MODEL CODES

Minnesota law requires the State Building Code to conform as much as possible to model building codes generally accepted and in use throughout the United States. A model code is a book of published construction regulations developed by members of an organization having subject-matter expertise and are intended for adoption into law by local governments, states and even countries. Because writing codes requires a great deal of work by many experienced and varied industry experts, this is usually beyond the capacity of a local government to produce on its own. The preferred way to efficiently regulate building safety, accessibility for the disabled and energy efficiency is through the adoption and enforcement of model codes. However, because model codes are produced for widespread use throughout all parts of the country, state government must usually amend or change some provisions in order to address its own particular geography, climate and legislative mandates.

MINNESOTA RULES

Minnesota law states that the commissioner of the Minnesota Department of Labor and Industry shall by rule and in consultation with the Construction Codes Advisory Council establish a code of building standards. A rule is a type of Minnesota law that is produced by a state agency through a legally prescribed process. Although authority for making a rule must be granted by the legislature, the legislature is not directly involved in this process. Adopting a model code into the State Building Code is done by rule as well as when making changes. Usually these are referred to as amendments or amending the model code.

MINNESOTA STATUTES

Even though the State Building Code is established by rule using model codes, the legislature can still enact specific requirements into law to regulate the construction of buildings. Most often, this occurs as a result of a tragedy or string of accidents where the State Building Code may not have provided adequate protections. Examples of some of the special provisions passed into law by the legislature include:

- Window-fall protection
- Safety devices for garage door openers
- Radon control
- Smoke detection devices
- Cedar and redwood decking
- Residential energy code study

MINNESOTA STATE BUILDING CODE CHAPTERS

The Minnesota State Building Code consists of 18 chapters. Most of them adopt by reference a model code or standard that has been developed by a national code-making organization. The remaining chapters contain subject matter that has been written specifically for Minnesota.

1300—Minnesota Building Code Administration
1303—Minnesota Special Provisions
1305—Minnesota Commercial Building Code
1307—Elevators and Related Devices
1309—Minnesota Residential Code
1311—Minnesota Conservation Code for Existing Buildings
1315—Minnesota Electrical Code
1322/23—Minnesota Energy Code
1335—Flood-proofing Regulations
1341—Minnesota Accessibility Code
1346—Minnesota Mechanical and Fuel Gas Code
1350—Manufactured Homes
1360—Prefabricated Structures

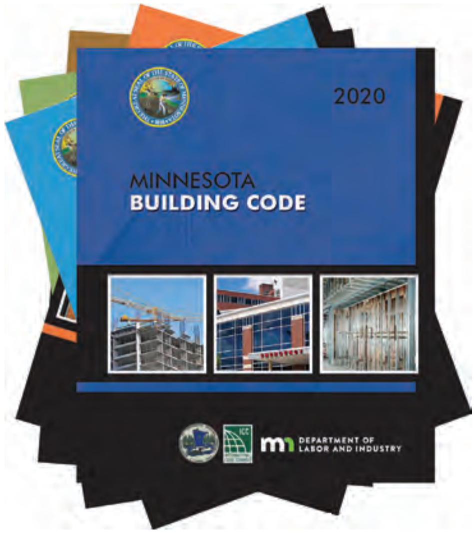


FIGURE 1-1 Minnesota State Building Codes

1361—Industrialized/Modular Buildings
1370—Storm Shelters (Manufactured Home Parks)
4714—Minnesota Plumbing Code
5230—Minnesota High Pressure Piping Systems

PURPOSE

The purpose of the State Building Code is described in Minnesota Statutes 326B.101 where it reads:

> The commissioner shall administer and amend a state code of building construction which will provide basic and uniform performance standards, establish reasonable safeguards for health, safety, welfare, comfort, and security of the residents of this state and provide for the use of modern methods, devices, materials, and techniques which will in part tend to lower construction costs. The construction of buildings should be permitted at the least possible cost consistent with recognized standards of health and safety.

In other words, the code should satisfy each of the following:

- **Basic**—minimum
- **Uniform**—everyone designs and builds to comply with the same requirements
- **Performance standards**—requirements should focus on the outcome, not specific methods
- **Reasonable safeguards**—not overly complex, costly, or difficult
- **Health**—safe clean water, proper sewer, sanitation, air quality, light, ventilation
- **Safety**—protection from fire, smoke, falling, wind, snow, frost, extreme temperature, electrocution, hazardous materials, panic, breaking glass, structural collapse
- **Welfare**—accessibility, conserves energy resources, peace of mind, habitability
- **Comfort**—heating facilities, soundproofing between apartments, room size
- **Security**—school safety, nursing home dementia units, correctional facilities
- Provide for the use of modern methods, devices, materials and techniques which will in part tend to lower construction costs—encourage and recognize innovation and technologies that provide cost savings in labor, equipment, and building materials
- The construction of buildings should be permitted at the least possible cost consistent with recognized standards of health and safety—manage adoption of nationally recognized safety and health codes to keep construction costs as low as possible

BENEFITS

- Provides safe and healthy buildings
- Provides peace of mind that buildings are safe to be used as intended
- Provides accessible buildings for all people, regardless of ability
- Provides energy-efficient buildings
- Provides buildings that are resilient to weather extremes
- Provides reduced property loss in the event of fire, flood, wind, and snow
- Provides consistency in building design, bidding process, and building construction
- Provides financial institutions with assured minimum level of quality and safety. Most require evidence of this through the certificate of occupancy
- Provides insurance companies with permit, inspection, and occupancy approvals to verify insurability

- Provides prospective property owners with documented improvement records that are sometimes necessary for real estate transfers and tax purposes
- Provides the Insurance Services Office (ISO) with a measurable industry standard to determine cost-effective state-wide insurance rates
- Provides FEMA with a reasonable safety standard to base reconstruction cost to replace or repair disaster-destroyed property
- Provides the public with a way to verify that work is done by licensed contractors, architects, and engineers
- Provides a standard for consumer protection through Minnesota's Contractor Licensing program and Contractor Recovery Fund
- Provides compatibility with the State Fire Code
- Provides quality community development through the construction of buildings that meet the needs of society, municipalities, building owners and residents

MINNESOTA RESIDENTIAL CODE (MRC)

The provisions of the MRC generally apply to the construction, alteration, use and occupancy of detached one- and two-family dwellings and townhouses (Figures 1-2, 1-3 and 1-4). Such buildings are limited to not more

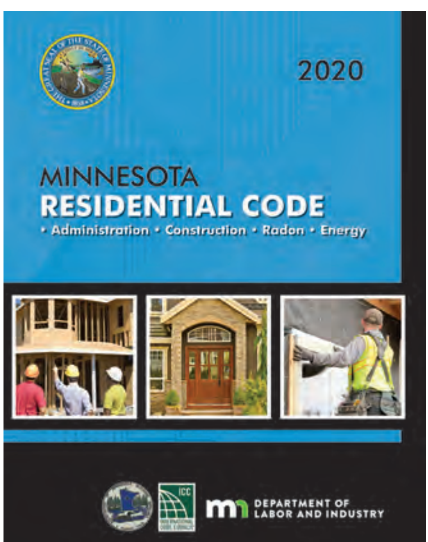


FIGURE 1-2 2020 *Minnesota Residential Code*

than three stories above grade plane in height, and each dwelling unit must have a separate means of egress. This code includes provisions for structural elements, fire and life safety, and a healthy living environment. The MRC incorporates prescriptive provisions for conventional light frame construction as well as performance criteria that allow the use of new materials and new building designs (see Chapter 4). The purpose of the MRC is to safeguard the public safety, health and general welfare from fire and other potential hazards attributed to the built environment.

FIGURE 1-3 Detached single-family dwelling regulated by the MRC

FIGURE 1-4 Townhouses

Dwellings and Townhouses

The building height and means of egress requirements of the MRC apply equally to one- and two-family dwellings and townhouses. Although the code generally limits these residential buildings to three stories above ground level, this still permits a full basement in addition to three stories above, effectively creating a building with four floor levels. In addition, the MRC permits a habitable attic, which is not counted as a story, conceivably creating a fifth habitable level, though such an installation is not common (Figure 1-5). As will be seen in later chapters, structural and other design criteria of the code may further limit the height and number of stories of the building. The code does not limit the total area of dwellings, however.

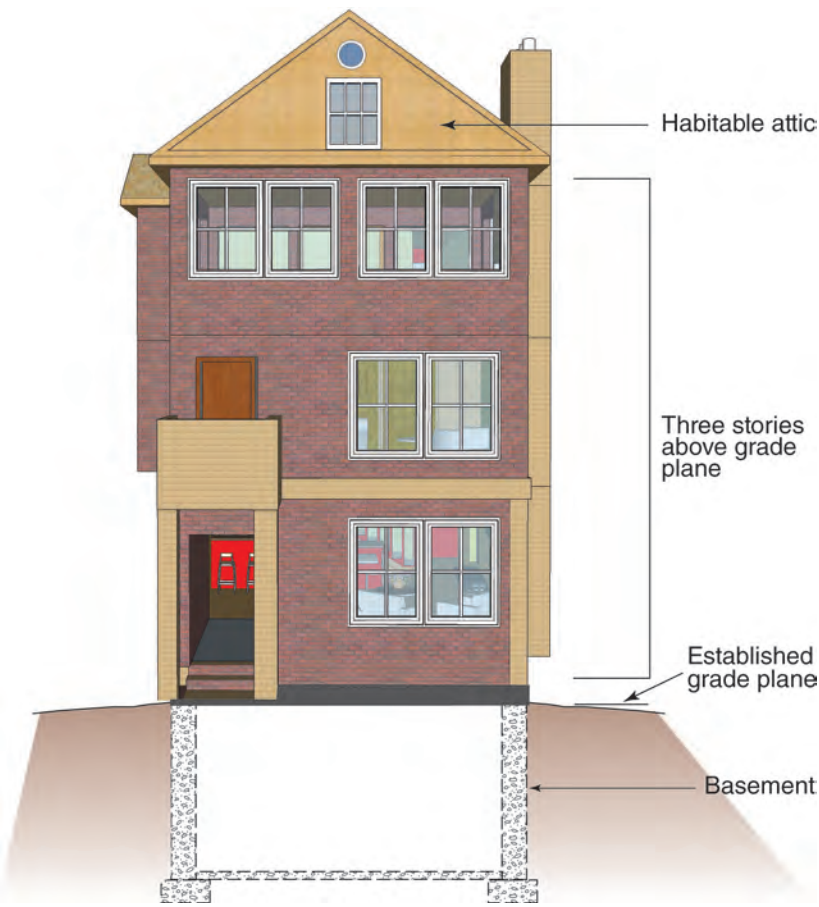


FIGURE 1-5 Three stories above grade plane with basement and habitable attic

In addition to height considerations, each dwelling unit requires its own separate means of exiting the building to the outdoors (see Chapter 8). Only one exterior exit door is required, and the travel distance to that exit is not regulated, no matter the size or number of stories of the dwelling unit. Two-family dwellings (Figure 1-6) and townhouses require fire-resistant separations between dwelling units. Limited protection against the spread of fire is also required between a dwelling unit and an attached garage (see Chapter 9).

The MRC does not limit the number of townhouses in a group of townhouses but does require the building to satisfy certain other conditions. To qualify as a townhouse, there must be at least two attached dwelling units, and

Code Essentials

MRC dwelling unit limits
- Three stories above grade plane
- Separate means of egress

No limits on
- Number of townhouses
- Dwelling unit area
- Travel distance to exit

FIGURE 1-6 Detached two-family dwelling regulated by the MRC

each unit must run from foundation to roof. That is, any portion of a townhouse is not permitted to be placed above any portion of another townhouse. In addition, each townhouse must be open to a yard or public way on at least two sides (Figure 1-7). Multifamily dwellings that do not meet the definition of townhouses fall under the provisions of the *Minnesota Commercial Building Code* (MBC) (Figure 1-8). [Ref. R202]

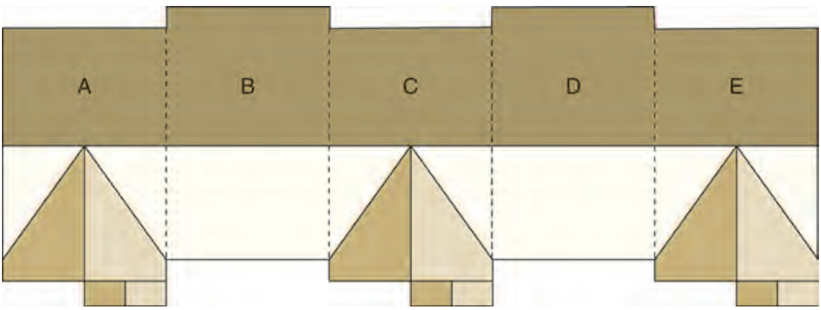


FIGURE 1-7 Townhouses open on front and back

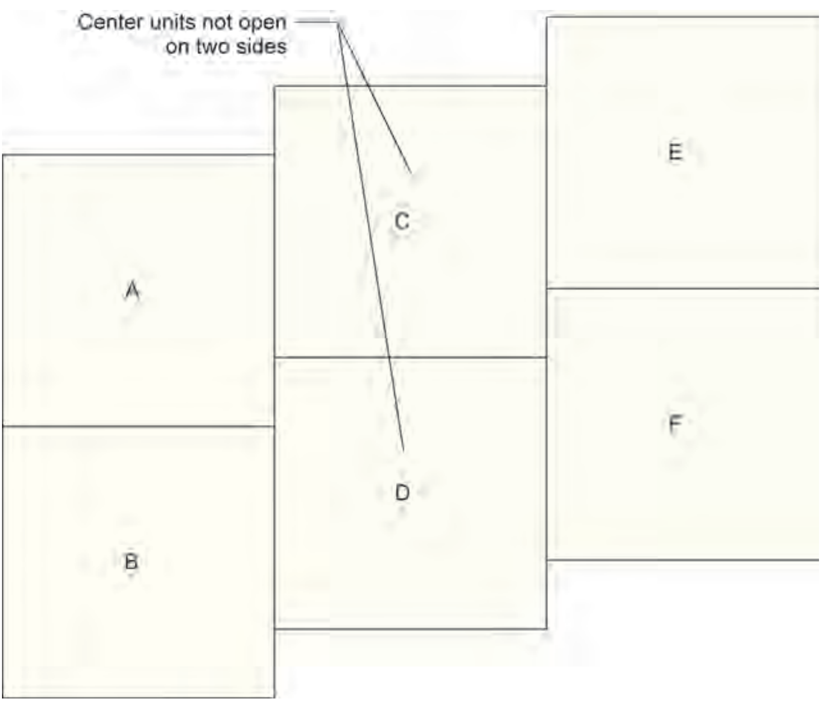


FIGURE 1-8 Six-unit multifamily dwelling outside the scope of the MRC

Minnesota Manufactured Home Code

- Regulates the installation and sales of manufactured homes and licensing of manufacturers, dealers and installers of manufactured homes built and installed to Code of Federal Regulations.
- Contains detailed regulations for installation and certification of manufactured homes, application forms to sell manufactured homes and record keeping of the sales and installations.
- Is contained in Minnesota Rules Chapter 1350 and the Code of Federal Regulations, CFR 3280, 3282, 3285, 3286 and 3288.
- Manufactured homes are required only to be constructed to the Manufactured Home Code, CFR 3280 and 3282.

For purposes of the MRC, a manufactured home is considered the same as a mobile home, though the preferred term since 1974 federal legislation is manufactured home. The United States Department of Housing and Urban Development (HUD) regulates the construction of manufactured homes which are built in a manufacturing plant to comply with the Manufactured Home Construction and Safety Standards (HUD code). Compliance is verified through state or third-party inspection agencies. Each transportable section must display a red certification label on the exterior.

Manufactured homes are built on a permanent chassis and are designed to be used as a dwelling with or without a permanent foundation. This design assures transportability for relocation and differentiates manufactured homes from modular homes and other factory-built, panelized, or component structures.

Local jurisdictions have no authority to regulate the design or construction of a HUD-regulated manufactured home. However, any modification or

FIGURE 1-9 Manufactured Home

addition must be in compliance with HUD regulations and cannot proceed if otherwise prohibited. Attachment of an accessory building, such as a garage, is generally prohibited unless the design is substantiated through engineering calculations.

Industrialized Modular Buildings

- Regulates the construction, review process and approval for industrialized modular buildings built away from the site of occupancy by approved modular builders. Modular buildings may be any occupancy or construction type allowed by code.
- Provides for Minnesota to become a member of the Interstate Industrialized Buildings Commission.
- Contained in Minnesota Rules Chapter 1361. The rule incorporates parts of the 2007 Model Rules and Regulations and 2007 Uniform Administrative Procedures of the Model Rules and Regulations for Industrialized/Modular Buildings as adopted by the Industrialized Buildings Commission.
- Regardless of where it is manufactured, the building must be constructed to the Minnesota State Building Code when it is to be installed in Minnesota.
- Industrialized Modular Buildings must be constructed in accordance with the 2020 Minnesota Building Code.

FIGURE 1-10 Industrialized Modular Buildings

Prefabricated Buildings

- Governs the construction of prefabricated buildings. These buildings are intended for use as one- and two-family dwellings or accessory buildings of closed construction built away from the site of occupancy, typically by vocational schools or lumber yards.
- Contains detailed regulations for the submittal of documents to be reviewed and approved prior to construction. Includes requirements for inspections to determine compliance with the Minnesota State Building Code.
- Contained in Minnesota Rules Chapter 1360.
- Prefabricated buildings must be constructed in accordance with the 2020 Minnesota Residential Code.

FIGURE 1-11 Prefab Single Family Home

CHAPTER 2

Administration, Permits, Plans, and Inspections

The Administrative provisions of the State Building Code establish the process and legal basis for enforcement by the building official. This includes but is not limited to:

- The code—Where can you get a copy, specific edition, year, etc.
- Where the code applies—Where is it in effect and when permits are required
- Authority—What the building official can legally require
- Alternate materials and methods—Process for deviating from specific code language
- Appealing—Process for appealing the building official's decision
- Permit requirements—Applications, plans, fees, expiration, posting
- Plans—When they are required and what must be included
- Inspections—When required, requesting, approving
- Orders—Violations, corrections, stop-work
- Approvals—Final inspection and certificate of occupancy

APPLICABILITY

The State Building Code is the standard that applies statewide for the construction, reconstruction, alteration, and repair of buildings and other structures of the type governed by the code. The State Building Code supersedes the building code of any municipality.

The code applies to the design, construction, addition, alteration, moving, replacement, demolition, repair, equipment, installation, use and occupancy, location, maintenance, and inspection of any building, structure, or building service equipment in a municipality.

"Code" means the Minnesota State Building Code adopted under Minnesota Statutes, section 326B.106, subdivision 1, and includes the chapters identified in part 1300.0050.

If different provisions of the code specify different materials, methods of construction, or other requirements, the most restrictive provision governs. If there is a conflict between a general requirement and a specific requirement, the specific requirement applies.

AUTHORITY

The MRC establishes a department of building safety, commonly referred to as the building department, and designates the officer in charge of the administration and enforcement of the code as the building official. The appointing authority of the jurisdiction appoints the building official, though

Code Essentials

Building official duties:

- Enforce the code
- Review construction documents
- Issue permits
- Issue notices and orders
- Conduct inspections
- Maintain records

Building official authority:

- Make interpretations
- Adopt policies and procedures
- Approve modifications and alternatives

Limits on authority:

- Cannot waive code requirements
- Cannot require more than the code

jurisdiction job titles may vary. The building official in turn assigns some degree of decision-making authority to deputies, plans examiners, inspectors, permit technicians and other employees. The role of a building official in protecting public safety is complex and challenging. It follows that the position demands skills, knowledge, and abilities to not only fulfill the duties, but elevate the credibility of the department in the eyes of the public.

Authority and Duties of the Building Official

The MRC charges the building official with enforcing the provisions of the code and assigns broad authority and discretion to do so. The building official has the authority to render interpretations of the code and adopt policies and procedures in order to clarify the application of the provisions. With discretion comes the responsibility to make decisions in keeping with the intent of the MRC. The building official does not have authority to waive code requirements. In the same way, the building official has no authority to require more than the code stipulates. The MRC also authorizes the building official to develop policies and procedures for consistent application of the code provisions. [Ref. MR 1300.0110]

In effectively performing the duties listed in the code, the building official must also have an understanding of the legal aspects of code administration. While given broad authority for enforcement, including the issuance of notices and orders, the building official must also recognize the rights of due process afforded to the public. Equally important to the building department in securing safe buildings for the community is to build the public trust through communication, respect, and fairness, so that the department is viewed as a resource rather than an adversary.

Interpretations

Many code provisions are clear and easily understood. The dimensions for stair rise and run, handrail height, and spacing for openings in guards, for example, are specific and objectively measurable. Such provisions are referred to as *prescriptive*—a clear set of rules to follow to gain compliance. The shape of other than round handrails, on the other hand, is less clearly defined. Although the code sets some parameters for dimensions of these handrails, it also permits any handrail that provides equivalent graspability.

The term "equivalent graspability" is a performance requirement, meaning that an element must function to satisfy certain acceptable criteria. Determination of compliance requires some level of judgment on the part of the building official. Though the MRC intends to be largely prescriptive in nature, it purposely offers performance criteria as well, to allow flexibility in design and construction and to not favor certain materials or methods over any other.

You Should Know

Prescriptive vs. performance in the MRC

Prescriptive code provisions:

- Form a specific set of rules (a recipe) to follow to gain compliance with the code

Performance code provisions:

- Require systems or components to function in a certain way to meet the desired level of safety and performance but do not specify the method of construction

Alternative Methods and Materials

The MRC is specific in its intention to not exclude the use of any material or method of construction, even if such methods are not specifically described by the code, subject to approval by the building official. The building official has an obligation, as instructed by the code, to approve such alternatives where he or she finds that the proposed material or construction meets the intent of the MRC and is equivalent to the code provisions. The details of any action granting or denying approval of an alternate shall be recorded and entered in the files of the Department of Building Safety. The permit applicant may request written documentation of the denial, including the reasons for the denial. With modern technology advancing at a record pace, new and innovative building products are continuously introduced to the market on a global scale. Reports issued by the International Code Council's Evaluation Service (ICC-ES) are valuable resources in verifying performance equal to the code requirements. In the absence of ICC-ES evaluation reports and where insufficient data or documentation exists, the building official may require that tests be performed by an approved agency to demonstrate compliance with the code. Also, compliance with the specific performance-based provisions of the referenced Minnesota Codes satisfies the MRC requirements. The performance and alternative-methods provisions of the MRC and the use of the ICC Evaluation Reports provide for flexibility and encourage innovative and new materials, design and construction while protecting the public safety. All published ICC Evaluation Reports are available free of charge and can be accessed online at www.icc-es.org. [Ref. MR 1300.0110, Subp. 13]

You Should Know

Alternative methods and materials:

- The building official shall approve alternatives that comply with the intent of the code.

ICC Evaluation Service (ES) Reports:

- ES Reports are valuable tools for verifying that alternative methods and materials perform satisfactorily and are equivalent to that prescribed by the code

Modifications

Occasionally there are instances where it is not feasible to fully comply with the strict letter of the code. In this case, the MRC allows a modification of the code provision for individual cases when approved by the building official. The decision is based on documentation demonstrating that the modification complies with the intent and purpose of the code and does not lessen health, safety or structural requirements. The building official records the decision in the building department files. [Ref. MR 1300.0110, Subp. 12]

PERMITS

Except for a short list of work of a minor nature, any construction requires a permit before work begins, including work for the relocation or demolition of buildings. Work exempt from permits must still comply with the applicable MRC requirements. [Ref. MR 1300.0120]

Permit Application

The owner or authorized agent must make application for a permit on a form furnished by the building department. In addition to providing a legal description of the property, the permit application must include the description of the work, the valuation of the proposed work, the use of the building and the applicant's signature (Figure 2-1). [Ref. MR 1300.0120, Subp. 7]

Building Department
City Of

Application for Permit

Project Address ____________
Parcel ________ Lot ________ Subdivision ________
________ Zone ________ Flood Zone ________
Owner ________ Phone ________
Address ____________
Contractor ________ Phone ________
Address ____________
Project Type ☐ New ☐ Addition ☐ Alteration ☐ Repair ☐ Demolition
Proposed Use ____________
Work Description ____________

Total Square Ft ________ Valuation $ ________ Fee ________

I hereby certify that I have read and examined this document and know the same to be true and correct. All provisions of laws and ordinances governing this type of work will be complied with whether specified herein or not. I further certify that I am the owner or the owner's authorized agent and that the proposed work is authorized by the owner. I understand that work shall not begin until the permit is issued by this department, that I am responsible for calling for all required inspections, that work shall be accessible for inspection, that a final inspection, approval and Certificate of Occupancy are required prior to occupying this building. Fees are non-refundable except when the permit and construction are cancelled before work begins, in which case the applicant may apply for a partial refund in accordance with the refund policy. This permit application is only for the work described above. Every permit issued shall become invalid unless the work authorized by such permit is commenced within 180 days after its issuance, or if the work authorized by such permit is suspended or abandoned for a period of 180 days after the time the work is commenced.

Applicant ________ Signature ________
Address ________ Phone ________
Amount Paid ________ Date ________ Received by ________

FIGURE 2-1 Application for permit

Code Essentials

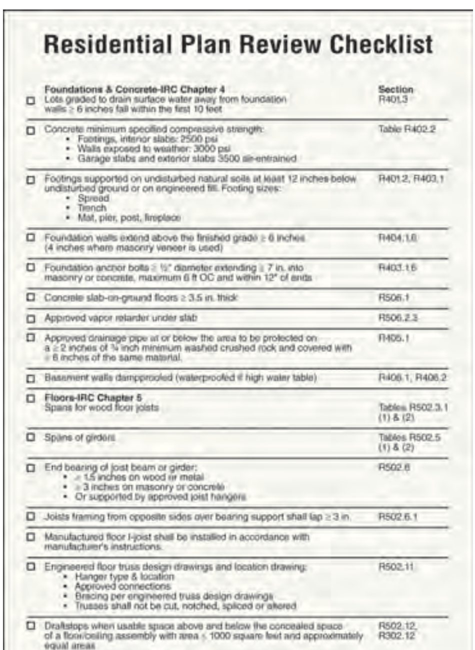
Building work exempt from permits:

- One-story tool and storage sheds, playhouses and similar uses ≤200 square feet
- Fences ≤7 feet high
- Retaining walls ≤4 feet high
- Sidewalks and driveways
- Painting, papering, tiling, carpeting
- Cabinets, countertops and similar finish work
- Prefabricated swimming pools ≤24 inches deep
- Swings and playground equipment
- Window awnings that project ≤54 inches
- Decks ≤30 inches above grade, not attached to dwelling and not serving required exit door

Plans and Specifications

Construction drawings and other submittal documents must accompany the permit application and be of sufficient detail and clarity to verify compliance with the code. The code also requires a site plan showing all new and existing structures with distances to lot lines. The extent of construction documents varies with the complexity and scope of the project. The building official is authorized to waive submittal documents for work of a minor nature, provided that code compliance can be verified by other means. State laws determine requirements for a registered design professional to prepare the construction documents. In the case of any special conditions as determined by the building official, such as the sizing of a steel beam or the support for a concentrated load, the building official is also authorized to require plans to be prepared by a registered architect or engineer. [Ref. MR 1300.0130]

A detailed review of plans and specifications is necessary to verify that the design complies with the code, thereby avoiding costly modifications during the course of construction. Jurisdictional policies differ in the handling of incomplete or incorrect plans. Depending on the complexity of the project and the significance of errors or omissions, the plans examiner, on behalf of the building official, may furnish comments or a list of code requirements to the applicant, may request supplemental information from the applicant, or may reject the plans and require submittal of revised documents (Figure 2-2).



Residential Plan Review Checklist

		Section
☐	**Foundations & Concrete-IRC Chapter 4** Lots graded to drain surface water away from foundation walls ≥ 6 inches fall within the first 10 feet	R401.3
☐	Concrete minimum specified compressive strength: • Footings, interior slabs: 2500 psi • Walls exposed to weather: 3000 psi • Garage slabs and exterior slabs 3500 air-entrained	Table R402.2
☐	Footings supported on undisturbed natural soils at least 12 inches below undisturbed ground or on engineered fill. Footing sizes: • Spread • Trench • Mat, pier, post, fireplace	R401.2, R403.1
☐	Foundation walls extend above the finished grade ≥ 6 inches (4 inches where masonry veneer is used)	R404.1.6
☐	Foundation anchor bolts ≥ ½" diameter extending ≥ 7 in. into masonry or concrete, maximum 6 ft OC and within 12" of ends	R403.1.6
☐	Concrete slab-on-ground floors ≥ 3.5 in. thick	R506.1
☐	Approved vapor retarder under slab	R506.2.3
☐	Approved drainage pipe at or below the area to be protected on a ≥ 2 inches of ¾ inch minimum washed crushed rock and covered with ≥ 6 inches of the same material.	R405.1
☐	Basement walls dampproofed (waterproofed if high water table)	R406.1, R406.2
☐	**Floors-IRC Chapter 5** Spans for wood floor joists	Tables R502.3.1 (1) & (2)
☐	Spans of girders	Tables R502.5 (1) & (2)
☐	End bearing of joist beam or girder: • ≥ 1.5 inches on wood or metal • ≥ 3 inches on masonry or concrete • Or supported by approved joist hangers	R502.6
☐	Joists framing from opposite sides over bearing support shall lap ≥ 3 in.	R502.6.1
☐	Manufactured floor I-joist shall be installed in accordance with manufacturer's instructions.	
☐	Engineered floor truss design drawings and location drawing: • Hanger type & location • Approved connections • Bracing per engineered truss design drawings • Trusses shall not be cut, notched, spliced or altered	R502.11
☐	Draftstops when usable space above and below the concealed space of a floor/ceiling assembly with area ≤ 1000 square feet and approximately equal areas	R502.12, R302.12

FIGURE 2-2 Sample portion of a plan review checklist

Fees

The jurisdiction establishes a schedule of fees at a level sufficient to offset the costs of providing the associated services to the public, including administration, plan review and inspection. Permit fees are based on the total value of the work included in the scope of the permit. Valuation for manufactured homes, prefabricated buildings and industrialized or modular buildings with labels from HUD, DLI or IIBC should only have a permit fee based on work done at the job site. Residential projects may be charged a fixed fee for maintenance permits. Similar plans may only require a plan review fee of 25-percent of the normal permit fee. Each building must have its own individual plan set submitted. [Ref. MR 1300.0160]

Permit Issuance

In the language of the code, the building official must review the application and construction documents within a reasonable time and, when approved, issue the permit as soon as is practicable (Figure 2-3). The length of time considered reasonable will vary based on several factors, such as the complexity of the project and the completeness of the construction documents. The intent of the code is to allow sufficient time for a thorough review of plans to determine code compliance and to issue the permit in a timely manner to avoid unnecessary delays in the construction schedule, resulting in hardship to the applicant. A copy of the permit and the approved construction documents must be kept on the jobsite until completion of the project. [Ref. MR 1300.0120, Subp. 9, 11, and 13]

Code Essentials

Permit-holder responsibilities:

- Permit on jobsite
- Approved plans on jobsite
- Call for inspection
- Provide access for inspection
- Compliance with code.

Building Department
City Of

Notice
Building Permit

Permit No. 00-0000

Has been issued to

Owner ______________________

Contractor ______________________

For (Work Description) ______________________

At (Project Address) ______________________

(Date) — **Issue Date**

(Building Official Signature) — **Building Official**

The issuance or granting of a permit shall not be construed to be a permit for, or an approval of, any violation of any of the provisions of the city building code or of any other ordinance of the jurisdiction.

A copy of this building permit shall be kept on the site of the work until the completion of the project.

The permit holder or authorized agent is responsible for calling for all required inspections before work is covered and for providing access to the work. Do not occupy this building, or portion of building as described, until final inspection, approval and issuance of the certificate of occupancy.

This permit expires ___/___/___

City Building Department
(000) 000-0000

FIGURE 2-3 Issued building permit card

INSPECTIONS

Inspection of the work by qualified personnel at various stages throughout the construction process is essential to verify compliance with the code and the approved plans. The building official shall provide the applicant with policies, procedures, and a timeline for requesting inspections. It is the responsibility of the permit holder or agent to call for the required inspections before work is concealed and to provide access to such work. If inspection reveals work that does not comply with the code, the inspector notifies the permit holder or agent of the deficiencies requiring correction. The inspector must approve the corrected portions of the work before they are concealed. When work is satisfactory, the inspector typically indicates approval with an inspection sticker or tag (Figure 2-4), email to the permit holder, or by signing a record-of-inspections card authorizing work to proceed (Figure 2-5). [MR 1300.0210]


Department of Building Safety
Phone (###) 555-4567

INSPECTION APPROVED

Building
Electrical
Plumbing
Mechanical

Description: ____________

Comments ____________

Date: ____________

Inspector: ____________

FIGURE 2-4 Inspection approval tag

Required Inspections

The MRC specifically requires certain inspections during the course of construction when applicable. [Ref. MR 1300.0210, Subp. 6]

Foundation

Inspection begins when the excavation is complete, the forms have been set, reinforcing is in place and concrete has not been placed. This inspection checks:

- Setback from lot lines
- Dimensions
- Reinforcing
- Suitable soil or base materials
- Vegetation, loose soil and debris removed
- Sufficient depth for frost protection
- Concrete mix specifications

Flood Plain

The inspection begins when lowest floor is in place in designated flood hazard areas. This inspection is not required in areas with no flood hazard.

- Elevation certificate is prepared and sealed by a registered design professional before work proceeds above.

Inspection Record

Building Department
City Of

Permit No. ____________________

Name ____________________

Address ____________________

INSPECTOR SHALL SIGN ALL SPACES WHICH APPLY TO THIS JOB

Inspection Category	Date	Comment	Inspector
Foundation Inspection:			
Setbacks, Footings			
Under Slab Inspections:			
Plumbing			
Mechanical			
Electrical			
Utility Inspections:			
Electrical Service			
Gas Piping/Air Test			
Rough-In Inspections:			
Plumbing			
Mechanical (HVAC)			
Electrical			
Framing			

DO NOT COVER WORK
UNTIL IT IS INSPECTED, APPROVED AND ABOVE SPACES ARE SIGNED

Inspection Category	Date	Comment	Inspector
Final Inspection			

DO NOT OCCUPY
Final Inspection Approval and Certificate of Occupancy
issued by the building department are required before occupying this building

FIGURE 2-5 Jobsite inspection record card

Plumbing, Mechanical, Gas and Electrical Rough-In

These inspections occur when underground work is complete, rough-in stage is complete and utility connections have been made. These inspections check:

- Materials, fittings and methods
- Work properly supported and protected
- Pressure testing of piping systems

Frame and Masonry

This inspection occurs after plumbing, mechanical and electrical rough inspections are approved, and the framing and masonry are complete. This inspection checks:

- Size, spacing, connection and continuity of all structural members
- Load path from roof to foundation
- Engineered components
- Draftstopping and fireblocking
- Stair rise and run
- Locations and dimensions of emergency-escape openings
- Applicable areas of energy efficiency
- Fireplaces

Fire-Resistance-Rated Construction

This inspection occurs when gypsum board fire-resistance-rated assemblies have been installed between dwelling units and any exterior walls close to lot lines are complete. The inspection checks:

- Gypsum materials
- Fastener type, size and spacing conform to the approved fire-resistance-rated assembly details

Final

This inspection checks that all work under a permit is complete and the building is ready for occupancy. The following are checked for proper functioning and/or placement:

- Comfort heating, cooling and ventilation equipment and systems
- Plumbing fixtures and systems
- Electrical circuits, devices and fixtures
- Stairs, railings, landings and other means-of-egress components
- Smoke alarms
- Emergency-escape and -rescue openings
- Applicable areas of energy efficiency

- Exterior finish, siding and roofing
- Grading and drainage
- Energy code inspections

Installation of manufactured homes shall be made after the installation of the support systems and all utility service connections are in place, but before any covering or skirting is in place.

Other Inspections

The building official is authorized to require additional inspections as may be necessary to ensure compliance with the code. Inspections may also be desirable to verify the installation of unusual, special, or engineered components or systems. For example, a cast-in-place or precast structural concrete floor or deck (Figure 2-6) is an engineered structure, the design of which is outside the prescriptive provisions of the MRC. The inspector must verify dimensions, materials, anchorage, reinforcing and other details to ensure conformance to the engineered drawings.

FIGURE 2-6 Precast concrete is outside the prescriptive provisions of the MRC but is approved as an engineered system and inspected for conformance to the construction documents.

Certificate of Occupancy

Jurisdiction of ____________________

This structure or portion of structure as described below has been inspected for compliance with the International Residential Code (IRC) and is hereby issued a certificate of occupancy.

Description of applicable portion of structure ____________________

Building permit number ____________

Address of the structure ____________________

Code edition ____________

Name of owner or owner's authorized agent ____________________

Sprinkler system required ☐ yes ☐ no

Sprinkler system installed ☐ yes ☐ no

Address of owner or owner's authorized agent ____________________

Special conditions ____________________

Building Official ____________________

FIGURE 2-7 Required information for certificate of occupancy

Certificate of Occupancy

The MRC requires issuance of a certificate of occupancy (Figure 2-7), indicating that the work has passed final inspection before a dwelling unit, or the portion of the dwelling unit covered by the permit can be occupied. [Ref. MR 1300.0220]

BOARD OF APPEALS

The administration chapter of the MRC creates authority and duties for the building official but intends that actions in enforcing the code be reasonable, and also clearly expresses rights of due process for the public. Such is the case in the right to appeal an order, decision or determination of the building official. Any aggrieved party with a material interest in the decision of the building official may apply for redress to the board of appeals. The governing body, such as the city council, appoints the board members, who are qualified by experience and training to hear and rule on matters related to building construction. The intent is to put in place an objective and knowledgeable group of citizens to review the decisions of the building official and consider the merits of any appeal. For jurisdictions without a board of appeals, an appeal may be made to the appeals board of the Minnesota Department of Labor and Industry's Construction Codes and Licensing Division.

The MRC limits the basis for appeal to matters pertaining to the code requirements. The appellant must claim that the building official has erred in interpreting the code or has wrongly applied a code section. The other basis for appeal is that the appellant considers a proposed alternative to be equal to the code requirements. The MRC does not permit the filing of an appeal seeking a variance or a waiver, and the board has no authority to waive code requirements. [Ref. MR 1300.0230]

Code Essentials

Basis for appeal:

- The code has been interpreted incorrectly.
- The code does not apply.
- An equal alternative is proposed.

PART II Site Development

Chapter 3 Site Preparation

CHAPTER 3

Site Preparation

In preparation for constructing buildings on a property, the builder must consider a number of factors related to code requirements. The buildings must be located according to the approved site plan to meet the requirements of the *Minnesota Residential Code* (MRC) and any applicable local ordinances. The soil must be suitable for the support of the building and is factored into the design of the foundations. The building must be elevated sufficiently and the site graded to provide surface drainage away from the building. The plans examiner considers these factors when checking the construction drawings and site plan, but the inspector will be responsible for verifying the requirements at the jobsite (Figure 3-1).

FIGURE 3-1 Sitework

LOCATION ON PROPERTY

The MRC regulates a building's location on the property primarily to guard against the spread of fire. The code is concerned with not only protecting the new building on the property being developed, but preventing the spread of fire to buildings on the adjacent property. Structural considerations also play a part in locating buildings on a lot. The code regulates distances between the structure and adjacent steep slopes to protect the integrity of the foundation. Local zoning or other ordinances may be more restrictive in regulating the location, height and area of buildings on properties.

Fire Separation Distance

By definition, fire separation distance (FSD) is measured from the face of the building to the lot line, centerline of a street or alley, or to an imaginary line between two buildings. However, for all practical purposes, fire separation distance typically will be of concern only when measured to the interior lot line. No separation distance or fire resistance rating is required for opposing walls of detached dwellings and accessory structures on the same lot. Fire separation distance is measured at a right angle to the face of the exterior wall (Figure 3-2). [Ref. R202]

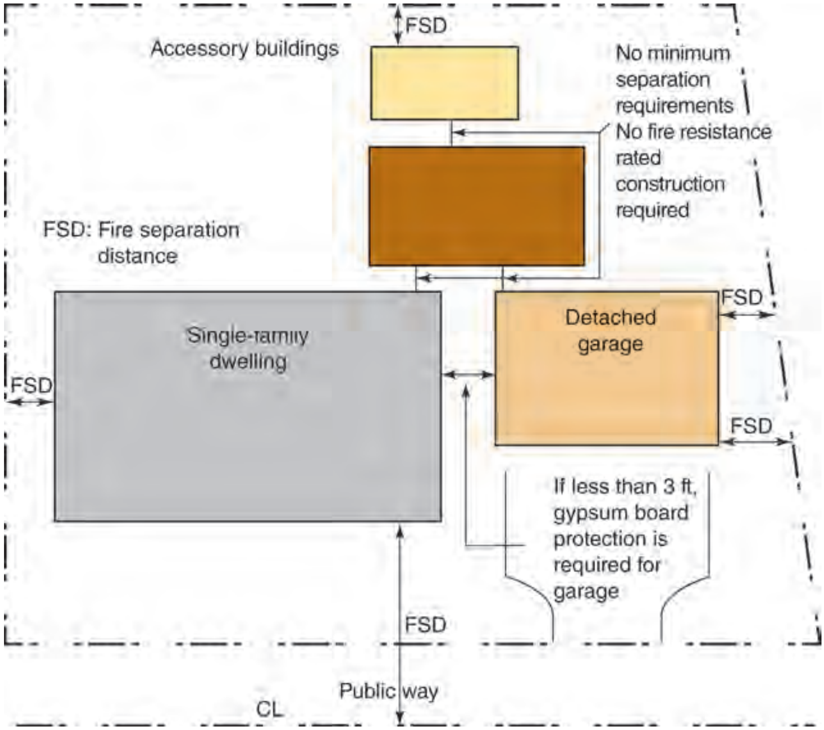


FIGURE 3-2 Measuring fire separation distance

Provisions that regulate the construction of exterior walls in proximity to lot lines have long been recognized as effective in preventing the spread of fire from a building on one property to a building on another property. Protection can be achieved by providing a clear space between the building and lot line or by using fire-resistant-rated construction. The code does not prohibit placing a building with zero clearance to the lot line provided the exterior wall meets the prescribed fire resistance requirements. When the building is set a certain distance away from the lot line, fire resistance is not required. For dwellings and townhouses protected with an automatic fire sprinkler system, this minimum separation distance is 3 feet. For dwellings without sprinkler systems and for detached accessory buildings, the minimum separation between the unrated wall and the lot line is 5 feet. (See Chapter 9 for further discussion of fire separation distance and fire-resistant protection of exterior wall). [Ref. R302.1]

Code Essentials

Exterior walls perpendicular to the wall facing the property line
- No minimum fire separation distance
- Fire resistance not required
- Unlimited openings
- No protection required for penetrations

Location of Foundations Adjacent to Slopes

Where slopes are steeper than 33.3 percent (4 inches per foot), foundations must be located a sufficient distance away from the slope to protect the integrity of the structure and provide adequate lateral support to the footing. The clearance distance is based on the height of the slope. For a building located adjacent to the top of the slope (descending), the minimum distance is the height divided by 3, but does not need to exceed 40 feet. For a building located adjacent to the bottom of the slope (ascending), the minimum clearance is the height divided by 2, but does not need to exceed 15 feet. The code gives the building official the authority to approve alternate setbacks with lesser distances to slopes based on a design by a qualified engineer taking all site conditions into consideration (Figure 3-3). [Ref. R403.1.7]

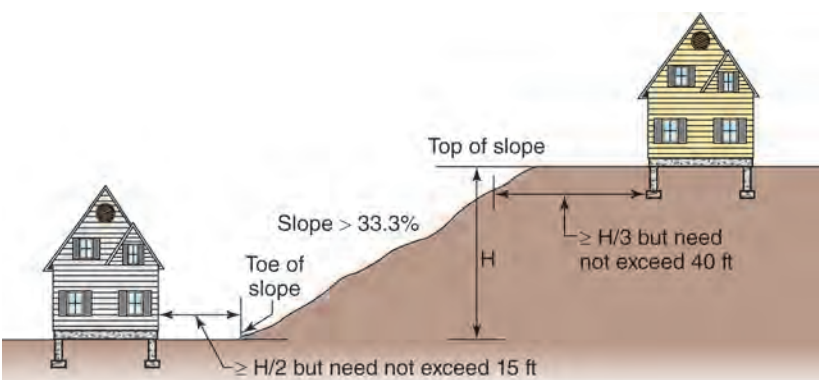


FIGURE 3-3 Foundations adjacent to slopes

SITE PREPARATION

Regulation of site preparation activities related to construction of buildings under the MRC varies based on geographic location and local or site-specific conditions. The code is basically concerned with two things: soil characteristics related to the support and stability of foundations and grading to provide surface drainage away from foundations. Additionally, construction in flood hazard areas must comply with the elevation and design requirements of the MRC and Minnesota Floodproofing requirements contained in Minnesota Rules, chapter 1335. There may also be local ordinances or state laws that require grading permits and regulate erosion control, storm water management and soil conservation measures. A number of other factors may affect site preparation and building design, including high water tables and sloped sites.

General Site Requirements

Preparation of the site for construction includes stripping of vegetation and topsoil, grading to the rough contours if necessary and excavation for basements and foundations. The MRC requires that all exterior footings be placed at least 12 inches below the undisturbed ground level and be protected against frost. The code requires frost protection of footings by extending footings below the frost line, constructing a frost-protected shallow foundation, slab-on-grade construction as permitted by the MRC, or an alternative design prepared by an engineer competent in soil mechanics. Required footing depths below grade shall be either 42″ (Zone II) or 60″ (Zone I) depending on the county where the structure is being built (Figure 3-4). Footings must bear on undisturbed natural soil or compacted engineered fill (covered later in this chapter under "Fill"). The code also prescribes suitable base requirements for basement and garage floors, other slabs on grade and the base for crawl spaces. In all cases, the ground must be stripped of vegetation and organic material. The base for concrete floor slabs within the perimeter walls must be of suitable materials and compacted to prevent settlement. The thickness of compacted fill material below slabs is generally limited to 24 inches for clean sand or gravel and 8 inches for soil unless otherwise approved by the building official. [Ref. R403.1, R408.5, R506.2]

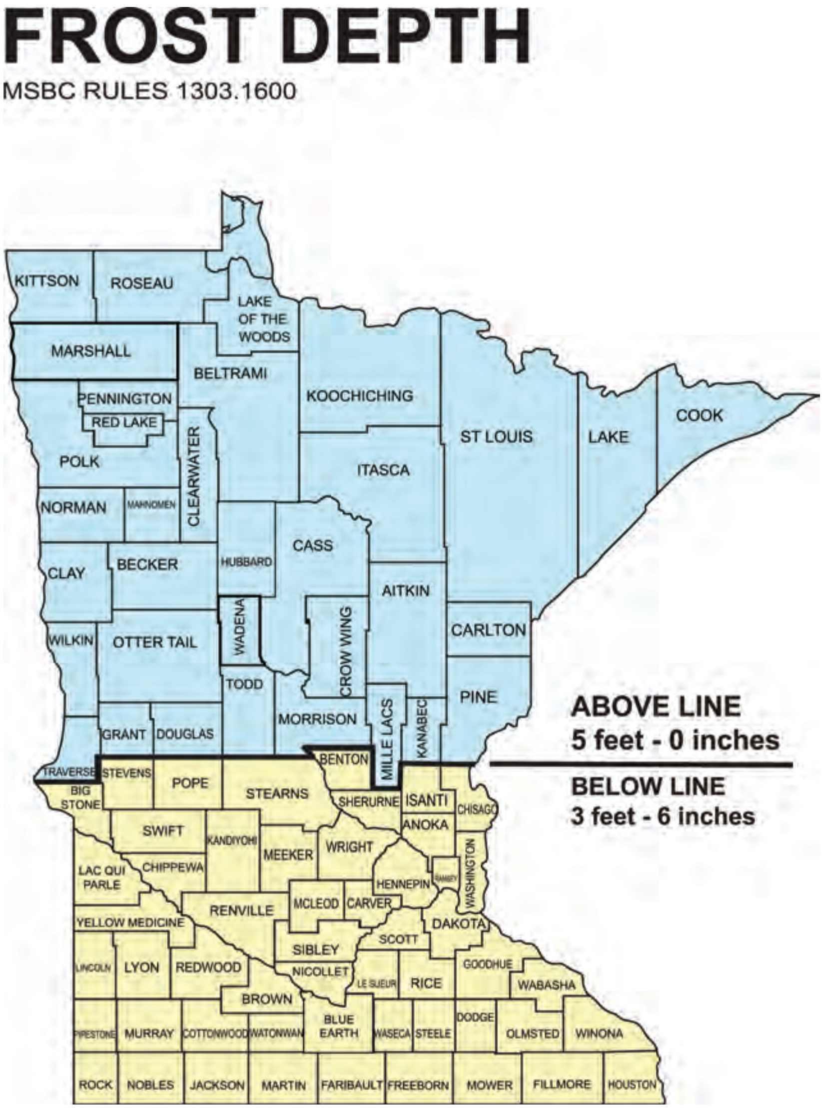


FIGURE 3-4 Minnesota Frost Depth Map

Soil Properties

The designer or builder must carefully consider soil properties not only for adequate support of the foundation but also for stability to prevent future damage to the structure. Based on experience and known local soil conditions, the building official will often permit design based on a presumptive load-bearing value without soil testing or a geotechnical report. Typically, the presumed load-bearing value will range from 1,500 to 3,000 pounds per square foot (psf) based on local soil conditions and according to the values in Table 3-1. The building official may assume conservative values based on the average or the lowest soil characteristics likely to be encountered on a site. Soil type is verified at the time of footing inspection. If found to be of a poorer grade than the presumed value, testing or mitigation is required prior to placing concrete footings. The builder always has the option of providing the results of soil testing in a geotechnical report in order to use a higher load-bearing value than would otherwise be presumed. [Ref. R401.4.1]

Where available data indicates that the soil may not be suitable for the foundation design, the building official is authorized to require a geotechnical evaluation and report prepared by an approved agency or registered design professional. Expansive, compressible or shifting soils have the potential to damage the structure. Highly organic soils (laden with decayed material from plants and animals), such as organic clays, organic silts and peat and are outside the scope of foundation design under the MRC. In addition to organic materials, certain inorganic clays and silts are highly expansive. Such soils expand when wet and contract as they dry, exerting significant pressures against the footing and foundation and thereby causing shifting or differential settlement that could result in structural failure. Expansive soil conditions require an engineered foundation design in accordance with the MRC. In some cases it may be possible to remove unsuitable shifting or compressible soils from the building site and replace them with approved fill to stabilize the soil below and around foundations. Under these conditions, the MRC permits a prescriptive foundation design without a full geotechnical evaluation. [Ref. R401.4.2]

Fill

Overexcavation to remove unsuitable soils or the addition of material to raise the elevation of the footings above the level of the natural undisturbed soil requires engineered fill material to support the footings and foundation. A registered design professional is responsible for the design and placement of the fill material in accordance with accepted engineering practice. The engineered fill must be installed and tested in conformance with the design requirements. Fill materials are typically sand, crushed rock, clean gravel or a mix of granular materials. Fill material may contain finer particles that fill voids and help bind the larger elements together. Materials with rounded edges such as river rock or pea gravel are not usually considered suitable for structural fill. The engineer's design specifies the maximum thickness of each layer of fill, called a lift, prior to mechanical compaction. A technician tests the compacted fill to verify that it meets

TABLE 3-1 Properties of Soils Classified According to the Unified Soil Classification System

Soil Group[b]	Unified Soil Classification System Symbol	Soil Description	Drainage Characteristics[a]	Frost Heave Potential	Load Bearing Pressure (psf)
Group I	GW	Well-graded gravels, gravel sand mixtures, little or no fines	Good	Low	3,000
	GP	Poorly graded gravels or gravel sand mixtures, little or no fines	Good	Low	3,000
	SW	Well-graded sands, gravelly sands, little or no fines	Good	Low	2,000
	SP	Poorly graded sands or gravelly sands, little or no fines	Good	Low	2,000
	GM	Silty gravels, gravel-sand-silt mixtures	Good	Medium	2,000
	SM	Silty sand, sand-silt mixtures	Good	Medium	2,000
Group II	GC	Clayey gravels, gravel-sand-clay mixtures	Medium	Medium	2,000
	SC	Clayey sands, sand-clay mixture	Medium	Medium	2,000
	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity	Medium	High	1,500
	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	Medium	Medium	1,500

(continued)

TABLE 3-1 (continued)

Soil Group[b]	Unified Soil Classification System Symbol	Soil Description	Drainage Characteristics[a]	Frost Heave Potential	Load Bearing Pressure (psf)
Group III	CH	Inorganic clays of high plasticity, fat clays	Poor	Medium	1,500
	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	Poor	High	1,500
Group IV	OL	Organic silts and organic silty clays of low plasticity	Poor	Medium	-
	OH	Organic clays of medium to high plasticity, organic silts	Unsatisfactory	Medium	-
	Pt	Peat and other highly organic soils	Unsatisfactory	Medium	-

For SI: 1 inch = 25.4 mm. [Ref. excerpt of Tables R401.4.1 and 405.1]

a. The percolation rate for good drainage is over 4 inches per hour, medium drainage is 2 inches to 4 inches per hour, and poor is less than 2 inches per hour.

b. See the MRC for "Volume Change Potential Expansion" information.

the minimum compaction and design specifications. Builders should also exercise care during the backfill of foundations with suitable fill materials to provide adequate drainage and to prevent damage to the foundation. [Ref. MR 1300.0130, R401.2]

STORM DRAINAGE

The MRC prescribes methods to direct surface water away from the foundation to an approved location. Water held against the foundation leads to wet or damp basements or crawl spaces and over time can cause damage to construction materials both inside and outside the structure. Mold thrives in such moist environments, contributing to an unhealthy living environment. In addition, water saturation of the soils adjacent to foundations increases the lateral pressure against the structure. Proper design of surface drainage also prevents nuisance ponding on the lot and possible flooding of structures during periods of heavy rain.

The MRC lends some discretion to the building official in determining alternate methods for adequate drainage. Department policy for verifying proper surface drainage on properties will likely vary depending on geographic location, permeability of soils and local history of damage and nuisances created by inadequate drainage. The building official is authorized to require submittal documentation sufficient to demonstrate compliance with the code. If deemed necessary, this may entail a detailed drainage plan with existing and proposed topographic contours, elevations, points of discharge and any containment features. The building official may require that a registered design professional prepare such drainage plans. In many cases, a drainage plan is already established as part of the master plan for the entire housing development and additional plans are not necessary. Other jurisdictions may require only some indication of the direction of drainage flow on the required site plan or may verify drainage on site visually without measurement at the time of inspection (Figure 3-5).

The MRC is most concerned with drainage in the immediate vicinity of the structure. The surface of the final grade is required to fall a minimum of 6 inches within the first 10 feet away from the foundation (Figure 3-6). Depending on local site conditions, it is not always possible to achieve that much fall and the code permits alternative designs to drain the water away from the foundation. In this case, the surface water may be directed to swales or drains to ensure adequate drainage away from the structure. Impervious surfaces within 10 feet of the foundation, such as concrete driveways, sidewalks and patios, must be sloped not less than 2 percent away from the structure (Figure 3-7). [Ref. R401.3, R404.1.6]

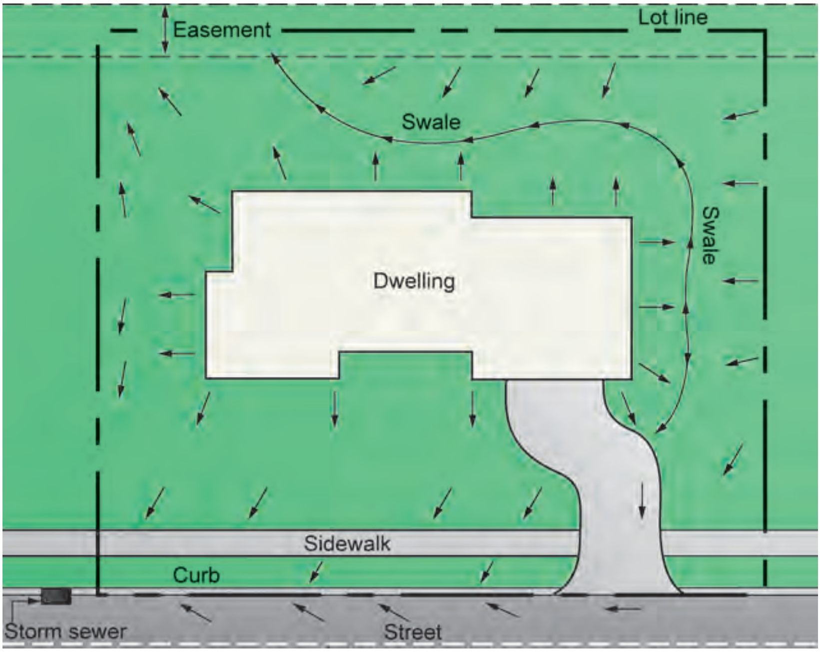


FIGURE 3-5 Drainage plan

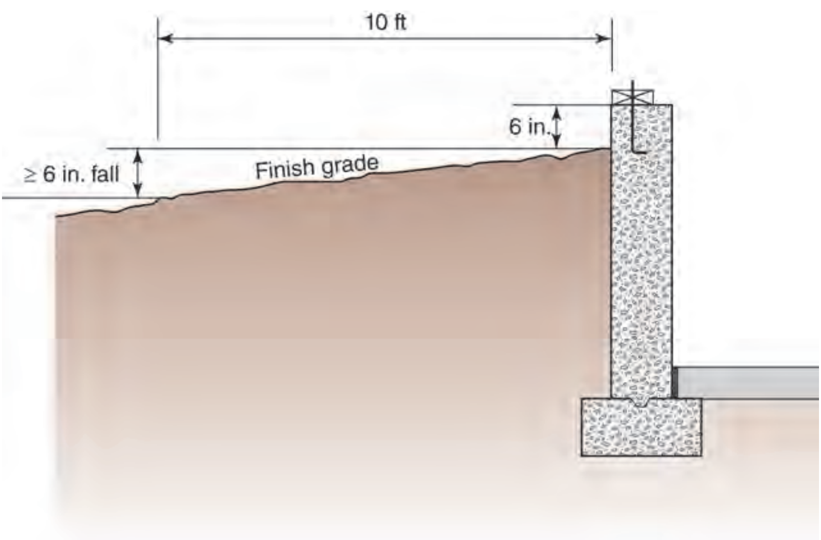


FIGURE 3-6 Grade sloped 6 inches in 10 feet to provide surface drainage away from foundation

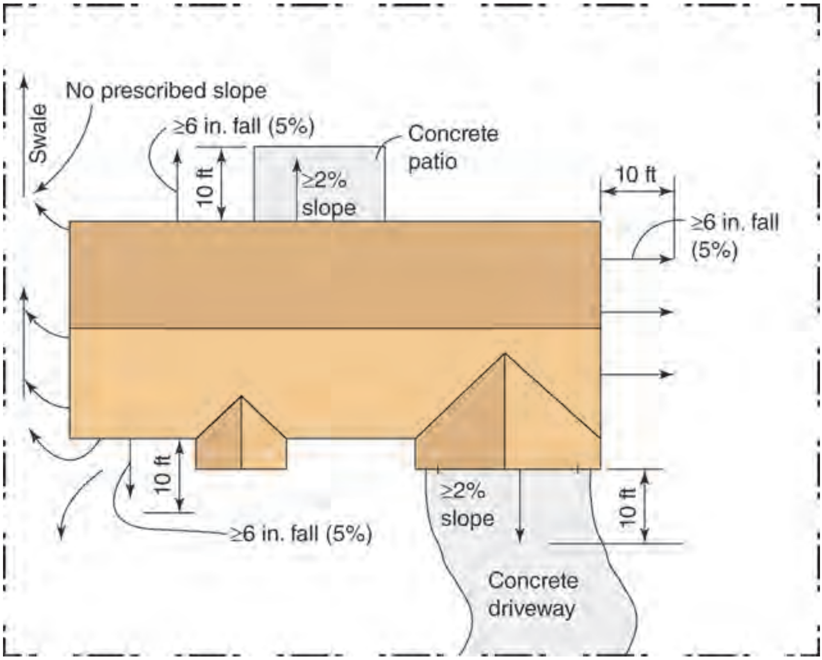


FIGURE 3-7 Grade to ensure surface drainage away from structure

Though the prescribed slopes as previously discussed are concerned with the first 10 feet away from the structure, the MRC also has requirements for drainage to an approved location such as a storm drain, storm sewer inlet or the street gutter that leads to a storm drain. The drainage design must consider the entire lot for any impediments to drainage during heavy rains. [Ref. R401.3]

FLOOD HAZARD AREAS

Flood-resistant construction requirements shall comply with Minnesota Rules, chapter 1335. [Ref. R322]

PART III
Structural

CHAPTER 4 Structural Design Criteria

The *Minnesota Residential Code* (MRC) establishes minimum structural design criteria necessary to accommodate normal loads placed on a building and to resist the forces of natural hazards such as wind, snow, and flood. In most cases, the prescriptive provisions of the code incorporate these criteria and offer a means of conventional construction without the need for an engineered design or complex calculations (Figure 4-1). To correctly apply the values of the tables and the prescriptive methods of construction, it is necessary to understand the structural design criteria based on geographic location and climate. The applicable design criteria and corresponding values are located in Table R301.2(1) (Table 4-1). In addition to structural design considerations, there are criteria for environmental hazards such as roof ice dams and termites. These topics are discussed in later chapters. [Ref. R301.1, R301.2]

FIGURE 4-1 Concrete, dimension lumber, engineered wood and steel structural elements of a single-family dwelling

PRESCRIPTIVE AND PERFORMANCE

The intent of the code is to provide comprehensive but easy to use minimum standards for the conventional construction of residential buildings and at the same time provide the greatest design flexibility in recognizing other methods and materials of construction. With this in mind, the MRC contains both prescriptive and performance requirements. Prescriptive means a set of rules the builder may follow to ensure that the building complies with the code. Performance means an expectation that the building system will function in a certain way to meet the minimum requirements of the code. In terms of the structural requirements, performance is typically achieved through engineering.

