User's Guide to Technical Bulletins

Developed in Accordance with the National Flood Insurance Program

NFIP Technical Bulletin 0 / January 2021

FEMA

Comments on the Technical Bulletins should be directed to:

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Acronyms

ACI	American Concrete Institute
BFE	base flood elevation
CFR	Code of Federal Regulations
DFE	design flood elevation
FEMA	Federal Emergency Management Agency
FHBM	Flood Hazard Boundary Map
FIMA	Federal Insurance and Mitigation Administration
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
IBC®	International Building Code®
ICC®	International Code Council®
I-Codes®	International Codes®
IRC®	International Residential Code®
NFIP	National Flood Insurance Program
ORNL	Oak Ridge National Laboratory
SEI	Structural Engineers Institute
SFHA	Special Flood Hazard Area
TB	Technical Bulletin

1 Introduction and Background

Beginning in the early 1990s, the Federal Insurance and Mitigation Administration of FEMA has issued 11 Technical Bulletins that provide guidance on interpreting, enforcing, and complying with the minimum building performance requirements in the National Flood Insurance Program (NFIP) regulations (Title 44 of the Code of Federal Regulations [CFR] Parts 59 and 60). These requirements are intended to reduce the loss of life and property as well as the economic and social hardships that can result from flooding.

The NFIP is a federal program established by the National Flood Insurance Act of 1968, as amended (42 U.S. Code §§ 4011 et seq.). The primary purposes of the Act are to:

- Better indemnify individuals for flood losses through insurance
- Reduce future flood damage through state and community floodplain management regulations
- Reduce federal expenditures for disaster assistance and flood control

To participate in the NFIP, communities must adopt and enforce floodplain management regulations that meet or exceed NFIP floodplain management requirements. Owners of property located in communities that participate can purchase NFIP flood insurance as a protection against the financial impact of flood losses.

NFIP REQUIREMENTS AND HIGHER REGULATORY STANDARDS

State or Local Requirements. State or local requirements that are more restrictive or stringent than the minimum requirements of the NFIP take precedence. The Technical Bulletins and other FEMA publications provide guidance on the minimum requirements of the NFIP and describe best practices. Design professionals, builders, and property owners should contact local officials to determine whether more restrictive provisions apply to buildings or sites in question. All other applicable requirements of the state or local building codes must also be met.

Substantial Improvement and Substantial Damage. As part of issuing permits, local officials must review not only proposals for new construction but also for work on existing buildings to determine whether the work constitutes Substantial Improvement or repair of Substantial Damage. If the work is determined to constitute Substantial Improvement or repair of Substantial Damage, the buildings must be brought into compliance with the NFIP requirements for new construction. Some communities modify the definitions of Substantial Improvement and/or Substantial Damage to be more restrictive than the NFIP minimum requirements. For more information on Substantial Improvement and Substantial Damage, see FEMA P-758, *Substantial Improvement/Substantial Damage Desk Reference* (2010), and FEMA 213, *Answers to Questions About Substantially Improved/Substantially Damaged Buildings* (2018).

Higher Building Elevation Requirements. Some states and communities require that buildings be elevated or dry floodproofed (non-residential in Zone A only) above the NFIP minimum requirement. The additional elevation is called freeboard. Design professionals, builders, and property owners should check with local officials to determine whether a state or community has freeboard requirements. References to building elevations in this Technical Bulletin should be construed as references to the community's elevation requirement in areas where freeboard is required.

The NFIP floodplain management regulations, codified in Title 44 of the Code of Federal Regulations (CFR) Part 60, specifically 44 CFR § 60.3, include minimum building performance criteria that apply to (1) new construction, (2) work determined to be Substantial Improvement such as improvements, alterations, and additions, and (3) the repair of buildings determined to have incurred Substantial Damage and that are in Special Flood Hazard Areas (SFHAs).

1.1 Intended Audience

The Technical Bulletins are intended for use primarily by state and local officials who are responsible for interpreting and enforcing the NFIP floodplain management regulations.

The Technical Bulletins may also be used by design professionals (e.g., architects, engineers), contractors, building owners and operators, planners, and other interested stakeholders to help understand and comply with NFIP floodplain management requirements. Using the information in the Technical Bulletins will improve the design and construction of buildings, including their utility systems, that are in floodprone areas, thereby reducing the potential for damage and increasing building and community resilience.

1.2 Purpose of Technical Bulletins

The Technical Bulletins provide specific FEMA guidance for state and local floodplain management officials on complying with the NFIP's minimum floodplain management criteria. While the primary focus of the Technical Bulletins is on how to meet the minimum NFIP floodplain management requirements, they also include information on:

- Recommended best practices for reducing flood losses
- Considerations related to NFIP flood insurance rates
- Building codes and standards

Additional information on how to use the Technical Bulletins is provided in Section 2.

TECHNICAL BULLETINS AND FLOODPLAIN MANAGEMENT BULLETINS

The NFIP Technical Bulletins provide guidance on complying with the minimum NFIP floodplain management requirements that apply to buildings. FEMA's Floodplain Management Bulletins provide guidance on administering the NFIP requirements that apply to development other than buildings and guidance on some building requirements. The Floodplain Management Bulletins are available at https://www.fema.gov/floodplain-management.

1.3 Synopses of Technical Bulletins (as of January 2021)

Table 1: Technical Bulletin Synopses

TB No.	Title (Date)	Synopsis
0	*User's Guide to Technical Bulletins* (2021)	Introduction and background for the TBs, including the intended audience, purpose, and synopses of available TBs; how to use the TBs; crosswalk of NFIP regulations and the TBs; key concepts and requirements used in the TBs; key terms and useful resources; supplemental information, including how to obtain copies of the TBs; FEMA Headquarters and Regional Office locations; and a key word/subject index for the TBs.

Table 1: Technical Bulletin Synopses (cont.)

TB No.	Title (Date)	Synopsis
1	*Requirements for Flood Openings in Foundation Walls and Walls of Enclosures Below Elevated Buildings in Special Flood Hazard Areas* (2020)	Guidance on the NFIP requirements for flood openings in foundation walls and walls of enclosures below elevated buildings in Zones A, AE, A1-30, AR, AO, and AH, with clarifications for use of non-engineered and engineered openings.
2	*Flood Damage-Resistant Materials Requirements for Buildings Located in Special Flood Hazard Areas* (2008)	Guidance on the NFIP requirements on the use of flood damage-resistant construction materials in building components below the BFE in SFHAs (both Zones A and V).
3	*Requirements for the Design and Certification of Dry Floodproofed Non-Residential and Mixed-Use Buildings Located in Special Flood Hazard Areas* (2021)	Guidance on the NFIP requirements for the design and certification of dry floodproofing systems for new and substantially improved non-residential and mixed-use buildings with lowest floors below the BFE in Zones A, AE, A1-30, AR, AO, and AH. The guidance can also be used as a best practice for improving the flood resilience of existing buildings that are not substantially improved. New in the 2020 edition are appendices with guidance for completing FEMA Form 086-0-34, NFIP Floodproofing Certificate for Non-Residential Structures, and an example calculation for estimating total seepage. FEMA Form 086-0-34 is used to satisfy the requirement for design professionals to certify designs and as-built drawings and inspection and is a requirement for an NFIP flood insurance policy. The total seepage estimation is used to determine if dry floodproofing measures are considered substantially impermeable to floodwaters.
4	*Elevator Installation for Buildings Located in Special Flood Hazard Areas* (2019)	Guidance on the NFIP requirements for elevator machinery and equipment that serve buildings and on the installation of elevators below the Base Flood Elevation (BFE) in Special Flood Hazard Areas (SFHAs) (both Zones A and V).
5	*Free-of-Obstruction Requirements for Buildings Located in Coastal High Hazard Areas* (2020)	Guidance on NFIP requirements concerning obstructions to floodwaters and waves beneath and associated with elevated buildings in Coastal High Hazard Areas (Zones V, VE, V1-30, and VO). Obstructions can include portions of elevated buildings and building site modifications.
6	*Requirements for Dry Floodproofed Below-Grade Parking Areas Under Non-Residential and Mixed-Use Buildings Located in Special Flood Hazard Areas* (2021)	Guidance on the NFIP requirements for the design and construction of dry floodproofing systems below-grade parking area under new and substantially improved non-residential and mixed-use buildings located in Zones A, AE, A1-30, AR, AO, and AH. Used in conjunction with TB 3 to highlight issues specific to dry floodproofed below-grade parking areas.
7	*Wet Floodproofing Requirements for Structures Located in Special Flood Hazard Areas* (1993)	Guidance on the NFIP requirements concerning measures referred to as "wet floodproofing" applied to certain types of structures in Zones A, AE, A1-30, AR, AO, and AH.
8	*Corrosion Protection for Metal Connectors and Fasteners in Coastal Areas* (2019)	Why maintaining the load paths in buildings is important and the important role that the proper corrosion protection of metal connectors and fasteners has in ensuring that buildings in coastal areas are adequately anchored and connected to resist floods and high wind events.

Table 1: Technical Bulletin Synopses (cont.)

TB No.	Title (Date)	Synopsis
9	*Design and Construction Guidance for Breakaway Walls Below Elevated Buildings Located in Coastal High Hazard Areas* (2008)	Prescriptive, simplified, and performance-based design approaches to meeting NFIP requirements in the design and construction of wood-framed breakaway walls beneath elevated buildings in Coastal High Hazard Areas (Zones V, VE, and V1-30).
10	*Ensuring That Structures Built on Fill In or Near Special Flood Hazard Areas Are Reasonably Safe From Flooding* (2001)	Regulatory and technical guidance on ensuring that the construction of the following buildings are reasonably safe from flooding: buildings with various types of foundations, including basements, in areas that have been proposed to be removed from the SFHA through the placement of fill and in areas near the SFHA.
11	*Crawlspace Construction for Buildings Located in Special Flood Hazard Areas* (2001)	Interim guidance on minimum NFIP requirements for below-grade crawlspace construction that may extend 1 or 2 feet below grade.

BFE = base flood elevation
FEMA = Federal Emergency Management Agency
NFIP = National Flood Insurance Program
SFHA = Special Flood Hazard Area
TB = Technical Bulletin

1.4 Organization of Technical Bulletin 0 – User's Guide to Technical Bulletins

This User's Guide to Technical Bulletins contains:

- Information on how to use the Technical Bulletins
- Crosswalk of the NFIP regulations and the Technical Bulletins
- Key concepts and requirements in the Technical Bulletins
- Glossary of acronyms and key terms
- How to obtain copies of Technical Bulletins and submit comments
- FEMA Headquarters and Regional office contact information
- Index of key words and subjects in the Technical Bulletins
- References and resources

2 How to Use the Technical Bulletins

FEMA revises or develops new Technical Bulletins as needed to provide guidance to state and local officials, design professionals, contractors, building owners and operators, planners, and other interested stakeholders to help them comply with NFIP floodplain management requirements.

The Technical Bulletins are focused on minimum NFIP floodplain management criteria. They also provide guidance on best practices for floodplain management and flood hazard-resistant construction, building codes and standards, and NFIP flood insurance considerations.

2.1 Minimum NFIP Floodplain Management Criteria

To participate in the National Flood Insurance Program, communities must adopt regulations that meet or exceed the minimum requirements in 44 CFR § 60.3. The Technical Bulletins provide specific FEMA guidance on complying with minimum NFIP floodplain management requirements. If a community chooses not to use the methods or implement the measures that are described in the Technical Bulletins, the community must demonstrate how it is meeting the requirements of 44 CFR § 60.3.

In addition to the community's responsibility to ensure specific building requirements are met, such as elevating or dry floodproofing buildings, elevating or otherwise protecting utilities, and installing openings in enclosure walls, communities are also required to review development proposals "to determine whether such proposals will be reasonably safe from flooding" (44 CFR § 60.3(a)(4)).

To participate in the NFIP, all communities must adopt a resolution or ordinance that expresses a "commitment to recognize and evaluate flood hazards in all official actions and to take such other official action as reasonably necessary to carry out the objectives of the program" (44 CFR § 59.22(a)(8)). This is in addition to the general requirement that communities "take into account flood hazards to the extent that they are known in all official actions relating to land management and use" (44 CFR § 60.1(c)).

MINIMUM FLOODPLAIN MANAGEMENT CRITERIA

The guidance in the Technical Bulletins represents established, application methodologies for minimum NFIP floodplain management criteria.

REASONABLY SAFE FROM FLOODING

The Technical Bulletins can be used by communities to help them evaluate whether proposed development will be reasonably safe from flooding.

COMMUNITY COMMITMENT TO REDUCING FLOOD LOSSES

Using the guidance in the Technical Bulletins illustrates a community's commitment towards evaluating and addressing flood hazards.

2.2 Best Practices

Some of the best practices for floodplain management and flood hazard-resistant construction that are described in the Technical Bulletins are recommendations for increasing hazard resistance in buildings and their utility systems and for reducing the loss of life and property and economic and social hardships.

FEMA strongly encourages that these best practices be:

- Incorporated into state or community floodplain management ordinances or building codes

USE OF SHALL OR MUST

"Shall" or "must" in the Technical Bulletins indicates official guidance on methods or measures required for compliance with 44 CFR § 60.3. Descriptions of other measures, such as best practices, do not use "shall" or "must." FEMA strongly encourages that best practice measures be considered.

- Implemented by designers, builders, or other stakeholders to reduce risk and improve resilience
- Used to potentially lower NFIP flood insurance premiums

Many of these best practices are based on field-verified data including data from decades of post-disaster building performance assessments.

EXAMPLE OF A BEST PRACTICE FROM TECHNICAL BULLETIN 2, *FLOOD DAMAGE-RESISTANT MATERIALS REQUIREMENTS*

If the lowest floor of a building is elevated higher than the BFE, which is common when the owner wants a full story of elevation to accommodate parking under the building, FEMA recommends that flood damage-resistant materials also be used up to the level of the lowest floor to reduce damage in these areas should flooding exceed the BFE.

2.3 Building Codes and Standards

In addition to complying with the NFIP requirements, all new construction, Substantial Improvements, and repair of Substantial Damage must comply with the applicable building codes and standards that have been adopted and that are enforced by states and communities. Building codes govern the design, construction, alteration, and maintenance of structures. They specify the minimum requirements to adequately safeguard the health, safety, and welfare of building occupants. Rather than create and maintain their own building codes, most states and local jurisdictions adopt the International Codes® (I-Codes®), which are a family of model building codes published by the International Code Council® (ICC®).

I-Codes include the International Residential Code® (IRC®), International Building Code® (IBC®), International Existing Building Code® (IEBC®), and codes that govern the installation of mechanical, plumbing, fuel gas service, and other aspects of building construction. Provisions in state- and community-adopted building codes can vary from these model codes, so coordination with local building officials is necessary to confirm which requirements apply within a given jurisdiction.

The IBC applies to all applicable buildings and structures whereas the scope of the IRC is limited to one- and two-family dwellings and townhomes not more than three stories above grade plane. The IBC can be used to design dwellings, but it is used primarily for buildings and structures other than dwellings within the IRC scope. The flood provisions in the IBC are included by reference to ASCE 24, *Flood Resistant Design and Construction*, a standard developed by the American Society of Civil Engineers (ASCE).

FEMA has deemed that the latest published editions of the I-Codes generally meet or exceed NFIP requirements for buildings and structures. Excerpts of the flood provisions of the I-Codes are available on FEMA's

BUILDING CODES AND STANDARDS COMPARISON WITH NFIP REQUIREMENTS

Each Technical Bulletin provides a comparison of the building codes and standards that are related to the Technical Bulletin's topic and the NFIP requirements. The comparison indicates the aspects of the codes/standards and the NFIP requirements that are equivalent and the aspects of the codes/standards that exceed the NFIP requirements.

BUILDING CODE ADOPTION AND ENFORCEMENT

Building codes are only enforceable if adopted by the State or community but can serve as best practices in communities that have not adopted codes.

Building Science – Flood Publications webpage (https://www.fema.gov/emergency-managers/risk-management/building-science/flood).

The joint ICC and FEMA publication *Reducing Flood Losses Through the International Codes: Coordinating Building Codes and Floodplain Management Regulations, 5th Edition* (2019) recommends that communities coordinate the administration of floodplain management provisions and building codes. Differences in requirements between the regulatory tools can lead to inconsistencies or confusion when administering and enforcing requirements for development in floodprone areas.

2.4 NFIP Flood Insurance Considerations

Each Technical Bulletin addresses NFIP flood insurance considerations related to the topic of the Technical Bulletin. The following stakeholders should be aware of these considerations:

- Local officials, designers, builders, and other stakeholders
- Property owners who are concerned about the impact of design and construction decisions on their NFIP flood insurance premiums

NFIP flood insurance premiums are based on factors that include, but are not limited to, flood risk zone, elevation of the lowest floor above or below the BFE, type of building and foundation, the number of floors, and whether there is a basement or enclosure below the elevated building.

The Technical Bulletins address situations in which a compliant building might still be subject to higher NFIP flood insurance premiums. As only one example, NFIP Technical Bulletin 3, *Requirements for the Design and Certification of Dry Floodproofed Non-Residential and Mixed-Use Buildings Located in Special Flood Hazard Areas*, notes that the minimum NFIP requirements allow a new or Substantially Improved non-residential building in Zone A to have a lowest floor below the base flood elevation (BFE), provided that the building has been designed, constructed, and certified to be floodproofed to the BFE and meets established criteria. However, the NFIP flood insurance rating procedures provide credit for dry floodproofing only if the dry floodproofing measures are certified to be at least 1 foot above the BFE, even if that level of protection is not required by local floodplain management regulations.

NFIP FLOOD INSURANCE

The Technical Bulletins describe how NFIP flood insurance premiums can be affected by changes in design and construction. For example, some best practices can significantly lower annual NFIP flood insurance premiums.

3 Crosswalk of NFIP Regulations and Technical Bulletins

Table 2 is a crosswalk of select NFIP regulations and the Technical Bulletins that provide guidance on them. The table is intended to be a general guide to the Technical Bulletins; it does not include all of the NFIP regulations. See the index in Section 7 for more information on where to find guidance in the Technical Bulletins on specific NFIP regulations.

Table 2: Crosswalk of NFIP Regulations, Technical Bulletins, and Key Concepts

NFIP Regulation	Technical Bulletin Relevant to the NFIP Regulation	Key Concepts in the NFIP Regulations Covered in the Technical Bulletins
44 CFR § 60.3(a)(3) Review all permit applications to determine whether proposed building sites will be reasonably safe from flooding. If a proposed building site is in a flood-prone area, all new construction and substantial improvements shall (i) be designed (or modified) and adequately anchored to prevent flotation, collapse, or lateral movement of the structure resulting from hydrodynamic and hydrostatic loads, including the effects of buoyancy, (ii) be constructed with materials resistant to flood damage, (iii) be constructed by methods and practices that minimize flood damages, and (iv) be constructed with electrical, heating, ventilation, plumbing, and air conditioning equipment and other service facilities that are designed and/or located so as to prevent water from entering or accumulating within the components during conditions of flooding.	**Technical Bulletin 1** *Requirements for Flood Openings in Foundation Walls and Walls of Enclosures Below Elevated Buildings in Special Flood Hazard Areas*	Flood openings in foundation walls and walls of enclosures relieve hydrostatic loads, helping to meet the basic performance requirement to prevent flotation, collapse, or lateral movement due to flood forces.
	Technical Bulletin 2 *Flood Damage-Resistant Materials Requirements for Buildings Located in Special Flood Hazard Areas*	Typical construction materials are classified as acceptable or unacceptable for use below the BFE. Using acceptable materials improves resistance to flood damage.
	Technical Bulletin 3 *Requirements for the Design and Certification of Dry Floodproofed Non-Residential and Mixed-Use Buildings Located in Special Flood Hazard Areas*	When designed to account for flood loads at the flood protection level, dry floodproofed non-residential and the non-residential portions of mixed-use buildings meet the basic performance requirement to be constructed using methods and practices that minimize flood damage.
	Technical Bulletin 4 *Elevator Installation for Buildings Located in Special Flood Hazard Areas*	Installing elevators and associated equipment above the BFE prevents water from entering or accumulating within most elevator components during conditions of flooding.
	Technical Bulletin 5 *Free-of-Obstruction Requirements for Buildings Located in Coastal High Hazard Areas*	Obstructions that divert or obstruct the free flow of floodwater and waves below elevated buildings in Zone V could impose additional flood loads on foundation systems or adjacent buildings.
	Technical Bulletin 6 *Requirements for Dry Floodproofed Below-Grade Parking Areas Under Non-Residential and Mixed-Use Buildings Located in Special Flood Hazard Areas*	Non-residential and mixed-use buildings in Zone A may have dry floodproofed, below-grade parking areas, provided the buildings and garages are designed to account for flood loads and meet the basic performance requirement to be constructed using methods and practices that minimize flood damage.
	Technical Bulletin 7 *Wet Floodproofing Requirements for Structures Located in Special Flood Hazard Areas*	Measures known as “wet floodproofing” may be used for specific types of buildings, including detached garages, storage buildings, some agricultural buildings, and buildings that meet the definition for functionally dependent use. Wet floodproofing reduces hydrostatic loads on buildings by allowing floodwater to enter.

Table 2: Crosswalk of NFIP Regulations, Technical Bulletins, and Key Concepts (cont.)

NFIP Regulation	Technical Bulletin Relevant to the NFIP Regulation	Key Concepts in the NFIP Regulations Covered in the Technical Bulletins
44 CFR § 60.3(a)(3) (cont.)	**Technical Bulletin 8** *Corrosion Protection for Metal Connectors and Fasteners in Coastal Areas*	Corrosion protection for metal fasteners and connectors in buildings in coastal areas is important in helping to ensure that the buildings are adequately anchored and connected to resist flood loads. In buildings that are exposed to moisture and airborne salt, protecting metal connectors and fasteners from corrosion helps prevent structural failure.
	Technical Bulletin 9 *Design and Construction Guidance for Breakaway Walls Below Elevated Buildings Located in Coastal High Hazard Areas*	Walls designed to break away under flood loads help to prevent the walls from obstructing the floodwater and to minimize the transfer of flood and wave loads to the foundations of elevated buildings.
	Technical Bulletin 10 *Ensuring That Structures Built on Fill In or Near Special Flood Hazard Areas Are Reasonably Safe From Flooding*	Residual flood hazards may exist on sites proposed to be modified by placement of compacted earthen fill material and are subject to the requirement to be reasonably safe from flooding.
	Technical Bulletin 11 *Crawlspace Construction for Buildings Located in Special Flood Hazard Areas*	The ground or floor inside certain crawlspace foundations may be below grade if specific limitations are met including, but not limited to, flood velocities, perimeter wall height, and depth below grade.
Applies to All Zone A		
44 CFR § 60.3(c)(2) Require that all new construction and substantial improvements of residential structures within Zones A1-30, AE, and AH zones on the community's FIRM have the lowest floor (including basement) elevated to or above the base flood level.	**Technical Bulletin 10** *Ensuring That Structures Built on Fill In or Near Special Flood Hazard Areas Are Reasonably Safe From Flooding*	The requirement that the lowest floor, including basement, of new and Substantially Improved residential buildings in Zone A be at or above the BFE may be met by elevating buildings on compacted earthen fill material.
	Technical Bulletin 11 *Crawlspace Construction for Buildings Located in Special Flood Hazard Areas*	Although technically basements, below-grade crawlspaces are permitted if communities modify local regulations to explicitly allow below-grade crawlspaces with specific limitations including, but not limited to, flood velocities, perimeter wall height, and depth below grade.

Table 2: Crosswalk of NFIP Regulations, Technical Bulletins, and Key Concepts (cont.)

NFIP Regulation	Technical Bulletin Relevant to the NFIP Regulation	Key Concepts in the NFIP Regulations Covered in the Technical Bulletins
44 CFR § 60.3(c)(3) Require that all new construction and substantial improvements of non-residential structures within Zones A1-30, AE, and AH zones on the community's FIRM (i) have the lowest floor (including basement) elevated to or above the base flood level, or (ii) together with attendant utility and sanitary facilities, be designed so that below the base flood level the structure is watertight with walls substantially impermeable to the passage of water and with structural components having the capability of resisting hydrostatic and hydrodynamic loads and effects of buoyancy.	**Technical Bulletin 3** *Requirements for the Design and Certification of Dry Floodproofed Non-Residential and Mixed-Use Buildings Located in Special Flood Hazard Areas*	Numerous planning and engineering design considerations factor into whether dry floodproofing systems are viable options. Dry floodproofing features include flood shields for openings (doors, windows, louvers), walls and floors that are substantially impermeable and adequately reinforced to withstand floodwater pressures and impact forces generated by floating debris, use of membranes and sealants, installation of pumps, and utility protection.
	Technical Bulletin 6 *Requirements for Dry Floodproofed Below-Grade Parking Areas Under Non-Residential and Mixed-Use Buildings Located in Special Flood Hazard Areas*	Below-grade parking areas are permitted beneath non-residential and mixed-use buildings in Zone A if buildings and below-grade parking areas are dry floodproofed (watertight and substantially impermeable).
	Technical Bulletin 10 *Ensuring That Structures Built on Fill In or Near Special Flood Hazard Areas Are Reasonably Safe From Flooding*	The requirement that the lowest floor, including a basement, of new and Substantially Improved non-residential buildings in Zone A be at or above the BFE may be met by elevating buildings on compacted earthen fill material.
	Technical Bulletin 11 *Crawlspace Construction for Buildings Located in Special Flood Hazard Areas*	Although technically basements, below-grade crawlspaces are permitted if communities modify local regulations to explicitly allow below-grade crawlspaces with specific limitations including, but not limited to, flood velocities, perimeter wall height, and depth below grade.
44 CFR § 60.3(c)(4) Provide that where a non-residential structure is intended to be made watertight below the base flood level, (i) a registered professional engineer or architect shall develop and/or review structural design, specifications, and plans for the construction, and shall certify that the design and methods of construction are in accordance with the accepted standards of practice for meeting the applicable provisions of paragraphs (c)(3)(ii) or (c)(8)(ii) of this section, and (ii) a record of such certificates which includes the specific elevation (in relation to mean sea level) to which such structures are floodproofed shall be maintained with the official designated by the community.	**Technical Bulletin 3** *Requirements for the Design and Certification of Dry Floodproofed Non-Residential and Mixed-Use Buildings Located in Special Flood Hazard Areas*	FEMA Form 086-0-34, NFIP Floodproofing Certificate for Non-Residential Structures provides information necessary for insurance underwriters to rate dry floodproofed buildings. The same form should be used to satisfy the requirement that design professionals certify designs and as-built drawings and inspection. The certificate contains information on the building, certification of the elevation to which the building is floodproofed, and certification by the design professional that the building has been designed and constructed to the accepted standard of practice (ASCE 24-05, ASCE 24-14, or their equivalent).

Table 2: Crosswalk of NFIP Regulations, Technical Bulletins, and Key Concepts (cont.)

NFIP Regulation	Technical Bulletin Relevant to the NFIP Regulation	Key Concepts in the NFIP Regulations Covered in the Technical Bulletins
44 CFR § 60.3(c)(5) Require, for all new construction and substantial improvements, that fully enclosed areas below the lowest floor that are usable solely for parking of vehicles, building access or storage in an area other than a basement and which are subject to flooding shall be designed to automatically equalize hydrostatic flood forces on exterior walls by allowing for the entry and exit of floodwaters. Designs for meeting this requirement must either be certified by a registered professional engineer or architect or meet or exceed the following minimum criteria: A minimum of two openings having a total net area of not less than one square inch for every square foot of enclosed area subject to flooding shall be provided. The bottom of all openings shall be no higher than one foot above grade. Openings may be equipped with screens, louvers, valves, or other coverings or devices provided that they permit the automatic entry and exit of floodwaters.	**Technical Bulletin 1** *Requirements for Flood Openings in Foundation Walls and Walls of Enclosures Below Elevated Buildings in Special Flood Hazard Areas*	Flood openings in foundation walls and walls of enclosures relieve hydrostatic loads, helping to meet the basic performance requirement to prevent flotation, collapse, or lateral movement due to flood forces. Proper design, selection, and installation of flood openings help meet the basic performance requirement to automatically equalize hydrostatic flood forces on exterior walls and prevent flotation, collapse, or lateral movement due to flood forces.
	Technical Bulletin 7 *Wet Floodproofing Requirements for Structures Located in Special Flood Hazard Areas*	Measures known as "wet floodproofing" may be used for specific types of buildings, including detached garages, storage buildings, some agricultural buildings, and buildings that meet the definition for functionally dependent use. Wet floodproofing reduces hydrostatic loads on buildings by allowing floodwater to enter
	Technical Bulletin 11 *Crawlspace Construction for Buildings Located in Special Flood Hazard Areas*	Crawlspaces, including below-grade crawlspaces, are treated as enclosures below elevated buildings. Below-grade crawlspaces may be permitted if communities modify local regulations to explicitly allow below-grade crawlspaces with specific limitations including, but not limited to, flood velocities, perimeter wall height, and depth below grade.
Applies to Zone AO (in addition to requirements for Zone A)		
44 CFR § 60.3(c)(7) Require within any AO zone on the community's FIRM that all new construction and substantial improvements of residential structures have the lowest floor (including basement) elevated above the highest adjacent grade at least as high as the depth number specified in feet on the community's FIRM (at least two feet if no depth number is specified).	**Technical Bulletin 10** *Ensuring That Structures Built on Fill In or Near Special Flood Hazard Areas Are Reasonably Safe From Flooding*	Placing the lowest floor, including basement, of new and Substantially Improved residential buildings in Zone A at or above the BFE may be accomplished by elevating buildings on compacted earthen fill material.
	Technical Bulletin 11 *Crawlspace Construction for Buildings Located in Special Flood Hazard Areas*	Although technically basements, below-grade crawlspaces are permitted if communities modify local regulations to explicitly allow below-grade crawlspaces with specific limitations including, but not limited to, flood velocities, perimeter wall height, and depth below grade.

Table 2: Crosswalk of NFIP Regulations, Technical Bulletins, and Key Concepts (cont.)

NFIP Regulation	Technical Bulletin Relevant to the NFIP Regulation	Key Concepts in the NFIP Regulations Covered in the Technical Bulletins
44 CFR § 60.3(c)(8) Require within any AO zone on the community's FIRM that all new construction or substantial improvements of nonresidential structures (i) have the lowest floor (including basement) elevated above the highest adjacent grade at least as high as the depth number specified in feet on the community's FIRM (at least two feet if no depth number is specified), or (ii) together with attendant utility and sanitary facilities, be completely floodproofed to that [base flood] level to meet the floodproofing standard specified in paragraph 60.3(c)(3)(ii).	**Technical Bulletin 3** *Requirements for the Design and Certification of Dry Floodproofed Non-Residential and Mixed-Use Buildings Located in Special Flood Hazard Areas*	Numerous planning and engineering design considerations factor into whether dry floodproofing is a viable option. Dry floodproofing features include watertight closures, walls and floors that are substantially impermeable and adequately reinforced to withstand base floodwater pressures and impact forces generated by floating debris, use of membranes and sealants, installation of pumps, and utility protection.
	Technical Bulletin 6 *Requirements for Dry Floodproofed Below-Grade Parking Areas Under Non-Residential and Mixed-Use Buildings Located in Special Flood Hazard Areas*	Below-grade parking areas are permitted beneath non-residential and mixed-use buildings in Zone A if the Below-grade parking area is dry floodproofed.
Applies to All Zone V		
44 CFR § 60.3(e)(4) A community shall require that all new construction and substantial improvements in Zones V1-30, VE, and also Zone V if base flood elevation data is available, on the community's FIRM, are elevated on pilings and columns so that: (i) the bottom of the lowest horizontal structural member of the lowest floor (excluding the pilings or columns) is elevated to or above the base flood level; and (ii) the pile or column foundation and the structure attached thereto is anchored to resist flotation, collapse, and lateral movement due to the combined effects of wind and water loads acting simultaneously on all building components. Water loading values used shall be those associated with the base flood. Wind loading values used shall be those required by applicable State or local building standards. A registered professional engineer or architect shall develop or review the structural design, specifications, and plans for the construction, and shall certify that the design and methods of construction to be used are in accordance with accepted standards of practice for meeting the provisions of paragraphs (e)(4)(i) and (ii) of this section.	**Technical Bulletin 5** *Free-of-Obstruction Requirements for Buildings Located in Coastal High Hazard Areas*	Obstructions that divert or obstruct the free flow of floodwater and waves below elevated buildings in Zone V could impose additional flood loads on foundation systems or adjacent buildings. Free-of-obstruction requirements apply to: access stairs and ramps; attached and detached decks and porches; elevators; enclosed areas at or above grade; equipment and tanks; foundation bracing; grade beams; shear walls; concrete slabs; accessory storage structures; detached garages; erosion control structures; fences and privacy walls; fill; on-site septic systems; restroom buildings and comfort stations; and swimming pools and spas.
	Technical Bulletin 8 *Corrosion Protection for Metal Connectors and Fasteners in Coastal Areas*	Where buildings are exposed to moisture and airborne salt, corrosion of light gauge metal connectors and fasteners contributes to the loss of load path. Corrosion protection for metal fasteners and connectors in buildings in coastal areas is important in helping to ensure that the buildings are adequately anchored to resist flotation, collapse, and lateral movement due to the combined effects of wind and water loads acting simultaneously on all building components

Table 2: Crosswalk of NFIP Regulations, Technical Bulletins, and Key Concepts (cont.)