Code Essentials

Prescriptive vs. performance (structural)

Prescriptive provision:

- Spans for wood floor joists shall be in accordance with Tables R502.3.1(1) and R502.3.1(2)

Performance provision:

- Wood floor trusses shall be designed in accordance with approved engineering practice

TABLE 4-1 Climatic and geographic design criteria

Roof snow load	Wind design		Seismic design category
	Speed (mph)	Topographic effects	
$P_f = 0.7 * p_g$	115	Yes	A

Subject to damage from			Winter design temp	Ice barrier underlayment required	Flood hazard	Air freezing index	Mean annual temp
Weathering	Frost line depth	Termite					
Severe	See MR part 1303.1600[c]	See Footnote 'a'	See MR Chapter 1322	Yes	See MR Chapter 1335	See Table R403.3(2)	See Footnote[b]

[Ref. excerpt of Table R301.2(1)]

a. The jurisdiction shall fill in this part of the table to indicate the need for protection depending on whether there has been a history of local subterranean termite damage.

b. The jurisdiction shall fill in this part of the table with the mean annual temperature from the National Climatic Data Center data table "Average Mean Temperature Index" at www.ncdc.noaa.gov.sites/default/files/attachments/Air-Freezing-Index-Return-Periods-and-Associated-Probabilities.pdf.

c. Reference MRC for complete table and footnote content.

When using the conventional construction provisions, an engineered design is necessary for only those structural elements that exceed the limits of or are otherwise not included in the prescriptive provisions of the code. For example, the sizing of wide flange steel beams commonly used in dwelling construction is outside the scope of the MRC conventional framing systems and must be designed in accordance with accepted engineering practice. This does not prevent the designer and builder from using the prescriptive methods for the rest of the building. In other words, the MRC permits partial or complete engineering of the structure and offers the prescriptive methods as an option, but they are not mandatory. The code imposes seismic, wind and snow loading limitations on the use of the prescriptive framing methods, as will be discussed in later sections of this chapter. [Ref. R301.1.2, R301.1.3]

BASIC LOADS (LIVE AND DEAD)

Building construction must safely support all loads, meaning the forces acting on the building. Gravity loads refer to the weight of objects bearing down on the structure and include live loads, dead loads and roof loads. Live loads are the variable loads related to the use of the structure, such as people and furniture. Prescriptive design presumes uniform distribution of the live loads expressed in pounds per square foot (psf) based on the use of the space (Table 4-2). Dead loads are permanent in nature and include the weights of all construction materials and fixed equipment incorporated into the building. The prescriptive tables in the MRC include the combined effects of live loads and dead loads. The total roof load is a combination of dead and live loads, except for buildings in regions where the roof snow load exceeds the roof live load. The roof framing is required to support the roof snow load. [Ref. R301.4, R301.5, R301.6, Table R301.5 , MR 1303.1700]

Live Loads

Designs for bedroom areas assume a uniform floor live load of not less than 30 psf, and all other living areas of a dwelling require a minimum live load of 40 psf. Such loads are reflected in the prescriptive tables of the code. Elevated garage floors for vehicles must be designed for a minimum uniform live load of 50 psf and be capable of supporting a concentrated load of 2,000 pounds on any 20-square-inch area. Typically requiring an engineered design, this criterion is necessary to accommodate the concentrated load of a vehicle transferred to the relatively small area of the tires in contact with any portion of the floor.

TABLE 4-2 Minimum live loads

Use	Live load (psf)	Note
Rooms other than sleeping rooms	40	
Sleeping rooms	30	
Balconies and decks	40	
Stairs	40	Concentrated load of 300 lb./4 sq. in. of tread
Guards and handrails		Concentrated load of 200 lb. applied in any direction
Guard in-fill components		Horizontally applied load of 50 lb. on an area of 1 sq. ft.
Passenger vehicle garages	50	Elevated garage floors must support a concentrated load of 2,000 lb./20 sq. in.
Attics without storage	10	
Attics with limited storage	20	A storage area that is at least 24 in. wide × 42 in. high with an access hatch or pull-down stair
Attics served by a fixed stair	30	
Habitable attics	30	Floor area ≥ 70 sq. ft. meeting ceiling height requirements

[Ref. excerpt of Table R301.5]

The performance requirements of stairs and railings present some challenges to the builder and inspector in verifying compliance with the code. Although the MRC does specify minimum loading requirements, it does not include prescriptive structural design provisions for these elements, although numerous conventional and traditional methods are often deemed acceptable without requiring engineering or supporting documentation. Guards and handrails must be secured to safely resist the code-prescribed forces that could act against them. Handrails and top rails of guards are required to be constructed so that they are capable of resisting a 200-pound concentrated force from any direction. The infill components of a guard—often spindles, balusters or intermediate rails—must be able to safely resist 50 pounds applied over a 1-square-foot area.

Although engineering methods could be used to design guard systems and mechanical instruments are available to measure the forces applied to railing components, inspectors more often make a subjective determination of their adequacy based on the perceived strength and rigidity of the components when force is applied against them.

The same may be said for stairs. Stairs are required to be designed for a uniform load of 40 psf, and the treads must be able to support a concentrated load of 300 pounds acting on an area of 4 square inches. This is a conservative value to account for the entire weight of a person on the ball of the foot bearing on the tread. In most cases, $1^1/_4$-inch and 2-inch nominal thickness dimension lumber and manufactured composite stair treads are presumed to accommodate this concentrated load without supporting justification. The builder and inspector often judge the adequacy of the stair to resist the required loads by experience and simply walking the stair. Stiffness or bounce of the stair should be comparable to walking across a floor system that is properly constructed to comply with the code.

Dead Loads

Average dead loads are also included in the prescriptive tables for footings, floors, walls, and roofs. For example, spread footing sizes for conventional frame construction assume average weights of construction materials being supported. Therefore, additional calculations are typically not required. The material and component weights in Tables 4-3 and 4-4 may be helpful in sizing a post or pad footing or another structural element not covered in the MRC tables.

TABLE 4-3 Building material weights

Materials	Weight (psf)
Plywood, $^{1}/_{4}$ in.	0.8
Plywood, $^{1}/_{2}$ in.	1.6
Plywood, $^{3}/_{4}$ in.	2.4
Brick, 4 in.	39
Gypsum board, $^{1}/_{2}$ in.	2.2
Gypsum board, $^{5}/_{8}$ in.	2.75
Plaster, 1 in.	8.0
Stucco, $^{7}/_{8}$ in.	10.0
Quarry tile, $^{1}/_{2}$ in.	7.0
Hardwood flooring, $^{25}/_{32}$ in.	4.0
Built-up roofing	6.5
Shingles, asphalt	2.0
Shingles, wood	3.0
Common dimension lumber (pcf)	27–29 pcf
Concrete (pcf)	150 pcf

pcf = pounds per cubic foot

TABLE 4-4 Average weights of building components

Description	Weight (psf)
Roof dead load (framing, sheathing, asphalt shingles, insulation, drywall)	10
Exterior wall (2 × 4 framing, sheathing, siding, insulation, drywall)	10
Floor (joist, sheathing, carpeting, drywall)	10
Concrete wall, 8 in. thick	100
10 in. thick	125
12 in. thick	150
Concrete block wall, 8 in. thick	60

Deflection

Allowable deflection in structural framing members such as studs, joists, and beams is a way to ensure adequate stiffness when such members are subjected to bending under code-prescribed loads. For a floor joist, this may be understood as the bounce or give in the floor system as a person walks across a room. A design for less deflection will translate to more stiffness and therefore less bounce in the floor. The MRC sets limits on the maximum allowable deflection depending on the type of member involved. The code permits greater deflection, for example, in ceiling joists and rafters than in floor joists. These are minimum code requirements, and the homebuilder or homeowner may desire more stiffness and less bounce in a floor than the code would otherwise allow. Although deflection limitations are incorporated into the prescriptive tables, it is important to understand deflection in using the appropriate table for sizing a framing member. Allowable deflection is measured by dividing the span (L) of the member by a prescribed factor, such as 360 for floor joists. Thus the allowable deflection of a floor joist is expressed as L/360. [Ref. R301.7, Table R301.7]

WIND, SNOW, SEISMIC AND FLOOD LOADS

In addition to supporting the live and dead loads, the building must safely resist environmental load effects such as wind, snow, earthquake, and flood hazards. These forces may be vertical (up or down) or lateral (sideways) and are also referred to as loads. [Ref. R301.1]

Wind

Lateral wind pressure may be positive (pushing against the building on the windward side) or negative (suction forces on the leeward side of a building). Wind pressure can also produce upward suction forces referred to as uplift. The building resists wind forces with wall bracing, sheathing, and positive load path connections from the roof down to the foundation (Figure 4-2).

Conventional construction in accordance with the prescriptive provisions of the MRC is permitted throughout the state because the ultimate design wind speed is 115 mph. [Ref. R301.2.1]

Exposure Category

In addition to the wind speed for a geographic area, ground surface irregularities affect the wind forces placed on a building. Forested terrain or groups of buildings in close proximity shield a building from wind. Flat,

FIGURE 4-2 Wind forces acting on building

FIGURE 4-3 Wind exposure B

open terrain, on the other hand, exposes a building to the full effects of wind.

The MRC classifies wind exposure into three categories: B, C and D. Exposure B, the default and most common application, affords some wind protection with trees and buildings characteristic of urban and suburban settings (Figure 4-3). Exposure C is basically open terrain with scattered obstructions (Figure 4-4). Exposure D applies to buildings in flat, unobstructed areas exposed to wind flowing over open water or mud flats for a distance of 5,000 feet or more.

FIGURE 4-4 Wind exposure C

Exposure categories are important design criteria for engineering of buildings or portions of buildings resisting the effects of wind, and such criteria should appear on engineering submittal documents. Many of the prescriptive methods of wood frame construction in the MRC are generally deemed in compliance without consideration of the wind exposure category. However, wind exposure category is considered when applying the provisions for wall sheathing, wood wall bracing, roof uplift resistance, and exterior wall and roof coverings. Siding, roofing, windows, skylights, exterior doors and overhead doors must be manufactured and installed to resist wind loads based on wind speed, exposure factors and other criteria in accordance with the code. [Ref. R301.2.1]

Tornadoes

The MRC does not specifically address tornadoes, whose winds may exceed 250 mph, far in excess of design wind speeds. The intent of the code is to provide minimum standards of construction, including those to resist the effects of natural hazards. Buildings constructed in conformance with the code have demonstrated effectiveness in limiting damage due to high winds. The forces and effects of tornadoes are variable and unpredictable. It is not anticipated that a building of wood frame construction in the direct path of a high-intensity tornado will escape without significant damage (Figure 4-5).

FIGURE 4-5 Tornado damage

FIGURE 4-6 Minnesota ground snow loads are either 50 or 60 psf

Snow

Minnesota Rules, part 1303.1700, sets a ground snow load of 60 psf in the following counties: Aitkin, Becker, Beltrami, Carlton, Cass, Clearwater, Cook, Crow Wing, Hubbard, Itasca, Kanabec, Kittson, Koochiching, Lake, Lake of the Woods, Mahnomen, Marshall, Mille Lacs, Morrison, Norman, Otter Tail, Pennington, Pine, Polk, Red Lake, Roseau, St. Louis, Todd, and Wadena. The ground snow is 50 psf for all other counties (Figure 4-6). The prescriptive rafter tables reflect ground snow loads of 30, 50 and 70 psf. Engineered components such as roof trusses are designed for the roof snow

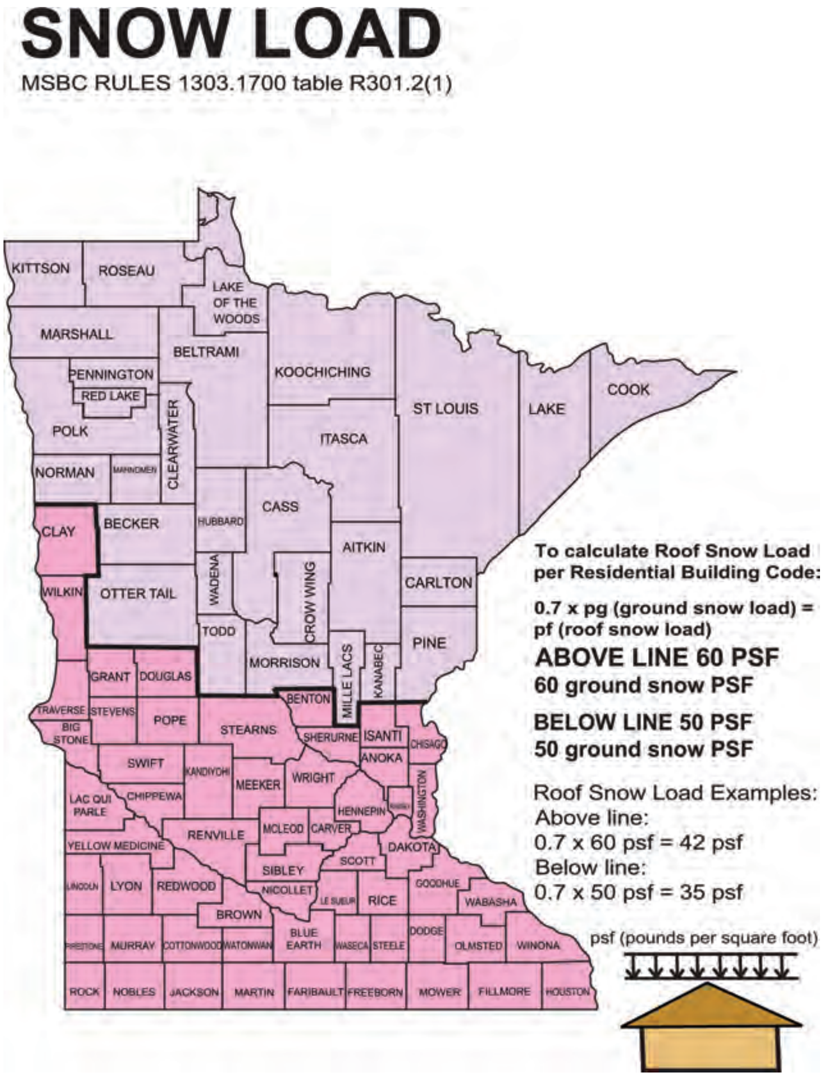


FIGURE 4-7 Minnesota Snow Map

load. Ground snow load is the basis for determining the roof snow load design criteria for engineered components (Figure 4-7). [Ref. R301.2.3]

Earthquake

Buildings must resist the effects of earthquakes and limit the resulting damage. Minnesota is located in an area of low seismicity, in Seismic Design Category (SDC)A, and all buildings are exempt from seismic design requirements. [Ref. R301.2.2]

CHAPTER

5 Foundations

The *Minnesota Residential Code* (MRC) contains prescriptive foundation designs to safely support building loads and transmit those loads to the soil. This chapter will focus primarily on the provisions for conventional concrete footings and concrete and masonry foundation walls (Figure 5-1). Soil characteristics and bearing capacities affecting foundation design are discussed in Chapter 3.

FIGURE 5-1 Concrete foundation forms for a single-family dwelling

MATERIALS

The two most common materials for foundation construction are concrete and *concrete masonry units* (CMUs), the latter often referred to as concrete block or simply masonry. The code does not intend to limit the use of different materials, however. In addition to prescriptive designs for other foundation systems incorporating wood, precast concrete, or *insulating concrete forms* (ICFs), the MRC permits engineered or alternative designs. [Ref. R402]

Concrete

Concrete continues to gain strength after the initial set through a chemical curing process. The compressive strength of concrete is related to the proportions of portland cement, sand, gravel, and water in the mix and is expressed in pounds per square inch (psi) after 28 days' curing time. The code requires concrete to have a minimum 28-day compressive strength of 2,500 psi for most applications, but concrete used for footings is required to have compressive strength of 5,000 psi (Table 5-1). Higher-strength concrete, often including entrained air, is specified for Minnesota because of the severe weathering potential when the concrete is exposed to the weather or is for a garage floor slab (Figure 5-2). [Ref. Table R402.2]

FIGURE 5-2 Pump to place concrete for the basement of a single-family dwelling

TABLE 5-1 Minimum specified compressive strength of concrete

Type or location of concrete construction	Minimum specified compressive strength[a] at 28 Days (psi) Weathering potential[b] Severe
Footing[g,h]	5,000
Basement walls, foundations and other concrete not exposed to the weather	2,500[c]
Basement slabs and interior slabs on grade, except garage floor slabs	2,500[c]
Basement walls, foundation walls, exterior walls and other vertical concrete work exposed to the weather	3,000[d]
Porches, carport slabs and steps exposed to the weather, and garage floor slabs	3,500[d,e,f]
[Ref. excerpt of Table R402.2]	

a. Strength at 28 days psi.
b. See Table R301.2(1) for weathering potential.
c. Concrete in these locations that may be subject to freezing and thawing during construction shall be air-entrained concrete in accordance with Footnote d.
d. Concrete shall be air-entrained. Total air content (percent by volume of concrete) shall be not less than 5 percent or more than 7 percent.
e. See Section R402.2 for maximum cementitious materials content.
f. For garage floors with a steel-troweled finish, reduction of the total air content (percent by volume of concrete) to not less than 3 percent is permitted if the specified compressive strength of the concrete is increased to not less than 4,000 psi.
g. Compressive strength (f′c) of 2,500 psi, with an approved admixture that provides a water and vapor resistance at least equivalent to 5,000 psi concrete.
h. Compressive strength (f′c) of 5,000 psi, is not required for post footings for decks or porches, wood foundations, slab-on-grade foundation walls, and footings for floating slabs.

FOOTINGS

In order to properly support the loads of a building, footing design must address not only the size of the footing, but factors such as the condition and characteristics of the soil, footing depth, slope and reinforcing. [Ref. R403]

Depth, Bearing and Slope

For other than engineered soil conditions, footings must bear on undisturbed ground and extend below the frost depth to provide a stable foundation. In addition, exterior footings require excavation to at least 12 inches below the undisturbed soil. Vegetation, wood, debris, loose or frozen soil and any other detrimental materials are removed prior to placing concrete (Figure 5-3). [Ref. R403.1.4]

Placing footings below the frost depth protects foundations from the expansive effects of freezing and thawing soil. The minimum footing depth to provide frost protection is 60 inches in the following counties: Aitkin, Becker, Beltrami, Carlton, Cass, Clay, Clearwater, Cook, Crow Wing, Douglas, Grant, Hubbard, Itasca, Kanabec, Kittson, Koochiching, Lake, Lake of the Woods, Mahnomen, Marshall, Mille Lacs, Morrison, Norman, Otter Tail, Pennington, Pine, Polk, Red Lake, Roseau, St. Louis, Todd, Traverse, Wadena, and Wilkin. In all other counties the minimum depth is 42 inches. Otherwise, frost heave can exert stresses sufficient to cause

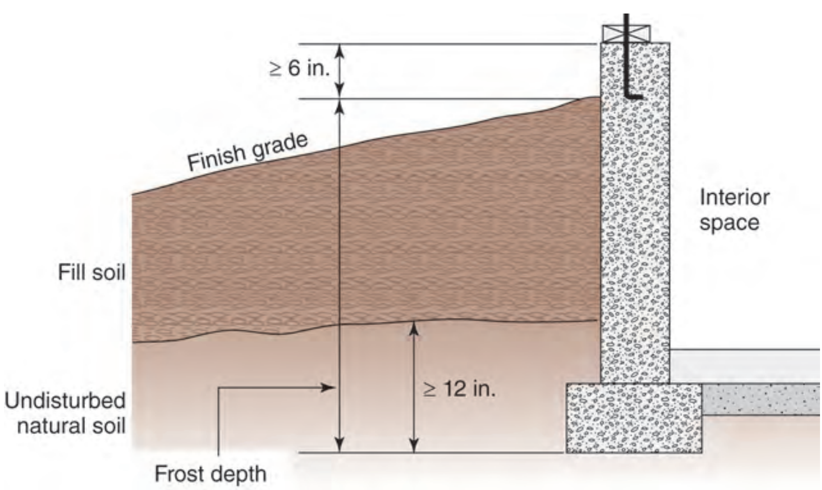


FIGURE 5-3 Depth of exterior footings

significant damage to a foundation. The code offers exceptions to the frost depth requirements when construction is protected from frost heave following either the code or ASCE 32, where solid rock supports the building or where following the provisions of Minnesota Rules Chapter 1303. [Ref. MR1303.1600; R403.1.4.1]

To prevent sliding and to adequately transfer loads to the soil, the code limits the slope of the bottom of footings to a maximum 1 unit vertical in 10 units horizontal (10 percent slope). Transitions that would result in greater slopes must be achieved through stepping of the footings (Figure 5-4). [Ref. R403.1.5]

Sizing Concrete Footings

Soil-bearing capacity and the average gravity loads (dead, live, and snow) determine footing size. As the load-bearing capacity of the soil decreases, footing size increases to distribute the load to a greater area. For example, soil with a bearing capacity of 1,500 psf will require a footing with twice the bearing area as soil with a bearing capacity of 3,000 psf when supporting the same total gravity load. Footings must have sufficient bearing area to prevent differential settlement (when the ground settles unevenly), which can cause structural and performance problems. The MRC prescribes the width of continuous footings based on the number of stories supported, the method of construction, the type of foundation (basement, crawl space or slab-on-grade), the snow load and the load-bearing value of the soil (Figure 5-5). The minimum thickness of footings is 6 inches (Table 5-2). [Ref. R403.1.1, Tables R403.1(1) through R403.1(3)]

You Should Know

For best practice, step height should not exceed three-fourths of the step length in the continuous footing in Figure 5-4.

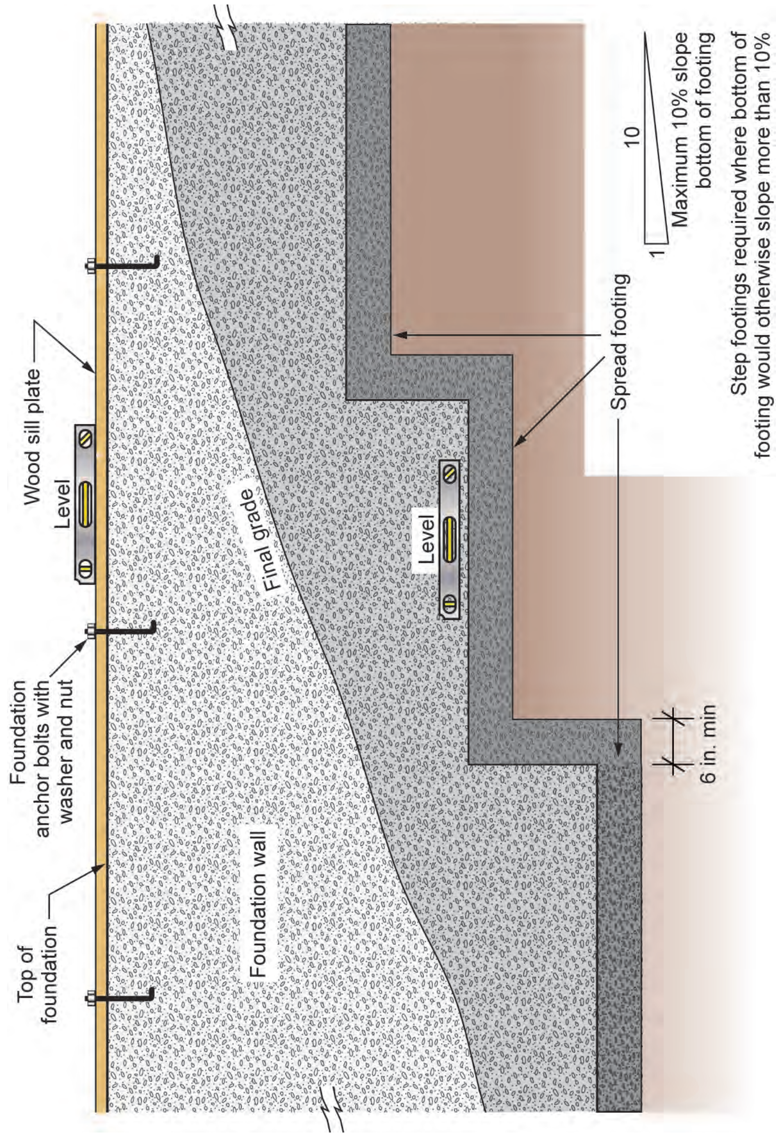


FIGURE 5-4 Stepped footing

TABLE 5-2 Minimum width and thickness for concrete footings (inches)

Snow load (psf)		Load-bearing value of soil (psf)			
50	Type of foundation	1,500	2,000	2,500	3,000
Light-frame construction					
1 story	Slab-on-grade	12 x 6	12 x 6	12 x 6	12 x 6
	With crawl space	16 x 6	12 x 6	12 x 6	12 x 6
	Plus basement	21 x 6	16 x 6	13 x 6	12 x 6
2 story	Slab-on-grade	14 x 6	12 x 6	12 x 6	12 x 6
	With crawl space	19 x 6	14 x 6	12 x 6	12 x 6
	Plus basement	25 x 7	19 x 6	15 x 6	12 x 6
Light-frame construction with brick veneer					
1 story	Slab-on-grade	13 x 6	12 x 6	12 x 6	12 x 6
	With crawl space	18 x 6	14 x 6	12 x 6	12 x 6
	Plus basement	24 x 7	18 x 6	14 x 6	12 x 6
2 story	Slab-on-grade	18 x 6	14 x 6	12 x 6	12 x 6
	With crawl space	24 x 7	18 x 6	14 x 6	12 x 6
	Plus basement	29 x 10	22 x 6	18 x 6	15 x 6

[Ref. excerpt from Tables R403.1(1) and R403.1(2)]

Note: Values are based on a 32-foot wide house with load bearing center wall that carries half of the tributary attic and floor framing loads. For every 2 feet of adjustment to the width of the house, add or subtract 2 inches of footing width and 1 inch of footing thickness (but not less than 6 inches thick).

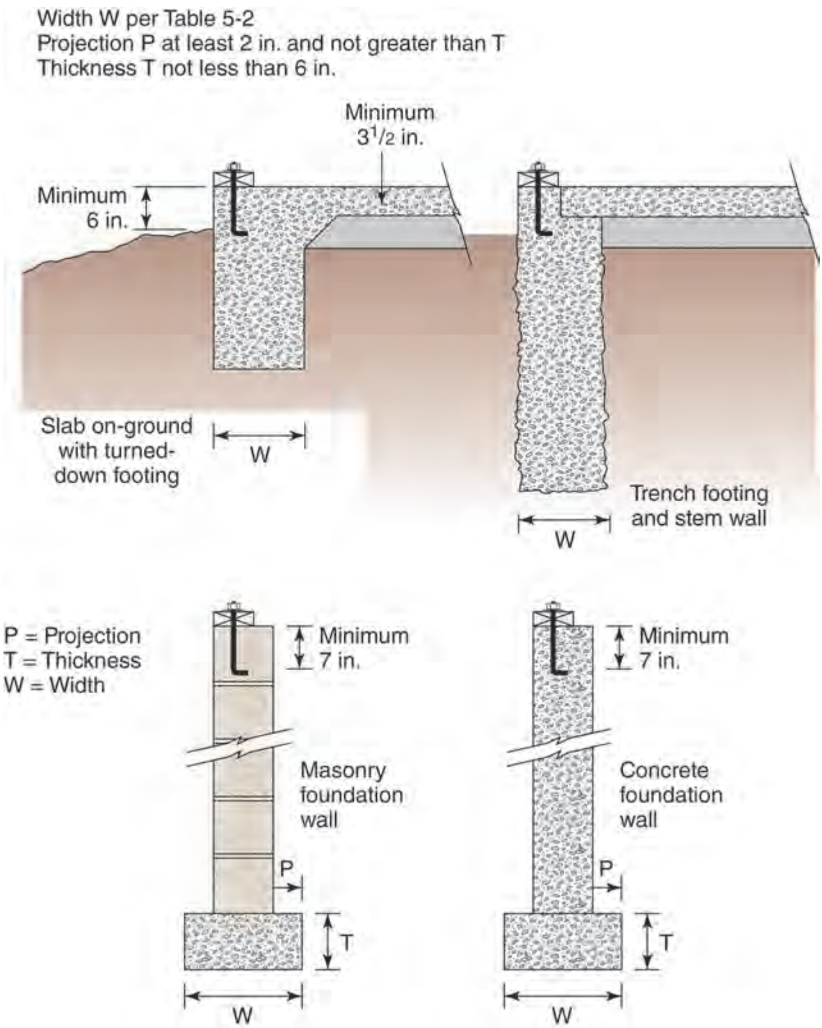


FIGURE 5-5 Types of continuous footings

EXAMPLE 5-1

Size of a continuous footing (width and depth)
Determine minimum width (W), projection (P) and thickness (T) of a continuous spread footing for a two-story dwelling (Figure 5-6) assuming 1,500 psf soil bearing, 50 psf ground snow load and a building width of 32 feet. Use the prescriptive values of Table 5-2. Projection (P) must be at least 2 inches and cannot exceed thickness (T). The minimum footing thickness (T) is 6 inches. The solution is shown in Figure 5-7.

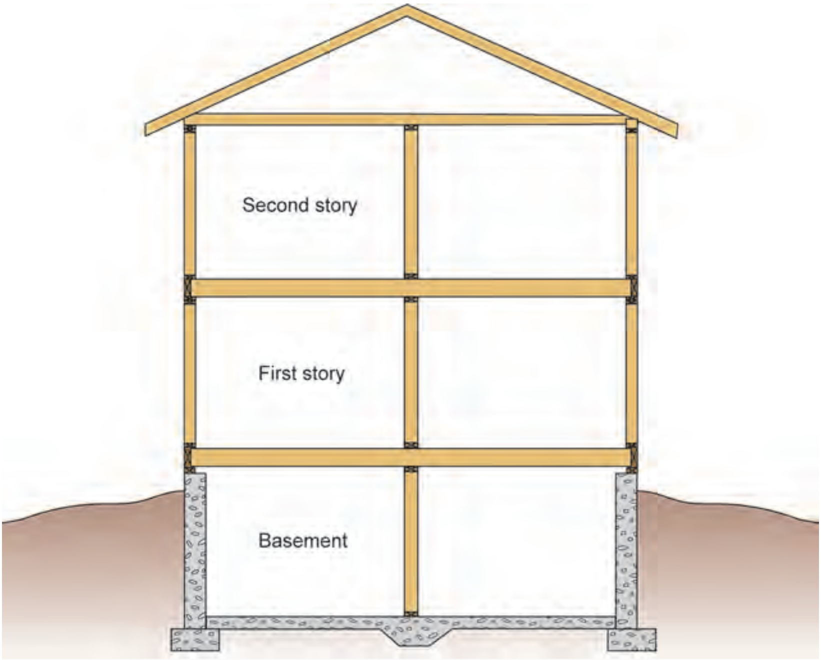


FIGURE 5-6 Cross section of two-story dwelling for determining footing size in Figure 5-7

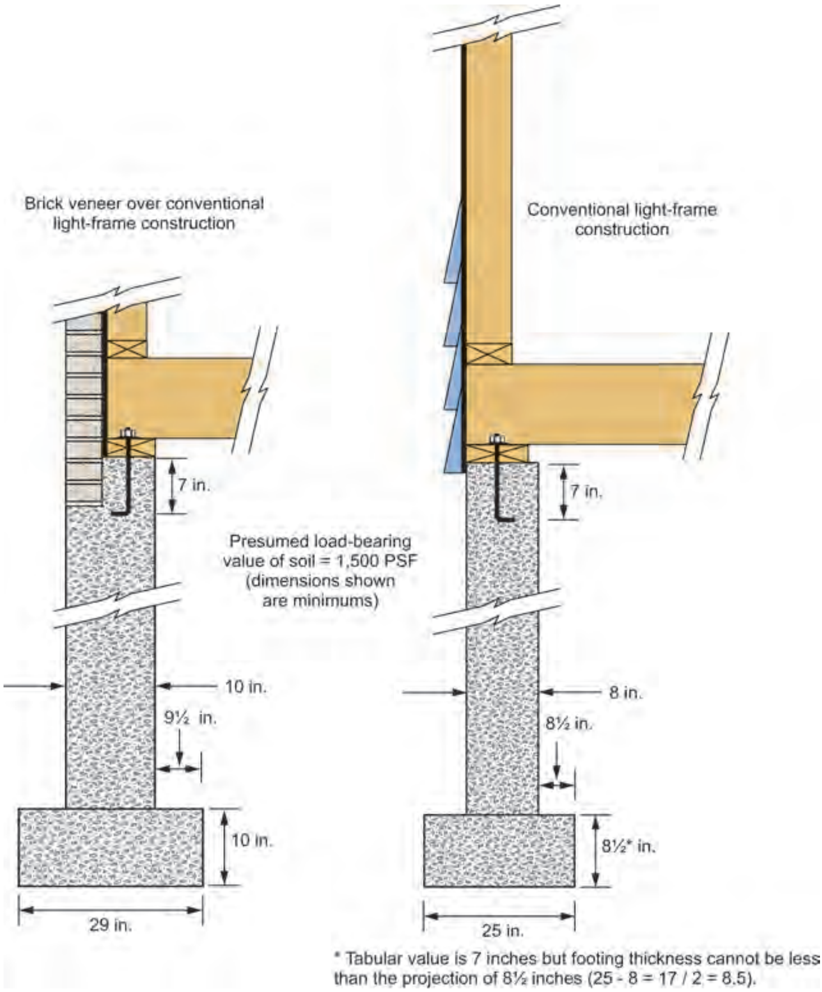


FIGURE 5-7 Minimum size of continuous spread footing for a two-story house with basement based on Table 5-2 and Figure 5-6

EXAMPLE 5-2

Size of isolated footing for a column load

The soil type and the total tributary load being supported determine pier and column footing size. See Figure 5-8 for a simple example of tributary floor load transferred to a column. Assuming a total floor load of 50 psf (40 psf live load plus 10 psf dead load), a tributary area of 120 square feet will result in a column load of 6,000 pounds (120 × 50 = 6,000). A post carrying a 6,000-pound load will require a footing area of 4 square feet (2 feet by 2 feet) for a soil-bearing capacity of 1,500 psf (6,000/1,500 = 4). Minimum footing dimensions are shown in Figure 5-9.

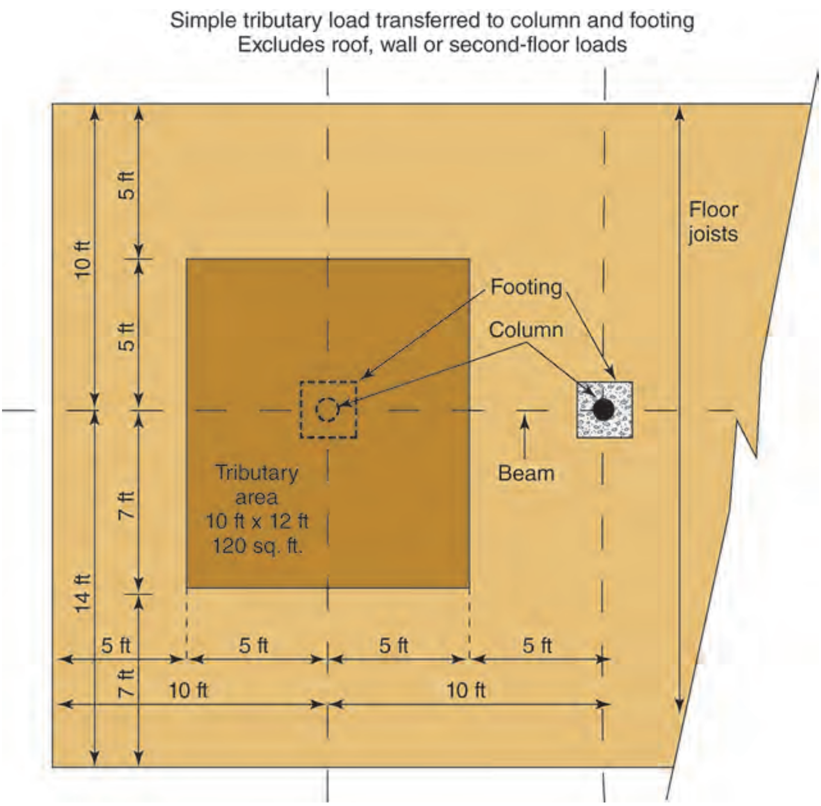


FIGURE 5-8 Tributary load

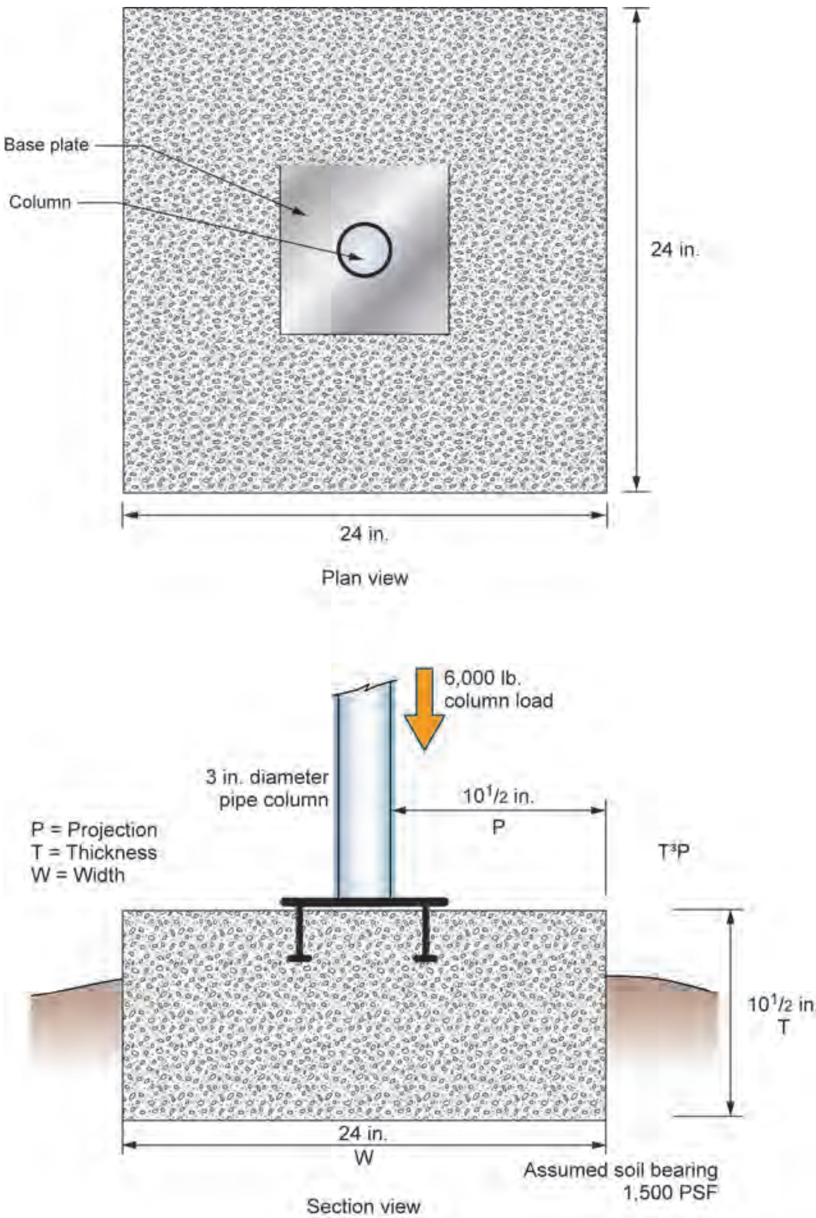


FIGURE 5-9 Minimum dimensions of an isolated column footing based on tributary load and assumed soil-bearing capacity

Reinforcing for Footings

For the most part, the MRC permits footings without reinforcement (Figure 5-10). Some alternate methods for narrow wall bracing require reinforcing in footings and foundations at the braced wall panel locations. Further information is provided in the discussion on wall bracing in Chapter 6 of this publication. [Ref. Figure R403.1(1)]

Foundation Anchorage

Anchorage to the foundation is a critical part of the load path to resist lateral and uplift forces acting on the framing system of the building. The MRC prescribes anchor bolt criteria for connecting the sill plate to the foundation. Other methods, such as foundation straps, may be used if installed according to the manufacturer's instructions and in a way to provide equivalent anchorage. Such alternatives typically require closer spacing than for embedded anchor bolts (Figures 5-11 through 5-13). [Ref. R403.1.6]

FIGURE 5-10 Concrete spread footing

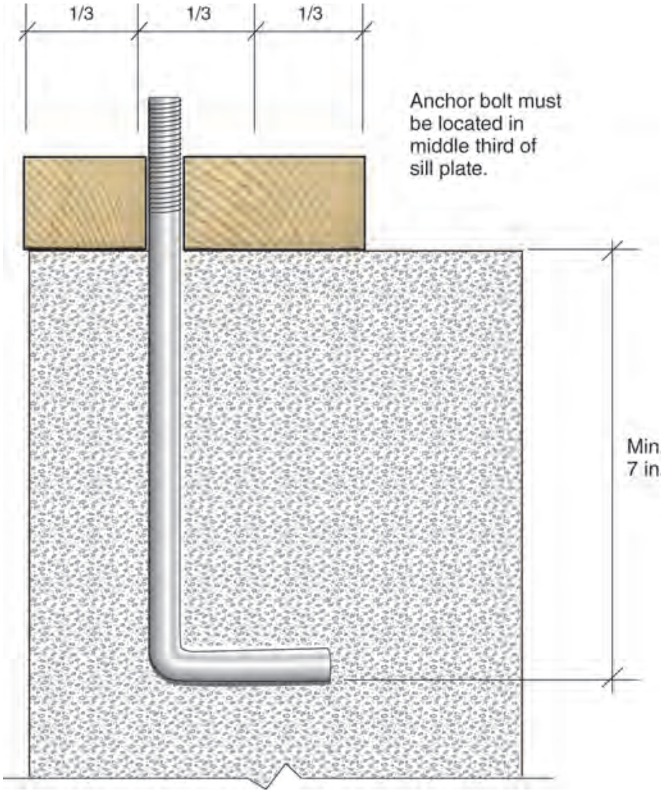


FIGURE 5-11 Anchor bolt placement in center third of sill plate

FIGURE 5-12 Anchor bolts in a wall offset

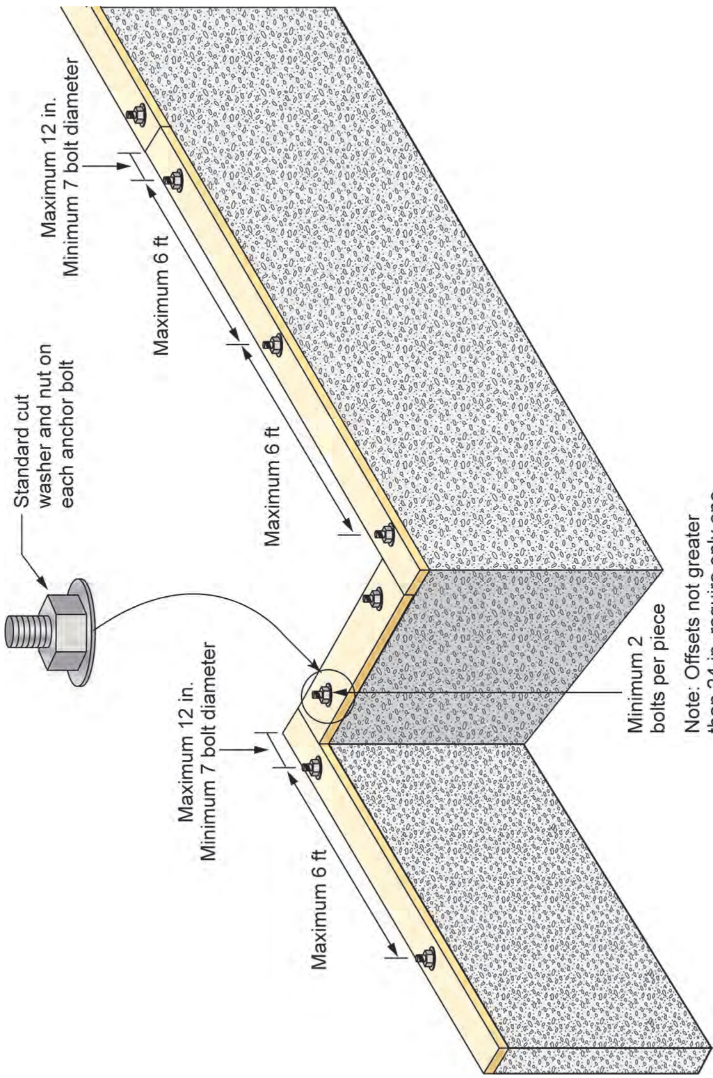


FIGURE 5-13 Wood sill plate anchorage to foundation

MASONRY AND CONCRETE FOUNDATION WALLS

The MRC includes prescriptive methods for the construction of foundation walls that are supported at their top and bottom. Top support to prevent lateral movement is typically achieved through adequate connections to the floor system. Bottom lateral support is provided by the placement of the concrete basement slab floor directly against the foundation wall.

Specifically, a full basement floor shall be at least 3.5 inches thick with the concrete slab poured tight against the foundation wall. The floor joists and blocking must connect to the minimum 2 by 6 sill plate at the top of wall with an approved connector meeting the top of wall reaction in Table 5-3. Floor joists may be spaced up to 24 inches on center and must be blocked perpendicular to the joist in the first three joist bays from the wall as required in Footnote f. Bolt spacing and blocking must meet the requirements in Table 5-3.

Anchor bolts are cast-in-place with a minimum 7-inch embed. The bolts shall be within 8 inches of any vertical reinforcing. Anchor bolts installed in masonry shall be grouted in place with at least 1 inch of grout between the inside face of the masonry and the anchor bolt. Anchor bolts shall have a 2 inch by $^{1}/_{8}$-inch thick round or square washer tightened and countersunk $^{1}/_{4}$-inch into the top of the sill plate. Use of standard and non-countersunk washers requires anchor bolt spacing at half the table spacing. The bolts are placed at least $2^{1}/_{2}$ inches from the edge of the sill plate and foundation wall.

Cantilevered foundation walls supporting backfill without lateral support at the top of the foundation must meet the requirements of Table 5-4. Foundation walls must be spaced every 35 feet or less. The concrete slab is placed tight to the wall. Maximum wall height is 10 feet from top of slab to bottom of floor joists. The unbalanced backfill height is the difference in height of the exterior ground level and the top of the concrete slab. The footing must be at least 20 inches by 8 inches on soil with a bearing capacity of 2,000 psf.

Eighteen-inch long dowels must connect the footing to wall when footnote h to MRC Tables R404.1.1(5) to R404.1.1(7) is applicable. Embed dowels at least 5 inches into footing. Place dowels in center of the wall spaced at no more than 32 inches on center. Dowels are not required where length of the foundation wall between perpendicular walls is two times the foundation wall height or less.

TABLE 5-3 Maximum anchor bolt and blocking spacing excerpt

Max. Wall Height	Max. Unbalanced Backfill Height	Soil Classes	Soil Load (pcf/ft)	Top of Wall Reaction	$^{1}/_{2}$ Dia. Anchor Bolt Spacing (in.)	Spacing of Blocking Perpendicular to Floor Joists (in.)[f]
9′-0″	8′-6″	GW, GP, SW, & SP	30	340	72	72
		GM, GC, SM, SM-SC, & ML	45	510	48	48
		SC, MH, ML-CL, & inorganic CL	60	680	32	32

f. Perpendicular blocking shall be 2-by the full depth joists or an approved alternative full depth joist material that is installed in the first three joist spaces adjacent to the foundation wall. The blocking shall be connected to the sill plate with an approved fastener sized in accordance with Footnote e. The floor sheathing shall be nailed to the blocking through the subfloor with a minimum of 8d common (2½ x 0.131) nails at 3 inches on center or an equivalent connector. Blocking shall be installed within 8 inches of an anchor bolt location.

See table for additional wall heights and footnotes.

[Ref. excerpt of Table R404.1(1)]

TABLE 5-4 Cantilevered Concrete and Masonry Foundation Walls

Max. Wall Height (ft)	Max. Unbalanced Backfill Height (ft)	Minimum Vertical Reinforcement Size and Spacing for 10-inch Nominal Wall Thickness (in.)		
		Soil Classes		
		GW, GP, SW, and SP	GM, GC, SM, SM-SC, and ML	SC, MH, ML-CL, and Inorganic CL
5	3	NR	NR	NR
	4	NR	4 @ 72	4 @ 64
	5	4 @ 72	4 @ 72	4 @ 56

NR = Not required
See tables for additional wall thickness, height and footnotes.
[Ref. excerpt of Tables R404.1.1(5), (6) and (7)]

Vertical reinforcement in the wall must be placed within 2.5 inches of the side of the wall supporting soil.

Foundation walls that exceed the limits of the prescriptive methods in the code must be designed and constructed in accordance with the referenced standards or accepted engineering practices. [Ref. R404.1, Table R404.1(1), Tables R404.1.1(5) through R404.1.1(7)]

Wall Height and Thickness

Unlike footings, where gravity loads are the primary consideration, foundation walls must be constructed to resist lateral loads, particularly from soil pressure. Therefore, the soil type, height of backfill and height of the foundation determine the wall thickness and reinforcement of masonry and concrete foundation walls without consideration of the height or number of stories of the dwelling. Soil descriptions and types are given in Table 3-1 in Chapter 3.

When required, the location, size and spacing of vertical reinforcing depend on the minimum yield strength (grade) of the steel, the thickness of the wall, and other variables. As wall thickness increases, the amount of vertical reinforcing required decreases. Said another way, to reduce the thickness of a foundation wall, say from 12 inches to 8 inches, larger-diameter reinforcing bars or closer spacing of the vertical bars, or both, may be necessary. For concrete basement walls constructed under the prescriptive provisions, 2 or 3 rows of horizontal reinforcing are required based on the unsupported height of the wall [Ref. Tables R404.1.2(1) through R404.1.2(9)].

You Should Know

Alternatives for construction of concrete foundations

- MRC
- PCA 100
- ACI 332
- ACI 318
- Engineering

EXAMPLE 5-3

Determine the minimum thickness and reinforcing requirements for the concrete basement foundation walls in Figures 5-14 and 5-15 based on Tables 5-5 and 5-6.

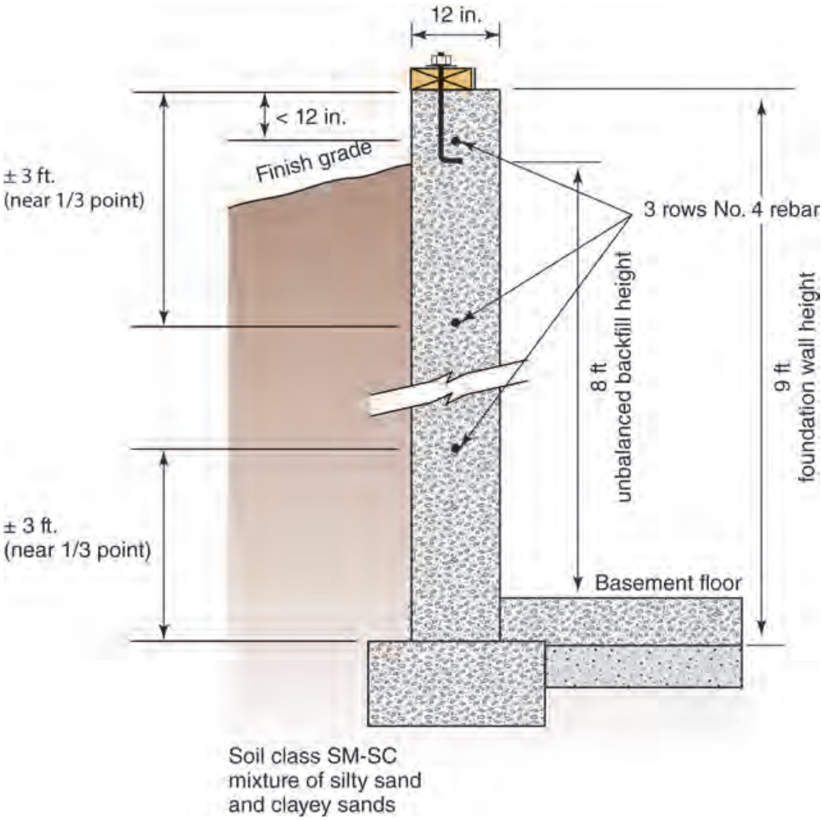


FIGURE 5-14 Wall thickness and horizontal reinforcing requirements for concrete basement wall with no vertical reinforcing based on Tables 5-5 and 5-6

TABLE 5-5 Minimum horizontal reinforcement for concrete basement walls

Minimum unsupported height of basement wall (feet)	Location of horizontal reinforcement
≤ 8	One No. 4 bar within 12 inches of the top of the wall story and one No. 4 bar near mid-height of the wall story
> 8	One No. 4 bar within 12 inches of the top of the wall story and one No. 4 bar near one-third points in the wall story

[Ref. excerpt of Table R404.1.2(1)]

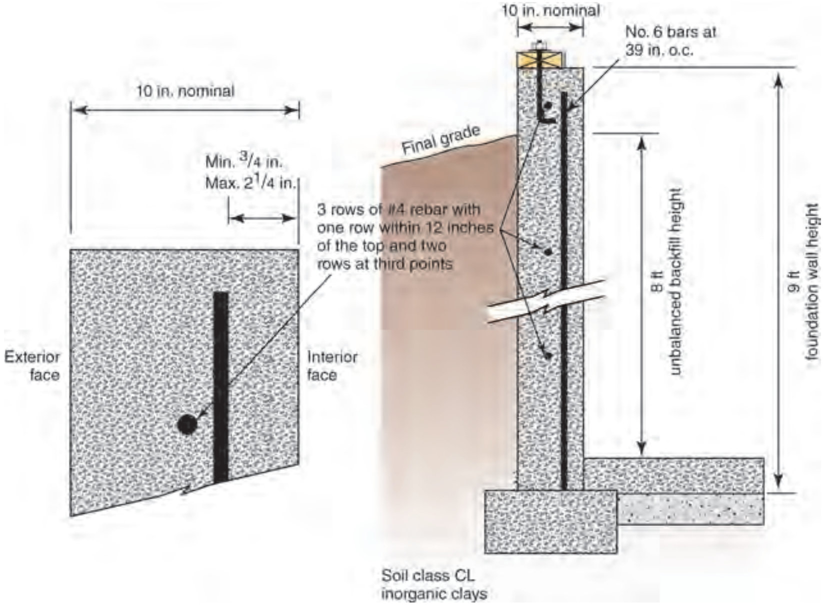


FIGURE 5-15 Wall thickness and reinforcing requirements for flat concrete basement wall with vertical reinforcing based on Tables 5-5 and 5-6

An example for determining the thickness of a masonry foundation wall is given in Table 5-7 and Figure 5-16. [Ref. R404.1.2, Tables R404.1.1(1) through R404.1.1(4)]

EXAMPLE 5-4

Determine the minimum thickness and reinforcing requirements for the masonry basement foundation wall in Figure 5-16 based on Table 5-7.

TABLE 5-6 Minimum vertical reinforcement for concrete basement walls

Maximum wall height (feet)	Maximum unbalanced backfill height (feet)	Minimum vertical reinforcement—Bar size and spacing (inches)											
		Soil classes and lateral soil load (psf per foot of depth)											
		GW, GP, SW and SP				GM, GC, SM, SM-SC and ML				SC, ML-CL and inorganic CL			
		30				45				60			
		Minimum nominal wall thickness (inches)											
		6	8	10	12	6	8	10	12	6	8	10	12
9	6	4 @ 34	NR	NR	NR	6 @ 48	NR	NR	NR	6 @ 36	6 @ 39	NR	NR
	7	5 @ 36	NR	NR	NR	6 @ 34	5 @ 37	NR	NR	6 @ 33	6 @ 38	5 @ 37	NR
	8	6 @ 38	5 @ 41	NR	NR	6 @ 33	6 @ 38	5 @ 37	NR	6 @ 24	6 @ 29	6 @ 39	4 @ 48
	9	6 @ 34	6 @ 46	NR	NR	6 @ 26	6 @ 30	6 @ 41	NR	6 @ 19	6 @ 23	6 @ 30	6 @ 39

[Ref. excerpt of Table R404.1.2(8)]

NR = Not required
See MRC to view applicable footnotes not shown (footnote indicators "l" and "m" omitted from table)

TABLE 5-7 Masonry foundation walls with reinforcing

Eight-inch masonry foundation walls with reinforcing where d ≥ 5 inches				
		Minimum vertical reinforcement		
		Soil classes and lateral soil load (psf per foot below grade)		
		GW, GP, SW and SP soils	GM, GC, SM, SM-SC and ML soils	SC, ML-CL and inorganic CL soils
Wall height	Unbalanced backfill height	30	45	60
8 feet 8 inches	6 feet	#4 at 48″ o.c.	#5 at 48″ o.c.	#6 at 48″ o.c.
	7 feet	#5 at 48″ o.c.	#6 at 48″ o.c.	#6 at 40″ o.c.
	8 feet 8 inches	#6 at 48″ o.c.	#6 at 32″ o.c.	#6 at 24″ o.c.
[Ref. excerpt of Table R404.1.1(2)]				

See MRC to view applicable footnotes not shown

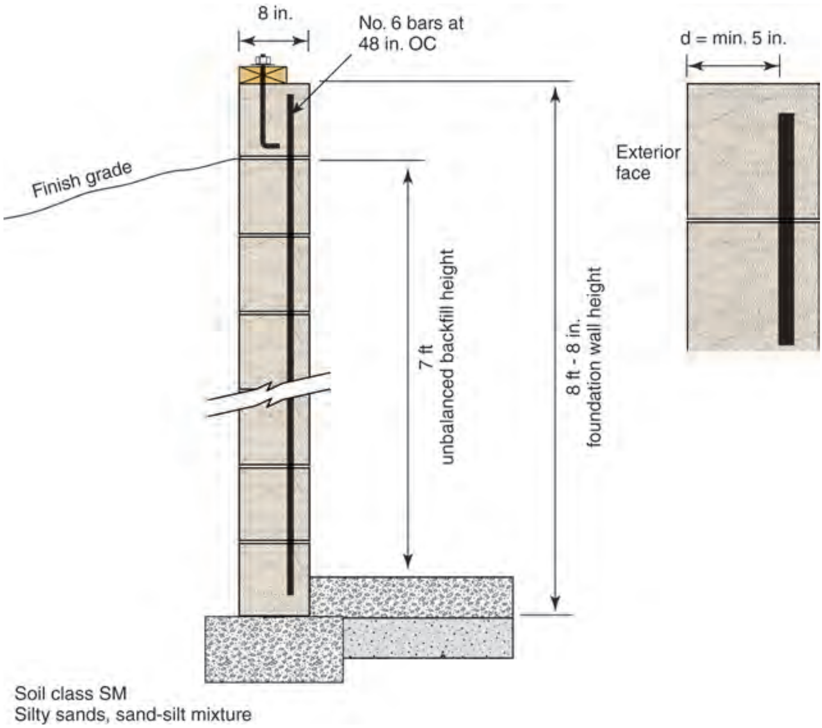


FIGURE 5-16 Wall thickness and reinforcing requirements for masonry foundation wall with reinforcing based on Table 5-7

Height Above Finished Grade

The MRC intends to protect the building from moisture intrusion that may damage portions of the structure and cause an unhealthy living environment. As part of these requirements, concrete and masonry foundation walls must extend above the finished grade a minimum of 6 inches. Masonry veneer provides somewhat better protection against moisture intrusion at ground level than do siding and other exterior wall finishes, and the elevation requirement for the top of the foundation wall is reduced accordingly to 4 inches above finished grade (Figure 5-17). [Ref. R404.1.6]

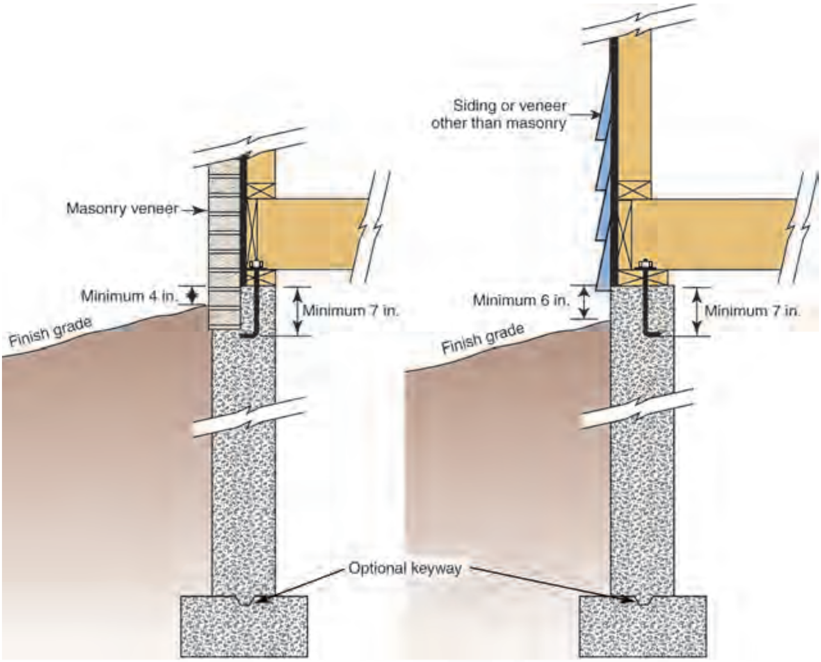


FIGURE 5-17 Foundation height above finished grade

MOISTURE PROTECTION

Exterior concrete and masonry foundations that retain earth and enclose spaces located below grade, the MRC requires foundation drainage and waterproofing to prevent moisture from penetrating into such spaces (Figure 5-18).

Foundation Drainage

Except in areas with well-drained soils, the code requires perforated pipe or other approved drains to carry groundwater away from the foundation. Such drains must be installed at or below the level of the basement or crawl space floor using approved methods and the prescribed amounts of washed gravel. Perforated drains require installation of a filter membrane unless the manufacturer recommends otherwise. The drainage system is required

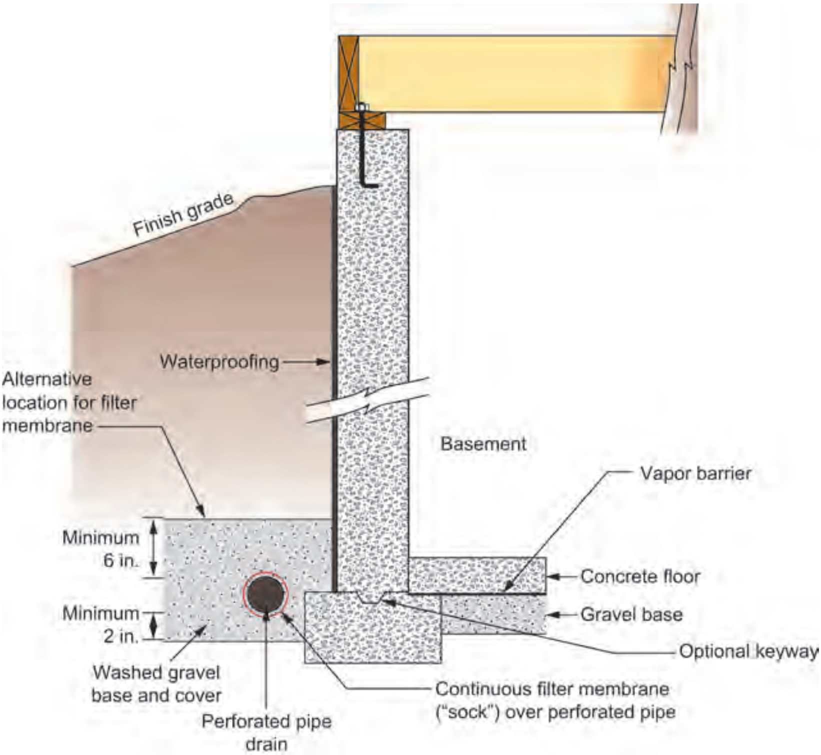


FIGURE 5-18 Foundation drain and waterproofing

to discharge by gravity or mechanical means to an approved location. [Ref. R405]

Waterproofing

Concrete and masonry foundations require waterproofing. Waterproofing typically consists of approved flexible sealants or other impervious material applied on the exterior of foundation walls providing a higher level of protection against moisture under hydrostatic pressure.These provisions are located in both the building code and the energy code, with the latter being more restrictive. The energy code requires waterproofing to extend from the top interior wall edge, across the top of the wall, and down the exterior wall face to the top of the footing. As an alternative to waterproofing the top of the wall, the energy code permits the installation of a full width, closed cell material to create a seal between the sill plate and the top of the foundation wall. Waterproofing that is exposed to the exterior environment must be protected from degradation by a a rigid protective covering that extends at least 6” below grade. See MRC R406.2 and RE402.1.1 for full text and acceptable waterproofing methods. [Ref. R406]

UNDERFLOOR SPACE

Depending on climatic conditions, significant amounts of condensation can accumulate in enclosed crawl spaces, causing decay and other damage to the structure. The code requires ventilation openings through the foundation or exterior walls in the prescribed size and location to circulate air and dissipate condensation (Figure 5-19).

An alternative method permits a crawl space without foundation openings when equipped with mechanical exhaust ventilation or connection to the conditioned air supply of the dwelling. In this case, the code requires insulation of the exterior walls and a vapor retarder over the ground and sealed to the enclosing foundation wall.

The MRC requires access to the underfloor spaces. Access openings through the floor must be at least 18 inches by 24 inches but may be reduced to not less than 16 inches by 24 inches when access is through a perimeter wall. [Ref. R408]

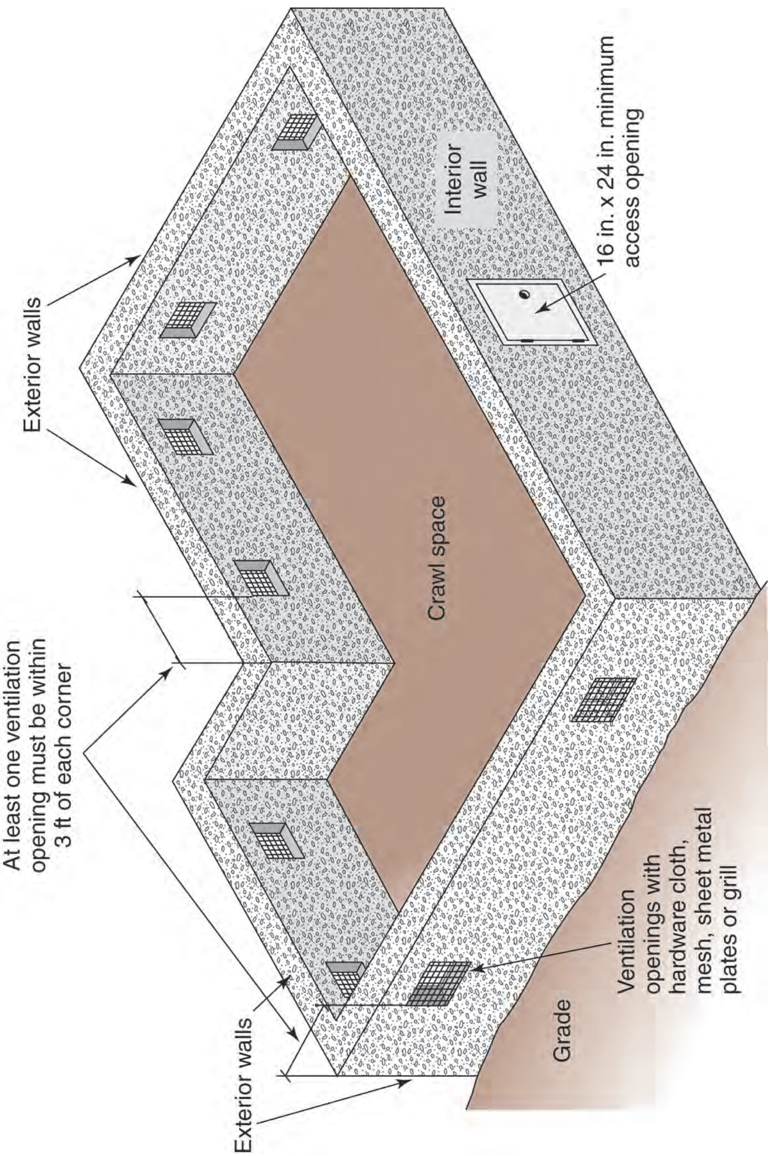


FIGURE 5-19 Crawl space ventilation and access

CHAPTER 6 Framing

The repetitive system of wood or cold-formed steel framing members forming the structural elements of floor, wall and roof construction is referred to as *light-frame construction* (Figure 6-1). The framing system, with its connections and bracing, must resist the code-prescribed vertical and lateral forces that act on the building. These loads must be adequately transferred through the framing system by a complete load path to the foundation. The *Minnesota Residential Code* (MRC) prescribes specific framing requirements that when followed preclude the need for an engineered design. This chapter will focus on the prescriptive provisions for conventional wood light-frame construction.

FIGURE 6-1 Wood framing

GRADE MARKS

Load-bearing dimension lumber for framing members and wood structural panels must be identified by a grade mark (Figure 6-2). Sawn lumber grade marks indicate the wood species, grade, moisture content, grading agency and lumber mill identification. Species and grade determine, in part, the

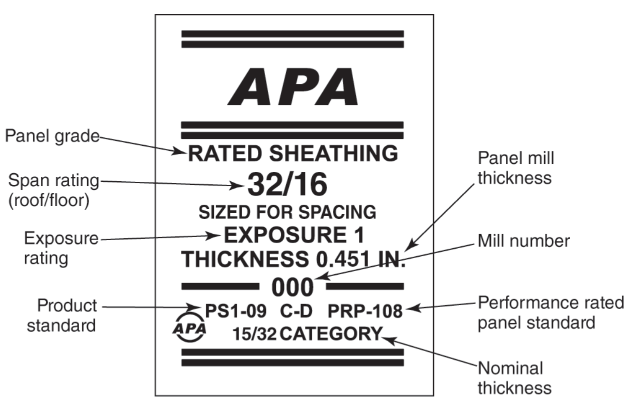


FIGURE 6-2 Wood structural panel grade mark

strength and stiffness properties that establish the maximum permissible spans for wood beams, joists and rafters. Wood structural panel grade marks include the maximum span ratings for roof and floor applications to meet minimum performance requirements. [Ref. R502.1, R503.2, R602.1, R803.1, R803.2]

ENGINEERED WOOD PRODUCTS

Engineered wood products include plate-connected open web trusses, I-joists, glued laminated lumber, laminated veneer lumber and other structural composite lumber. The MRC permits the use of engineered components in otherwise prescriptive conventional framing systems. These engineered components must be designed in accordance with accepted engineering practice and the applicable referenced standards. Installation of engineered wood products must conform to the manufacturer's installation instructions (Figure 6-3).

FIGURE 6-3 Engineered wood products: I-joists and LVL beam

TRUSSES

In addition to structural design criteria, truss design drawings include manufacturing and installation specifications for each truss (Figures 6-4 and 6-5). The MRC requires the manufacturer or contractor to submit the truss design drawings to the building official for review and approval prior to

FIGURE 6-4 Open-web floor trusses

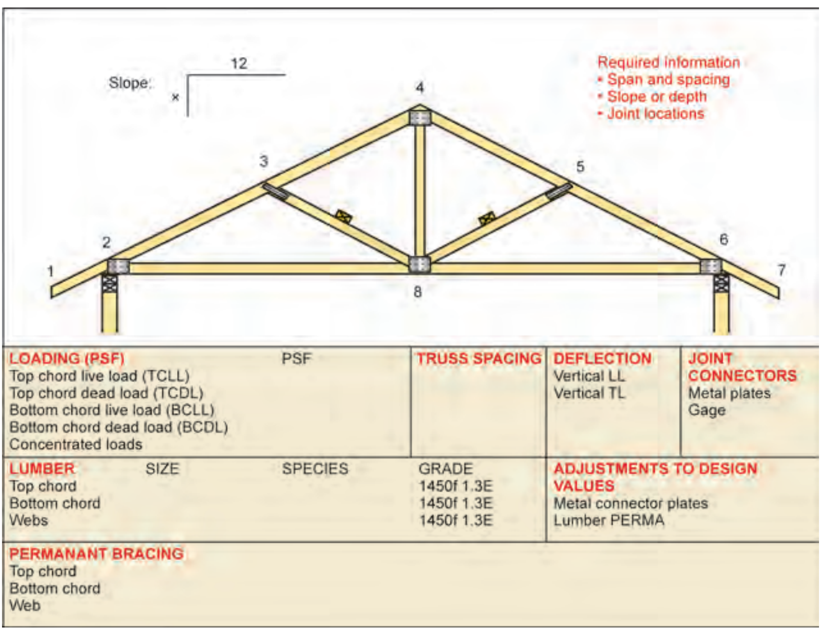


FIGURE 6-5 See R502.11.4 for the complete list of information required for truss drawings.

truss installation. The truss design drawings detail bracing for web members and top and bottom chords, which provide support for the structural elements of the truss to prevent buckling. Because they contain permanent bracing details, nailing specifications for bracing and multiple-member trusses, and minimum bearing and other important installation information, the truss design drawings must also be delivered to the jobsite with the trusses. The floor or roof sheathing and gypsum board ceiling materials typically provide adequate lateral support and thus satisfy the permanent bracing requirements for the top and bottom chords of the truss. In order to adequately resist the design loads and resist buckling, truss web members in compression often require additional lateral support that is provided by the specified permanent bracing. The building designer provides details on the construction documents for permanent lateral bracing of the trusses to prevent rotation of the roof system. The Structural Building Component Association's (SBCA) Building Component Safety Information (BCSI) Guide to Good Practice for Handling, Installing & Bracing of Metal Plate Connected Wood Trusses contains these details for permanent bracing. Alterations to trusses are not allowed without the approval of a registered design professional. [Ref. R502.11, R802.10]

WOOD TREATMENT

Portions of wood construction in locations subject to decay require naturally durable wood or wood treated with preservatives. The heartwoods of decay-resistant redwood, cedar, black locust and black walnut are considered naturally durable. An approved quality mark or label is required on preservative-treated lumber and plywood, indicating that the products meet the standards of the American Wood Protection Association (AWPA) (Figure 6-6). Preservative-treated wood suitable for ground contact is required for structural supports that are in contact with the ground, embedded in concrete in contact with the ground, or embedded in concrete exposed to the weather. Naturally durable wood is not permitted in these ground contact locations. Some chemicals used in the preservative treatment process are corrosive to steel. To resist corrosion and maintain structural load capacity, the code generally requires fasteners and connectors used in preservative- and fire-retardant-treated wood to be hot-dipped, zinc-coated galvanized steel, stainless steel, silicon bronze, copper or material recommended by the manufacturer (Figures 6-7 and 6-8). [Ref. R317]

Decking and the upper portion of exterior wood decks may be constructed of: (1) heartwood from species of wood having natural resistance to decay or termites, including redwood and cedars, (2) grades of lumber

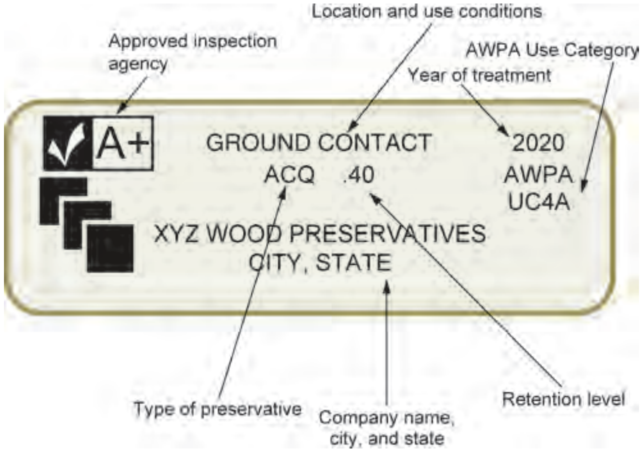


FIGURE 6-6 Example of information on end tag of preservative-treated wood

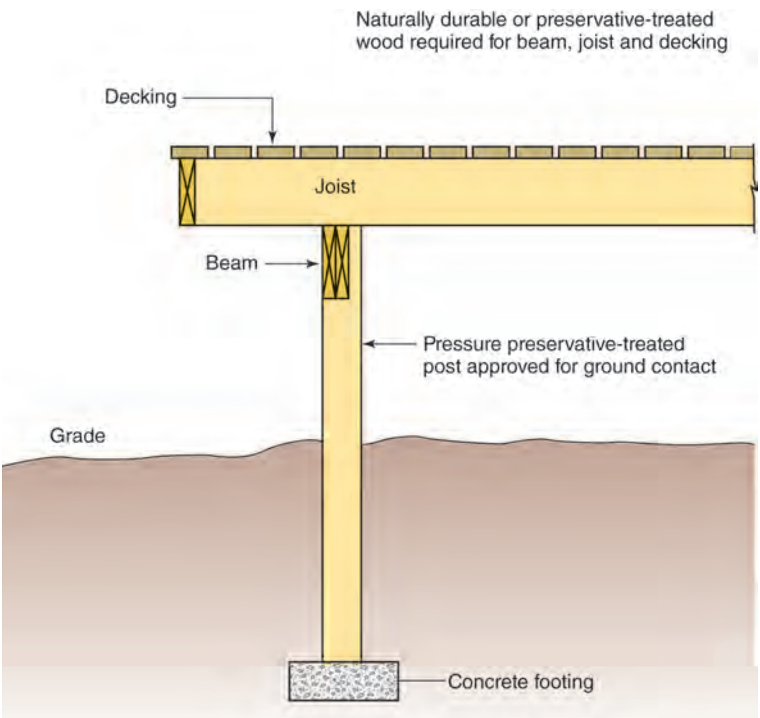


FIGURE 6-7 Protection against decay for wood decks

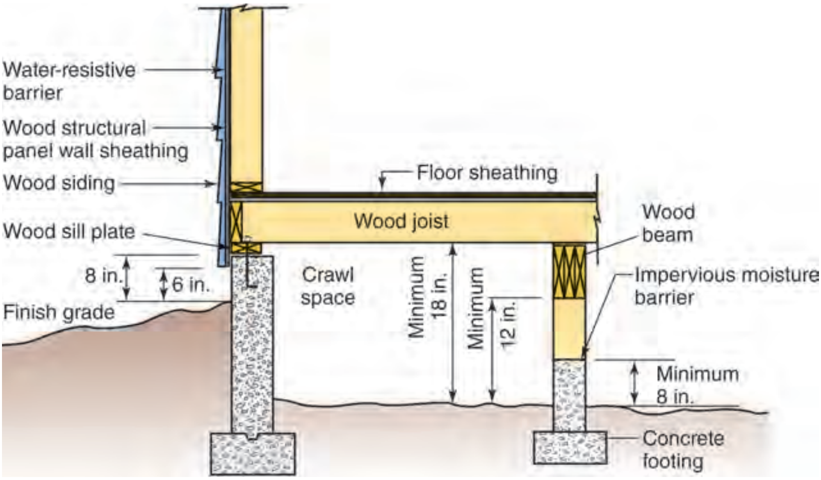


FIGURE 6-8 Clearance above ground for protection against decay

which contain sapwood from species of wood having natural resistance to decay or termites, including redwood and cedars, or (3) treated wood. [MN Stat 326B.106 Subd. 4 (j)]

CUTTING, BORING AND NOTCHING

In order to maintain the structural strength and integrity of wood framing, the code limits the amount and location of bored holes and notches in dimension lumber, as shown in Figures 6-9 through 6-12. Fractions and percentages related to the depth of the framing member are converted to inches in Table 6-1. The MRC generally prohibits boring, cutting or notching of trusses and other engineered wood products except as specifically permitted by the manufacturer. Otherwise, a registered design professional must consider any such alterations in the design of the engineered component. [Ref. R502.8, R602.6, R802.7]

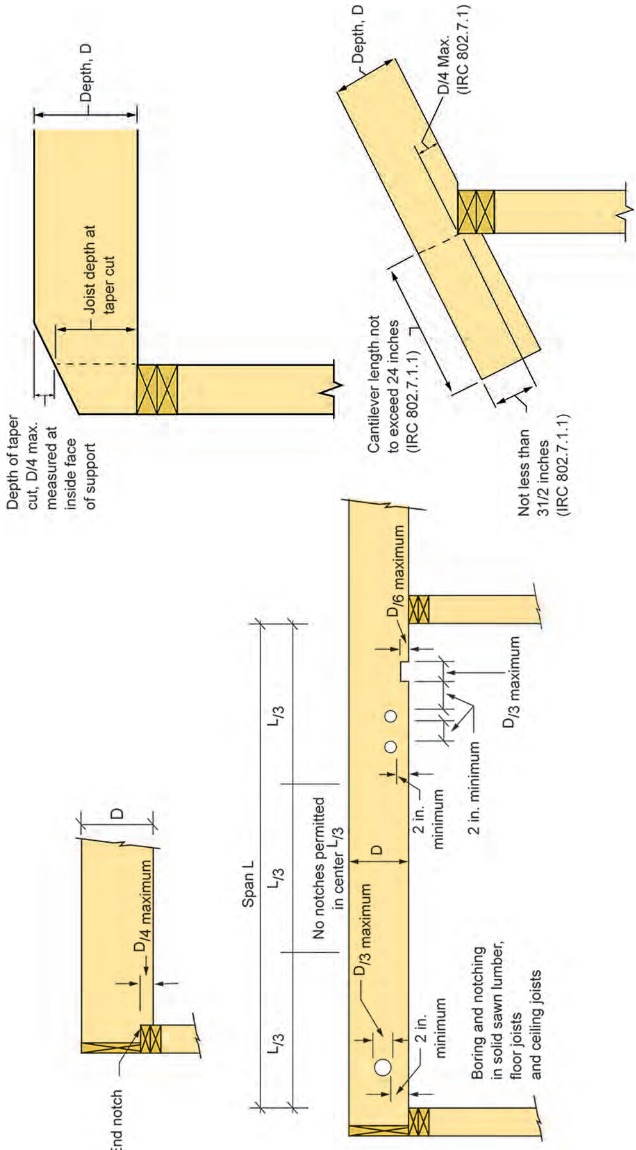


FIGURE 6-9 Boring and notching in solid sawn beams, floor joists, ceiling joists and rafters

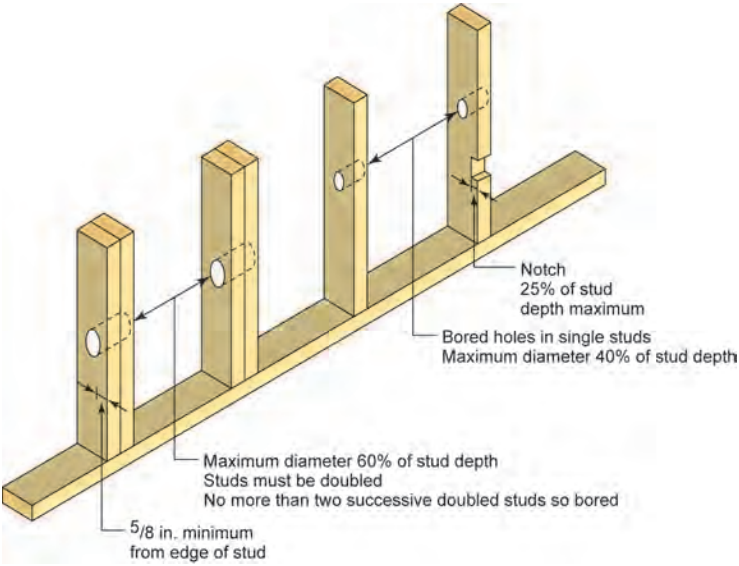


FIGURE 6-10 Boring and notching of studs in exterior wall or bearing interior wall

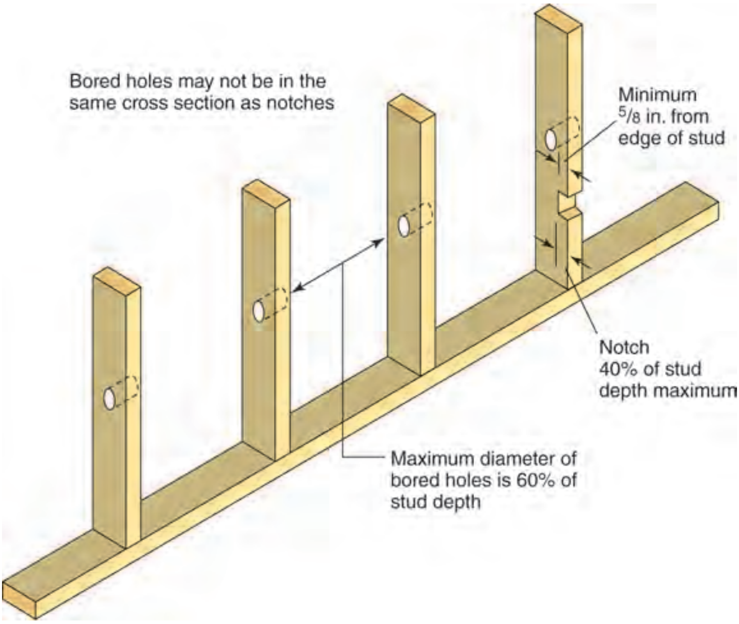


FIGURE 6-11 Boring and notching of studs in nonbearing interior wall

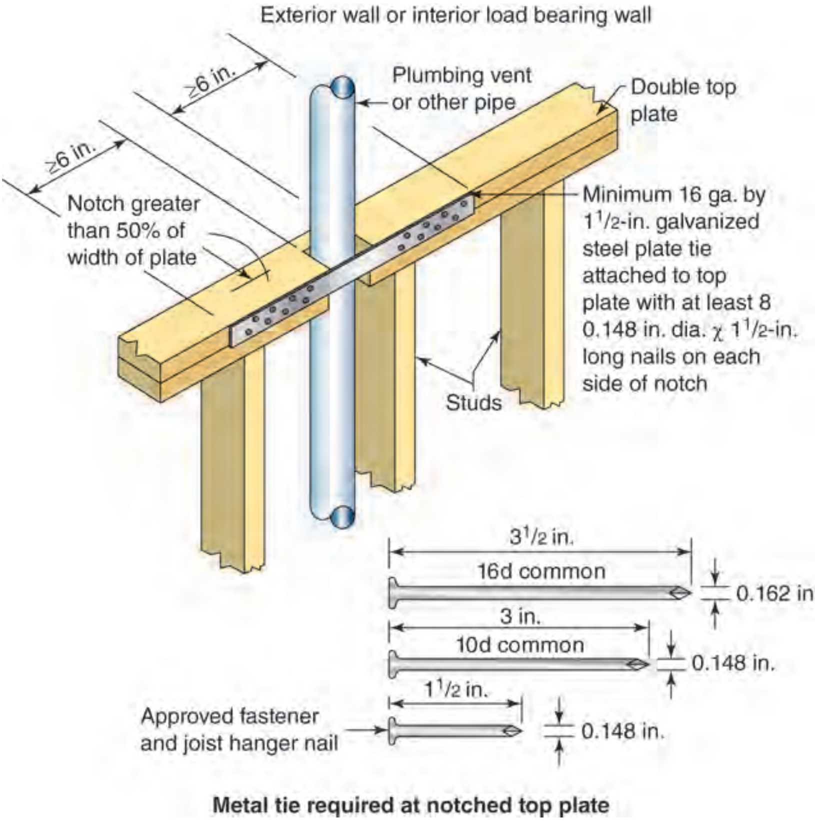


FIGURE 6-12 Drilling and notching of top plate in exterior wall or bearing interior wall

FIREBLOCKING

To stop the spread of fire in concealed spaces of wood frame construction, fireblocking is required to form an effective barrier between stories and between the top story and the attic. Concealed spaces of stud walls and partitions require fireblocking vertically at the ceiling and floor levels. In platform framing, the top wall plates typically satisfy the fireblocking requirement. The studs generally provide effective fireblocking in the horizontal direction, but for walls with offset studs or other openings, fireblocking is required horizontally at 10-foot intervals or less. Fireblocking also is required at all interconnections between concealed vertical and horizontal spaces, such as those created by soffits, and at the top and bottom of stair stringers (Figure 6-13). Openings around vents, pipes, ducts, cables

TABLE 6-1 Boring and notching limits for wood joists, rafters and studs converted to inches

Sawn lumber floor joists, ceiling joists and rafters		Approximate notch and hole limitations in inches		
Nominal size	Approximate depth 'D' in inches	D/3	D/4	D/6
2 x 4	$3^1/_2$	$1^1/_8$	$^7/_8$	$^1/_2$
2 x 6	$5^1/_2$	$1^3/_4$	$1^3/_8$	$^7/_8$
2 x 8	$7^1/_4$	$2^3/_8$	$1^3/_4$	$1^1/_8$
2 x 10	$9^1/_4$	3	$2^1/_4$	$1^1/_2$
2 x 12	$11^1/_4$	$3^3/_4$	$2^3/_4$	$1^7/_8$
Wood studs		60%	40%	25%
2 x 4	$3^1/_2$	$2^1/_8$	$1^3/_8$	$^7/_8$
2 x 6	$5^1/_2$	$3^1/_4$	$2^1/_8$	$1^3/_8$

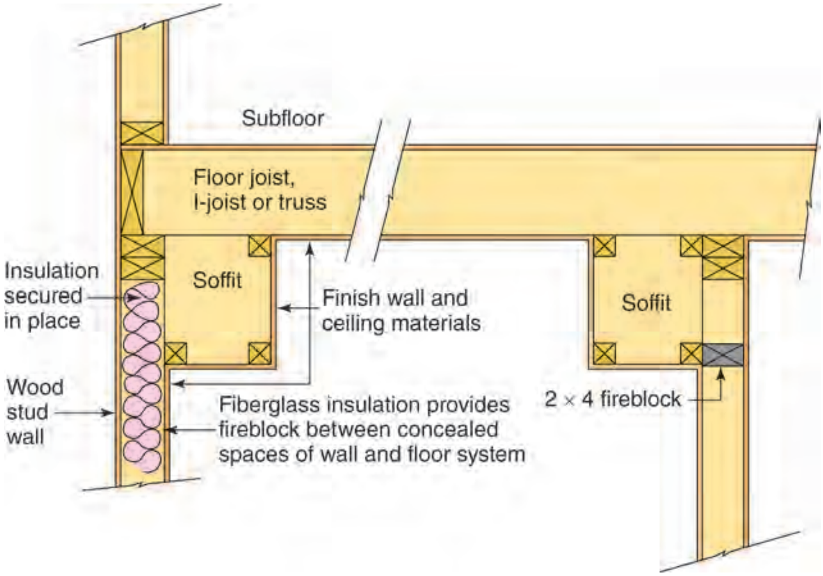


FIGURE 6-13 Fireblocking at soffits

and wires must also be sealed at the ceiling and floor level (Figure 6-14). Fireblocking materials include nominal 2-inch-thick lumber, equivalent layers of structural wood panels, and glass fiber insulation securely retained in place. [Ref. R302.11]

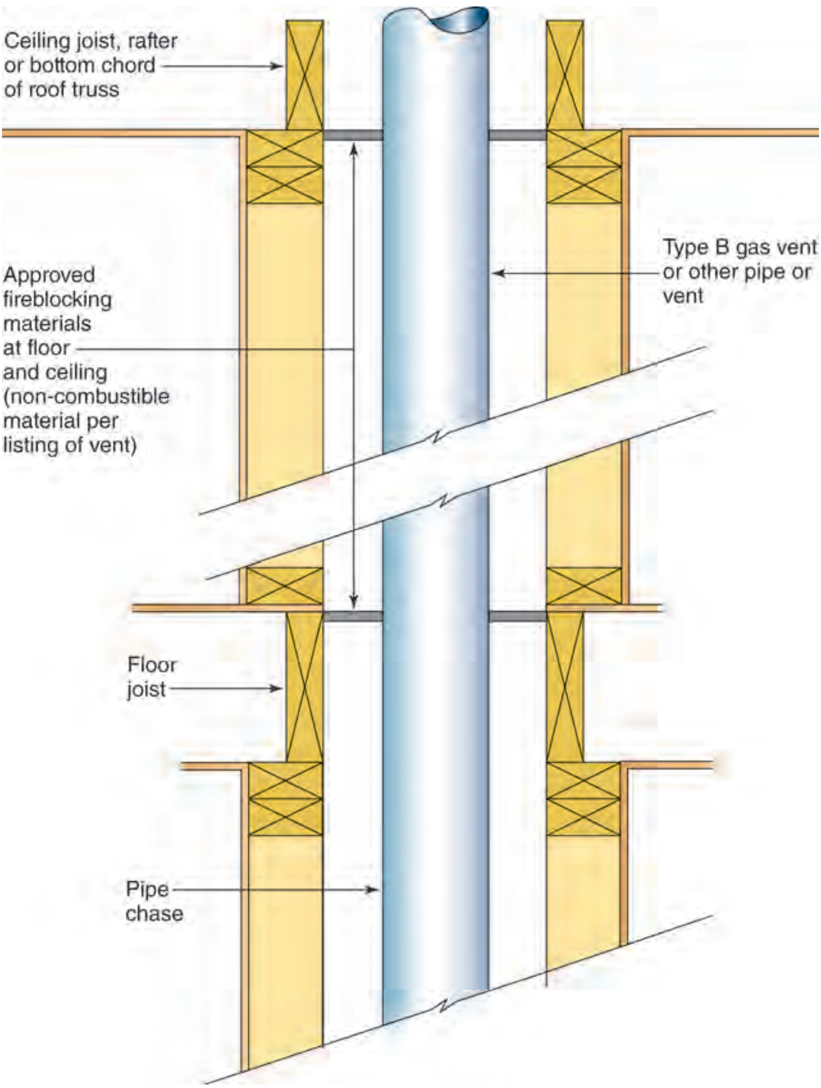


FIGURE 6-14 Fireblocking at pipe chase

DRAFTSTOPPING

When a ceiling is applied to the bottom side of open web floor trusses, or large areas of communicating spaces are otherwise created in the floor assembly, the MRC requires draftstopping to divide the horizontal spaces into areas of 1,000 square feet or less. One-half-inch gypsum board and $^{3}/_{8}$-inch wood structural panels are approved draftstopping materials. [Ref. R302.12]

FLOORS

The conventional wood framing floor system includes the support beams or girders, floor joists, floor sheathing and connections necessary for the load path to the foundation. The MRC provides the lumber framing and wood structural panel spans in prescriptive tables. Floor framing details are shown in Figures 6-15 through 6-17. [Ref. R502]

Beams and Girders

The prescriptive spans and support requirements for headers, beams, and girders are based on common species of #2 grade lumber and incorporate the required strength and deflection criteria under code-prescribed uniform loads. [Ref. Tables R602.7(1), R602.7(2)]

EXAMPLE 6-1

Determine the minimum size and bearing support requirements for an interior beam of #2 hem-fir lumber supporting two floors. The width of the building is 24 feet, and the beam span is 6 feet. Refer to Table 6-2 and Figure 6-15.

You Should Know

A multi-span continuous beam increases stresses across an interior support. A splice over the support helps transfer forces from one beam to the next. Beam ends at the splice should be supported by a length of bearing on each side of the splice equal to the number of jack studs. See Figure 6-15.

TABLE 6-2 Maximum girder and header spans for interior bearing walls for # 2 Douglas fir-larch, hem-fir, southern pine and spruce-pine-fir, and required number of jack studs

Headers and girders supporting	Size	Building width (feet)			
		24		36	
		Span	Jack studs	Span	Jack studs
	2-2 × 4	1-11	1	1-7	1
	2-2 × 6	2-11	2	2-5	2
	2-2 × 8	3-8	2	3-1	2
	2-2 × 10	4-4	2	3-7	2
	2-2 × 12	5-2	2	4-3	3
Two floors	3-2 × 8	4-7	2	3-10	2
	3-2 × 10	5-6	2	4-6	2
	3-2 × 12	6-5	2	5-4	2
	4-2 × 8	5-4	1	4-5	2
	4-2 × 10	6-4	2	5-3	2
	4-2 × 12	7-5	2	6-2	2

[Ref. excerpt of Table R602.7(2)]

Spans are given in feet and inches
See MRC to view applicable footnotes not shown

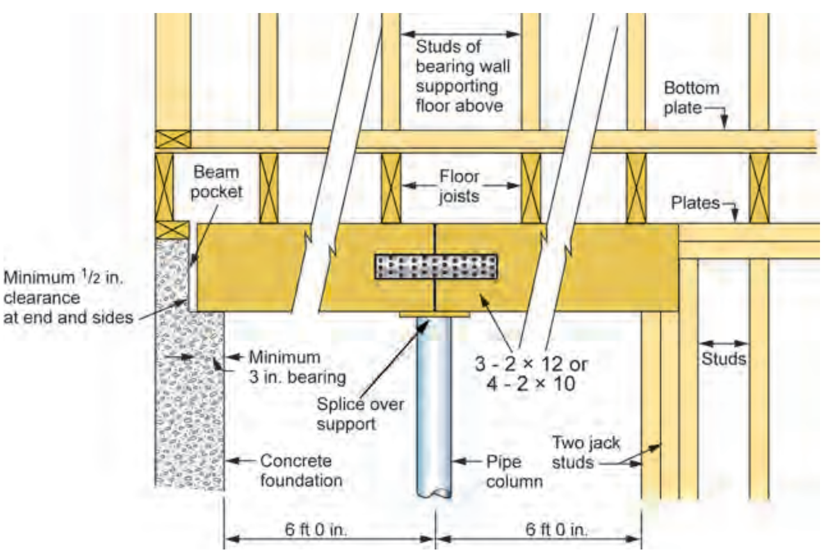


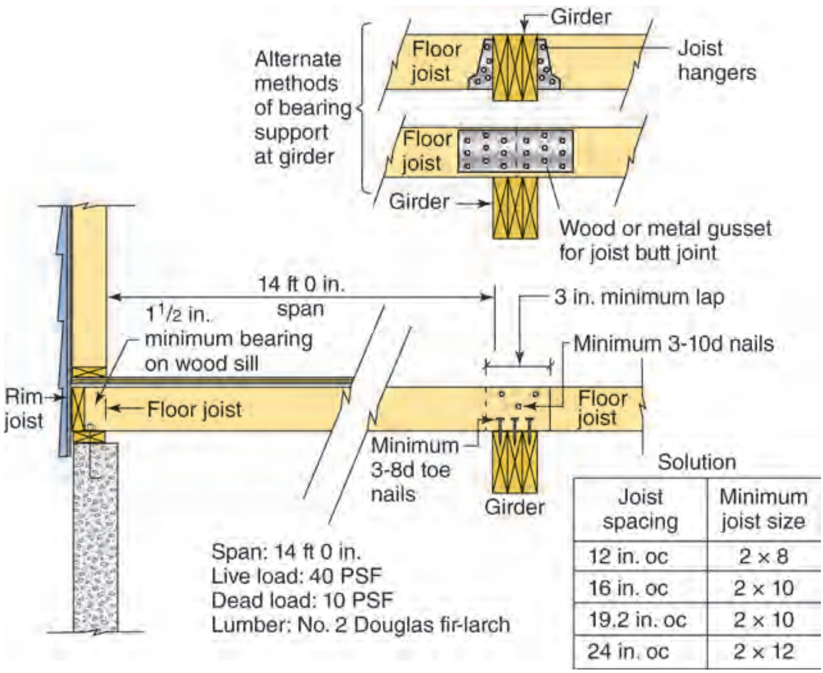
FIGURE 6-15 Solution for interior beam span and bearing support based on Table 6-2

Joists

In determining the minimum size of a floor joist for a given span, the designer or builder must consider a number of criteria, including live load, dead load, spacing of joists and the species and grade of lumber. The minimum live load for residential areas is 40 psf, except for sleeping areas, habitable attics and attics served by fixed stairs, where a live load of 30 psf is permitted. The assumed value for uniform dead load

EXAMPLE 6-2

Determine the minimum size and maximum spacing of a floor joist of #2 Douglas fir-larch with a span of 14 feet. The floor joists are for a family room, dining room, and kitchen area, and the dead load is 10 psf. Refer to Table 6-3 and Figure 6-16.



Joist spacing	Minimum joist size
12 in. oc	2 × 8
16 in. oc	2 × 10
19.2 in. oc	2 × 10
24 in. oc	2 × 12

FIGURE 6-16 Floor joist.

in conventional wood frame construction is typically 10 psf. The use of heavier flooring materials such as lightweight concrete or natural stone floor covering may necessitate a joist size based on 20 psf dead load. Table 6-4 contains typical fastening requirements for floor systems. [Ref. Tables R502.3.1(1) and R502.3.1(2)]

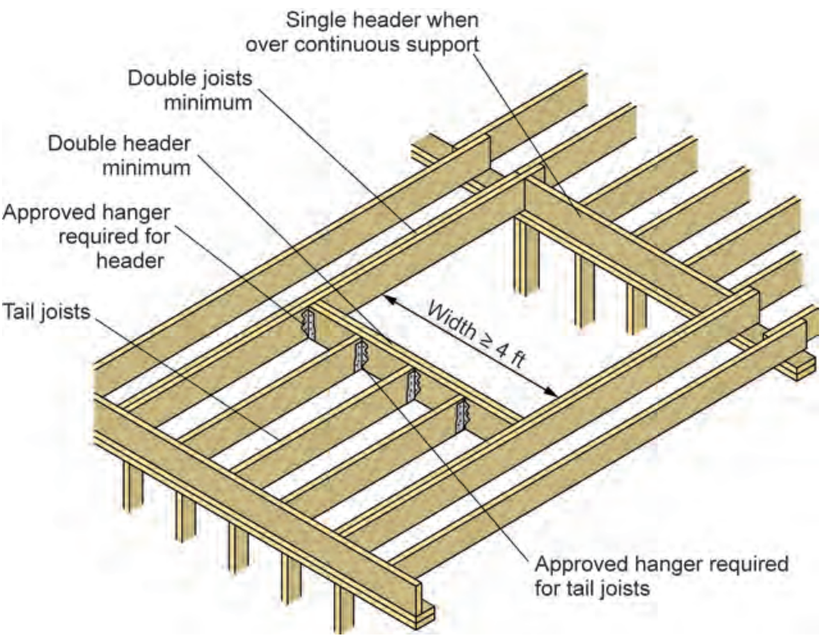


FIGURE 6-17 Floor joist.

TABLE 6-3 Floor joist spans for common lumber species, #2 grade (residential living areas, live load = 40 psf, L/360)

Joist spacing (Inches)	Species and grade		10 psf dead load		
			2 × 8	2 × 10	2 × 12
			Maximum floor joist spans		
			(ft - in.)	(ft - in.)	(ft - in.)
12	Douglas fir-larch	#2	14 - 2	18 - 0	20 - 11
	Hem-fir	#2	13 - 2	16 - 10	20 - 4
	Southern pine	#2	13 - 6	16 - 2	19 - 1
	Spruce-pine-fir	#2	13 - 6	17 - 3	20 - 7
16	Douglas fir-larch	#2	12 - 9	15 - 7	18 - 1
	Hem-fir	#2	12 - 0	15 - 2	17 - 7
	Southern pine	#2	11- 10	14 - 0	16 - 6
	Spruce-pine-fir	#2	12 - 3	15 - 5	17 - 10

(continued)

TABLE 6-3 (continued)

Joist spacing (Inches)	Species and grade		10 psf dead load		
			2 × 8	2 × 10	2 × 12
			Maximum floor joist spans		
			(ft - in.)	(ft - in.)	(ft - in.)
19.2	Douglas fir-larch	#2	11 - 8	14 - 3	16 - 6
	Hem-fir	#2	11 - 3	13 - 10	16 - 1
	Southern pine	#2	10 - 10	12 - 10	15 - 1
	Spruce-pine-fir	#2	11 - 6	14 - 1	16 - 3
24	Douglas fir-larch	#2	10 - 5	12 - 9	14 - 9
	Hem-fir	#2	10 - 2	12 - 5	14 - 4
	Southern pine	#2	9 - 8	11 - 5	13 - 6
	Spruce-pine-fir	#2	10 - 3	12 - 7	14 - 7

[Ref. excerpt of Table R502.3.1(2)]

Spans are given in feet and inches.

TABLE 6-4 Floor framing fastening schedule for typical box, sinker and pneumatic-driven nails

Description	Number and size of nails	Spacing, location and method
Joist to sill, top plate or girder	3 - 10d box (3" × 0.128") or 3 - 3" × 0.131" nails	Toe nail
Rim joist, band joist or blocking to sill or top plate	10d box (3" × 0.128") or 3" × 0.131" nails	6″ o.c. toe nail
Band or rim joist to joist	4 - 10d box (3" × 0.128") or 4 - 3" × 0.131" nails	End nail
Built-up girders and beams, 2-inch lumber layers	10d box (3" × 0.128") or 3" × 0.131" nails	24″ o.c. face nail at top and bottom stag-gered on opposite sides
	and 3 - 10d box (3" × 0.128") or 3 - 3" × 0.131" nails	Face nail at ends and at each splice
[Ref. excerpt of Table R602.3(1)]		

Note: Some approved nail and staple sizes are not shown.

DECKS

The MRC provides prescriptive methods for conventional wood deck construction that reflect widely accepted construction techniques in use over many decades. The provisions do not intend to limit design flexibility, and other approved methods may be used. Deck support provisions describe maximum joist and beam spans, appropriate joist spacing for the type of decking material, minimum post sizes, connections between beams and posts, and minimum bearing lengths. Details also are provided for attachment of the deck to the structure. Deck posts must be supported on footings and restrained at the bottom to prevent lateral movement. [Ref. R507]

Deck Footings

The code prescribes the minimum size and depth of concrete deck footings based on the tributary area, deck live load of 40 psf, and soil bearing pressure. The MRC Table provides prescriptive values for either square or round footings (Table 6-5 and Figure 6-19). See Figure 5-8 in Chapter 5 for more information on tributary loads. [Ref. R507.3]

EXAMPLE 6-3

Determine the minimum round concrete footing size for the deck corner post and interior post of a 20-foot × 12-foot deck based on Table 6-5 and Figure 6-19. The live load is 40 psf and the dead load is 10 psf. The presumed soil-bearing pressure is 1500 psf.

FIGURE 6-18 Deck Support

You Should Know

Wood deck reference:
DCA 6—Prescriptive Residential Wood Deck Construction Guide

- Published by American Wood Council (AWC)
- Available at www.awc.org
- Includes foundation details
- Provides construction and connection details
- Meets or exceeds MRC requirements
- Other construction methods can be used

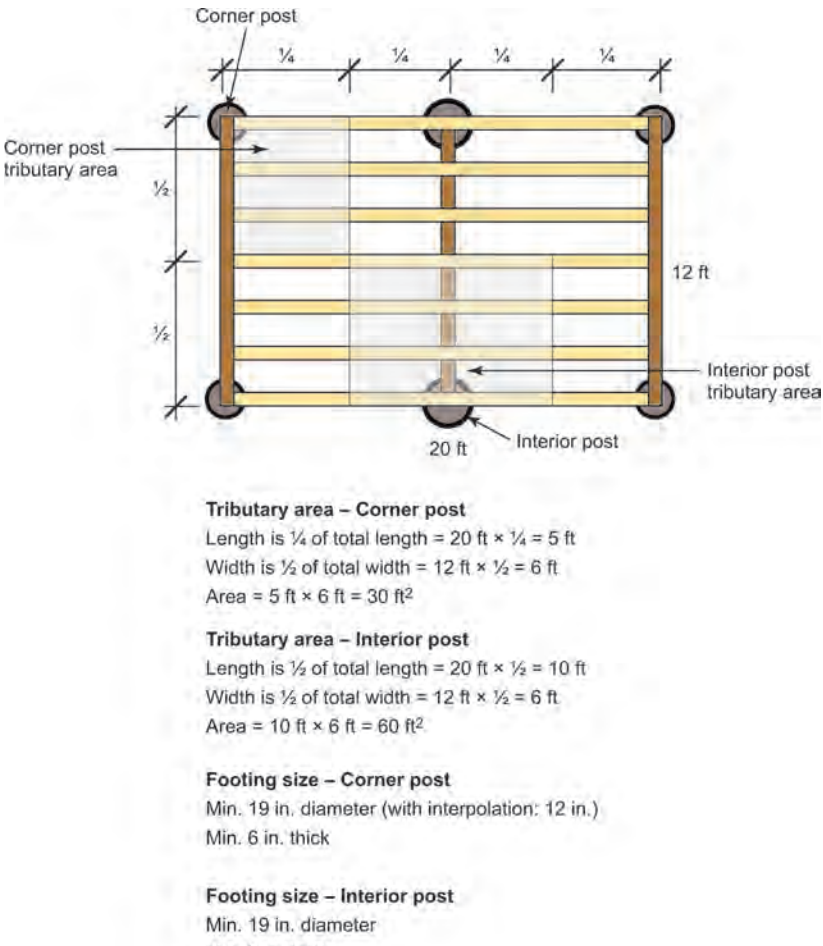


FIGURE 6-19 Determing concrete footing size based on deck tributary area and Table 6-5

TABLE 6-5 Minimum concrete footing size for decks

Live Load (psf)	Tributary area (ft^2)	Load Bearing Value of Soil (psf)					
		1500			2000		
		Side of a square footing (in)	Diameter of a round footing (in)	Thickness (in)	Side of a square footing (in)	Diameter of a round footing (in)	Thickness (in)
40	20	12	14	6	12	14	6
	40	14	16	6	12	14	6
	60	17	19	6	15	17	6
	80	20	22	7	17	19	6
	100	22	25	8	19	21	6
	120	24	27	9	21	23	7
	140	26	29	10	22	25	8
	160	28	31	11	24	27	9

[Ref. excerpt of Table R507.3.1]

Spans are given in feet and inches.
See MRC to view applicable footnotes not shown.

TABLE 6-6 Deck joist spans (feet – inches) based on 40 psf live load

Species	Size	Allowable joist span — Spacing of deck joists with no cantilever (in.)			Maximum cantilever — Spacing of deck joists with cantilevers (in.)		
		12	16	24	12	16	24
Southern pine	2 × 6	9-11	9-0	7-7	1-3	1-4	1-6
	2 × 8	13-1	11-10	9-8	2-1	2-3	2-5
	2 × 10	16-2	14-0	11-5	3-4	3-6	2-10
	2 × 12	18-0	16-6	13-6	4-6	4-2	3-4
Douglas fir-larch, hem-fir, spruce-pine-fir	2 × 6	9-6	8-8	7-2	1-2	1-3	1-5
	2 × 8	12-6	11-1	9-1	1-11	2-1	2-3
	2 × 10	15-8	13-7	11-1	3-1	3-5	2-9
	2 × 12	18-0	15-9	12-10	4-6	3-11	3-3
Redwood, western cedars, ponderosa pine, red pine	2 × 6	8-10	8-0	7-0	1-0	1-1	1-2
	2 × 8	11-8	10-7	8-8	1-8	1-10	2-0
	2 × 10	14-11	13-0	10-7	2-8	2-10	2-8
	2 × 12	17-5	15-1	12-4	3-10	3-9	3-1

[Ref. excerpt of Table R507.6]

Note: Spans based on No. 2 grade lumber with wet service factor , 40 psf live load and 10 psf dead load.
See MRC to view applicable footnotes not shown.

TABLE 6-7 Deck beam spans (feet - inches) based on 40 psf live load

Species	Size	Deck joist span (ft.)				
		8	10	12	14	16
Southern pine	2 – 2 x 8	7-7	6-9	6-2	5-9	5-4
	2 – 2 x 10	9-0	8-0	7-4	6-9	6-4
	2 – 2 x 12	10-7	9-5	8-7	8-0	7-6
	3 – 2 x 8	9-6	8-6	7-9	7-2	6-8
	3 – 2 x 10	11-3	10-0	9-2	8-6	7-11
	3 – 2 x 12	13-3	11-10	10-9	10-0	9-4
Douglas fir-larch, hem-fir, spruce-pine-fir, redwood, western cedars, ponderosa pine, red pine	2 – 2 x 8	5-11	5-4	4-10	4-6	4-1
	2 – 2 x 10	7-3	6-6	5-11	5-6	5-1
	2 – 2 x 12	8-5	7-6	6-10	6-4	5-11
	3 – 2 x 8	8-6	7-7	6-11	6-5	6-0
	3 – 2 x 10	10-5	9-4	8-6	7-10	7-4
	3 – 2 x 12	12-1	10-9	9-10	9-1	8-6

[Ref. excerpt of Table R507.5]

Note: Spans based on No. 2 grade lumber with wet service factor, 40 psf live load, 10 psf dead load and 220 lb point load at the cantilever end. See MRC to view applicable footnotes not shown.

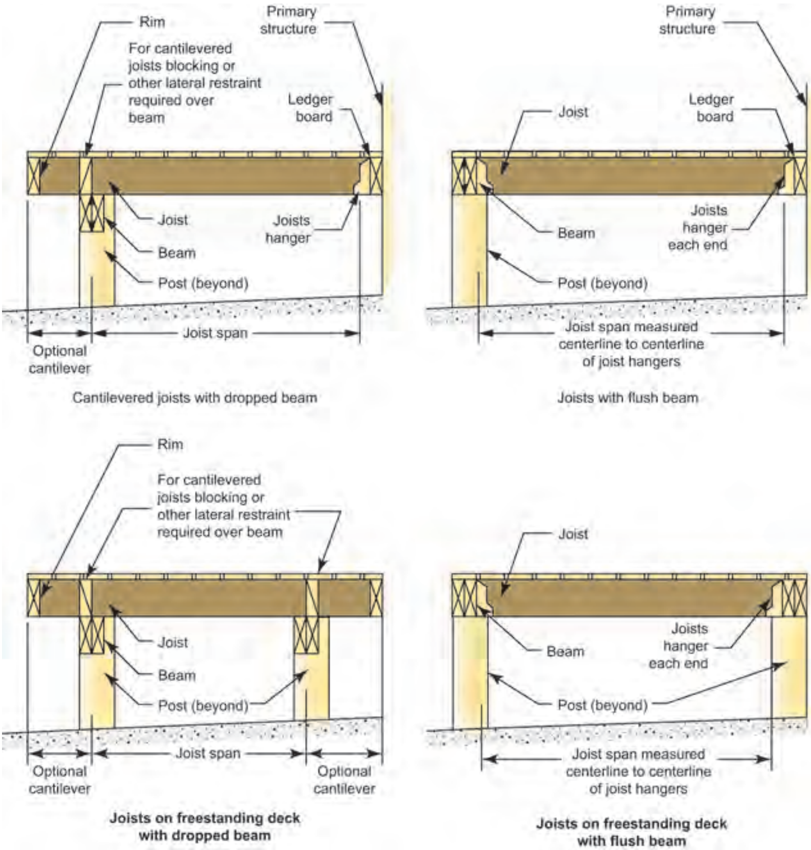


FIGURE 6-20 Typical deck joist span and supports

Deck Joists and Beams

The joist and beam span values in Tables 6-6 and 6-7 assume outdoor, potentially wet conditions and include wood species such as redwood, southern pine, ponderosa pine and red pine that are commonly used in deck construction. Minimum bearing lengths match those for interior floor joists and beams: $1^1/_2$ inches on wood or metal and 3 inches on concrete or masonry.

Joists framing into the side of a ledger board or beam require joist hangers (Figure 6-20). [Ref. R507.5, R507.6, Table R507.5, Table R507.6]

Deck Posts

Provisions for sizing wood deck posts are limited to single-level decks and are based on the height of the post measured to the bottom of the beam.

TABLE 6-8 Deck post size and height for single-level wood-framed decks

Deck post size	Maximum height*(ft.)	Notes
4 × 4	8	When supporting one-ply or two-ply beams
4 × 4	6-9	When supporting three-ply beams on a post cap
4 × 6	8	
6 × 6	14	
8 × 8	14	
[Ref. Table R507.4]		

*Measured to the underside of the beam and based on a 40 psf live load
See MRC to view applicable footnotes not shown.

The code prescribes either a notched post with two through-bolts or a manufactured post cap for connecting the post to the beam. In the case of a notched post, the post must be at least a 4 × 6 or 6 × 6 to provide a minimum cross section of $5^1/_2$ inches for notching (Table 6-8 and Figure 6-21). A manufactured connector is required for the post connection to the footing unless the post is embedded at least 12 inches in the ground or concrete pier. [Ref. R507.4, R507.5, Table R507.4]

Deck Attachment

The prescriptive methods for deck attachment apply to a minimum 2 by 8 deck ledger connected to a 2-inch nominal solid-sawn lumber band joist or a minimum 1-inch by $9^1/_2$-inch Douglas fir laminated veneer lumber (LVL) rim board. Attachment to other structural composite lumber band joists requires a design in accordance with accepted engineering practice. Fasteners must be minimum $^1/_2$-inch diameter hot-dipped galvanized or stainless steel lag screws or bolts installed with washers of the same material. The maximum spacing is based on the deck joist span. The code requires a staggered fastener pattern with the bolts or lag screws located not less than 2 inches from the top edge and not less than $^3/_4$ inch from the bottom edge of the deck ledger and from 2 to 5 inches from the end of the ledger (Table 6-9 and Figure 6-22). Other methods may still be used, and often are, to provide equivalent connection capacities, as long as the method is approved by the building official. For example, proprietary fasteners are commonly installed following the manufacturer's instructions and based on equivalent capacities. [Ref. R507.9]

Deck attachment also requires lateral connections. The MRC includes two compliance methods. The first requires at least two hold-down tension devices each with a minimum design capacity of 1,500 pounds and located

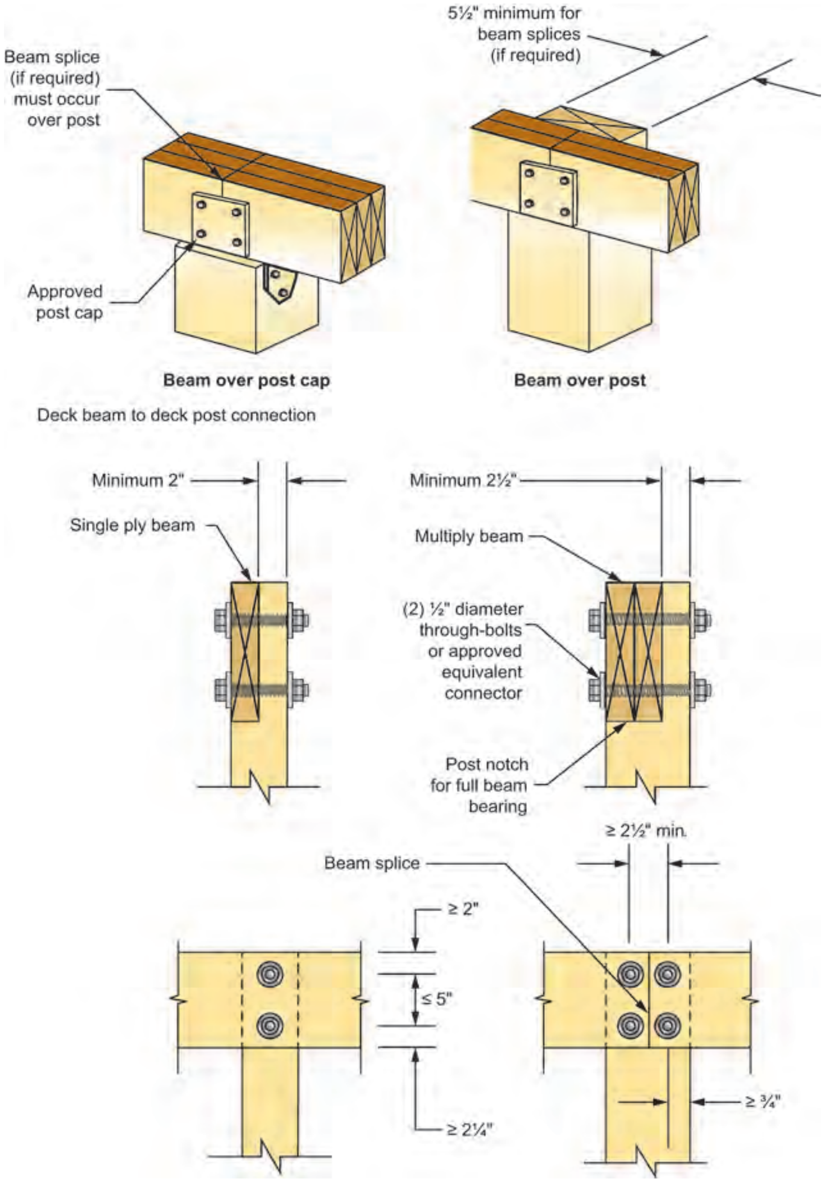


FIGURE 6-21 Connection of deck posts to deck beam

within 24 inches of each end of the deck. The other method requires the installation of at least four hold-down tension devices each with a design capacity of 750 pounds.

Figure 6-22 illustrates one method of lateral connection

TABLE 6-9 Fastener spacing for a southern pine or hem-fir deck ledger and a 2-inch nominal solid-sawn spruce-pine-fir band joist (deck live load = 40 psf, deck dead load = 10 psf)

Joist span	8′–1″ to 10′–0″	10′–1″ to 12′–0″	12′–1″ to 14′–0″	14′–1″ to 16′–0″	16′–1″ to 18′–0″
Connection details	**On-center spacing of fasteners**				
$^{1}/_{2}$″ diameter lag screw with $^{1}/_{2}$″ maximum WSP sheathing	18	15	13	11	10
$^{1}/_{2}$″ diameter bolt with $^{1}/_{2}$″ maximum WSP sheathing	34	29	24	21	19
$^{1}/_{2}$″ diameter bolt with 1″ maximum sheathing	29	24	21	18	16
[Ref. excerpt of Table R507.9.1.3(1)]					

See MRC to view applicable footnotes not shown.

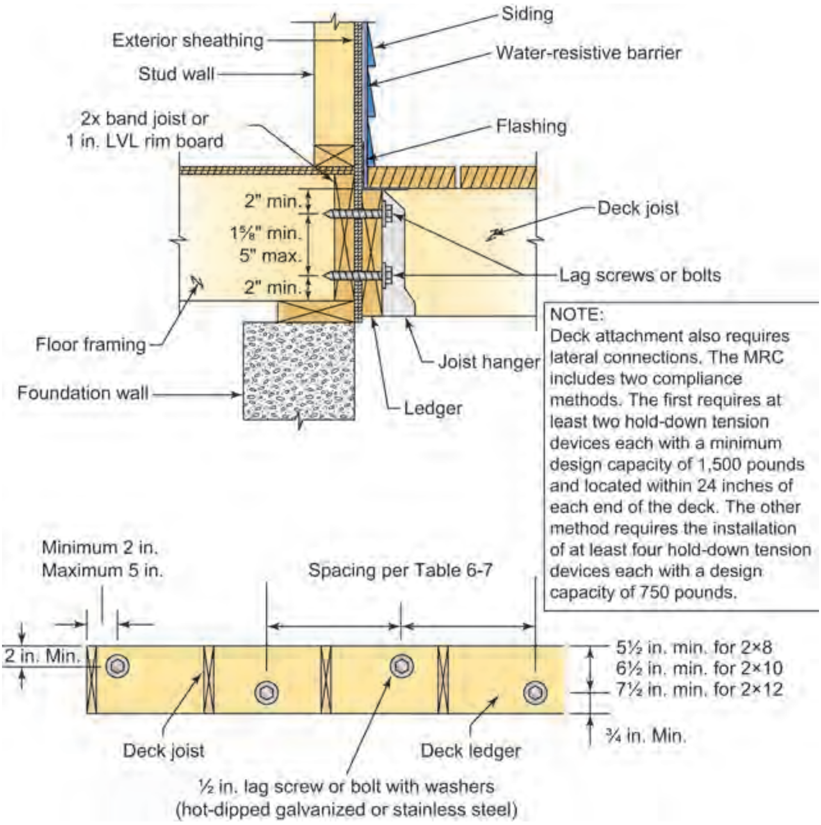


FIGURE 6-22 Deck ledger connection to band joist

WALLS

Walls must be designed and constructed to safely support all code-prescribed loads and transfer those loads to the supporting structure and foundation. In addition to setting limits on the size, length, and spacing of studs, the code includes a number of methods for wall bracing, which is critical to the structural integrity of the building. Wall framing details are shown in Figure 6-23. Table 6-10 contains typical fastening requirements for wall framing. [Ref. R602]

TABLE 6-10 Wall framing fastening schedule for typical box, sinker and pneumatic-driven nails

Description	Number and size of nails	Spacing, location and method
Stud to stud (not at braced wall panels)	10d box (3" × 0.128") or 3" × 0.131" nails	16" o.c. face nail
Stud to stud and abutting studs at intersecting wall corners (at braced wall panels)	16d box (3½" × 0.135") or 3" × 0.131" nails	12" o.c. face nail
Built-up header (2" to 2" header with ½" spacer)	16d box (3½" × 0.135")	12" o.c. each edge face nail
Continuous header to stud	4 - 10d box (3" × 0.128")	Toe nail
Top plate to top plate	10d box (3" × 0.128") or 3" × 0.131" nails	12" o.c. face nail
Double top plate splice	12 - 10d box (3" × 0.128") or 12 - 3" × 0.131" nails	Face nail on each side of end joint (minimum 24" lap)

(continued)

TABLE 6-10 (continued)

Bottom plate to joist, rim joist, band joist or blocking (not at braced wall panels)	16d box (3½" × 0.135") or 3" × 0.131" nails	12" o.c. face nail
Bottom plate to joist, rim joist, band joist or blocking (at braced wall panel)	3 - 16d box (3½" × 0.135") or 4 - 3" × 0.131" nails	3 each 16" o.c. face nail 4 each 16" o.c. face nail
Top or bottom plate to stud	3 - 10d box (3" × 0.128") or 3 - 3" × 0.131" nails	End nail
Top plates, laps at corners and intersections	3 - 10d box (3" × 0.128") or 3 - 3" × 0.131" nails	Face nail
[Ref. excerpt from Table R602.3(1)]		

Note: Some approved nail and staple sizes are not shown.
See MRC to view applicable footnotes not shown.