NFIP Regulation	Technical Bulletin Relevant to the NFIP Regulation	Key Concepts in the NFIP Regulations Covered in the Technical Bulletins
44 CFR § 60.3(e)(5) Provide that all new construction and substantial improvements within Zones V1-30, VE, and V on the community's FIRM have the space below the lowest floor either free of obstruction or constructed with non-supporting breakaway walls, open wood lattice-work, or insect screening intended to collapse under wind and water loads without causing collapse, displacement, or other structural damage to the elevated portion of the building or supporting foundation system. For the purposes of this section, a breakaway wall shall have a design safe loading resistance of not less than 10 and no more than 20 pounds per square foot. Use of breakaway walls which exceed a design safe loading resistance of 20 pounds per square foot (either by design or when so required by local or State codes) may be permitted only if a registered professional engineer or architect certifies that the designs proposed meet the following conditions: (i) Breakaway wall collapse shall result from a water load less than that which would occur during the base flood; and (ii) The elevated portion of the building and supporting foundation system shall not be subject to collapse, displacement, or other structural damage due to the effects of wind and water loads acting simultaneously on all building components (structural and non-structural). Water loading values used shall be those associated with the base flood. Wind loading values used shall be those required by applicable State or local building standards. Such enclosed space shall be useable solely for parking of vehicles, building access, or storage.	**Technical Bulletin 5** *Free-of-Obstruction Requirements for Buildings Located in Coastal High Hazard Areas*	Obstructions that divert or obstruct the free flow of floodwater and waves below elevated buildings in Zone V could impose additional flood loads on foundation systems or adjacent buildings. Free-of-obstruction requirements apply to: access stairs and ramps; attached and detached decks and porches; elevators; enclosed areas at or above grade; equipment and tanks; foundation bracing; grade beams; shear walls; concrete slabs; accessory storage structures; detached garages; erosion control structures; fences and privacy walls; fill; on-site septic systems; restroom buildings and comfort stations; and swimming pools and spas.
	Technical Bulletin 9 *Design and Construction Guidance for Breakaway Walls Below Elevated Buildings Located in Coastal High Hazard Areas*	Walls designed to break away under flood loads help to prevent the walls from obstructing the floodwater and to minimize the transfer of flood and wave loads to the foundations of elevated buildings.

BFE = base flood elevation
CFR = Code of Federal Regulations
FEMA = Federal Emergency Management Agency
FIRM = Flood Insurance Rate Map

4 Key Concepts and Requirements for Structures

Users of the Technical Bulletins should have a basic understanding of the following key concepts:

- Special Flood Hazard Areas (SFHAs)
- Lowest floor, enclosure, and basement
- Substantial Improvement and Substantial Damage
- Open foundations in Zone V

These concepts underlie the requirements that are critical in determining compliance with minimum NFIP floodplain management criteria. Most of these concepts and other key terms used in NFIP regulations are defined in Sections 4 and 5.

4.1 Special Flood Hazard Areas

The SFHA is the land area subject to flooding by the base flood. SFHAs are shown on FIRMs prepared by FEMA as Zones A and V. The base flood is the flood that has a 1 percent chance of being equaled or exceeded in any given year (commonly called the "100 year flood"). FIRMs also show Zone X, which are areas outside the SFHA.

In communities that participate in the NFIP, the minimum floodplain management requirements govern development in SFHAs, including buildings and other structures, subdivisions, new and replacement water supply systems, and new and replacement sanitary sewage systems. Floodplain management requirements for buildings and other structures can differ depending on the flood zone in which a structure is located.

NFIP DEFINITION OF DEVELOPMENT

"Any man-made change to improved or unimproved real estate, including but not limited to buildings or other structures, mining, dredging, filling, grading, paving, excavation or drilling operations, or storage of equipment or materials" (44 CFR § 59.1).

Figure 1 shows the typical flood zones from coastal and riverine flood sources. The criteria for construction in Zones V, VE, V1-30 and VO, which are collectively referred to as Zone V or Coastal High Hazard Areas, are generally more stringent than in Zones A, AE, A1–30, AR, AO, and AH, which are collectively referred to as Zone A. Zone A exists in both coastal and riverine flood source environments.

Zone A. In SFHAs identified as Zone A (Zones A, AE, A1-30, AR, AO, and AH), the principal source of flooding is runoff from rainfall, snowmelt, or coastal storms when the potential base flood wave height is less than 3.0 feet. Zone A has minimum requirements that specify the elevation of the lowest floor, including the basement, in relation to the BFE or depth of the base flood. Specific requirements apply to fully enclosed areas below the lowest floor.

Zone V. Zone V (Zones V, VE, V1-30, and VO), also called Coastal High Hazard Areas, extends from offshore to the inland limit of a primary frontal dune along an open coast, and any other area subject to high-velocity wave

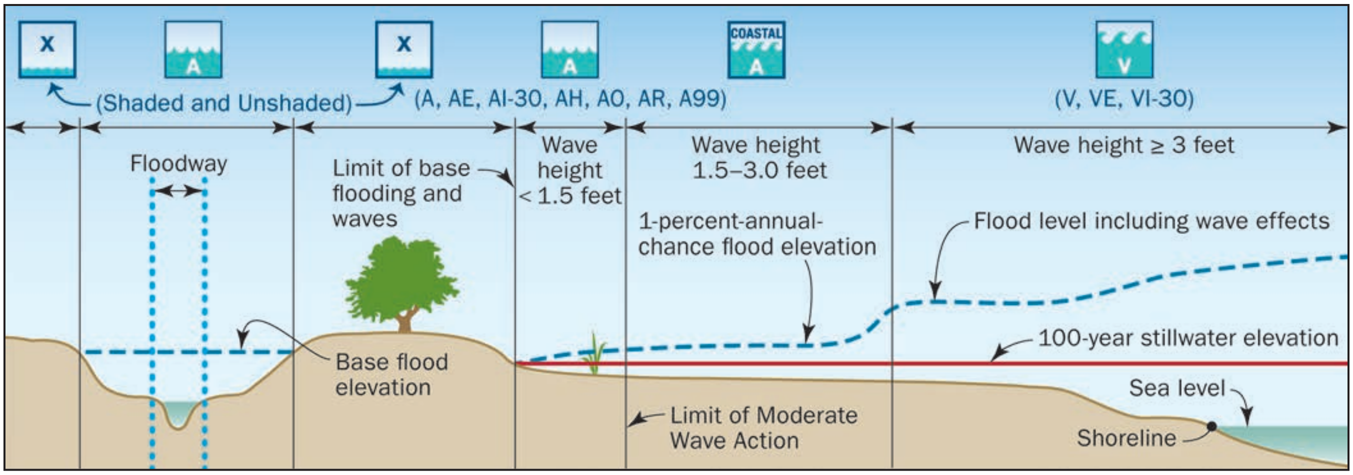

Figure 1: Typical flood zones from coastal and riverine flood sources

action from storms or tsunamis where the potential base flood wave height is 3.0 feet or more. Zone V has minimum requirements pertaining to the siting of buildings, elevation of the lowest horizontal structural member of the lowest floor in relation to the BFE, foundation design, enclosures below the lowest floor, and alterations of sand dunes and mangrove stands.

Zone X. Zone X identifies areas outside the SFHA. Zone X (shaded) identifies two areas of moderate flood hazard: (1) areas subject to inundation by the flood that has a 0.2 percent chance of being equaled or exceeded during any given year (commonly called the "500-year flood") and (2) areas protected by accredited levee systems. Zone X (unshaded) identifies areas of minimal flood hazard, which are outside the 500-year floodplain. The NFIP floodplain management requirements do not apply in Zone X.

Example of Criteria Difference. An example of a difference in criteria for Zone A and Zone V is where the lowest floor is measured (see Figure 2):

- In Zone A, the lowest floor (including basement) of a structure must be elevated to or above the BFE.
- In Zone V, the bottom of the lowest horizontal structural member of the lowest floor of a structure (excluding pilings or columns) must be elevated to or above the BFE.

COASTAL A ZONE

Since 2009, coastal flood studies have examined wave conditions in Zone A. Based on the studies, FEMA delineates an informational line called the Limit of Moderate Wave Action (LiMWA) on FIRMs where wave heights in Zone A are expected to be 1.5 feet or greater during base flood conditions. See Figure 1.

FEMA uses the term "Coastal A Zone" to refer to areas seaward of the LiMWA and landward of the Zone V boundary or landward of the shoreline where Zone V is not identified. The term refers to some areas identified as Zone A that are subject to flooding from a coastal or tidal source. However, Coastal A Zones are not identified on FIRMs, and the NFIP regulations for development in SFHAs and the NFIP regulations that govern the identification of SFHAs on maps do not use the term "Coastal A Zone."

The NFIP floodplain management requirements regulate areas identified as Coastal A Zones to Zone A standards. FEMA's Community Rating System awards credits to communities that regulate Coastal A Zones to Zone V standards. The latest editions of the I-Codes and ASCE 24 require buildings in Coastal A Zones to meet Zone V requirements; FEMA guidance, best practices, and FEMA Mitigation Assessment Team reports support this requirement.

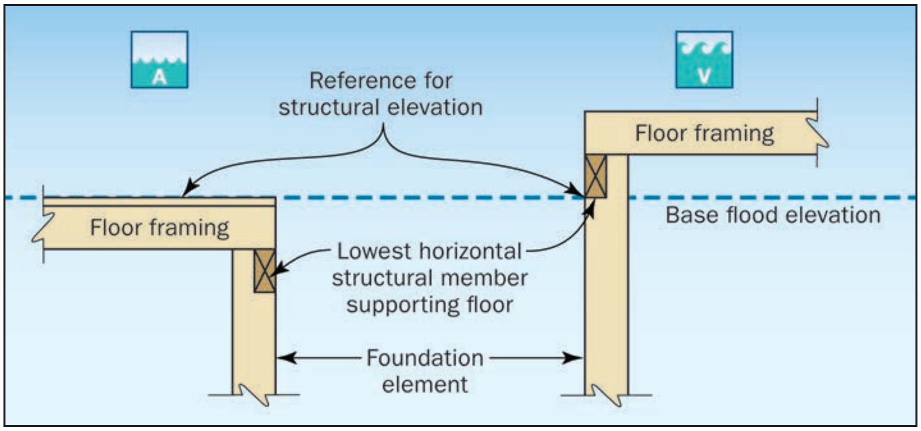

Figure 2: Lowest floor reference point for Zone A (at top of lowest floor) versus Zone V (at bottom of lowest horizontal structural member of lowest floor)

4.2 Lowest Floor, Enclosure, and Basement

Under the NFIP:

- The **lowest floor** is defined as "the lowest floor of the lowest enclosed area (including basement). An unfinished or flood resistant enclosure, usable solely for parking of vehicles, building access or storage in an area other than a basement area is not considered a building's lowest floor; *Provided*, that such enclosure is not built so as to render the structure in violation of the applicable non-elevation design requirements of § 60.3" (44 CFR § 59.1).
- An **enclosure** is an area below an elevated building that is enclosed by walls on all sides.
- A **basement** is defined as "any area of the building having its floor subgrade (below ground level) on all sides" (44 CFR § 59.1).

4.3 Substantial Improvement and Substantial Damage

The repair or improvement of buildings presents an opportunity to reduce future flood damage to structures and to improve their resilience. Local floodplain management regulations based on the NFIP and building codes contain requirements that apply not only to new structures but also to buildings with proposed Substantial Improvements or repair of Substantial Damage (described below).

As part of issuing permits, local officials must review not only proposals for new construction but also for work on existing buildings to determine whether the work constitutes Substantial Improvement or repair of Substantial Damage. If the work is determined to constitute Substantial Improvement or repair of Substantial Damage, the buildings must be brought into compliance with the NFIP requirements for new construction, including the requirement that the lowest floor be elevated to or above the BFE. Meeting this requirement can also be accomplished by demolishing the building followed by constructing a new building that meets the NFIP requirements on the same site or by relocating the building to outside the SFHA. More information on Substantial Improvement and Substantial Damage can be found in FEMA P-758, *Substantial Improvement/Substantial Damage Desk Reference* (2010), and FEMA 213, *Answers to Questions About Substantially Improved/Substantially Damaged Buildings* (2018).

Substantial Improvement is defined in 44 CFR § 59.1 as:

> … Any reconstruction, rehabilitation, addition, or other improvement of a structure, the cost of which equals or exceeds 50 percent of the market value of the structure before the "start of construction" of the improvement. This term includes structures which have incurred "substantial damage," regardless of the actual repair work performed. The term does not, however, include either:
>
> (1) Any project for improvement of a structure to correct existing violations of state or local health, sanitary, or safety code specifications which have been identified by the local code enforcement official and which are the minimum necessary to assure safe living conditions or
>
> (2) Any alteration of a "historic structure," provided that the alteration will not preclude the structure's designation as a "historic structure."

Substantial Damage is defined in 44 CFR § 59.1 as "damage of any origin sustained by a structure whereby the cost of restoring the structure to its before-damaged condition would equal or exceed 50 percent of the market value of the structure before the damage occurred." Substantial Damage can have any cause, not just flooding.

Some communities modify the definitions of Substantial Improvement and Substantial Damage requirements in one of two ways: (1) adopting a lower threshold than 50 percent (e.g., 40 percent, 30 percent) or (2) tracking costs of improvements and costs of repairs over a specific period, referred to as "cumulative Substantial Improvement."

4.4 Open Foundations in Zone V

Coastal waves and flooding can exert strong hydrodynamic forces on any building element that is exposed to waves or the flow of water. Therefore, open foundation systems that offer minimal resistance to waves and floodwaters passing beneath elevated buildings (e.g., pile and column foundations) are required in Zone V.

The NFIP requires that all new construction and Substantially Improved buildings in Zone V be elevated to or above the BFE on open foundations (pilings, columns) that allow floodwater and waves to pass beneath the elevated structure. The NFIP further requires that areas below elevated structures remain free of obstructions that would prevent the free flow of coastal floodwater and waves during a base flood event. The NFIP considers shear walls acceptable in limited circumstances where lateral loads on upper stories of buildings cannot be adequately resisted by piling or column foundations.

COASTAL A ZONE WAVE HAZARD

Coastal A Zones are subject to conditions similar to those in Zone V (Coastal High Hazard Areas), including breaking waves, erosion, and scour.

Although the minimum NFIP requirements for Coastal A Zones are the same as Zone A, it is recommended that structures in Coastal A Zones be designed and constructed to Zone V standards.

5 Acronyms and Key Terms

The acronyms and key terms that are used in the Technical Bulletins are defined in Sections 5.1 and 5.2, respectively.

5.1 Acronyms Used in the Technical Bulletins

ACI	American Concrete Institute
ADA	Americans with Disabilities Act
AF&PA	American Forest & Paper Association
ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
ASD	Allowable Stress Design
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWC	American Wood Council
BFE	base flood elevation
CAZ	Coastal A Zone
CCA	chromated copper arsenate
CFR	Code of Federal Regulations
CMU	concrete masonry unit
DFE	design flood elevation
DHS	Department of Homeland Security
EIFS	Exterior Insulation Finishing System
FEMA	Federal Emergency Management Agency
FHBM	Flood Hazard Boundary Map
FIA	Federal Insurance Administration
FIMA	Federal Insurance and Mitigation Administration
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
IBC	International Building Code®
ICC	International Code Council
ICC-ES	ICC Evaluation Service
I-Codes	International Codes®
IEBC	International Existing Building Code®
IMOA	International Molybdenum Association
IRC	International Residential Code®
LAG	lowest adjacent grade
LiMWA	Limit of Moderate Wave Action
LOMC	Letter of Map Change
LOMR-F	Letter of Map Revision based on fill
MAT	Mitigation Assessment Team
MRL	machine room-less traction elevators
MSJC	Masonry Standard Joint Committee
NDS	National Design Specification
NEMA	National Emergency Management Agency; National Electrical Manufacturers Association
NFIP	National Flood Insurance Program
NFPA	National Fire Protection Association
NGVD	National Geodetic Vertical Datum
ORNL	Oak Ridge National Laboratory
oz/ft^2	ounces per square foot
PFD	primary frontal dune
PWF	Permanent Wood Foundation
SBX/DOT	sodium borate disodium octaborate tetrahydrate
SEI	Structural Engineering Institute
SERRI	Southeast Region Research Initiative
SFHA	Special Flood Hazard Area
SFIP	Standard Flood Insurance Policy
SSPC	Society for Protective Coatings
TB	Technical Bulletin
TPI	Truss Plate Institute
USACE	U.S. Army Corps of Engineers
VPL	vertical platform lift
WTCA	Wood Truss Council of America

5.2 Glossary of Terms Used in Technical Bulletins

The quoted material from ASCE 24-14 in this glossary is used with permission.

> **DEFINITION OF TERMS**
>
> Readers are cautioned that the definitions of some of the terms that are used in the Technical Bulletins are not the same when used by the NFIP for the purpose of rating flood insurance policies. Definitions specific to NFIP flood insurance can be found in FEMA's *Flood Insurance Manual*.

Accessory structure: A structure on the same parcel of property as a principal structure, the use of which is incidental to the use of the principal structure. Detached garages used for parking of vehicles and limited storage and small sheds used for limited storage are considered accessory structures (see FEMA Policy #104-008-03 and FEMA Floodplain Management Bulletin P-2140, *Floodplain Management Requirements for Agricultural Structures and Accessory Structures* (2020)).

Active: Dry floodproofing measures or dry floodproofing system components that require human intervention or action before the onset of flooding to be effective (e.g., flood shields that must be installed valves that must be closed).

Area of special flood hazard: "Land in the flood plain within a community subject to a 1 percent or greater chance of flooding in any given year. The area may be designated as Zone A on the Flood Hazard Boundary Map (FHBM). After detailed ratemaking has been completed in preparation for publication of the flood insurance rate map, Zone A usually is refined into Zones A, AO, AH, A1-30, AE, A99, AR, AR/A1-30, AR/AE, AR/AO, AR/AH, AR/A, VO, or V1-30, VE, or V. For purposes of these regulations, the term 'special flood hazard area' is synonymous in meaning with the phrase 'area of special flood hazard' " (44 CFR § 59.1).

Ancillary area: Common area such as a lobby, foyer, office used by building management, exercise space, meeting room, and mail room (FEMA P-2037, *Flood Mitigation Measures for Multi-Family Buildings* [2019])

Base flood: "Flood having a one percent chance of being equaled or exceeded in any given year" (44 CFR § 59.1).

Base flood elevation (BFE): The computed elevation to which floodwater is anticipated to rise during the base flood, including wave height, relative to the datum specified on the Flood Insurance Rate Map. The BFE is shown on the FIRM for Zones AE, AH, A1–30, AR, AR/A, AR/AE, AR/A1–30, V1–30, and VE. For Zones AR/AH and AR/AO, a depth of flooding is provided for the 1 percent annual chance event. SFHAs without BFEs are identified on FIRMs as Zone A or Zone V. When BFEs are not identified, communities must obtain, review and reasonably use any BFE data available from a federal, state, or other source.

Basement: "Area of the building having its floor subgrade (below ground level) on all sides" (44 CFR § 59.1). NFIP regulations do not allow basements to extend below the BFE except in dry-floodproofed, non-residential buildings.

Breakaway wall: "A wall that is not part of the structural support of the building and is intended through its design and construction to collapse under specific lateral loading forces without causing damage to the elevated portion of the building or supporting foundation system" (44 CFR § 59.1).

Coastal A Zone: "Area within *a special flood hazard area*, landward of a *V Zone* or landward of an open coast without mapped *V Zones*. In a Coastal A Zone, the principal source of flooding must be astronomical tides, storm surges, seiches, or tsunamis, not riverine flooding. During the *base flood* conditions, the potential for breaking *wave heights* shall be greater than or equal to 1.5 feet. The inland limit of the Coastal A Zone is (1) the *Limit of Moderate Wave Action* if delineated on a *FIRM*, or (2) designated by the *authority having jurisdiction*" (ASCE 24-14).

Coastal High Hazard Area: "An area of special flood hazard extending from offshore to the inland limit of a primary frontal dune along an open coast and any other area subject to high velocity wave action from storms or seismic sources" (44 CFR § 59.1). The coastal high hazard area is shown on a FIRM or other flood hazard map as Zone V, VO, VE, or V1-30.

Community: "Any State or area or political subdivision thereof, or any Indian tribe or authorized tribal organization, or Alaska Native village or authorized native organization, which has authority to adopt and enforce floodplain management regulations for the areas within its jurisdiction" (44 CFR § 59.1).

Design flood: "The flood associated with the greater of the following two areas: (1) area within a *floodplain* subject to a 1% or greater chance of flooding in any year, or (2) area designated as a *flood hazard area* on a *community's flood hazard map* or otherwise legally designated" (ASCE 24-14).

Design flood elevation (DFE): "Elevation of the *design flood*, including *wave height*, relative to the *datum* specified on the *community's flood hazard map*" (ASCE 24-14). In areas designated as Zone AO, the design flood elevation is the elevation of the highest existing grade of the building's perimeter plus the depth number (in feet) specified on the flood hazard map. In areas designated as Zone AO where a depth is not specified on the map, the depth is taken as equal to 2 feet. The DFE is the locally adopted regulatory flood elevation. If a community regulates based on the FIRM, the DFE is identical to the BFE. If a community chooses to regulate based on a different flood hazard map, a lower frequency flood, or adds freeboard, the DFE must be at least as high as the BFE.

Detailing: Design practice of using structural and architectural drawings and specifications to arrange, configure, and connect structural and nonstructural building components of a building system. Design details convey to the contractor exactly how the structural and nonstructural components of a building should be built.

Development: "Any man-made change to improved or unimproved real estate, including but not limited to buildings or other structures, mining, dredging, filling, grading, paving, excavation or drilling operations or storage of equipment or materials" (44 CFR § 59.1).

Elevation Certificate: An NFIP administrative tool used to document elevation and other information necessary to determine compliance with a community's floodplain management requirements, determine proper insurance premium rates, or support requests for Letters of Map Change (LOMCs). FEMA Form 086-0-33.

Enclosure or enclosed area: An area below an elevated building that is enclosed by walls on all sides. The NFIP does not explicitly define "enclosure," but it is mentioned in the definition of "lowest floor." Enclosures may be formed by foundation perimeter walls (crawlspace), framed walls, or breakaway walls. Also defined in ASCE 24-14 as the "confined area below the *DFE*, formed by walls on all sides of the enclosed space."

Existing construction (may also be referred to as existing construction/structures): For the purposes of determining flood insurance rates, structures for which the "start of construction" commenced before the effective date of the FIRM or before January 1, 1975, for FIRMs effective before that date. "Existing construction" may also be referred to as "existing structures" (44 CFR § 59.1). Also defined in ASCE 24-14 as "any structure for which the *start of construction* commenced before the effective date of the first *floodplain* management code, ordinance, or standard adopted by the *authority having jurisdiction*."

Flood Hazard Boundary Map (FHBM): "Official map of a community, issued by the Federal Insurance Administrator, where the boundaries of the flood, mudslide (i.e., mudflow) related erosion areas having special hazards have been designated as Zones A, M and/or E" (44 CFR § 59.1).

Flood Insurance Rate Map (FIRM): "Official map of a community, on which … [FEMA] has delineated both the special hazard areas and the risk premium zones applicable to the community" (44 CFR § 59.1).

Flood Insurance Study (FIS) (flood elevation study): "An examination, evaluation and determination of flood hazards and, if appropriate, corresponding water surface elevations, or an examination, evaluation and determination of mudslide (i.e., mudflow) and/or flood-related erosion hazards" (44 CFR § 59.1). The FIS is the official report provided by FEMA that contains the FIRM, the Flood Boundary and Floodway Map (if applicable), the water surface elevations of the base flood, and supporting technical data.

Flood protection level: Elevation to which flood protection measures are designed. The flood protection level is the most restrictive of (1) the BFE plus the prescribed amount of freeboard specified in ASCE 24, (2) the design flood elevation (DFE) if a different flood is used for regulatory purposes, and (3) the elevation relative to the BFE specified in local floodplain management regulations.

Flood shield: Removable or permanent, substantially impermeable protective cover or panel for openings in the portions of a dry floodproofed building that are below the flood protection level (e.g., doors, windows, and louvers).

Floodplain or floodprone area: "Any land area susceptible to being inundated by water from any source" (44 CFR § 59.1).

Floodproofing, dry: "Any combination of structural and non-structural additions, changes, or adjustments to structures which reduce or eliminate flood damage to real estate or improved real property, water and sanitary facilities, structures and their contents" (44 CFR § 59.1). Referred to simply as "flood proofing" in 44 CFR § 59.1. Further defined in ASCE 24-14 as "a combination of measures that results in a structure, including the *attendant utilities and equipment*, being water tight, with all elements *substantially impermeable* and with structural components having the capacity to resist flood loads."

Floodproofing, wet: "*Floodproofing* method that relies on the use of *flood damage-resistant materials* and construction techniques in areas of a structure that are below the elevation required by this standard by intentionally allowing those areas to flood" (ASCE 24-14). The NFIP does not define wet floodproofing. Wet floodproofing measures allow areas to flood in such a way that damage to a structure and its contents is minimized by using specific design, construction, and planning measures outlined in Technical Bulletin 7, *Wet Floodproofing Requirements for Structures Located in Special Flood Hazard Areas*.

Floodproofing Certificate for Non-Residential Structures: An NFIP administrative tool that documents certification by a registered professional engineer or architect that the design and methods of construction of a non-residential building are in accordance with accepted standard of practices for meeting a community's floodplain management requirements for floodproofing. This documentation is required for both floodplain management requirements and NFIP flood insurance rating purposes. FEMA Form 086-0-034.

Flow diversion: Change in the course of flood flow when it encounters an object or structure. Diversion can be accompanied by an increase in the local flood level and/or flood velocity when the blockage is large relative to the area through which the flow would otherwise pass.

Hydrodynamic loads: "Loads imposed on an object [such as a building or foundation element] by water flowing against and around it" (ASCE 24-14). Examples are positive frontal pressure against the structure, drag effect along the sides, and negative pressure on the downstream side. The magnitude of hydrodynamic load varies as a function of the square of velocity and other factors.

Hydrostatic loads: "Loads imposed on an object [or a surface, such as a wall or floor slab] by a standing mass of water" (ASCE 24-14). Hydrostatic loads can be caused by slowly moving masses of water. Hydrostatic load increases as water depth increases.

Limit of Moderate Wave Action (LiMWA): "The inland limit of the area affected by [breaking] waves greater than 1.5 feet" (FEMA Procedure Memorandum No. 50). FEMA began delineating the LiMWA on coastal FIRMs in 2009.

Lowest floor: Lowest floor of the lowest enclosed area of a building, including basement. An unfinished or flood-resistant enclosure that is used solely for parking of vehicles, building access, or storage in an area other than a basement area is not considered a building's lowest floor, provided the enclosure is built in compliance with applicable requirements.

Mixed-use building: Building that has both residential and commercial or other non-residential uses. The term does not include multi family residential buildings that have ancillary areas but no non-residential uses.

Net open area: Permanently open area of a non-engineered flood opening.

New construction (may also be referred to as new construction/structures): "… For floodplain management purposes, new construction means structures for which the *start of construction* commenced on or after the effective date of a floodplain management regulation adopted by a community and includes any subsequent improvements to such structures" (44 CFR § 59.1). Further defined in ASCE 24-14 as "structures for which the *start of construction* commenced on or after the effective date of the first *floodplain* management code, regulation, ordinance, or standard adopted by the *authority having jurisdiction*, including any subsequent improvements to such structures. New construction includes work determined to be *substantial improvement*."

Non-residential building: Building that has a commercial or other non-residential use.

Opening, engineered: Opening, with moving parts, used to meet the requirement in 44 CFR § 60.3(c)(5) that is "certified by a registered professional engineer or architect" for meeting the requirement in 44 CFR § 60.3(c)(5) to "be designed to automatically equalize hydrostatic flood forces on exterior walls by allowing for the entry and exit of floodwaters."

Opening, non-engineered: Opening, without moving parts, used to meet the prescriptive requirement in 44 CFR § 60.3(c)(5) to provide "a total net area of not less than one square inch for every square foot of enclosed area subject to flooding."

Passive: Dry floodproofing measures or dry floodproofing systems that do not require human intervention or action before the onset of flooding to be effective (e.g., specially designed doors that are sealed when closed, designed window systems, flood shields that are designed to close automatically when triggered by rising floodwater).

Primary frontal dune: "A continuous or nearly continuous mound or ridge of sand with relatively steep seaward and landward slopes immediately landward and adjacent to the beach and subject to erosion and overtopping from high tides and waves during major coastal storms. The inland limit of the primary frontal dune occurs at the point where there is a distinct change from a relatively steep slope to a relatively mild slope" (44 CFR § 59.1).

Registered design professional: Individual who is registered or licensed to practice his or her design profession (e.g., architect, engineer, land surveyor) as defined by the statutory requirements of the professional registration laws of the state or jurisdiction in which a project is to be constructed.

Residential building: Building designated for habitation. Ancillary areas that serve only residents are residential ancillary areas. They include laundry facilities, storage rooms, mail rooms, recreational rooms, parking garages and exercise facilities.

Special Flood Hazard Area (SFHA): Area subject to flooding by the base flood (1-percent-annual chance flood) and shown on Flood Insurance Rate Maps (FIRMs) as Zones A, AO, AH, A1-30, AE, A99, AR, AR/A1-30, AR/AE, AR/AO, AR/AH, AR/A, VO, or V1-30, VE, or V (see "area of special flood hazard" in 44 CFR § 59.1).

Standard residential garage door: A door, typically up to 18 feet wide by up to 8 feet tall, intended for use in a residential garage for vehicular access and normally expected to be operated less than 1,500 cycles per year.

Structure: For floodplain management purposes, "a walled and roofed building, including a gas or liquid storage tank, that is principally above ground, as well as a manufactured home" (44 CFR § 59.1).

Substantial Damage: "Damage of any origin sustained by a structure whereby the cost of restoring the structure to its before damaged condition would equal or exceed 50 percent of the market value of the structure before the damage occurred" (44 CFR § 59.1).

Substantial Improvement: "Any reconstruction, rehabilitation, addition, or other improvement of a structure, the cost of which equals or exceeds 50 percent of the market value of the structure before the "start of construction" of the improvement. This term includes structures that have incurred "substantial damage," regardless of the actual repair work performed. The term does not, however, include either:

(1) Any project for improvement of a structure to correct existing violations of state or local health, sanitary, or safety code specifications which have been identified by the local code enforcement official and which are the minimum necessary to assure safe living conditions or

(2) Any alteration of a 'historic structure,' provided that the alteration will not preclude the structure's continued designation as a 'historic structure.'" (44 CFR § 59.1).

Substantially impermeable: The use of materials and techniques that restrict the passage of water and seepage through pathways (joints, cracks, openings, channels) and points of entry and that limits the accumulation of water during flooding. According to ASCE 24 and the U.S. Army Corps of Engineers (USACE), a structure is considered substantially impermeable if the maximum accumulation of water is not more than 4 inches in a 24-hour period without relying on devices for the removal of the water (USACE, 1995).

Variance: "Grant of relief by a community from the terms of a flood plain management regulation" (44 CFR § 59.1).

Wave reflection: Return or redirection of a wave striking an object.

Wave runup: Rush of water running up a slope or structure.following wave breaking.

Zone A: Flood zones shown on FIRMs as Zone A, AE, A1-30, AH, AO, A99, and AR.

Zone V: Flood zones shown on FIRMs as Zone V, VE, V1-30, and VO.

6 Supplemental Information

6.1 How to Obtain Technical Bulletins

Download Technical Bulletins at no charge from the FEMA website at https://www.fema.gov/emergency-managers/risk-management/building-science/national-flood-insurance-technical-bulletins.

Order Technical Bulletins at no charge from the FEMA Publications Warehouse by:

- Calling 1-800-480-2520, Monday-Friday, 8 a.m.- 5 p.m. Eastern Time
- Faxing a request to 1-719-948-9724
- Sending an email to FEMApubs@gpo.gov

6.2 How to Submit Comments on the Technical Bulletins

FEMA welcomes your comments and recommendations on the Technical Bulletins and may include, for example:

- Requests for clarifications of the guidance in the Technical Bulletins
- Requests for additional guidance
- Recommendations for new Technical Bulletins

Send your comments to:

DHS/FEMA
ATTN: Federal Insurance and Mitigation Administration,
Risk Management Directorate – Building Science Branch
400 C Street, S.W., Sixth Floor
Washington, DC 20472-3020

6.3 How to Get More Information

For questions on any of the Technical Bulletins, email the Building Science Helpline at FEMA-buildingsciencehelp@fema.dhs.gov or call 1-866-927-2104.

For additional guidance on NFIP regulatory requirements, contact your NFIP State Coordinating Agency (www.floods.org) or the FEMA Regional office in your Region (see Section 6.4).

6.4 FEMA Regional Offices

The locations of FEMA Headquarters and the 10 FEMA Regional Offices are shown in Figure 3, and addresses and telephone numbers are listed in Table 3. Staff members of the FEMA Regional Offices for your area can provide you with more information about the NFIP and Technical Bulletins.

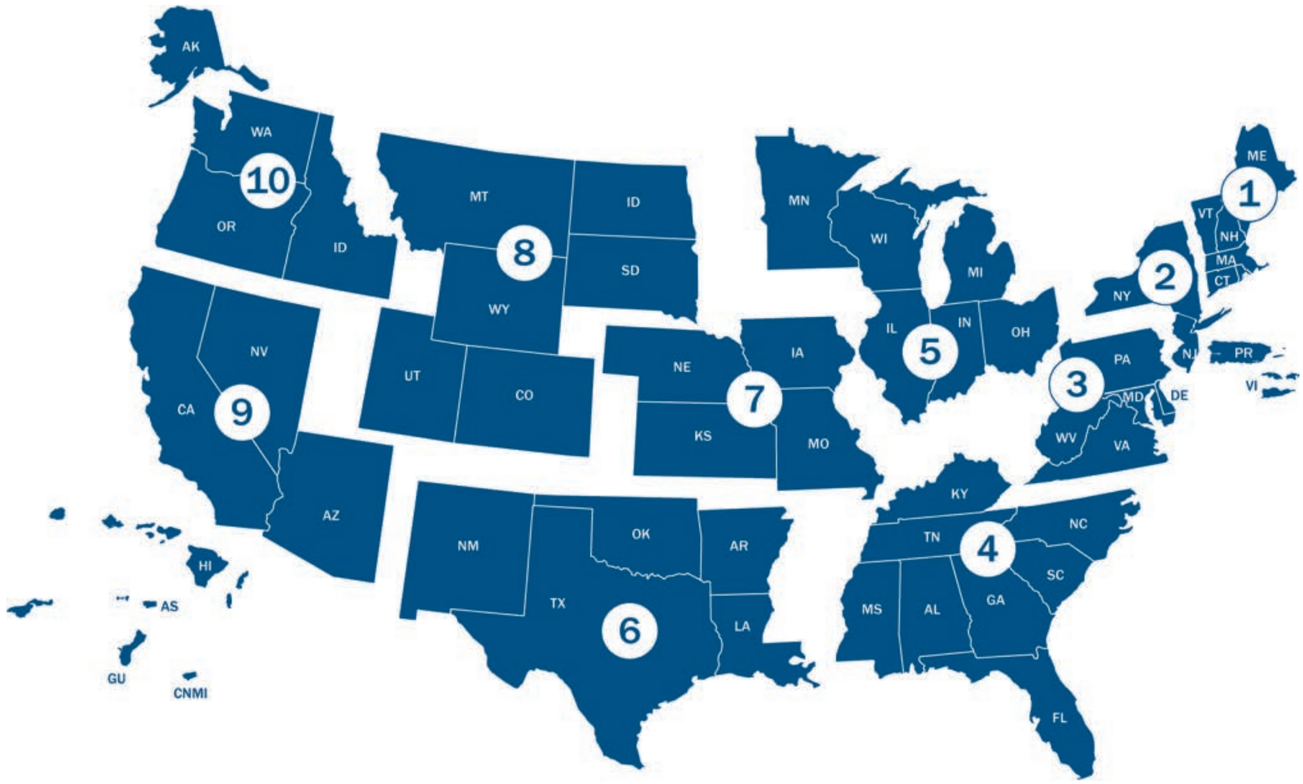

Figure 3: Locations of FEMA Headquarters and 10 FEMA Regional Offices

Table 3: FEMA Headquarters and Regional Office Contact Information

HQ / Region	States/Territories	Address	Phone No.
FEMA / FIMA Headquarters		400 C Street, S.W. Washington, DC 20472-3020	202-646-2500 800-621-FEMA (3362) TTY: 800-462-7585
Region 1	Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont	99 High Street Boston, MA 02110	877-336-2734
Region 2	New Jersey, New York, Puerto Rico, Virgin Islands	One World Trade Center 52nd Floor	212-680-3600
Region 3	Washington, D.C., Delaware, Maryland, Pennsylvania, Virginia, West Virginia	New York, NY 10007-0101 615 Chestnut Street One Independence Mall, 6th Floor Philadelphia, PA 19106-4404	215-931-5500
Region 4	Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee	3003 Chamblee Tucker Road Atlanta, GA 30341-4112	770-220-5200
Region 5	Illinois, Indiana, Michigan, Minnesota, Ohio, Wisconsin	536 South Clark Street, Sixth Floor Chicago, IL 60605-1521	312-408-5500

Table 3: FEMA Headquarters and Regional Office Contact Information (Cont.)

HQ / Region	States/Territories	Address	Phone No.
Region 6	Arkansas, Louisiana, New Mexico, Oklahoma, Texas	Federal Regional Center 800 North Loop 288 Denton, TX 76209-3698	940-898-5399
Region 7	Iowa, Kansas, Missouri, Nebraska	9221 Ward Parkway, Suite 300 Kansas City, MO 64114-3372	816-283-7061
Region 8	Colorado, Montana, North Dakota, South Dakota, Utah, Wyoming	Denver Federal Center Building 710, Box 25267 Denver, CO 80255-0267	303-235-4800
Region 9	Arizona, California, Hawaii, Nevada, American Samoa, Commonwealth of the Northern Mariana Islands, Federated States of Micronesia, Guam, Republic of the Marshall Islands,	1111 Broadway, Suite 1200 Oakland, CA 94607-4052	510-627-7100 Pacific Area Office: 808-851-7900
Region 10	Alaska, Idaho, Oregon, Washington	Federal Regional Center 130 228th Street, SW Bothell, WA 98021-8627	425-487-4600

Other federal agencies that provide floodplain management assistance include the U.S. Army Corps of Engineers and the U.S. Soil Conservation Service. For their nearest locations, see http://www.usace.army.mil/Locations.aspx and http://www.nrcs.usda.gov/wps/portal/nrcs/sitenav/soils/states/.

7 Index of Key Words and Subjects in the Technical Bulletins

The numbers in the index indicate the Technical Bulletin number.

8 References

Section 8.1 lists the references that are cited in this Technical Bulletin. Section 8.2 lists additional resources related to NFIP requirements.

8.1 References

ASCE/SEI (American Society of Civil Engineers / Structural Engineering Institute). 2014. *Flood Resistant Design and Construction*. ASCE/SEI 24-14. Available at https://ascelibrary.org/doi/book/10.1061/9780784413791.

FEMA (Federal Emergency Management Agency). Various editions. *Flood Insurance Manual*. Available at https://www.fema.gov/flood-insurance/work-with-nfip/manuals#flood-insurance.

FEMA. Various. NFIP Technical Bulletins. Current editions available at https://www.fema.gov/emergency-managers/risk-management/building-science/national-flood-insurance-technical-bulletins.

FEMA. 2010. *Substantial Improvement/Substantial Damage Desk Reference*. FEMA P-758. Available at https://www.fema.gov/emergency-managers/risk-management/building-science/multi-hazard#:~:text=Document-,FEMA%20P-758.

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FEMA. 2019. FEMA P-2037, *Flood Mitigation Measures for Multi-Family Buildings*. Available at https://content.govdelivery.com/attachments/USDHSFEMA/2020/06/24/file_attachments/1481529/16-J-0218_Multi-FamilyGuidance_06222020.pdf.

FEMA. 2020. FEMA P-2140, *Floodplain Management Requirements for Agricultural Structures and Accessory Structures*. Available at https://www.fema.gov/media-collection/floodplain-management-requirements-agricultural-and-accessory-structures.

ICC (International Code Council). Various editions. *International Building Code; International Existing Building Code; International Residential Code*. Available at https://www.iccsafe.org/.

ICC and FEMA. 2019. *Reducing Flood Losses Through the International Codes: Coordinating Building Codes and Floodplain Management Regulations*, 5th Edition. Available at https://www.fema.gov/sites/default/files/2020-07/fema_reducing_flood_losses_rfl_5th-ed.pdf.

USACE. 1995. *Flood Proofing Regulations*. Available at https://www.publications.usace.army.mil/Portals/76/Publications/EngineerPamphlets/EP_1165-2-314.pdf.

8.2 Useful Resources

Author	Date	Doc. No.	Title	Website
ASCE (American Society of Civil Engineers)	2005	ASCE 24-05	*Flood Resistant Design and Construction*	https://ascelibrary.org/
	2005	ASCE/SEI 7-05	*Minimum Design Loads for Buildings and Other Structures*	
	2010	ASCE/SEI 7-10	*Minimum Design Loads for Buildings and Other Structures*	
	2014	ASCE 24-14	*Flood Resistant Design and Construction*	
	2016	ASCE/SEI 7-16	*Minimum Design Loads and Associated Criteria for Buildings and Other Structures*	
FEMA (Federal Emergency Management Agency)	Various	—	*Flood Insurance Manual*	https://www.fema.gov/flood-insurance/work-with-nfip/manuals#flood-insurance
	2004	FEMA 467-1	*Floodplain Management Bulletin:Elevation Certificate*	https://www.fema.gov/multimedia-library
	2009	FEMA P-85	*Protecting Manufactured Homes from Floods and Other Hazards*	
	2009	FEMA P-550	*Recommended Residential Construction for Coastal Areas: Building on Strong and Safe Foundations*	
	2009	FEMA P-762	*Local Officials Guide for Coastal Construction*	
	2010	FEMA P-499	*Home Builder's Guide to Coastal Construction Technical Fact Sheet Series*	
	2010	FEMA P-758	*Substantial Improvement / Substantial Damage Desk Reference*	
	2011	FEMA P-55	*Coastal Construction Manual: Principles and Practices of Planning, Siting, Designing, Construction, and Maintaining Residential Buildings in Coastal Areas (Fourth Edition)*	
	2012	FEMA P-259	*Engineering Principles and Practices for Retrofitting Flood-Prone Residential Structures, Third Edition*	
	2013	FEMA P-936	*Floodproofing Non-Residential Buildings*	
	2013	FEMA P-942	*Mitigation Assessment Team Report: Hurricane Sandy in New Jersey and New York*	
	2014	FEMA P-312	*Homeowner's Guide to Retrofitting, 3rd Edition*	
	2014	FEMA P-1019	*Emergency Power Systems for Critical Facilities: A Best Practices Approach to Improving Reliability*	

Author	Date	Doc. No.	Title	Website
FEMA (Federal Emergency Management Agency)	2016	FEMA P-787	*Catalog of FEMA Building Science Branch Publications and Training Courses*	
	2017	FEMA P-348	*Protecting Building Utilities from Flood Damage*	
	2018	FEMA 213	*Answers to Questions About Substantially Improved/Substantially Damaged Buildings*	
	2019	FEMA Form 086-0-33	*NFIP Elevation Certificate and Instructions*	
	2019	FEMA Form 086-0-34	*Floodproofing Certificate for Non-Residential Structures*	
	2021	NFIP TB 0	*User's Guide to Technical Bulletins*	https://www.fema.gov/emergency-managers/risk-management/building-science/national-flood-insurance-technical-bulletins
	2020	NFIP TB 1	*Requirements for Flood Openings in Foundation Walls and Walls of Enclosures Below Elevated Buildings in Special Flood Hazard Areas*	
	2009	NFIP TB 2	*Flood Damage-Resistant Materials Requirements for Buildings Located in Special Flood Hazard Areas*	
	2021	NFIP TB 3	*Requirements for the Design and certification of Dry Floodproofed Non-Residential and Mixed-Use Buildings Located in Special Flood Hazard Areas*	
	2019	NFIP TB 4	*Elevator Installation for Buildings Located in Special Flood Hazard Areas*	
	2020	NFIP TB 5	*Free-of-Obstruction Requirements for Buildings Located in Coastal High Hazard Areas*	
	2021	NFIP TB 6	*Requirements for Dry Floodproofed Below-Grade Parking Areas Under Non-Residential and Mixed-Use Buildings Located in Special Flood Hazard Areas*	
	1993	NFIP TB 7	*Wet Floodproofing Requirements for Structures Located in Special Flood Hazard Areas*	
	2019	NFIP TB 8	*Corrosion Protection for Metal Connectors and Fasteners in Coastal Areas*	
	2008	NFIP TB 9	*Design and Construction Guidance for Breakaway Walls Below Elevated Buildings in Coastal High Hazard Areas*	

Author	Date	Doc. No.	Title	Website
FEMA (Federal Emergency Management Agency)	2001	NFIP TB 10	*Ensuring that Structures Built on Fill In or Near Special Flood Hazard Areas Are Reasonably Safe From Flooding*	
	2001	NFIP TB 11	*Crawlspace Construction for Buildings Located in Special Flood Hazard Areas*	
	Various	—	*Mitigation Assessment Team (MAT) Reports and Recovery Advisories (RAs)*	https://www.fema.gov/fema-mitigation-assessment-team-mat-reports
ICC (International Code Council)	2012, 2015, 2018	—	• International Building Code • International Existing Building Code • International Fuel Gas Code • International Mechanical Code • International Plumbing Code • International Private Sewage Disposal Code • International Residential Code	https://codes.iccsafe.org/category/I-Codes
HUD (U.S. Department of Housing and Development)	2017	—	*Residential Structural Design Guide: A State-of-the-Art Engineering Resource for Light-Frame Homes, Apartments, and Townhouses, Second Edition*	https://www.huduser.gov/publications/pdf/residential.pdf
NFPA (National Fire Protection Association)	2017	NFPA 225	*Model Manufactured Home Installation Standard*	https://www.nfpa.org/
USACE (U.S. Army Corps of Engineers)	1995	EP 1165-2-314	*Flood Proofing Regulations*	https://www.publications.usace.army.mil/portals/76/publications/engineerpamphlets/ep_1165-2-314.pdf
	2002	EM 1110-2-1100	*Coastal Engineering Manual*	https://www.publications.usace.army.mil/USACE-Publications/Engineer-Manuals/u43544q/636F617374616C20656E67696E656572696E67206D616E75616C/

NFIP = National Flood Insurance Program
SEI = Structural Engineering Institute
TB = Technical Bulletin

Requirements for Flood Openings in Foundation Walls and Walls of Enclosures

Below Elevated Buildings in Special Flood Hazard Areas In Accordance with the National Flood Insurance Program

NFIP Technical Bulletin 1 / March 2020

FEMA

Comments on the Technical Bulletins should be directed to:
Department of Homeland Security / Federal Emergency Management Agency
Federal Insurance and Mitigation Administration (FIMA) Risk Management Directorate
Building Science Branch
400 C Street, S.W., Sixth Floor
Washington, DC 20472-3020

NFIP Technical Bulletin 1 (2020) replaces NFIP Technical Bulletin 1 (2008), *Openings in Foundation Walls and Walls of Enclosures*.

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Figure 3. Bill Bryant, Anne Arundel County, Maryland
Figure 17. North Carolina Emergency Management/T. Riddle

For more information, see the FEMA Building Science Frequently Asked Questions website at http://www.fema.gov/frequently-asked-questions-building-science.

If you have any additional questions on FEMA Building Science Publications, contact the helpline at FEMA-Buildingsciencehelp@fema.dhs.gov or 866-927-2104.

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Acronyms

ASCE	American Society of Civil Engineers
BFE	base flood elevation
CFR	Code of Federal Regulations
DHS	Department of Homeland Security
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
IBC	International Building Code®
ICC	International Code Council®
ICC-ES	ICC Evaluation Service
I-Codes	International Codes®
IRC	International Residential Code®
LiMWA	Limit of Moderate Wave Action
NFIP	National Flood Insurance Program
NFPA	National Fire Protection Association
SEI	Structural Engineering Institute
SFHA	Special Flood Hazard Area

1 Introduction

This Technical Bulletin explains the National Flood Insurance Program (NFIP) requirements for flood openings in foundation walls and walls of enclosures below elevated buildings in Special Flood Hazard Areas (SFHAs) that are designated as Zone A (A, AE, A1-30, AH, and AO) on Flood Insurance Rate Maps (FIRMs). The flood opening requirements are intended to equalize hydrostatic forces (loads or pressure caused by standing or slow-moving water) on walls, thus preventing damage to or collapse of the building (see Figure 1). The requirements are not intended to reduce flood damage caused by hydrodynamic loads associated with fast-moving water (e.g., faster than 10 feet per second), wave impacts, or debris impacts.

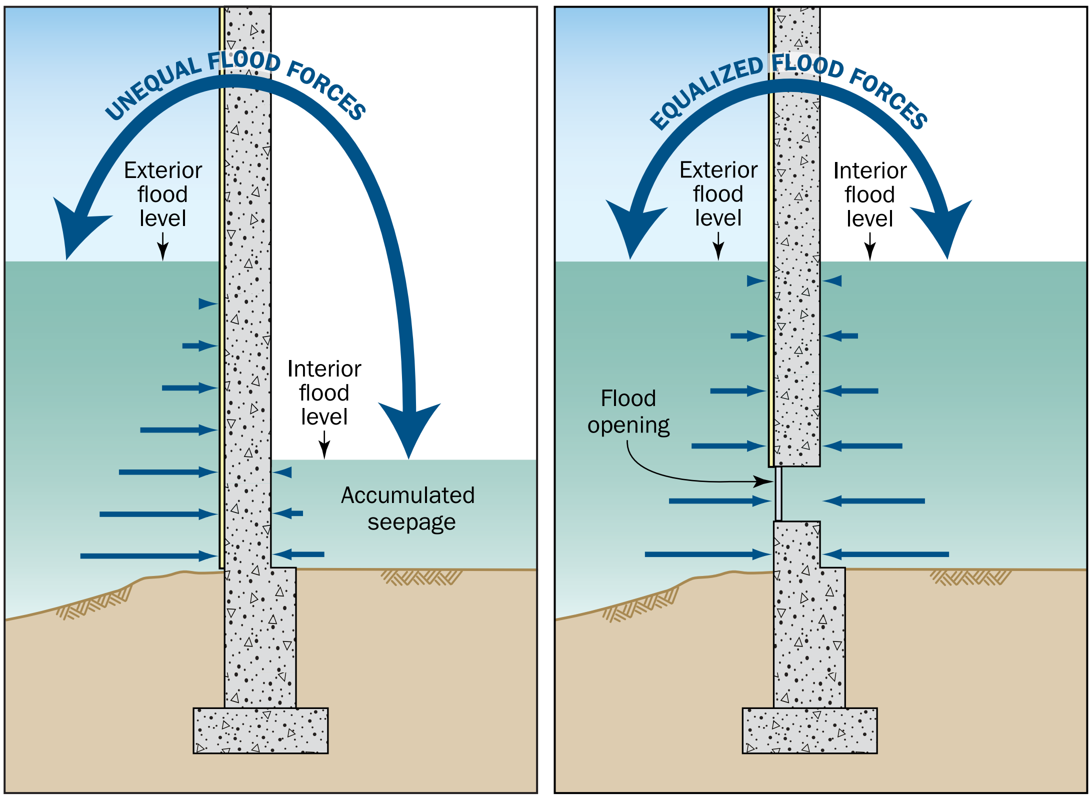


Figure 1: Equalizing flood forces (hydrostatic loads) on exterior walls

This Technical Bulletin includes the following:

- Examples of foundation walls and enclosure walls that require openings. Figure 2 illustrates typical enclosures with flood openings in Zone A: a crawlspace foundation wall, a non-load-bearing wood-framed wall surrounding an enclosed area under a piling- or column-supported building, and a concrete or masonry load-bearing foundation wall surrounding an enclosed area. Other types of enclosures or situations may require the advice of a registered design professional.
- Information on installing flood openings, including the minimum number and minimum height above grade, and examples of installations.

- Guidance on prescriptive (non-engineered) and engineered flood openings. Non-engineered openings do not have moving parts and may be used to meet the NFIP prescriptive requirement for 1 square inch of net open area for every square foot of enclosed area. Engineered openings may be used if designed and certified by a registered design professional as meeting certain performance characteristics.
- Description of how flood openings affect NFIP flood insurance premiums.
- Guidance on documenting building elevations and flood openings using the NFIP Elevation Certificate (FEMA Form 086-0-33) (FEMA, 2015).

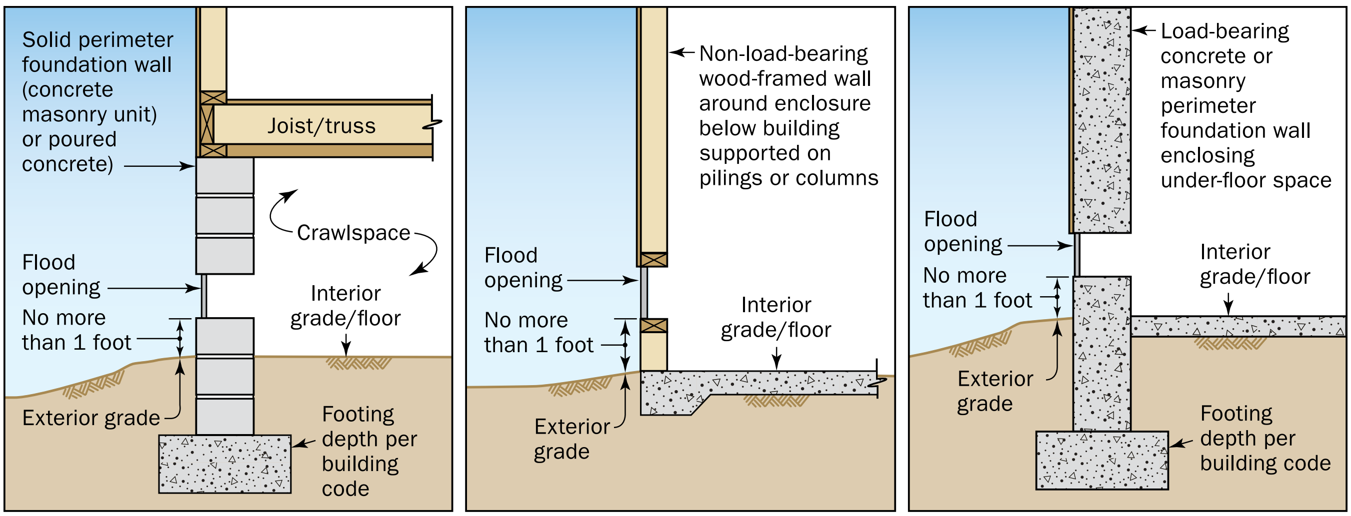


Figure 2: Typical enclosures with flood openings in Zone A

Questions about enclosure and flood opening requirements should be directed to the appropriate local official, NFIP State Coordinating Office, or Federal Emergency Management Agency (FEMA) Regional Office.

> **NFIP TECHNICAL BULLETIN 0**
>
> NFIP Technical Bulletin 0, *User's Guide to Technical Bulletins*, should be used as a reference in conjunction with this Technical Bulletin. Technical Bulletin 0 describes the purpose and use of the Technical Bulletins, includes common concepts and terms, lists useful resources, and includes a crosswalk of the sections of the NFIP regulations identifying the Technical Bulletin that addresses each section of the regulations and a subject index.
>
> Readers are cautioned that the definitions of some of the terms that are used in the Technical Bulletins are not the same when used by the NFIP for the purpose of rating flood insurance policies.

NFIP TERMS USED IN THIS TECHNICAL BULLETIN

- **Basement:** Area of a building that has its floor subgrade (below ground level) on all sides. NFIP regulations do not allow basements to extend below the base flood elevation (BFE) except in dry-floodproofed, non-residential buildings.
- **Enclosed area (enclosure):** An area below an elevated building that is enclosed by walls on all sides.
- **Lowest floor:** Lowest floor of the lowest enclosed area of a building, including basement. An unfinished or flood-resistant enclosure that is used solely for parking of vehicles, building access, or storage is not the lowest floor, provided the enclosure is built in compliance with applicable requirements.
- **Net open area:** Permanently open area of a non-engineered flood opening.
- **Special Flood Hazard Area (SFHA):** Area subject to flooding by the base flood (1-percent-annual-chance flood) and shown on Flood Insurance Rate Maps (FIRMs) as Zone A or Zone V.
- **Zone A:** Flood zones shown on FIRMs as Zone A, AE, A1-30, AH, AO, A99, and AR.
- **Zone V:** Flood zones shown on FIRMs as Zone V, VE, V1-30, and VO.

2 National Flood Insurance Program Regulations

An important NFIP objective is protecting buildings constructed in SFHAs from damage caused by flooding. The SFHA, composed of Zones A and V, is the areal extent of the base flood shown on Flood Insurance Rate Maps (FIRMs) prepared by FEMA. The base flood is the flood that has a 1 percent chance of being equaled or exceeded in any given year (commonly called the “100-year” flood).

The NFIP floodplain management regulations include minimum building design criteria that apply to:

- New construction
- Work determined to be Substantial Improvements, including improvements, alterations, and additions
- Repair of buildings determined to have incurred Substantial Damage

A defining characteristic of the NFIP regulations applicable in Zone A is the requirement for the lowest floor (including basement) to be elevated to or above the BFE. Non-residential buildings in Zone A must be elevated or dry floodproofed. The requirements in Zone V, not addressed in this Technical Bulletin, also specify building elevation, foundation, and enclosure requirements.

Enclosed areas (enclosures) are permitted below elevated buildings if the enclosed areas meet requirements, including limitations on use (parking of vehicles, building access, or storage), use of flood damage-resistant materials, and installation of flood openings that allow automatic entry and exit of floodwater (i.e., free inflow and outflow in both directions) to equalize the hydrostatic flood loads.

The NFIP regulations for enclosures and flood openings are codified in Title 44 of the Code of Federal Regulations (CFR) Part 60. Specific to NFIP Technical Bulletin 1, 44 CFR § 60.3(c)(5) states that a community shall:

> Require, for all new construction and substantial improvements, that fully enclosed areas below the lowest floor that are usable solely for parking of vehicles, building access or storage in an area other than a basement and which are subject to flooding shall be designed to automatically equalize hydrostatic flood forces on exterior walls by allowing for the entry and exit of floodwaters. Designs for meeting this requirement must either be certified by a registered professional engineer or architect or meet or exceed the following minimum criteria: A minimum of two openings having a total net area of not less than one square inch for every square foot of enclosed area subject to flooding shall be provided. The bottom of all openings shall be no higher than one foot above grade. Openings may be equipped with screens, louvers, valves, or other coverings or devices provided that they permit the automatic entry and exit of floodwaters.

NFIP REQUIREMENTS AND HIGHER REGULATORY STANDARDS

State or Local Requirements. State or local requirements that are more restrictive or stringent than the minimum requirements of the NFIP take precedence. The Technical Bulletins and other FEMA publications provide guidance on the minimum NFIP requirements and describe best practices. Design professionals, builders, and property owners should contact local officials to determine whether more restrictive requirements apply to buildings or sites in question. All other applicable requirements of state or local building codes must also be met for buildings in flood hazard areas.

Substantial Improvement and Substantial Damage. As part of issuing permits, local officials must review not only proposals for new construction but also for work on existing buildings to determine whether the work constitutes Substantial Improvement or repair of Substantial Damage. If the work is determined to constitute Substantial Improvement or repair of Substantial Damage, the buildings must be brought into compliance with the NFIP requirements for new construction. Some communities modify the definitions of Substantial Improvement and/or Substantial Damage to be more restrictive than the NFIP minimum requirements. For more information on Substantial Improvement and Substantial Damage, see FEMA P-758, *Substantial Improvement/Substantial Damage Desk Reference* (2010), and FEMA 213, *Answers to Questions About Substantially Improved/Substantially Damaged Buildings* (2018).

Elevation Above Minimum NFIP Requirements. Some communities require that buildings be elevated above the NFIP minimum requirement. The additional elevation is called freeboard. Design professionals, builders, and property owners should check with local officials to determine whether a community has freeboard requirements. References to building elevations in this Technical Bulletin should be construed as references to the community's elevation requirement where freeboard is required.

Legal Nonconforming Buildings. Owners of older, legal nonconforming buildings that are elevated with enclosures below the BFE may wish to retrofit the enclosures to conform to current requirements for enclosures, even when the enclosure is below grade on all sides. Lower NFIP flood insurance rates may apply if retrofit enclosures have flood openings that meet the requirements in this Technical Bulletin and other requirements for enclosures (e.g., limited use, flood damage-resistant materials, elevated utilities).

3 Building Codes and Standards

In addition to complying with the NFIP requirements, all new construction, Substantial Improvements, and repair of Substantial Damage must comply with the applicable building codes and standards adopted by states and communities.

The International Codes® (I-Codes®), published by the International Code Council® (ICC®), are a family of codes that includes the International Residential Code® (IRC®), International Building Code® (IBC®), International Existing Building Code® (IEBC®), and codes that govern the installation of mechanical, plumbing, fuel gas service, and other aspects of building construction. FEMA has deemed that the latest published editions of the I-Codes meet or exceed NFIP requirements for buildings and structures in flood hazard areas. Excerpts of the flood provisions of the I-Codes are available on FEMA's Building Code Resource webpage (https://www.fema.gov/building-code-resources).

3.1 International Residential Code

The IRC applies to one- and two-family dwellings and townhomes not more than three stories above grade plane. The IRC requirements related to flood openings, summarized in Table 1, are similar to but generally exceed NFIP requirements.

Table 1 refers to selected requirements of the 2018 IRC and notes changes from the 2015 and 2012 editions; subsequent editions of the IRC should include comparable requirements.

IRC COMMENTARY

The ICC publishes companion commentary for the IRC. Although not regulatory, the commentary provides guidance that is useful in complying with, interpreting, and enforcing the requirements of the code.

Table 1: Comparison of Selected 2018 IRC and NFIP Flood Opening Requirements

Topic	Summary of Selected 2018 IRC Requirements and Changes from 2015 and 2012 Editions	Comparison with NFIP Requirements
Flood openings	**Section R322.2.2(2) Enclosed area below design flood elevation.** Requires enclosed areas below the design flood elevation, including crawlspaces, to have flood openings (non-engineered or engineered) that meet listed criteria and that are installed in accordance with R322.2.2.1. The enclosed area is measured on the exterior of the enclosure. The listed criteria are equivalent to non-engineered and engineered openings, with the addition of a minimum size (not less than 3 inches in any direction in the plane of the wall). <u>Change from 2015 to 2018 IRC:</u> No change. <u>Change from 2012 to 2015 IRC:</u> No change.	Equivalent to NFIP 44 CFR § 60.3(c)(5) but with more specificity: measurement of enclosed area and minimum dimensions of opening.
Installation of flood openings	**Section R322.2.2.1 Installation of openings.** Specifies the following for the installation of flood openings: • At least two openings on different sides of an enclosure are required, and if more than one enclosed area is present, each must have openings on exterior walls. • The bottom of each opening must be not more than 1 foot above the higher of the final interior grade (or floor) and the finished exterior grade immediately under each opening. • Openings are permitted to be installed in doors and windows. <u>Change from 2015 to 2018 IRC:</u> No change. <u>Change from 2012 to 2015 IRC:</u> Installation requirements moved to new section.	More specificity than NFIP 44 CFR § 60.3(c)(5): openings on different sides, openings installed above higher of interior and exterior grade or floor, and openings installed in doors.
Breakaway walls	**Section R322.3.5 Walls below design flood elevation.** Requires walls below elevated dwellings in Coastal High Hazard Areas (Zone V) and Coastal A Zones that are intended to break away under flood loads to have flood openings that meet the requirements of Section R322.2.2(2). <u>Change from 2015 to 2018 IRC:</u> Section number was R322.3.4. <u>Change from 2012 to 2015 IRC:</u> New requirement in Coastal High Hazard Areas (Zone V) and Coastal A Zones if delineated.	Exceeds NFIP 44 CFR § 60.3(e)(5): openings in breakaway walls and Zone V requirements applied in Coastal A Zones if delineated.

3.2 International Building Code and ASCE 24

The flood provisions of the latest published editions of the IBC meet or exceed NFIP requirements for buildings, largely through reference to the standard ASCE 24, *Flood Resistant Design and Construction*, developed by the American Society of Civil Engineers (ASCE). The IBC applies to all applicable buildings and structures. While primarily used for buildings and structures other than dwellings within the scope of the IRC, the IBC may be used to design dwellings. ASCE 24 requirements for flood openings, summarized in Table 2, are similar to but generally exceed and are more specific than NFIP requirements. Table 2 refers to selected requirements of the 2018 IBC and ASCE 24-14 (noting changes from 2015 and 2012 IBC and ASCE 24-05); subsequent editions of the IBC and ASCE 24 should include comparable requirements.

IBC AND ASCE 24 COMMENTARIES

The ICC publishes companion commentary for the IBC, and ASCE publishes companion commentary for ASCE 24. Although not regulatory, the commentaries provide guidance that is useful in complying with, interpreting, and enforcing the requirements.

Table 2: Comparison of Selected 2018 IBC and ASCE 24-14 Flood Opening Requirements with NFIP Requirements

Topic	Summary of Selected 2018 IBC/ASCE 24-14 Requirements and Changes from 2015 and 2012 IBC/ASCE 24-05	Comparison with NFIP Requirements
Certification of engineered openings	**Section 1612.4(1.2).** Requires submission of a certification statement that the design provides for equalization of hydrostatic flood forces in accordance with ASCE 24, Section 2.7.2.2 (for engineered openings), if flood openings do not meet the requirements of ASCE 24, Section 2.7.2.1 (for non-engineered openings). Change from 2015 to 2018 IBC: Section number was 1612.5. Change from 2012 to 2015 IBC: No change.	Equivalent to NFIP 44 CFR § 60.3(c)(5).
Breakaway walls	**ASCE 24 Section 2.7.1.1.** Requires openings in breakaway walls. Change from ASCE 24-05: New requirement for openings in breakaway walls in Coastal High Hazard Areas and Coastal A Zones.	Exceeds NFIP 44 CFR § 60.3(e)(5) by requiring openings in breakaway walls.
Non-engineered openings	**ASCE 24 Section 2.7.2.1.** Specifies non-engineered openings, requires enclosed areas to be measured on the exterior, specifies minimum size (not less than 3 inches in any direction in the plane of the wall), and requires that the presence of louvers, blades, screens, faceplates or other covers, and devices be accounted for in determining net open area. Change from ASCE 24-05: Specifies measurement of enclosed areas to determine square footage. Clarifies that the presence of louvers, blades, screens, faceplates, and devices must be accounted for in the measurement of net open area of flood openings.	Equivalent to NFIP 44 CFR § 60.3(c)(5) but with more specificity: measurement of enclosure area, minimum dimension of openings, and measurement of net open area.
Engineered openings	**ASCE 24 Section 2.7.2.2.** Specifies engineered openings with emphasis on performance accounting for the presence of louvers, blades, screens, grilles, faceplates or other covers, and devices and ensuring that the difference between exterior and interior flood levels does not exceed 1 foot, with guidance related to the rate of rise and fall in excess of (or less than) 5 feet per hour. Specifies minimum size (not less than 3 inches in any direction in the plane of the wall). Provides the formula for calculating the total net area of required engineered openings. Change from ASCE 24-05: Greater emphasis on performance and the effects of louvers, blades, screens, grills, faceplates, and devices and revises the table of coefficients of discharge	Equivalent to NFIP 44 CFR § 60.3(c)(5) but with more specificity: minimum rate of rise and fall, minimum dimension of openings, and formula for engineered openings.
Installation of flood openings	**ASCE 24 Section 2.7.3.** Specifies the following for the installation of openings: • At least two openings in at least two walls of each enclosed area • The bottom of each opening not more than 1 foot above the higher of the final interior grade or floor and the finished exterior grade immediately under each opening • Openings in doors and windows permitted Change from ASCE 24-05: Consolidates installation requirements, which apply to both non-engineered and engineered openings, and clarifies that the position is relative to the higher of the interior and exterior grade or floor.	Equivalent to NFIP 44 CFR § 60.3(c)(5) but with more specificity: openings on different sides, bottom of openings above higher of interior and exterior grade or flood, and openings in doors and windows.