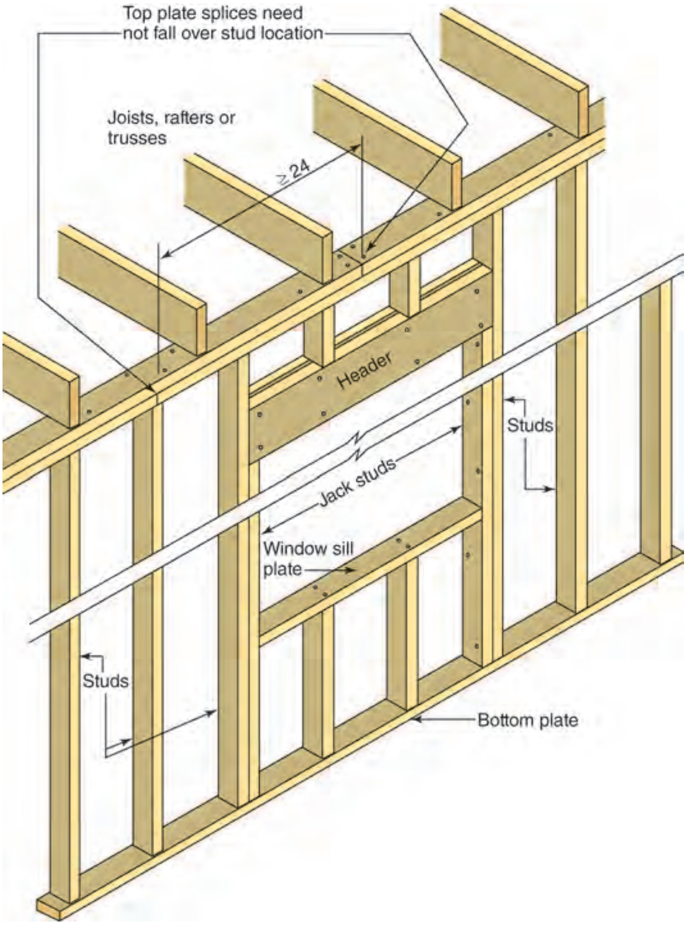


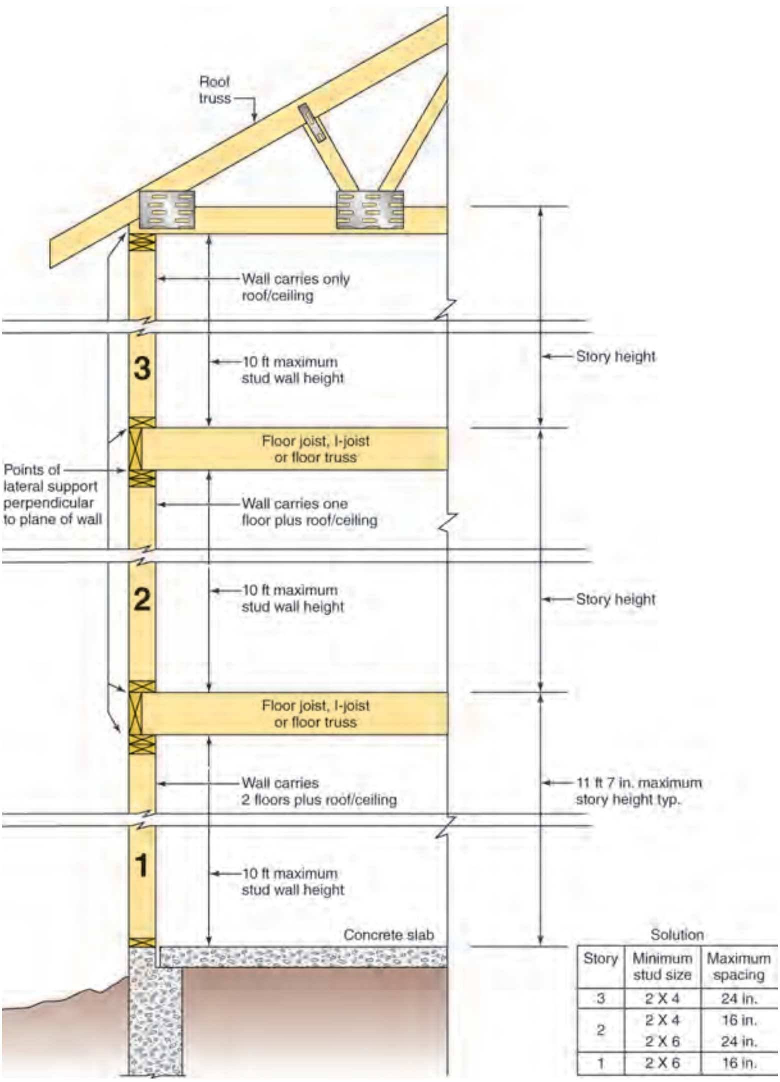
FIGURE 6-23 Typical wall framing details

Studs and Plates

The prescriptive provisions of the MRC limit stud height in bearing walls to 24 feet. The height is the distance between points of lateral support perpendicular to the plane of the wall, which are typically where the top and bottom plates are connected to the floor or ceiling framing. The size and spacing of studs is related to the number of floors being supported with or without the additional load of the roof-ceiling assembly (Table 6-11 and Figure 6-24). For bearing walls supporting a roof only and a combination of snow loads and wind loads, the code provides tables for wall heights up to 24 feet (Table 6-12). [Ref. Table R602.3.1 and R602.3(5)]

EXAMPLE 6-3

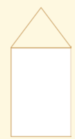
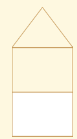
Determine the minimum size, maximum height, and maximum spacing of standard studs in an exterior bearing wall, as shown in Figure 6-24. Refer to Table 6-11.



Story	Minimum stud size	Maximum spacing
3	2 X 4	24 in.
2	2 X 4	16 in.
	2 X 6	24 in.
1	2 X 6	16 in.

FIGURE 6-24 Stud size, height and spacing based on Table 6-11

TABLE 6-11 Size, height and maximum spacing of wood studs

	Bearing walls			Nonbearing walls	
Stud size	Laterally unsupported stud height	Supporting a roof-ceiling assembly only	Supporting one floor, plus a roof-ceiling assembly	Laterally unsupported stud height	Maximum spacing
(inches)	(feet)	(inches)	(inches)	(feet)	(inches)
					
2 × 3	—	—	—	10	16
2 × 4	10	24	16	14	24
3 × 4	10	24	24	14	24
2 × 5	10	24	24	16	24
2 × 6	10	24	24	20	24

[Ref. excerpt of Table R602.3(5)]

TABLE 6-12 Maximum allowable length of wood wall studs exposed to wind speeds up to 115 mph

Roof spans greater than 26 ft and up to 30 ft supporting a roof only					
Maximum wall height (feet)	Exposure category	On-center spacing (inches)			
		24	16	12	8
10	B	2 × 6	2 × 6	2 × 4	2 × 4
	C	2 × 6	2 × 6	2 × 6	2 × 4
12	B	2 × 6	2 × 6	2 × 6	2 × 4
	C	2 × 8	2 × 6	2 × 6	2 × 6
14	B	2 × 8	2 × 6	2 × 6	2 × 6
	C	2 × 8	2 × 8	2 × 6	2 × 6
16	B	2 × 8	2 × 6	2 × 6	2 × 6
	C	2 × 8	2 × 8	2 × 8	2 × 6
18	B	2 × 8	2 × 8	2 × 6	2 × 6
	C	DR	2 × 8	2 × 8	2 × 8
20	B	DR	2 × 8	2 × 8	2 × 6
	C	DR	DR	2 × 8	2 × 8
24	B	DR	DR	2 × 8	2 × 8
	C	DR	DR	DR	2 × 8
[Ref. excerpt of Table R602.3.1 – see footnotes in the code for applicability]					

DR - Design required

Headers

Headers are required above door and window openings to carry the loads of construction above and transfer the loads to the wall framing at the sides of the opening. The prescriptive tables for girders and headers provide the span and bearing support requirements for dimension lumber headers. In addition, the MRC prescribes the minimum number of full-height (king) studs at each end of a header in an exterior wall to resist out-of-plane wind loads on the window or door opening. [Ref. Tables R602.7(1), R602.7(2) and R602.7.5]

EXAMPLE 6-4

Determine the minimum size and bearing support requirements for a #2 Douglas fir-larch header in an exterior bearing wall as shown in Figure 6-25. Determine the minimum number of full-height studs at each end of all headers. The width of the building is 24 feet, the header span is 7 feet and the ground snow load is 50 psf. Wind speed is 115 mph in wind exposure category C. Refer to Tables 6-13 and 6-14 and Figure 6-25.

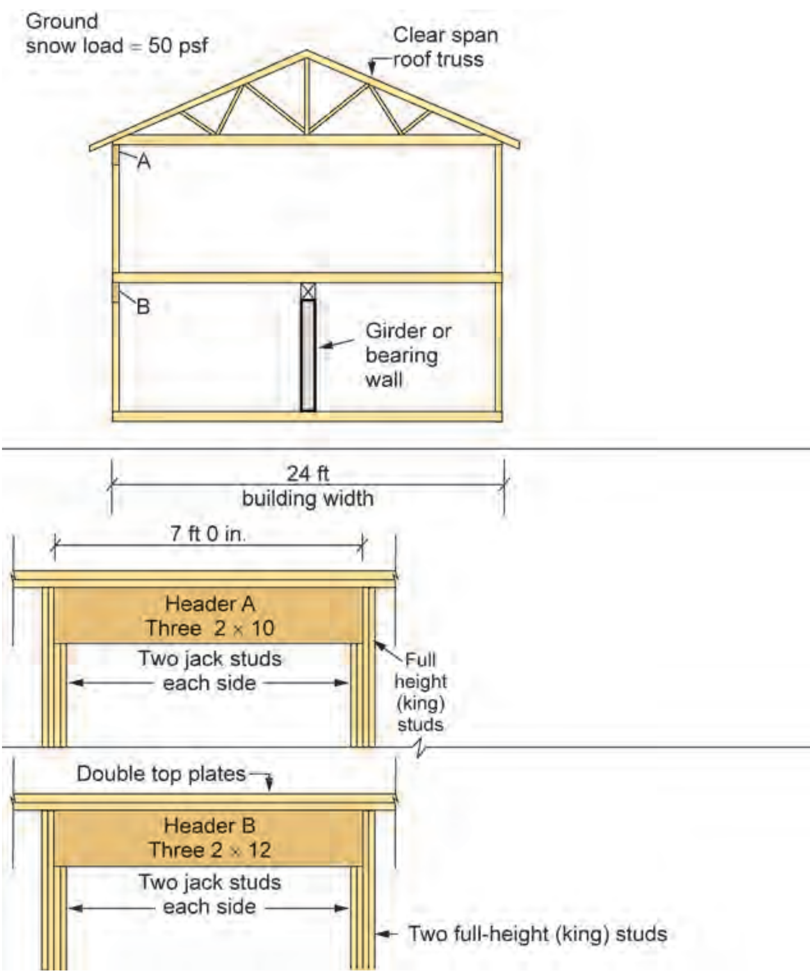
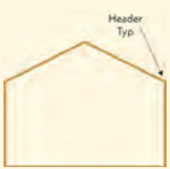


FIGURE 6-25 Exterior header span, bearing support and minimum number of full-height studs based on Tables 6-13 and 6-14

TABLE 6-13 Girder spans and header spans for exterior bearing walls (maximum spans for # 2 grade Douglas fir-larch, hem-fir, southern pine, and spruce-pine-fir) and required number of jack studs

Girders and headers supporting	Size	Ground snow load (psf)			
		50			
		Building width (feet)			
		24		36	
		Span	Jack studs	Span	Jack studs
Roof and ceiling	2 - 2 × 8	5-0	2	4-2	2
	2 - 2 × 10	5-11	2	4-11	2
	2 - 2 × 12	6-11	2	5-10	2
	3 - 2 × 8	6-3	1	5-3	2
	3 - 2 × 10	7-4	2	6-2	2
	3 - 2 × 12	8-8	2	7-4	2

(continued)

TABLE 6-13 (continued)

Girders and headers supporting	Size	Ground snow load (psf)			
		50			
		Building width (feet)			
		24		36	
		Span	Jack studs	Span	Jack studs
Roof, ceiling and one center-bearing floor	2 - 2 × 8	4-5	2	3-9	2
	2 - 2 × 10	5-3	2	4-5	2
	2 - 2 × 12	6-2	2	5-3	3
	3 - 2 × 8	5-6	2	4-8	2
	3 - 2 × 10	6-7	2	5-7	2
	3 - 2 × 12	7-8	2	6-7	2

[Ref. excerpt of Table R602.7(1)]

Spans are given in feet and inches.

Single Member Headers

Traditionally, headers in conventional wood frame construction have consisted of at least two dimension lumber members side-by-side, each having a nominal dimension of 2 inches in thickness. As an alternative, the MRC allows single member headers of 2-inch nominal thickness under limited loading conditions to increase the energy efficiency of the dwelling and reduce the cost of construction. Installation of a single header results in a greater thickness of cavity insulation to reduce heat loss through the header in exterior walls. The prescriptive provisions for single headers are limited to areas with a maximum 50-psf ground snow load. [Ref. R602.7.1, Tables R602.7(1)and R602.7.5]

EXAMPLE 6-5

Determine the minimum size and the minimum number of jack studs and full-height studs for a single header in an exterior bearing wall, as shown in Figure 6-26. The width of the building is 24 feet, the header span is 3 feet 11 inches, and the ground snow load is 50 psf. Wind speed is 115 mph in wind exposure category B. Refer to Tables 6-14 and 6-15 and Figure 6-26.

TABLE 6-14 Minimum number of full-height studs at each end of headers in exterior walls

Maximum header span (feet)	Ultimate design wind speed and exposure category	
	≤ 115 mph, Exposure B	< 140 mph, Exposure B or < 130 mph, Exposure C
4	1	1
6	1	2
8	1	2
10	2	3
12	2	3
14	2	3
16	2	4
18	2	4

Ref. Table R602.7.5; see footnotes in the code for applicability

TABLE 6-15 Single header spans for exterior bearing walls (maximum spans for # 2 grade Douglas fir-larch, hem-fir, southern pine, and spruce-pine-fir) and required number of jack studs

Single headers supporting	Size	Ground snow load (psf)	
		50	
		Building width (feet)	
		24	
		Span	Jack studs
Roof and ceiling	2 × 10	4–0	2
	2 × 12	4–8	3
[Ref. excerpt from Table R602.7(1)]			

Spans are given in feet and inches.

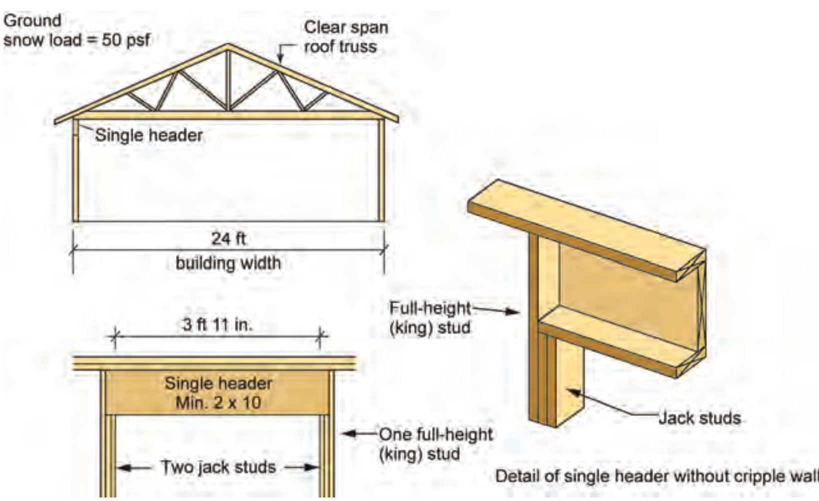


FIGURE 6-26 Single header in exterior bearing wall based on tables 6-14 and 6-15

You Should Know

Wood wall bracing

- Prescriptive methods
- Engineering not required but still an option
- Consists of sections of wall with sheathing nailed in a prescribed pattern
- Establishes minimum length of bracing along exterior walls and some interior walls
- Stiffens walls to resist winds

Wall Bracing

Wall bracing is necessary to provide resistance to racking from lateral loads, in other words, wind loads. The MRC includes twelve distinct, prescriptive methods of panel and diagonal wall bracing, referred to as intermittent bracing methods and four methods of continuous sheathing. Discussion in this chapter focuses on the most common bracing material—wood structural panels (Method WSP). A braced wall panel is the segment of bracing that is the full height of the wall, and its horizontal dimension is referred to as the length of the panel. The minimum length of a braced wall panel is typically 4 feet, but the code offers a number of alternatives to reduce this length by increasing the strength of the panel through specific material, connection, and anchorage details (Figures 6-27, 6-28, 6-29).

The series of braced wall panels, typically in an exterior wall, is considered a braced wall line. A braced wall line must contain the prescribed total length of bracing in feet and meet the maximum spacing requirements of braced wall panels as well as braced wall lines. For this reason, interior braced wall lines also may be required. The amount and location of bracing is determined by numerous factors, including the number of stories of the building, the design wind speed, the wind exposure category and the method of bracing. Another path for compliance with the wall bracing provisions is to apply structural panels to all areas of one side of a braced wall line, including above and below windows. An alternative to intermittent bracing, this continuous sheathing method increases the rigidity of the lateral resistance system and allows reduced lengths for full height braced wall panels. [Ref. R602.10]

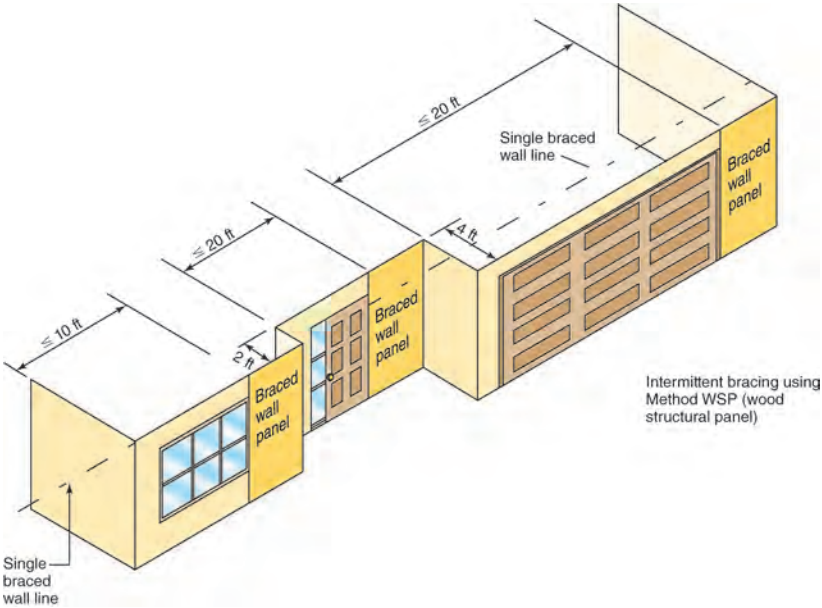


FIGURE 6-27 Location of braced wall panels in a braced wall line

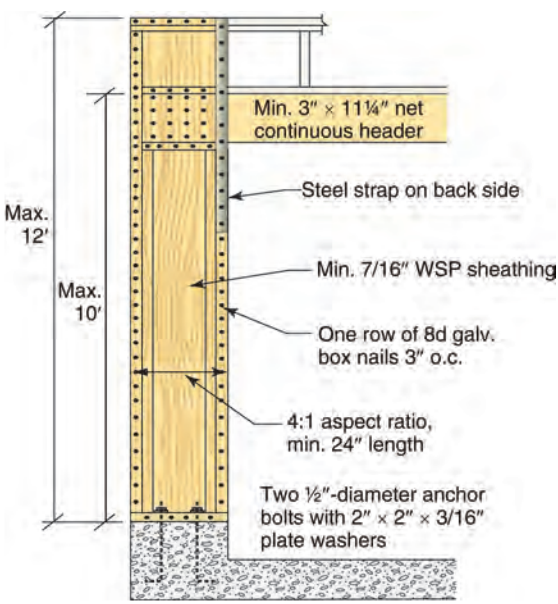


FIGURE 6-28 Method PFG—portal frame at garage door openings

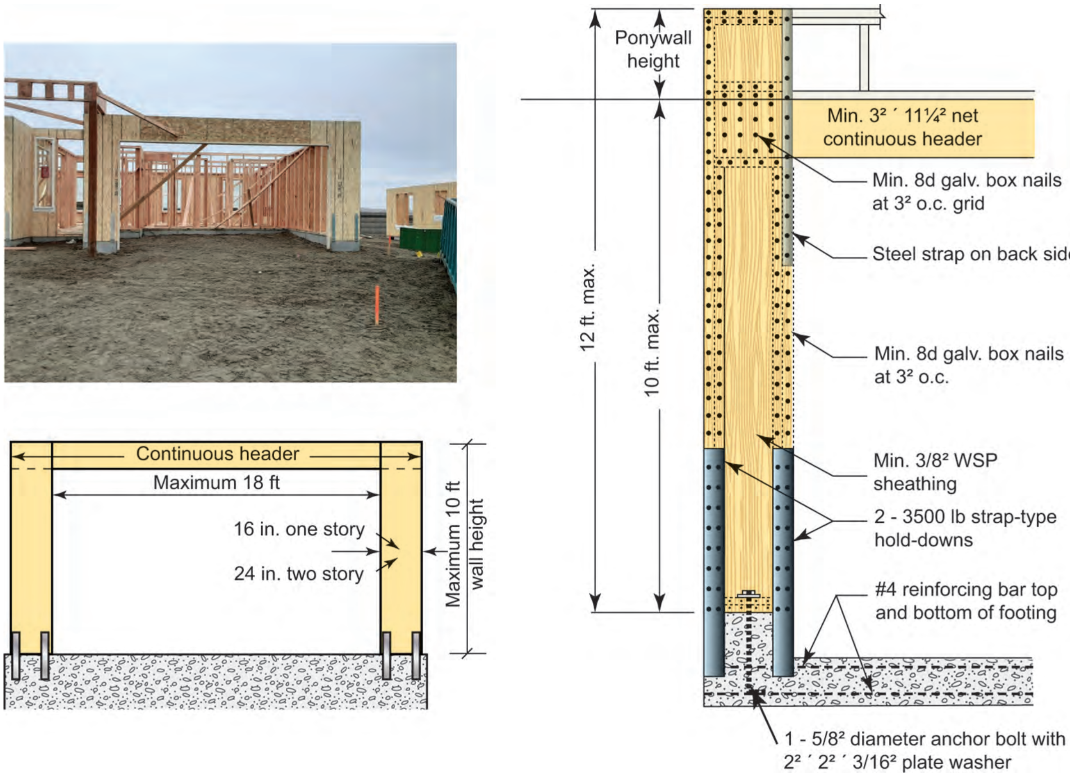


FIGURE 6-29 Method PFH—portal frame with hold-downs

CEILING AND ROOF

The scope of wood roof framing details in the code is limited to roofs with a minimum slope of 3 units horizontal to 12 units vertical (3:12).

Ceiling Joist

In addition to supporting ceiling materials, ceiling joists also serve as rafter ties to resist the outward thrust of the rafters at the top of the wall. It follows that the ceiling joist requires adequate connection to the rafter, which is in turn fastened to the top of the wall. Maximum ceiling joist spans are provided for attics without storage and attics with limited storage. Attics with fixed stair access require joists sized as floor joists. [Ref. R802.5]

Rafters

The prescriptive tables giving maximum spans for rafters are based on the snow load of the geographic area and whether the ceiling material is attached to the bottom of the rafter rather than a ceiling joist. Rafters line up opposite each other at the ridge and are typically framed to a ridge board, but gusset plate ties also are permitted. [Ref. R802.5]

Where ceiling joists are not connected to the rafters at the top plate or are installed perpendicular to the rafters, minimum 2 × 4 rafter ties are required to resist the outward thrust forces of the rafters on the wall. In the absence of joists or rafter ties, the ridge must be supported by a bearing wall or girder, or be designed as a beam (Figures 6-30 through 6-32). [Ref. R802.3, R802.4]

EXAMPLE 6-6

Determine the minimum size and maximum spacing of a #2 spruce-pine-fir rafter with a span of 12 feet, as shown in Figure 6-30. The ground snow load is 50 psf and the dead load is 10 psf. Refer to Figure 6-30 and Table 6-16.

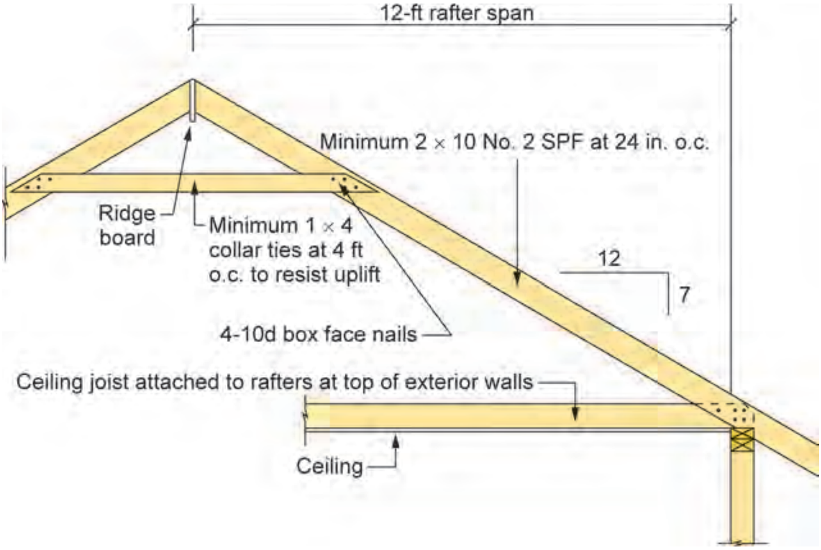


FIGURE 6-30 Rafter span with no ceiling attached based on Table 6-15

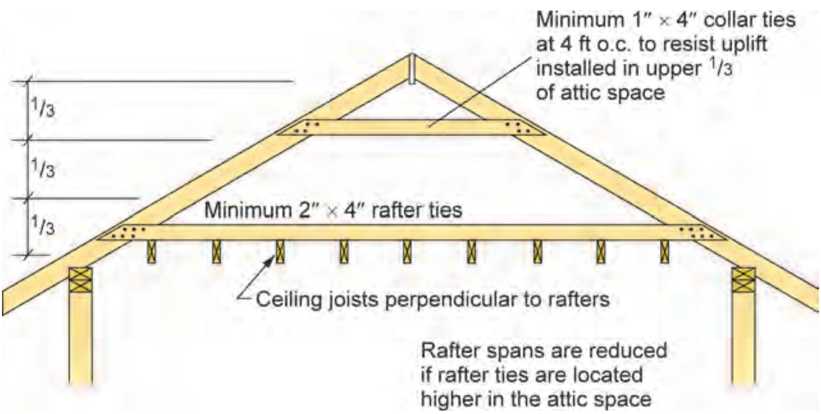


FIGURE 6-31 Rafter ties

TABLE 6-16 Rafter spans for common lumber species, # 2 grade (ground snow load = 50 psf, ceiling not attached to rafters, L/180, dead load = 10 psf)

Rafter spacing (inches)	Species and grade		Dead load = 10 psf				
			2 × 4	2 × 6	2 × 8	2 × 10	2 × 12
			Maximum rafter spans				
			ft - in.	ft - in.	ft - in.	ft - in.	ft - in.
24	Douglas fir-larch	#2	5-6	8-1	10-3	12-6	14-6
	Southern pine	#2	5-0	7-5	9-5	11-3	13-2
	Spruce-pine-fir	#2	5-5	7-11	10-1	12-4	14-3

[Ref. excerpt of Table R802.4.1(5)]

Spans are given in feet and inches.

TABLE 6-17 Roof framing fastening schedule for typical box, sinker and pneumatic-driven nails

Description	Number and size of nails	Spacing, location and method
Blocking between ceiling joists or rafters to top plate	Three 10d box (3" × 0.128") or Three 3" × 0.131" nails	Toe nail
Ceiling joists to top plate	Three 10d box (3" × 0.128") or Three 3" × 0.131" nails	Per joist, toe nail
Ceiling joist not attached to parallel rafter, laps over partitions	Four 10d box (3" × 0.128") or Four 3" × 0.131" nails	Face nail
Ceiling joist attached to parallel rafter (heel joint)	Table R802.5.2	Face nail
Rafter or roof truss to plate	Three 16d box (3½" × 0.135") or Four 10d box (3" × 0.128") or Four 3" × 0.131" nails	2 toe nails on one side and 1 toe nail on opposite side of each rafter or truss
Roof rafters to ridge, valley or hip	Four 16d box (3½" × 0.135") or Four 10d box (3" × 0.128") or Four 3" × 0.131" nails	Toe nail
	Three 16d box (3½" × 0.135") or Three 10d box (3" × 0.128") or Three 3" × 0.131" nails	End nail
[Ref. excerpt from Table R602.3(1)]		

Note: Some approved nail and staple sizes are not shown.

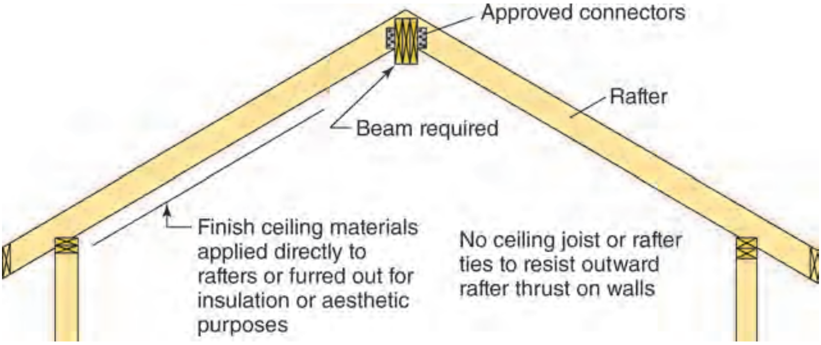


FIGURE 6-32 Ridge beam

Roof Uplift Connections

Roof-to-wall connections to resist wind uplift forces are one component of a complete load path necessary to transmit all loads bearing on a structure through the other structural elements to the foundation. The MRC provides prescriptive values for roof uplift resistance based on building width, wind speed, exposure category, and roof pitch. In many cases, the fastener schedule for wood structural members provides for adequate connection through conventional nailing methods. In the case of rafters or roof trusses, this toe-nail connection is achieved with three 16d box nails or three 10d common nails. Two toe nails are placed on one side and one on the other side of the truss or rafter and driven into the top wall plate. However, when the table values for uplift exceed 200 pounds, or the building otherwise exceeds the specified wind speed, exposure or building width criteria, a manufactured connector is required. The connector must have a rated capacity meeting or exceeding the uplift value for connecting each rafter or truss to the wall (Table 6-18 and Figure 6-33). As an alternative to the table values in the MRC, the manufactured roof truss design drawings may be used for determining minimum uplift resistance. [Ref. R802.11, Table R802.11]

Attic Ventilation and Access

The code requires cross ventilation for each attic or enclosed roof space to prevent moisture from accumulating in the space and causing damage to the structure. In poorly ventilated attics, warm moist air escaping from the conditioned space condenses on the framing and sheathing of the cooler attic space. The total net free ventilating area must be at least $^1/_{150}$ of the area of the space. A reduction to $^1/_{300}$ the area of the space is permitted

TABLE 6-18 Rafter or truss uplift connection forces from wind (pounds per connection)

Rafter or truss spacing	Roof span (feet)	Exposure B Ultimate design wind speed (mph) 115 Roof pitch < 5:12	 ≥ 5:12
16 in. o.c.	28	132	117
	32	145	129
	36	160	141
24 in. o.c.	28	198	176
	32	218	194
	36	240	212

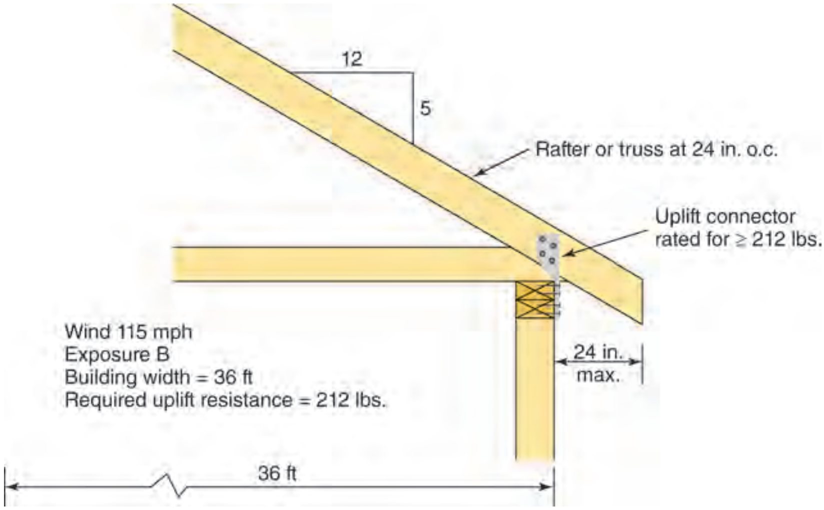


FIGURE 6-33 Roof connection to resist wind uplift based on Table 6-17

when 40 to 50 percent of the required ventilating area is in the upper portion of the space, with the balance of the ventilating area provided by eave or cornice vents. This reduction is also permitted for attics in cold climates when a vapor retarder is installed on the warm-in-winter side of the ceiling. Unvented attics are permitted under certain conditions. [Ref. R806]

Access is required to attic areas with a ceiling height of 30 inches and an area that exceeds 30 square feet. The access requires a rough opening of at least 22 by 30 inches with headroom above the opening at least 30 inches high. The access opening must be located in a hallway or other readily accessible location. Where located in a wall, the opening shall be not less than 22 inches wide by 30 inches high. [Ref. R807]

PART IV Finishes and Weather Protection

Chapter 7 Interior and Exterior Finishes and Weather Protection

CHAPTER 7 Interior and Exterior Finishes and Weather Protection

As part of its purpose statement to protect the health and general welfare of the public, the *Minnesota Residential Code* (MRC) sets minimum requirements for durable interior and exterior finishes. Exterior wall and roof coverings protect the structure against the damaging effects of water intrusion and provide an envelope for a healthy and livable interior environment.

INTERIOR FINISHES

The MRC includes minimum installation requirements for gypsum board (drywall), plaster, ceramic tile and wood paneling for walls and ceilings. Inspection is not specifically required for other than attachment of lath or gypsum board that is part of a fire resistant rated assembly. Fire resistance requirements for walls and ceilings are covered in Chapter 9. Interior finishes require protection from moisture and are typically installed at a stage of construction when the building is substantially weather tight. The MRC does not regulate the installation of floor coverings or the application of paint and wallpaper. [Ref. R702]

Gypsum Board

Gypsum board is the generic term for sheet panel products with a noncombustible gypsum core and paper facing that is commonly used for the wall and ceiling finish of dwelling construction. When taped and finished, it is often referred to as drywall. Type X gypsum board contains core additives for greater fire resistance than regular gypsum board. Gypsum products may also be reinforced for greater strength or manufactured for greater water resistance or durability.

The minimum fastening and thickness requirements for gypsum board relate to the spacing of the framing members and the location and intended application of the gypsum board. Generally, gypsum board may be installed with the long dimension perpendicular or parallel to framing members. The code requires installation perpendicular to ceiling framing members for $^{3}/_{8}$-inch material and places additional limitations on ceiling applications receiving water-based textures or serving as a fire-resistant-rated separation. Tables 7-1 and 7-2 summarize gypsum board application requirements. [Ref. R702.3, Table R702.3.5]

Backing for Ceramic Tile and Other Nonabsorbent Finishes

To prevent deterioration of the substrate and damage to the wall structure, only fiber-cement, fiber-mat-reinforced cementitious backer units, glass mat gypsum backers, or fiber-reinforced gypsum backers are permitted as backing material for wall tile installed in tub and shower areas. This requirement also applies to backers for nonabsorbent plastic panels in showers. In addition, installation of water-resistant gypsum backing board is not allowed where directly exposed to water or in areas subject to continuous high humidity. Water-resistant gypsum backing board is permitted on ceilings where framing spacing does not exceed 12 inches on center (O.C.) for $^{1}/_{2}$-inch material or 16 inches O.C. for $^{5}/_{8}$-inch material. [Ref. R702.3.7, R702.4.2]

TABLE 7-1 Minimum thickness and application of gypsum board

Thickness of gypsum board (in.)	Orientation of gypsum board to framing	Maximum spacing of framing members (in. o.c.)	Maximum spacing of fasteners (in.)	
			Nails	Screws
Wall Applications				
3/8	Either direction	16	8	16
1/2	Either direction	24	8	12
		16	8	16
5/8	Either direction	24	8	12
		16	8	16
Ceiling application with water-based texture material				
1/2	Perpendicular	16	7	12
1/2 sag-resistant	Perpendicular	24	7	12
5/8	Perpendicular	16	7	12
	Perpendicular	24	7	12

(continued)

TABLE 7-1 (continued)

Thickness of gypsum board (in.)	Orientation of gypsum board to framing	Maximum spacing of framing members (in. o.c.)	Maximum spacing of fasteners (in.)	
			Nails	Screws
Garage ceiling application with habitable space above				
5/8 Type X	Perpendicular	16	6	6
	Perpendicular	24	6	6
[Ref. excerpt of Table R702.3.5]				

*Not permitted to support insulation. o.c. = on center.

TABLE 7-2 Fasteners for the application of gypsum board

Thickness of gypsum board (in.)	Screws		Nails			
	Attached to steel framing	Attached to wood framing	Attached to wood framing			
	Type S	Type W or Type S	13 gauge	Ring-shank	Cooler	Gypsum board nail
	Minimum length (in.)					
$^{3}/_{8}$	$^{3}/_{4}$	1	$1^{1}/_{4}$	$1^{1}/_{4}$	$1^{3}/_{8}$	
$^{1}/_{2}$	$^{7}/_{8}$	$1^{1}/_{8}$	$1^{3}/_{8}$	$1^{1}/_{4}$	$1^{5}/_{8}$	$1^{5}/_{8}$
$^{5}/_{8}$	1	$1^{1}/_{4}$	$1^{5}/_{8}$	$1^{3}/_{8}$	$1^{7}/_{8}$	$1^{7}/_{8}$
$^{5}/_{8}$ Type X at garage ceiling beneath habitable rooms	1	$1^{1}/_{4}$	—	—	$1^{7}/_{8}$	$1^{7}/_{8}$

[Ref. excerpt of Table R702.3.5]

EXTERIOR WALL COVERINGS

Water-resistant barriers, flashing, windows, doors and siding or veneers form the protective exterior wall envelope of a dwelling. [Ref. R703]

Code Essentials

Water-resistive barrier for exterior walls

- Felt paper or approved house wrap
- Required under all types of veneer and siding
- Covers all wall sheathing of dwelling including unheated areas
- Required for all buildings including detached accessory buildings
- Upper layer laps lower layer by 2 inches
- Laps over flashings to carry moisture to the outside
- Vertical laps of 6 inches

Water and Moisture Management

In wood or steel light-frame construction, including detached accessory buildings, the code requires a water-resistant barrier over the sheathing of all exterior walls. Siding and veneers are typically not impervious to wind-driven rain, and the water-resistive barrier in combination with flashings completes the weather protective system to keep moisture out of the wall assembly. The MRC prescribes one layer of No. 15 asphalt felt applied horizontally with 2-inch laps for the water-resistive barrier, but approved house wrap and other materials tested to perform equivalently to the felt satisfy the requirement. House wraps must be installed in accordance with the manufacturer's instructions to shed water away from the sheathing to the outside of the wall coverings. [Ref. R703.1, R703.2]

Code Essentials

No. 15 asphalt felt or approved house wrap shall overlap the required flashings at least 2 inches. Material shall be continuous up to the underside of the rafter or truss bottom chord.

Flashing

To prevent water entering behind exterior wall coverings and penetrating the wall assembly, the code requires corrosion-resistant flashing at specific locations, including exterior window and door openings, penetrations, projections, wall and roof intersections, and intersections of dissimilar materials. Flashing is particularly important for the ledger attachment joining a porch or deck to the house structure and protects not only the concealed framing but the structural integrity of the deck or porch (Figure 7-1). [Ref. R703.4]

Code Essentials

Flashing shall be installed:

- Where exterior material meets in other than a vertical line
- Where the lower portion of a sloped roof stops within the plane of an intersecting wall cladding in a manner to divert water away from the assembly
- At the foundation and rim joist framing intersection when the exterior wall covering does not lap the foundation insulation

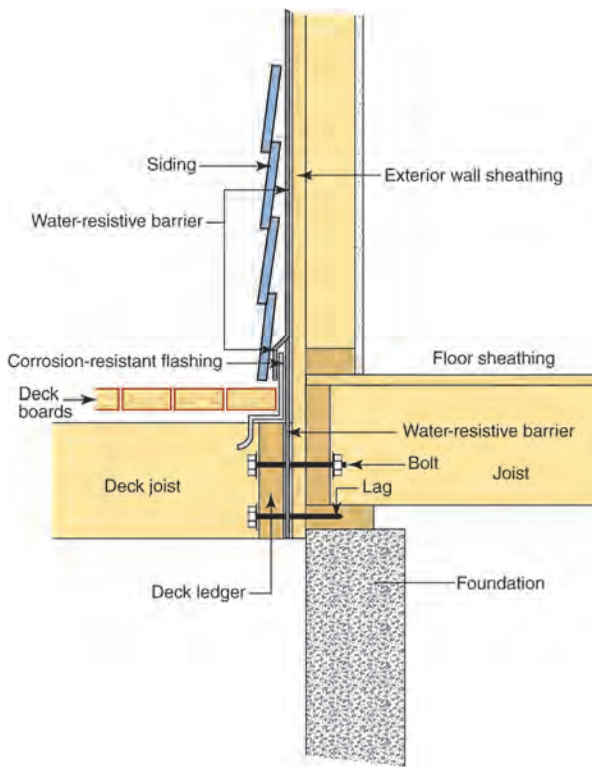


FIGURE 7-1 Wall flashing at deck

Masonry and Stone Veneer

The code generally permits veneers up to three stories and 30 feet above noncombustible foundations, with an additional 8 feet for gable end walls. Maximum thickness is 5 inches and the maximum weight is 50 psf. See Figure 7-2 for typical masonry veneer details. [Ref. R703.8, Table R703.8(1)]

Support

Masonry veneer typically is supported by a continuous concrete or masonry foundation. Light-frame construction may support exterior veneer weighing not more than 40 psf when designed to limit deflection to $^{1}/_{600}$ of the span of the supporting members. Steel or noncombustible lintels are required above openings and must have bearing support of at least 4 inches at each end. Steel lintels require a rust-inhibitive shop coat on all surfaces or otherwise be protected against corrosion (Table 7-3 and Figure 7-3). [Ref. R703.8.2, R703.8.3]

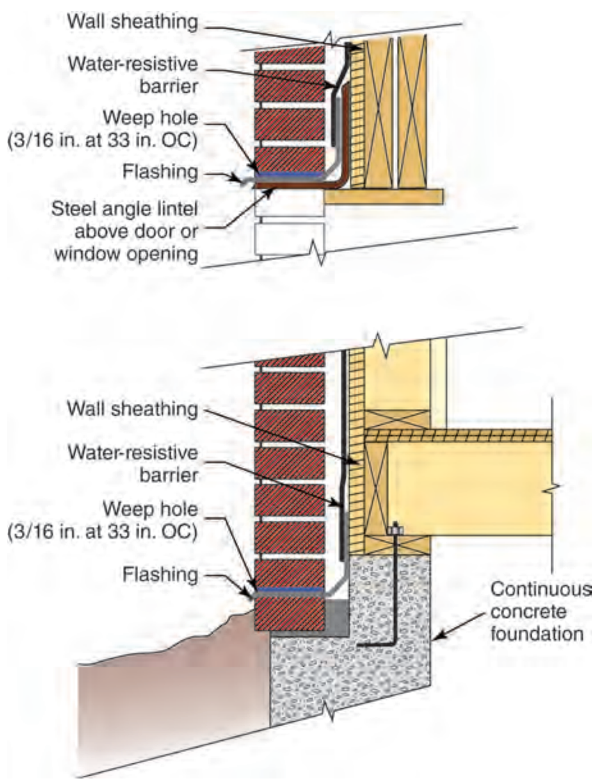


FIGURE 7-2 Brick veneer details

EXAMPLE 7-1

Based on Table 7-3, determine the minimum size of a steel lintel supporting masonry veneer with one story above. The width of the opening is 6 feet 0 inches. The solution is shown in Figure 7-3.

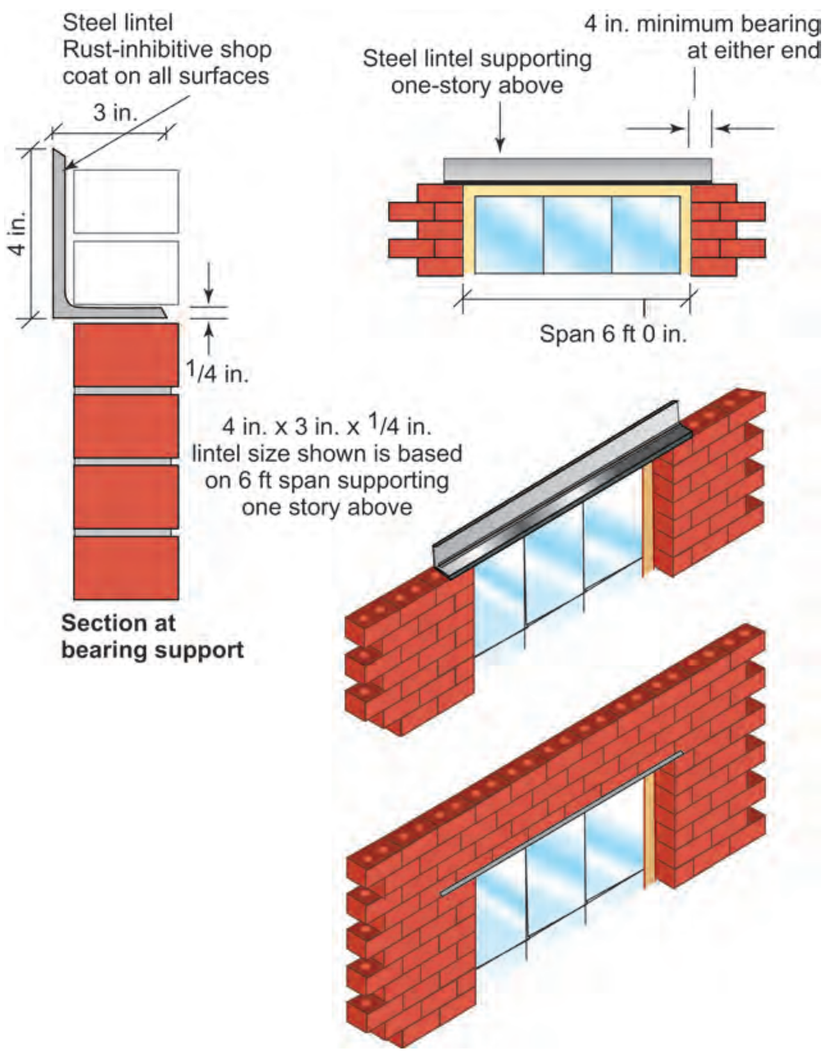


FIGURE 7-3 Steel lintel supporting masonry veneer for one story above based on Table 7-3

TABLE 7-3 Allowable spans for steel lintels supporting masonry veneer

Size of steel angle (in.)	No story above	One story above	Two stories above
$3 \times 3 \times 1/4$	6′-0″	4′-6″	3′-0″
$4 \times 3 \times 1/4$	8′-0″	6′-0″	4′-6″
$5 \times 3\,1/2 \times 5/16$	10′-0″	8′-0″	6′-0″
$6 \times 3\,1/2 \times 5/16$	14′-0″	9′-6″	7′-0″
$2 \times 6 \times 3\,1/2 \times 5/16$	20′-0″	12′-0″	9′-6″
[Ref. excerpt of Table R703.8.3.1]			

Note: Long leg of the angle shall be placed in a vertical position.

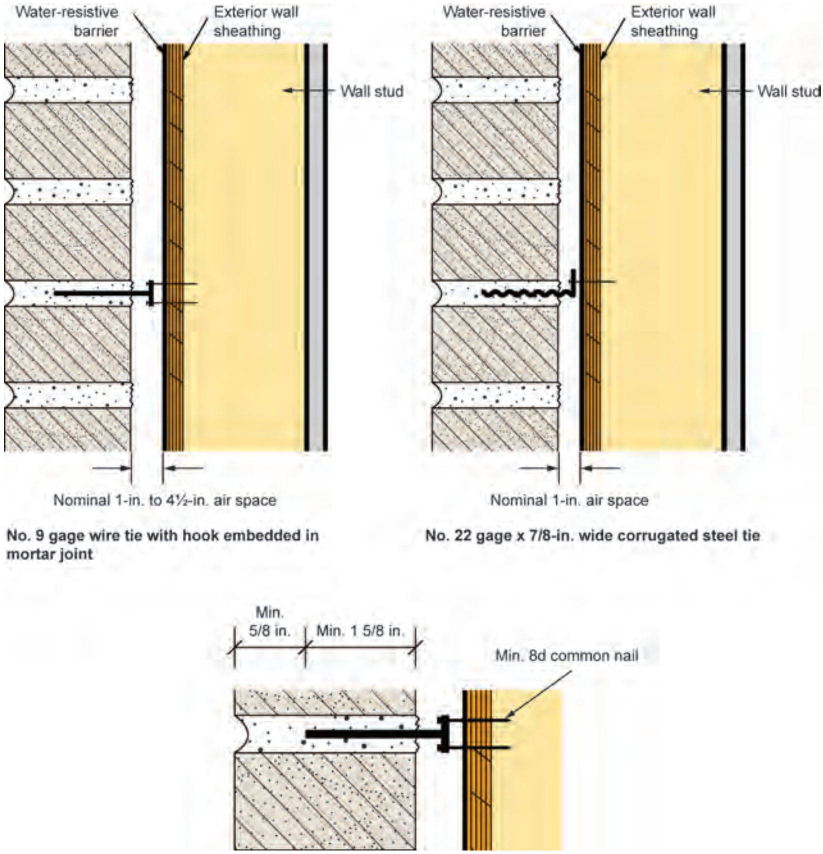


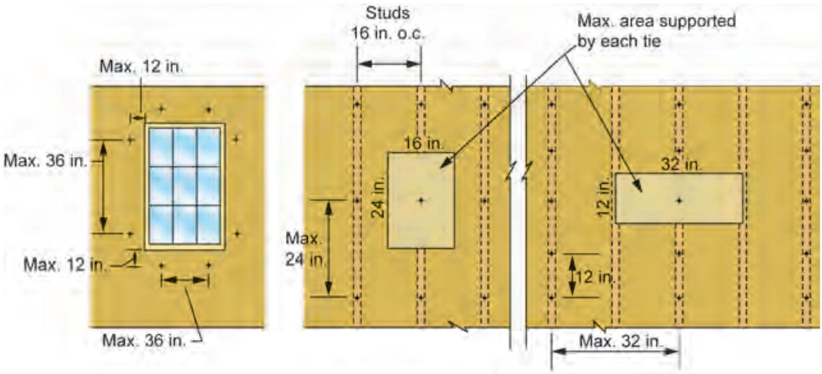
FIGURE 7-4 Brick veneer attachment and air space requirements

Veneer Anchoring

Veneer is anchored to the structure with corrosion-resistant metal ties of No. 9-gauge strand wire or No. 22-gauge × $^7/_8$-inch corrugated sheet metal (Figures 7-4 and 7-5). [Ref. R703.8.4, Table R703.8.4]

Siding

Vertical panel siding and horizontal lap siding must be installed with proper joint treatments and flashing to resist penetration of moisture. Vertical joints require batten covers or a combination of flashing and sealants. Horizontal joints of panel siding require a minimum 1-inch lap,



Max. area supported by each tie			
Width	Height	Sq. in.	Sq. ft.
16 in.	24 in.	384	2.67
32 in.	12 in.	384	2.67

FIGURE 7-5 Veneer tie spacing

You Should Know

Anchored masonry veneer

- Veneer is not totally impervious to water penetration
- Air space and a water-resistive barrier are needed to keep moisture out of the wall assembly
- Mortar is not permitted to fill the air space
- Air space can be filled with approved grout
- Air space between sheathing and veneer
  - nominal 1 in. for corrugated ties
  - nominal 1 in. to $4^1/_2$ in. for wire ties

shiplap or a "Z" flashing over solid backing. Horizontal lap siding must be installed in accordance with the manufacturer's recommendations. In the absence of recommendations, the code requires a minimum lap of 1 inch to $1^1/^4$ inches depending on the siding material. All siding requires secure attachment with approved corrosion-resistant fasteners, which generally must penetrate into the wood framing 1 to $1^1/_2$ inches, depending on the type of wall sheathing, siding material and the manufacturer's

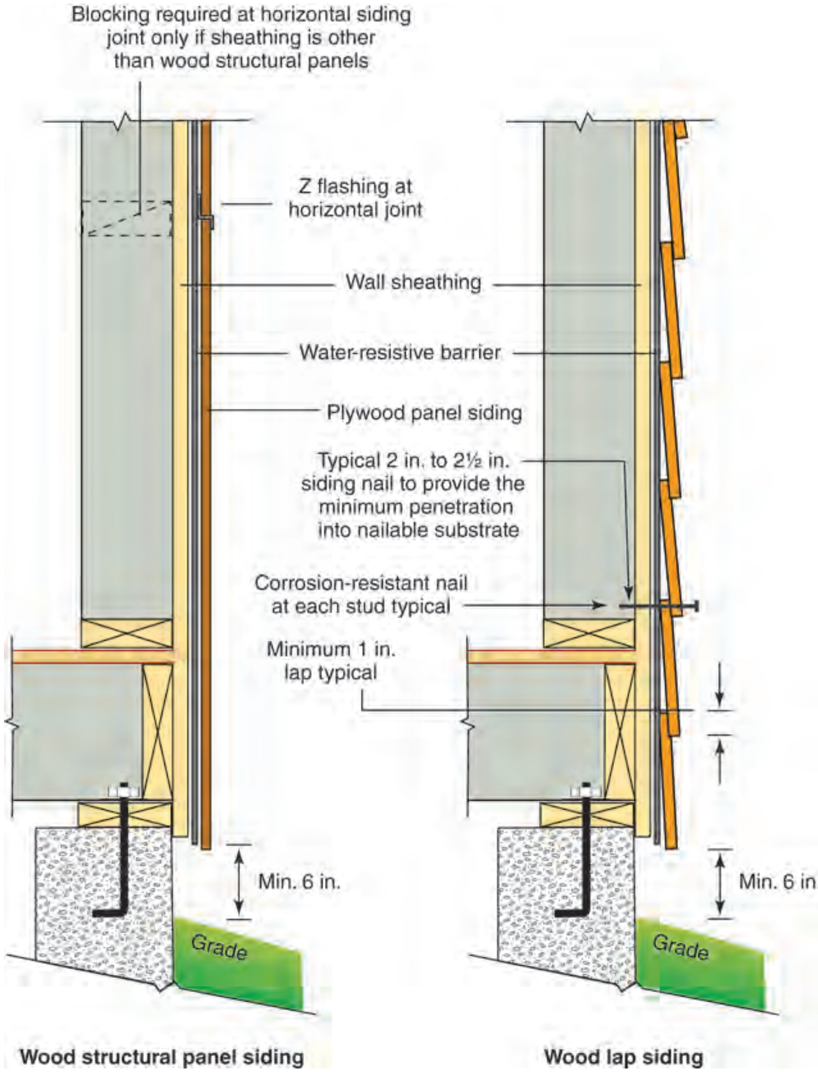


FIGURE 7-6 Siding details

recommendations (Figure 7-6). Vinyl siding must be installed in accordance with the manufacturer's installation instructions and meet other applicable requirements based on design wind speed and wind exposure category (Figure 7-7). [Ref. R703.3 through R703.6, R703.10, R703.11, Table R703.3(1)]

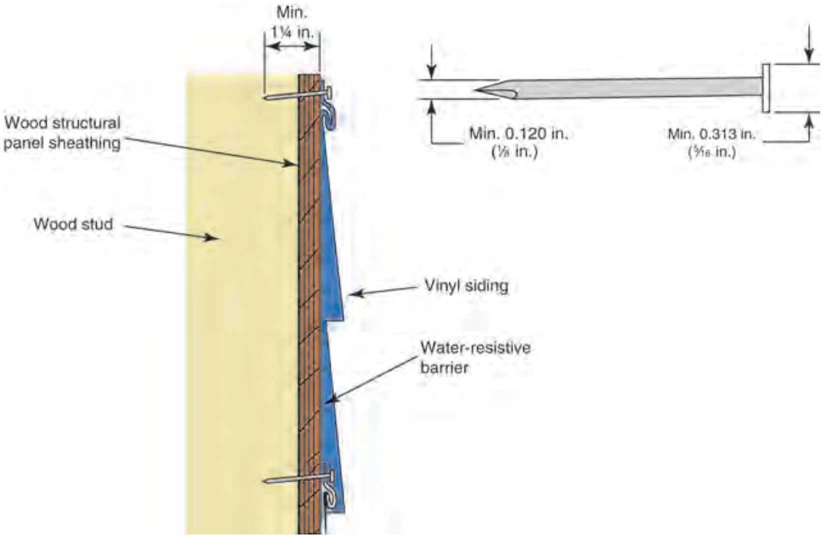


FIGURE 7-7 Vinyl siding attachment over wood structural panel sheathing

Exterior Insulation Finish System (EIFS)

EIFS, sometimes referred to as synthetic stucco due to its textured appearance, consists of a water-resistive barrier, drainage plane, rigid polystyrene insulation, a reinforced base coat and a trowel-applied textured finish coat. Where installed over frame construction, the code requires EIFS with drainage to provide a means to drain any moisture trapped behind the EIFS to the exterior. To protect the integrity of the weather repellant surface and prevent moisture penetration, face nailing of trim through the EIFS is not permitted. A minimum of 6-inches clearance is required between the ground and the lowest edge of the EIFS. In addition to the above code requirements, all EIFS must be installed in accordance with the manufacturer's installation instructions. [Ref. R703.9]

Windows

In the installation of windows and exterior doors (both known as fenestration), the code is concerned with the strength of the unit and its attachment to the structure to resist applicable wind loads, as well as the water resistance of the installation in the wall assembly. In this regard, fenestration must be manufactured to comply with the applicable referenced standards, and installation must follow the manufacturer's written instructions. The MRC also requires the manufacturer to provide installation and

Code Essentials

Pan flashing exceptions:

1. Windows or door installed per with the manufacturer's installation instructions for alternate flashing method.
2. Windows or doors in detached accessory structures.
3. Skylights, bow or bay windows.
4. Doors required to meet accessibility requirements that would prevent installation of pan flashing.
5. Repairs or replacement of existing windows and doors.
6. A method provided by a registered design professional.

flashing detail instructions with each window and exterior door. Many manufacturers require a pan flashing installed at the base of the opening to direct water to the exterior. If installation instructions are not available, the code requires pan flashing sealed or sloped in a manner to direct water to the exterior wall finish surface or to the water-resistive barrier for drainage (Figures 7-8 and 7-9). [Ref. R609, R703.4]

ROOF COVERING

The MRC prescribes the design, materials, construction and quality of roofing assemblies to provide weather protection for the building. Roof coverings must be installed according to the code and the manufacturer's instructions. This section will focus on the installation of asphalt and wood shingles, as well as the associated underlayment and flashing requirements.