4 NFIP Flood Insurance Implications

Careful attention to compliance with NFIP requirements for enclosures below elevated lowest floors and flood openings is important during the design, plan review, construction, and inspection of buildings in SFHAs. Compliance influences vulnerability to flood damage and also the cost of NFIP flood insurance policies. The presence of enclosures may result in higher NFIP flood insurance premiums. If flood openings are not compliant, the floor of a crawlspace or the floor of an enclosure will be deemed the lowest floor for insurance rating purposes, which may result in higher NFIPflood insurance premiums, especially if the floor of the crawlspace or enclosure is more than 1 foot below the BFE.

5 Documenting Building Elevations and Flood Openings Using the NFIP Elevation Certificate

Communities are required to obtain the following from permit holders for buildings in SFHAs: the surveyed elevation of lowest floors of new buildings and buildings that have been Substantially Improved or repaired after incurring Substantial Damage. The elevations may be provided on the NFIP Elevation Certificate or in other formats.

The NFIP Elevation Certificate is designed to facilitate the collection of information that will help local officials evaluate compliance with floodplain management requirements and to provide the information necessary for the proper rating of NFIP flood insurance policies. For guidance on completing the certificate, see *NFIP Elevation Certificate and Instructions* (FEMA, 2015) and FEMA 467-1, *Floodplain Management Bulletin: Elevation Certificate* (FEMA, 2004).

The required information includes the following characteristics of crawlspaces, enclosures, and attached garages:

- Square footage of the enclosed area, measured on the outside of the enclosure walls
- Number of permanent flood openings within 1.0 foot above adjacent grade
- Total net open area of flood openings
- Whether engineered openings are used

According to the NFIP Elevation Certificate instructions, when an enclosed area has no flood openings or if all flood openings (non-engineered

NFIP ELEVATION CERTIFICATE COMMENTS

The comment section of the NFIP Elevation Certificate should be used to note characteristics of enclosures and flood openings that comply with the requirements but that, without close inspection, may appear to be non-compliant. In particular, without clarifying comments on engineered openings, local officials and insurance agents may inadvertently determine that enclosures are non-compliant and deem the floor of the enclosure the lowest floor, resulting in unnecessarily high NFIP flood insurance premiums.

or engineered) are higher than 1.0 foot above the adjacent grade, "N/A" (not applicable) should be entered for both the number of flood openings within 1.0 foot above adjacent grade and total net open area of flood openings. If the bottoms of some flood openings are within 1.0 foot above the adjacent grade, only the number and net open area of those openings should be recorded (openings that are higher than 1.0 foot are not included).

The certificate does not require users to determine whether any portion of a flood opening is above the BFE. However, for compliance purposes, see Section 8.3.6 of this Technical Bulletin for guidance on flood openings that extend above the BFE, which can occur in areas with shallow flooding. In these areas, even if the bottom of an opening is less than 1.0 foot above grade, a portion of the opening may extend above the BFE.

The NFIP Elevation Certificate has space for comments. Comments must be entered when engineered openings are used. Section 9.3.2 of this Technical Bulletin describes the documentation that is required for engineered openings and that must be attached to the certificate.

6 Use of Enclosed Areas Below Elevated Buildings

The NFIP regulations specify that enclosed areas under elevated buildings in SFHAs may be allowed if the enclosed areas are used solely for:

- Parking of vehicles (attached garages or parking areas below elevated buildings)
- Building access (stairwells, foyers)
- Storage (recommended to be limited to storage of low-value items)

The NFIP regulations do not list crawlspaces and under-floor spaces as allowable uses of enclosed areas. However, buildings in Zone A may be elevated using perimeter foundation walls that create these enclosed areas. Crawlspaces and under-floor spaces provide access to under-floor utilities such as pipes, ductwork, and electric conduits.

DRY FLOODPROOFED BUILDINGS

The only buildings with enclosed areas that are not required to have flood openings are non-residential buildings that are engineered to be dry floodproofed. For information on dry floodproofing, see FEMA P-936, *Floodproofing Non-Residential Buildings* (FEMA, 2013), and NFIP Technical Bulletin 3, *Non-Residential Floodproofing – Requirements and Certification*. FEMA has granted exceptions to a small number of communities to allow engineered, dry-floodproofed basements in specific circumstances.

A compliant enclosed area below the BFE can be rendered non-compliant by installing features that are inconsistent with the limitations on uses. Examples of features that are not allowed below the BFE are:

- Appliances
- Heating and air conditioning equipment
- Ventilation
- Ductwork
- Plumbing fixtures
- Materials that are not flood damage-resistant materials
- More than the minimum electric service required to address life-safety and electric code requirements for vehicle parking, building access, or storage

NON-CONVERSION AGREEMENTS

When some communities issue permits for buildings with enclosed areas below the BFE, permittees are required to execute Non-Conversion Agreements. These agreements document the permittees' understanding that the allowed use of enclosures is limited, that conversion to other uses is not allowed, and that modifying enclosed areas may render a building non-compliant with minimum requirements and result in higher NFIP flood insurance rates.

7 Foundation Walls and Enclosure Walls that Require Flood Openings

The NFIP regulations require that enclosed areas below the lowest floors of elevated buildings in Zone A have flood openings to equalize the hydrostatic flood forces (loads) on the enclosure walls. This requirement applies whether the walls are crawlspace, load-bearing, or non-load-bearing walls.

Examples of foundation and enclosure walls that require openings are listed below and described in Sections 7.1 through 7.9.

- Solid perimeter foundation walls (crawlspaces and under-floor spaces)
- Solid perimeter foundation walls (below-grade crawlspaces)
- Garages attached to elevated buildings
- Enclosed areas under buildings elevated on open foundations
- Enclosed areas with breakaway walls under buildings elevated on open foundations
- Above-grade (elevated) enclosed areas
- Two-level enclosed areas
- Solid perimeter foundation walls on which manufactured homes are installed
- Accessory structures (detached garages and storage sheds)

7.1 Solid Perimeter Foundation Walls (Crawlspaces and Under-Floor Spaces)

The crawlspace or under-floor space that is created when a building is elevated on a solid perimeter foundation wall that is below the BFE (see Figure 2) must meet all of the requirements for enclosed areas, including flood openings. If brick veneer, siding, or other material covers the wall, the openings in the wall must penetrate into the enclosed area. A crawlspace access door does not qualify as a flood opening unless the door has an opening installed in it or otherwise meets the performance requirement to allow automatic entry and exit of floodwater.

> **CONDITIONED CRAWLSPACES MUST HAVE FLOOD OPENINGS**
>
> In many parts of the country, a common practice is to build "conditioned crawlspaces" that are sealed and have mechanical ventilation. In SFHAs, all crawlspaces must have flood openings that meet the NFIP requirements and building codes.

Section 8.2 of this Technical Bulletin explains that the bottom of each opening must be no higher than 1 foot above the higher of the finished interior grade (or floor) or the finished exterior grade immediately under the opening. Therefore, the expected finished exterior grade and the final interior grade (or floor) of a crawlspace must be known before the location of the openings in a perimeter foundation wall can be determined.

Building codes may require ventilation of under-floor spaces. Ventilation openings are typically positioned near the top of the foundation wall to facilitate air flow. In most cases, ventilation openings are too far above grade to satisfy flood opening requirements.

In SFHAs where BFEs are several feet above grade or when owners want enough head room in an under-floor space to allow for parking of vehicles and storage, solid perimeter foundation walls may be used to create a full-height, under-floor space (see Figure 3). The walls surrounding an under-floor space must meet all flood-opening requirements.

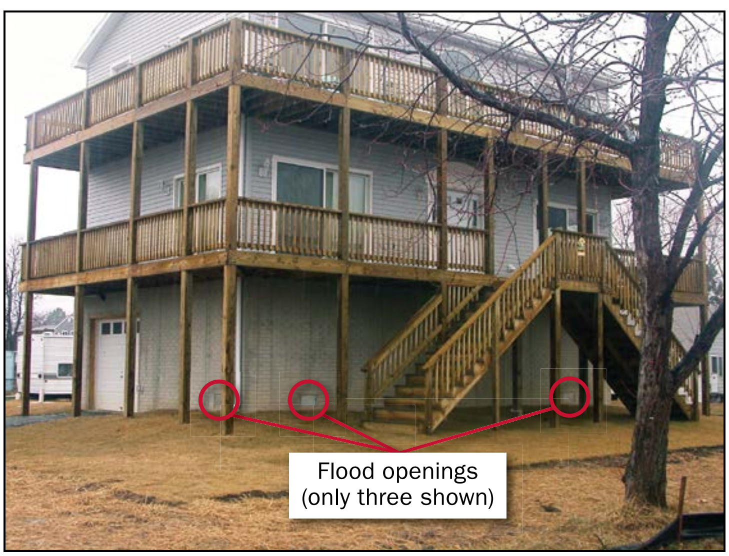


Figure 3: Full-height, solid perimeter walls surrounding a garage and storage area with flood openings (only three openings are shown)

Full-height, under-floor spaces must also meet all other NFIP requirements, which will minimize the likelihood of future conversion to uses other than the allowed uses (parking of vehicles, building access, or storage). Features that are inconsistent with the allowed uses are not permitted (see Section 6).

A backfilled stem wall foundation (also called chain wall, raised-slab-on-grade, and slab-on-stem-wall-with-fill) can look like a solid perimeter foundation wall from the outside, but a backfilled stem wall foundation is backfilled with compacted structural fill, concrete, or gravel that supports the floor slab (see Figure 4). Because stem wall foundations are backfilled, flood openings are not required and should not be installed.

BACKFILLED STEM WALLS AND NFIP ELEVATION CERTIFICATES

When the NFIP Elevation Certificate for a building elevated on a backfilled stem wall is completed, the foundation should be described in the comment section to clarify that the foundation is not a crawlspace and therefore does not require and should not have flood openings.

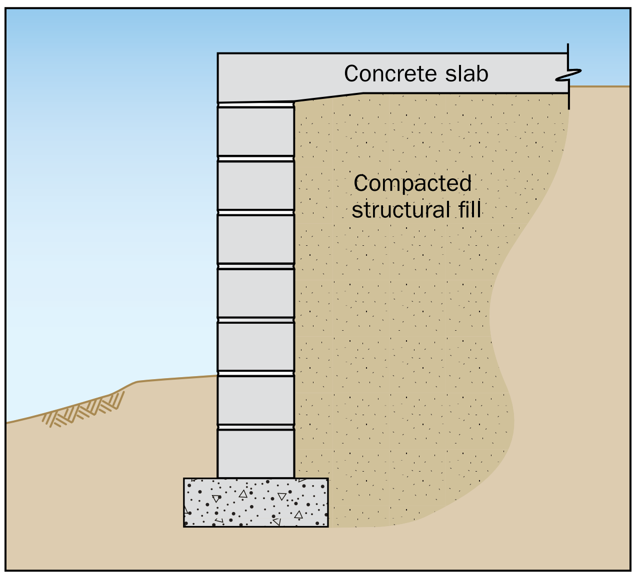


Figure 4: Backfilled stem wall foundation; flood openings not required

7.2 Solid Perimeter Foundation Walls (Below-Grade Crawlspaces)

The NFIP regulations do not allow buildings in SFHAs to have basements (areas below grade on all sides) except for engineered, non-residential buildings in Zone A that are designed and certified to be dry floodproofed. Therefore, crawlspaces that are below grade on all sides are not allowed because they are basements. An exception is available **only in SFHAs with shallow flooding** and then only if specific requirements and limitations are met. For more information,

LIMITATIONS ON BELOW-GRADE CRAWLSPACES

Before authorizing below-grade crawlspaces, communities are required to adopt specific provisions in their ordinances to be consistent with the limitations specified in NFIP Technical Bulletin 11. Communities should consult NFIP State Coordinators or FEMA Regional Offices for the appropriate language.

see NFIP Technical Bulletin 11, *Crawlspace Construction for Buildings Located in Special Flood Hazard Areas: National Flood Insurance Program Interim Guidance.*

According to Technical Bulletin 11, below-grade crawlspaces may be allowed if the foundation wall height is less than 4 feet from the bottom of the floor joist/truss to the top of the footing or interior grade/floor (whichever is higher). The top of the footing or interior grade/floor must be no more than 2 feet below grade (see Figure 5). Flood openings are required in the foundation walls surrounding below-grade crawlspaces and, as noted in Section 7.1, ventilation may be required. Because below-grade crawlspaces may contribute to increased humidity and mold growth, Technical Bulletin 11 requires that below-grade crawlspaces have adequate drainage systems to minimize moisture damage.

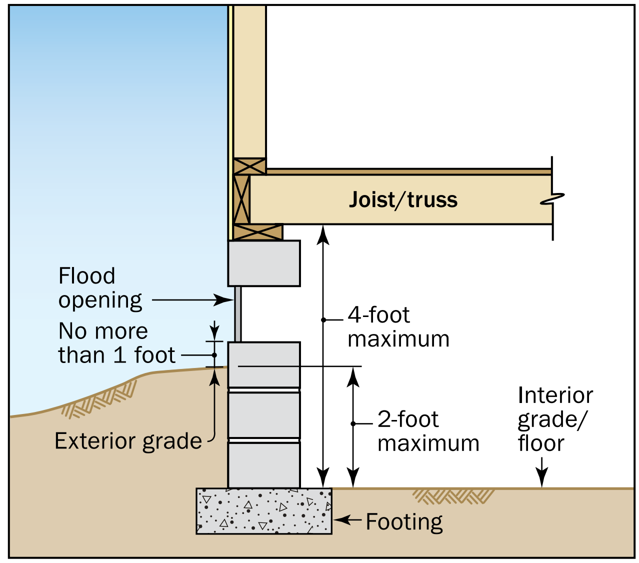


Figure 5: Limitations on below-grade crawlspaces in shallow flood hazard areas (see NFIP Technical Bulletin 11 for more information)

Although crawlspaces that meet the limitations in Technical Bulletin 11 are not considered basements for floodplain management purposes, they are considered basements for NFIP flood insurance purposes, and premiums will be higher if the grade inside a crawlspace is below the exterior grade on all sides.

7.3 Garages Attached to Elevated Buildings

Many buildings, especially homes, have an attached garage that extends laterally from the building and may or may not have living space above it. The floor of a garage that is attached to a building in an SFHA is allowed to be below the BFE if the garage meets all of the requirements for an enclosed area below the BFE. The use of the garage space must be limited to parking of vehicles, building access, or storage.

Flood openings are required in the exterior walls of garages in Zone A. Openings may be installed in garage doors (see Figure 6). However, because garage doors are likely to be replaced over the life of a building and subsequent owners may inadvertently replace garage doors without openings, flood openings should be installed in garage doors only when there is insufficient wall area in which to install the required number of openings.

Garage doors themselves do not meet the requirements for openings because human intervention would be needed to open garage doors when flooding is expected. Human intervention is inconsistent with the requirement that openings allow for the automatic entry and exit of floodwater. Garage doors with mechanisms that open the doors when water is detected do not meet the requirements because electric service cannot be guaranteed even if a backup power source is provided. Similarly, gaps that may be present between the garage door and the door jamb or walls do not guarantee automatic entry and exit of floodwater and do not count toward the net open area requirement.

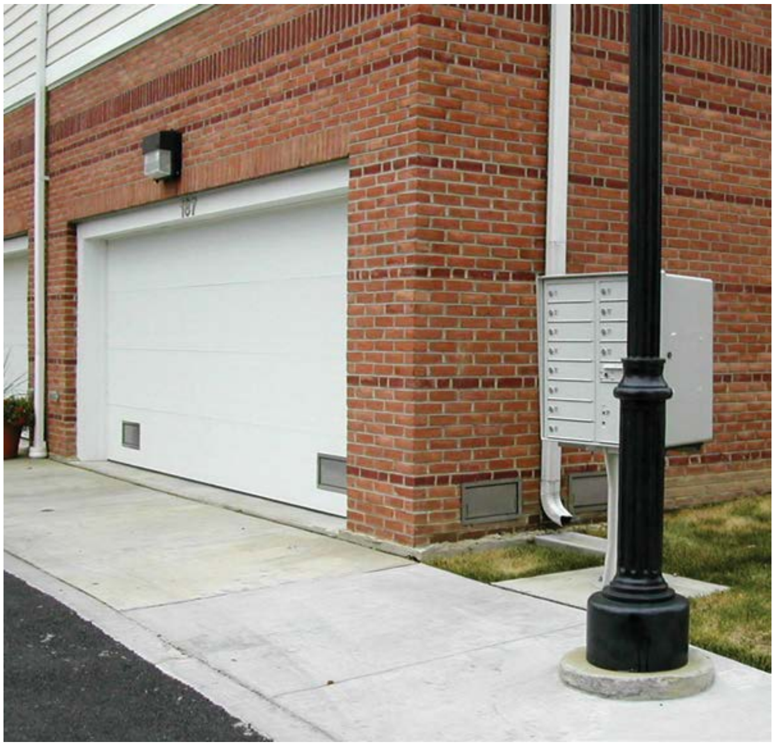


Figure 6: Engineered openings in garage doors

7.4 Enclosed Areas Under Buildings Elevated on Open Foundations

A building that is elevated on an open foundation (e.g., piers, posts, columns, pilings) in Zone A may have enclosed areas below the elevated floor (see Figure 7). Sometimes, only part of the footprint is enclosed, such as for a stairwell or storage room. All of the requirements for enclosed areas apply. Requirements include openings, elevated utilities, flood damage-resistant materials, and limitations on use (parking of vehicles, building access, or storage).

Skirting used to enclose areas under manufactured homes or other elevated buildings is typically made of weather-resistant material and extends from the bottom of the floor system down to grade. Rigid vinyl and aluminum skirting must have flood openings. Flood openings are not required when flexible skirting is used, but flexible skirting may be pushed against foundations if floodwater rises rapidly, in which case open lattice may be more appropriate. Unattached skirting can become dislodged during flooding and generate damaging debris.

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA) INSTALLATION STANDARD AND SKIRTING

NFPA 225, *Model Manufactured Home Installation Standard* (NFPA, 2017), specifies that the installation of skirting does not trigger the requirement for flood openings if the skirting does not provide structural support and would collapse under wind and water loads that are less than those expected during the base flood event without causing structural damage to the elevated home or foundation.

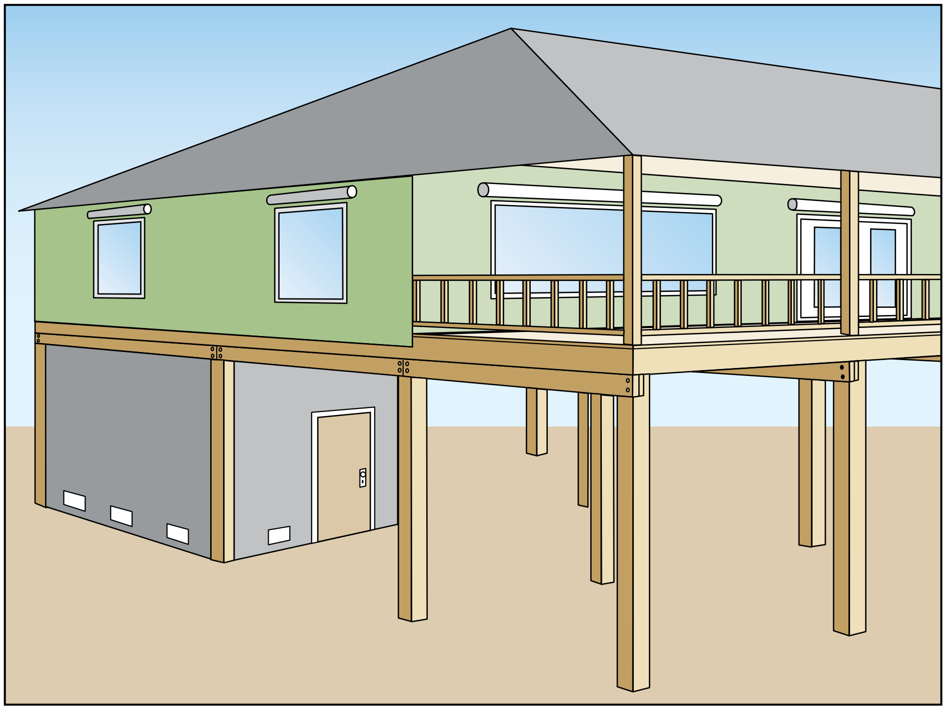


Figure 7: Enclosure with flood openings under a house elevated on pilings

UTILITY CHASES

For floodplain management and NFIP flood insurance purposes, utility chases designed to protect utility lines from freezing are not considered enclosures. Utility chases must be small and not allow access for a person to enter the space (access panels for servicing the lines are appropriate).

Because a utility chase is not considered an enclosure, it does not have to have flood openings (but flood openings may be provided). The utility chase must be constructed of flood damage-resistant materials below the BFE, and the enclosed utility lines must meet the requirement to be watertight and capable of withstanding flood loads (hydrostatic, hydrodynamic, wave).

7.5 Enclosed Areas with Breakaway Walls Under Buildings Elevated on Open Foundations

Open foundations (e.g., piers, posts, columns, pilings) are recommended in riverine SFHAs where flow velocities are expected to exceed 10 feet per second and in coastal areas where breaking wave heights during base flood conditions are expected to be between 1.5 and 3 feet (called Coastal A Zones). Buildings in these areas may be exposed to significant hydrodynamic loads, debris impact, and scour, any of which could be sufficient to damage typical perimeter foundation walls and enclosure walls even when there are flood openings.

Many Flood Insurance Rate Maps (FIRMs) for coastal communities that have been revised since 2009 show a Limit of Moderate Wave Action (LiMWA), which delineates the inland extent of the 1.5-foot wave. In Coastal A Zones, identified as Zone A on FIRMs, FEMA recommends that walls surrounding enclosed areas be designed as breakaway walls. To comply with the NFIP requirements, flood openings are required in breakaway walls in Zone A.

The NFIP regulations require that enclosures below elevated buildings in SFHAs identified as Zone V meet the same requirements for enclosures in Zone A, except that (1) walls must be non-supporting breakaway walls, open lattice-work, or insect screening and (2) flood openings are not required (see NFIP Technical Bulletin 9, *Design and Construction Guidance for Breakaway Walls*). The guidance in Technical Bulletin 9 should be used when flood openings are installed in breakaway walls to minimize wall failure under flooding that occurs more frequently than the base flood.

I-CODES AND COASTAL A ZONE

Starting with the 2015 editions, I-Codes treat Coastal A Zones like Zone V if the LiMWA is delineated on FIRMs or if communities designate Coastal A Zones. In addition, the I-Codes and ASCE 24-14 require flood openings in all breakaway walls, including those in Coastal A Zones and Zone V.

Post-flood assessments indicate that breakaway walls with openings prevent wall failure under frequent, shallow flood events. Preventing frequent wall failures reduces debris, keeps enclosure interiors and contents protected from wind-driven rain and sand, and reduces the cost of replacing walls.

7.6 Above-Grade (Elevated) Enclosed Areas

In flood hazard areas that experience frequent flooding, some owners construct enclosures with floor systems that are elevated above grade, not in contact with the ground, but still below the BFE (see Figure 8). Placing the enclosure floor above grade minimizes the potential for damage to the enclosure and contents during frequent, low-level flood events.

"HANGING ENCLOSURE"

The term "hanging enclosure" has been used to refer to raised, above-grade enclosures although above-grade enclosures are typically supported by other means and do not actually hang from elevated buildings.

Above-grade enclosures must meet all requirements applicable to enclosures (flood openings, flood damage-resistant materials, and used only for storage or building access). The floor system of above-grade enclosures may be independently supported on piers or posts, or enclosures may be structurally attached to the building's column or piling foundation. Although the floors of above-grade enclosures are not the lowest floor for floodplain management purposes, the enclosure floors are the lowest floor for NFIP flood insurance rating purposes.

One or more floor grates should be installed in the enclosure floor to reduce the potential for structural damage. Damage could result from buoyancy loads on the enclosure floors before water enters through the flood openings installed in walls. Openings in floors also allow enclosures to drain completely, reducing the potential for damage caused by the added weight of water.

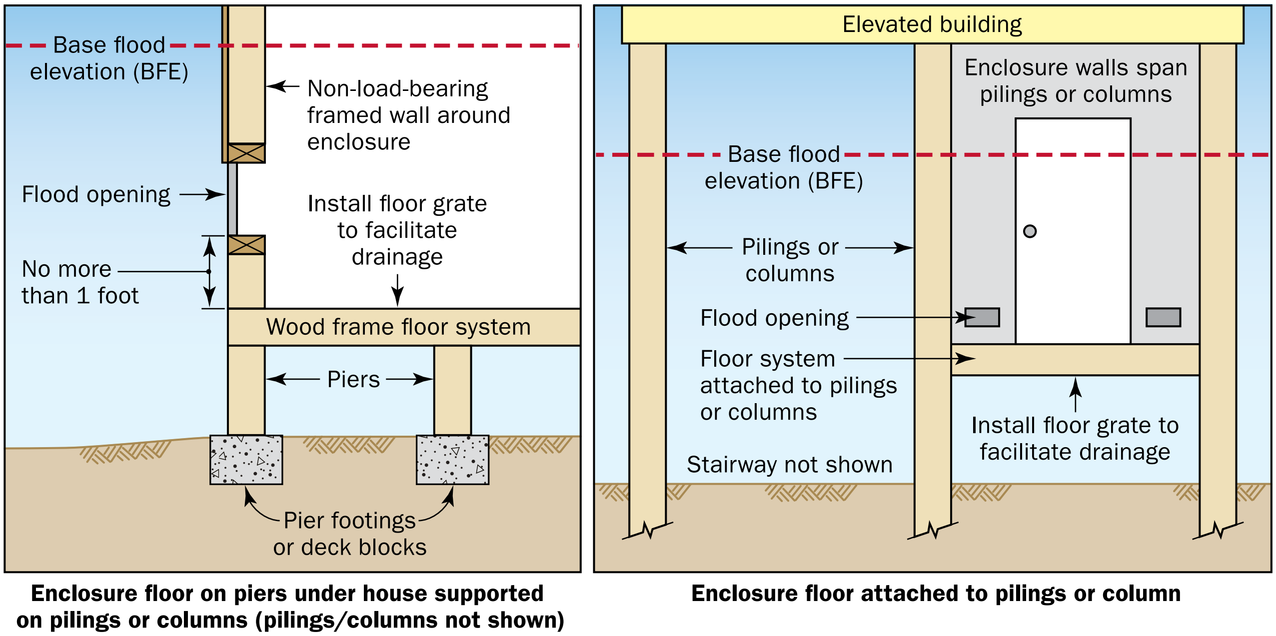


Figure 8: Above-grade enclosures

ABOVE-GRADE ENCLOSURES AND NFIP FLOOD INSURANCE

NFIP flood insurance policies for elevated buildings with above-grade enclosures are rated assuming the above-grade enclosure is the lowest floor (i.e., the floor of the enclosure instead of the floor of the elevated building). See the "Lowest Floor Guide" section of the *NFIP Flood Insurance Manual* (FEMA, 2019). Above-grade enclosures can result in higher NFIP flood insurance premiums than enclosures with floors that are at-grade or close to grade. Owners should ask their insurance companies to submit requests to the NFIP for a special rating for buildings with above-grade enclosures.

7.7 Two-Level Enclosed Areas

In flood hazard areas where the BFE is more than one story above the ground, some owners want to build two-level enclosures (see Figure 9). For compliance purposes, to avoid the second-level enclosure from being identified as the lowest floor, both enclosure levels must meet all of the requirements for enclosed areas, including openings, elevated utilities, flood damage-resistant materials, and limitations on use (parking of vehicles, building access, or storage). To facilitate drainage from the upper level of the enclosure, an opening with a grate should be installed in the floor.

TERMS USED FOR TWO-LEVEL ENCLOSURES

Two-level enclosures are also referred to as two-story enclosures, double enclosures, and stacked enclosures.

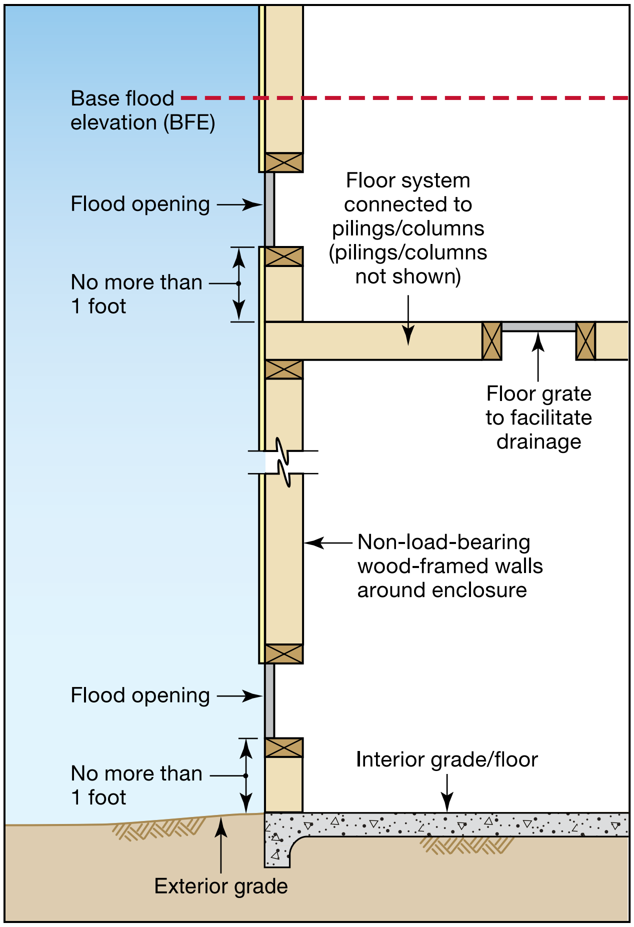


Figure 9: Two-level enclosure with non-load-bearing walls under building elevated on pilings or columns; configuration also applies if walls are load-bearing

Figure 9 shows a two-level enclosure in which the surrounding walls are not load-bearing; the same configuration and requirement apply if the surrounding walls are load-bearing perimeter walls.

Two-level enclosures are unusual and warrant consideration of flood loads based on site-specific flood conditions. Local officials may require that buildings with two-level enclosures be designed and certified by a registered design professional rather than rely on non-engineered foundations and enclosure configurations.

TWO-LEVEL ENCLOSURES AND NFIP FLOOD INSURANCE

Designers and owners should be aware that a building with a two-level enclosure, even if allowed by permit, will have a higher NFIP flood insurance premium than if the building has a one-level enclosure. Even if a two-level enclosure complies with building codes and floodplain management requirements for enclosures, the upper floor of the two-level enclosure will be deemed the lowest floor for insurance rating purposes (the lowest floor for flood insurance purposes is the first floor elevated above ground). Owners should ask their insurance companies to submit requests to the NFIP for a special rating for buildings with two-level enclosures.

7.8 Solid Perimeter Foundation Walls on which Manufactured Homes Are Installed

Manufactured homes may be installed on solid perimeter foundation walls that enclose the space below the homes (see Figure 10). Even if not part of a home's load-bearing support system, a solid perimeter foundation wall is required to have openings; otherwise, hydrostatic loads may damage the wall, which could lead to damage of the home's supporting foundation and anchor system.

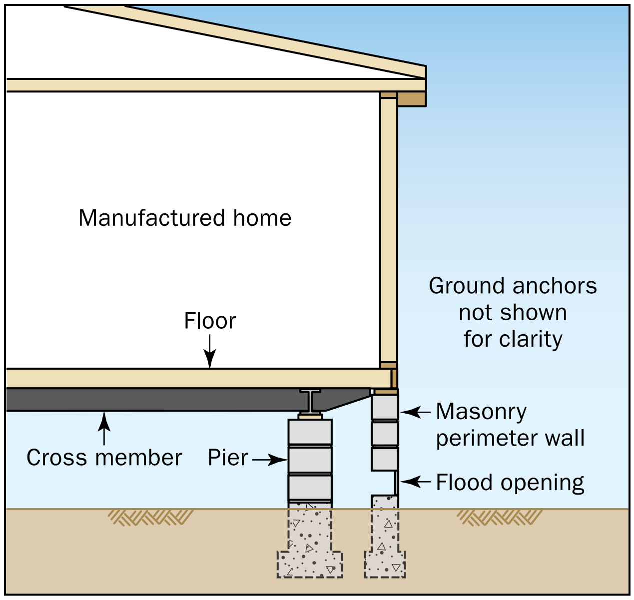


Figure 10: Manufactured home supported on interior piers and masonry perimeter wall with flood openings (ground anchors not shown)

7.9 Accessory Structures

Communities participating in the NFIP are required to regulate all development in SFHAs, including detached garages, detached storage buildings, and small storage sheds. Accessory structures may be elevated in accordance with the requirements for elevated buildings or dry floodproofed.

When communities have FEMA-approved limitations on the size of accessory structures or when communities grant variances for non-elevated accessory structures, the structures may be allowed without elevation provided the structures are wet floodproofed (see NFIP Technical Bulletin 7, *Wet Floodproofing Requirements for Certain Buildings Located in Special Flood Hazard Areas*). Alternatively, communities without FEMA-approved size limits may consider granting variances for non-elevated accessory structures in accordance with FEMA policies and guidance.

ADDITIONAL ACCESSORY STRUCTURE CONSIDERATIONS

Some communities have FEMA-approved regulations that specify limitations on the size of accessory structures that are allowed in SFHAs without having to comply with elevation requirements. Other considerations for accessory structures are set forth in FEMA policies and guidance.

Local officials should consult NFIP State Coordinators or FEMA Regional Offices for additional guidance and for appropriate size limits and language to include in local regulations.

Wet-floodproofed accessory structures must comply with the following measures:

- Use is limited to parking of vehicles and storage
- Utilities are elevated
- Materials below the BFE are flood damage-resistant materials
- Flood opening requirements are satisfied
- Structures are anchored to resist flotation, collapse, or lateral movement under flood conditions

A best practice is to require Non-Conversion Agreements when non-elevated accessory structures are allowed. These agreements, when recorded with property deeds, inform future owners about the limitations and the wet-floodproofing measures. Accessory structures that are allowed to be wet floodproofed must not be used for any habitable or other prohibited purpose.

8 Requirements and Guidance for Installation of Flood Openings

The NFIP regulations specify installation requirements for all flood openings, whether non-engineered or engineered. See Section 9 of this Technical Bulletin for information on non-engineered and engineered flood openings. Installation requirements specify the minimum number of openings and the maximum height of openings above grade. The requirements and guidance on installation are provided in Sections 8.1 through 8.3.

8.1 Location and Minimum Number of Flood Openings

Every enclosed area is required to have at least two flood openings on exterior walls. Flood openings should be installed in at least two sides of each enclosed area to decrease the chance that all openings will be blocked by floating debris and to allow for more even filling and drainage of enclosed areas than if openings are installed on only one side. FEMA recommends that openings be distributed around the perimeter of enclosed areas unless there is clear justification for putting all of the openings on only one or two sides, such as in townhouses with limited exterior walls (see Section 8.3.4) and buildings set into sloping sites (see Section 8.3.2). If openings are not distributed around the perimeter, an imbalance in flood loads could result in damage to or collapse of walls.

> **LOCATION OF FLOOD OPENINGS**
>
> The IRC and IBC (by reference to ASCE 24) require flood openings "on different sides of each enclosed area" (IRC R322.2.2.1) and "in at least two walls of each enclosed area" (ASCE 24, Section 2.7.3).

Figure 11 shows a foundation plan with multiple enclosures and openings in the perimeter wall of each enclosed area. Note that the number of openings shown is for illustration purposes only; the total number of openings and the adequacy of the net open area of the openings depend on the type of opening and whether air-vent devices or engineered openings are installed.

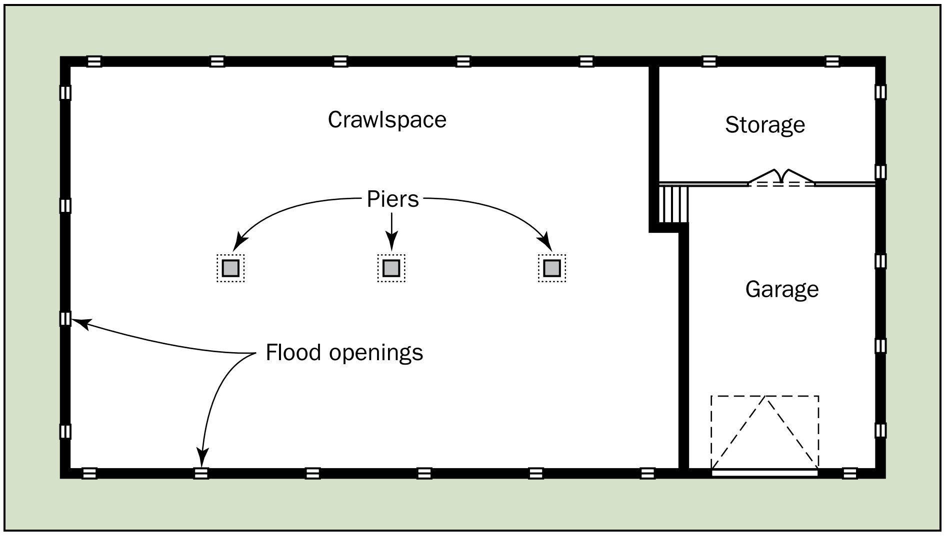


Figure 11: Foundation plan of home with multiple enclosed areas, each with flood openings (number of openings for illustration purposes only)

In some situations, openings in interior walls or partitions are necessary to ensure that floodwater can reach all enclosed areas and minimize unbalanced hydrostatic loads on interior and exterior walls. When openings are used in interior walls, the total number of openings and their net open area should be based on the size of the enclosed area, but openings in interior walls are not counted toward the required total opening requirement based on the exterior measurement of the enclosed area. To maintain safe fire separation, flood openings should not be placed in the wall separating a garage from living spaces and crawlspaces unless devices used as flood openings that are designed to satisfy fire-separation requirements are used.

8.2 Height of Flood Openings Above Grade or Floor

The bottom of each flood opening must be positioned no higher than 1 foot above the higher of the final (finished) interior or exterior grade or the floor that is immediately under each opening so water will begin to flow through the opening when water rises just above the bottom of the opening. The purpose of this requirement is to satisfy the performance expectation that the difference in water levels between the interior and exterior will not exceed 1 foot as floodwater begins to rise and as it recedes from the site. To reduce the amount of water trapped inside, a good practice is to install some openings closer to grade than the maximum 1 foot allowed. See Section 8.3.6 for information on openings that extend above the BFE in areas with shallow flooding.

When interior and exterior grades are different, the higher of (1) the finished exterior grade immediately under each opening and (2) the final interior grade or floor is used to determine

ENCLOSURES BELOW GRADE ON ALL SIDES ARE BASEMENTS

An enclosure that is below grade on all sides is a basement regardless of whether the interior grade or floor is below grade because backfill, topsoil, or landscaping materials were added or because the footing trenches inside the perimeter foundation walls are not completely backfilled. Basements do not comply with the minimum NFIP requirements. In addition, the presence of such below-grade enclosures will result in higher NFIP flood insurance premiums.

the position of flood openings. The following should be considered when determining which grade or floor to use:

- **Finished exterior grade.** Care should be taken when placing backfill, topsoil, or landscaping materials around the outside of enclosures, especially solid perimeter foundation walls. If the finished exterior grade is higher than the interior grade on all sides of the building, the enclosed area will be a basement as defined by the NFIP.
- **Final interior grade or floor.** The trench that is excavated to construct footings and foundation walls must be backfilled completely; otherwise, a basement will be created. If the interior grade or floor is higher than the exterior grade, the openings must be no higher than 1 foot above the interior grade or floor.

8.3 Examples of Flood Opening Installations

The following examples of flood opening installations are described in Sections 8.3.1 through 8.3.6:

- Interior grade or floor higher than the exterior grade
- Sloping sites
- Buildings with large enclosed areas
- Townhouses with limited exterior walls
- Buildings with multiple enclosures
- Openings in areas with shallow flooding

8.3.1 Interior Grade or Floor Higher than the Exterior Grade

This section describes enclosures in which the interior grade or floor is higher than the exterior grade. As water rises against the outside of the foundation, the interior fill or slab resists the hydrostatic load. When water rises above the interior grade or slab, the lateral load will become unbalanced and therefore must be equalized with openings that allow water to automatically enter and exit.

Figure 12 is an example of a framed enclosure below a manufactured home that is elevated on columns. As indicated by the driveway on the left, the interior slab is higher than the exterior grade along the side of the building. The flood openings are within 1 foot of the interior floor surface. Here, the full-height enclosed area is used for parking of vehicles and storage.

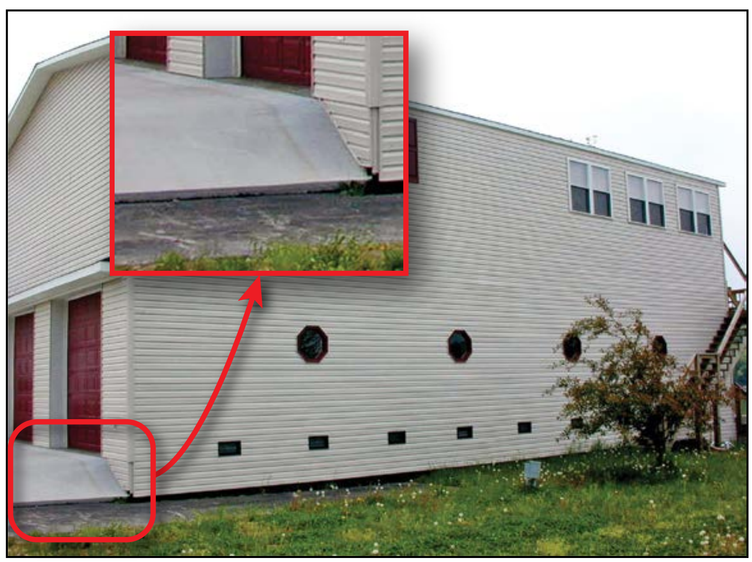


Figure 12: Manufactured home installed on columns above a full-height, framed garage (note elevation of thick driveway slab on left; the flood openings are within 1 foot of interior floor surface)

When viewed from the outside, an enclosure with the interior grade or floor higher than the exterior grade may appear non-compliant with the installation requirements for openings because the openings appear to be too high above the exterior grade. Therefore, the final documentation of as-built elevations should note the difference in interior and exterior grades. For example, if the NFIP Elevation Certificate is used, the comments should indicate whether the openings are (or are not) within 1 foot of the higher of the two grades and should explain that the interior grade or floor is higher than the exterior grade. Without the explanation, NFIP flood insurance premiums may be higher than necessary.

INTERIOR GRADE OR FLOOR ABOVE BFE

When the interior grade or floor of an enclosure below an elevated building is entirely above the BFE, flood openings are recommended but not required. When the floor of an enclosure is above the BFE, the NFIP flood insurance policy will be rated using the enclosure floor as the lowest floor rather than the next higher floor above the enclosure. Installing flood openings in these situations will result in lower NFIP flood insurance premiums.

8.3.2 Sloping Sites

Buildings on solid perimeter foundation walls set into sloping sites present a special situation for the installation of flood openings. Careful attention must be paid to the following:

- The interior grade or floor along the lowest side of the building must be at or above the exterior grade across the entire length of the lowest side, and there must be positive surface drainage away from the building; otherwise, the enclosure will be considered a basement as defined by the NFIP.
- The bottom of each opening must be no higher than 1 foot above the exterior or interior grade immediately below the opening, whichever is higher (see Figure 13).
- For flood openings to perform their intended function, they should be below the BFE.

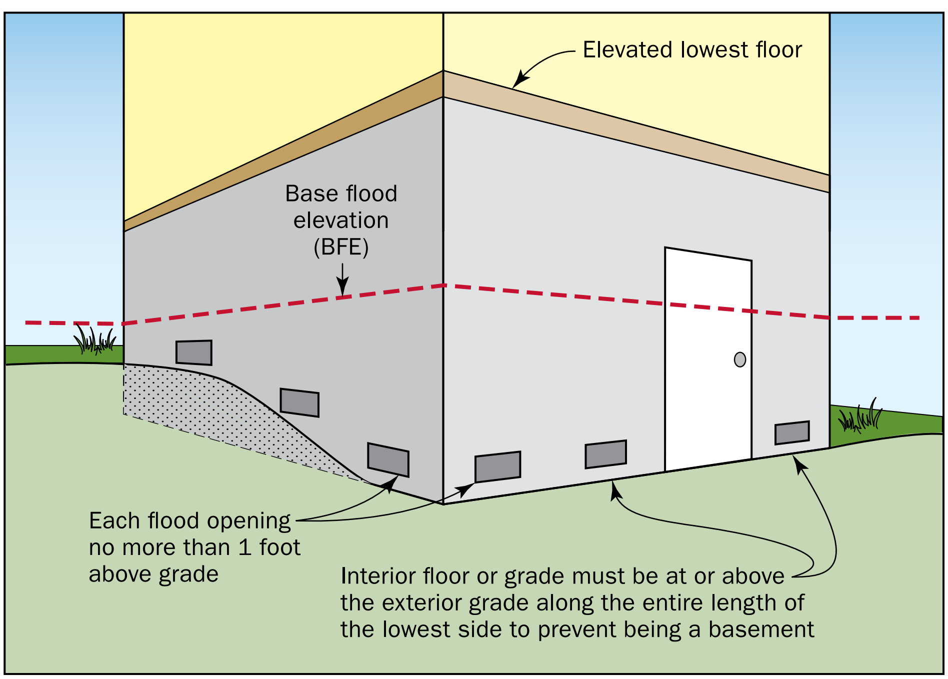


Figure 13: Flood openings in enclosure walls on a sloping site

- Interior partitions and load-bearing walls must have openings to allow water to readily reach every enclosed area (see Section 8.3.5 for information on buildings with multiple enclosures).

8.3.3 Buildings with Large Enclosed Areas

Some buildings, especially commercial and industrial buildings, have large under-floor spaces, crawlspaces, or enclosures. Flood openings may be stacked or grouped (see Figure 14), or large-dimension openings may be used, provided all of the requirements for openings are satisfied. Vertically stacked or closely spaced openings function together as one opening, and the bottom of the lowest opening must be no higher than 1 foot above the exterior grade or interior grade, whichever is higher.

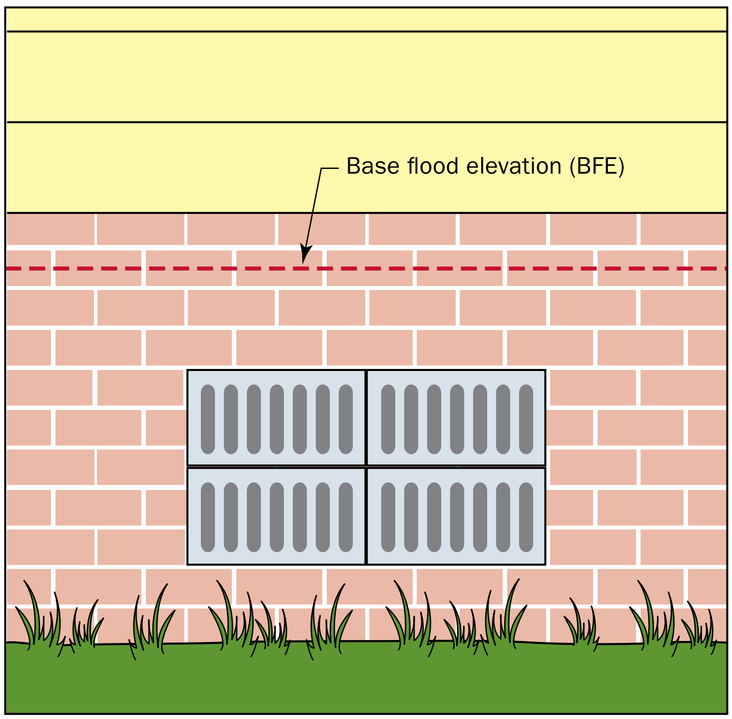


Figure 14: Flood openings that are stacked and closely grouped to satisfy the required total net open area

8.3.4 Townhouses with Limited Exterior Walls

Townhouses are single-family dwelling units constructed in groups of three or more attached units in which each unit extends from foundation to roof with exterior walls on at least two sides. Flood openings are required for townhouses in SFHAs that are constructed with solid perimeter foundation walls or solid walls surrounding enclosed areas under the elevated portion of the building.

Because interior townhouse units have less linear exterior wall length than end units, meeting all of the requirements for flood openings can be a challenge, especially the requirement for adequate opening area and the requirement that each enclosed area have openings. If openings cannot be provided in at least two exterior walls of each enclosed area, the NFIP allows all openings to be installed in one wall.

The design of interior townhouse units can satisfy the guidance that openings should be located on different sides of each enclosed area if interior partitions and walls have openings to connect enclosed spaces from front to back. Figure 15 shows suggested locations for openings. Note that the number of openings in Figure 15 is for illustration purposes only; the total number of openings and the adequacy of the opening area depend on the type of opening and whether non-engineered or engineered openings are installed. Fire-safety limitations generally preclude openings in the walls that separate townhouse units.

Providing adequate openings in enclosures below elevated townhouse units, other than end units, may be even more challenging if a multi-unit building is set into a sloping site. In this case, it may be appropriate to consider an open foundation or a backfilled stem wall foundation that does not require openings.

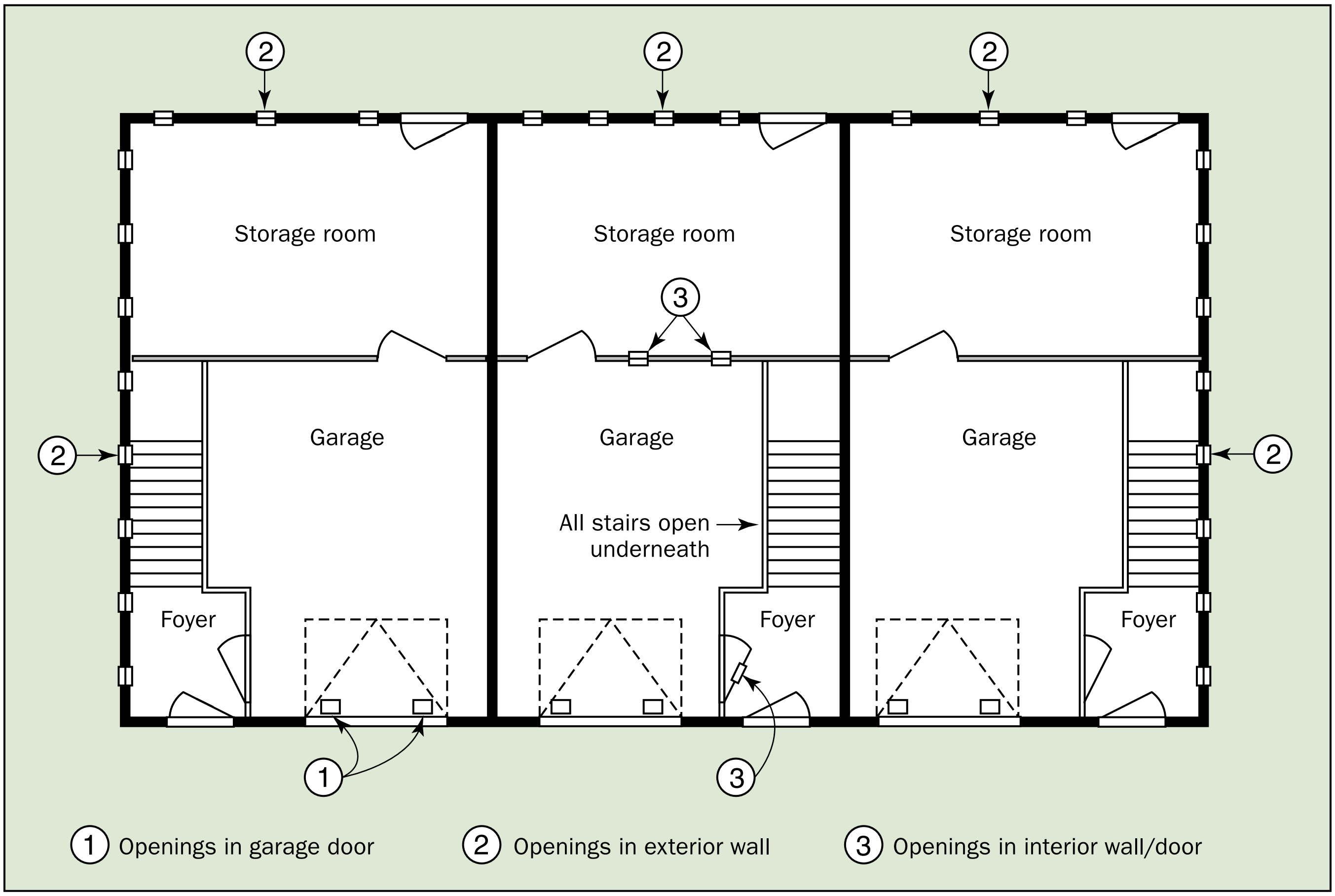


Figure 15: Suggested flood openings in enclosures under elevated townhouses (number of openings for illustration purposes only)

8.3.5 Buildings with Multiple Enclosures

Every enclosed area is required to meet the requirements for enclosures, including the requirement for flood openings in exterior walls. Figure 11 in Section 8.1 shows a home foundation plan with multiple enclosures. In some situations, openings in interior walls or partitions may be necessary to ensure that floodwater can reach all areas to minimize unbalanced hydrostatic loads on load-bearing interior walls and exterior walls (see middle townhouse in Figure 15 in Section 8.3.4). When openings are used in interior walls, the total number of openings in exterior walls and the total opening area should be based on the size of the entire enclosed area. Openings in interior walls do not count toward the total opening requirements based on the exterior measurement of the enclosed area.

8.3.6 Flood Openings in Areas with Shallow Flooding

Some FIRMs show mapped SFHAs where the depth of floodwater above grade will be shallow (2 feet or less during the base flood). Shallow flooding occurs toward the landward boundary of SFHAs and in areas identified as being subject to sheet flow or ponding. The NFIP regulations require flood openings in enclosures even if the depth of flooding is only 1 foot and the difference in water depth between the inside and outside of enclosures is 1 foot or less.

> **NFIP ELEVATION CERTIFICATE AND SHALLOW FLOODING**
>
> The NFIP Elevation Certificate requires users to input the number of flood openings within 1.0 foot above the adjacent grade or floor. The certificate does not require users to determine how much of a flood opening is above or below the BFE.

Depending on the depth of floodwater in areas with shallow flooding, flood openings may extend above the BFE if the bottom of the opening is no higher than 1 foot above the higher of the final interior grade or floor and the finished exterior grade of the crawlspace or enclosure. When flood openings extend above the BFE, alternatives to satisfy the requirements include:

- Raise the floor of the enclosure to be at or above the BFE, perhaps by using a thicker slab, resulting in no need for openings. Although this alternative satisfies the construction requirement, for NFIP flood insurance rating purposes, the top of the slab is the elevation of the lowest floor, not the next higher floor (see the text box "Interior Grade or Floor above BFE" in Section 8.3.1).
- Install openings as close to grade (or floor) as possible to maximize the open area available for inflow and outflow of floodwater (see Figure 16). The total net open area of the openings must be based on the enclosed area even if some portion of the opening is above the BFE.

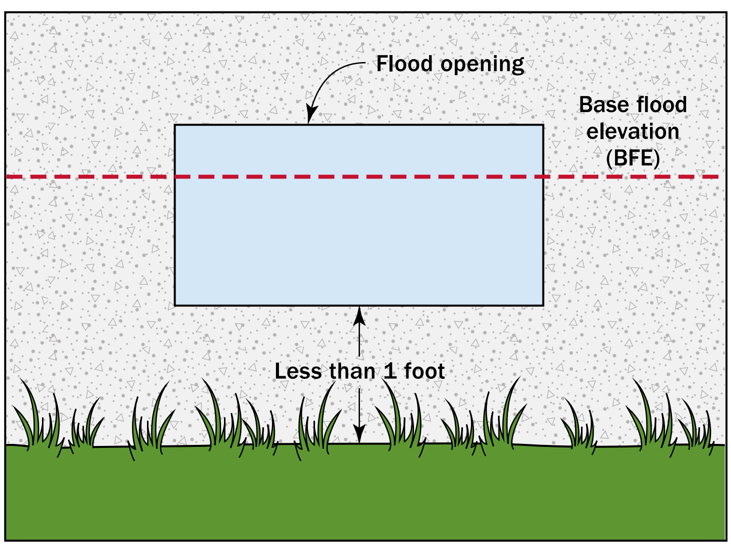


Figure 16: Bottom of the flood opening positioned as close as possible to grade (or floor) when any portion of the opening extends above the BFE

9 Non-Engineered Flood Openings and Engineered Flood Openings

The NFIP regulations, described in previous sections, identify options for providing sufficient size and number of flood openings to allow for the automatic (free) entry and exit of floodwater. This section describes how the automatic entry and exit of floodwater can be accomplished by the use of:

- Non-engineered openings that meet the prescriptive requirement to provide 1 square inch of net open area for each square foot of enclosed area, where the enclosed area is measured on the exterior of the enclosure walls. Section 9.2 describes a variety of options that can serve as non-engineered openings.
- Engineered openings for which Evaluation Reports are issued by the ICC Evaluation Service (ICC-ES), a subsidiary of the ICC, or equivalent reports issued by other product certification organizations.
- Engineered openings designed and certified by a registered design professional for a specific building and site-specific conditions.

All of the following requirements for installation apply regardless of whether engineered openings or non-engineered openings are used to satisfy the NFIP requirements (also see Section 8):

- Each enclosed area must have a minimum of two openings. When multiple enclosed areas are present, each area must have openings in its exterior walls. Section 8.3.5 describes connecting multiple areas by installing openings in interior walls or partitions to ensure that floodwater can reach all enclosed areas.
- The bottom of each opening must be no more than 1 foot above the higher of the final interior grade or floor or the finished exterior grade immediately under the opening.
- Insect screens, grates, grilles, fixed louvers, blades, faceplates, or other devices, if any, must not block the automatic flow of floodwater into and out of the enclosed area.

Section 9.1 provides a list of measures that are not acceptable as flood openings.

I-CODE REQUIREMENTS FOR FLOOD OPENINGS

The IRC includes requirements for non-engineered and engineered flood openings, and the IBC includes the same requirements by reference to ASCE 24.

FLOOD DAMAGE-RESISTANT MATERIALS

Flood openings must be made of flood damage-resistant materials in order to satisfy the requirement that materials used below the BFE be resistant to flood damage. Metals should be corrosion resistant, and plastics should be weather resistant. For guidance, see NFIP Technical Bulletin 2, *Flood Damage-Resistant Materials Requirements*.

9.1 Measures Not Acceptable as Flood Openings

FEMA has determined that the following measures do not satisfy the requirements for flood openings:

- Standard foundation air-ventilation devices that can be closed manually unless they are permanently disabled in the open position because otherwise, they do not allow for the automatic entry and exit of floodwater (see Figure 17).
- Standard foundation air-ventilation devices that have detachable solid covers intended to be manually installed over the vent because they do not allow for the automatic entry and exit of floodwater when the cover is in place.
- Standard foundation air-ventilation devices that are designed to open and close based on temperature unless they are also designed to allow for the automatic entry and exit of floodwater.
- Devices with covers or panels that are intended to displace when floodwaters rise on only one side of a wall because they do not satisfy the requirement for automatic entry and exit of floodwater in both directions.
- Windows below the BFE because the automatic entry and exit of floodwater cannot be satisfied by the expectation that windows will break under rising floodwater.
- Garage doors without openings because human intervention is required to open garage doors when flooding is expected. Gaps between the garage door and the door jamb or walls do not count toward the net open area requirement.

Figure 17: Standard air vent that is unacceptable as a flood opening because it is not disabled in the open position

9.2 Non-Engineered Flood Openings

Flood openings without moving parts are non-engineered openings, while those with moving parts should be certified as engineered openings (see Section 9.3). Non-engineered openings are used to provide 1 square inch of net open area for each square foot of enclosed area. The size of an enclosed area in square feet should be measured on the exterior of the enclosure walls. A variety of non-engineered opening options are available.

"Net open area" refers to the permanently open area of a non-engineered opening. The NFIP regulations indicate that flood openings may be equipped with "coverings or devices" if they permit the automatic (free) entry and exit of floodwater in both directions.

The measurement of the net open area must take into consideration any solid obstructions such as grilles, fixed blades and louvers, or faceplates. Methods used by the ventilation industry to account for such obstructions when determining net open area for air flow may be used. Figure 18 shows a typical standard air-vent faceplate and measurements of the net open area. Figure 19 shows a typical ventilation louver with fixed blades and indicates how the net open area is determined.

Some manufacturers of standard air vents stamp the number of square inches the device provides for air flow into the frame of the device or may note the number in the packaging. The measurement accounts for

MEASUREMENT MUST ACCOUNT FOR OBSTRUCTIONS

Section C2.7.2.1 of the ASCE 24 commentary emphasizes that the measurement of net open area is not based on the dimensions of the opening (void) in the wall. The measurement must account for any portion of the void that is obstructed or covered in any way (other than by screening).

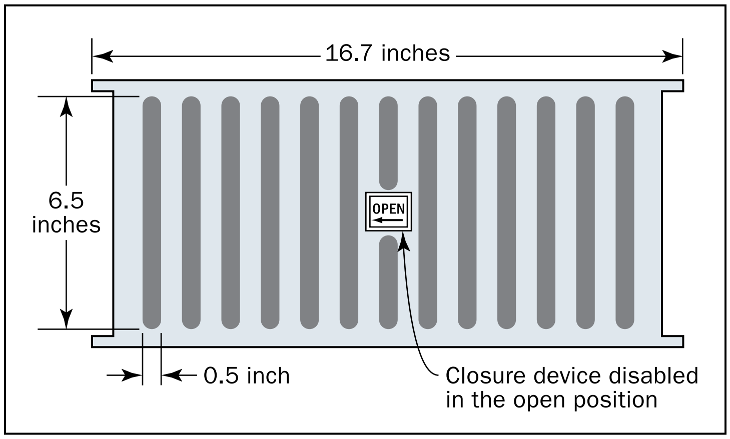


Figure 18: Example of non-engineered opening: Typical standard air vent faceplate providing 42 square inches of net open area if disabled in the open position; measurement of net open area uses a slot width of 0.5 inch times a slot height of 6.5 inch times the total number of slots

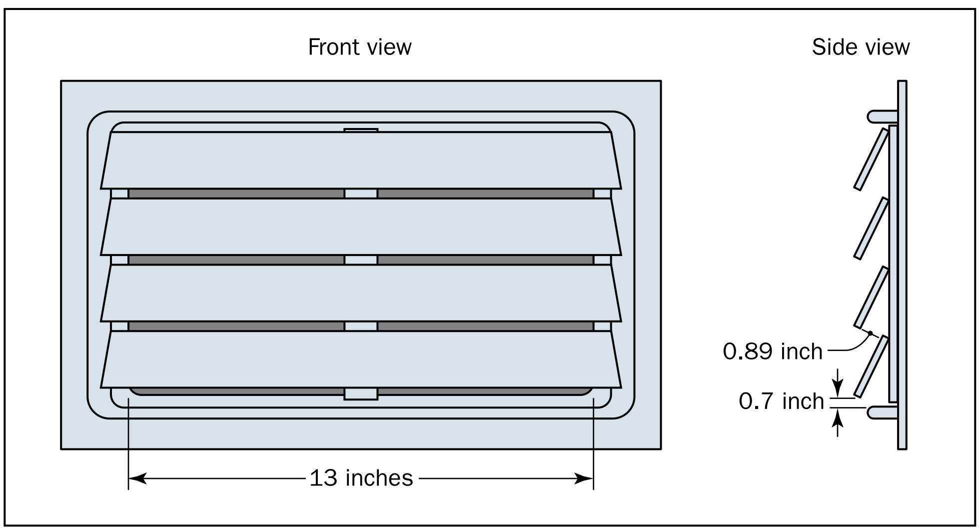


Figure 19: Example of non-engineered opening: Typical standard air vent with fixed, angled blades providing approximately 44 square inches of net open area; measurement of net open area uses slot width of 13 inches times the sum of the spaces between the blades

the presence of fixed blades, insect screens, and other obstructions. The same number of square inches should be used for the net open area calculation when these devices are installed as non-engineered openings. If not indicated by the manufacturer, the net open area must be measured. Guidance on measuring the net opening area may be available from manufacturers or other sources.

To qualify as non-engineered flood openings that permit the automatic entry and exit of floodwater:

- Standard air vents must not have solid covers (detachable or integrated with the vent) that are intended to be manually installed.
- Typical air-vent devices that are designed to be opened and closed manually must be disabled permanently in the open position.
- Air-vent devices that are designed to open and close based on temperature must also be designed to allow the automatic entry and exit of floodwater.

Insect screens that do not block the entry and exit of floodwater are allowed and do not affect the determination of the net open area. Communities that administer the IBC or IRC should note the requirement to cover ventilation openings for crawlspaces and under-floor spaces. The codes provide a list of acceptable covering materials.

The IBC and IRC commentaries note that some covering materials for ventilation openings may reduce the gross open area of the vent by as much as 50 percent. Although the net open area is not reduced by screens, in areas where floodwater is expected to carry debris such as grass clippings and leaves, insect screens tend to clog (see Figure 20). Engineers, architects, and local officials may determine that a different type of opening is appropriate or that more than the minimum number of flood openings is required to increase the likelihood that openings will perform as expected during flooding, even if some of them become clogged with debris.

AREAS LIKELY TO HAVE DEBRIS AND SEDIMENT

Section C2.7.2.1 of the ASCE 24 commentary suggests using caution in selecting or specifying openings with louvers, blades, screens, or faceplates that may be blocked by debris and sediment. In areas where experience indicates that floodborne debris and sediment are likely, ASCE 24 recommends avoiding the use of openings with components that have been shown to become blocked or clogged.

Figure 20: Typical air vents with insect screens blocked by flood debris

Examples of non-engineered openings are described below and shown in Figures 21 through 24.

MINIMUM DIMENSION SPECIFIED BY I-CODES

The IRC and IBC (by reference to ASCE 24) require that openings be not less than 3 inches in any direction in the plane of the wall. This requirement applies to the opening in the wall, excluding any device that may be inserted.

- Figure 21 shows typical standard air-ventilation devices that are intended for crawlspace foundation walls. If installed as flood openings, they must be disabled permanently in the open position to satisfy the requirement for automatic entry and exit of floodwater.
- Figure 22 shows decorative masonry units and decorative brickwork with closely spaced, open holes. Only the net open area of each hole is counted.
- Figure 23 shows standard concrete blocks that are turned sideways and have insect screening. The voids in the blocks are measured to determine the net open area.
- Figure 24 shows a foundation in which a hole was created when the concrete was poured. The horizontal dimension should be greater than the vertical dimension to facilitate flow-through. A wood frame covered with insect screening is inserted into the hole. The framed void is measured to determine the net open area. A similar situation results when a block is omitted from perimeter foundation walls constructed of concrete masonry units, resulting in a void the size of the omitted block.