Underlayment and Ice Barrier

At a minimum, for slopes of 4:12 or greater, one layer of No. 15 asphalt-saturated organic felt or other approved material is required to cover the roof deck before application of shingles. The code requires horizontal laps of at least 2 inches with end laps offset at least 6 feet in successive courses of felt (Figure 7-10). Slopes of at least 2:12 and less than 4:12 require two layers of felt with 19-inch horizontal overlaps (Figure 7-11). [Ref. R905.1.1]

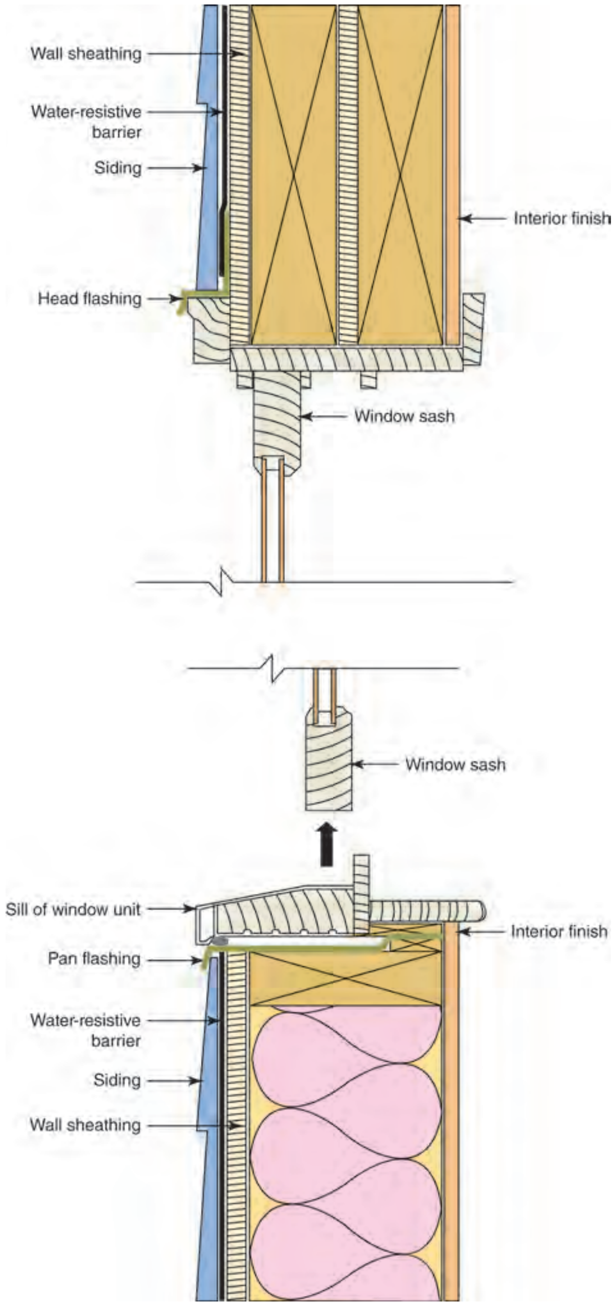


FIGURE 7-8 Window flashing

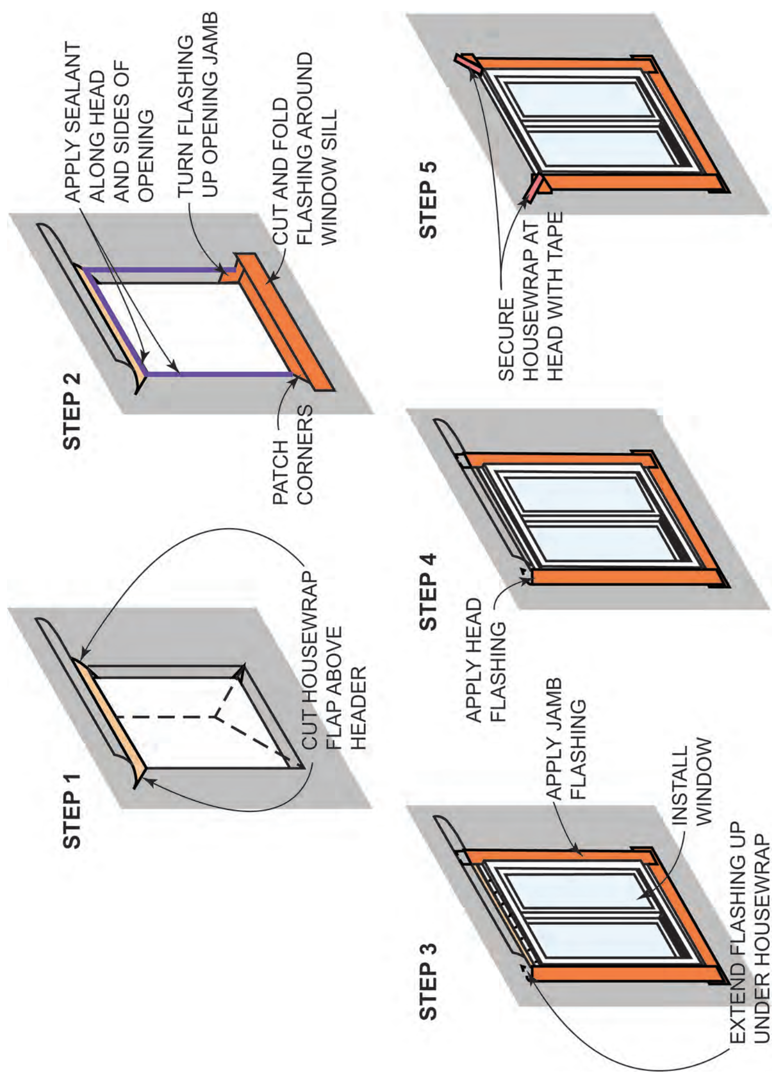


FIGURE 7-9 Pan Flashing. Installations may vary based on specific manufacturer's installation instructions.

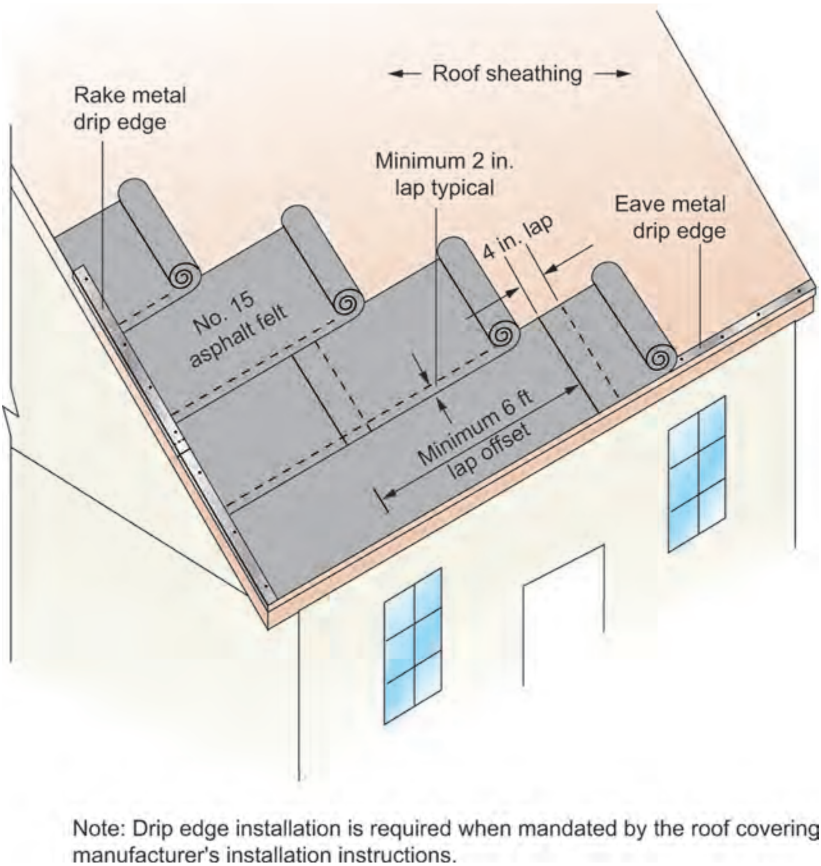


FIGURE 7-10 Underlayment for asphalt shingles on slopes of 4:12 or greater

In Minnesota's cold climate, ice dams often form in gutters and along eaves. Freeze-thaw cycles combined with warm air escaping from the conditioned space thaws ice above the eave area. Water unable to drain past the ice dam is often forced back under the shingles and underlayment, causing damage to the structure beneath. In areas with a history of water damage to structures from ice dams at roof eaves, an ice barrier is required for added protection. The ice barrier consists of self-adhering polymer-modified bitumen material or two layers of cemented underlayment, which must extend from the eave to at least 24 inches inside the exterior wall line of the building (Figure 7-12). As damage from ice damming is less likely to occur, ice barriers are not required in unheated detached accessory buildings. [Ref. R905.1.2]

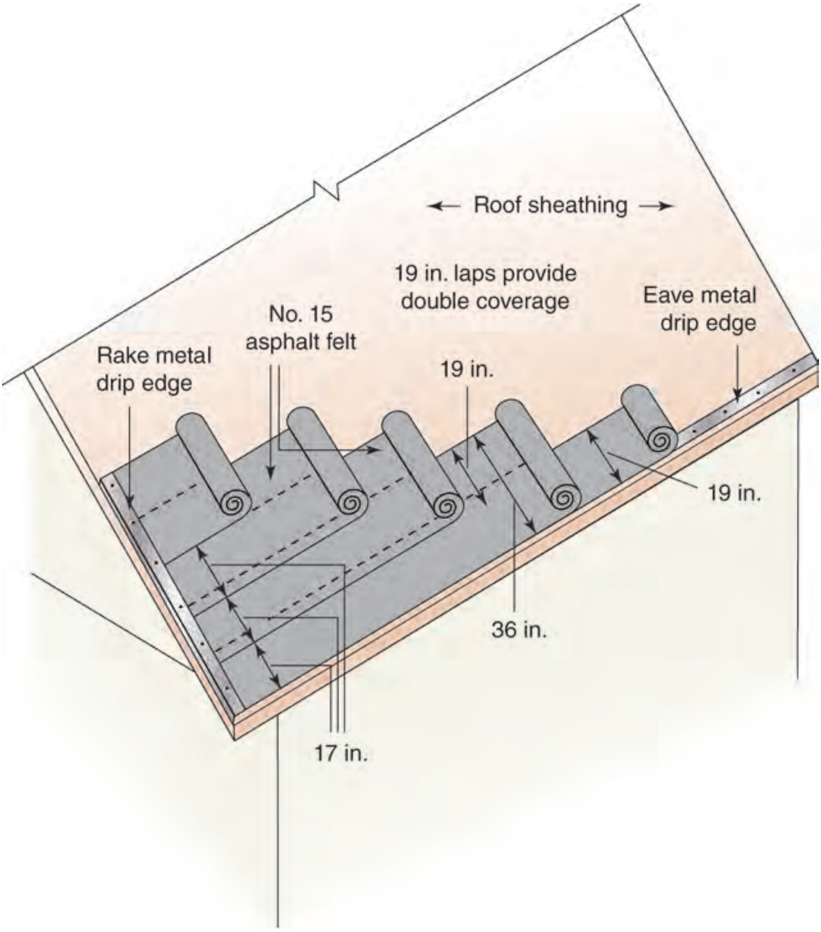


FIGURE 7-11 Underlayment for low slope application of asphalt shingles, slopes 2:12 or greater and less than 4:12

Flashing

To effectively seal against entry of water, flashing is required at roof/wall intersections, at points of change in slope or direction, and around roof openings or penetrations. Where the roof joins a sidewall, either overlapping individual flashings at each course of shingles (Figure 7-13) or continuous flashing is required. The code requires flashing to be corrosion-resistant metal at least 0.019 inch thick (No. 26 galvanized sheet). Any chimney penetration more than 30 inches wide requires a cricket or saddle to divert water from the roof above to each side of the chimney. Crickets may be the same material as the roof covering or sheet metal (see Chapter 11). [Ref. R903.2, R905.2.8]

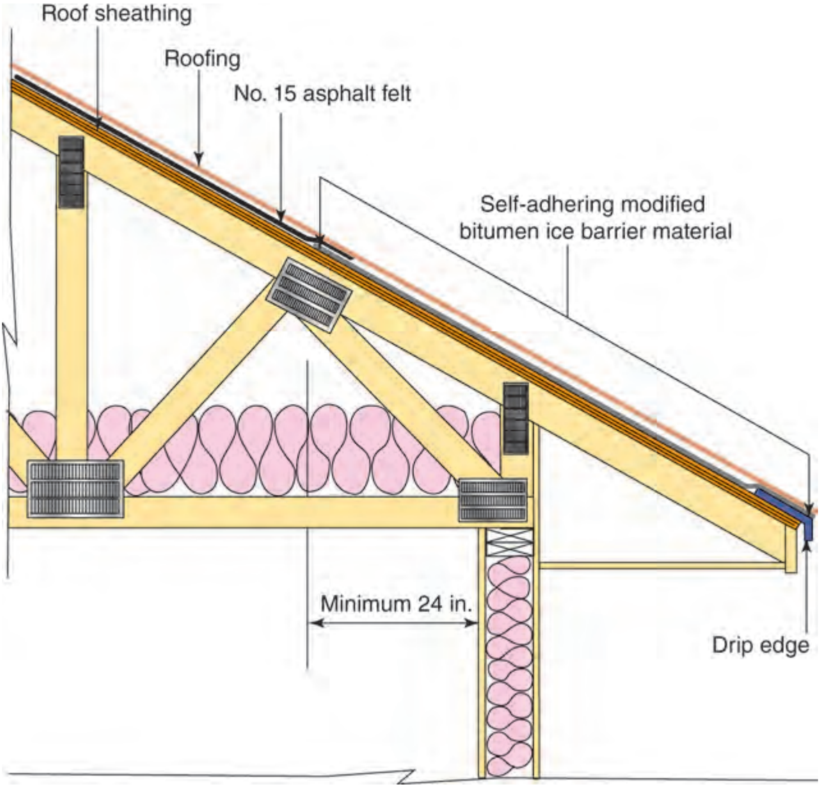


FIGURE 7-12 Ice barrier

Code Essentials

A kick-out flashing shall be installed to divert water away from where the eave of a sloped roof intersects a vertical sidewall. The kick-out flashing on the roof shall be a minimum of $2^1/_2$ inches long.

Asphalt Shingles

Asphalt shingles require a roof slope of at least 2:12 and must be installed in accordance with the manufacturer's instructions. Adequate wind resistance is addressed through testing to the appropriate standard for self-sealing or unsealed shingles and labeling to indicate the applicable classification for the design wind speed of the geographic location. Fasteners must be galvanized steel, stainless steel, aluminum, or copper roofing nails of at

FIGURE 7-13 Kick-out flashing for asphalt shingles

least 12 gauge (0.105 inch) with a head diameter not less than $^{3}/_{8}$ inch. Nails must penetrate at least $^{3}/_{4}$ inch into the roof sheathing or penetrate through the sheathing. [Ref. R905.2]

The code recognizes a number of accepted practices for valley construction for asphalt shingles. Closed valleys (covered with shingles) require a valley lining consisting of a self-adhering polymer-modified bitumen sheet, an approved 24-inch-wide metal valley, one ply of approved smooth roll roofing at least 36 inches wide or two plies of mineral-surfaced roll roofing (Figure 7-14). Open valleys consist of an approved 24-inch-wide metal valley or two plies of mineral-surfaced roll roofing. [Ref. R905.2.8.2]

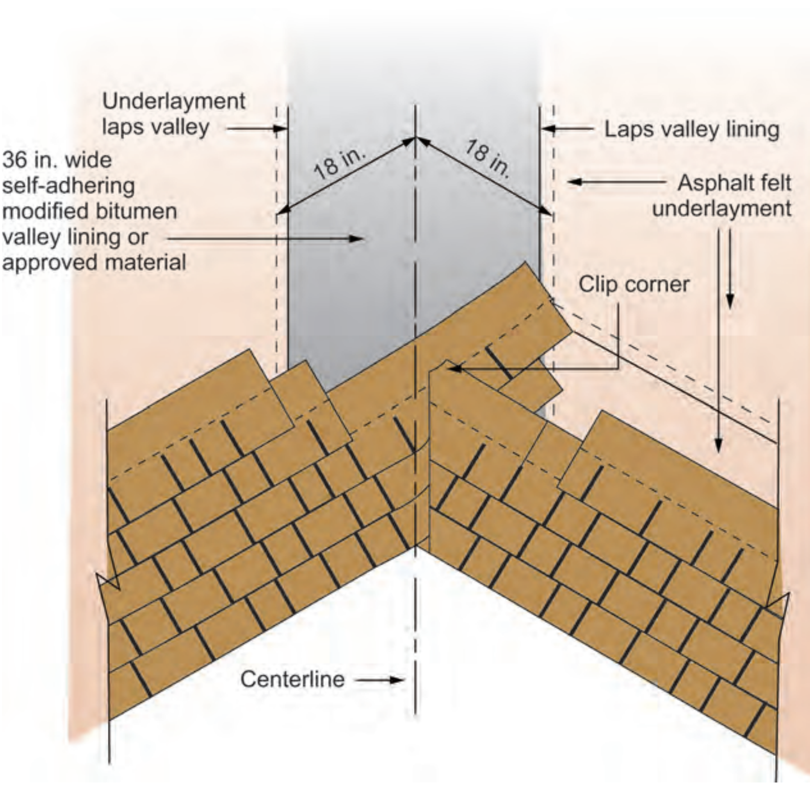


FIGURE 7-14 Cut closed valley option for asphalt shingles

You Should Know

Asphalt shingles

- Installation per the manufacturer's instructions
- Dimensions of shingles, exposure and nail locations vary
- Minimum requirements of MRC must still be met
- Roofing staples not permitted, only roofing nails
- At least 4 nails required per strip shingle

Wood Shingles and Wood Shakes

The MRC includes requirements specific to wood shingles and shakes used for roofing. In addition to material and grading requirements, the code provides installation details related to slope, decking, underlayment, laps and exposure. Fastening must be in accordance with the manufacturer's instructions. The minimum slope is 3:12. Valleys require at least No. 26-gauge corrosion-resistant sheet metal extended 10 inches from the centerline each way for wood shingles and 11 inches from the centerline each way for shakes. End laps must be at least 4 inches (Table 7-4 and Figure 7-15). [Ref. R905.7, R905.8]

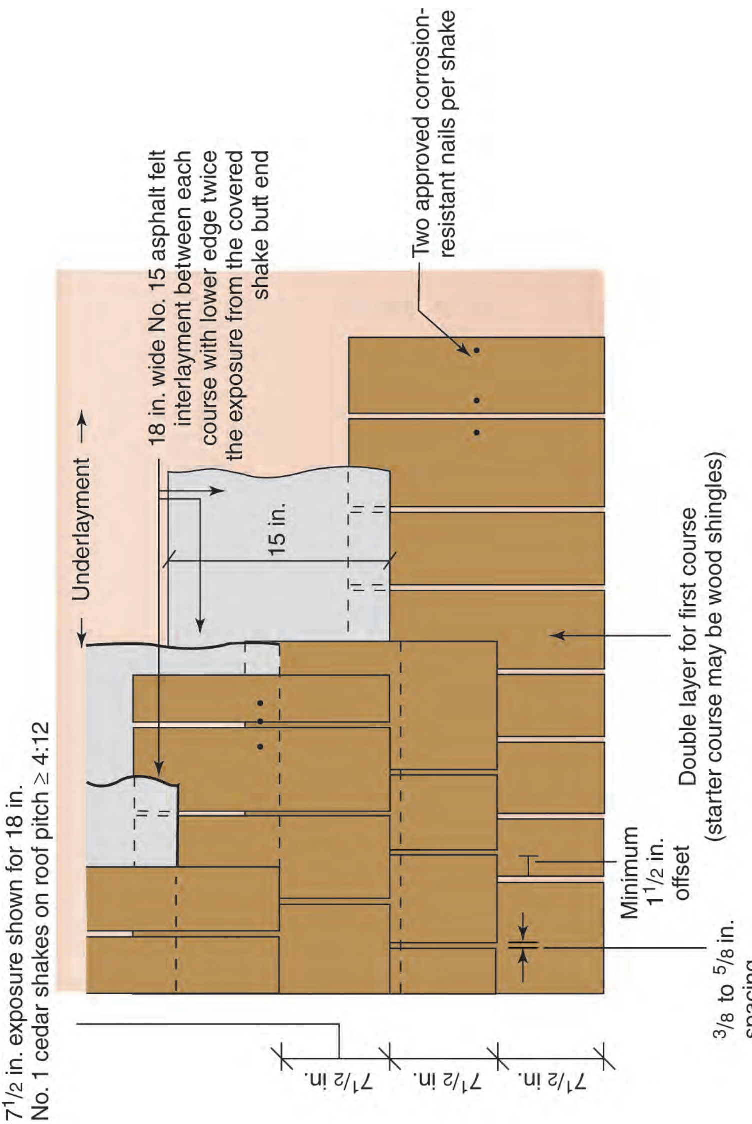


FIGURE 7-15 Wood shakes

TABLE 7-4 Wood shake weather exposure and roof slope

Roofing material	Length (in.)	Grade	Exposure (in.), 4:12 pitch or steeper
Shakes of naturally durable wood	18	No. 1	$7^1/_2$
	24	No. 1	10*
Preservative-treated taper-sawn shakes of southern yellow pine	18	No. 1	$7^1/_2$
	24	No. 1	10
	18	No. 2	$5^1/_2$
	24	No. 2	$7^1/_2$
Taper-sawn shakes of naturally durable wood	18	No. 1	$7^1/_2$
	24	No. 1	10
	18	No. 2	$5^1/_2$
	24	No. 2	$7^1/_2$
[Ref. excerpt of Table R905.8.6]			

*For 24-in. by $^3/_8$-in. handsplit shakes, the maximum exposure is $7^1/_2$ in.

PART V Health and Safety

CHAPTER 8

Home Safety

In protecting the health, safety, and welfare of the dwelling occupants, the *Minnesota Residential Code* (MRC) sets minimum requirements for a safe means of exiting the building, protection from falls and from the hazards associated with breaking glass. The code also sets minimum room dimensions to support a healthy living environment (Figure 8-1).

FIGURE 8-1 A spiral stairway is one type of stair permitted as a means of egress

ROOM AREAS

Though most homes will far exceed the minimum requirements, the MRC recognizes the need for basic living spaces. The code requires habitable rooms other than kitchens to be 70 square feet or larger, with the smallest dimension no less than 7 feet. [Ref. R304]

CEILING HEIGHT

Adequate ceiling height contributes to a healthy living environment and provides the ability to move about and safely exit the building. The general rule establishes a minimum ceiling height of 7 feet for habitable space and hallways in a dwelling (Figure 8-2). The code allows for sloped ceilings, provided that half of the required room area accommodates the 7-foot height. Reductions are also permitted in basements, laundry rooms and bathrooms. The MRC has specific requirements and exceptions for ceiling heights in new dwellings and basements of existing dwellings. [Ref. R305]

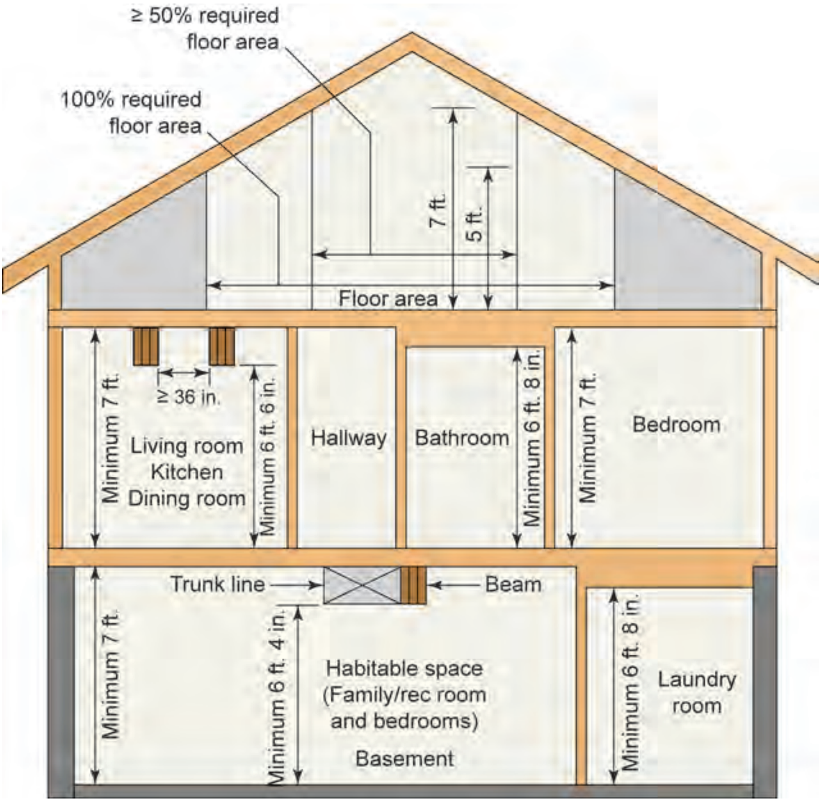


FIGURE 8-2 Ceiling height for new buildings

MEANS OF EGRESS

Means of egress describes the path of travel from any location in the dwelling to the exterior. The MRC regulates stairways, ramps, hallways and doors as the primary components of that path for a safe exit from the building. Hallways must have a clear width of 3 feet, and one exterior exit door is required, also a nominal 3 feet in width. Otherwise, the MRC does not regulate the size or type of doors or limit the distance from any portion of the dwelling unit to the required exit. As a measure for protecting the path for safe exit from the building, the code requires limited fire resistance on the underside of stairs when the space below is enclosed. Protection is achieved by applying $^1/_2$-inch gypsum board on the enclosed side. Another important principle for safe egress from the building to the outdoors is to ensure that the occupant can open the required exit door without a key or special knowledge. Double cylinder dead bolt locks are permitted for existing single-family homes, townhouses, and the first floor of two-family homes. The code does not restrict the type of hardware on other doors of the dwelling unit. [Ref. R302.7, R311]

Doors and Landings

For each dwelling unit, the code requires one side-hinged exterior exit door providing a net opening of 32 inches by 78 inches, typically achieved with the installation of a door with nominal measurements of 3 feet by 6 feet 8 inches. Occupants in any location of the dwelling must be provided a route to the required exit door without passing through a garage. A landing or floor is generally required on each side of exterior doors with a maximum threshold height above the landing of $1^1/_2$ inches. An exception allows the exterior landing at the required exit door to be not more than $7^3/_4$ inches below the top of the threshold, provided the door swings in. At other than the required exit door, the floor or landing on either side of the door is permitted to be $7^3/_4$ inches below the top of the threshold, and the door may swing in either direction (Figures 8-3 and 8-4). The code requires landings to be at least as wide as the door and not less than 36 inches in the direction of travel. A stair without a landing is permitted outside a door other than the required exit door if the door swings in and the stair has a height of less than 30 inches (Figure 8-5). [Ref. R311.3 , MRC R311.3.2 exception]

Stairs

The code endeavors to improve stair safety and prevent injuries from falls by limiting the slope of the stair and by providing for minimum tread size, clearances, uniformity, and graspable handrails. The minimum 10-inch treads and maximum $7^3/_4$-inch risers determine the maximum steepness of the stairway, but just as important in stair safety is the uniformity of those treads and risers for the full flight of the stair. As a person walks a stair, he or she anticipates that the next step will be the same as the previous one. Variations that are not visually apparent may break the user's rhythm or otherwise cause a misstep and fall (Figures 8-6 through 8-8). [Ref. R311.7]

Winders

Winder treads have nonparallel edges, and the code permits a tread depth of 6 inches at the narrow end, provided the full tread depth of 10 inches is achieved within 12 inches of the narrow side (Figure 8-9). A person walking on winder treads and holding the handrail will typically be positioned approximately 12 inches from the narrow side (referred to as the "walk

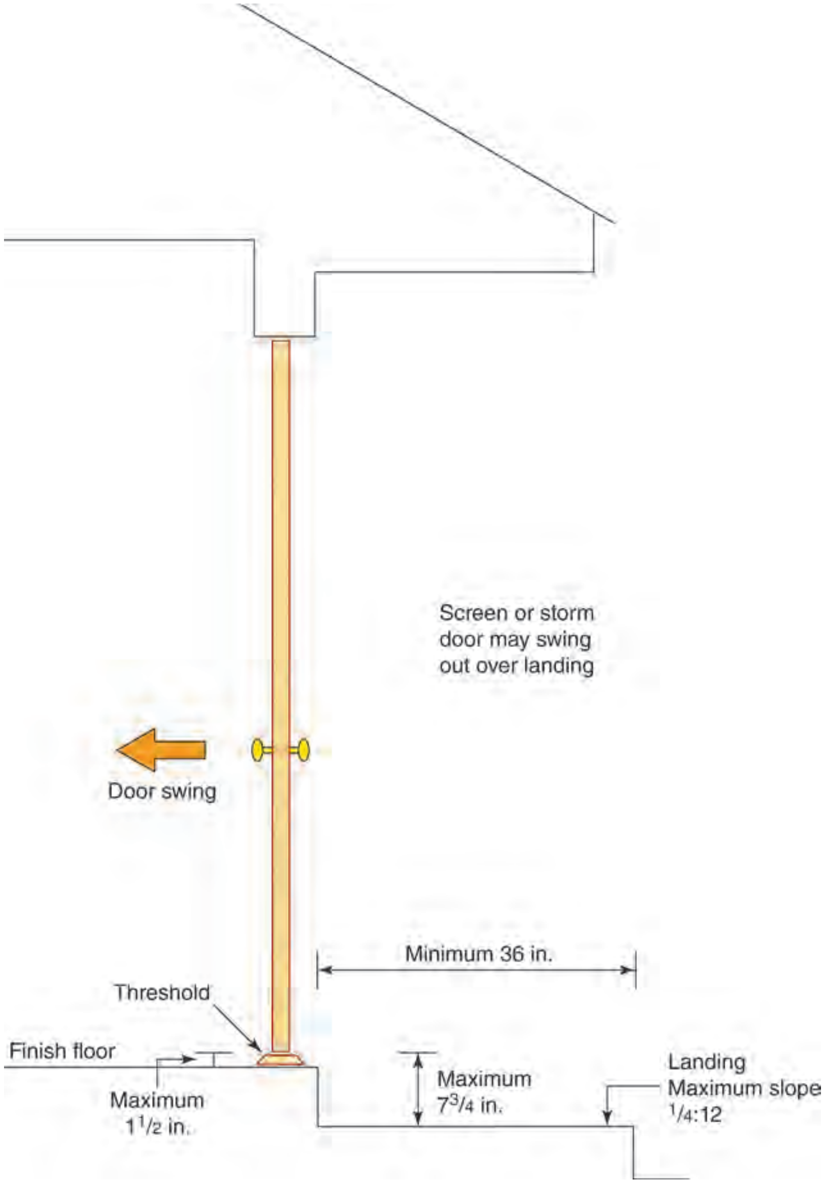


FIGURE 8-3 Landing at required exterior exit door

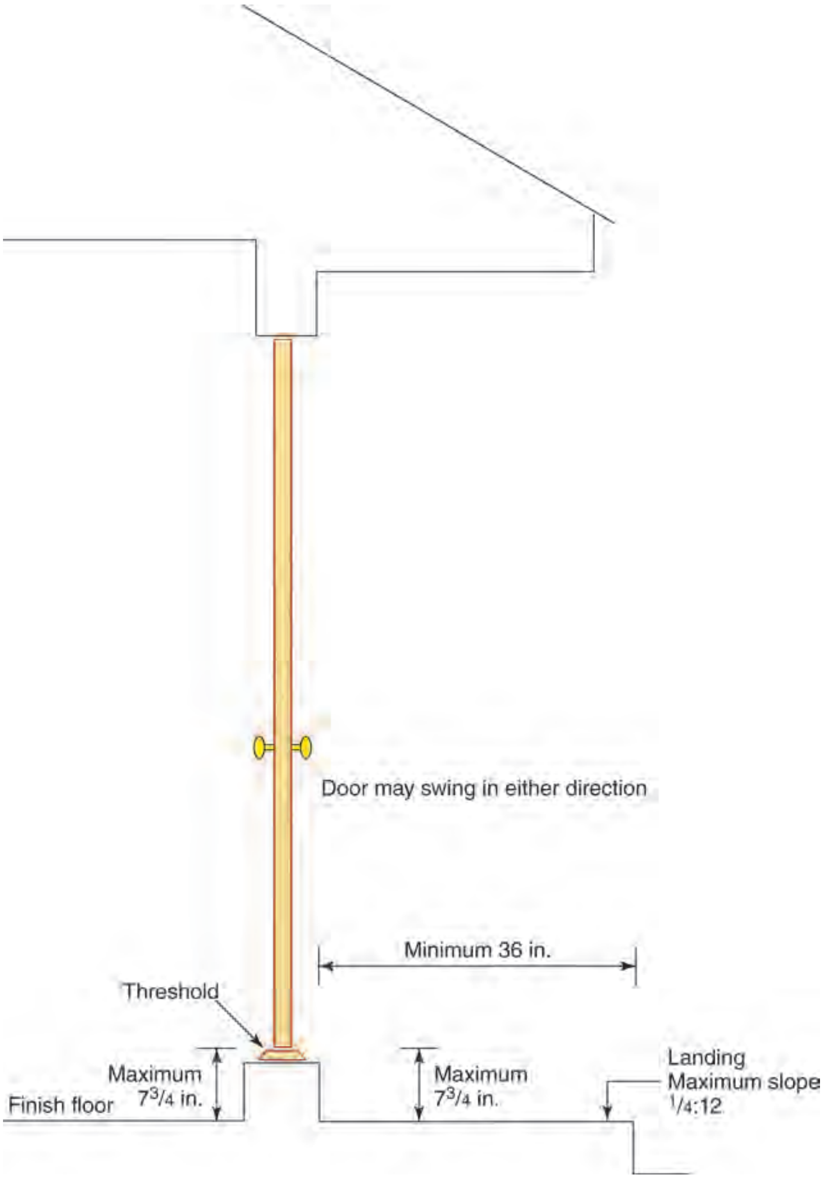


FIGURE 8-4 Landing and floor at exterior door that is not the required exit

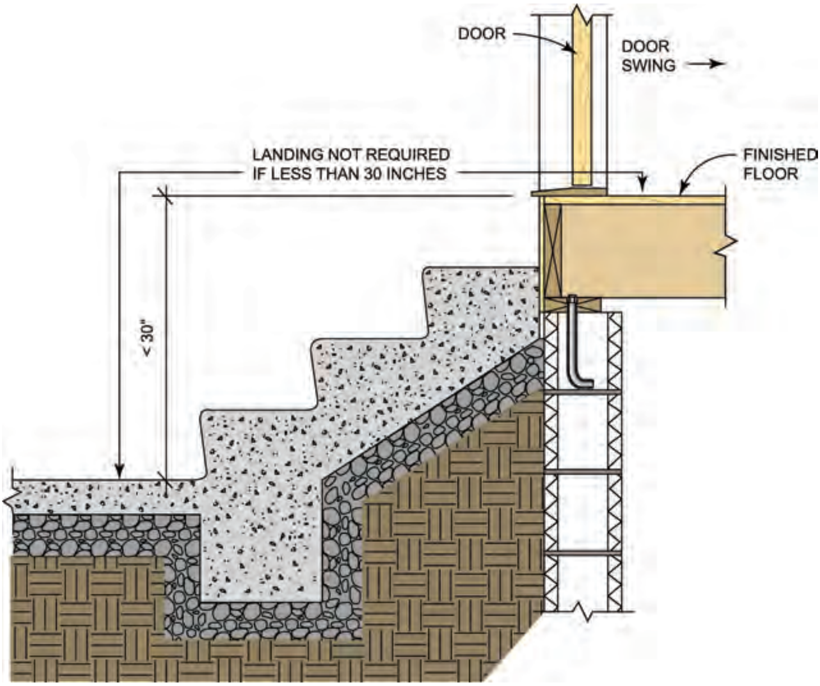


FIGURE 8-5 No landing required if interior floor measured vertically to grade is less than 30 inches

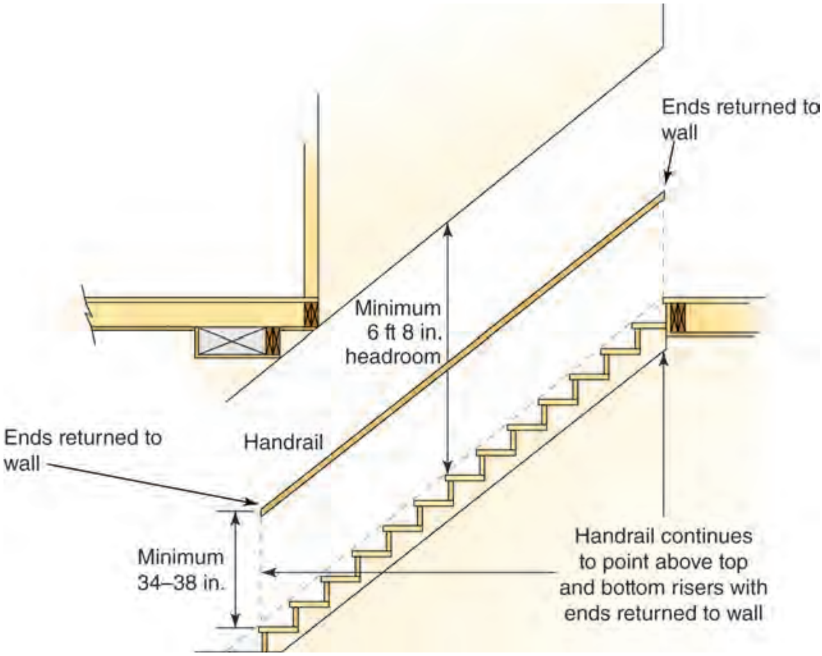


FIGURE 8-6 Stairway headroom and handrail height

Code Essentials

Prescriptive vs. performance

Prescriptive code provisions

- Handrail height is 34–38 inches
- Min. guard height is 36 inches

Performance code provisions

- Handrails shall provide equivalent graspability
- Handrails and guard top rails shall resist a single concentrated load of 200 pounds

line"), and this configuration allows a turn in the stairway without a landing and without creating an undue hazard. [Ref. R311.7.5.2.1]

Spiral Stairways

The code permits spiral stairways at any location in a dwelling (Figure 8-10). They have lesser dimensions for width, treads and headroom and greater

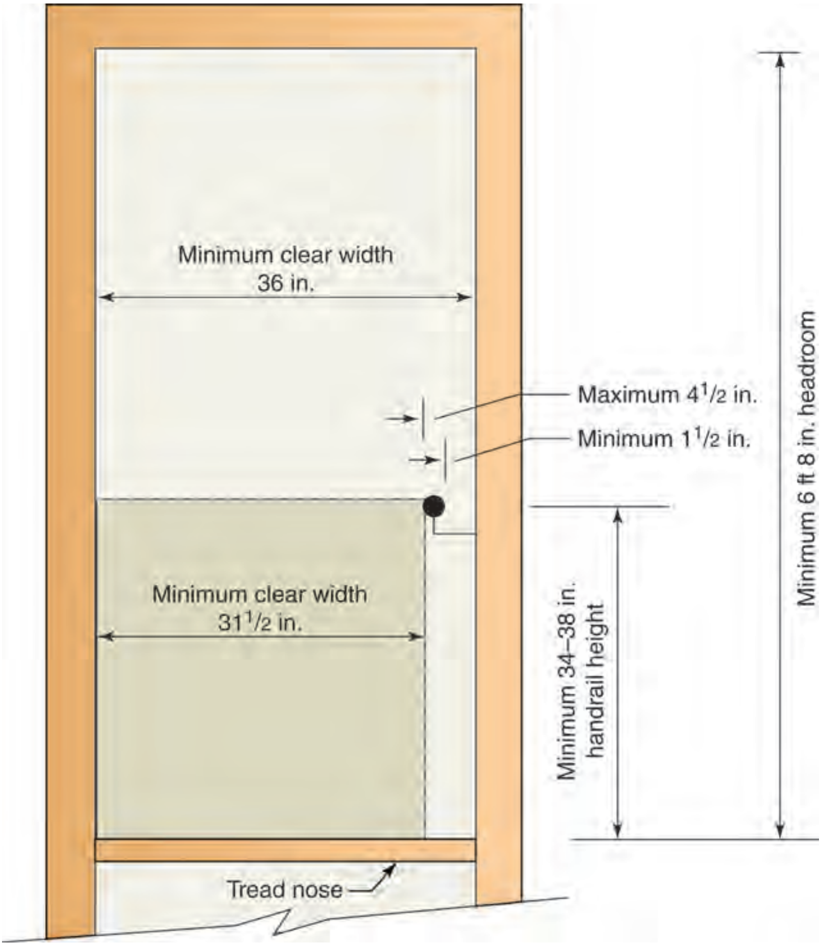


FIGURE 8-7 Stairway section, minimum width and height

riser heights than conventional stairs. A spiral stairway is permitted to serve as a means of egress from one level or story to another. [Ref. R311.7.10.1]

Stair Landings

Similar to the general rule requiring landings at exterior doors, a floor or landing is required at the top and bottom of stairs. This is usually not an issue in new construction where adequate space is provided between the stair and a wall or door. The landing requirement prevents the installation of a door in close proximity to the bottom tread. Such an installation would create not

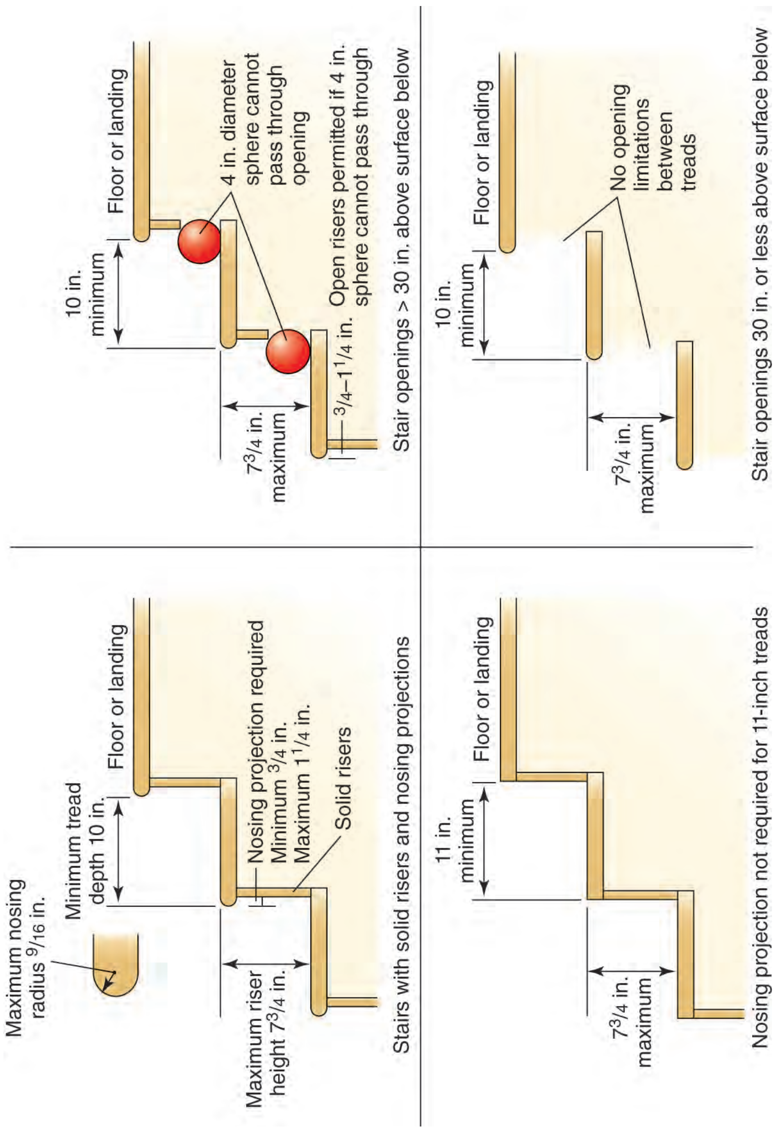


FIGURE 8-8 Stair profiles

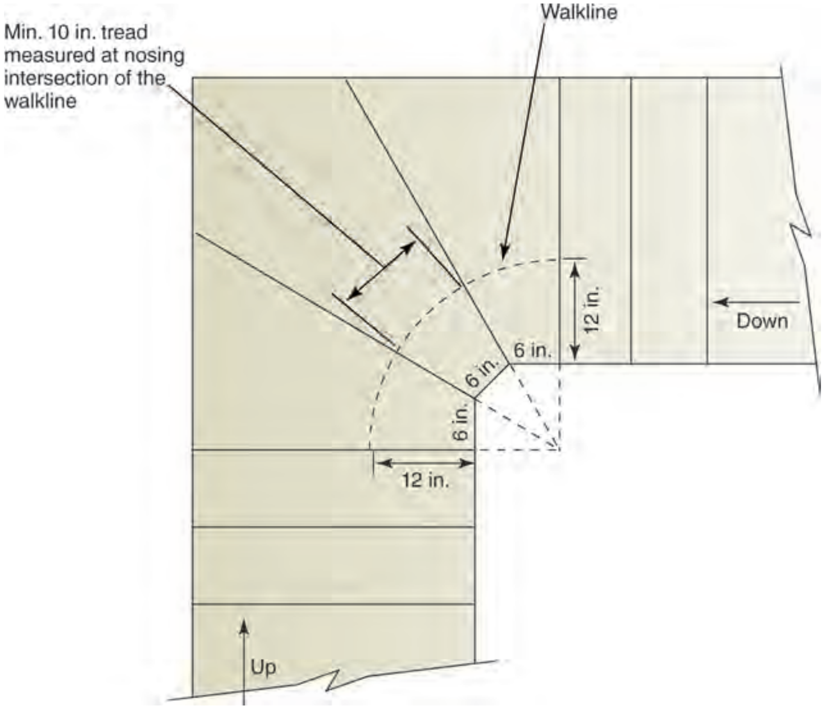


FIGURE 8-9 Winders are permitted in the same flight of stairs as rectangular treads.

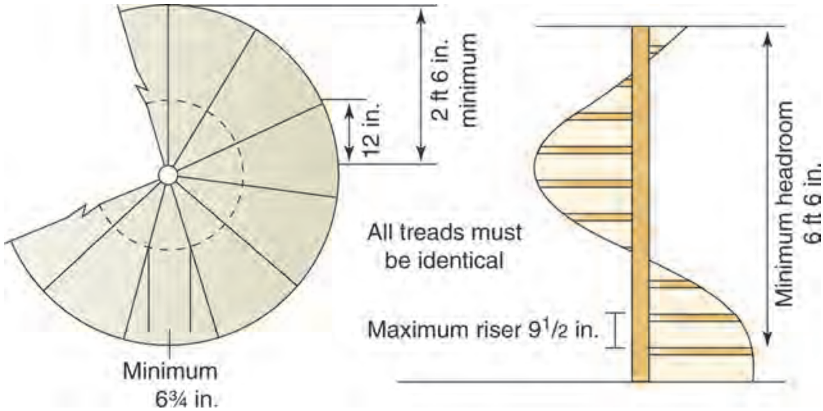


FIGURE 8-10 Spiral stair

only a headroom problem but a falling hazard as well. An exception to the landing requirement allows a door at the top of an interior flight of stairs, provided the door does not swing over the step (Figure 8-11). [Ref. R311.7.6]

Handrails

Handrails are a critical component of stair safety. To be effective, they must be placed 34 to 38 inches above the tread nosing, be continuous, and have a shape that is easily grasped and held (Figures 8-12 and 8-13). For circu-

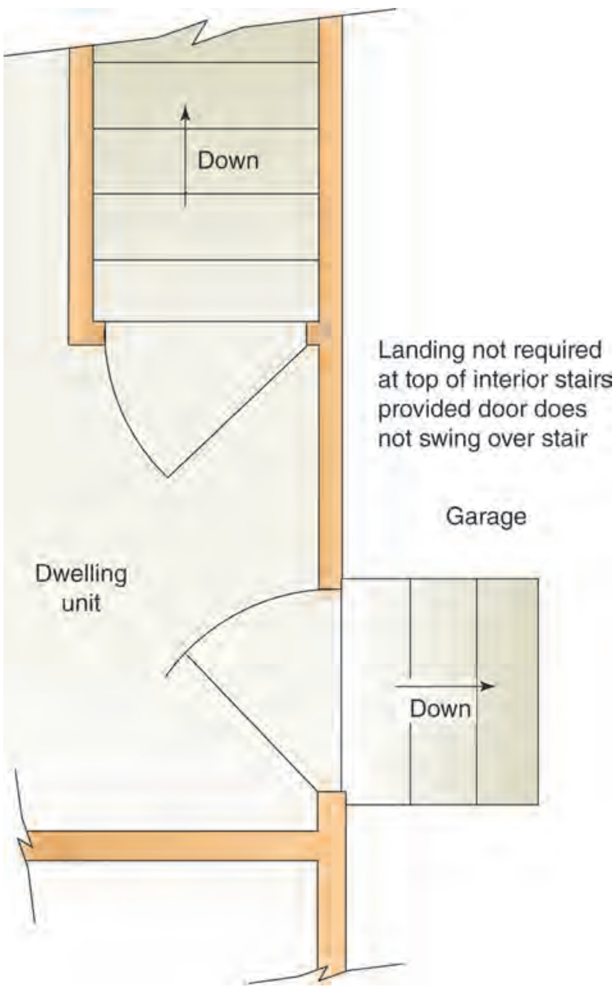


FIGURE 8-11 Door permitted at top of interior stairways

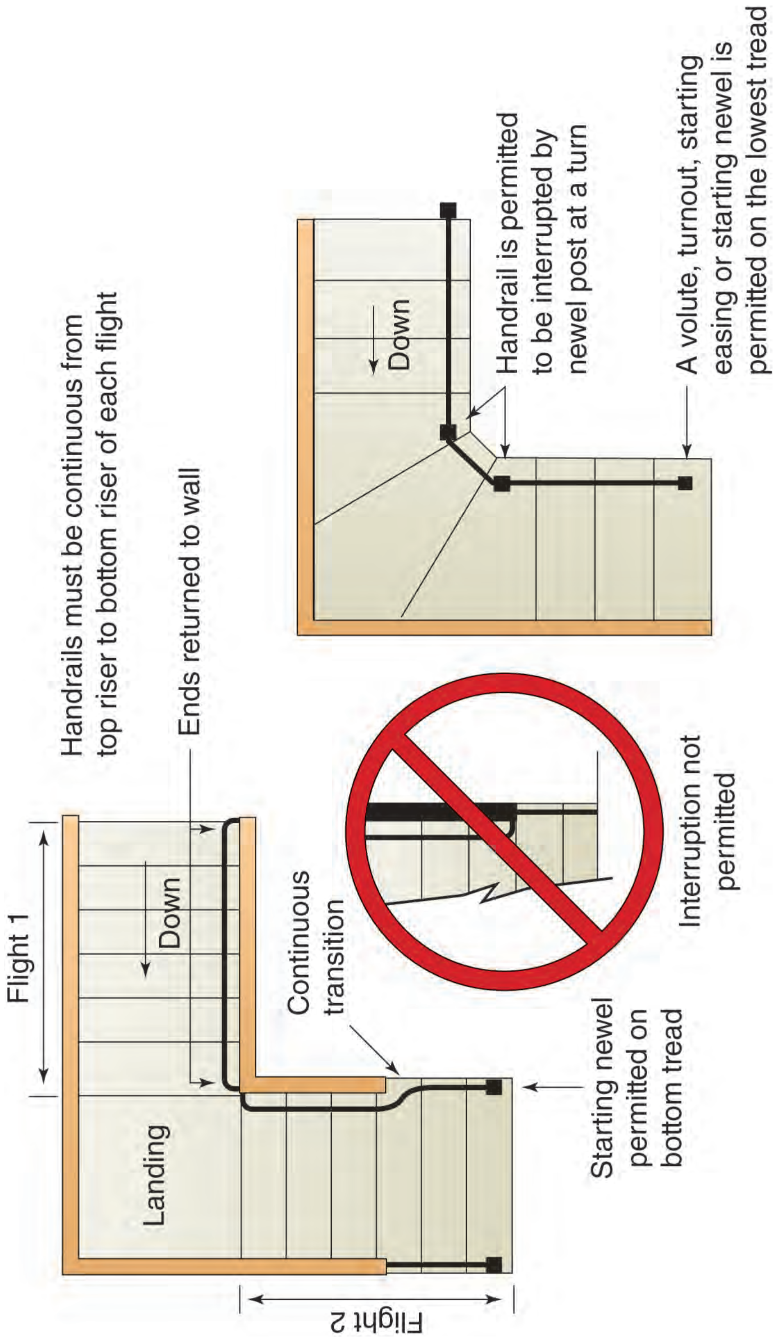


FIGURE 8-12 Handrail continuity

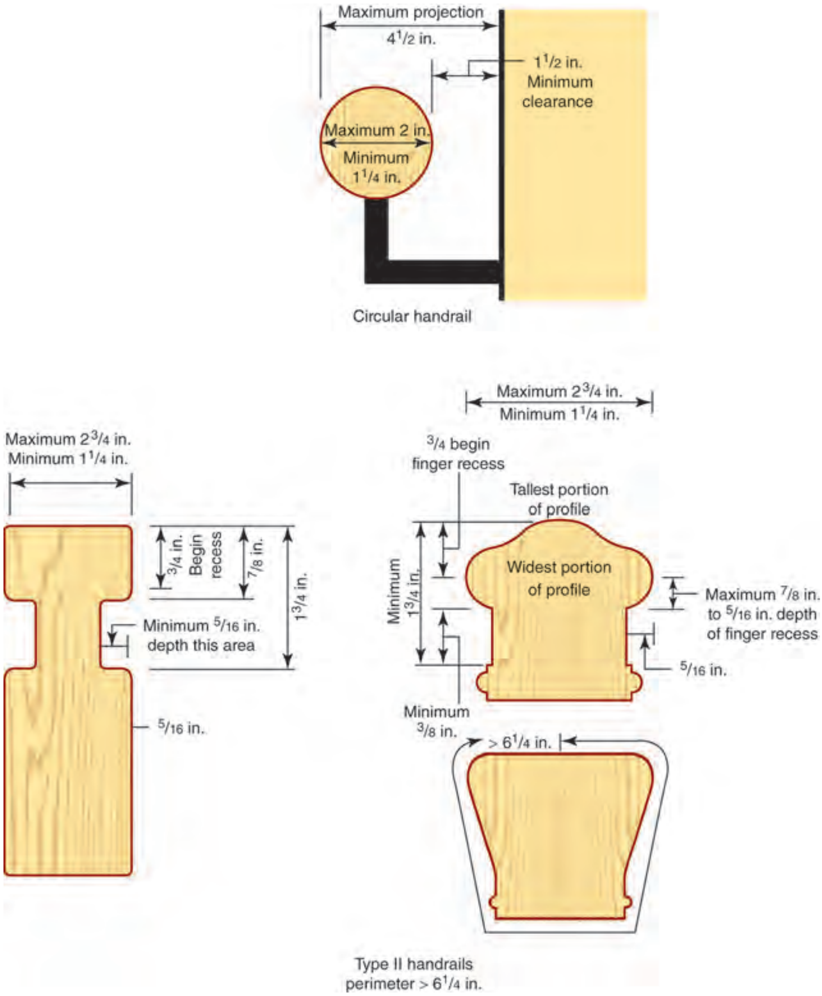


FIGURE 8-13 Handrail shapes for graspability

lar handrails, the MRC prescribes a diameter of $1^1/_4$ to 2 inches. The code provides dimensions for other than round handrails, but any shape, type or size of handrail that provides equivalent graspability is acceptable. This is a performance criterion, and the building official is responsible for determining equivalency. Handrails must also be securely anchored to resist a single concentrated load of 200 pounds applied in any direction. [Ref. R311.7.8]

PROTECTION FROM FALLS

The MRC intends to protect occupants from fall injuries at prescribed locations considered hazardous by regulating the location, design and installation of guards and the height of window sills.

Guards

The MRC generally requires a minimum 36-inch-high guard as protection against falling from a walking surface to a lower surface that is more than 30 inches below. In determining where a guard is required, the vertical distance from the walking surface to the grade or floor below is measured vertically to the lowest point from the edge of the open sided walking surface. The minimum guard height is measured from the walking surface (Figure 8-14). At the sides of stairs, the minimum guard height is reduced to 34 inches to correlate with the minimum handrail height. The top rail of a stair guard often also serves as the stair handrail.

Guards also must be constructed in such a way that a 4-inch sphere will not pass through, a dimension determined after lengthy research to prevent small children from maneuvering through or becoming entrapped in such a barrier. The code grants two exceptions at the sides of stairs. The first increases the dimension to a 6-inch sphere at the triangle formed by the tread, riser, and bottom rail because of the impracticality of reducing the triangle and the negligible hazard. The second stipulates that a $4^3/_8$-inch sphere cannot pass through a guard on the sides of stairs, a measurement that accommodates a practical wood spindle layout for staircases when building to the code-prescribed stair dimensions. Both exceptions are reasonable compromises, particularly when considered against the more common incidence of a child falling down the stair itself (Figure 8-15).

The height and allowable openings in guards are prescriptive requirements that are objectively measurable for compliance with the code. On the other hand, construction of a top rail to resist a single concentrated load of 200 pounds applied in any direction and the infill components to resist a 50-pound horizontal load applied to an area of 1 square foot are performance requirements. The adequacy of a guard or handrail to resist these loading requirements is not so easily measured or verified, though an experienced builder or inspector can fairly accurately gauge the strength and stiffness of a guard or handrail assembly. For additional information on construction of guards, see the discussion of live loads in Chapter 4.

Although the most common type of guard may be constructed of wood or steel posts or balusters and a top rail, the code by no means limits the materials or methods of construction when the guard performs to the stated criteria. [Ref. R312.1]

Window-Sill Height

The minimum window-sill height requirements are intended to reduce the number of injuries to children from falls through open windows. The 24-inch sill height is above a small child's center of gravity, reducing the likelihood of the child's toppling over the sill. The code regulates this minimum sill height only when the window opening is more than 72 inches above the grade below. In such locations where the sill height is lower than 24 inches, protection can still be achieved by installing window fall prevention devices or window control devices meeting ASTM F2090 requirements. These approved devices limit the opening size so that a 4-inch sphere cannot pass through. The MRC references ASTM F 2090 for both window opening control devices and window fall prevention devices. Both devices must have a release mechanism for emergency. This applies to any window equipped with either device (Figures 8-16 and 8-17). [Ref. R312.2]

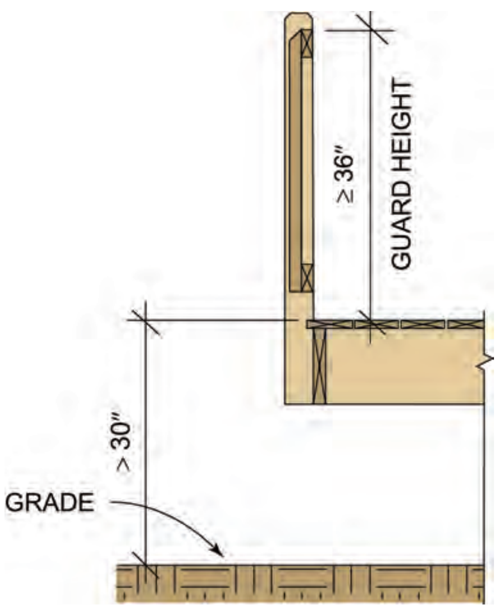


FIGURE 8-14 Determining when a guard is required at a deck

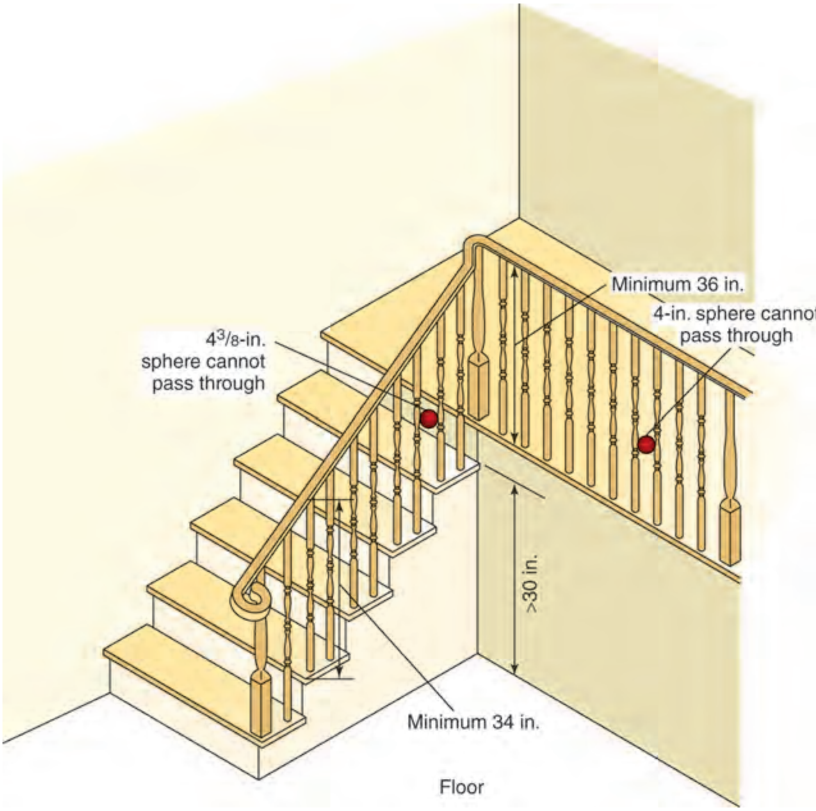


FIGURE 8-15 Guard at interior stair and landing open on one side

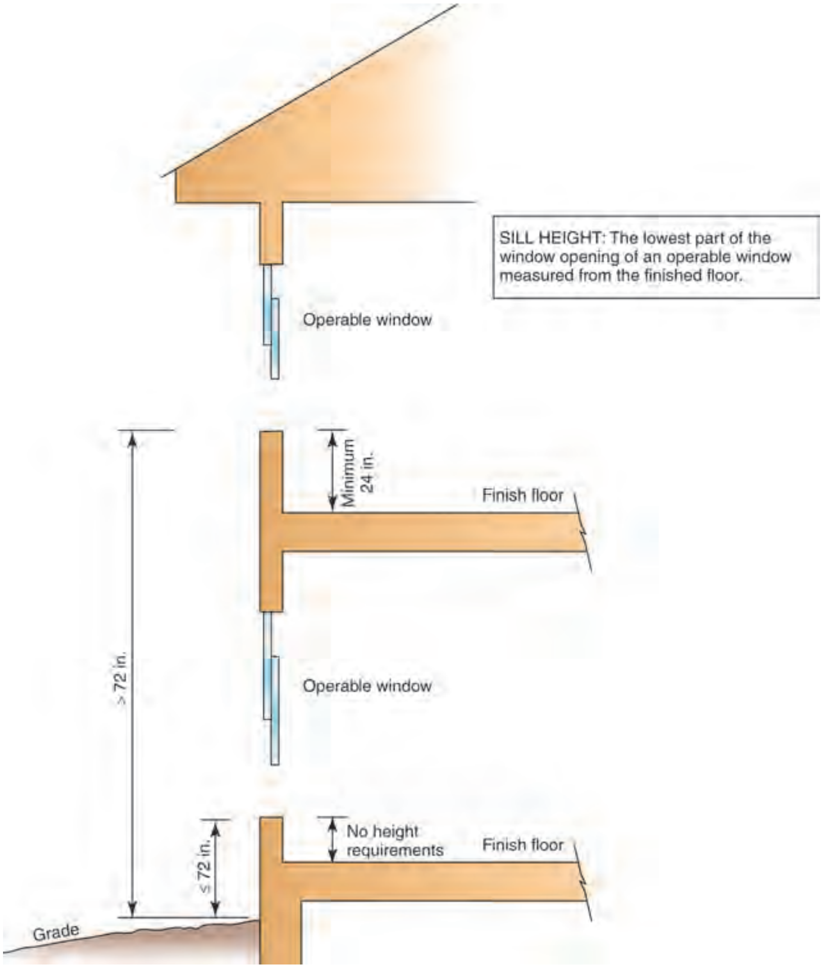


FIGURE 8-16 Window-sill height

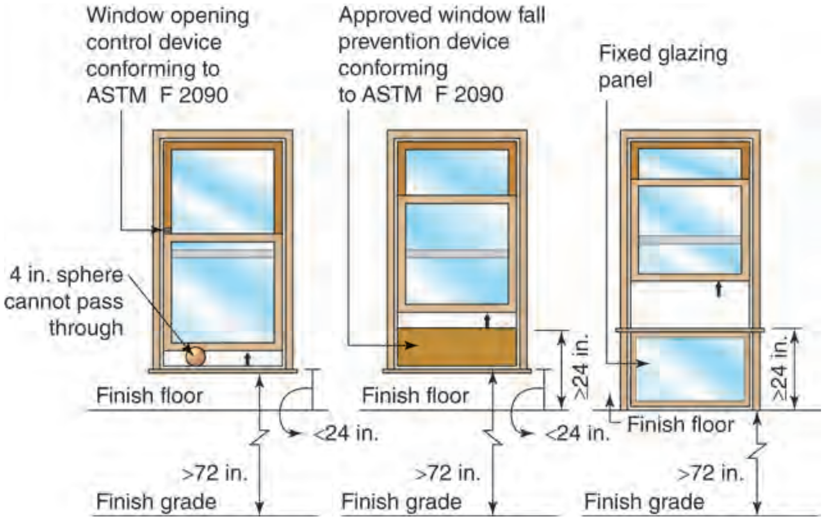


FIGURE 8-17 Alternatives to 24-inch window-sill height

EMERGENCY ESCAPE AND RESCUE OPENINGS

One of the most important safety provisions in the MRC concerns openings for emergency escape and rescue. These openings provide alternate means to escape from a sleeping room or basement in the event that a fire or other emergency blocks the usual path of egress. They allow occupants to escape directly to the safety of the outdoors and allow rescue personnel fully equipped with breathing apparatus to enter the room from the outside. Occupants are most vulnerable to the hazards of fire when they are not fully alert or when they are occupying a basement, a space that traditionally has few windows or doors and often serves as a play or recreation area. The code addresses these life-safety issues by requiring an emergency escape and rescue opening in the basement and in every sleeping room. Basements are only exempt from emergency escape and egress requirements if 200 square feet or less in area and only housing mechanical equipment, the entire building is protected with an automatic sprinkler system, or the entire basement including the means of egress are protected by automatic sprinkler system. In addition, habitable attics, which are unusual in new homes, require an emergency escape and rescue opening (Figure 8-18).