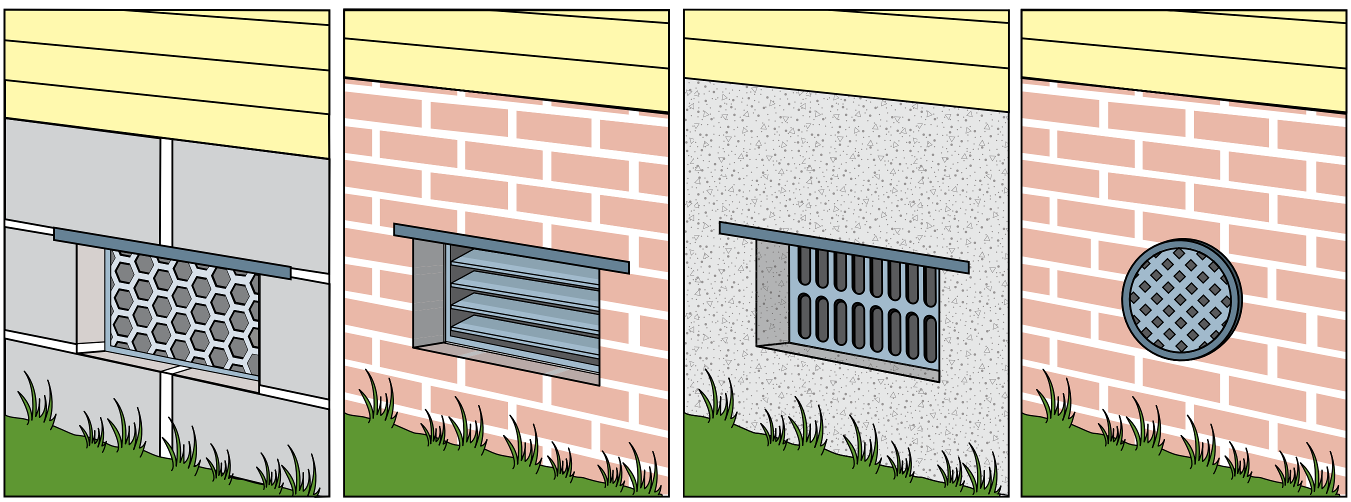


Figure 21: Examples of typical air vents in crawlspace foundation walls used as flood openings with varying net open areas

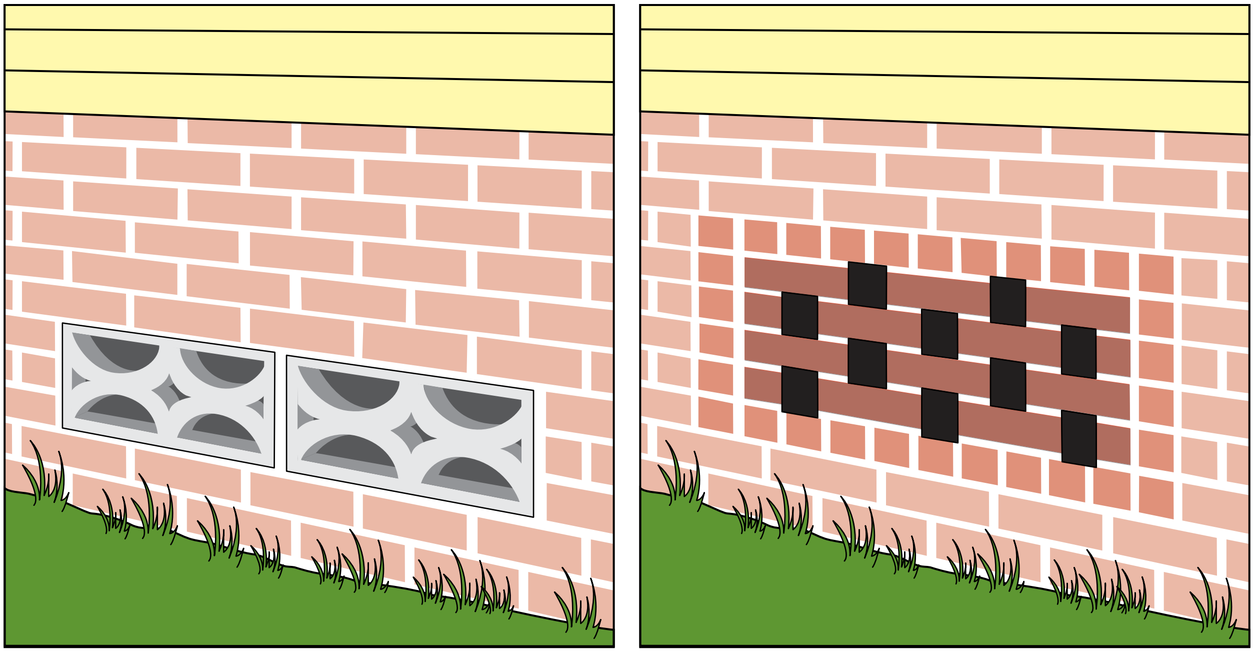


Figure 22: Decorative masonry units and closely spaced holes in brickwork; the area of each hole counts toward the total net open area

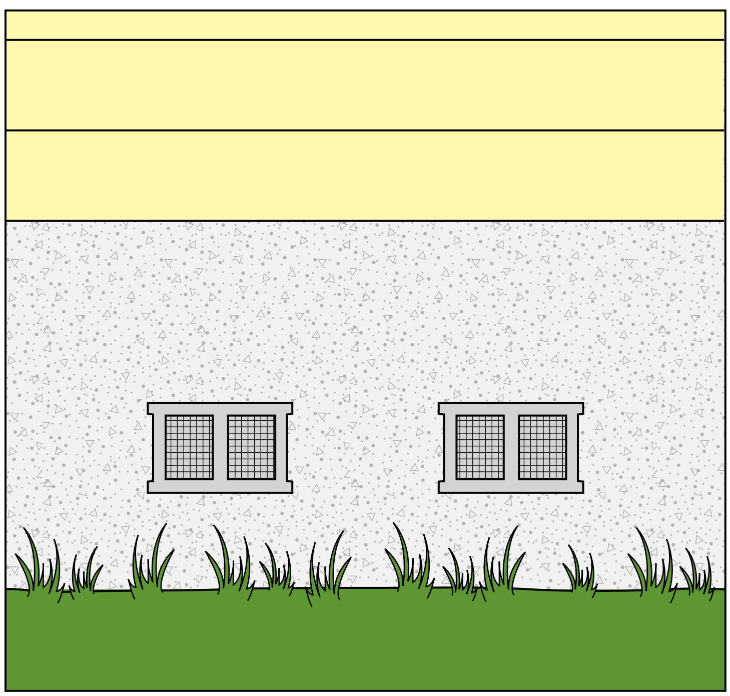


Figure 23: Concrete blocks turned sideways with insect screening; a typical 8- by 16-inch block provides approximately 60 square inches of net open area

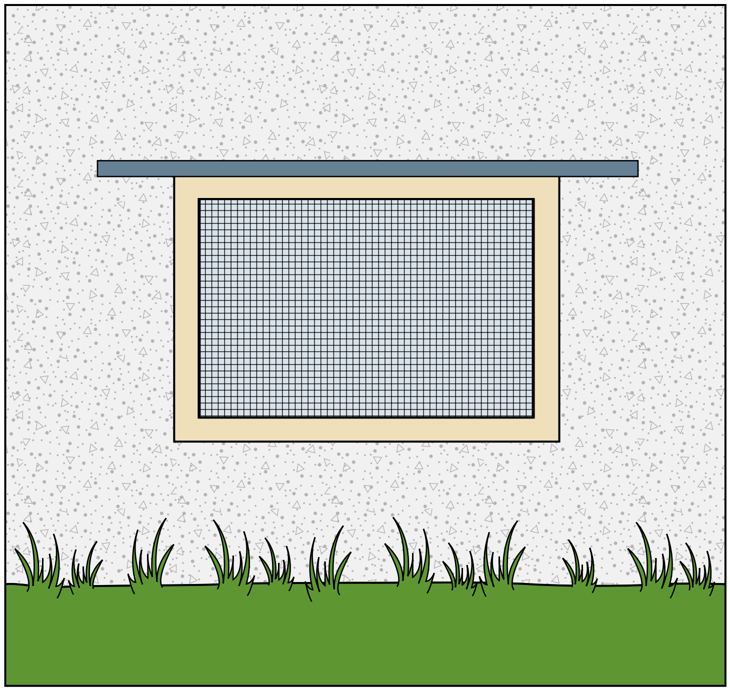


Figure 24: Wood frame with insect screen inserted in void in poured concrete foundation wall; inside dimensions of frame determine net open area

9.3 Engineered Flood Openings

Engineered flood openings, which have moving parts, must be designed and certified by registered design professionals as engineered flood openings (see Section 9.2 for openings without moving parts). The certification must specifically address the performance required by the NFIP regulations. Devices with moving parts should be certified as engineered openings. In general, engineered openings remain closed until flood conditions trigger the movable parts to allow floodwater and debris to freely and automatically enter or exit. This section describes the design and performance requirements and the certification and documentation requirements for engineered openings.

9.3.1 Design and Performance Requirements

The design and performance criteria for engineered openings are in ASCE 24, Section 2.7.2.2. Section C2.7.2.2 of the ASCE 24 commentary provides additional information on engineered openings and the best means to test expected performance.

The equation from ASCE 24, shown in Figure 25, is used to determine the total net area of engineered openings required for a given total enclosed area, based on some of the characteristics of the openings. The calculated minimum net area of engineered openings may be called the "coverage" or "rated" area.

$$A_0 = 0.033\ [1/c]\ R\ A_e$$

Where:

A_0 = total net area of openings required (in^2)

0.033 = coefficient corresponding to a factor of safety of 5.0 ($in^2 \bullet hr/ft^3$)

c = opening coefficient (non-dimensional; see ASCE 24, Table 2-2)

R = worst case rate of rise and fall (ft/hr)

A_e = total enclosed area (ft^2)

Figure 25: Equation used to determined total net area of engineered openings (ASCE 24-14; used with permission)

The equation includes a coefficient (0.033) that corresponds to a factor of safety of 5, which is consistent with design practices related to the protection of life and property. The ASCE 24 commentary provides additional background on the derivation of the equation.

Design and performance criteria for engineered openings specified in ASCE 24 include all of the following:

- Performance must allow for the automatic entry and exit of floodwater. The ASCE 24 commentary notes that the certification requires consideration of a number of factors that represent expected base flood conditions and not simply application of the equation. (Flood conditions in different areas can vary widely; in some areas, the onset of flooding may be rapid while in other areas, flood conditions may develop over much longer periods.)
- Performance must account for the presence of obstructions such as louvers, blades, screens, grilles, faceplates, and devices that are part of the engineered opening assembly itself. In accordance with ASCE 24, Table 2-2 (see Table 3 of this Technical Bulletin), the opening coefficient of discharge *(c)* is 0.20 for openings of all shapes if partially obstructed during design flood conditions by "louvers, blades, screens, grilles, faceplates, or other covers or devices [that] are present during the design flood," as opposed to blocked by debris.

ASCE 24 EMPHASIS ON PERFORMANCE AND CERTIFICATION

Engineered opening requirements changed between the 2005 and 2014 editions of ASCE 24. The 2014 edition places more emphasis on evidence of performance and consideration of factors that represent expected flood conditions. Section C2.7.2.2 of the ASCE 24-14 commentary notes that the best means to certify performance is to test engineered openings under conditions that mimic a range of rates of rise and fall, including rates many times the minimum rate of 5 feet per hour.

Documentation of performance under faster rates of rise and fall provides building designers and local officials with sufficient information on which to base decisions regarding whether to increase the number or size of openings to account for faster rates. The ASCE 24 commentary also notes that testing should be done with water containing debris typical of flooding around buildings (e.g., leaves, grass clippings, small branches, trash).

(The coefficient of discharge, also called an orifice coefficient, is selected to characterize the shape of the portion of an engineered opening through which water flows.)

Table 3: Flood Opening Coefficient of Discharge(1)

Opening Shape and Condition	*c*
All shapes, partially obstructed during design flood(2)	0.20
Circular, unobstructed during design flood	0.60
Rectangular, long axis horizontal, short axis vertical, unobstructed during design flood	0.40(3)
Square, unobstructed during design flood	0.35
Rectangular, short axis horizontal, long axis vertical, unobstructed during design flood	0.25(4)
Other shapes, unobstructed during design flood	0.30

Source: ASCE 24-14, Table 2-2 (used with permission)

(1) Different coefficients of discharge shall be permitted: (1) where a designer has performed detailed, opening-specific calculations, a coefficient of discharge up to 10% different than given in Table 2-2 shall be permitted; or (2) where laboratory testing or numerical modeling of flow through the opening has been conducted, the resulting coefficient of discharge shall be permitted. In no case shall a coefficient of discharge >0.60 be permitted.

(2) Openings shall be classified as partially obstructed if louvers, blades, screens, grilles, faceplates, or other covers or devices are present during the design flood.

(3) When the horizontal dimension is twice or more the vertical dimension, use 0.4; as the dimensions approach a square, interpolate from 0.4 to 0.35.

(4) When the horizontal dimension is half or less the vertical dimension, use 0.25; as the dimensions approach a square, interpolate from 0.25 to 0.35.

- Performance must account for the potential for debris blockage even if there are no louvers, blades, screens, grilles, faceplates, or other devices, preferably by allowing typical floodborne debris to pass through.
- Performance must ensure that the difference between the exterior and interior water levels will not exceed 1 foot. (Because the minimum requirement allows the bottom of openings to be no more than 1 foot above the higher of the finished interior grade [or floor] or exterior grade, a difference of no more than 1 foot is maintained when water begins to pass through as it crests the bottom of the opening frame.)
- The minimum dimension of an opening in a wall must not be less than 3 inches in any direction in the plane of the wall.

FLOODWATER RATE OF RISE AND FALL

Section C2.7.2.2 of the ASCE 24 commentary notes that a rate of rise of 5 feet per hour, only 1 inch per minute, is not representative of many flood hazard areas and advises building designers to be cautious about relying entirely on that rate. Faster rates of rise and fall are likely in watersheds where rainfall runoff accumulates rapidly and in many areas that are subject to storm surge flooding. ASCE 24 advises that information on rates of rise may be available from stream and tide gauges; federal, state, and local sources; and video documentation of past flood events.

- Reliable data on the rates of rise and fall at specific locations are usually not readily available. Therefore, engineered openings must be designed and must function based on the assumption that the minimum rate of rise and fall will be 5 feet per hour. Reinforcing the importance of testing for faster rates of rise and fall, building designers must increase the specified total net area of engineered openings when site-specific data or analyses of anticipated flood conditions indicate that more rapid rates of rise and fall are likely.

9.3.2 Documentation of Engineered Openings for Compliance

Engineered openings should be accepted by local officials when the designs are certified and the certifications are submitted as part of permit applications. Acceptable documentation of certification are the certification reports (i.e., ICC-ES Evaluation Reports or equivalent reports from other product certification organizations) and individual certifications for specific buildings (see Section 9.3.4).

Copies of the certifications must be kept in the community's permanent permit files. Community retention of these documents is important not only to demonstrate compliance but also in the event that future building owners do not receive copies of the certifications when they buy buildings. Owners must submit certifications with applications for NFIP flood insurance policies.

I-CODES REQUIRE DESIGN STATEMENTS

The IBC and IRC require that construction documents submitted for building permits include design statements by registered design professionals when applicants propose using engineered openings. ICC-ES Evaluation Reports and equivalent certification reports satisfy this requirement.

Individual certifications prepared for specific buildings also satisfy the requirement for design statements.

9.3.3 Engineered Openings with Certification Reports

The ICC-ES and other product certification organizations develop criteria for acceptance of a variety of building products, construction methods, and materials. Each organization issues certification reports after technical evaluation of documentation that is submitted by manufacturers. Documentation typically includes technical design reports, certifications, and testing results to demonstrate performance and compliance with codes and standards. Certification reports provide evidence that products comply with specific building codes and standards. Designers, builders, and local officials who rely on these reports must determine whether the reports identify the editions of the building codes and ASCE 24 that are applicable to individual projects. If applicable editions of the codes and standard are not identified, the certification report should not be used.

Documentation submitted by manufacturers to obtain an ICC-ES Evaluation Report or equivalent certification report for engineered openings must be supported by certifications describing the performance of the openings and the name, title, address, type of license, license number, the state in which the license was issued, and the signature and seal of the certifying registered

SITE-SPECIFIC APPLICABILITY OF ENGINEERED OPENINGS

When an engineered opening product with a certification report issued by ICC-ES or an equivalent product certification organization is specified in construction documents, the engineer, architect, or builder should determine whether the product, given its limitations and conditions of use, is appropriate for the conditions of flooding at the site, especially the rate of rise and fall of floodwater. Designers should consult with local officials regarding observations of past rates of rise and fall during conditions of flooding.

design professional. The certification reports must include a description of installation requirements or limitations that, if not followed, would void the certification. FEMA considers the following documentation important:

- Statement certifying that the openings, when properly installed, are designed to automatically equalize hydrostatic flood loads on exterior walls by allowing the automatic entry and exit of floodwater in accordance with the design and performance requirements in ASCE 24.
- Statement certifying that the performance accounts for the presence of louvers, blades, screens, grilles, faceplates, or devices with consideration of the potential for debris blockage when these features are present.
- Description of the measurement of the actual net area of the engineered opening that is being certified and identification of the opening coefficient of discharge, which is the variable *c* in the formula in ASCE 24 (see Figure 25 and Table 3 of this Technical Bulletin). The coefficient of discharge is selected by the designer based on the shape and dimensions of the opening and whether the engineered opening has features such as louvers, blades, screens, grilles, faceplates, or devices that partially obstruct flow during conditions of flooding.
- The range of flood characteristics tested for which the certification is valid, specifically the rates of rise and fall of floodwater, which is the variable *R* in the formula in ASCE 24 (see Figure 25), and whether there are any limitations based on rates of rise and fall that are faster than 5 feet per hour. Given the ASCE 24 performance expectations, engineered openings must function during conditions of the minimum 5 feet per hour rate of rise and fall.

9.3.4 Engineered Openings Individually Certified for Specific Buildings

Engineered openings that do not have ICC-ES Evaluation Reports or equivalent certification reports must be individually certified as meeting the design requirements described in Section 9.3.1 of this Technical Bulletin and for acceptability in specific buildings based on site-specific conditions. The formula in Section 9.3.1 includes the variable *R*, which is the worst-case rate of rise and fall at a specific location. ASCE 24 allows the assumption of a minimum rate of rise and fall of 5 feet per hour only in the absence of reliable data on site-specific rates of rise and fall. Building designers who specify engineered openings that are individually certified should consult local officials regarding observations of past rates of rise and fall during conditions of flooding.

Generic certifications for manufactured products place the burden on users (who may not be design professionals) to determine whether a specific location is subject to rates of rise and fall greater than 5 feet per hour. For this reason, generic "fill-in-the-blank" certifications are not acceptable when a manufactured product is used for a specific building unless the builder or design professional for that building, or the local official, determines that the rates of rise and fall at the specific location are no faster than 5 feet per hour. Alternatively, the builder or design professional may submit documentation that there are no reliable data for site-specific rates of

INDIVIDUAL CERTIFICATION FOR SPECIFIC BUILDINGS MUST ADDRESS SEVERAL FACTORS

Section C2.7.2.2 of the ASCE 24 commentary indicates that "certification requires more than simply applying the equation … it requires consideration of a number of factors that represent expected base flood conditions." The commentary also notes that engineered openings should be tested unless uniquely designed for a specific location.

rise and fall, in which case the local official may concur that the rates may be assumed to be no faster than 5 feet per hour.

When engineered openings that have been individually certified for specific buildings are used, the permit application must include a certification that is signed and sealed by the registered design professional, who must be licensed to practice in the state in which the building is located. In addition, the submitted plans must identify the location for the openings and specify installation instructions.

The original certification for engineered openings prepared for specific buildings must include the design professional's name, title, address, signature, type of license, license number, the state in which the license was issued, and the signature and applied seal of the certifying registered design professional. The original certification must identify the physical location of the building in which the engineered openings will be installed.

This Technical Bulletin relies on the ASCE 24 requirements for engineered openings as the accepted standard of practice. The certification must include a description of installation requirements or limitations that, if not followed, will void the certification. In addition to the design and certification criteria listed in Section 9.3.1, the certification must include the following:

- Statement certifying that the openings, when properly installed, are designed to automatically equalize hydrostatic flood loads on exterior walls by allowing the automatic entry and exit of floodwater in accordance with the design and performance requirements in ASCE 24.
- Statement certifying that the performance accounts for the presence of louvers, blades, screens, grilles, faceplates, or devices with consideration of the potential for debris blockage when these features are present.
- Description of the measurement of the actual net area of the engineered opening and identification of the opening coefficient of discharge, which is the variable c in the formula in ASCE 24 (see Figure 25 and Table 3 of this Technical Bulletin). The coefficient of discharge is selected by the designer based on the shape and dimensions of the opening and whether the engineered opening has features such as louvers, blades, covers, screens, grilles, faceplates, or other elements that partially obstruct flow during conditions of flooding.
- Determination of the rate of rise and fall of floodwater at the site and a statement certifying that the openings are designed for that rate of rise and fall or a statement that the opening is designed for a minimum rate of rise and fall of 5 feet per hour because reliable data on site-specific rates of rise and fall are not available.

9.3.5 NFIP Elevation Certificate and Documentation of Engineered Openings for Flood Insurance

When engineered openings are used, the NFIP Elevation Certificate must be completed carefully. The question “Engineered flood openings?” must be answered with “Yes” (see A8.d and A9.d in Figure 26). The engineered opening documentation must be attached to the NFIP Elevation Certificate. Insurers and insurance agents must ask property owners to provide the documentation as part of applications for NFIP flood insurance policies. The following are acceptable forms of documentation:

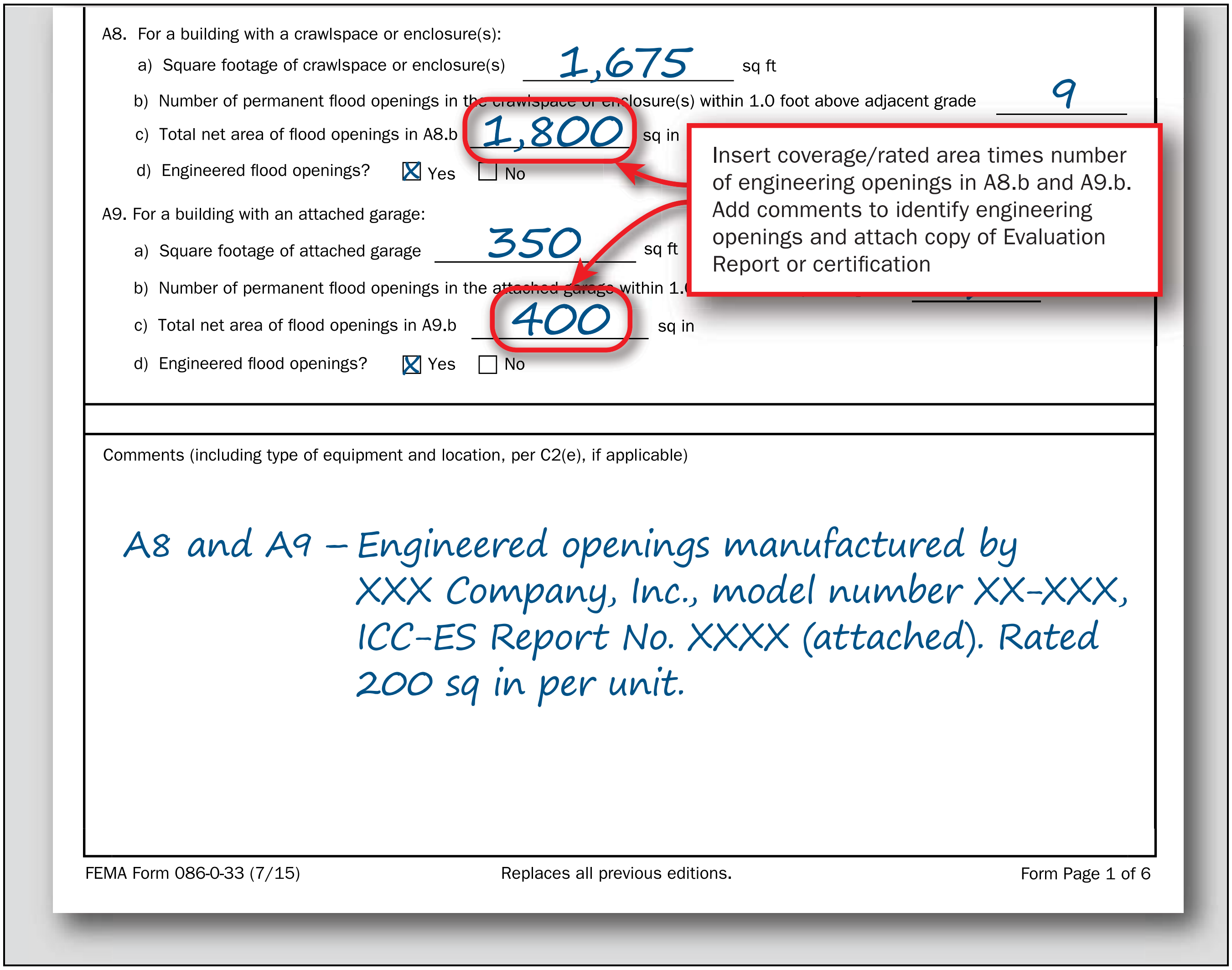
- For engineered openings with ICC-ES Evaluation Reports or equivalent reports from other product certification organizations, a copy of the report that identifies the manufacturer’s model number and specifies the number of such openings that are required for a specified square footage of enclosed area
- For engineered openings individually certified for installation in a specific building, a certification that is signed and sealed by a registered design professional who is licensed in the state where the building is located, and that addresses the statements described in Section 9.3.4

NFIP ELEVATION CERTIFICATES AND NON-ENGINEERED OPENINGS

When non-engineered openings are used, the total net open area of the openings that are within 1.0 foot above the higher of the exterior or interior grade or floor should be determined by measurement (see examples in Section 9.2) or by using the manufacturer’s specifications.

To complete the NFIP Elevation Certificate with information required for proper rating of NFIP flood insurance policies for buildings with engineered openings, Item A8.c, “Total net area of flood openings in A8.b,” must be filled in with the total coverage or rated area of engineered openings. The total coverage or rated area is the number of engineered openings identified in Item A8.b multiplied by the “coverage” area, “rated” area, or “enclosed area coverage” identified in the ICC-ES Evaluation Report, equivalent report, or individual certifications. When engineered openings are used in attached garages, Item A9.c must be completed in the same manner. The coverage or rated area usually is given in square feet of enclosed area for which an engineered opening can provide automatic inflow and outflow of floodwater, which is, in effect, equivalent to the performance that would be provided by that number of square inches of non-engineered openings.

Also, in Section D, “Check here if attachments” must be selected, and a copy of the certification report must be attached to the NFIP Elevation Certificate (see Figure 26). Notes must be added in the Section D comment section to identify the manufacturer and the manufacturer’s model number of the engineered opening.



A8. For a building with a crawlspace or enclosure(s):

a) Square footage of crawlspace or enclosure(s) 1,675 sq ft

b) Number of permanent flood openings in the crawlspace or enclosure(s) within 1.0 foot above adjacent grade 9

c) Total net area of flood openings in A8.b 1,800 sq in

d) Engineered flood openings? ☒ Yes ☐ No

A9. For a building with an attached garage:

a) Square footage of attached garage 350 sq ft

b) Number of permanent flood openings in the attached garage within 1.0 foot above adjacent grade

c) Total net area of flood openings in A9.b 400 sq in

d) Engineered flood openings? ☒ Yes ☐ No

Comments (including type of equipment and location, per C2(e), if applicable)

A8 and A9 – Engineered openings manufactured by XXX Company, Inc., model number XX-XXX, ICC-ES Report No. XXXX (attached). Rated 200 sq in per unit.

FEMA Form 086-0-33 (7/15) Replaces all previous editions. Form Page 1 of 6

Figure 26: Completing the NFIP Elevation Certificate when engineered openings are used

10 References

This section lists the references cited in this Technical Bulletin. Additional resources related to NFIP requirements are provided in Technical Bulletin 0.

ASCE/SEI. 2014. ASCE/SEI 24-14, *Flood Resistant Design and Construction*. Available at https://www.asce.org/.

FEMA (Federal Emergency Management Agency). Various NFIP Technical Bulletins. Current editions are available at https://www.fema.gov/nfip-technical-bulletins:

- Technical Bulletin 0, *Users Guide to Technical Bulletins.*
- Technical Bulletin 2, *Flood Damage-Resistant Materials Requirements.*
- Technical Bulletin 3, *Non-Residential Floodproofing – Requirements and Certification.*
- Technical Bulletin 7, *Wet Floodproofing Requirements for Certain Buildings Located in Special Flood Hazard Areas.*
- Technical Bulletin 9, *Design and Construction Guidance for Breakaway Walls.*
- Technical Bulletin 11, *Crawlspace Construction for Buildings Located in Special Flood Hazard Areas: National Flood Insurance Program Interim Guidance.*

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FEMA. 2010. FEMA P-758, *Substantial Improvement/Substantial Damage Desk Reference*. Available at https://www.fema.gov/media-library/assets/documents/18562.

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FEMA. 2018. FEMA 213, *Answers to Questions About Substantially Damaged Improved/Damaged Buildings*. Available at https://www.fema.gov/media-library/assets/documents/169099.

FEMA. 2019. *NFIP Flood Insurance Manual*. Available at https://www.fema.gov/flood-insurance-manual

ICC (International Code Council). International Codes. Available at https://codes.iccsafe.org/category/I-Codes.

- 2012 International Building Code
- 2012 International Residential Code
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- 2018 International Building Code
- 2018 International Residential Code

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Free-of-Obstruction Requirements

For Buildings Located in Coastal High Hazard Areas in Accordance with the National Flood Insurance Program

NFIP Technical Bulletin 5 / March 2020

FEMA

Comments on the Technical Bulletins should be directed to:

DHS/FEMA
Federal Insurance and Mitigation Administration (FIMA) Risk Management Directorate
Building Science Branch
400 C Street, S.W., Sixth Floor
Washington, DC 20472-3020

NFIP Technical Bulletin 5 (2020) replaces NFIP Technical Bulletin 5 (2008), *Free-of-Obstruction Requirements.*

Cover photograph: Area beneath an elevated building that is free of obstruction.

For more information, see the FEMA Building Science Frequently Asked Questions website at https://www.fema.gov/frequently-asked-questions-building-science.

If you have any additional questions on FEMA Building Science Publications, contact the helpline at FEMA-Buildingsciencehelp@fema.dhs.gov or 866-927-2104.

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Visit the Building Science Branch of the Risk Management Directorate at FEMA's Federal Insurance and Mitigation Administration at https://www.fema.gov/building-science.

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Revision History

April 2020 Added 44 CFR citation for swimming pools and spas topic in Table 1 (page 8)

April 2020 Corrected caption for Figure 1 (page 16)

Acronyms

ASCE	American Society of Civil Engineers
BFE	base flood elevation
CFR	Code of Federal Regulations
DFE	design flood elevation
DHS	Department of Homeland Security
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
IBC	International Building Code®
ICC	International Code Council®
I-Codes	International Codes®
IRC	International Residential Code®
ISPSC	International Swimming Pool and Spa Code®
NFIP	National Flood Insurance Program
PFD	primary frontal dune
SEI	Structural Engineering Institute
SFHA	Special Flood Hazard Area

1 Introduction

This Technical Bulletin provides guidance on the National Flood Insurance Program (NFIP) free-of-obstruction requirements in Coastal High Hazard Areas, which are designated as Zone V (V, VE, V1-30, and/or VO) on a community's Flood Insurance Rate Map (FIRM), as well as the NFIP requirements for construction in Zone V to minimize flood damage potential that is applicable to construction in Zone V. The free-of-obstruction requirements were instituted to minimize the transfer of flood forces to an elevated building's foundation and also to minimize the diversion or deflection of floodwater or waves that could damage the elevated building or neighboring buildings.

> **NFIP TECHNICAL BULLETIN 0**
>
> NFIP Technical Bulletin 0, *User's Guide to Technical Bulletins*, should be used as a reference in conjunction with this Technical Bulletin. Technical Bulletin 0 describes the purpose and use of the Technical Bulletins, includes common concepts and terms, lists useful resources, and includes a crosswalk of the sections of the NFIP regulations identifying the Technical Bulletin that addresses each section of the regulations and a subject index.
>
> Readers are cautioned that the definitions of some of the terms that are used in the Technical Bulletins are not the same when used by the NFIP for the purpose of rating flood insurance policies.

This Technical Bulletin also discusses how the presence or absence of obstructions can affect NFIP flood insurance premiums.

Coastal waves and flooding can exert strong hydrodynamic forces on building elements in their path. Therefore, the NFIP requires that all new and Substantially Improved structures in Coastal High Hazard Areas (Zone V) be elevated on pilings or columns with the bottom of the lowest horizontal structural members of the lowest floor elevated to or above the base flood elevation (BFE). These open foundations allow floodwater and waves to pass beneath the elevated structure.

> **EFFECTS OF OBSTRUCTIONS**
>
> The NFIP requires the area beneath elevated structures in Zone V to remain *free of any obstructions that would prevent the free flow of coastal floodwater and waves* during a base flood event. An area beneath a structure elevated on an open foundation is considered to be free of obstructions if flood flow and waves can pass through the area without significant ***flow diversion, wave reflection, or wave runup***.
>
> - **Flow diversion.** Change in the course of flood flow when it encounters an object or structure. Diversion can be accompanied by an increase in the local flood level and/or flood velocity when the blockage is large relative to the area through which the flow would otherwise pass.
> - **Wave reflection.** Return or redirection of a wave striking an object.
> - **Wave runup.** Rush of water up a slope or structure following wave breaking.
>
> Some flow diversion, wave reflection, and wave runup can occur even with open foundations, but if the guidance in this Technical Bulletin is followed, the effects should be minimized during flood conditions up to the base flood event.

Any element constructed below the BFE that is attached to a building in Zone V is considered part of the building and must meet the free-of-obstruction requirements.

Standard solid foundation walls, such as masonry, concrete, and wood-frame walls, are not permitted in Zone V because they would obstruct flow and be at risk of damage from high-velocity flood forces. In addition, solid foundations and other obstructions could cause wave runup or reflection or divert floodwater into the elevated portion of the building or nearby buildings.

The NFIP interprets the free-of-obstruction requirements to apply to certain site development practices that prevent the free flow of coastal floodwater and waves under or around buildings or increase flood loads on nearby buildings. Construction elements outside the perimeter (footprint) of and not attached to a coastal building (e.g., bulkheads, retaining walls, decks, swimming pools, accessory structures) and site development practices (e.g., addition of fill) may alter the physical characteristics of flooding or significantly increase wave or flood forces affecting nearby buildings. As part of the design certification process for a building in Zone V, the registered design professional must consider the effects these elements and practices will have on the building and on nearby buildings.

The NFIP requires buildings to be constructed using methods and materials that minimize the potential for flood damage. Therefore, any construction element placed on a building site in Zone V (see Sections 6 and 7) has the potential to affect the building and nearby buildings, which must be taken into account. In addition to potential wave and floodwater diversion effects, obstructions can break free and become floodborne debris that may strike and damage other buildings.

The building elements and site development issues in regard to obstruction that are discussed in this Technical Bulletin include:

Building elements below the BFE

- Access stairs and ramps
- Decks, porches, and patios
- Elevators
- Enclosed areas
  - Below elevated structures
  - Above-grade (elevated)
  - Two levels
- Equipment and tanks
- Foundation bracing
- Grade beams
- Shear walls
- Slabs

Site development: Practices and issues

- Accessory storage structures
- Detached garages
- Erosion control structures
- Fences and privacy walls
- Fill
- Ground elevations at or above the BFE
- On-site septic systems
- Restroom buildings and comfort stations
- Swimming pools and spas

Building elements and site development practices that are not specifically prohibited by the NFIP may be used as long as they will not adversely affect other structures. However, some building elements and site development practices may increase flood-related loading on the building where those practices are proposed. In such cases, the building must be designed to withstand the additional flood-related loading and the registered design professional must provide the required Zone V certification for the building.

Questions about free-of-obstruction requirements should be directed to the appropriate local official, NFIP State Coordinating Office, or Federal Emergency Management Agency (FEMA) Regional Office.

NFIP TERMS USED IN THIS TECHNICAL BULLETIN

- **Special Flood Hazard Area (SFHA):** Area subject to flooding by the base flood (1-percent-annual-chance flood) and shown on FIRMs as Zone A or Zone V.
- **Zone A:** Flood zones shown on FIRMs as Zone A, AE, A1-30, AH, AO, A99, and AR.
- **Zone V:** Flood zones shown on FIRMs as Zone V, VE, V1-30, and VO.
- **Coastal High Hazard Area:** Area shown on FIRMs and other flood hazard maps as Zone V, VO, VE, or V1-30.

2 National Flood Insurance Program Regulations

An important NFIP objective is protecting buildings constructed in Special Flood Hazard Areas (SFHAs) from damage caused by flooding. The SFHA is the land area subject to flooding by the base flood. SFHAs are shown on Flood Insurance Rate Maps (FIRMs) prepared by FEMA as Zones A and V. The base flood is the flood that has a 1 percent chance of being equaled or exceeded in any given year (commonly called the "100-year" flood).

The NFIP floodplain management regulations include minimum building design criteria that apply to:

- New construction
- Work determined to be Substantial Improvements such as improvements, alterations, and additions
- Repair of buildings determined to have incurred Substantial Damage

A defining characteristic of the NFIP regulations applicable in Zone V is the requirement for the lowest horizontal structural member of the lowest floor to be elevated to or above the BFE. This requirement applies to both residential and non-residential buildings. Furthermore, the area beneath elevated structures must be free of obstructions that would prevent the free flow of coastal floodwater and waves during a base flood event.

ZONE V CERTIFICATION OF STRUCTURAL DESIGN AND METHODS OF CONSTRUCTION

The NFIP regulations require communities to ensure that construction meets Zone V requirements, including the free-of-obstruction requirement. Registered professional engineers or architects must develop or review structural designs, specifications, and plans for new construction and Substantial Improvements and certify that designs and methods of construction are in accordance with the accepted standards of practice. Building engineers and architects should consult with communities on their certification requirements before starting design, and communities must obtain and retain the certifications.

Satisfying the NFIP free-of-obstruction requirement is part of the certification. Local officials should determine that construction and/or site plans show all proposed site improvement elements described in this Technical Bulletin. The NFIP requires Zone V certification prior to construction. The community must ensure that what is constructed is compliant; some jurisdictions may require post-construction certification by the registered design professional.

See Technical Fact Sheet 1.5 in the *Home Builder's Guide to Coastal Construction* (FEMA P-499) (2010a) for a discussion of Zone V certification requirements.

The NFIP regulations for Zone V construction are codified in Title 44 Code of Federal Regulations (44 CFR) Part 60 Criteria for Land Management and Use. Specific to this Technical Bulletin, Section 60.3(a)(3) of the NFIP regulations states:

> If a proposed building site is in a flood-prone area, all new construction and substantial improvements shall … (iii) be constructed by methods and practices that minimize flood damages …

Section 60.3(e)(4) states that a community shall require (emphasis added):

> … that **all new construction and substantial improvements** in Zones V1 V30, VE, and also Zone V if base flood elevation data is available, on the community's **FIRM, are elevated on pilings and columns so that (i) the bottom of the lowest horizontal structural member of the lowest floor (excluding the pilings or columns) is elevated to or above the base flood level; and (ii) the pile or column foundation and structure attached thereto is anchored to resist flotation, collapse, and lateral movement due to the effects of wind and water loads acting simultaneously on all building components.** Water loading values used shall be those associated with the base flood. Wind loading values used shall be those required by applicable State or local building standards. A registered professional engineer or architect shall develop or review the structural design, specifications and plans for the construction, and shall certify that the design and methods of construction to be used are in accordance with accepted standards of practice for meeting the provisions of paragraphs (e)(4)(i) and (ii) of this section.

Section 60.3(e)(5) further states that a community shall require (emphasis added):

> **… that all new construction and substantial improvements within Zones V1-V30, VE, and V on the community's FIRM have the space below the lowest floor either free of obstruction or constructed with non-supporting breakaway walls, open wood lattice-work, or insect screening intended to collapse under wind and water loads without causing collapse,**

> **displacement, or other structural damage to the elevated portion of the building or supporting foundation system.** For the purpose of this section, a breakaway wall shall have a design safe loading resistance of not less than 10 and no more than 20 pounds per square foot. Use of breakaway walls which exceed a design safe loading resistance of 20 pounds per square foot (either by design or when so required by local or State codes) may be permitted only if a registered professional engineer or architect certifies that the designs proposed meet the following conditions: (i) Breakaway wall collapse shall result from a water load less than that which would occur during the base flood; and (ii) The elevated portion of the building and supporting foundation system shall not be subject to collapse, displacement, or other structural damage due to the effects of wind and water loads acting simultaneously on all building components (structural and non-structural). Water loading values used shall be those associated with the base flood. Wind loading values used shall be those required by applicable State or local building standards. Such enclosed space shall be useable solely for parking of vehicles, building access, or storage.

Section 60.3(e)(6) states that a community shall "prohibit the use of fill for structural support of buildings within Zones V1-30, VE, and V on the community's FIRM."

Section 60.3(e)(7) states that a community shall "prohibit man-made alteration of sand dunes and mangrove stands within Zones V1–30, VE, and V on the community's FIRM which would increase potential flood damage."

For more information on NFIP regulations, refer to the following for:

- Guidance on coastal construction in the *Coastal Construction Manual* (FEMA P-55) (2011) and in the *Home Builder's Guide to Coastal Construction* (FEMA P-499) (2010a)
- Guidance on design considerations, buildings codes and regulations, and best practices for coastal communities in *Local Officials Guide for Coastal Construction* (FEMA P-762) (2009)
- Guidance on the breakaway wall requirements of Section 60.3(e)(5) of the NFIP regulations in NFIP Technical Bulletin 9, *Design and Construction Guidance for Breakaway Walls Below Elevated Buildings Located in Coastal High Hazard Areas*
- Guidance on the requirement that building materials used below the BFE must meet the flood damage-resistant materials requirement of Section 60.3(a)(3) of the NFIP regulations in NFIP Technical Bulletin 2, *Flood Damage-Resistant Materials Requirements for Buildings Located in Special Flood Hazard Areas*

NFIP REQUIREMENTS AND HIGHER REGULATORY STANDARDS

State and Local Requirements. State or local requirements that are more restrictive or stringent than the minimum requirements of the NFIP take precedence. The Technical Bulletins and other FEMA publications provide guidance on the minimum requirements of the NFIP and describe best practices. Design professionals, builders, and property owners should contact local officials to determine whether more restrictive provisions apply to buildings or sites in question. All other applicable requirements of the state or local building codes must also be met for buildings in flood hazard areas.

Substantial Improvement and Substantial Damage. As part of issuing permits, local officials must review not only proposals for new construction but also for work on existing buildings to determine whether the work constitutes Substantial Improvement or repair of Substantial Damage. If the work is determined to constitute Substantial Improvement or repair of Substantial Damage, the buildings must be brought into compliance with NFIP requirements for new construction. Some communities modify the definitions of Substantial Improvements and/or Substantial Damage to be more restrictive than the NFIP minimum requirements. For more information on Substantial Improvement and Substantial Damage, see FEMA P-758, *Substantial Improvement/Substantial Damage Desk Reference* (2010b), and FEMA 213, *Answers to Questions About Substantially Damaged/Substantially Damaged Buildings* (2018a).

Higher Building Elevation Requirements. Some communities require that buildings be elevated above the NFIP minimum requirements. The additional elevation is called freeboard. Design professionals, builders, and property owners should check with local officials to determine whether a community has freeboard requirements. References to building elevations in this Technical Bulletin should be construed as references to the community's elevation requirement in areas where freeboard is required.

3 Building Codes and Standards

In addition to complying with the NFIP requirements, all new construction, Substantial Improvements, and repair of Substantial Damage must comply with applicable building codes and standards that have been adopted by states and communities.

The International Codes® (I-Codes®), published by the International Code Council® (ICC®), are a family of codes that includes the International Residential Code® (IRC®), International Building Code® (IBC®), International Existing Building Code® (IEBC®), and codes that govern the installation of mechanical, plumbing, fuel gas service, and other aspects of building construction. FEMA has deemed that the latest published editions of the I-Codes meet or exceed NFIP requirements for buildings and structures in flood hazard areas. Excerpts of the flood

I-CODES AND COASTAL A ZONES

The 2018 International Codes (I-Codes) treat Coastal A Zones like Zone V if a Limit of Moderate Wave Action (LiMWA) is delineated on FIRMs. If a community designates an area as a Coastal A Zone through its building code or floodplain management regulations, buildings in that area are required to comply with the Zone V requirements for foundations, including the free-of-obstruction requirement, with an exception that permits filled stem wall foundations.

Note: Per the I-Codes and ASCE 24-14, breakaway walls in the Coastal A Zone and Zone V must have flood openings.

provisions of the I-Codes are available on FEMA's Building Code Resource webpage (https://www.fema.gov/building-code-resources).

3.1 International Residential Code

The IRC applies to one- and two-family dwellings and townhomes not more than three stories above grade plane. The IRC's free-of-obstruction requirements are summarized in Table 1 and compared to NFIP requirements.

Table 1 refers to selected requirements of the 2018 IRC and notes changes from the 2015 and 2012 editions.

IRC COMMENTARY

ICC publishes companion commentary for the IRC. Although not regulatory, the commentary provides guidance that is useful in complying with, interpreting, and enforcing the requirements of the code.

Table 1: Comparison of Selected 2018 IRC Requirements and NFIP Requirements

Topic	Summary of Selected 2018 IRC Requirements and Changes from 2015 and 2012 Editions	Comparison with NFIP Requirements
Free of obstruction	**Section R322.3.3 Foundations.** Requires in Coastal High Hazard Areas (Zone V) and Coastal A Zones that areas below elevated buildings be either free of obstructions or constructed of breakaway walls. In Coastal A Zones, filled stem wall foundations must be designed to resist flood loads, erosion, and scour. Change from 2015 to 2018 IRC: Changes to subsection numbering due to insertion of new subsections expanding requirements for 322.3.4, Concrete slabs; R322.3.7, Stairways and ramps; and R322.3.8, Decks and porches. Change from 2012 to 2015 IRC: Applies Zone V requirements in Coastal A Zone, if delineated, with an exception that permits stem wall foundations.	Equivalent to NFIP 44 CFR §§ 60.3(e)(4) and (5), except that 2018 IRC applies in both Zone V and Coastal A Zones, with an exception that permits stem wall foundations in Coastal A Zones.
Use of fill	**Section R322.3.2 Elevation requirements [excerpt].** Prohibits the use of fill for structural support in Coastal High Hazard Areas (Zone V) and Coastal A Zones, while allowing minor quantities of nonstructural fill to be used for drainage and landscaping purposes under and around buildings and for support of parking slabs, pool decks, patios, and walkways. Change from 2015 to 2018 IRC: No change. Change from 2012 to 2015 IRC: No change.	Equivalent to NFIP 44 CFR § 60.3(e)(6), with more specificity for use of fill for specific, nonstructural purposes.
Enclosed areas	**Section R322.3.5 Walls below design flood elevation.** In Coastal High Hazard Areas (Zone V) and Coastal A Zones, (1) requires that enclosures below elevated buildings be designed to break away under certain wind and flood loads without damaging the elevated building or the building foundation and (2) prohibits mounting of electrical, mechanical, and plumbing system components on breakaway walls or penetration of the breakaway walls. Change from 2015 to 2018 IRC: No change. Change from 2012 to 2015 IRC: Clarifies that attachment or penetration by electrical, mechanical or plumbing systems to breakaway walls is not permitted.	Exceeds NFIP 44 CFR § 60.3(e)(5) by specifying components that are not to be mounted on or penetrate through breakaway walls and by requiring flood openings in breakaway walls.

Table 1: Comparison of Selected 2018 IRC Requirements and NFIP Requirements (continued)

Topic	Summary of Selected 2018 IRC Requirements and Changes from 2015 and 2012 Editions	Comparison with NFIP Requirements
Equipment and tanks	**Section R322.1.6 Protection of mechanical, plumbing, and electrical systems.** Requires that new electrical, plumbing, and mechanical system elements, along with replacements due to Substantial Improvements, be elevated to the design flood elevation (DFE) or if below the DFE, to be designed and installed to prevent water from entering or accumulating within the element and be able to withstand certain loads and stresses. Change from 2015 to 2018 IRC: No change. Change from 2012 to 2015 IRC: No change. **Section R322.3.7 Tanks.** Requires tanks to either be located underground or elevated to the DFE. When located underground, tanks must be anchored to resist flotation, collapse, and lateral movement during the base flood. If elevated, tanks must be on platforms that are cantilevered or knee-braced against the building or on a platform with a foundation that resists certain wind and flood loads. Change from 2015 to 2018 IRC: No change. Change from 2012 to 2015 IRC: Added requirements for tanks.	Equivalent to NFIP 44 CFR § 60.3(a)(3)(iv) but with more specificity: components are not to be mounted on or penetrate through breakaway walls and there are explicit requirements for tanks.
Concrete slabs	**Section R322.3.4 Concrete slabs.** Requires that slabs used for parking, floors of enclosures, landings, decks, walkways, patios, and similar uses that are beneath buildings or located such that they could be undermined or displaced and could cause damage be either (1) structurally independent of foundations and no more than 4 inches thick, have no turn-downed edges, have no reinforcing, and have isolation joints at pilings and columns and control or construction joints in both directions no more than 4 feet apart or (2) self-supporting and will remain intact under base flood conditions, taking into account scour and erosion, and have building foundations capable of resisting any added loads due to the presence of the slabs. Change from 2015 to 2018 IRC: Moved specifications for slabs from R322.3.3. to separate subsection. Change from 2012 to 2015 IRC: No change.	Exceeds NFIP 44 CFR § 60.3(e)(5) by specifying requirements for concrete slabs.
Swimming pools and spas	**Section R326.1 [Swimming Pools, Spas and Hot Tubs] General.** Requires pools and spas to comply with the *International Swimming Pool and Spa Code®* (ISPSC), which requires compliance with American Society of Civil Engineers (ASCE) 24. Change from 2015 to 2018 IRC: No change. Change from 2012 to 2015 IRC: Added requirement to comply with the ISPSC.	Exceeds NFIP 44 CFR § 60.3(e)(5) by specifying requirements for pools and spas.
Building envelope	**Section R322.3.6.1 Protection of building envelope.** Requires an exterior door at the top of stairs that provides access to the building. Change from 2015 to 2018 IRC: No change. Change from 2012 to 2015 IRC: Added requirement for door.	Exceeds NFIP 44 CFR § 60.3(e)(5) by specifying requirements for door at top of stairway.

Table 1: Comparison of Selected 2018 IRC Requirements and NFIP Requirements (continued)

Topic	Summary of Selected 2018 IRC Requirements and Changes from 2015 and 2012 Editions	Comparison with NFIP Requirements
Stairways and ramps	**Section R322.3.7 Stairways and ramps.** Provides four options for stairs and ramps located below the lowest floor elevation: (1) open or partially open risers and guards, (2) breakaway, (3) retractable, or (4) designed to resist flood loads. In all cases, the area below stairs and ramps must not be enclosed with walls unless the walls are designed to break away. Change from 2015 to 2018 IRC: New section for stairways and ramps incorporating language from R322.3.3.	Exceeds NFIP 44 CFR § 60.3(e)(5) by specifying requirements for stairways and ramps.
Decks and porches	**Section R322.3.8 Decks and porches.** Requires attached decks and porches to meet lowest floor elevation requirement and either have compliant foundations or be cantilevered from or knee-braced to the building. Self-supporting decks and porches must be designed to remain in place or break away and may be below the BFE if not enclosed by solid walls (including breakaway walls). Change from 2015 to 2018 IRC: New section for decks and porches incorporating language from R322.3.3.	Exceeds NFIP 44 CFR § 60.3(e)(5) by specifying requirements for decks and porches.
Elevators and foundation bracing	No explicit provisions; see free-of-obstruction requirement in the first row of this table (Table 1).	Meets NFIP 44 CFR § 60.3(e)(5), which has no specific requirements.

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3.2 International Building Code and ASCE 24

The flood provisions of the International Building Code® (IBC®) meet or exceed the NFIP requirements for buildings largely through reference to the ASCE 24, *Flood Resistant Design and Construction*. The IBC applies to all applicable buildings and structures. While primarily used for buildings and structures other than dwellings within the scope of the IRC, the IBC may be used to design dwellings. ASCE 24 applies to structures subject to building code requirements. The ASCE 24 requirements, summarized in Table 2, are more specific than the NFIP free-of-obstruction requirements.

IBC AND ASCE COMMENTARIES

ICC publishes companion commentary for the IBC, and ASCE publishes companion commentary for ASCE 24. Although not regulatory, the commentaries provide information and guidance that are useful in complying with, interpreting, and enforcing requirements.

Table 2: Comparison of Selected 2018 IBC and ASCE 24-14 Requirements with NFIP Requirements

Topic	Summary of Selected 2018 IBC / ASCE 24-14 Requirements and Changes from 2015 and 2012 IBC / ASCE 24-05	Comparison with NFIP Requirements
General design requirement	**2018 IBC Section 1612.2 Design and construction.** Requires design and construction of buildings and structures located in Coastal High Hazard Areas (Zone V) and Coastal A Zones to comply with Chapter 5 of ASCE 7 and ASCE 24. Change from 2015 to 2018 IBC: No change except renumbering of section. Change from 2012 to 2015 IBC: Applies Coastal High Hazard Area requirements in Coastal A Zones if delineated.	Exceeds NFIP 44 CFR § 60.3(e) by referring to ASCE 24, which has more specificity for some foundation elements and higher minimum building elevations, and which requires meeting Zone V design and construction standards in Coastal A Zones (which are not defined in the NFIP).
Obstruction	**ASCE 24-14 Section 1.2 Definitions.** "Obstruction – Any object or structural component attached to a structure below the DFE that can cause an increase in flood elevation, deflect floodwaters, or transfer flood loads to any structure." The DFE in the definition of obstruction is the Design Flood Elevation, which will be equal to or higher than the BFE. Change from ASCE 24-05: No change.	The NFIP does not define "obstruction."
Free of obstruction	**ASCE 24-14 Section 4.5.1 Foundation Requirements, General.** • Applies to foundation systems in Coastal High Hazard Areas (Zone V) and Coastal A Zones. • Requires foundations to be designed to minimize forces acting on foundations, to minimize damage to the foundations and the elevated structures, and to adequately transfer all loads imposed on the foundations and elevated structures to the supporting soils. With the exception of certain bracing and shear walls, requires foundation system to be free of obstructions that will restrict or eliminate free passage of high-velocity flood waters and waves during design flood conditions. Change from ASCE 24-05: No change.	Equivalent to NFIP 44 CFR § 60.3(e)(5).

Table 2: Comparison of Selected 2018 IBC and ASCE 24-14 Requirements with NFIP Requirements (continued)

Topic	Summary of Selected 2018 IBC / ASCE 24-14 Requirements and Changes from 2015 and 2012 IBC / ASCE 24-05	Comparison with NFIP Requirements
Use of fill	**2018 IBC Section 1804.5 Grading and fill in flood hazard areas.** Specifies that fill is only allowed where constructed and placed to avoid diversion of water and waves toward any building or structure. Where allowed, fill is required to be stable under conditions of flooding, including rapid rise and drawdown and wave action. Change from 2015 to 2018 IBC: Clarifies that fill where allowed must be stable under conditions of flooding. Change from 2012 to 2015 IBC: No change. **ASCE 24-14 Section 4.5.4 Use of Fill.** • Specifies that placement of nonstructural fill for minimal site grading and landscaping and to meet local drainage requirements is permitted. • Specifies that placement of nonstructural fill under and around a structure for dune construction or reconstruction is permitted if an engineering report documents that the fill will not result in wave runup, ramping, or deflection of floodwaters that can cause damage to structures. Change from ASCE 24-05: Clarifies that an engineering report is necessary to document the effect of fill, and the commentary clarifies that the intent is to allow minor amounts of nonstructural fill for specific purposes.	Equivalent to NFIP 44 CFR § 60.3(e)(6), with more specificity for use of fill for specific, nonstructural purposes.
Enclosed areas	**ASCE 24-14 Section 4.6 Enclosed Areas Below Design Flood Elevation.** Requires enclosed areas below DFE to be designed and constructed with breakaway walls, with flood openings in those walls, and requires stairways within the enclosed area to have an exterior door at the top of the stairs. Change from ASCE 24-05: Modified to refer to subsections for requirements and adds the requirement for an exterior door at the top of the stairs. **ASCE 24-14 Section 4.6.1 Breakaway Walls.** Change from ASCE 24-05: No change. **ASCE 24-14 Section 4.6.2 Openings in Breakaway Walls.** Change from ASCE 24-05: Modified to require flood openings in breakaway walls forming an enclosure.	Exceeds NFIP 44 CFR § 60.3(e)(5) by requiring flood openings in breakaway walls and a door at the top of stairways within enclosures.
Utilities and equipment	**ASCE 24-14 Section 7.1 General.** Requires attendant utilities and equipment to be at or above specified elevations or be specifically designed, constructed, and installed to prevent floodwaters from entering or accumulating within components. Change from ASCE 24-05: No change	Exceeds NFIP 44 CFR § 60.3(a)(3)(iv) with freeboard requirements for utility system platforms and equipment for most buildings.
Tanks	**ASCE 24-14 Section 9.7 Tanks.** Requires tanks in Coastal High Hazard Areas (Zone V) and Coastal A Zones to be (1) elevated on platforms meeting certain requirements or (2) installed and anchored below the eroded ground surface. Change from ASCE 24-05: Consolidated requirements for tanks in Section 9.7.	Exceeds NFIP 44 CFR § 60.3(a)(3)(iv) with specificity for platforms and requirements for tanks.

Table 2: Comparison of Selected 2018 IBC and ASCE 24-14 Requirements with NFIP Requirements (continued)

Topic	Summary of Selected 2018 IBC / ASCE 24-14 Requirements and Changes from 2015 and 2012 IBC / ASCE 24-05	Comparison with NFIP Requirements
Slabs	**ASCE 24-14 Section 9.3 Concrete Slabs.** Requires in Coastal High Hazard Areas (Zone V) and Coastal A Zones that concrete slabs be either (1) designed as frangible, not structurally connected to structure, and not capable of creating debris that would cause significant damage to other structures or (2) be self-supporting and remain in place and functional after the design flood. Change from ASCE 24-05: Slabs were moved from Section 4.8 to Section 9.3. New text permits (non-building-foundation) self-supporting structural slabs for parking/enclosure/deck/patio in Zone V and Coastal A Zone.	Exceeds NFIP 44 CFR § 60.3(e)(5) with requirements for concrete slabs.
Swimming pools and spas	**2018 IBC Section 3109.1 General.** Requires, within Coastal High Hazard Areas (Zone V) and Coastal A Zones, that the design and construction of swimming pools, spas, and hot tubs comply with the ISPSC, which requires pools to be designed in accordance with ASCE 24. Change from 2015 to 2018 IBC: No change Change from 2012 to 2015 IBC: Replaces specific requirements with reference to the ISPSC. **ASCE 24-14 Section 9.6.2 Pools in Coastal High Hazard Areas, Coastal A Zones and Other Flood Hazard Areas.** Requires pools to be (1) elevated, (2) designed to break away without producing damaging debris, or (3) designed to remain in the ground without obstructing flow that could cause damage. Pools must be structurally independent of buildings and structures unless located in or on elevated floors or roofs that are above the DFE. Change from ASCE 24-05: Clarifies pool requirements for pools within Coastal High Hazard Areas, Coastal A Zones, and other flood hazard zones.	Exceeds NFIP 44 CFR § 60.3(e)(5) with requirements for swimming pools and spas.
Elevators	**2018 IBC Section 3001.3 Referenced standards.** Requires the design, construction, installation, alteration, repair, and maintenance of elevators and conveying systems and their components to comply with the standard specified in 2018 IBC Section 3001.3, Table 3001.3, and ASCE 24 unless the code states otherwise. Change from 2015 to 2018 IBC: Standards moved to Table 3001.3. Change from 2012 to 2015 IBC: No change.	Exceeds NFIP 44 CFR § 60.3(e)(5) with requirements for elevators.
Access stairs and ramps	**ASCE 24-14 Section 8.1 General.** In Coastal High Hazard Areas (Zone V) and Coastal A Zones provides four options for the design and construction of stairways and ramps below the required elevation. Change from ASCE 24-05: Adds option for retractable stairways and ramps.	Exceeds NFIP 44 CFR § 60.3(e)(5) with requirements and alternatives for stairways and ramps.

Table 2: Comparison of Selected 2018 IBC and ASCE 24-14 Requirements with NFIP Requirements (continued)

Topic	Summary of Selected 2018 IBC / ASCE 24-14 Requirements and Changes from 2015 and 2012 IBC / ASCE 24-05	Comparison with NFIP Requirements
Decks and porches	**ASCE 24-14 Section 9.2 Decks and Porches** **9.2.1 Attached Decks and Porches.** In coastal high hazard areas (Zone V) and Coastal A Zones, specifies that attached decks and porches be elevated on certain foundations or cantilevered from the main structure. **ASCE 24-14 Section 9.2.2 Detached Decks and Porches.** In Coastal High Hazard Areas (Zone V) and Coastal A Zones, specifies that detached decks and porches be (1) designed and constructed to remain intact and in place during the base flood or (2) be designed to be frangible, minimizing debris capable of causing significant damage to any structure. Change from ASCE 24-05: Clarifications with no new requirements or limitations.	Exceeds NFIP 44 CFR § 60.3(e)(5) with requirements for decks and porches.
Foundation bracing	**ASCE 24-14 Section 4.5.11 Bracing.** Change from ASCE 24-05: No change.	Exceeds NFIP 44 CFR § 60.3(e)(5) with requirements for bracing.

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4 NFIP Flood Insurance Implications

Meeting the minimum NFIP floodplain management requirements does not necessarily result in the lowest NFIP flood insurance premium. NFIP flood insurance premiums depend on the presence, location, construction, size, age, and use of enclosures and other building components and equipment. Floodplain management regulations allow enclosures greater than 300 square feet, but structures with these enclosures have higher NFIP flood insurance premiums. Designers should consult a qualified insurance agent and review FEMA's *NFIP Flood Insurance Manual* to determine insurance implications of design and construction decisions.

EFFECT OF CONSTRUCTION BELOW THE BFE

Any construction or site development practice below the BFE (even piles and columns permitted by the NFIP) will cause a localized disruption of flow and waves during the base flood. The question is whether the localized disruption will be great enough to harm the elevated building or surrounding buildings.

NFIP floodplain management regulations allow certain construction elements below the BFE that may or may not break away during the base flood (e.g., stairwells, elevator shafts, shear walls). These elements may or may not be considered obstructions for NFIP flood insurance rating purposes. For example:

- The NFIP floodplain management regulations in 44 CFR § 60.3(e) allow open wood lattice, insect screening, and solid, non-load-bearing, breakaway walls below elevated buildings in Coastal High Hazard Areas. Even though floodplain management regulations permit solid breakaway walls, garage doors, and slats or lattice (with less than 40 percent of the area open), building designers and owners should be aware that these elements can result in higher NFIP flood insurance premiums. See the text box "NFIP Flood Insurance Free-of-Obstruction Rate" below for details.

- The NFIP floodplain management regulations in 44 CFR § 60.3(e) restrict uses of space below the BFE to parking of vehicles, building access, and storage. Stairs, ramps, and elevators are permitted. However, depending on how stairs, ramps, and elevators are constructed, they may be considered obstructions for NFIP flood insurance rating purposes and could result in higher premiums.

DETERMINING FLOOD INSURANCE IMPLICATIONS BEFORE THE DESIGN

Design professionals and property owners may wish to contact a qualified insurance agent or the NFIP regarding the flood insurance rating and premium implications of obstructions before a building is designed.

NFIP FLOOD INSURANCE FREE-OF-OBSTRUCTION RATE

In order for a structure to qualify for the NFIP flood insurance free-of-obstruction rate, the space below the lowest elevated floor must be free of obstructions with the following exceptions:

- Insect screening provided that no additional supports are required for the screening
- Wooden or plastic lattice with at least 40 percent of its area open and constructed of material no thicker than ½ inch
- Wooden or plastic slats or shutters with at least 40 percent of their area open and constructed of material no thicker than 1 inch
- One solid breakaway wall or garage door with the remaining sides of the enclosure constructed of the above-mentioned insect screening, wooden or plastic lattice, slats, or shutters

5 Free-of-Obstruction Requirement Considerations

Some NFIP flood-resistant design and construction requirements, including free-of-obstruction requirements, are performance related and are not prescriptive. In other words, the expected building performance is stated, but how to achieve the performance is not specified. It is up to the design professional to create a design that complies with the free-of-obstruction performance requirements and up to the local official to determine whether the design satisfies the community's requirements.

It is not always clear whether a particular building element or a site development practice would create a significant obstruction that would prevent the free passage of floodwater and waves. "Significant" is used because *any* construction element or site development practice below the flood level would cause a localized disruption of flow and waves during the base flood. Determining whether the disruption would be significant is not always easy because in most cases, there are no analytical or readily usable numerical tools to answer the question with certainty. Local experience, results of post-disaster assessments, and application of coastal processes and building science principles must be relied on to reach a conclusion.

Some local floodplain management regulations require potential obstructions below or near a building to be evaluated to determine their effects on flow and waves. Fluid mechanics and coastal engineering references, such as the U.S. Army Corps of Engineers *Coastal Engineering Manual* (2002), provide some guidance, but the methods in these references are not generally capable of evaluating the potential effects of small building elements or small amounts of fill on flooding and waves during a base flood. Numerical coastal storm surge and wave models used in Flood Insurance Studies do not have sufficiently detailed resolution to discern building-sized disruptions to flow and wave fields.

Currently, developing models with fine enough resolution is technically challenging, time consuming, and cost prohibitive. And although recently developed, sophisticated numerical models show some promise in analyzing flow around buildings, their use is not economically feasible for most communities, owners, or designers interested in examining the potential obstructions discussed in this Technical Bulletin.

6 Building Elements Below the Base Flood Elevation

This section discusses common building elements under elevated buildings that can impede the free passage of flood flow and waves. Following the guidance in this section will minimize potential obstructive effects and satisfy the NFIP free-of-obstruction requirement.

6.1 Access Stairs and Ramps

Access stairs and ramps that are attached to or beneath an elevated building may be enclosed with breakaway walls or unenclosed. However, like foundation bracing (see Section 6.8), stairs and ramps can impede breakaway walls from breaking away cleanly as intended. To minimize this possibility, unenclosed stairs and ramps are preferred, but if enclosures are used, the design should be such that the stairs and

ENTRY DOOR AT TOP OF ACCESS STAIRS

Access stairs to elevated buildings are often constructed inside a breakaway enclosure with an entry door at the bottom of the enclosure but no entry door into the building at the top of the stairs. The lack of an entry door at the top results in a large opening in the building envelope when enclosures break away. Numerous post-disaster damage assessments have shown that loss of breakaway enclosures exposes building interiors to higher internal wind pressures and wind-driven rain. Loss of breakaway enclosures can also provide an easy path for floodwater to enter buildings, resulting in damage that can be avoided when doors are provided at the top of the access stairs.