In order for emergency escape and rescue openings to effectively serve their intended purpose, the code prescribes a maximum sill height above the floor of 44 inches and a minimum net opening size of 5.7 square feet (5.0 square feet for grade floor or below-grade openings). Width and height

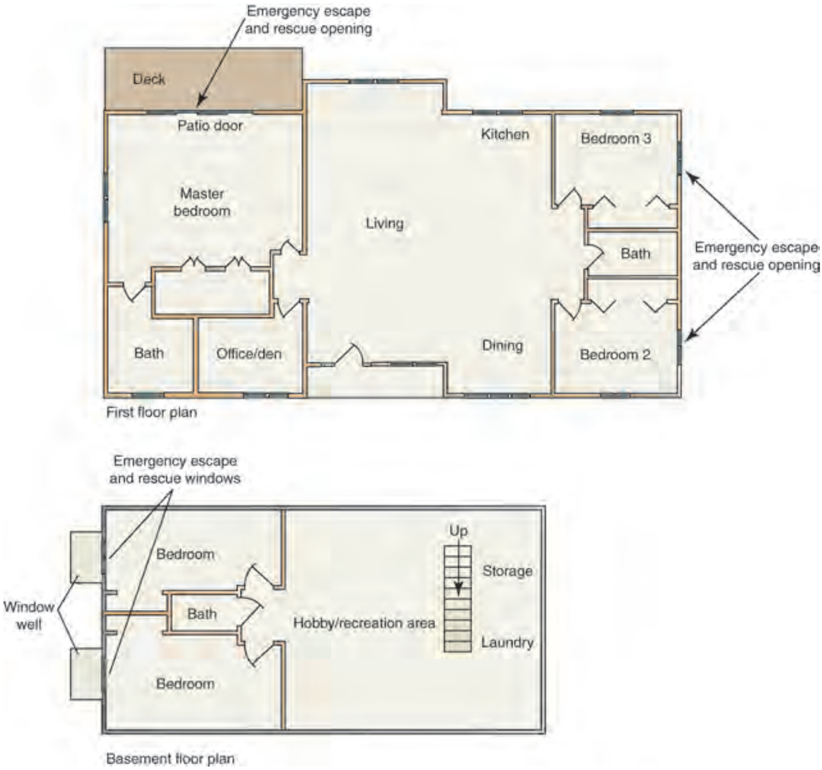


FIGURE 8-18 Required locations for emergency escape and rescue openings

may be any number of combinations to achieve the minimum required opening area, provided the net width of the opening is not less than 20 inches and the net height not less than 24 inches (Table 8-1 and Figure 8-19). Where the windows are located in rooms used for foster care or day care licensed or registered by the state of Minnesota, modifications to the minimum and maximum dimensions are established. [Ref. R310]

In an emergency, occupants need to move quickly and easily to an outside space. Therefore, the code requires that the prescribed opening dimensions be obtained by the normal operation of the emergency escape and rescue opening, usually a window or door, without the need for a key, tool, or any special knowledge. This precludes the removal of a window sash or mechanical fasteners to obtain the required opening dimensions. [Ref. R310.1.1]

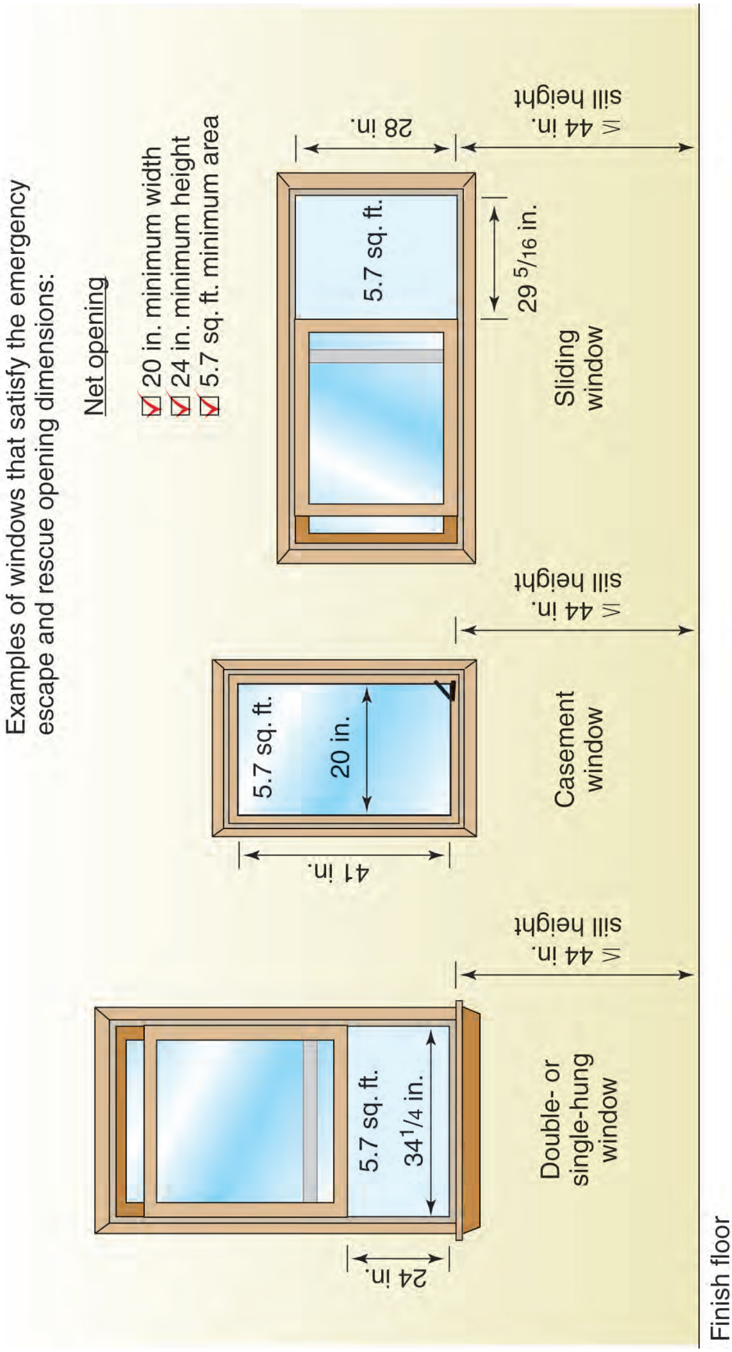


FIGURE 8-19 Emergency escape and rescue windows

TABLE 8-1 Emergency escape and rescue windows*

	Inches					
Width	20	20.5	21	21.5	22	22.5
Height	41	40	39.1	38.2	37.3	36.5
Width	23	23.5	24	24.5	25	25.5
Height	35.7	34.9	34.2	33.5	32.8	32.2
Width	26	26.5	27	27.5	28	28.5
Height	31.6	31	30.4	29.8	29.3	28.8
Width	29	29.5	30	30.5	31	31.5
Height	28.3	27.8	27.4	26.9	26.5	26.1
Width	32	32.5	33	33.5	34	34.2
Height	25.7	25.3	24.9	24.5	24.1	24

*Minimum net clear width/height combinations to obtain a net opening of 5.7 square feet.

You Should Know

Steps for window wells serving emergency escape and rescue openings
The MRC does not specify a maximum riser height or a minimum tread depth. Recommended practice is to construct these steps within the following limitations for ladders in window wells:

- Maximum riser height of 18 inches
- Minimum tread depth of 3 inches

Window Wells

The MRC requires a window well when the sill of the emergency escape and rescue window is below the adjacent ground elevation. The window well area must be at least 9 square feet with a minimum dimension of 36 inches. The code requires a ladder or steps when the window well is greater than 44 inches deep, a dimension consistent with the maximum window-sill height. A ladder or step is allowed to encroach into the required window well area no more than 6 inches. Except in areas with well-drained soils, window wells serving emergency escape and rescue openings must have a means to drain to the foundation drainage system (Figures 8-20 and 8-21). [Ref. R310.2.3]

Area Wells

Similar to window wells, area wells serve below-grade doors used as emergency escape and rescue openings. The same minimum dimensions apply to doors as to windows used for this purpose. Likewise, the area well minimum width and the provisions for ladders and steps align with the corresponding window well requirements. Ladders or steps are required when the area well (or window well) is deeper than 44 inches. The code specifically exempts these ladders and steps from the means of egress provisions (Figure 8-22). [Ref. R310.3.2]

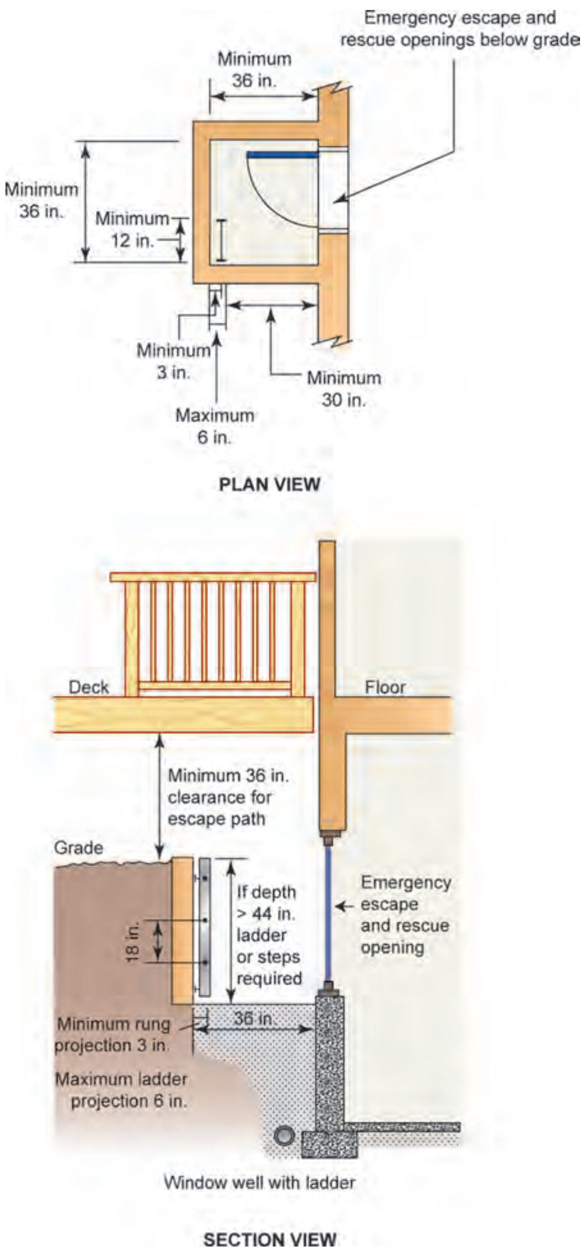


FIGURE 8-20 Ladder required for window wells deeper than 44 inches serving Emergency Escape and Rescue Openings

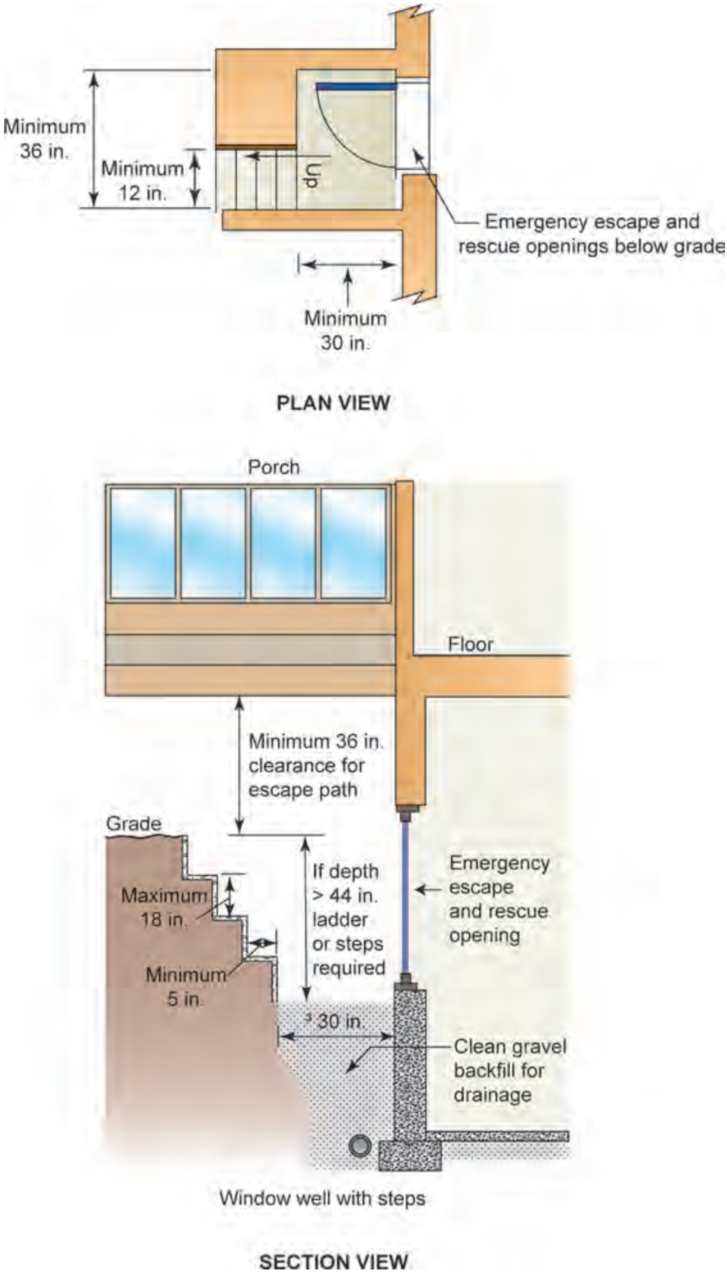


FIGURE 8-21 Steps required for window wells deeper than 44 inches serving Emergency Escape and Rescue Openings

CHAPTER 8

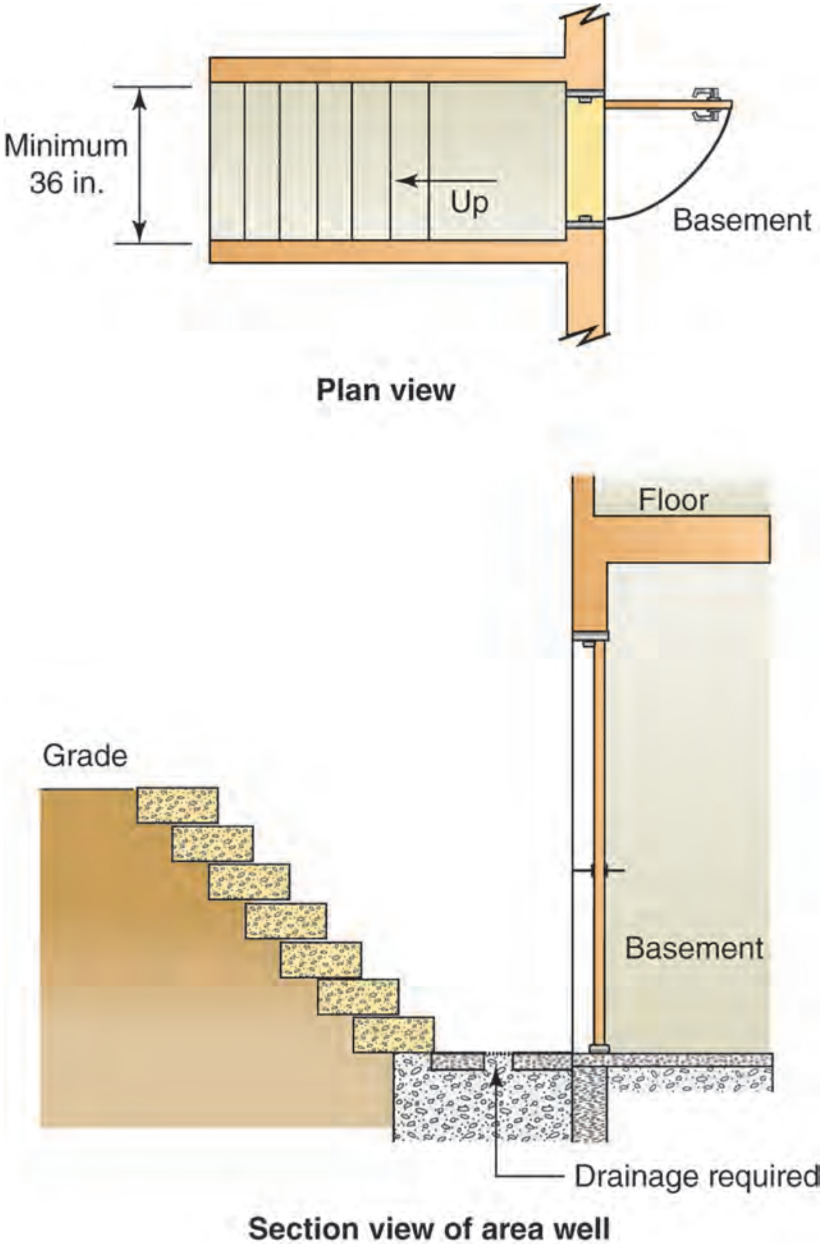


FIGURE 8-22 Door serving as a required emergency escape and rescue opening from a basement with an area well

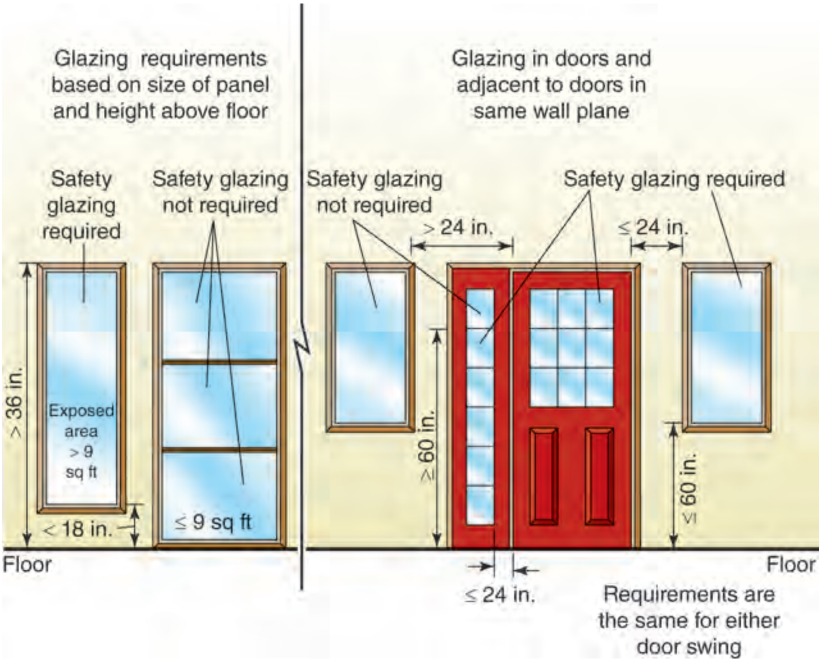


FIGURE 8-23 Safety glazing locations

SAFETY GLASS

To prevent serious injury from shards of breaking glass, the MRC identifies seven specific locations as subject to impact by people and therefore hazardous for the installation of glazing. For example, glass in doors and adjacent to doors has an increased likelihood of accidental breakage due to actions to open and close the door and the movement of the door itself. Large panels of glass lack the visual cues or physical barriers to prevent people from accidentally walking into them. Glass adjacent to stairs is considered in a hazardous location because of the increased chances of a misstep or fall. Examples of hazardous locations subject to human impact and requiring safety glazing when glazing is installed are illustrated in Figures 8-23 through 8-29. [Ref. R308.4]

Safety glazing, typically tempered or laminated glass, must pass the test requirements and be classified in accordance with the applicable referenced standard based on the location of the glazing. Polished wired glass is not permitted in hazardous locations requiring safety glazing, including those locations requiring fire resistance, unless it has received an approved classification through testing. The code generally requires a permanent manufacturer's designation on each panel of safety glazing indicating the type of glazing and the applicable standard. The designation is typically etched or embossed on the glass, but a label may be used, provided that it cannot be removed without being destroyed, thus preventing its reuse on a panel that is not safety glazing. For other than tempered glass, the building official may approve a certificate or affidavit of code compliance in lieu of a manufacturer's designation. [Ref. R308.1 and R308.3]

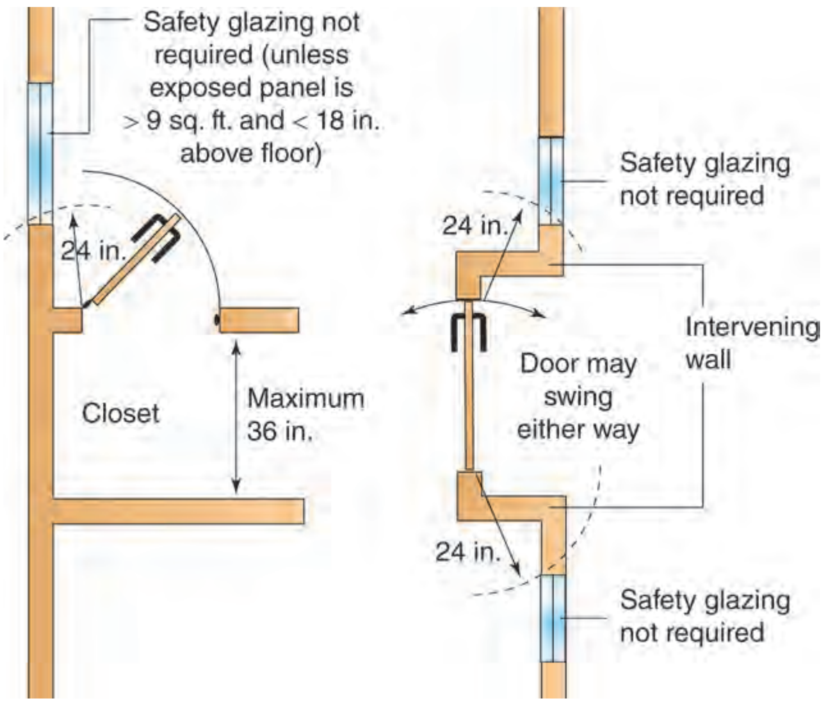


FIGURE 8-24 Glazing near doors

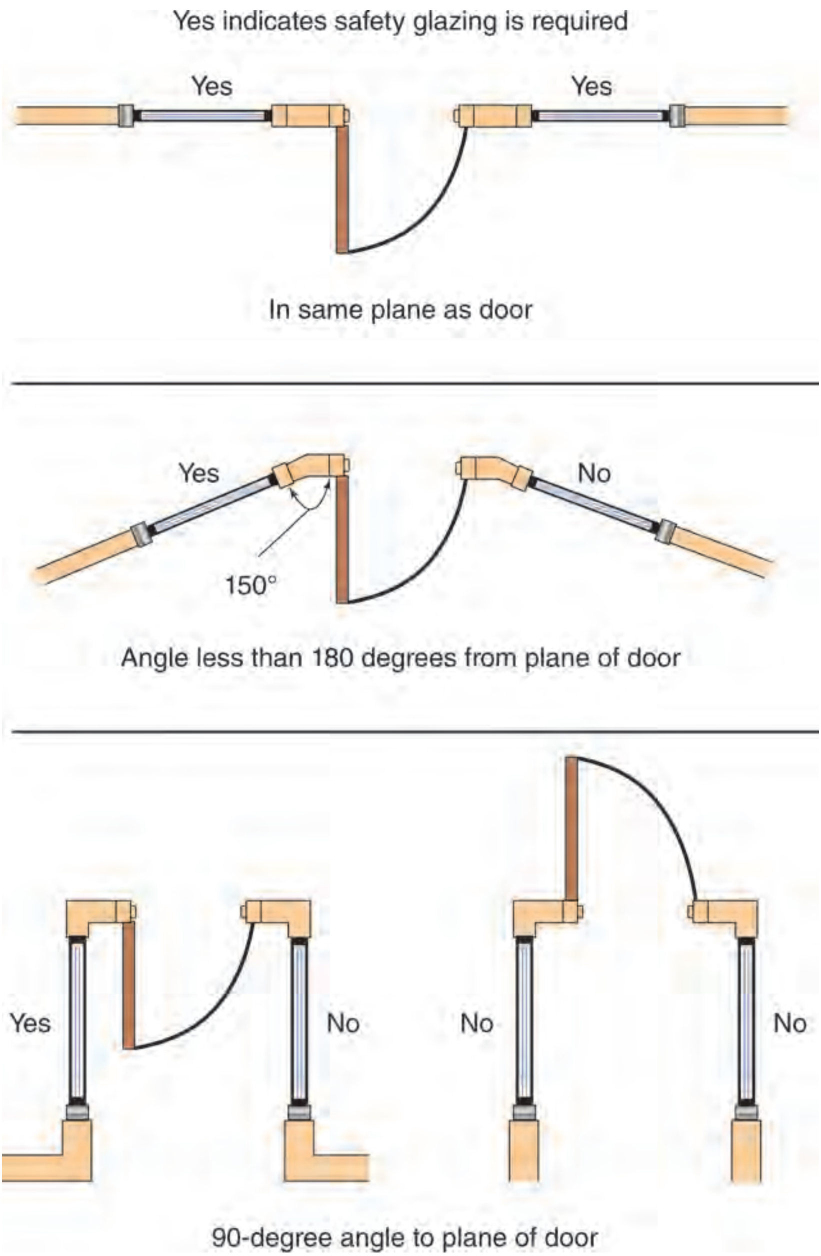


FIGURE 8-25 Glazing adjacent to doors

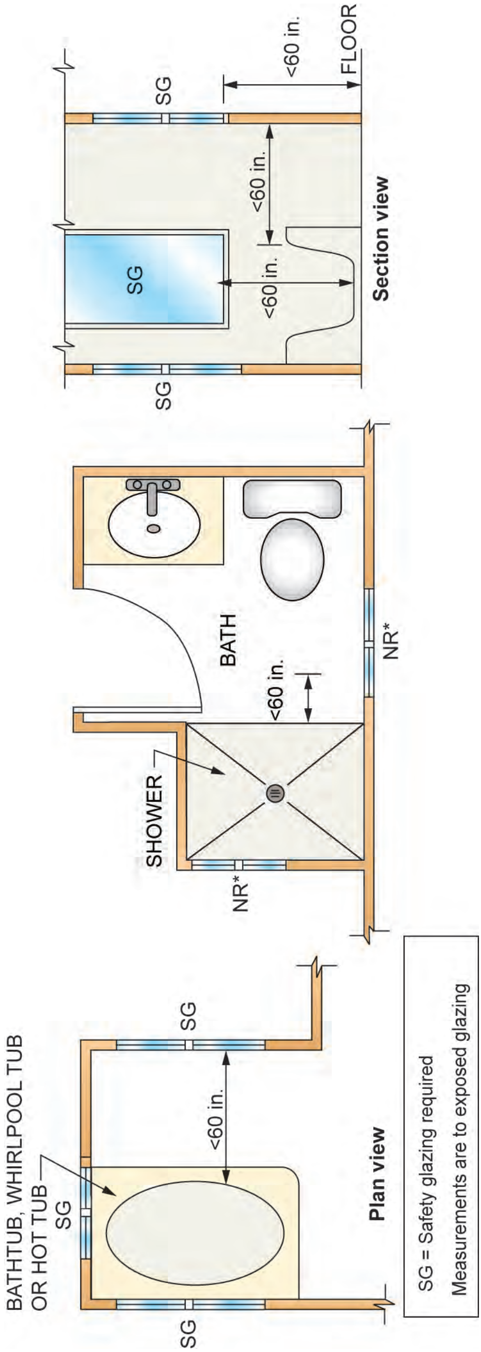


FIGURE 8-26 Glazing facing or enclosing bathtubs

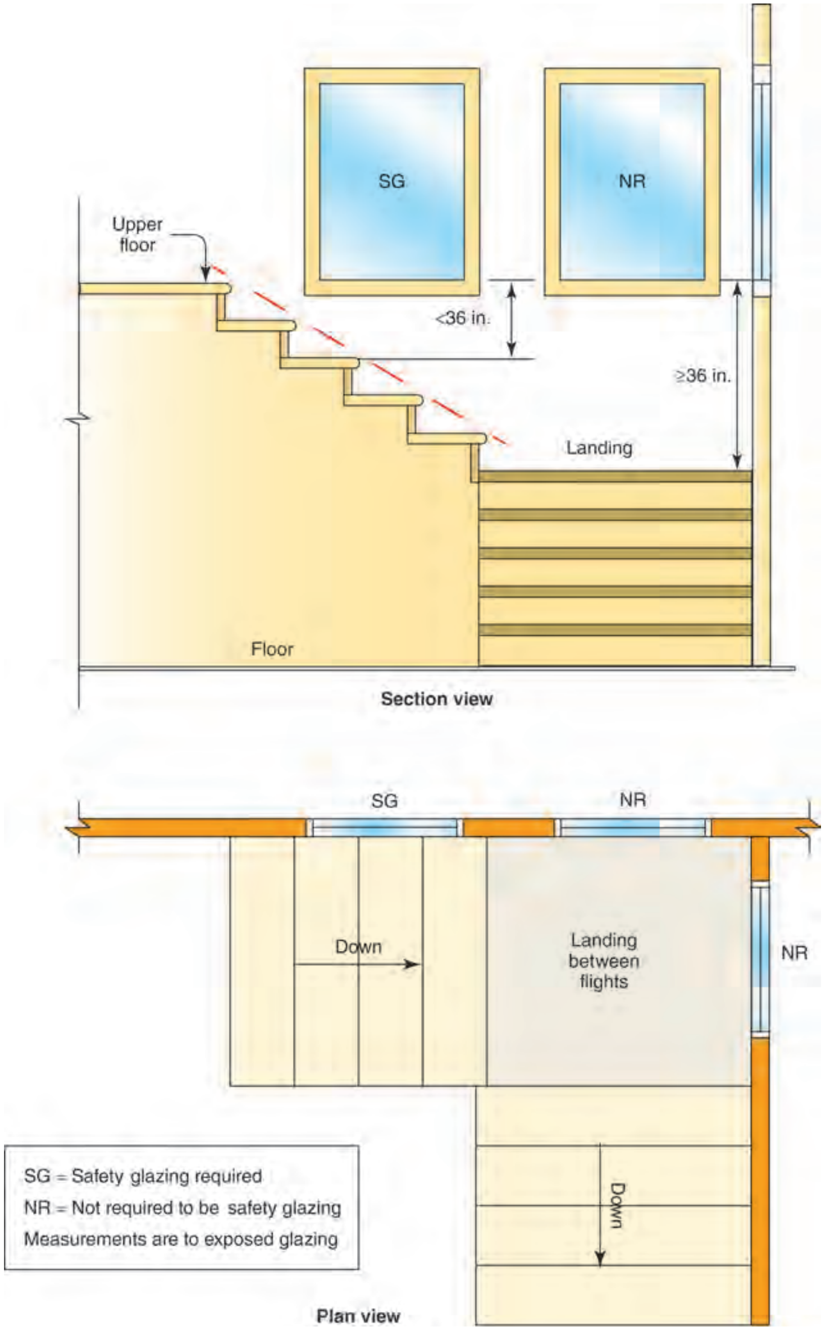


FIGURE 8-27 Glazing adjacent to stairs and landings between flights of stairs

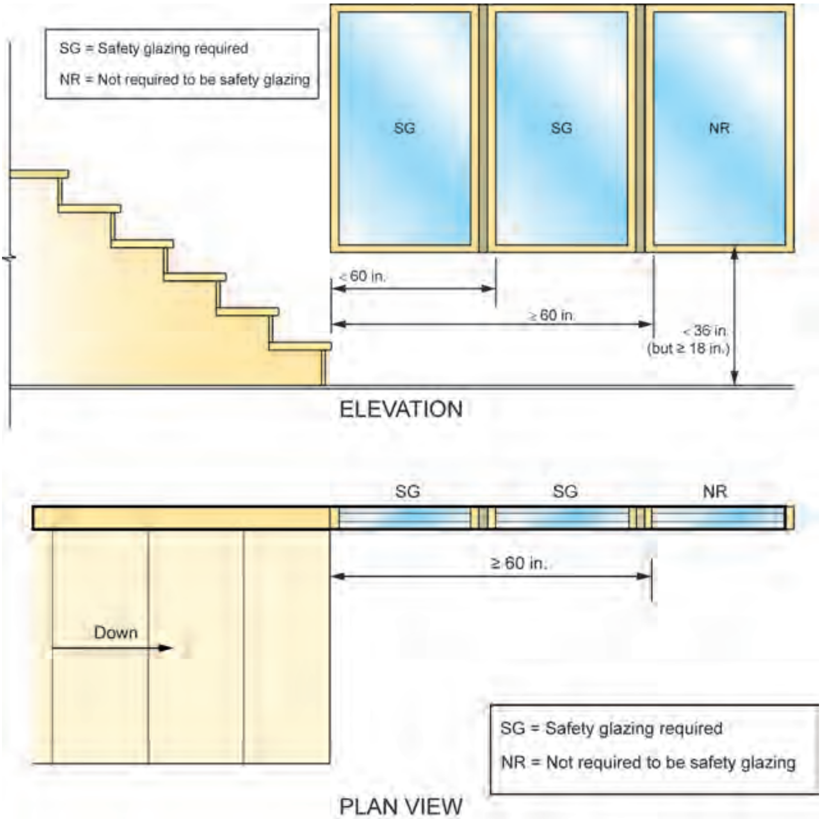


FIGURE 8-28 Glazing adjacent to the bottom landing of a stairway

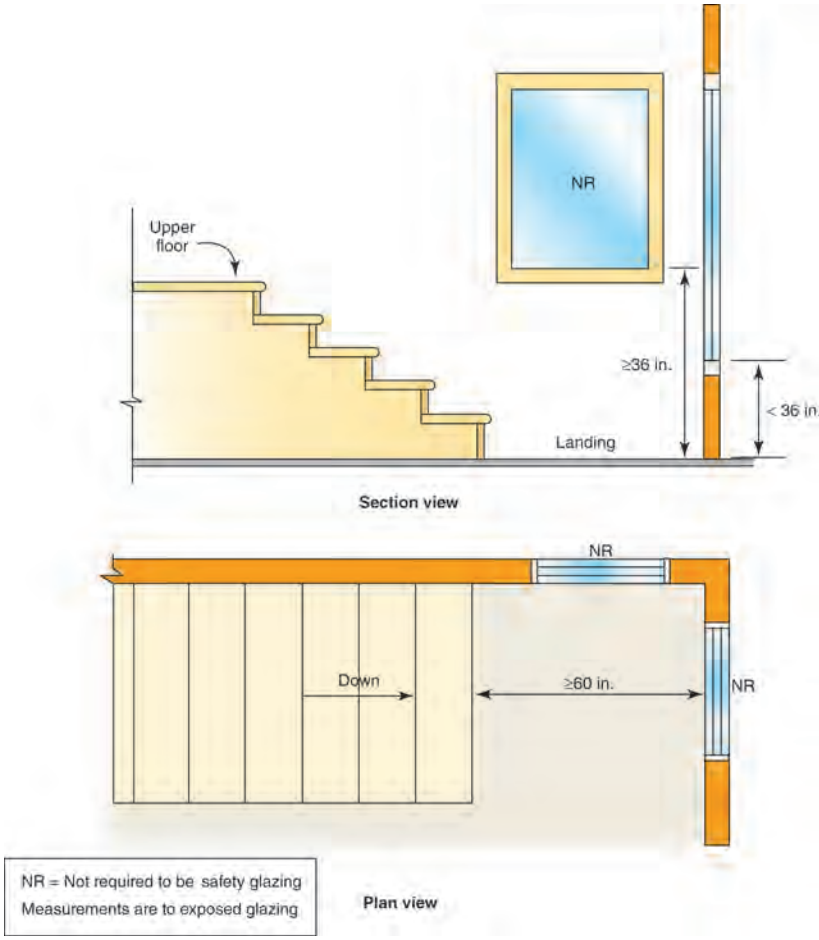


FIGURE 8-29 Safety glazing not required at bottom landing when glass is at least 36 inches above floor or at least 60 inches horizontally from bottom tread

CHAPTER 9 Fire Safety

Construction under the *Minnesota Residential Code* (MRC) protects occupants from the hazards of fire through interconnected smoke alarms, an automatic fire sprinkler system, and installation of fire-resistant materials at prescribed locations (Figure 9-1). Such fire protection systems are concerned primarily with life safety and provide occupants time to safely exit the building. Although smoke alarms, residential sprinkler systems and fire-resistant construction often buy time for effective fire fighting, resulting in reduced property damage, such protection is secondary to occupant safety.

FIGURE 9-1 Residential sprinkler in multipurpose loop system using PEX tubing (Courtesy of Uponor Inc.)

SMOKE ALARMS

Occupants are most vulnerable to the hazards of fire while sleeping. Detection and notification in the early stages of a fire provide residents with needed time to escape before the interior environment becomes intolerable and life-threatening. The MRC requires a smoke alarm in each sleeping room, outside each sleeping area and on each additional story of the dwelling unit including basements and habitable attics (Figure 9-2). The code also stipulates that the building wiring system provide the primary power to the smoke alarms and that batteries supply backup power when primary power is interrupted. [Ref. R314]

A smoke alarm is a self-contained device that provides both smoke detection and an alarm-sounding appliance. Smoke alarms must be listed as conforming to UL 217, *Single and Multiple Station Smoke Alarms*. The MRC requires interconnection of the devices such that when smoke is detected in one location, the alarms are activated in all locations. In addition to alerting residents on any story of the dwelling unit, interconnection ensures that the alarm is delivered to each bedroom at a sound-pressure level considered sufficient to wake a sleeping person. Wireless smoke alarms satisfy the interconnection requirements. [Ref. R314.1, R314.4]

The MRC also regulates smoke alarms for existing dwellings when one or more sleeping rooms are added or created or when interior work (including installation or replacement of windows and doors) or an addition requiring a permit occurs. In this case, the residence must be brought into conformance with the location requirements for smoke alarms in new con-

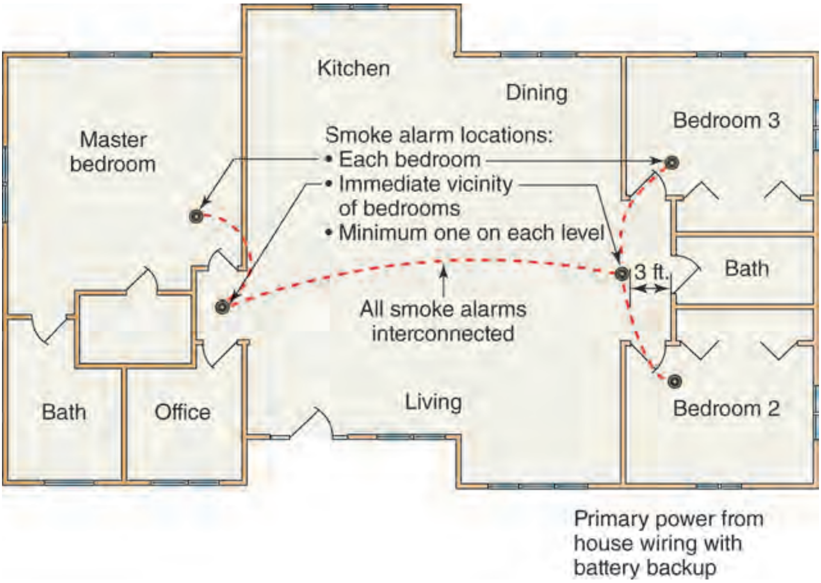


FIGURE 9-2 Smoke alarm locations

struction. However, the electrical power requirements differ from those for new buildings. Because of the costs of installing electrical wiring in existing dwellings, the code allows battery-operated alarms without a connection to the house wiring or interconnection to each other unless the alterations or repairs cause the removal of interior wall or ceiling finishes. The retroactive provisions for smoke alarms do not apply to exterior renovations or to the addition of a deck or porch. Plumbing, electrical, or mechanical work in existing dwellings also does not trigger the smoke alarm requirements. [Ref. R314.2.2, R314.4, R314.6]

As an alternative to smoke alarms, the MRC permits a fire alarm system installed in accordance with the household fire warning equipment provisions of NFPA 72, *National Fire Alarm Code*. A household fire alarm system typically has separate devices for smoke detection and alarm annunciation. Any such system must provide detection and notification equivalent to the MRC-prescribed requirements for smoke alarms. For example, a household fire warning system may have fewer notification devices placed in the building. When a detector in any of the prescribed locations activates the system, the alarm must be clearly audible in all bedrooms over background noise levels with all intervening doors closed. In general, the sound-pressure level at the pillow cannot be less than 70 decibels. [Ref. R314.7]

FIRE SPRINKLER SYSTEMS

An automatic fire sprinkler system conforming to MRC Section P2904, Dwelling Unit Fire Sprinkler Systems, or NFPA 13D, Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes, aids in the detection and control of fires in dwellings and intends to prevent total fire involvement (flashover) in the room of fire origin for a period of time to allow the escape or evacuation of the dwelling occupants (Figure 9-3). The MRC requires an automatic fire sprinkler system in all new townhouses having 3 or more units. However, two-unit townhouses and one- and two-family dwellings containing facilities licensed by the state of Minnesota may be required to be equipped with sprinkler protection by the licensing agency.

FIRE-RESISTANCE-RATED CONSTRUCTION

Fire-resistance-rated construction limits the spread of fire to protect property and occupants, and provides time for effective fire-fighting efforts. The components of the wall or floor-ceiling construction form an assembly that has proven through testing to resist the effects of fire for the designated time period. The fire-resistance rating is based on results under the specific test conditions and does not necessarily predict performance under actual field conditions.

Occupants have no control over the action of their neighbors, and the fire-resistant-rated construction of exterior walls located near lot lines and the separation between dwelling units offers an appropriate level of protection.

Exterior Walls

To protect against the spread of fire from a building on one property to a building on another property, the code prescribes an intervening clear space between buildings and the lot line or requires fire-resistant construction of exterior walls. When exterior walls are located less than the prescribed distance from the lot line (5 feet for buildings without fire sprinkler protection and 3 feet for buildings with fire sprinkler protection), the MRC requires a fire-resistance rating of one hour (Figure 9-3).

The MRC also regulates projections and openings within this setback zone of 3 to 5 feet. Openings, typically windows or doors, are not permitted less than 3 feet from the lot line. For dwellings without sprinklers and detached accessory buildings, openings that are at least 3 feet but less than 5 feet from the lot line are limited to 25 percent of the wall area. This area limitation does not apply to dwellings protected with an automatic fire sprinkler system. Foundation vents for ventilation of underfloor spaces are

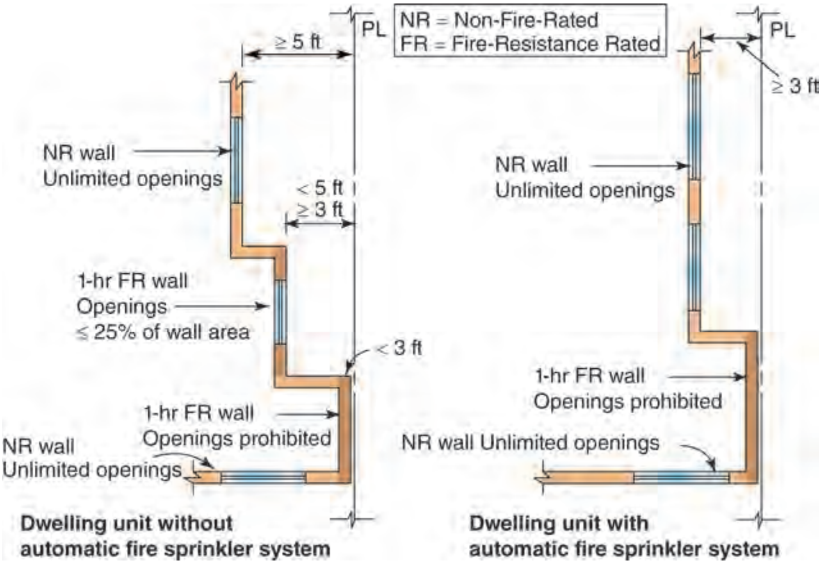


FIGURE 9-3 Fire resistance of exterior walls adjacent to lot lines

not regulated for minimum fire separation distance. Projections, typically roof overhangs, require one-hour fire protection on the underside when less than the prescribed distance from the lot line (5 feet without sprinklers and 3 feet with sprinklers) unless fireblocking is installed between the top of the rated wall and the roof sheathing. Roof overhangs typically cannot project closer than 2 feet from the lot line. An exception permits a garage located within 2 feet of the lot line to have a 4-inch roof eave projection (Table 9-1 and Figures 9-4 and 9-5). For further discussion of exterior walls and fire separation distances, see Chapter 3. [Ref. R302.1]

Two-Family Dwellings

The MRC requires a one-hour fire-resistance-rated separation between the dwelling units of a two-family dwelling. Horizontal floor-ceiling assemblies separating upper and lower units must extend to the exterior walls, and supporting wall construction must also be one-hour fire-resistance-rated (Figure 9-6). Wall assemblies separating side-by-side units must generally extend from the foundation through the attic space to the bottom of the roof sheathing (Figure 9-7). As an alternative, the MRC permits the wall assembly to terminate at a $^{5}/_{8}$-inch gypsum board ceiling when a draft stop is installed in the attic area and not less than $^{1}/_{2}$-inch gypsum board is installed on the walls supporting the ceiling (Figure 9-8). Compliance with the sound transmission requirements of MRC Appendix K are also applicable. [Ref. R302.3]

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TABLE 9-1 Fire resistance of exterior walls adjacent to lot lines

Exterior wall element	Fire separation distance to lot line	Dwellings without sprinkler system and detached accessory buildings[a]	
		Minimum fire-resistance rating	Restrictions
Walls	5 feet and greater	0 hours	
	3 feet to < 5 feet	1 hour	Tested for exposure from both sides
	0 feet to < 3 feet	1 hour	Tested for exposure from both sides
Projections	5 feet and greater	0 hours	
	3 feet to < 5 feet	1 hour[c]	On the underside
	2 feet to < 3 feet	1 hour[c]	On the underside
	0 feet to < 2 feet	Not permitted[b]	
Openings in walls	5 feet and greater	0 hours	Unlimited area
	3 feet to < 5 feet	0 hours	Maximum 25% of wall area
	0 feet to < 3 feet	Not permitted	

a. Detached sheds not greater than 200 square feet in area are not regulated for separation distance.
b. Detached garages within 2 feet of lot line are permitted to have a 4-inch roof eave overhang.
c. One layer of $^{5}/_{8}$″ type X gypsum sheathing is acceptable. No openings are permitted.

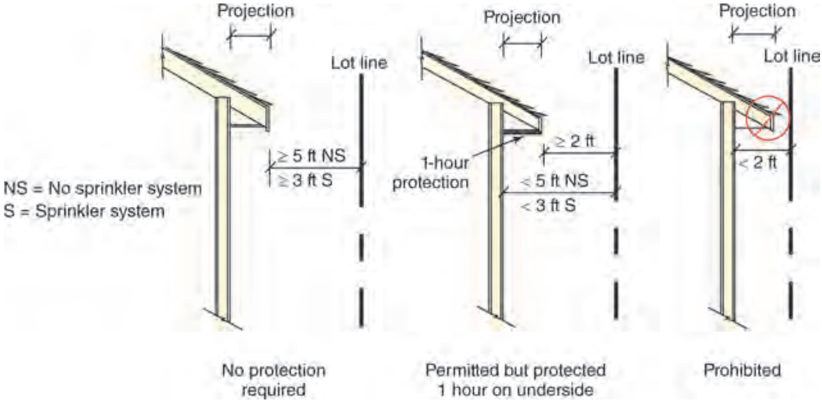


FIGURE 9-4 Roof projections at property line

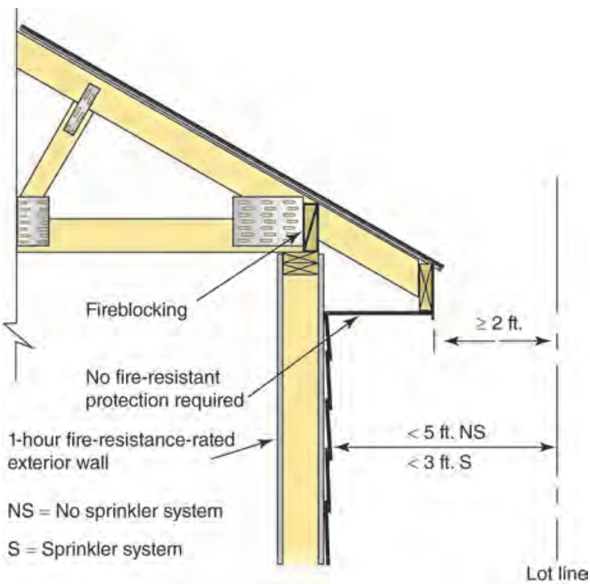


FIGURE 9-5 A fire-resistance rating is not required for roof eave projections when fireblocking is installed above the exterior wall.

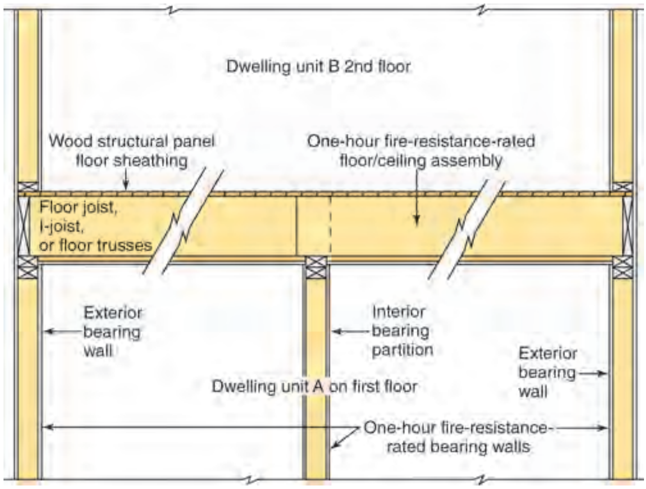


FIGURE 9-6 Horizontal separation for two-family dwelling

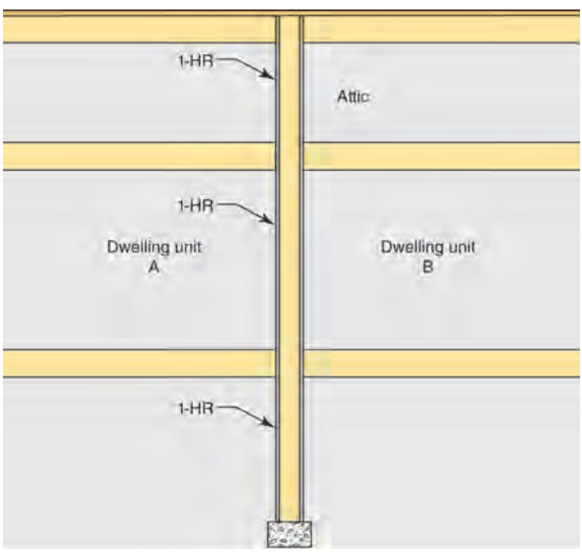


FIGURE 9-7 Two-family dwelling separation wall

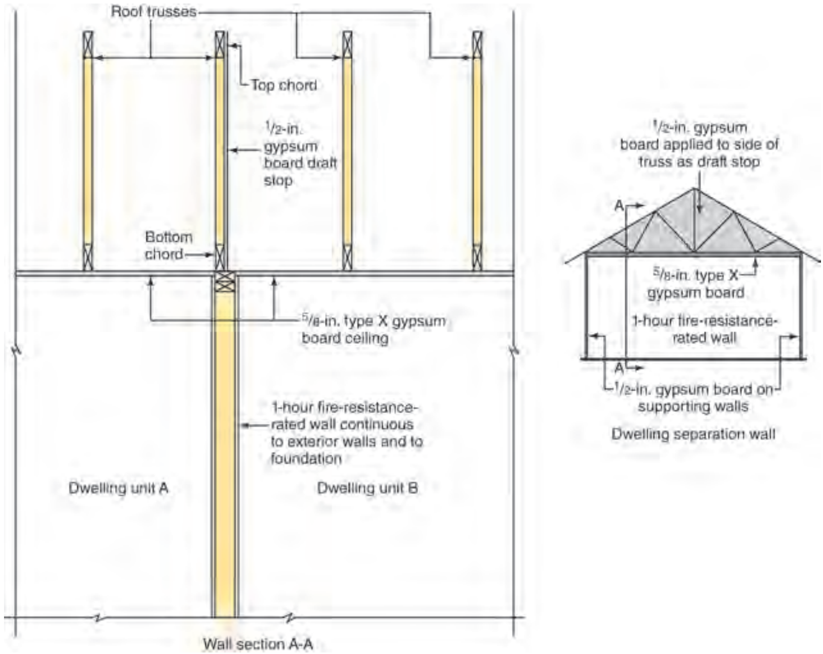


FIGURE 9-8 Alternate attic draft stop for vertical separation of two-family dwelling

Townhouses

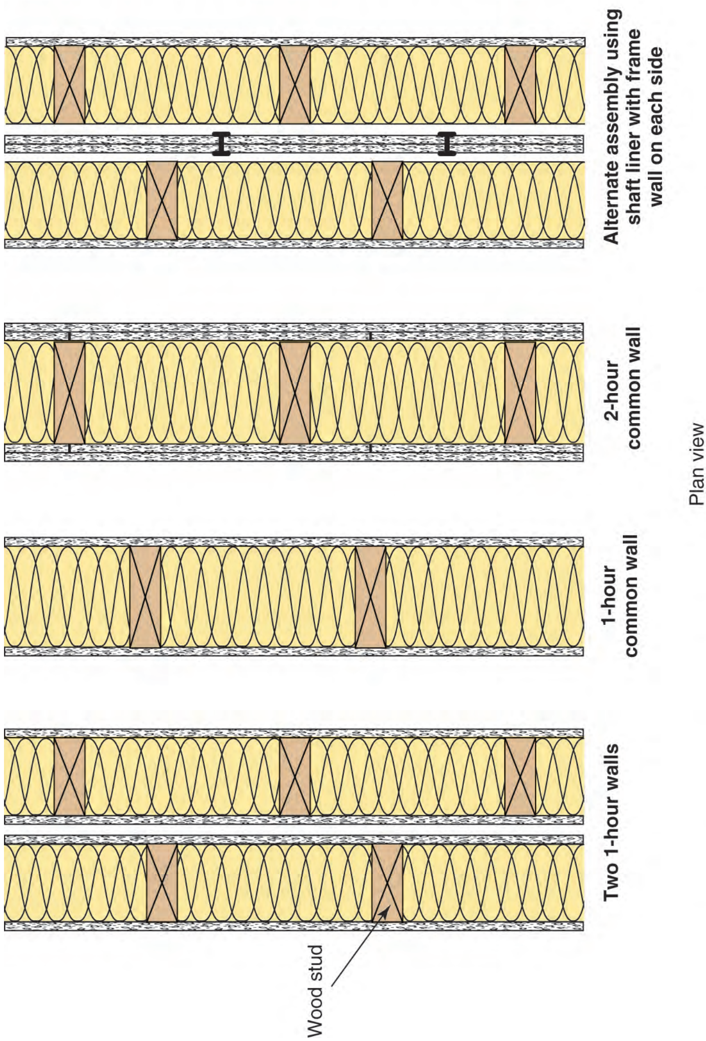
As with two-family dwellings, a priority of the code is to separate townhouse dwelling units with fire-resistant-rated wall assemblies to limit the spread of fire in the structure and to provide some protection to occupants from events that occur in the neighboring unit. Townhouses, by definition, are single-family dwelling units constructed in a group of three or more connected units. Because the total number of townhouse dwelling units in a single building is unlimited, the MRC treats their separation somewhat differently than duplexes to provide greater protection from the spread of fire. There are two paths to achieve compliance with the code for fire-resistant separation of townhouse dwelling units. The first method is to construct two one-hour-rated wall assemblies. In this case, each townhouse is required to be structurally independent as it relates to fire resistance. The second option permits construction of a common wall between dwelling units that does not require structural independence of the townhouse units. The fire-resistance rating of the common wall between townhouses is tied to the presence of an automatic fire sprinkler system. A 2-hour rating is required for non-sprinklered buildings. For townhouse dwelling units protected with an automatic sprinkler system, a 1-hour rating is required (Figures 9-9 and 9-10). To preserve structural integrity and limit penetrations of the fire-resistant membrane, the code does not permit the installation of plumbing or mechanical equipment, ducts or vents in the cavity of the common wall. Electrical installations are permitted and must meet the penetration requirements for fire-resistance-rated assemblies. [Ref. R302.2]

To prevent the spread of fire from one unit to the next at the roof line, the MRC provides two options. The first requires a 30-inch-high parapet wall with equivalent fire rating as the separation wall. The second option is the more common practice of installing the prescribed fire-resistant protection at the roof for a distance of 4 feet on each side of the separating wall. This protection is not a fire-resistant-rated assembly, but the materials specified perform satisfactorily in resisting the spread of fire. Because any penetration of this protected area of the roof would reduce the effectiveness in preventing the spread of fire, the code prohibits openings or penetrations in the roof within 4 feet of the separation wall (Figures 9-11 and 9-12). [Ref. R302.2.2]

Code Essentials

For townhouses without parapets, roof penetrations are prohibited within 4 feet of the separating wall

- Skylights
- Roof windows
- Gas vents
- Plumbing vents
- Exhaust outlets
- Air intakes
- Ridge vents
- Roof vents



Note: Gypsum wallboard and wood stud assemblies must meet all materials, dimensions, spacing, installation and fastening requirements of the specific tested assembly

FIGURE 9-9 Typical fire-resistant-rated wall assemblies for separating townhouse dwelling units

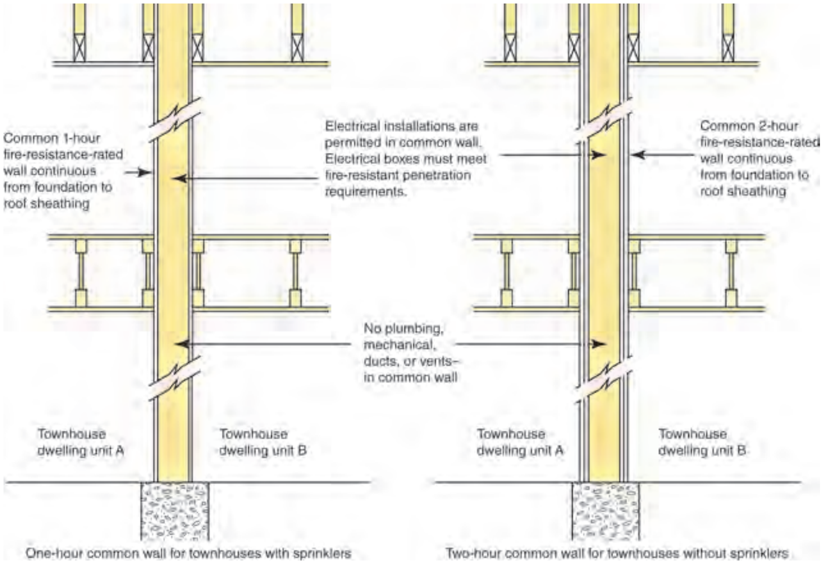


FIGURE 9-10 Common walls separating townhouses

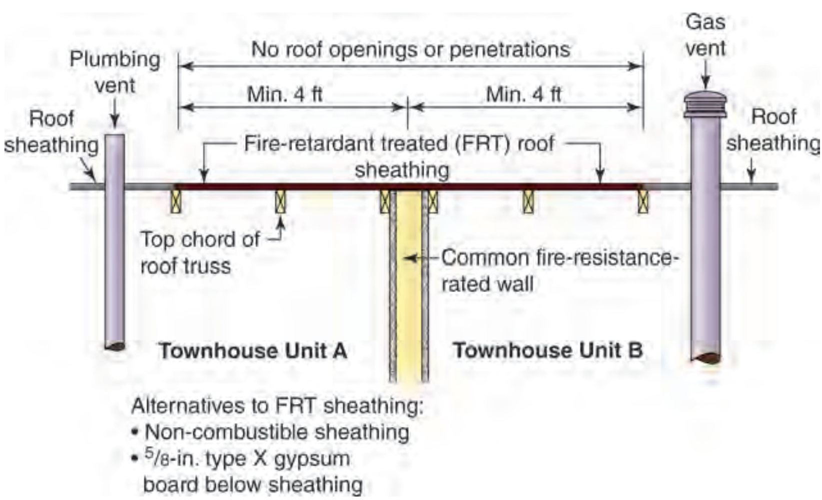


FIGURE 9-11 Townhouse roof protection on each side of separation wall

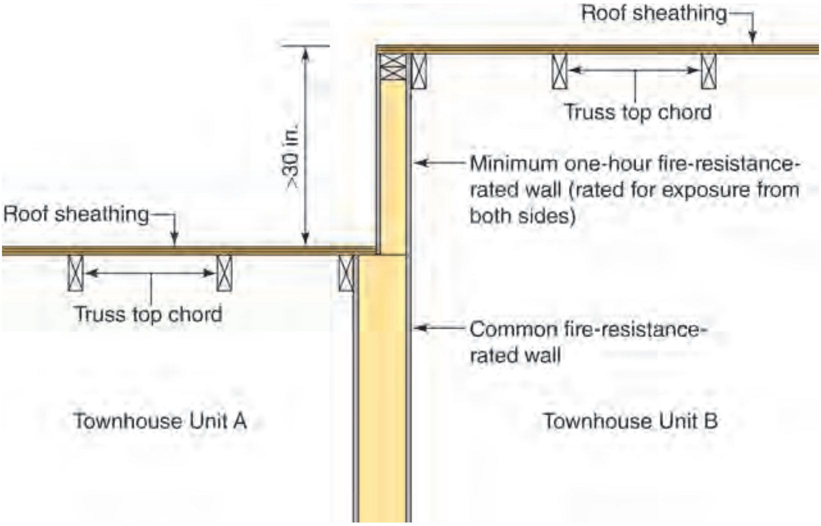


FIGURE 9-12 Townhouse separation for roofs with greater than 30-inch height difference

Fire-Resistance-Rated Assemblies

Many tested fire-resistance-rated assemblies are available utilizing various materials and methods of construction. In buildings regulated by the MRC, gypsum board applied to wood framing is the most common type of assembly. Assemblies are assigned an hourly fire-resistance rating through testing in accordance with ASTM E119, *Test Methods for Fire Tests of Building Materials and Construction,* or UL 263, *Fire Tests of Building Construction and Materials*. Tested assemblies are available in the *Gypsum Association Fire Resistance Design Manual* and from approved testing agencies. In addition, the code permits construction of fire-resistant-rated assemblies in accordance with Section 703.3 of the Minnesota Building Code (MBC). Construction must match the design specifications for types of materials, dimensions and methods of attachment (Figure 9-13). [Ref. R302.1, R302.2, R302.3]

Penetrations of Fire-Resistance-Rated Assemblies

When items such as pipes or ducts penetrate one or both sides of the fire-resistance-rated wall or floor-ceiling assembly separating dwelling units, both the penetrating item and the space around it must be protected to maintain the integrity of the fire-resistant assembly. In general, penetrations by metal pipe require that the space around the pipe be filled with approved materials to prevent the passage of flame and hot gases. The material, such as a listed fire-stop sealant, must be installed according to the manufacturer's instruc-

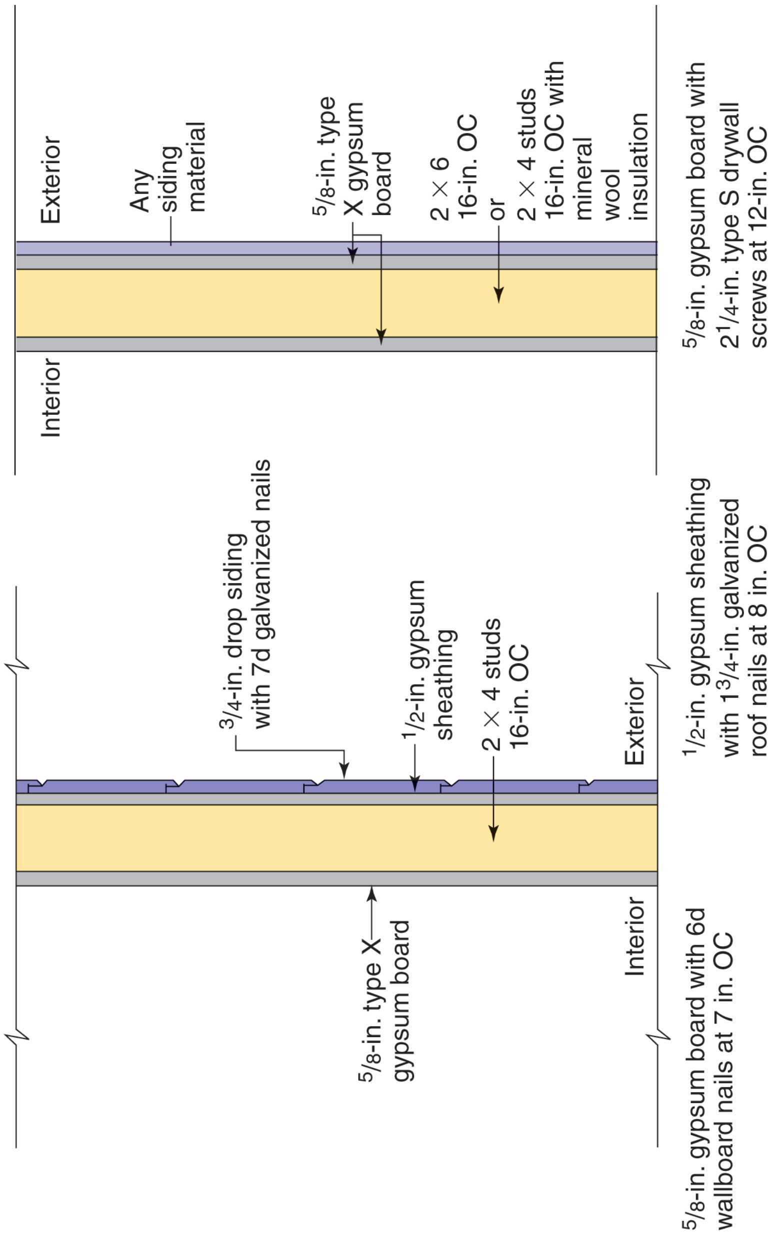


FIGURE 9-13 Examples of one-hour fire-resistance-rated exterior wall assemblies

tions to provide a fire-resistant time rating that is equivalent to that of the construction being penetrated. Other penetrating materials, such as plastic pipe (if permissible—plumbing piping is not permitted to penetrate or be located in the common wall separating townhouses), must be protected by an approved penetration fire-stop system. Such a system often consists of intumescent material that expands when heated by fire conditions, filling the penetration as the plastic pipe melts and preserving the fire-resistance rating of the wall or floor-ceiling assembly. [Ref. R302.4]

Steel electrical boxes up to 16 square inches and listed electrical boxes are permitted to penetrate the membrane of a fire resistance rated wall assembly. Steel box penetrations are limited to 100 square inches in any 100 square feet of wall area. When electrical boxes are installed on opposite sides of the wall assembly, they require a minimum horizontal separation distance or another approved means of separation. The installation of wood blocking between the boxes or application of a listed putty pad to each box satisfies the separation requirement. Putty pads consist of intumescent fire-stop material that expands when heated to seal off the electrical box penetration (Figure 9-16). Sound transmission is required between dwelling units in accordance with MRC Appendix K. [Ref. R302.4.2]

DWELLING SEPARATION FROM GARAGE

Unlike separations between dwelling units, the separation between the residence and garage is not a fire-resistance-rated assembly. Likewise, penetrations through the separation are not required to meet the rated penetration requirements for fire-resistance-rated assemblies. Attached garages and detached garages within 3 feet of the dwelling require installation of gypsum board on the garage side to provide limited resistance to the spread of fire. Generally, the MRC prescribes $^{1}/_{2}$-inch gypsum board installed on the garage side to achieve this separation (Figures 9-15 and 9-16). When there are habitable rooms above the garage, the code requires the installation of $^{5}/_{8}$-inch Type X gypsum board on the garage ceiling. The bearing walls supporting the ceiling framing in this instance also require the application of $^{1}/_{2}$-inch gypsum board on the interior surface (Figure 9-17). [Ref. R302.6]

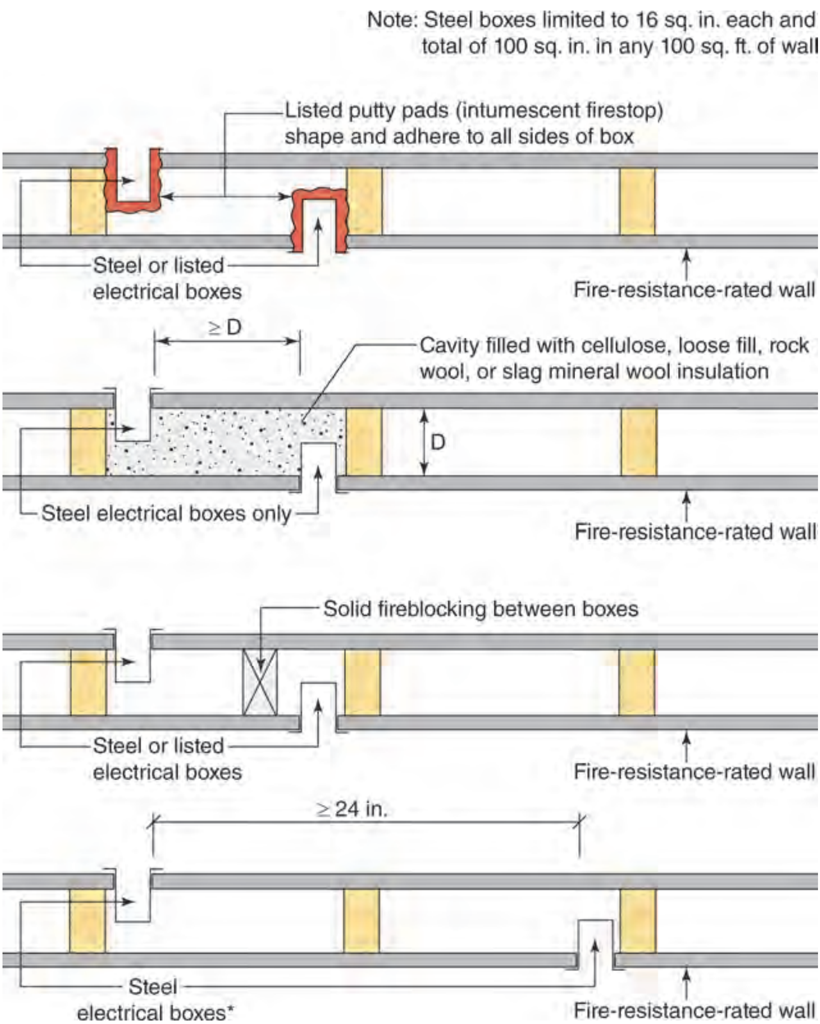
Doors between the dwelling and the garage also provide some resistance to fire but do not require an assembly with a fire-resistance rating. In other words, the frame, hardware, and sealing of the opening are not addressed, only the materials of the door leaf itself. Any one of the following types of door satisfies the separation requirement:

- $1^{3}/_{8}$-inch-thick solid-core wood
- $1^{3}/_{8}$-inch-thick solid-core steel. [See MRC R302.5.1]

- $1^3/_8$-inch-thick honeycomb-core steel
- A listed door with a 20-minute fire resistance rating.

Openings from the garage into a sleeping room are prohibited.

The MRC requires minimum No. 26-gauge sheet steel for ducts in the garage as well as ducts penetrating the walls or ceilings that separate the



*NOTE: SEPARATION DISTANCE FOR LISTED BOXES IS DETERMINED BY THE LISTING.

FIGURE 9-14 Electrical box penetrations on opposite sides of fire-resistance-rated wall assembly

CHAPTER 9

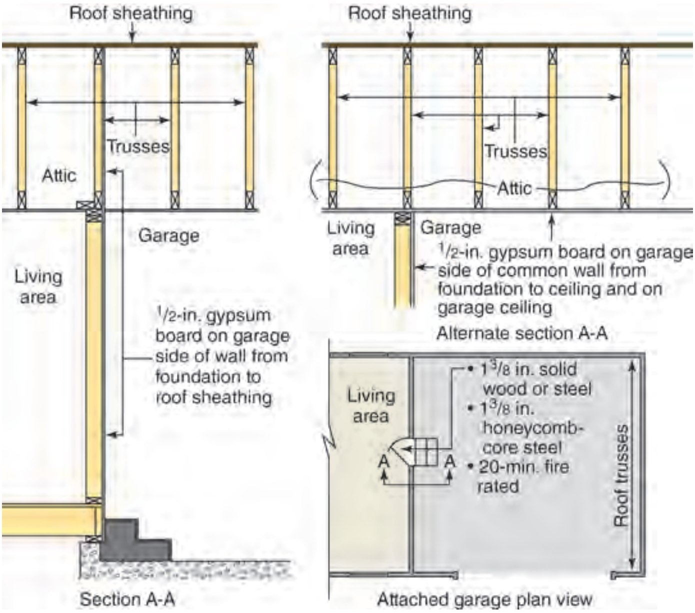


FIGURE 9-15 Dwelling and attached garage separation

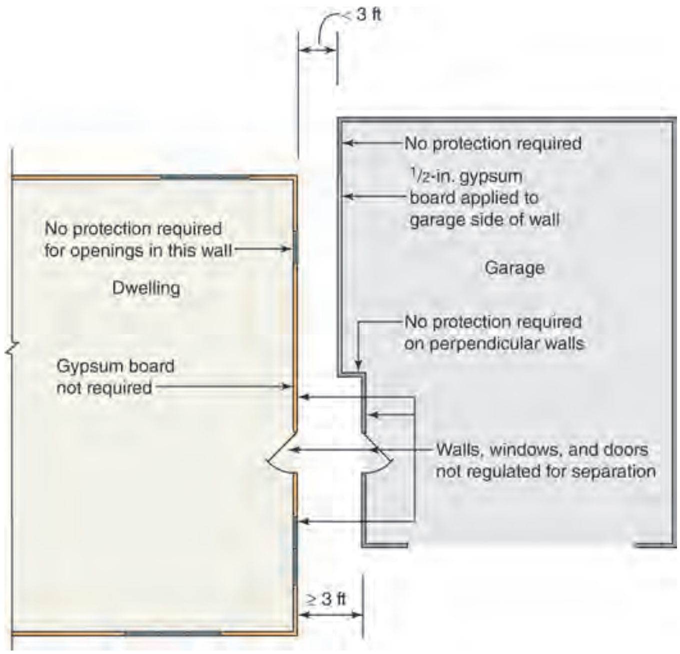


FIGURE 9-16 Dwelling and detached garage separation

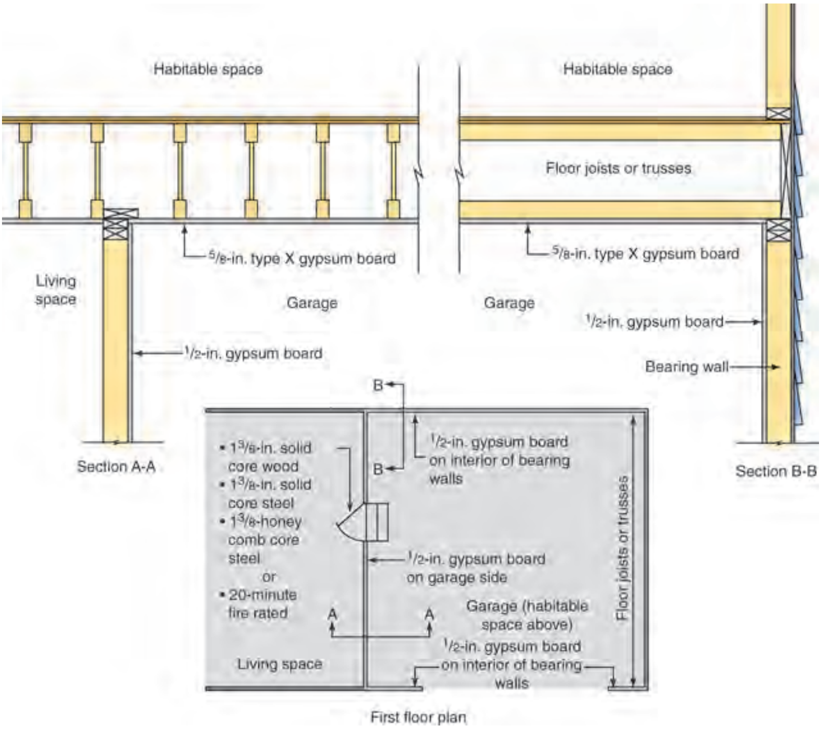


FIGURE 9-17 Separation for attached garage with habitable space above

dwelling from the garage. Ducts are not permitted to open into the garage. Other penetrations, such as plastic or steel pipe, require only that the space around the penetration be filled with approved materials to limit the free passage of fire and smoke. [Ref. R302.5]

FIRE PROTECTION OF FLOORS

Installation of 1/2-inch gypsum board, 5/8-inch wood structural panel or other approved material is required on the underside of certain floor assemblies of dwelling units and accessory buildings constructed under the MRC. The application of gypsum wallboard or other approved material intends to provide some protection to the floor system against the effects of fire and delay collapse of the floor, primarily as a safeguard for fire fighters. This provision applies to light-frame construction consisting of I-joists, manufactured floor trusses, cold-formed steel framing and

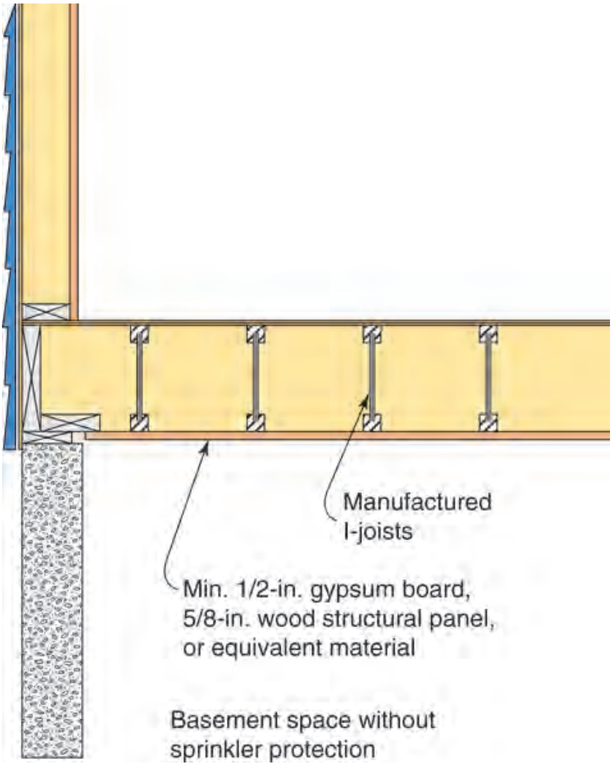


FIGURE 9-18 Fire protection of floors

other materials and manufactured products considered most susceptible to collapse in a fire. Solid-sawn lumber and structural composite lumber perform fairly well in retaining adequate strength under fire conditions. Therefore, floors framed with nominal 2 × 10 lumber or larger of these materials are exempt from this section's fire protection requirements. Similarly, if sprinklers are installed to protect the space below the floor assembly, additional protection is not required. Crawlspaces without storage or fuel-fired appliances are not considered to contain sufficient fuel load to present an undue hazard to floor collapse. The code also exempts small areas of ceiling, such as may occur in a utility room in a basement, from the fire protection requirements, provided the space is not open to other portions of the floor system. Therefore, fireblocking is required to isolate the unprotected area from the protected area of the floor system (Figure 9-18). [Ref. R302.13]

Code Essentials

Under-stair protection

Similar to fire protection of floors, enclosed spaces under stairs also require protection to inhibit the spread of fire and preserve the integrity of the means of egress. One-half-inch gypsum board must be installed on the enclosed side of

- Walls
- Soffits
- Under-stair surfaces.

FOAM PLASTIC

In addition to meeting the maximum flame spread and smoke-developed indices, foam plastic insulation must be isolated from exposure to fire from the dwelling interior by the installation of a thermal barrier. The MRC prescribes the application of $^1/_2$-inch gypsum board or an approved material providing equivalent protection to separate the foam plastic from the interior (Figure 9-19). In attics and crawl spaces entered only for maintenance or repairs, the MRC permits a reduction in protection, and the foam plastic may be covered with one of the prescribed ignition barrier materials (Figure 9-20). [Ref. R316.4, R316.5]

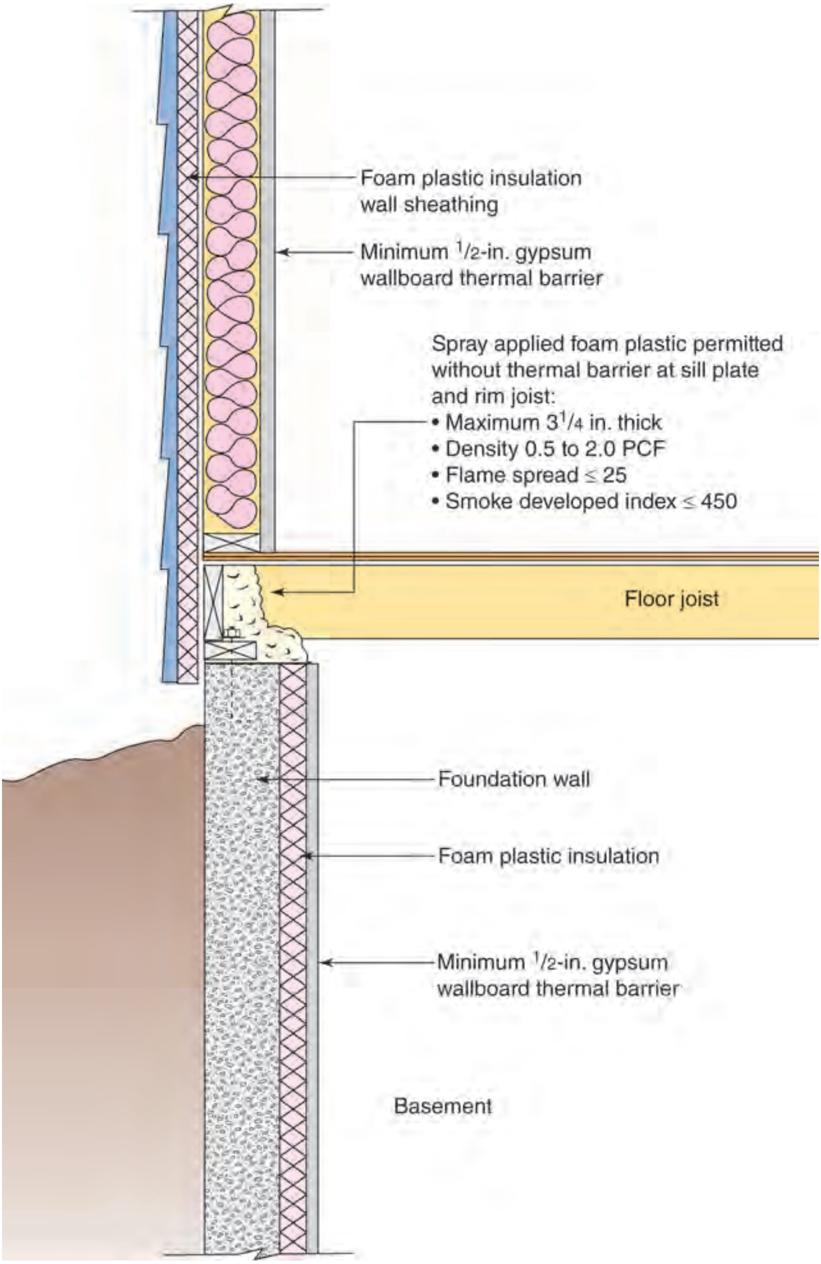


FIGURE 9-19 Foam plastic thermal barrier

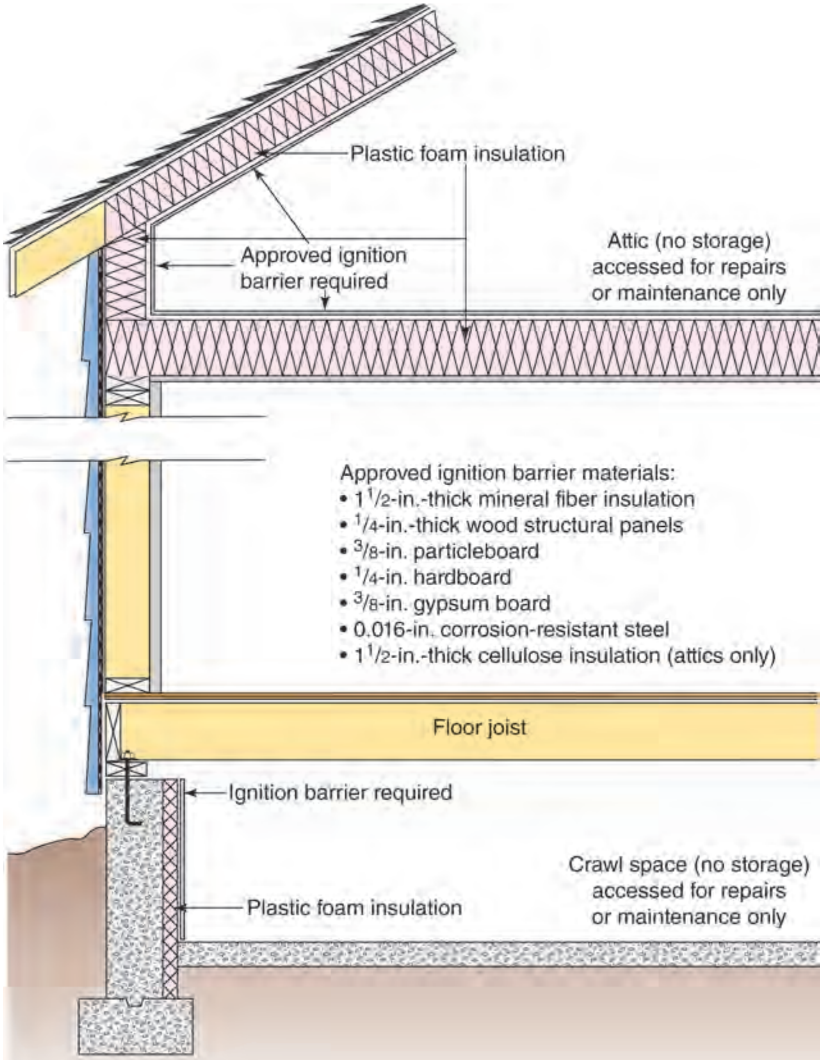


FIGURE 9-20 Foam plastic ignition barrier

CHAPTER 10 Healthy Living Environment

The *Minnesota Residential Code* (MRC) sets minimum requirements for natural or artificial light, fresh air ventilation, carbon monoxide alarms, comfort heating and sanitation to create a healthy and livable environment.

NATURAL AND ARTIFICIAL LIGHT

Though the code retains the traditional standards for natural light from windows, electric lighting satisfies the minimum illumination requirements for habitable rooms in almost all cases. The minimum average illumination level for artificial lighting in habitable rooms is 6 footcandles, far below typical indoor illumination levels and lighting industry recommendations of 50 footcandles or more. Although windows may be eliminated for lighting purposes, they may still be required for emergency escape and rescue and fresh air ventilation purposes. [Ref. R303.1]

Stairway Illumination

As part of the egress path and a component presenting increased hazards of fall injuries, stairway design and construction, including adequate illumination, is particularly important to safety in a dwelling. The MRC requires a minimum illumination level of 1 footcandle at treads and landings of interior stairs. For other than continuous or automatic illumination (such as provided with motion sensors), interior stairways with six or more risers require a wall switch at each floor level.

Exterior stairs require a light source located near the top landing. In addition, bottom landings require a light source if they provide access to the basement from grade level (Figure 10-1). [Ref. R303.7, R303.8]

NATURAL AND MECHANICAL VENTILATION

To provide fresh air ventilation to habitable rooms, the MRC requires an approved whole-house mechanical ventilation system that complies with the Minnesota Residential Energy Code. This is because new construction dwelling units must comply with the Minnesota Residential Energy Code and be sufficiently tight as to have an air infiltration rate threshold of three air changes per hour (ACH) or less as verified by a blower test at a pressure of 50 Pascals. Because of this tightness, a whole-house ventilation system capable of providing adequate outdoor air is necessary to maintain satisfactory indoor air quality under closed-house conditions. [Ref. R303.4; Minnesota Residential Energy Code R402.4.1.2]

Whole-house mechanical ventilation simply exchanges outdoor air for indoor air at the minimum air-flow rates prescribed in the Minnesota Residential Energy Code and based on the area of the dwelling and the number of bedrooms. The energy code requires the whole-house ventilation system to be balanced, meaning fresh air is introduced at approximately the same rate that stale indoor air is exhausted. This can be accomplished through the installation of heat recovery ventilator (HRV), energy recovery ventilator (ERV) or a combination of supply and exhaust fans. [Ref. Minnesota Residential Energy Code R403.5]

In addition to habitable rooms, bathrooms and toilet rooms require natural or mechanical ventilation. Due to Minnesota's cold climate, generally one or more exhaust fans are provided to exhaust air directly to the outside. Minimum mechanical exhaust rates for bathroom exhaust fans are found in the Minnesota Mechanical Code. [Ref. R303.3; Minnesota Mechanical Code 402; 403;]

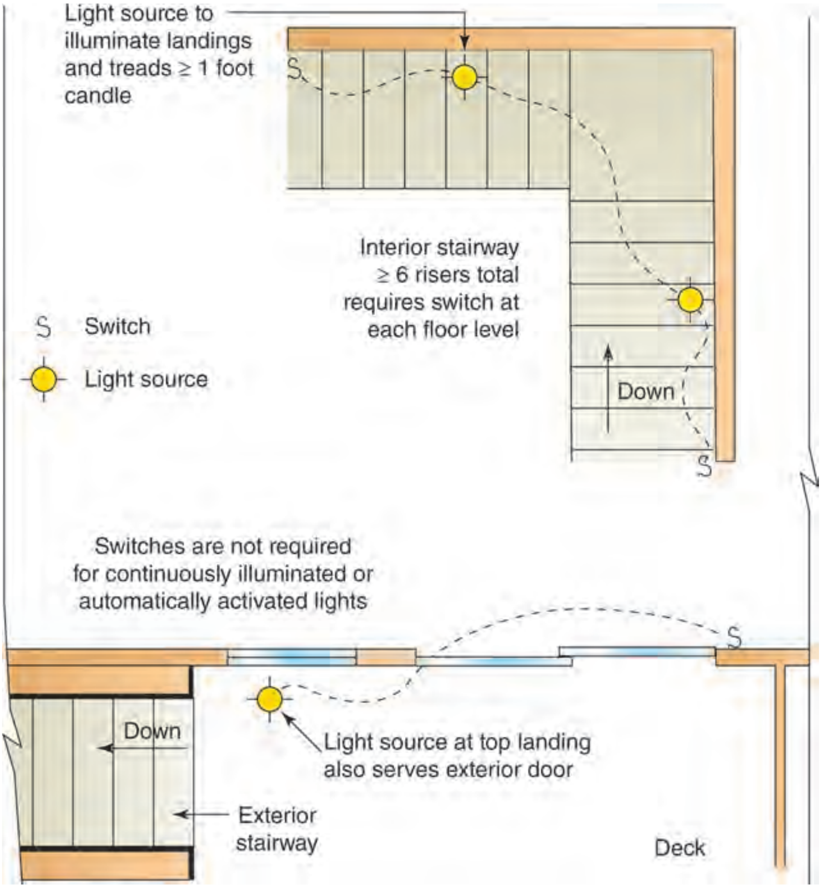


FIGURE 10-1 Stairway illumination

CARBON MONOXIDE ALARMS

As part of a safe and healthy interior living environment, the MRC provides for early warning to alert occupants to hazardous levels of carbon monoxide gas. The carbon monoxide alarm provisions are only in effect when the dwelling contains fuel-fired appliances or has an attached garage that communicates with the dwelling unit. A malfunctioning fuel-fired appliance, such as a gas-fired furnace, water heater or fireplace, is the most common cause of carbon monoxide poisoning in homes. Automobile exhaust migrating into the home from an attached garage is the other hazard addressed by the code requirements, but only if there is a door or other opening from the garage into the house. Attached garages that do not communicate with the house do not trigger the carbon monoxide alarm requirements.

The code requires carbon monoxide alarms to be installed outside of each separate sleeping area and not more than 10 feet from each separate sleeping area or bedroom. Alarms shall be installed on each level containing sleeping areas or bedrooms to protect people when they are most vulnerable to the effects of carbon monoxide poisoning—when they are sleeping or not fully alert. The MRC requires an additional alarm to be located in a bedroom when a fuel-fired appliance is installed in the bedroom or the adjoining bathroom (Figure 10-2). Connection to the house wiring system with battery backup is required for carbon monoxide alarms installed in new dwellings. Where two or more carbon monoxide alarms are installed to satisfy the location provisions, the code requires interconnection of the alarms so that when one alarm is activated all devices sound the alarm.

Similar to the smoke alarm provisions, the provisions for carbon monoxide alarms state that when interior work (including installation or replacement of windows or doors), an addition requiring a permit occurs, or one or more sleeping rooms are added or created, carbon monoxide alarms must be installed in the locations prescribed by the code. Exterior work, such as roofing, siding, and open porch and deck additions, does not trigger the retroactive carbon monoxide alarm requirements. Installation, alteration, or repairs of plumbing, electrical, or mechanical systems do not mandate retroactive carbon monoxide alarm installations. This language mirrors the exemption in the smoke alarm provisions. Battery-operated carbon monoxide alarms are permitted for satisfying the requirements in existing buildings.

Combination carbon monoxide and smoke alarms complying with the applicable standards are permitted and are commonly installed outside of bedroom areas in residential construction as an acceptable method for satisfying both smoke alarm and carbon monoxide alarm provisions in the MRC. [Ref. R315]

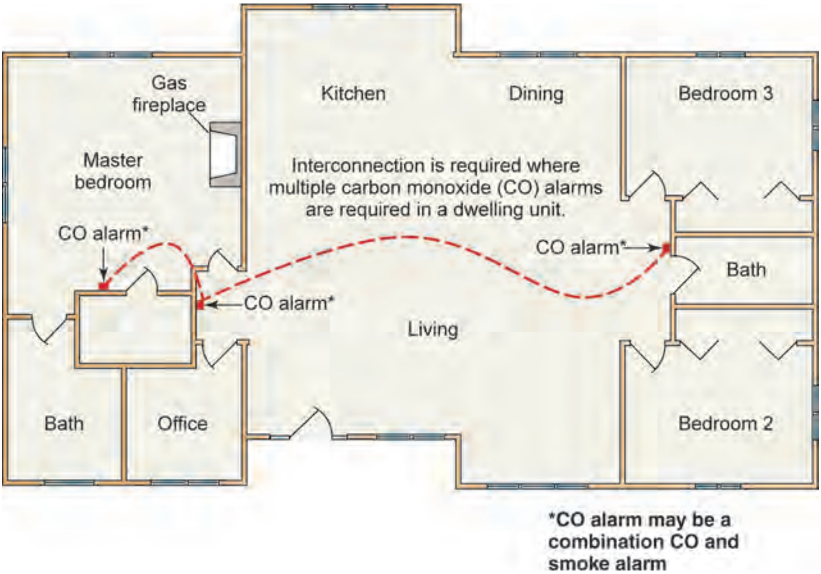


FIGURE 10-2 Carbon monoxide (CO) alarm required not more than 10 feet from each sleeping area and in bedrooms containing fuel-fired appliances

HEATING AND COOLING

Because the design temperature is less than 60°F, the MRC requires a heating system capable of maintaining a minimum temperature of 68°F at 3 feet above the floor and 2 feet from exterior walls. The code does not require the installation of an air conditioning or comfort cooling system. When mechanical equipment for heating or cooling is installed, it must comply with the Minnesota Mechanical and Fuel Gas Code. [Ref. R303.10]

SANITATION

In the building planning chapter of the code, the MRC establishes basic requirements for bathroom and kitchen fixtures, hot and cold water, and sewer connections. Installation must also comply with the requirements of Minnesota Rules, chapter 4714, Minnesota Plumbing Code.

Toilet and Bathing Facilities

In order to maintain a healthy and sanitary living environment, a residence must provide facilities for toilet, bathing and handwashing purposes. The MRC requires at least one water closet, one lavatory, and a bathtub or shower in every dwelling unit. Each fixture must be connected to an approved water supply and sewer. Lavatories, bathtubs, showers, and bidets require connection to both hot and cold water supply. [Ref. R306, MRC 4714]

Cooking and Cleaning Facilities

Also important to the health of the occupants are adequate and sanitary means to prepare meals, wash dishes, and wash clothes. The MRC requires a kitchen area and kitchen sink for every dwelling unit. Kitchen sinks, laundry tubs and washing machine outlets require connection to hot and cold water supply. [Ref. R306.2, R306.4]

Code Essentials

A dwelling unit is a single unit providing complete independent living facilities for one or more persons, including permanent provisions for

- Living
- Sleeping
- Eating
- Cooking
- Sanitation

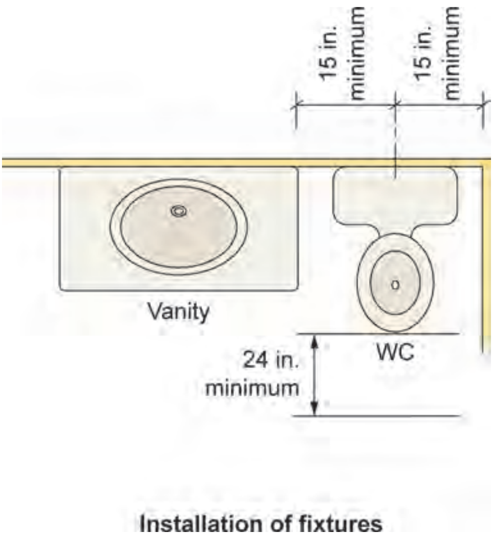


FIGURE 10-3 Bathroom fixture clearances

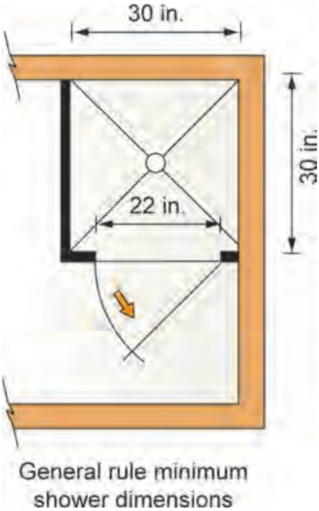


FIGURE 10-4 Minimum shower dimensions

CHAPTER 11 Chimneys and Fireplaces

The *Minnesota Residential Code* (MRC) contains prescriptive provisions for the construction of masonry chimneys and fireplaces, including requirements for combustion air supply, clearance to combustibles and hearth construction (Figure 11-1). The appliance listing and manufacturer's instructions typically govern the installation of approved factory-built fireplaces and chimneys.

FIGURE 11-1 A masonry chimney is constructed of solid masonry units, hollow masonry units grouted solid, stone or concrete.

EXTERIOR AIR SUPPLY

Both factory-built and masonry fireplaces require an adequate exterior air supply to assure proper fuel combustion and prevent depleting oxygen within the habitable space. Mechanical ventilation of the room is permitted as an alternative when controlled so that the indoor pressure of the room or space is neutral or positive. Exterior combustion air ducts or passageways for masonry fireplaces must be at least 6 square inches and not more than 55 square inches in cross-section area. Listed ducts for masonry fireplaces must be installed according to the terms of their listing and the manufacturer's instructions. Factory-built fireplaces require exterior air ducts that are a listed component of the fireplace and installed according to the fireplace manufacturer's instructions. [Ref. R1006.1, R1006.4]

Intakes for exterior air may be located on the exterior of the dwelling or in naturally ventilated attics or crawl spaces. The MRC does not permit the installation of combustion air intakes in garages, basements or mechanically ventilated spaces. Where combustion air openings are located inside the firebox, the exterior termination of the air intake cannot be higher than the firebox. Such an installation could result in combustion products being drawn to the outside through the air intake duct, creating a fire hazard. Exterior air intakes must be covered with a corrosion-resistant screen of $^1/_4$-inch mesh. [Ref. R1006.2]

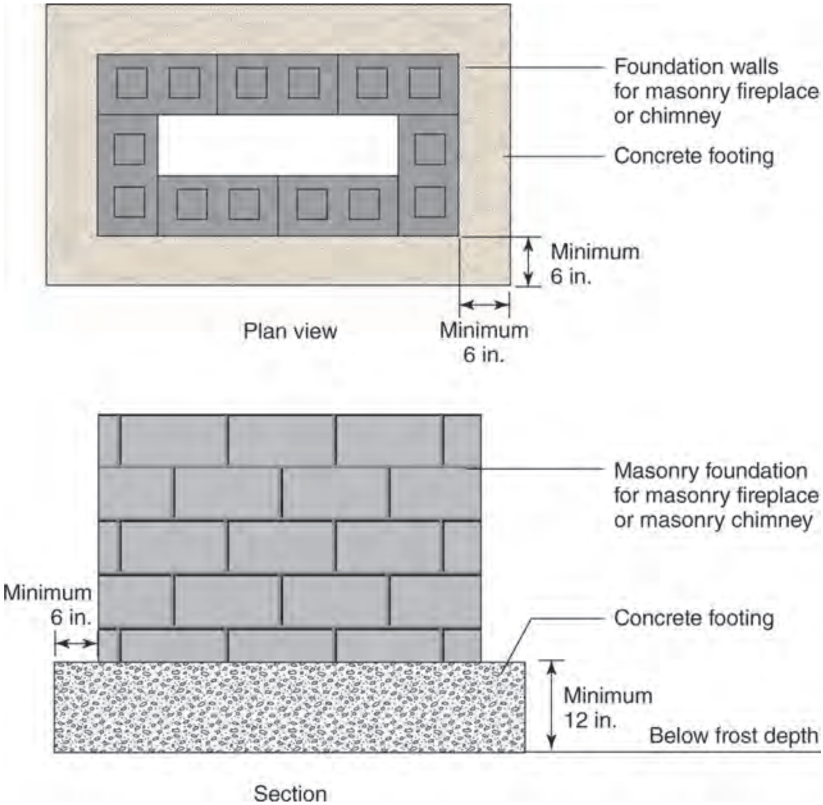


FIGURE 11-2 Footings for masonry chimneys and fireplaces

MASONRY CHIMNEYS AND FIREPLACES

The prescriptive provisions of the MRC address structural support, approved materials, dimensions, and fire safety for masonry fireplaces. The code also prescribes construction details of masonry chimneys for proper drafting, weather protection, and safety from fire.

Design for masonry chimneys and fireplaces also must comply with other structural provisions of the code, including foundation requirements.

Footings

For masonry chimneys and fireplaces, the MRC requires concrete or solid masonry footings that are at least 12 inches thick and extend at least 6 inches beyond the face of the fireplace or foundation wall on all sides (Figure 11-2). [Ref. R1001.2, R1003.2]

Masonry Fireplace Details

Solid masonry or concrete firebox walls with minimum 2-inch-thick fire brick lining require a total thickness of not less than 8 inches, including the lining. Prescribed dimensions for the firebox, throat, and smoke chamber facilitate the proper discharge of smoke and products of combustion through the chimney and intend to prevent downdrafts. Steel or other noncombustible lintels supporting masonry above the firebox require minimum 4-inch bearing support at each end. The code requires an operable steel or cast iron damper located not less than 8 inches above the firebox opening that can be closed when the fireplace is not in use (Figure 11-3). [Ref. R1001.5 to R1001.8]

Hearth and Hearth Extension

The hearth is the floor of the firebox and is constructed to withstand the intense heat of a wood fire. The hearth extension projects from the front of the firebox to provide a noncombustible area of protection against radiant heat and any embers, sparks or ash that may escape from the firebox. Hearths and hearth extensions must be constructed of concrete or masonry, supported by noncombustible materials, and reinforced to carry their own weight and all loads. The prescribed minimum thicknesses are 4 inches for the hearth and 2 inches for the hearth extension. When the firebox opening is raised at least 8 inches above the floor, the hazard of igniting underlying

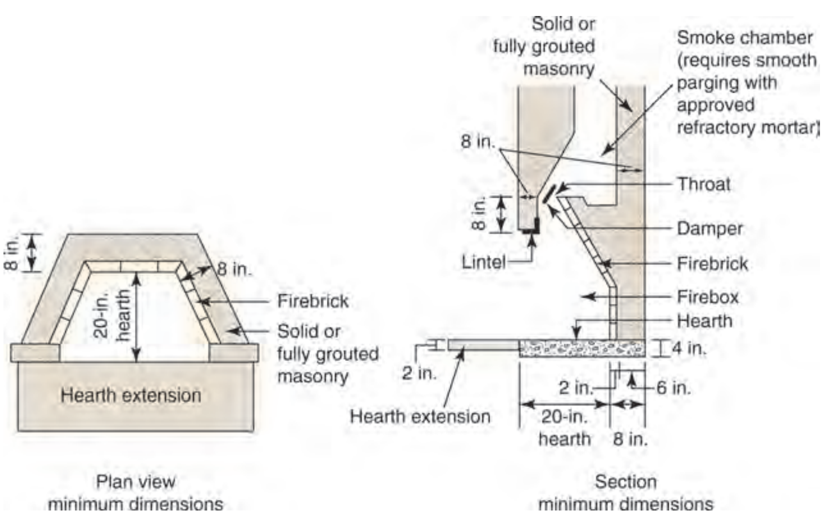


FIGURE 11-3 Masonry fireplace dimensions and details

materials is reduced, and the code permits a hearth extension of $^3/_8$-inch-thick brick, concrete, stone, tile or other approved noncombustible material supported by combustible construction. For fireplace openings with areas less than 6 square feet, hearth extensions must project at least 16 inches out from the face of the fireplace and at least 8 inches beyond each side of the opening. For larger openings, the dimensions are a minimum 20 inches in front of the face and a minimum 12 inches beyond each side of the fireplace opening (Figure 11-4). [Ref. R1001.9, R1001.10]

Clearance to Combustibles and Fireblocking

To prevent fires caused by conductive and radiant heat transfer, the MRC prescribes clearances to wood and other combustible materials in proximity to masonry fireplaces and chimneys. In general, wood floor, wall, ceiling, and roof framing requires a minimum 2-inch air clearance from the masonry, though this dimension is increased to 4 inches on the back

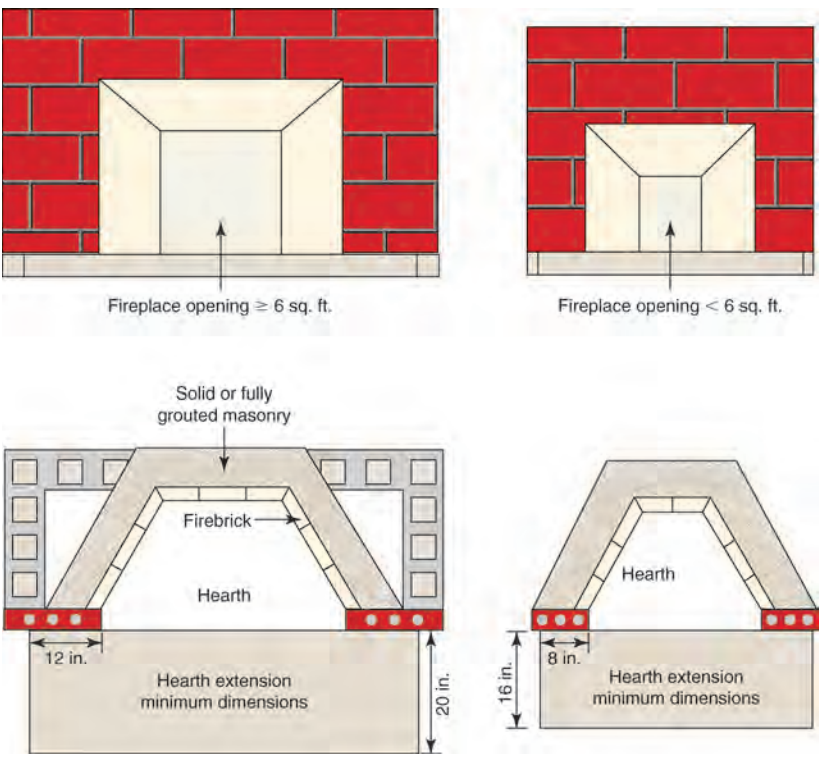


FIGURE 11-4 Hearth and hearth extensions for masonry fireplaces

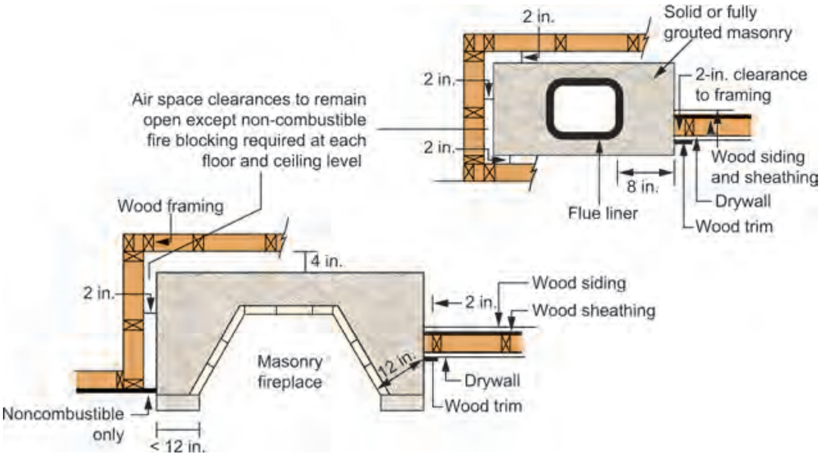


FIGURE 11-5 Clearances to combustible material from masonry fireplaces and chimneys

of the fireplace. Combustible sheathing, siding, flooring, trim and gypsum board may abut the masonry fireplace and chimney sidewalls, provided that such combustible material maintains a distance of not less than 12 inches from the inside surface of the firebox and 8 inches from the inside surface of the flue (Figure 11-5). [Ref. R1001.11, R1003.18]

Combustible mantels and trim placed directly on the front of the fireplace are not restricted when located more than 12 inches from the fireplace opening. Such materials located more than 6 inches but not greater than 12 inches from the fireplace opening are permitted but must not project more than $^1/_8$ inch from the face of the masonry for each inch of separation from the edge of the fireplace opening. The code does not permit combustible trim within 6 inches of the opening (Figure 11-6). [Ref. R1001.11]

The MRC requires fireblocking at prescribed intervals to stop the spread of fire in concealed spaces. This rule applies to the air spaces created by clearance to combustible materials around fireplaces and chimneys. In the case of masonry chimneys and fireplaces, the fireblocking must be noncombustible and must be installed at each floor and ceiling line. [Ref. R1001.12, R1003.19]

Chimney Termination

To provide proper drafting, masonry chimneys must terminate at least 3 feet above the roof and at least 2 feet higher than any portion of a build-

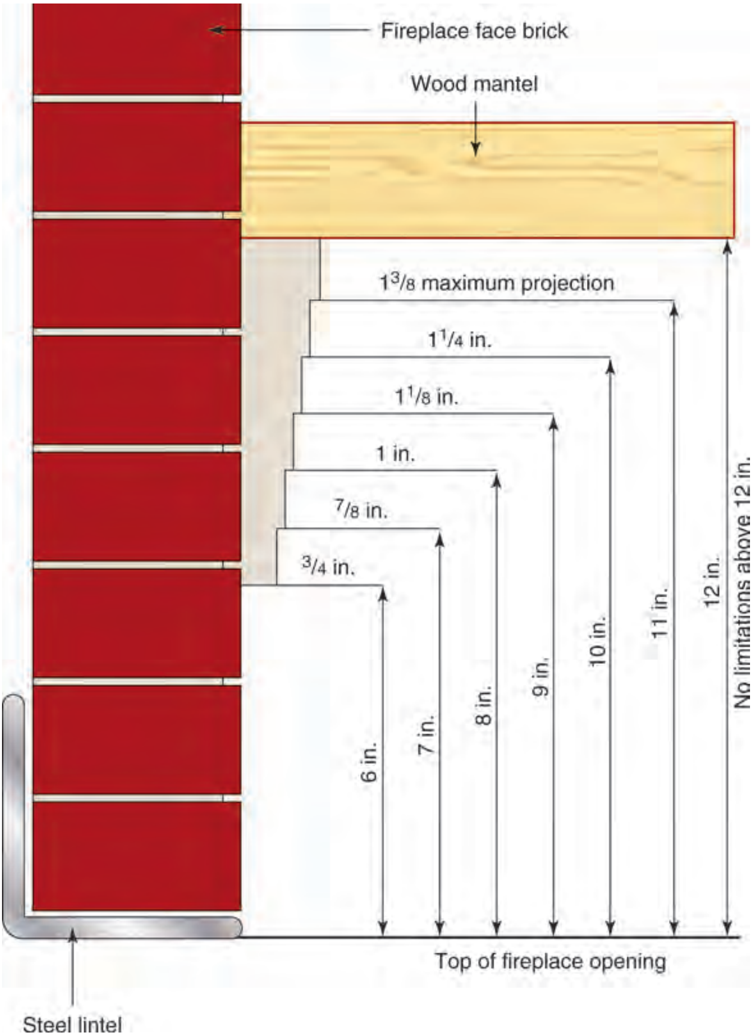


FIGURE 11-6 Clearances to combustible mantels and trim on the face of masonry fireplaces

ing within 10 feet (Figure 11-7). Flashing to weatherproof the chimney penetration at the roof must comply with the MRC roof covering and flashing requirements (see Chapter 7 of this publication). Where asphalt or wood shingles join the sides of a chimney, step flashing is required. For chimneys 30 inches wide or larger, the MRC also requires a cricket to direct water shed from the roof above around the sides of the chimney (Table 11-1 and Figure 11-8). [Ref. R1003.9, R1003.20, R903.2, R905.2.8]

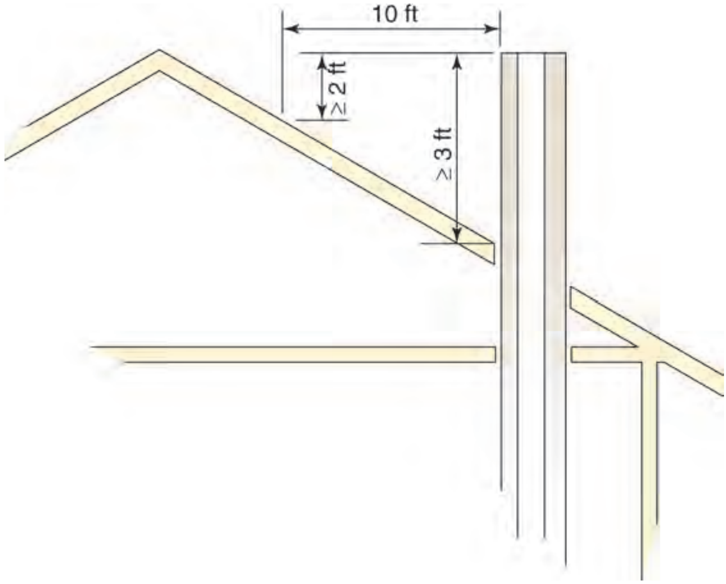


FIGURE 11-7 Masonry chimney termination

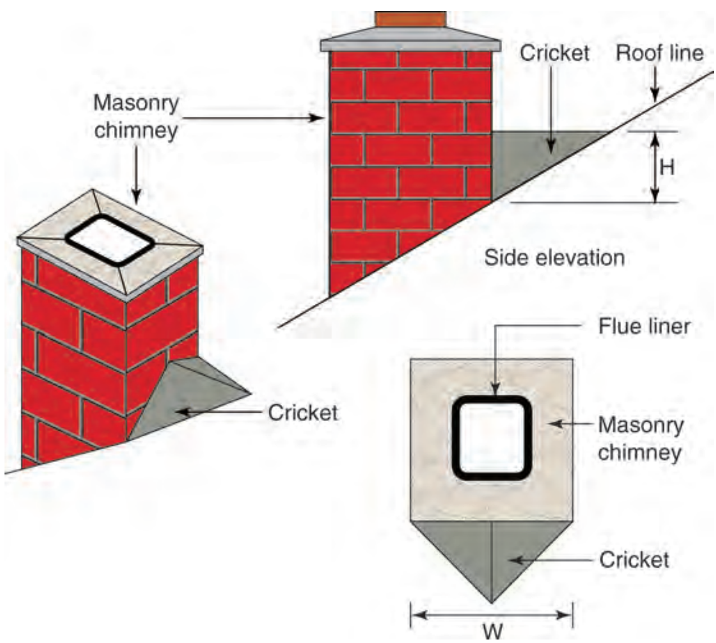


FIGURE 11-8 Cricket dimensions

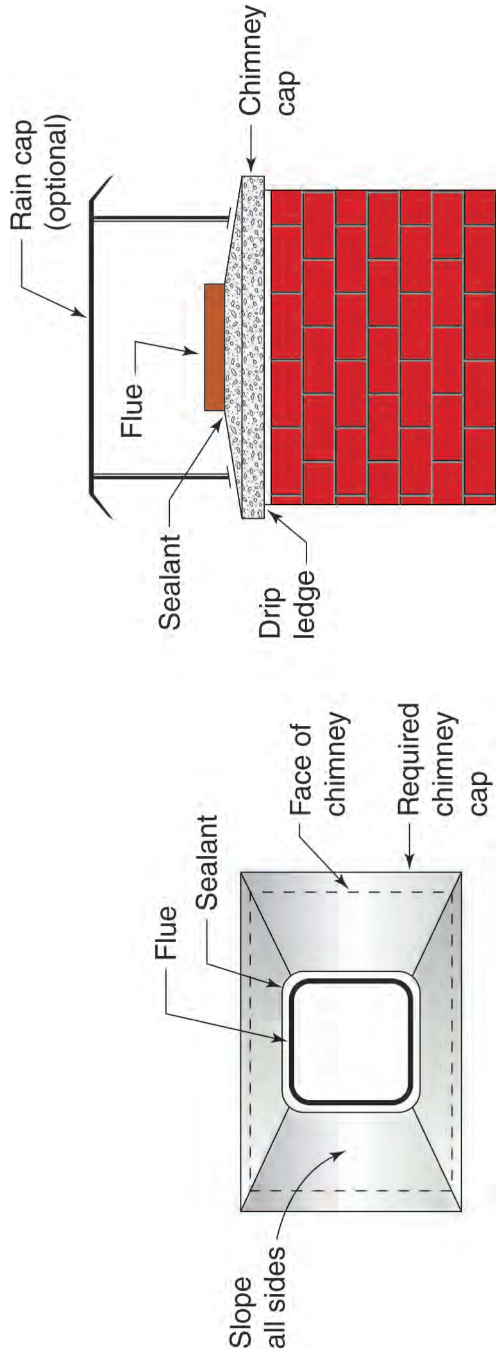


FIGURE 11-9 Masonry chimney cap and rain cap

TABLE 11-1 Cricket dimensions

Roof Slope	Height
12:12	$^1/_2$ of width
8:12	$^1/_3$ of width
6:12	$^1/_4$ of width
4:12	$^1/_6$ of width
3:12	$^1/_8$ of width
[Ref. Table R1003.20]	

Weather protection for masonry chimney terminations is accomplished with a required chimney cap and an optional rain cap. A chimney cap protects the top of the masonry surrounding the flue. The cap must be sloped to the outside and overhang the face of the masonry chimney to provide a drip edge. The prescribed caulking of the joint between the masonry and the flue serves as both a sealant and a bond break for any differential movement. Though not required, rain caps are installed a prescribed distance above a chimney flue termination to limit the amount of rain entering the flue while still providing adequate air flow for efficient venting of the products of combustion (Figure 11-9). [Ref. R1003.9.1, R1003.9.3]

MANUFACTURED CHIMNEYS AND FIREPLACES

Factory-built fireplaces and chimneys must be listed and labeled, tested in accordance with UL 127 and installed according to the conditions of the listing. The hearth extension dimensions prescribed for masonry fireplaces do not apply to manufactured fireplaces, which require hearth extensions to be installed in accordance with the listing of the fireplace. However, the MRC does require that hearth extensions be readily distinguishable from the surrounding floor area (Figure 11-10). [Ref. R1004, R1005]

Code Essentials

Factory-built chimneys

- Maximum offset 30 degrees from vertical
- No more than four elbows

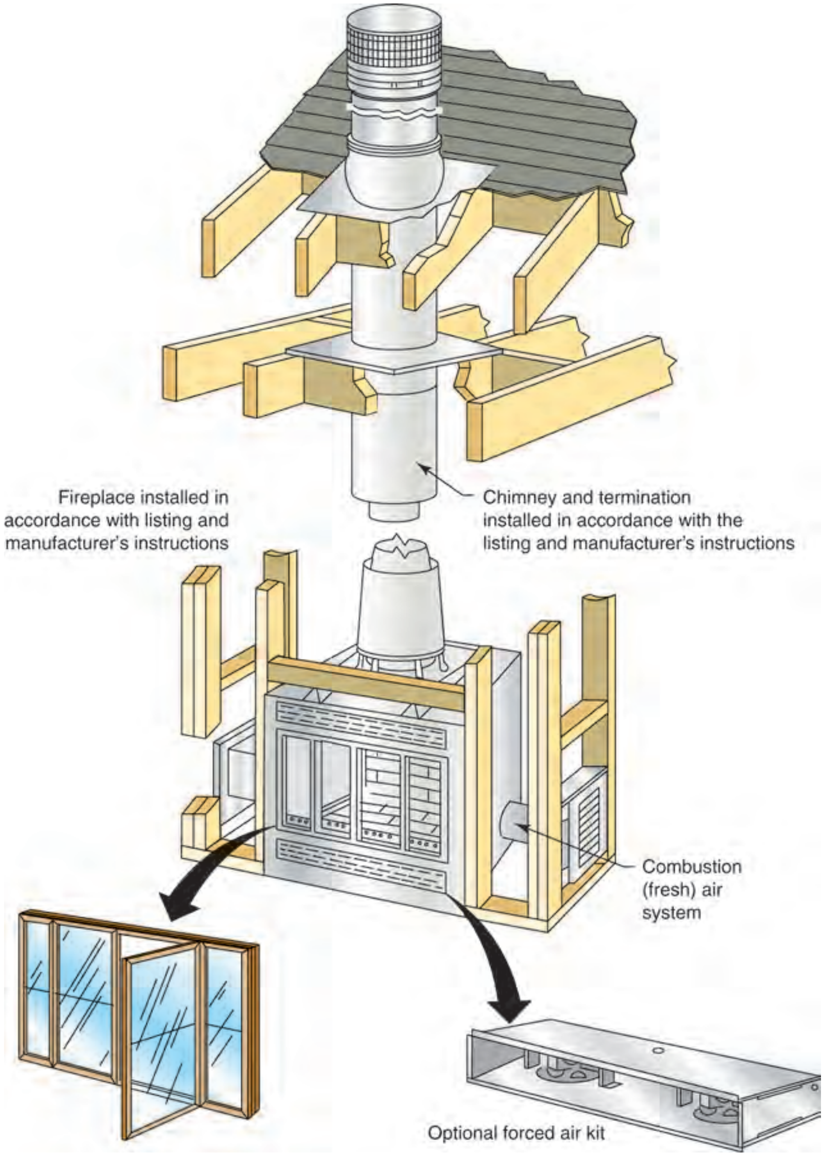


FIGURE 11-10 Factory-built fireplace and chimney

PART VI Energy Conservation

Chapter 12 Energy Efficiency

CHAPTER 12 Energy Efficiency

This chapter addresses the *2015 Minnesota Residential Energy Code* which regulates the design and construction of dwellings for the effective use and conservation of energy. The energy code offers many benefits to homeowners: it improves building durability by reducing the negative effects of moisture migration through the thermal envelope, ensures the indoor air quality of a home is safe and reduces pollutants and contaminants by limiting air leakage and requiring ventilation, and decreases temperature vulnerability to protect homeowners from extreme weather and power outages by requiring good windows and proper insulation, among others.

You Should Know

The first energy code for the state of Minnesota became effective in January 1976 in response to a state law that required efficient design and construction standards. The code was updated several times before the 1983 *Model Energy Code* (MEC) was adopted in 1984. This early version of the MEC would transform into the *International Energy Conservation Code,* which serves as the base for the Minnesota Energy Code to this day.

The provisions of the Minnesota Residential Energy Code are adapted from the residential provisions of the 2012 *International Energy Conservation Code* (IECC). In addition to setting minimum requirements for the building thermal envelope enclosing conditioned space, the code regulates the sealing of penetrations to reduce air infiltration and the insulation and sealing of ductwork for heating, ventilation and air conditioning (HVAC). Mechanical system controls, insulation of piping systems and energy-efficient lighting are also covered.

Climate Zones 6 and 7 are assigned to Southern and Northern Minnesota, respectively, and are the basis for specific thermal envelope requirements. These counties are assigned to Climate Zone 7: Aitkin, Becker, Beltrami, Carlton, Cass, Clay, Clearwater, Cook, Crow Wing, Grant, Hubbard, Itasca, Kanabec, Kittson, Koochiching, Lake, Lake of the Woods, Mahnomen, Marshall, Mille Lacs, Norman, Otter Tail, Pennington, Pine, Polk, Red Lake, Roseau, St. Louis, Wadena and Wilkin. All other counties in Minnesota are assigned to Climate Zone 6 (Figure 12-1).

BUILDING INSULATION

The energy conservation provisions detail methods for identifying components of the thermal envelope to verify compliance with the code. The prescriptive tabular values for minimum insulation R-values for each building component are based on the climate zone.

Insulation Identification and Verification

Each piece of insulation 12 inches or more in width requires a manufacturer's mark visible after installation that identifies its R-value. As an alternative,

FIGURE 12-1 Climate zone map

the code requires the installer to provide certification stating the type, manufacturer and R-value of the insulation. In addition, for fiberglass or cellulose blown-in or sprayed insulation, the certification must include:

- Initial installed thickness
- Settled thickness
- Settled *R*-value
- Installed density
- Coverage area
- Number of bags installed

The insulation installer must sign, date and post the insulation certificate in a conspicuous location. This certification is in addition to the mandatory permanent certificate discussed later in this chapter.

When fiberglass or cellulose insulation is blown or sprayed in the joist or truss spaces of the attic, the energy code requires fixed markers to indicate the installed thickness of the insulation. At least one marker must be installed for every 300 square feet. Minimum 1-inch-high numbers must be visible from the attic access for inspection purposes (Figure 12-2). [Ref. RE303.1.1 and RE303.1.1.1]

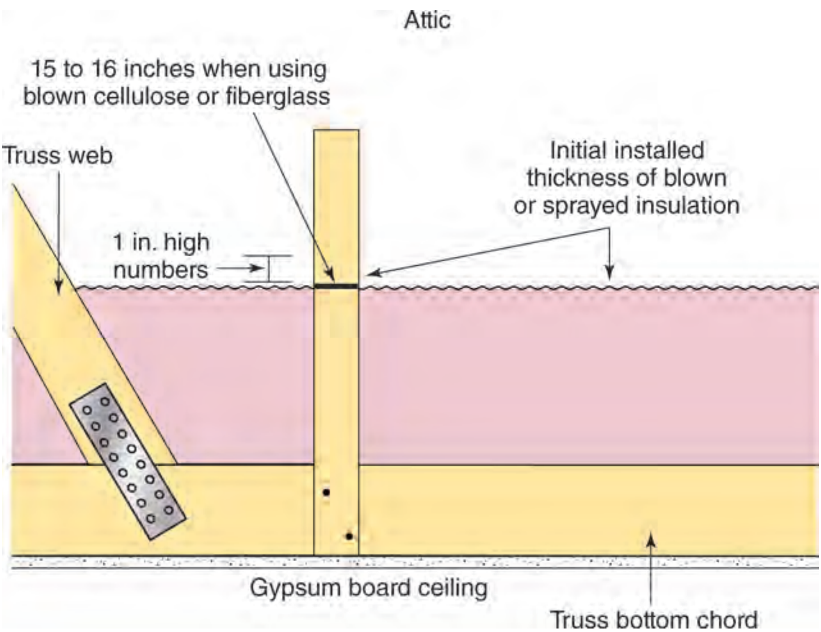


FIGURE 12-2 Attic insulation depth markers

Insulation Requirements

Table 12-1 lists the individual components of a typical building thermal envelope and the required performance level of each for Climate Zones 6 and 7. A number of exceptions to these values exist throughout the code; for example, the code recognizes the increased efficiency of an energy-type or raised-heel roof truss installed in cold climates (Figure 12-4). Where R-49 ceiling insulation is required in Minnesota, R-38 is permitted for an energy-type truss where the height of the truss heel allows full depth insulation to extend over the exterior wall plates. The code also recognizes the practical difficulties in achieving high R-values when the rafter or joist space is too small to accommodate the required thickness of insulation (Figure 12-5). These exceptions, along with the table footnotes, offer further details that may guide design choices. [Ref. RE402.1.1, RE402.2]

The values in Table 12-1 apply to wood frame construction. Due to the high thermal conductivity of steel, the energy code requires higher insulation R-values and, in most cases, continuous insulation to provide a thermal break for steel-frame floor, wall and ceiling construction. [Ref. RE402.2.6]

You Should Know

R-value

R-value is used to rate the relative thermal resistance to heat flow through insulation. A higher R-value indicates greater resistance and more effective insulation. The type of insulating material, its density, and the installed thickness determine the R-value of thermal insulation. The insulation R-value does not in itself indicate the overall wall, floor or ceiling R-value. The effectiveness of these insulated assemblies depends in part on the method of installation. For example, insulation installed between studs does not improve the resistance to heat flow through those studs. In this case, the overall average wall R-value will be less than the cavity insulation R-value.

All thermal insulation must comply with Minnesota Rules, Chapter 7640, Minnesota Thermal Insulation Standards as well as the specific requirements of the Minnesota energy code. Insulation installed on the exterior of foundation walls and the perimeter of slabs-on-grade that do not permit bulk water drainage must be covered with a 6-mil polyethylene slip sheet over the entire exterior surface. Where foundation insulation is exposed above grade, both draining and non-draining insulation must have a rigid, opaque, and weather-resistant protective covering to prevent degradation of the insulation's thermal performance. The protective covering must be flashed and extend a minimum of 6 inches below grade. [Ref. RE402.1.1.1 through RE402.1.1.3]

Slab-on-grade Floors

At the perimeter of the thermal envelope, slabs with a floor surface less than 12 inches below grade require R-10 insulation or greater to a minimum depth of 3.5 feet in Climate Zone 6 and 5 feet in Climate Zone 7, as shown in Table 12-1. Insulation for heated slabs must be installed to the specified depth or to the top of the footing, whichever is less. Perimeter rigid insulation placed horizontally beneath a slab performs the same function as vertical insulation placed alongside the foundation. Therefore, the code permits the depth requirement to be satisfied by a combination of vertical and horizontal insulation. The code also allows the option to install the insulation on either the exterior or the interior of the foundation wall.

Frost-protected shallow foundations designed to the requirements of Section 403.3 of the MRC must comply with more restrictive energy code requirements for the insulation of slab-on-grade floors. Prescriptive frost-protected shallow foundation designs direct dwelling heat loss through the slab to prevent the surrounding soil from freezing. Because

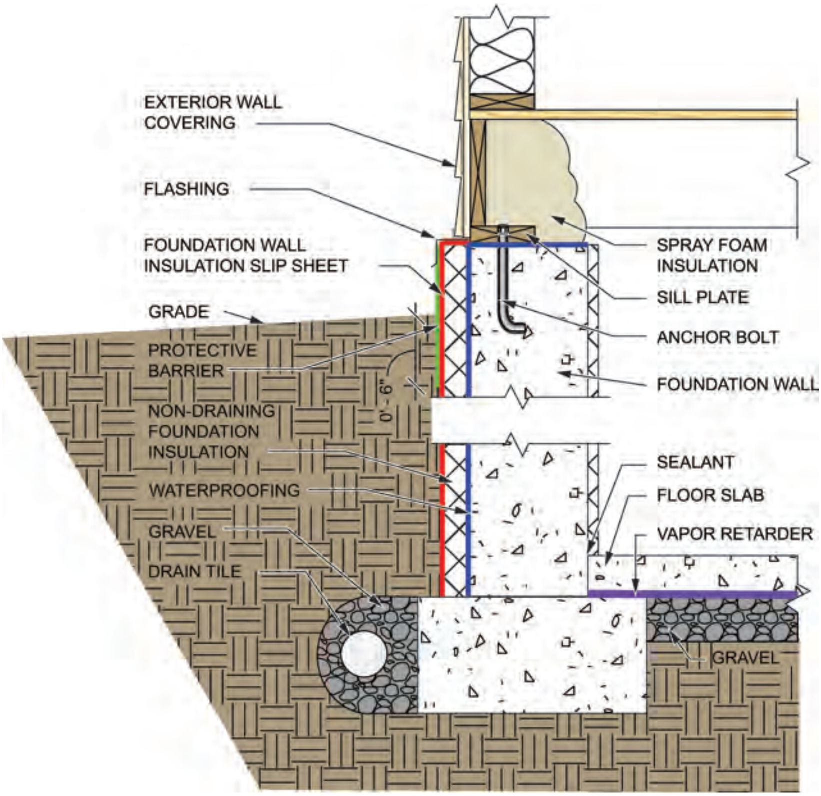


FIGURE 12-3 Foundation wall slip sheet

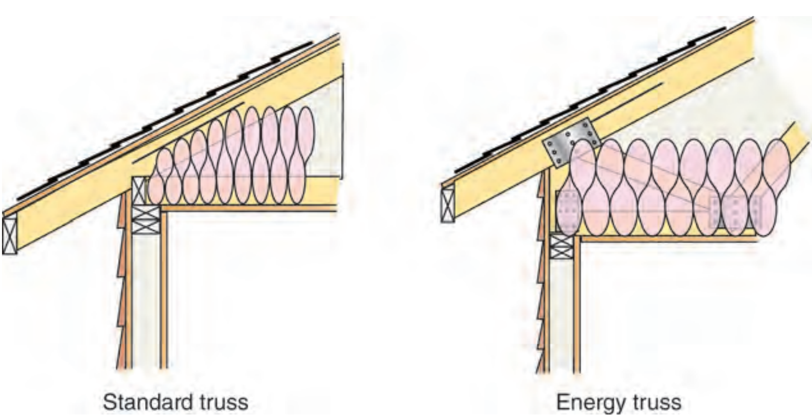


FIGURE 12-4 Insulation of standard and energy-type roof trusses

TABLE 12-1 Insulation and Fenestration Requirements by Component

Climate Zone	Fenestration *U*-Factor[b]	Skylight[b] *U*-Factor	Glazed Fenestration SHGC[b,e]	Ceiling[j] *R*-Value	Wood Frame Wall *R*-Value[f]	Mass Wall *R*-Value[i,g,h]	Floor *R*-Value	Basement[c,i] Wall *R*-Value	Slab[d] *R*-Value & Depth	Crawl Space[c,i] Wall *R*-Value
6	0.32	0.55	NR	49	20, 13 + 5	15/20	30[e]	15	10, 3.5 ft	15
7	0.32	0.55	NR	49	21	19/21	38[e]	15	10, 5 ft	15

[Ref. Table R402.1.1]

For SI: 1 foot = 304.8 mm.

a. *R*-values are minimums. *U*-factors and SHGC are maximums. When insulation is installed in a cavity that is less than the label or design thickness of the insulation, the installed *R*-value of the insulation shall not be less than the *R*-value specified in the table.
b. The fenestration *U*-factor column excludes skylights. The SHGC column applies to all glazed fenestration.
c. See Section RE402.2.8.
d. Insulation *R*-values for heated slabs shall be installed to the depth indicated or to the top of the footing, whichever is less.
e. Or insulation sufficient to fill the framing cavity, *R*-19 minimum.
f. First value is cavity insulation, second is continuous insulation or insulated siding, so "13 + 5" means *R*-13 cavity insulation plus *R*-5 continuous insulation or insulated siding. If structural sheathing covers 40 percent or less of the exterior, continuous insulation *R*-value shall be permitted to be reduced by no more than *R*-3 in the locations where structural sheathing is used to maintain a consistent total sheathing thickness.
g. The second *R*-value applies when more than half the insulation is on the interior of the mass wall.
h. When using log-type construction for thermal mass walls the following applies: (1) a minimum of a 7-inch diameter log shall be used; and (2) the *U*-value of fenestration products shall be 0.29 overall on average or better.
i. See Section RE402.2.8. A minimum *R*-19 cavity insulation is required in wood foundation walls.
j. Roof/ceiling assemblies shall have a minimum 6-inch energy heel.

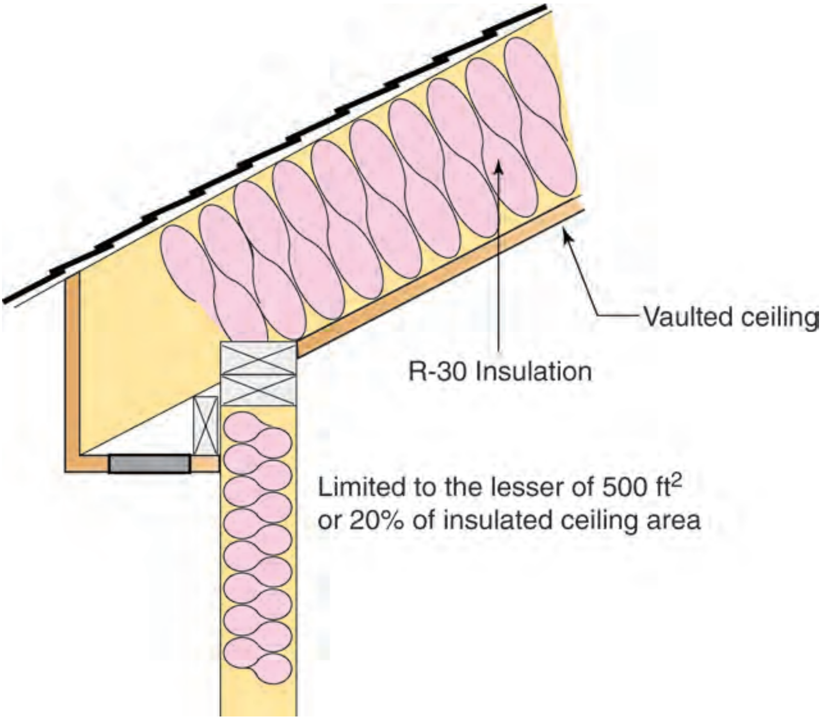


FIGURE 12-5 Reduced R-values for vaulted ceilings

the heat loss is necessary to protect the foundation from frost heave, these prescriptive designs cannot include in-floor heating systems that rely on insulation beneath the slab to direct heat away from the soil and into the dwelling. In-floor heating systems are permitted if footings are placed at the required minimum depth for frost protection. The building official may approve alternative designs by a registered design professional or designs in accordance with *ASCE 32 Standard for Frost Protected Shallow Foundations*. Because termites will readily excavate through foam plastic to create a path to wood construction, geographic locations subject to very heavy termite infestation are exempt from the slab-edge insulation requirements (Figure 12-6). [Ref. RE402.2.9, MRC R403.1.4]

Crawl Space Walls

The energy code offers two options for the insulation of crawl spaces (referred to as underfloor spaces in other parts of the code): insulation of the floor above the crawl space or, when the crawl space is not ventilated to the outside, insulation of the exterior walls. In both Climate Zone 6 and Climate Zone 7, a minimum R-15 insulation is required for crawl space walls, and the insulation must extend vertically to a point 2 feet below the interior grade or horizontally 2 feet. The code also specifies requirements for a vapor retarder on exposed earth of unventilated crawl spaces (Figure 12-7). See Chapter 5 of this publication for underfloor space ventilation and access requirements, and Chapter 9 for foam plastic insulation provisions. [Ref. RE402.2.10]

Basement Walls

When following the prescriptive provisions of the energy code and where a basement is conditioned, R-15 insulation must be installed from the top of the basement wall to at least 10 feet below grade or to the top of the footing, whichever is less. A minimum of R-10 must be installed on the exterior side of the foundation wall. The energy code includes an exception that allows the basement wall insulation to be reduced from R-15 to R-10 where the dwelling meets a more restrictive air leaking test rating of 2.6 air changes per hour (ACH) and the total square footage between the finished grade and the top of the foundation wall does not exceed 1.5 multiplied by the length of the foundation wall. The code allows a foundation wall insulation performance option as an alternative to prescriptive requirements. If the basement is designed as unconditioned space, the thermal envelope boundary must be shifted to the underside of the floor above.

Code Essentials

The code permits two prescriptive alternatives to R-value compliance: U-factor alternative and total UA alternative.

Table R402.1.3 provides maximum U-factors for assemblies and maximum U-factor for fenestration.

The total UA alternative allows a designer to use building components that do not comply with the maximum assembly U-factors and fenestration requirements of Table R402.1.3 if the area-weighted average thermal resistance is at least equivalent. Calculations must demonstrate that the total UA is the same as or less than that of a building of the same design that complies with the U-factor in Table R402.1.3. [Ref. RE402.1.3, RE402.1.4]

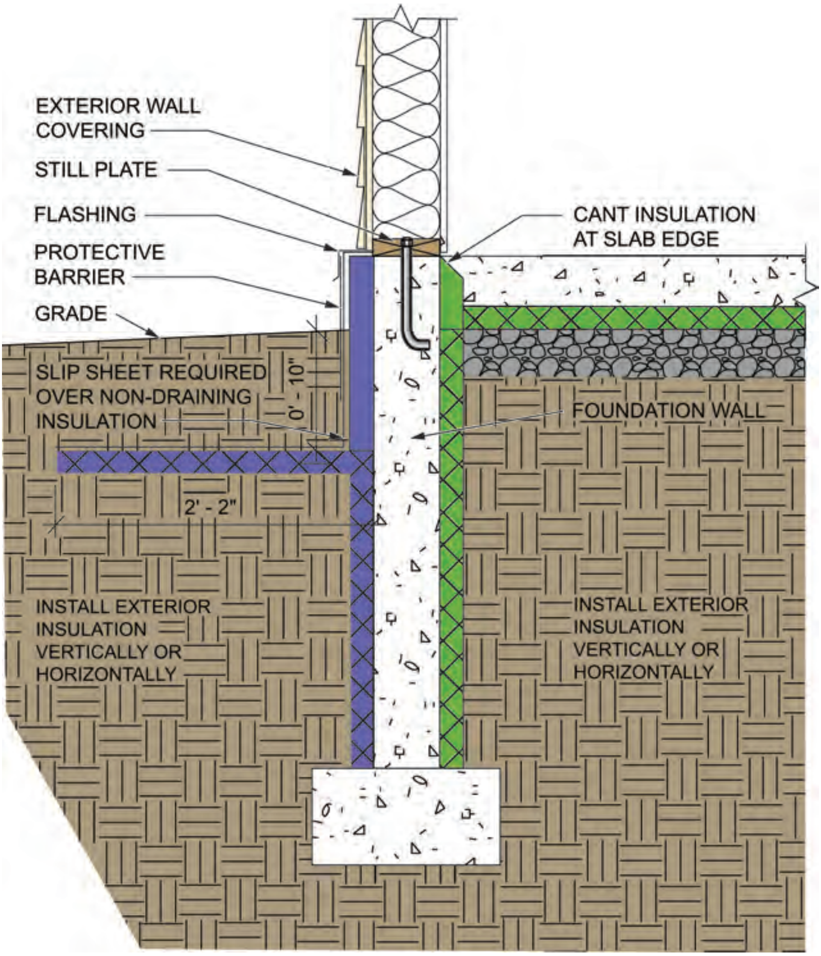


FIGURE 12-6 Slab-on-grade insulation

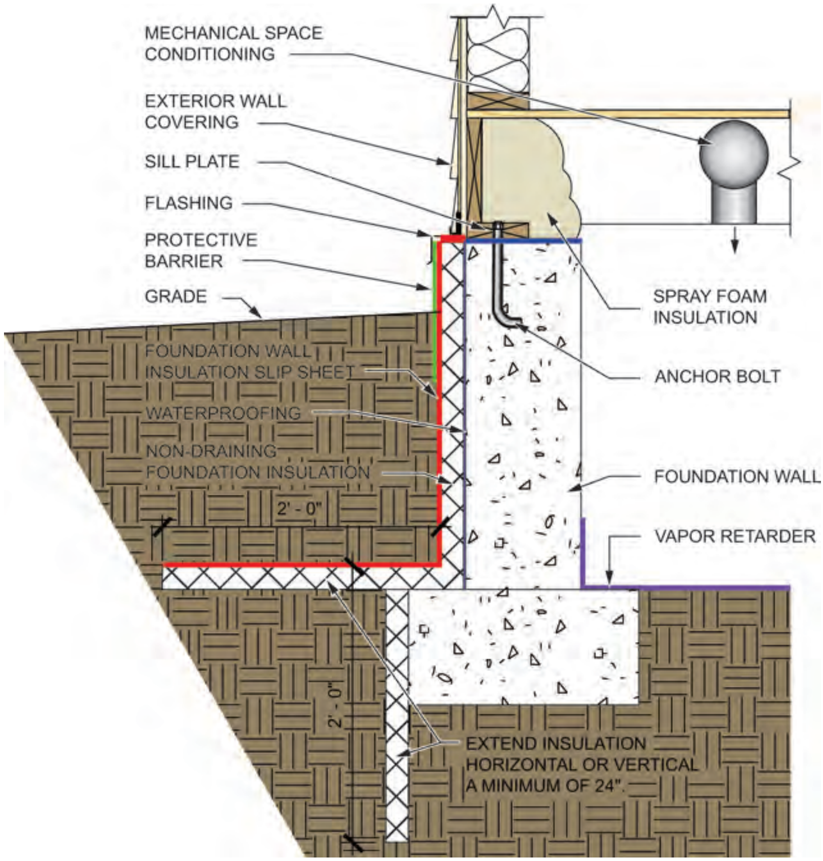


FIGURE 12-7 Insulation for unvented crawl spaces

Minimum R-19 cavity insulation is required in wood foundation walls. [Ref. RE402.2.8, RE402.1.1.8]

WINDOWS AND DOORS

Exterior windows, doors and skylights are referred to as fenestration products and must meet the prescribed energy efficiency requirements. The fenestration requirements apply to both glazed doors and opaque doors. The values of the U-factor, solar heat gain coefficient (SHGC), and visible transmittance for fenestration products are determined by the referenced standards of the National Fenestration Rating Council (NFRC). For products that lack a label certifying conformance to the applicable NFRC standard, the energy code assigns default values based on the construction of the product. [Ref. RE303.1.3]

Table 12-1 includes the maximum fenestration U-factor (0.32) and skylight U-factor (0.55) for homes built in Minnesota. SHGC is not regulated in Minnesota and similar climate zones due to the benefit of solar heat gain in the winter months. [Ref. RE402.1.1, RE402.3 and Table RE402.1.1]

The Minnesota energy code regulates air infiltration rates of fenestration products, which are also measured and labeled in accordance with NFRC standards. The maximum infiltration rate for windows, skylights and sliding glass doors is 0.3 cubic feet per minute (cfm) per square foot. For swinging doors, the maximum value is increased to 0.5 cfm per square foot (Figure 12-8). [Ref. RE402.4.3]

You Should Know

U-factor
The U-factor is a measurement of heat transmission through building components such as windows and doors. U-factor is the inverse of R-value (1/R); as such, a higher U-factor indicates a greater transmission of heat and a decreased effectiveness to conserve energy.

You Should Know

In every building there are numerous penetrations, connections and joints comprised of both similar and dissimilar materials—each providing opportunities for infiltration and/or exfiltration if not properly detailed and installed. Joints between materials create a break in the air barrier and must be caulked, taped or otherwise sealed. The sealing and air barrier materials must be compatible and installed according to the manufacturer's instructions.

FIGURE 12-8 Window NFRC energy performance label

AIR LEAKAGE

The energy conservation provisions intend to limit air leakage and infiltration through the building thermal envelope by requiring a continuous air barrier and the sealing of any breaks or penetrations in that air barrier. It is worth noting that, depending on the design of the dwelling, the air barrier and the vapor retarder may be the same material, or they may be entirely different materials. An example of a material serving both purposes is polyethylene sheeting. Unlike the vapor retarder which must be installed on the interior side of frame walls, the air barrier may be on the interior or exterior of the thermal envelope; in either location, the air barrier must be continuous. Challenges mount when the air barrier is installed on the exterior, and proper detailing becomes crucial to the continuity of the air barrier. Testing is required to verify compliance with the air leakage requirements.

Sealing

The building thermal envelope relies on properly installed insulation fit snugly to fill all gaps and a continuous air barrier to conserve energy (Figures 12-9 and 12-10). All joints, seams, and penetrations, including

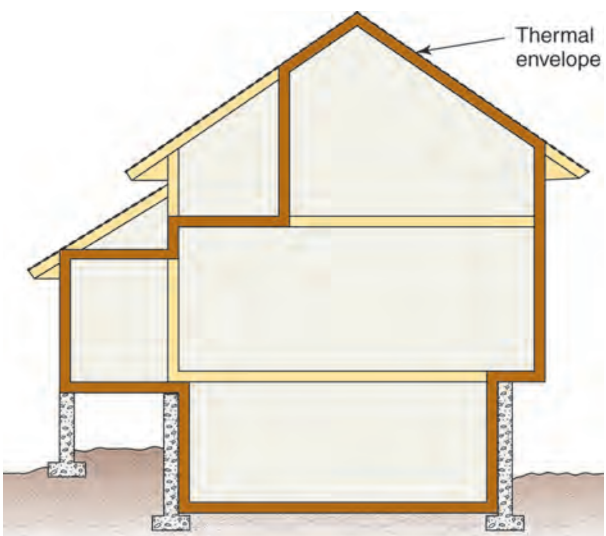


FIGURE 12-9 The building thermal envelope is an assembly of elements that provide a boundary between conditioned space and unconditioned space.

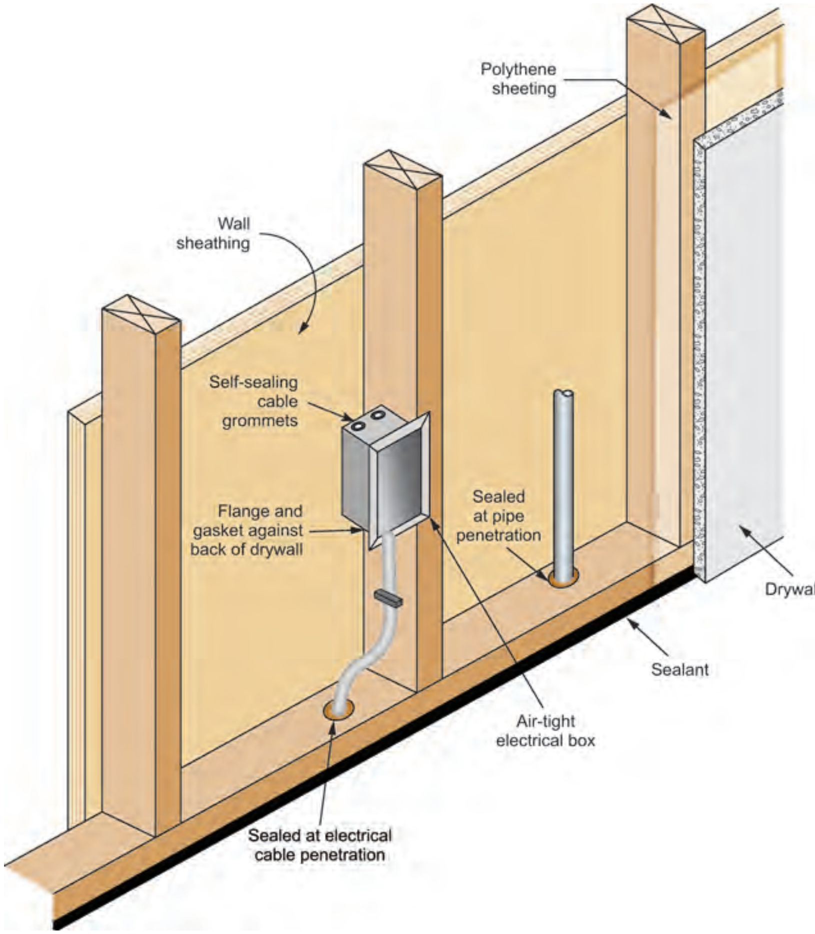


FIGURE 12-10 Components of a continuous air barrier

utility penetrations, of the building thermal envelope must be sealed against air movement. The code is specific in listing additional locations that are most vulnerable to air leakage and require sealing (Figure 12-11). These include:

- Openings around window and door assemblies
- Junctions in wall framing
- Garage separation from conditioned spaces
- Behind tubs and showers on exterior walls
- Attic access openings
- Rim joists

- Recessed lighting
- Shafts and penetrations to the exterior or unconditioned space
- Plumbing and wiring
- Electrical boxes on exterior walls
- HVAC register boots

Wood-burning fireplaces are also identified as significant sources of air leakage, and the code requires tight-fitting flue dampers or doors and outdoor combustion air. [Ref. Table RE402.4.1.1 and RE402.4.2]

Recessed Luminaires

Recessed luminaires (light fixtures) can be a major source of heat loss and moisture introduced into attic spaces. Often referred to as "can lights," recessed luminaires installed in the thermal envelope, typically an insulated ceiling, require a tight seal to limit air leakage. The energy code requires an IC-rated (insulation contact-rated) fixture tested and labeled to conform to the specified air movement standard (Figure 12-12). [Ref. RE402.4.4]

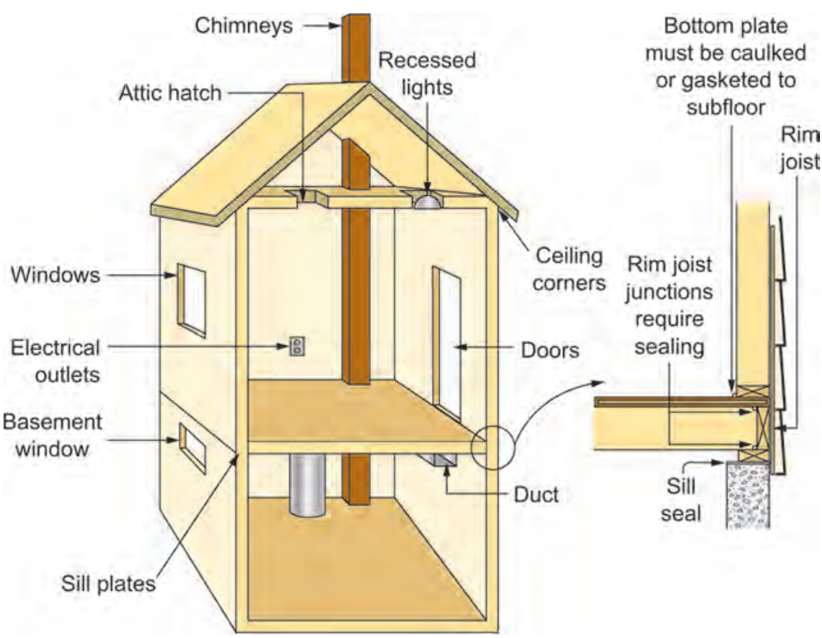


FIGURE 12-11 Typical sources of air leakage

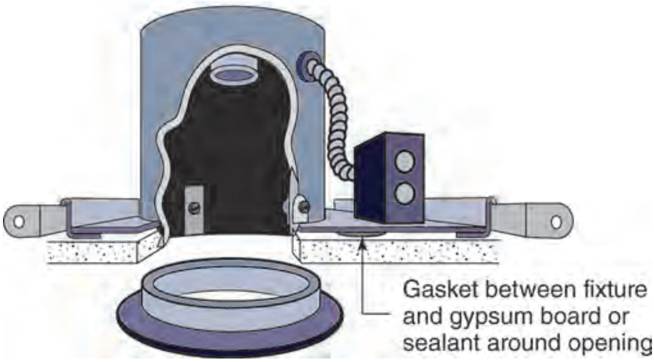


FIGURE 12-12 Recessed luminaires in thermal envelope

Testing

The code requires blower door testing of the building or dwelling unit to determine compliance with the established limits on air leakage through the building thermal envelope. The maximum air leakage rate in Minnesota is set at 3 air changes per hour (ACH) unless the dwelling is complying with the exception for basement wall insulation in Section RE402.2.8. Blower door testing is conducted at the prescribed pressure of 50 Pascals (Figure 12-13). Because such tight construction reduces the amount of fresh air infiltrating into the residence, whole-house mechanical ventilation is required to bring in outdoor air and improve the indoor air quality. The whole-house mechanical ventilation system must be balanced, meaning fresh air is introduced at approximately the same rate that stale indoor air is exhausted. See Chapter 10 for additional information on ventilation. [Ref. RE402.4.1.2, RE403.5]

Code Essentials

Heating and cooling equipment must be sized in accordance with ACCA Manual S based on building loads calculated in accordance with ACCA Manual J. [Ref. RE403.6]

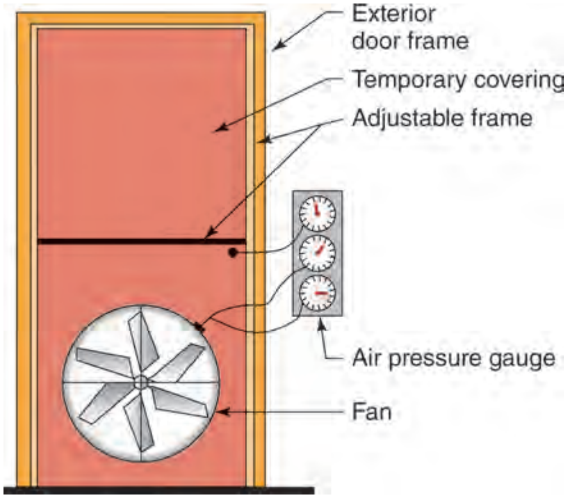


FIGURE 12-13 The air leakage rate of the building thermal envelope is tested with a blower door.

SYSTEMS

In addition to provisions regulating the building thermal envelope, the code also sets minimum requirements for certain components of mechanical, plumbing, and lighting systems to conserve energy. For example, a programmable thermostat is required for the primary heating and cooling system. Occupants then have the ability to conserve energy through optimum temperature settings on a daily schedule. [Ref. RE403.1.1]

Duct Insulation and Sealing

Exhaust, supply and return ducts and plenums must be insulated unless they are located within conditioned spaces or in basements with insulated walls, as shown in Table 12.2. Insulation is only required in the conditioned space for a distance of 3 feet from the exterior or unconditioned space. A vapor retarder that complies with the Minnesota Mechanical Code is also required, as well as a waterproof barrier for ducts located on the exterior of a building.

TABLE 12-2 Minimum Duct and Plenum Insulation Requirements

Duct Type/Location	Requirements[a,b]
Exterior of building	R-8, V and W
Attics, garages and ventilated crawl spaces	R-8 and V
Outdoor air intakes within conditioned spaces	R-3.3 and V
Exhaust ducts within conditioned spaces	R-3.3 and V
Within concrete slab or within ground	R-3.5 and V
Within conditioned spaces and in basements with insulated walls	None Required
[Ref. Table RE403.2.1]	

a. V means the vapor retarder in accordance with Minnesota Mechanical Code Section 604.11. When a vapor retarder is required, duct insulation required by Section RE403.2.1 shall be installed without respect to other building envelope insulation.
b. W means an approved weatherproof barrier.

The code requires sealing of all ducts, air handlers and filter boxes in accordance with the mechanical provisions of the *Minnesota Mechanical Code*. Unless ducts and air handlers are located entirely within the building thermal envelope, duct tightness testing is required to verify compliance with the total leakage criteria under the prescribed test pressures. Because building framing cavities are difficult to seal and impair the efficiency of the HVAC system, stud cavities and enclosed floor joist spaces are not permitted to serve as ducts or air plenums for supply or return air. [Ref. RE403.2.1 through RE403.2.3]

Code Essentials

Snow and ice accumulation on walkways, stairs, driveways and parking areas may create unsafe conditions around dwellings in cold climate zones; snow- and ice-melting systems help reduce this risk. For installed systems, operational controls are mandatory. [Ref. RE403.8]

CHAPTER 12

Piping Insulation

Piping insulation with a minimum value of R-3 is required for mechanical system piping (such as hydronic heating or cooling tubing) that is designed to carry fluids above 105°F or below 55°F. Similarly, hot water piping in many cases must also be insulated to a minimum of R-3. This insulation is always required for piping serving more than one dwelling unit, piping exceeding $^3/_4$-inch in diameter and for piping in the following locations:

- From the water heater to a distribution manifold
- Underground or under slab
- Outside the conditioned space.
- Piping from the water heater to kitchen outlets
- Supply and return piping in recirculation systems other than demand recirculation systems
- Piping that exceeds the maximum run length specified

[Ref. RE403.3, RE403.4.2]

You Should Know

Pools and spas can be a source of significant energy loss. The energy code includes requirements for controls and covers to help reduce the energy use of these systems. [Ref. RE403.9] *

Lighting

High-efficacy lamps (typically LED or compact fluorescent lamps) in a residential setting save electrical energy when compared to incandescent lighting. The code requires high-efficacy lamps in at least 75 percent of permanent lighting fixtures in dwelling units. [Ref. RE404.1]

You Should Know

The Minnesota Residential Energy Code does not regulate solar energy systems. Projects seeking additional energy efficiency through the installation of photovoltaic modules (solar panels) and systems must meet the requirements of Minnesota Residential Code Section R324, as well as electrical requirements located in Minnesota Rules, Chapter 1315. [Ref. RE403.12, MRC R324

ENERGY CERTIFICATE

The residential energy code requires the builder or registered design professional to complete a certificate that details the energy efficient components of the building. The certificate must also include all of the following:

1. *R*-values of insulation installed in or on ceilings, roofs, walls, foundation components such as slabs, basement walls, crawl space walls and floors, and ducts outside conditioned spaces
2. *U*-factors and SHGC of fenestration
3. Results from any required duct system and building envelope air leakage testing performed on the building
4. Calculated heat loss, cooling load and heat gain of the building
5. Types, input ratings, manufacturers, model numbers and efficiencies of heating, cooling and service water heating equipment
6. Type, location and capacity of the ventilation system, and the designated continuous and total ventilation rates
7. Type, size and location of any make-up air system installed
8. Location or future location of the radon fan

Because electric furnaces and baseboard heaters do not provide the lowest energy consumption when compared to other methods of comfort heating and their energy efficiency ratings may be misleading, the energy code requires such appliances to be individually listed on the certificate without an efficiency designation. The date the certificate is installed, address of the dwelling and contractor name and license number are also required.

The certificate must be posted on or in the electrical panel but cannot cover the service directory or other required information governed by the electrical code. [Ref. RE401.3]

PART VII Building Utilities

CHAPTER 13 Mechanical and Fuel Gas

The 2020 Minnesota Mechanical and Fuel Gas Code:

- Regulates the design, installation, maintenance, alteration and inspection of building mechanical systems that are used to provide control of environmental conditions and related processes.
- Contains detailed provisions governing mechanical and fuel gas systems using prescriptive and performance-based provisions with emphasis on performance.
- Located in Minnesota Rules Chapter 1346. This rule chapter adopts by reference Chapters 2 through 15 of the 2018 International Mechanical Code, Chapters 2 through 8 of the 2018 International Fuel Gas Code (including amendments to both), chapters 1 through 9 of ANSI/ASHRAE Standard 154-2016, Ventilation for Commercial Cooking Operations, and ANSI/ASHRAE 62.2-2016, Ventilation and Acceptable Indoor Air Quality in Residential Buildings.

To View Codes Online Free

Visit www.dli.mn.gov/business/codes-and-laws to view the code.

CHAPTER 14 Plumbing

The 2020 Minnesota Plumbing Code:

- Regulates the design and installation of plumbing systems statewide for all buildings including new, additions, alterations, repair and replacement.
- Contains requirements for drain, waste, and vent systems, water supply and distribution systems, backflow prevention, water conditioning equipment, roof drainage systems, plumbing fixtures, materials and nonpotable rainwater catchment systems.
- Minnesota Rules, Chapter 4714. The rule incorporates by reference Chapters 2 to 11, 16, and 17 of the 2018 edition of the Uniform Plumbing Code (UPC), and UPC Appendices A, B and I, with Minnesota amendments.

To View Codes Online Free

Visit www.dli.mn.gov/business/codes-and-laws to view the code.

CHAPTER 15 Electrical

The 2020 Minnesota Electrical Code:

- Provides the minimum installation criteria for electrical wiring for commercial, residential and industrial occupancies. The original code document was developed in 1897 as a result of united efforts of various insurance, electrical, architectural and allied interests.
- The purpose of the code is the practical safeguarding of persons and property from hazards arising from the use of electricity. Contains prescriptive installation requirements for premises wiring systems but is not intended to be a design specification or an instruction manual for untrained persons.
- The code is adopted by the Minnesota Board of Electricity as required by Minnesota Statutes 326B.32 Subd. 2 (3) pursuant to Chapter 14.
- Minnesota Rules, chapter 1315, adopts the 2020 National Electrical Code.

To View Codes Online Free

Visit www.dli.mn.gov/business/codes-and-laws to view the code.

CHAPTER 16 Radon

This chapter addresses the passive radon control system requirements for new dwellings that are located in Minnesota Rules, part 1303.2402. A passive radon control system is designed to naturally draw radon gas from under the slab and vent it by convective air flow to the exterior of the building. Some of the common features required of a passive system include:

- Gas-permeable soil, aggregate, sand or other approved material installed under the slab;
- Soil-gas membrane applied to the top of the gas-permeable material
- Sealed floor and foundation openings;
- “T” fitting shall be installed beneath the soil-gas membrane with a minimum of 10 feet of perforated pipe connected to any two openings of the “T” fitting, or by connecting the two openings to the interior drain tile system.
- Vent pipe(s) connected from the “T” fitting, extending a minimum of 12 inches above the roof
- Electrical power terminating at a box installed at an anticipated future fan location

RADON CONTROL

The Minnesota Provisions of the State Building Code establish prescriptive provisions for radon-resistant new construction and are located in Minnesota Rules, part 1303.2400. The prescribed measures act to reduce introduction of soil gases potentially containing radon into the living space of a dwelling and to provide a cost-effective means of reduction should testing reveal unacceptable levels of radon after construction. The provisions apply to all new residential construction in locations where radon gas may enter such as basements, conditioned crawlspaces, wood foundations, slab-on-grade designs, tuck-under garages, and other configurations that may allow radon gas to enter the building.

A decay product of uranium, radon is a radioactive gas that occurs naturally in the soil in varying concentrations and over time can cause damage to the lungs and increases the potential for developing lung cancer. It is not possible to predict with accuracy or certainty the levels of radon that will occur in a given house until the building is enclosed and tested. Houses in the same neighborhood, because of varying radon concentrations in the soil, may experience very different levels of radon.

The primary means for reducing entry of radon gas into the dwelling is through sub-slab depressurization. This method seals all entry points of the slab and basement foundation wall and vents the area below the slab out through the roof. Effectiveness of this system depends on a layer of 4″ minimum air-permeable granular base, such as sand or clean aggregate, below the slab. The passive vent pipe may terminate in a tee fitting below the floor or may connect directly to a gas-tight sump pit or foundation drain tile. Even a passive system without a fan on the vent pipe creates a chimney effect and maintains a lower air pressure below the slab than occurs in the dwelling. The provisions of Minnesota Rules, part 1303.2402 allow for the easy conversion from a passive system to an active system by installing an approved inline fan in the vent pipe in the attic. The fan runs continuously to draw air from below the slab. With lower sub-slab pressure, soil gases will follow the path of least resistance out through the roof rather than migrating into the living space (Figures 16-1 through 16-3). After a certificate of occupancy has been issued for a new residential structure, radon control is governed by the Minnesota Department of Health in accordance with Minnesota Statutes, section 144.4961 and Minnesota Rules, part 4620.7000. [Ref. MR 1303.2400, MS 144.4961.]

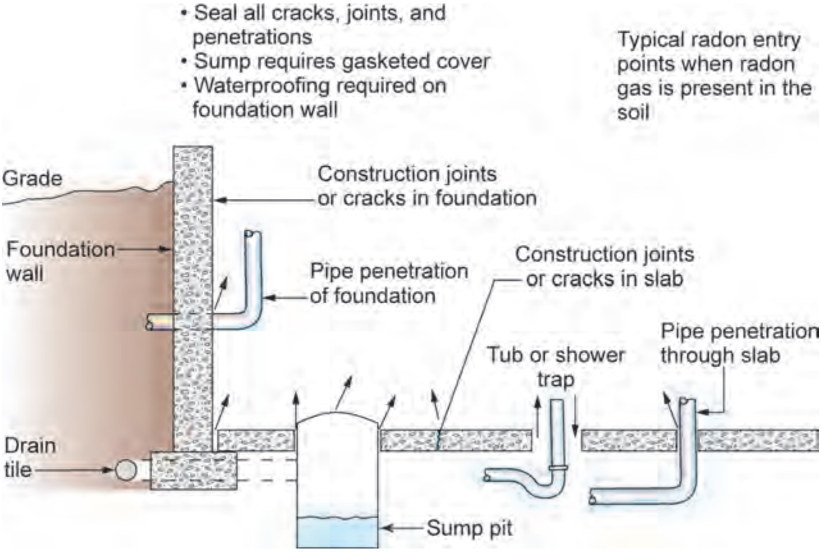


FIGURE 16-1 Sealing of soil gas-entry points

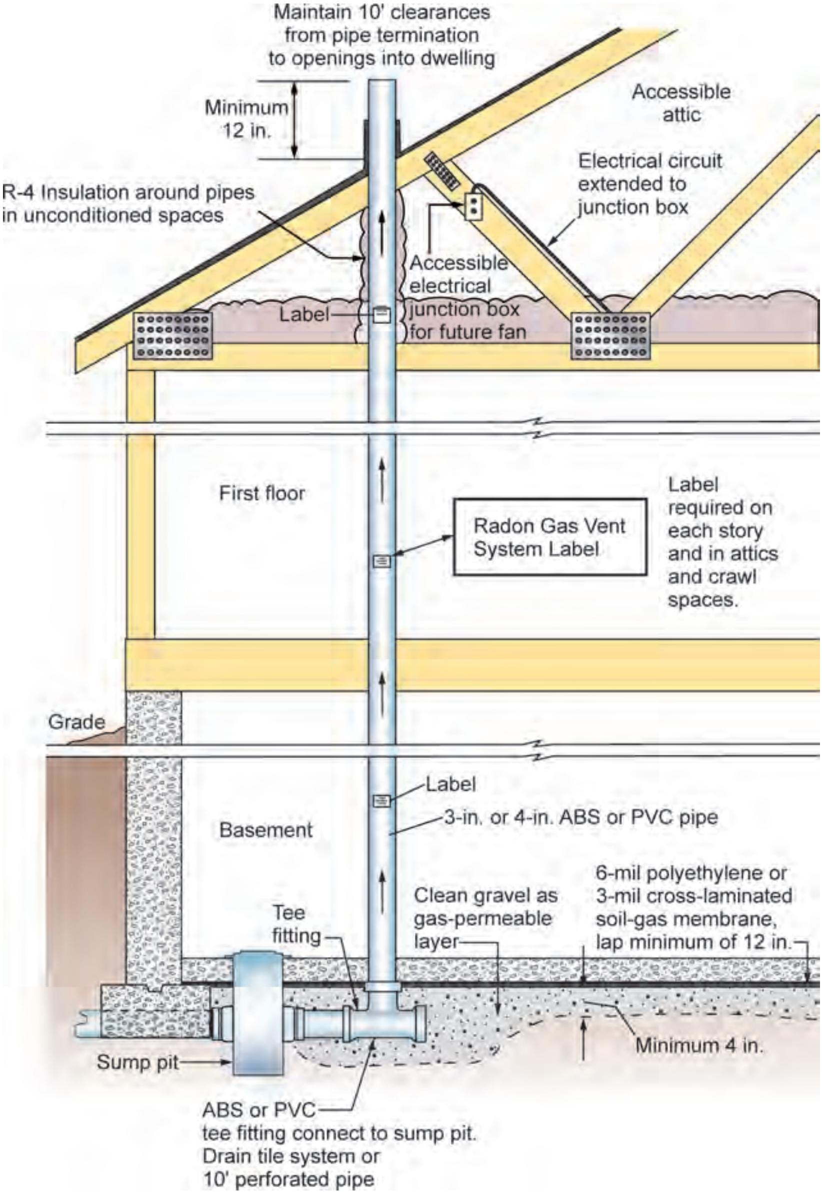


FIGURE 16-2 Passive sub-slab depressurization system

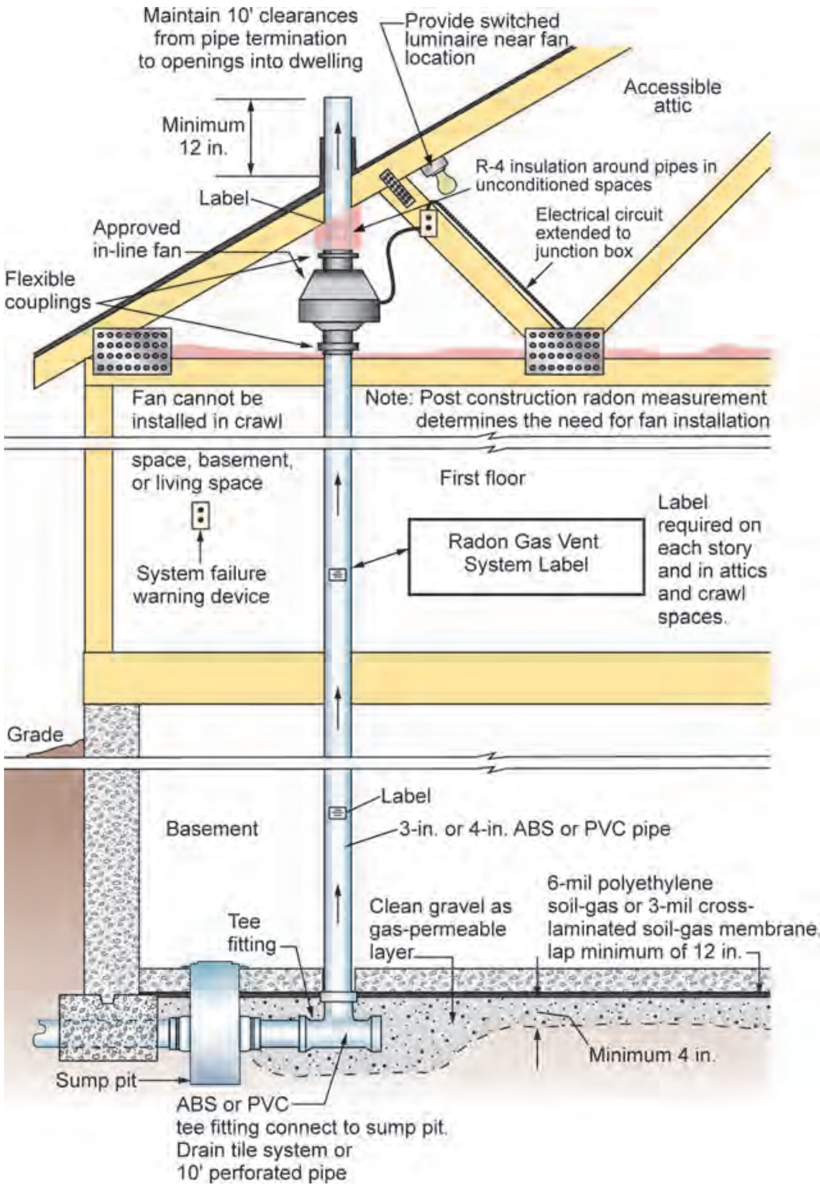


FIGURE 16-3 Active sub-slab depressurization system

Glossary

A

access (to) That which enables a device, an appliance or equipment to be reached by ready access or by a means that first requires the removal or movement of a panel, door or similar obstruction.

accessory structure A structure that is accessory to and incidental to that of the dwelling(s) and that is located on the same lot.

air barrier Material(s) assembled and joined together to provide a barrier to air leakage through the building envelope. An air barrier may be a single material or combination of materials.

approved Approval by the building official, pursuant to the Minnesota State Building Code, by reason of: a. inspection, investigation, or testing; b. accepted principles; c. computer simulations; d. research reports; or e. testing performed by either a licensed engineer or by a locally or nationally recognized testing laboratory.

approved agency An established and recognized agency that is regularly engaged in conducting tests, furnishing inspection services or furnishing product certification, and has been approved by the building official.

attic The unfinished space between the ceiling assembly and the roof assembly.

B

basement A story that is not a story above grade plane. (see "Story above grade plane").

building Any one- or two-family dwelling or portion thereof, including townhouses, used or intended to be used for human habitation, for living, sleeping, cooking or eating purposes, or any combination thereof, or any accessory structure.

building official The officer or other designated authority charged with the administration and enforcement of this code, or a duly authorized representative.

building thermal envelope The basement walls, exterior walls, floor, roof, and any other building elements that enclose conditioned space or provides a boundary between conditioned space and exempt or unconditioned space.

C

carbon monoxide alarm A single- or multiple-station alarm intended to detect carbon monoxide gas and alert occupants by a distinct audible signal. It incorporates a sensor, control components and an alarm notification appliance in a single unit.

ceiling height The clear vertical distance from the finished floor to the finished ceiling.

crawl space Areas or rooms with less than 6 feet 4 inches ceiling height measured to the finished floor or grade below.

cricket A sloped flashing on the up-roof side of a chimney to divert water from above the chimney to each side.

D

dead loads The weight of the materials of construction incorporated into the building, including but not limited to walls, floors, roofs, ceilings, stairways, built-in partitions, finishes, cladding, and other similarly incorporated architectural and structural items, and fixed service equipment.

draft stop A material, device or construction installed to restrict the movement of air within open spaces of concealed areas of building components such as crawl spaces, floor-ceiling assemblies, roof-ceiling assemblies and attics.

dwelling, single-family Any building that contains one dwelling unit used, intended, or designed to be built, used, rented, leased, let or hired out to be occupied, or occupied for living purposes.

dwelling, two-family Any building that contains two separate dwelling units with separation either horizontal or vertical on one lot that is used, intended, or designed to be built, used, rented, leased, let or hired out to be occupied, or occupied for living purposes.

dwelling, townhouse A single-family dwelling unit constructed in a group of two or more attached units in which each unit extends from the foundation to the roof and having open space on at least two sides of each unit. Each single-family dwelling unit shall be considered to be a separate building. Separate building service utilities shall be provided to each single-family dwelling unit when required by other chapters of the State Building Code.

dwelling unit A single unit providing complete independent living facilities for one or more persons, including permanent provisions for living, sleeping, eating, cooking and sanitation.

E

emergency escape and rescue opening An operable exterior window, door or similar device that provides for a means of escape and access for rescue in the event of an emergency.

exterior wall covering A material or assembly of materials applied on the exterior side of exterior walls for the purpose of providing a weather-resistive barrier, insulation or for aesthetics, including but not limited to, veneers, siding, exterior insulation and finish systems, architectural trim and embellishments such as cornices, soffits, and fascias.

F

fenestration Products classified as either vertical fenestration or skylights and sloped glazing, installed in such a manner as to preserve the weather-resistant barrier of the wall or roof in which they are installed. Fenestration includes products with glass or other transparent materials.

fireblocking Building materials or materials approved for use as fireblocking, installed to resist the free passage of flame to other areas of the building through concealed spaces.

fireplace An assembly consisting of a hearth and fire chamber of noncombustible material and provided with a chimney, for use with solid fuels.

fireplace, factory-built A listed and labeled fireplace and chimney system composed of factory-made components, and assembled in the field in accordance with manufacturer's instructions and the conditions of the listing.

fireplace, masonry A field-constructed fireplace composed of solid masonry units, bricks, stones or concrete.

fire separation distance The distance measured from the building face to the closest interior lot line; to the centerline of a street, an alley or public way; or to an imaginary line between two buildings on the lot. The distance is measured at a right angle from the face of the wall.

flashing Approved corrosion-resistive material provided in such a manner as to deflect and resist entry of water into the construction assembly.

G

grade floor opening A window or other opening located such that the sill height of the opening is not more than 44 inches above or below the finished ground level adjacent to the opening.

grade plane A reference plane representing the average of the finished ground level adjoining the building at all exterior walls. Where the finished ground level slopes away from the exterior walls, the reference plane shall be established by the lowest points within the area between the building and the lot line or, where the lot line is more than 6 feet from the building between the structure and a point 6 feet from the building.

guard A building component or a system of building components located near the open sides of elevated walking surfaces that minimizes the possibility of a fall from the walking surface to the lower level.

gypsum board The generic name for a family of sheet products consisting of a noncombustible core primarily of gypsum with paper surfacing. Gypsum wallboard, gypsum sheathing, gypsum base for gypsum veneer plaster, exterior gypsum soffit board and water-resistant gypsum backing board are types of gypsum board.

H

habitable attic A finished or unfinished habitable space within an attic.

habitable space Space in a building for living, sleeping, eating, or cooking. Bathrooms, toilet rooms, closets, halls, storage or utility spaces, and similar areas are not considered habitable spaces.

handrail A horizontal or sloping rail intended for grasping by the hand for guidance or support.

height, building The vertical distance from grade plane to the average height of the highest roof surface.

height, story The vertical distance from top to top of two successive tiers of beams or finished floor surfaces; and, for the topmost story, from the top of the floor finish to the top of the ceiling joists or, where there is not a ceiling, to the top of the roof rafters.

high-efficacy lamps Compact fluorescent lamps, T-8 or smaller diameter linear fluorescent lamps, or lamps with a minimum efficacy of: 1.60 lumens per watt for lamps over 40 watts; 2.50 lumens per watt for lamps over 15 watts to 40 watts; and 3.40 lumens per watt for lamps 15 watts or less.

I

insulating concrete form (ICF) A concrete forming system using stay-in-place forms of rigid foam plastic insulation, a hybrid of cement and foam insulation, a hybrid of cement and wood chips, or other insulating material for constructing cast-in-place concrete walls.

J

jurisdiction The governmental unit that has adopted this code.

K

kick-out flashing Flashing used to divert water where the lower portion of a sloped roof stops within the plane of an intersecting wall cladding.

L

labeled Equipment, materials or products to which have been affixed a label, seal, symbol or other identifying mark of a nationally recognized testing laboratory, approved agency or other organization concerned with product evaluation that maintains periodic inspection of the production of such labeled items and whose labeling indicates either that the equipment, material or product meets identified standards or has been tested and found suitable for a specified purpose.

light-frame construction Construction whose vertical and horizontal structural elements are primarily formed by a system of repetitive wood or cold-formed steel framing members.

listed Equipment, materials, products or services included in a list published by an organization acceptable to the code official and concerned with evaluation of products or services that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services and whose listing states either that the equipment, material, product or service meets identified standards or has been tested and found suitable for a specified purpose.

live loads Those loads produced by the use and occupancy of the building or other structure and do not include construction or environmental loads such as wind load, snow load, rain load, earthquake load, flood load or dead load.

loads Forces that are applied to the structural system of the building.

M

manufacturer's installation instructions Printed instructions included with equipment as part of the conditions of their listing and labeling.

means of egress The path of travel from any occupied portion of the building to the outdoors. Stairways, ramps, landings, hallways and doors are components of the means of egress.

multipurpose fire sprinkler system A system that supplies domestic water to both plumbing fixtures and fire sprinklers.

O

occupancy classifications IRC-1 - Single-family dwellings, IRC-2 - Two-family dwellings, IRC-3 - Townhouses, IRC-4 - Accessory structures: a. Garages; b. Storage sheds; and c. Similar structures.

P

pan flashing Corrosion-resistant flashing at the base of an opening that is integrated into the building exterior wall to direct water to the exterior and is premanufactured, fabricated, formed or applied at the job site.

permit An official document or certificate issued by the building official that authorizes performance of a specified activity.

public way Any street, alley or other parcel of land open to the outside air leading to a public street, that has been deeded, dedicated or otherwise permanently appropriated to the public for public use and that has a clear width and height of not less than 10 feet.

R

registered design professional An individual who is registered or licensed to practice their respective design profession as defined by the statutory requirements of the professional registration laws of the state or jurisdiction in which the project is to be constructed.

S

sill height The lowest part of the window opening of an operable window measured from the finished floor.

story above grade plane Any story having its finished floor surface entirely above grade plane, or in which the finished surface of the floor next above is either of the following: 1. More than 6 feet above grade plane. 2. More than 12 feet above the finished ground level at any point.

stair A change in elevation, consisting of one or more risers.

story That portion of a building included between the upper surface of a floor and the upper surface of the floor or roof next above.

structure That which is built or constructed.

T

townhouse (See dwelling)

W

water-resistive barrier A material behind an exterior wall covering that is intended to resist liquid water that has penetrated behind the exterior covering from further intruding into the exterior wall assembly

waterproofing Treatment of a surface or structure located below grade to resist the passage of water in liquid form, under hydrostatic pressure that bridges non-structural cracks.

walls, load-bearing A wall supporting any vertical load in addition to its own weight.

walls, nonbearing A wall which does not support vertical loads other than its own weight.

whole-house mechanical ventilation system An exhaust system, supply system, or combination thereof that is designed to mechanically exchange indoor air for outdoor air when operating continuously or through a programmed intermittent schedule to satisfy the whole-house ventilation rate.

wood structural panel A panel manufactured from veneers or wood strands or wafers bonded together with waterproof synthetic resins or other suitable bonding systems. Examples of wood structural panels are plywood, OSB and composite panels.

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