Beginning with the 2015 IRC and ASCE 24-14, solid entry doors capable of resisting all design loads are required to be installed at the top of access stairs inside breakaway enclosures.

ramps do not interfere with breakaway wall performance. Enclosing stairways also affects NFIP flood insurance rates.

Stairs and ramps are not required to break away, but it is a design option. Stairs and ramps must be designed and constructed to either:

- Resist flood loads and remain in place during floods up to and including the base flood. If this option is selected, the elevated building and its foundation must be designed to resist any flood loads that are transferred from the stairs or ramp to the building, or
- Break away during base flood conditions without causing damage to the building or its foundation.

Figure 1 shows an example of an elevated building that was damaged as a result of stairs that did not break away cleanly; the stairway pulled out the exterior wall of the elevated building as the stairway failed.

Figure 1:
Damage to an elevated building as a result of stairs that did not break away cleanly

Constructing access stairs with open sides (open guards and railings) and risers, to the extent allowed by building codes, minimizes the potential for flood loads acting on the stairs, thereby minimizing flood damage and also minimizing transfer of flood loads to the elevated building. Open stairs should be considered whenever possible (see Figure 2). Note that building codes may have maximum opening size limits on stair risers and railings, necessitating a longer run. Check with the local jurisdiction for requirements.

Ramps must be designed and constructed to minimize the obstruction of floodwater and waves and configured so that floodwater and waves cannot flow directly up the ramp toward the elevated building. This means that ramps should be positioned to avoid a straight alignment from the elevated building to the likely direction of wave and surge approach.

Figure 2:
Open stairs, which minimize transfer of flood and wave forces

Massive exterior stairs are not permitted because they are inconsistent with the free-of-obstruction requirement and because other types of stairs can provide access. Figure 3 shows massive stairs that are attached to an elevated coastal home. These massive stairs will act as an obstruction and increase the likelihood of trapping or reflecting waves and flood flow beneath the elevated building.

In some cases, life-safety code requirements dictate that stairs and stairwells in structures of certain occupancy categories be constructed to be fire resistant and structurally stable even if portions of the adjacent structure fail. Stairs and stairwells that meet these requirements are usually constructed of some combination of steel, reinforced masonry, and reinforced concrete and will not break away under

Figure 3:
Massive stairs attached to an elevated coastal home, which act as an obstruction

expected base flood loads and conditions. These stairs and stairwells, typically found in mid- and high-rise buildings, must be designed to withstand all base flood loads, including flow, waves, and floodborne debris impacts.

6.2 Decks, Porches, and Patios

Decks, porches, and patios are typically outside the footprint of elevated residential and commercial buildings and may be constructed at grade, above grade but below the BFE, at the BFE, or above the BFE.

In Coastal High Hazard Areas, decks and porches outside the building footprint must meet one of the following conditions:

- If structurally attached to a structure, the bottom of the lowest horizontal structural member of the deck or porch must be at or above the BFE. Deck and porch supports that extend below the BFE (e.g., pilings, bracing) must comply with Zone V design and construction requirements, and the structure must be designed to accommodate any increased loads resulting from the attached deck or porch.
- If an attached deck or porch is located above the BFE but relies on support elements (posts, columns, braces) that extend below the BFE, the supports must comply with Zone V design and construction requirements.
- If a deck, porch, or patio (not counting its supports) lies in whole or in part below the BFE, it must be structurally independent from the structure and its foundation system.

Decks that are constructed within the building footprint between the ground and the elevated building are sometimes referred to as mezzanine decks. In Coastal High Hazard Areas, mezzanine decks should be treated similar to the floors of above-grade (elevated) enclosures (see Section 6.5). If directly below the footprint, a mezzanine deck that is structurally attached to the host building is treated as the lowest floor elevation for NFIP flood insurance rating purposes.

From a floodplain management perspective, mezzanine decks must meet building code requirements for dead, live, and other applicable loads and must be designed to either:

1) Break apart into small pieces without causing collapse, displacement, or other structural damage to the elevated building or the supporting foundation under flood loads less than those that occur during the base flood or

2) Along with the building foundation, accommodate flood loads transferred from the mezzanine deck to the building foundation during flooding up to and including base flood conditions.

Mezzanine decks may be independently supported on an open foundation and must be designed to either withstand flooding up to and including the base flood or break apart into small pieces under base flood or lesser conditions. Structurally independent decks below the BFE and below a structure's footprint are not considered the lowest floor for NFIP flood insurance purposes.

Decks, porches, and patios must not adversely affect the structure with which they are associated, or nearby structures, by diverting floodwater and waves during flood conditions up to and including the base flood. Some decks and patios, such as low-profile decks and patios constructed at natural grade or on minor quantities of fill necessary to level the site (see the textbox in Section 7.5), are deemed to comply by minimizing harmful diversion of floodwater or wave runup and reflection. A low-profile deck or patio, as used here, has a floor system depth of 12 inches or less, some of which may be below the adjacent finished grade. The depth does not include railings, which should be open to allow water to flow through. Attaching seats, benches, tables, planters, or similar features will cause a deck or patio to lose its deemed-to-comply low-profile classification. These features may or may not be obstructions (depending on size, number, and configuration) and should be evaluated for potential effects on flow and waves.

Decks, porches, and patios must be designed and constructed so that when subject to flooding up to and including base flood conditions, they do not create debris capable of causing significant damage to nearby structures. This means that decks, porches, and patios must remain intact and in place during base flood conditions or break apart into small pieces so the resulting debris does not lead to structural damage to nearby structures.

Decks and porches that are structurally attached to structures in Zone V must be supported to resist the simultaneous action of design wind loads and base flood loads. Most attached decks and porches are supported on piles or columns embedded in the ground and are capable of surviving anticipated erosion and scour. Post-storm assessments frequently identify decks and porches that were elevated on posts whose diameters were too small or on structural elements without sufficient embedment into the ground. The result of inadequate support is loss of decks and porches and sometimes damage to elevated structures. Unless the building code or local community prescribes otherwise, the foundation for an elevated deck or porch attached to a structure in Zone V should be similar to the structure's foundation. Attached decks and porches may be cantilevered from main structures instead of supported on piles or columns.

6.3 Elevators

Elevators attached to or beneath elevated structures in Zone V must comply with building, fire, electrical, and mechanical code requirements. Elevators and elevator shafts are not required to break away but must meet flood damage-resistant material and equipment requirements.

Flood loads acting on elevator components, any non-breakaway shaft walls, and potential wave runup and reflection effects must be accounted for in the design of the elevated structure and its foundation system. Therefore, it is advantageous to minimize the size of elevators, especially residential elevators in one- and two-family structures. Elevators should be designed and installed to satisfy the requirements of ASCE 24, which FEMA has determined meets or exceeds the minimum NFIP requirements. Additional guidance can be found in NFIP Technical Bulletin 4, *Elevator Installation for Buildings Located in Special Flood Hazard Areas.*

NFIP FLOOD INSURANCE AND ELEVATOR SHAFTS AND ELEVATOR EQUIPMENT

Elevator shafts and elevator equipment below the BFE will result in higher NFIP flood insurance premiums. The presence of elevators always increases the premium, regardless of how the shafts are constructed.

6.4 Enclosed Areas

The types of enclosed areas that are discussed in this section are:

- Enclosed areas below elevated structures
- Above grade (elevated) enclosures
- Two-level enclosures

6.4.1 Enclosed Areas Below Elevated Structures

The use of enclosed areas below elevated structures is restricted to parking of vehicles, building access, and storage. Enclosed areas must not be used for habitable purposes. Enclosed areas, including foyers, must be constructed of flood damage-resistant materials and not be finished. All enclosed areas below elevated buildings will be considered when the NFIP flood insurance premium is determined.

The NFIP regulations in 44 CFR § 60.3(e)(5) state that the area beneath the elevated portion of a structure in Zone V may be enclosed only with open lattice, insect screening, or non-supporting breakaway walls (see NFIP Technical Bulletin 9, *Design and Construction Guidance for Breakaway Walls Below Elevated Buildings in Coastal High Hazard Areas*). However, while NFIP regulations permit all enclosure walls to be solid breakaway walls, construction of such will lead to a With-Obstruction rating by the NFIP.

FEMA guidance states that the following lattice and slats are acceptable:

- Wood or plastic lattice no thicker than ½ inch with at least 40 percent of its area open
- Wood or plastic slats or fixed louvers no thicker than 1 inch that, when installed, have at least 40 percent of their area open

Figure 4 and Figure 5 show examples of compliant slats, which are typically installed flat against foundation pilings (see Figure 4) or angled like louvers between the pilings (see Figure 5). Percent open area of a lattice or louver wall should be calculated based on the area through which water can flow through lattice or louvers, divided by the total area of the enclosure wall (see Figure 6).

PRIVACY SCREENING

Privacy screening around outdoor shower areas is permitted if the sides are open at top and bottom and the screening will break away under base flood or lesser conditions. If a space under the building footprint is enclosed with privacy screening, there will be an NFIP flood insurance premium increase.

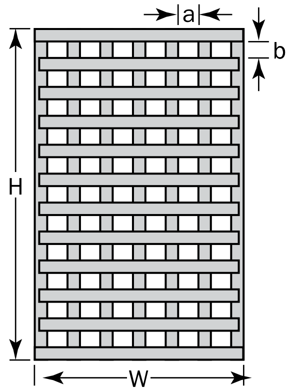
SIZE OF ENCLOSURES AND NFIP FLOOD INSURANCE

The NFIP does not limit the size of enclosures under elevated structures. However, higher NFIP flood insurance premiums will generally be assessed for structures in Zone V with enclosed areas of any size (including stairwells and elevator enclosures), even if enclosed by breakaway walls. Annual NFIP premiums can be even higher when buildings have enclosures that are 300 square feet or larger. Some communities have adopted restrictions or prohibitions on enclosures. Designers, contractors, and owners should check local requirements prior to construction.

The NFIP does not require flood openings in the walls of enclosures in Zone V. However, beginning with ASCE 24-14 and the 2015 IRC and IBC, enclosures in Zone V require flood openings.

Figure 4:
Compliant wood slats installed flat against foundation pilings

Figure 5:
Compliant, fixed, wood louvers installed between pilings

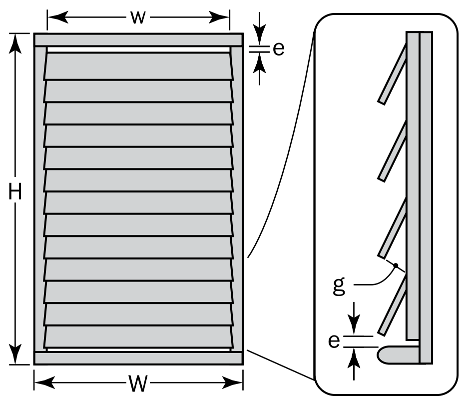


Lattice wall

Percent open area is the sum of all individual open areas, divided by the overall panel area, times 100.

Measure the height and width of the opening, multiply by the total number of openings, and divide by the total panel area (height times width). To get a percentage, multiply the result by 100.

$$\% \text{ open area} = \frac{\Sigma (ab) \times 100}{HW}$$



Louver wall

Percent open area is the sum of all individual open areas in gaps between louvers, plus top and bottom edge opening areas, divided by the overall panel area, times 100.

The individual open areas are calculated as the distance between louvers multiplied by the panel width. Multiply that area by the total number of gaps, add the edge opening areas, and divide by the total panel area (height times width). To get a percentage, multiply the result by 100.

$$\% \text{ open area} = \frac{(\Sigma (gw) + (2ew)) \times 100}{HW}$$

Figure 6: Determination of the percentage of open area for a lattice or louver wall

Figure 7 shows an elevated building in which a portion of a solid breakaway wall enclosure did not break away. Waves were not able to pass beneath the elevated structure, and wave runup against the enclosure wall likely caused damage above the elevated floor.

Figure 7:
Breakaway wall that did not break away, which led to wave runup and contributed to flood damage on the side of the elevated building

6.4.2 Above-Grade Enclosed Areas (Elevated)

Another enclosure option is to construct enclosures with floor systems that are elevated above grade and are not in contact with the ground (see Figure 8). Placing the enclosure floor above grade minimizes the potential for damage to the enclosure and contents during frequent, low-level flood events.

Figure 8: Above-grade enclosure

An above-grade enclosed area (sometimes referred to as a hanging enclosure) is any enclosure with its floor system above grade. The enclosure may be supported by a foundation beneath the enclosure or by the elevated building and/or building foundation. A hanging floor is the lowest floor elevation for NFIP flood insurance rating purposes.

Above-grade enclosures may be used only for storage and building access and must meet all other requirements applicable to enclosures, including the use of breakaway walls and flood damage-resistant materials below the BFE. Additionally, mechanical and electrical systems in the enclosure must be elevated to or above the BFE. A floor grate should be installed in the enclosure floor, and flood openings should be installed in breakaway enclosure walls. The grate will reduce vertical uplift (buoyancy) loads on the enclosure floor before water flows through the openings in the enclosure walls and allow the elevated enclosure to drain fully, reducing the downward load caused by water that would otherwise be trapped above the enclosure floor.

ABOVE-GRADE ENCLOSURES AND NFIP FLOOD INSURANCE

NFIP flood insurance policies for elevated buildings with above-grade enclosures are rated assuming the floor of the above-grade enclosure is the lowest floor (or based on the elevation of the lowest horizontal structural member of the enclosure instead of the lowest horizontal structural member of the lowest floor of the elevated building). Owners should ask their insurance companies to submit requests to the NFIP for a special rating for buildings with above-grade enclosures.

The design of the foundation and enclosure floor system for above-grade enclosures that are in Zone V must meet one of the following conditions:

- The floor system is designed to break away under flood loads less than those that occur during the base flood without causing collapse, displacement, or other structural damage to the elevated building or the supporting foundation (see Figure 9), or
- The floor system is designed to remain in place and intact, and the building foundation is designed to accommodate flood loads transferred from the enclosure floor system to the foundation during flood conditions up to and including the base flood (see Figure 9), or
- The enclosure floor system is independently supported on an open foundation (see Figure 10).

Flood openings in above-grade enclosure walls are required by the building code but do not reduce NFIP flood insurance premiums for the enclosure.

6.4.3 Two-Level Enclosed Areas

In flood hazard areas where the BFE is very high above the ground or where owners elect to elevate buildings very high, some owners opt to build two-level enclosures (see Figure 11 and Figure 12). Two-level enclosures are permitted but not recommended due to their more complicated construction and increased potential for

TWO-LEVEL ENCLOSURES

Two-level enclosures are also known as two-story enclosures, double enclosures, and stacked enclosures.

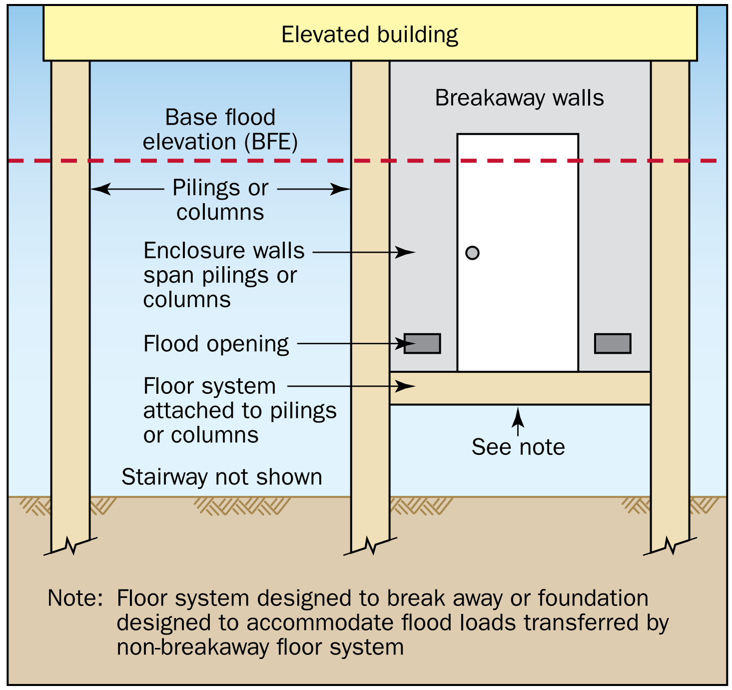


Figure 9: Above-grade enclosure floor system attached to building foundation

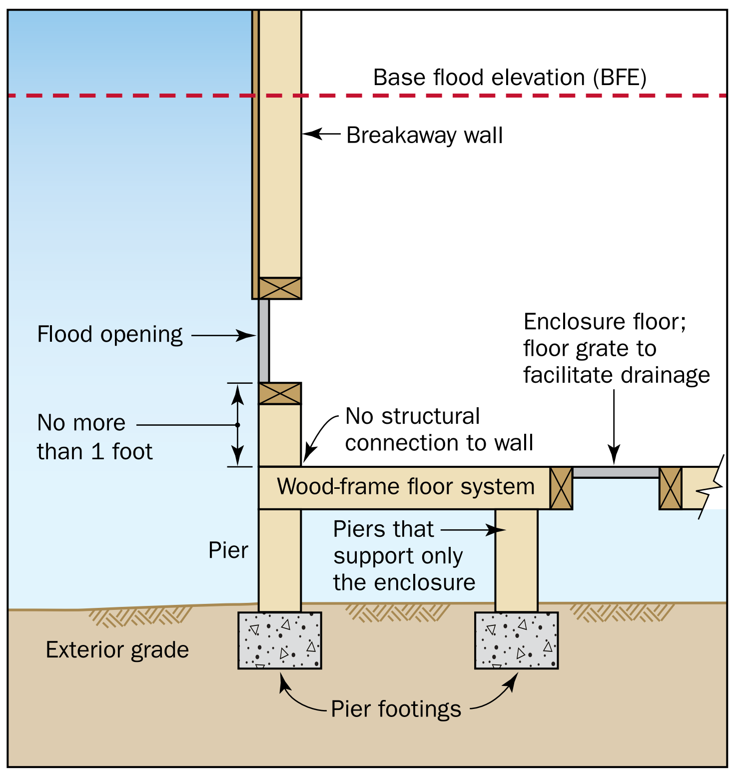


Figure 10: Above-grade enclosure supported by independent foundation

Figure 11:
Two-level enclosure

floodborne debris. Two-level enclosures could also result in the floor of the upper level being considered the lowest floor for NFIP flood insurance rating purposes.

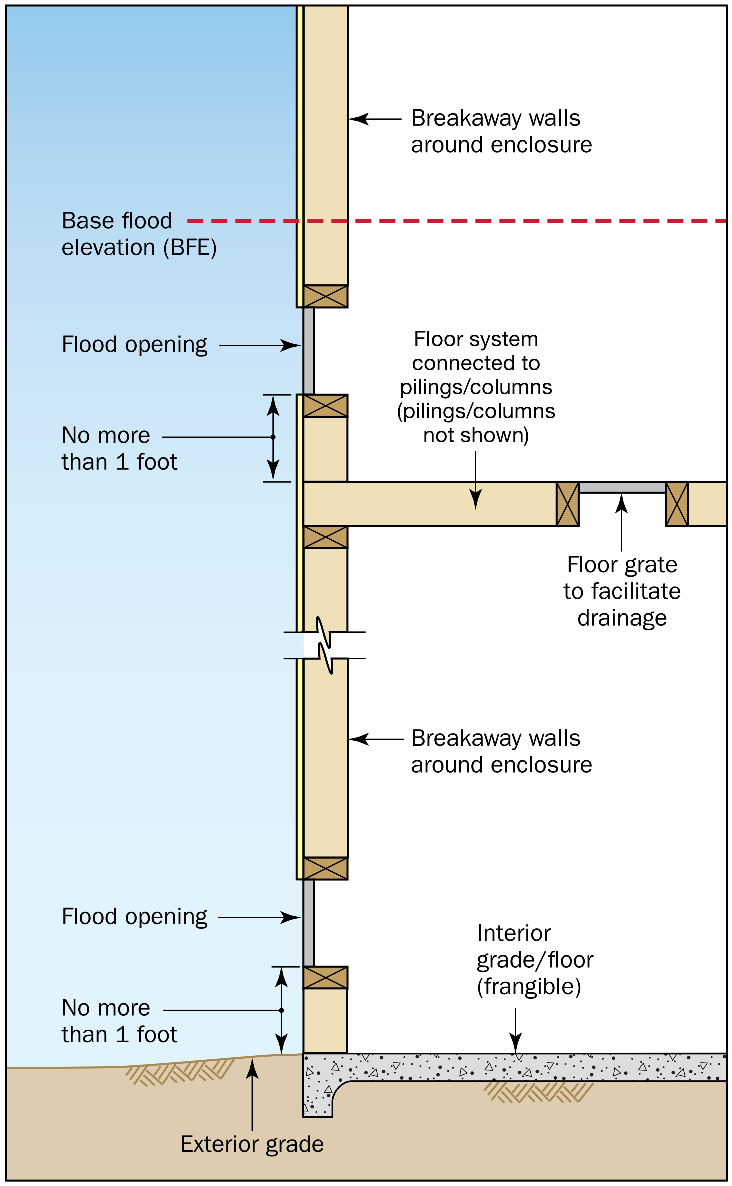
Both levels of the enclosure must meet all of the floodplain management and building code requirements for enclosed areas, including breakaway walls, elevated utilities, flood damage-resistant materials, and limitations on use (parking of vehicles, building access, and storage). The floor system of the upper enclosure level must be designed to meet one of the options for above-grade (elevated) enclosed areas (see Section 6.4.2).

Openings with grates should be installed in the floor to facilitate drainage from the upper level enclosure. In the event that floodwater enters the upper level but does not cause failure of the breakaway walls, the floor grates will allow trapped water to drain to the lower level and not overload the upper level floor system.

TWO-LEVEL ENCLOSURES AND NFIP FLOOD INSURANCE

Designers and owners should be aware that a building with a two-level enclosure, even if allowed by permit, could result in higher NFIP flood insurance premiums than if the building has a one-level enclosure. Even if a two-level enclosure complies with building code and floodplain management requirements for enclosures, the upper floor of the two-level enclosure could be deemed the lowest floor for NFIP flood insurance rating purposes (the lowest floor elevation for flood insurance purposes is the first floor elevated above ground). Owners should ask their insurance companies to submit requests to the NFIP for a special rating for buildings with two-level enclosures.

Figure 12:
Two-level enclosure schematic



6.5 Mechanical, Electrical, and Plumbing Equipment, Ducts, Tanks, and Fixtures

Mechanical, electrical, and plumbing equipment, ducts, tanks, and fixtures serving elevated buildings are required to be elevated to or above the BFE or protected from water entry during the base flood.

There are exceptions for elevator equipment that cannot be elevated (see NFIP Technical Bulletin 4, *Elevator Installation for Buildings Located in Special Flood Hazard Areas*, and ASCE 24).

EQUIPMENT BELOW AN ELEVATED BUILDING AND NFIP FLOOD INSURANCE

Designers and owners should be aware that elevator equipment and other equipment below an elevated building will result in higher NFIP flood insurance premiums, even if the equipment is allowed by permit.

Utility lines, pipes, risers, and chases may need to extend below the BFE but should be installed to minimize potential damage from flooding (some utility companies place meters below the BFE so they can be easily accessed). The following help minimize potential damage:

- Utility lines, pipes, risers, and chases are not allowed to be attached to or penetrate through breakaway walls (see Figure 13).
- Utility lines, pipes, risers, and chases should be located on the sides of piles and columns that are opposite the anticipated direction of flood flow and wave approach, where possible.

Fuel tanks and other tanks serving elevated buildings and located under or adjacent to the buildings must be in-ground or elevated above the BFE. In both cases, tanks should be anchored to prevent flotation or lateral movement during base flood conditions. Platforms supporting elevated tanks should resist flooding up to and including base flood conditions.

To satisfy free-of-obstruction requirements, above-ground tanks must not be located beneath elevated buildings or attached to elevated buildings below the BFE. This requirement also applies to permanently

UTILITY CHASES

For floodplain management and NFIP flood insurance purposes, utility chases designed to protect utility lines from freezing are not considered enclosures. Utility chases must be small and not allow access for a person to enter the space (access panels for servicing the lines are appropriate).

Because a utility chase is not considered an enclosure, it does not have to meet the requirement of breakaway walls, louvers, or open latticework; however, the chase may be breakaway under flood conditions.

The utility chase must be constructed of flood damage-resistant materials below the BFE, and the enclosed utility lines must meet the requirement to be watertight and capable of withstanding flood loads (hydrostatic, hydrodynamic, wave). Additionally, the portions of the utility system located below the BFE and the utility chase should not be attached to, mounted on, pass through, or be located along breakaway walls.

**Figure 13:
Utilities mounted on wall, which prevented the wall from breaking away cleanly**

installed fuel tanks for outdoor kitchens. Portable gas grills and associated propane fuel tanks and similar devices for which building permits are not required are not subject to these requirements. However, communities may have other fire and life-safety requirements that must be met. In addition, when flooding is anticipated, owners should move portable grills and propane fuel tanks to a safe location where they will not pose a hazard or become floodborne debris.

Additional guidance can be found in FEMA P-348, *Protecting Building Utilities from Flood Damage* (2017), and FEMA P-259, *Engineering Principles and Practices for Retrofitting Flood-Prone Residential Structures* (2012).

6.6 Foundation Bracing

Foundation bracing is often used to stiffen pile foundations and/or improve comfort and reduce sway in elevated buildings. However, foundation designs without bracing are preferred in coastal areas because they minimize obstructions to flow and waves.

Free-of-obstruction considerations call for using only the minimum amount of foundation bracing necessary to achieve a stable design, and such bracing should be designed to withstand flood conditions up to and including the base flood. Additional bracing may be used to improve the comfort of building occupants (i.e., reduce building sway under non-flood conditions), but the additional bracing should not be as strong as that required for structural stability and should not be relied on to yield a stable design, as it may be lost during a flood.

Many coastal construction experts and design references advise relying on shore-perpendicular bracing and minimizing the use of shore-parallel bracing. However, because wind and seismic loads can act in any direction, this alternative may not always provide the structural stability that is required in some locations. Increasing the number of piles (by decreasing horizontal spacing), detailing moment connections at the tops of the piles (in the case of concrete piles and beams), and using grade beams are accepted ways of eliminating or reducing the need for foundation bracing. Designers may determine other ways to minimize the amount and type of bracing.

Diagonal timber cross-bracing is the most common type of bracing used on foundations under coastal homes. Unfortunately, timber braces frequently fail during severe flood events as a result of wave or debris impacts. If they survive, they can interfere with breakaway wall failure, trap debris, and transfer lateral flood loads to the foundation. Metal rod braces, while less susceptible to failure, can also trap floating debris (see Figure 14). Knee braces at the tops of pilings are sometimes preferred (Figure 15) because their position higher up on the pilings will present less obstruction to flow and waves.

When foundation bracing below the BFE is used, it must be placed so as not to interfere with the intended failure of breakaway wall panels (see Figure 16). Avoiding interference may require eliminating breakaway walls, shifting the location of breakaway walls, or redesigning the foundation so the need for certain braces is eliminated. Breakaway walls and foundation bracing should not be placed close to each other if either could adversely affect the intended performance of the other.

Figure 14:
Floating debris trapped by metal rod cross bracing

Figure 15: Knee bracing

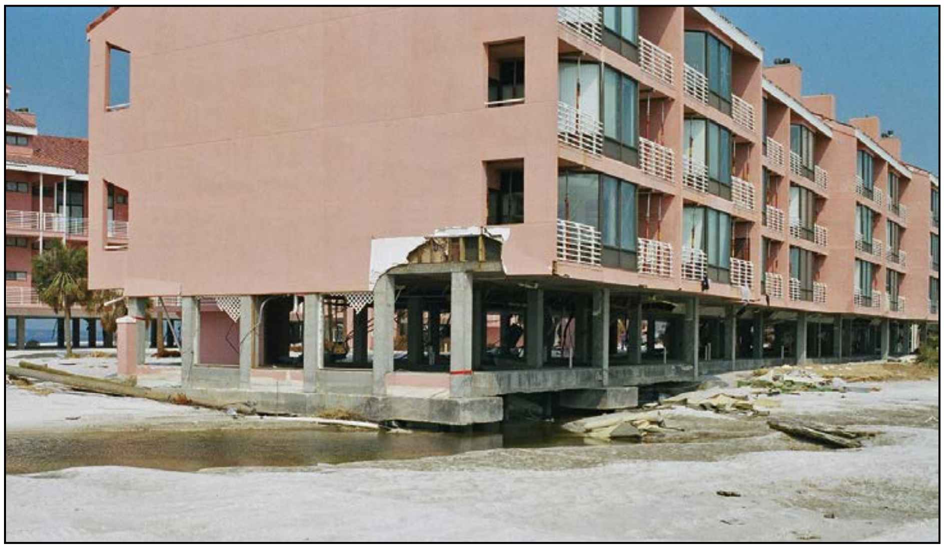
Figure 16: Cross bracing that interfered with the failure of a breakaway wall

6.7 Grade Beams

Grade beams are horizontal elements at or below the ground surface that tie the foundation piles or columns together and provide additional lateral support. They are typically reinforced concrete or wood.

Grade beams that are placed with their upper surfaces flush with or below the natural grade (the grade before the site is altered by fill or grading, if any) are not considered obstructions and are allowed by NFIP. However, storm erosion and local scour can expose and undermine grade beams, sometimes leaving them suspended above the post-storm ground profile. Designers must anticipate this circumstance and design grade beams to resist flood, wave, and debris loads and to remain in place and functional when undermined by scour and erosion (see Figure 17). Grade beams must also be designed and constructed so the vertical thickness is minimized, thereby reducing the lateral flood, wave, and debris loads acting on the beam and minimizing the transfer of these loads to the foundation.

Figure 17:
Grade beams that were exposed to flood forces during hurricane-induced scour; grade beams must resist flood, wave, and debris loads when undermined



6.8 Shear Walls

The NFIP regulations in 44 CFR § 60.3(e) state that only pile and column foundations are permitted in Zone V. In practice, this requirement has been relaxed by the NFIP and building codes for mid- and high-rise structures to allow certain types of solid walls, called shear walls, if detailed engineering calculations demonstrate that such walls are required to transfer lateral loads acting on upper stories to the ground, particularly in extreme-wind zones (see Figure 18). Even in these cases, shear walls should be used only if foundations and buildings are designed to resist all base flood conditions, all other design loads, and all appropriate load combinations.

SHEAR WALLS

ASCE 24 contains flood-related requirements and limitations for shear walls used to support buildings in Zone V. Contact your local building department for rules and building code requirements for shear walls in Zone V.

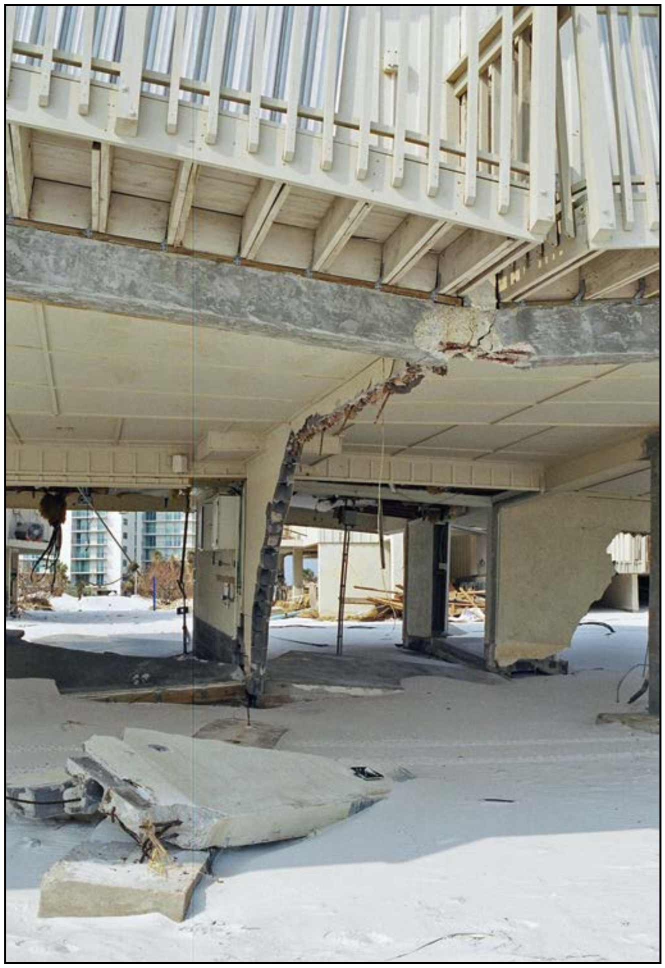
Shear walls should be constructed parallel to the anticipated direction of flood flow and wave attack (typically perpendicular to the shoreline) to allow floodwater and waves to pass freely. In some cases, building designs require both shore-perpendicular and shore-parallel shear walls. Use of shore-parallel shear wall segments should be limited to the minimum length required to transfer upper-story loads to

Figure 18:
High-rise buildings elevated on shore-perpendicular shear walls

the foundation. Shore-parallel shear walls should be designed with openings in the walls or gaps between shear wall segments to minimize trapping of floodwater, waves, and debris and minimize the total flood loads acting on the building. In any case, designs of these walls must be certified by registered design professionals as part of the requirement for certification of foundation designs.

Low-rise buildings in Zone V should be designed with pile or column foundations that are consistent with the NFIP regulations. Post-flood assessments have found that shear walls supporting older low-rise buildings often do not survive severe storm events. See Figure 19, which shows the failure of a wall section of a building supported on columns and shore-perpendicular walls. Wall failure led to failure of the elevated floor beam and floor. In this instance, the building was an older non-conforming building, and the solid walls rested on shallow footings (a means of support not permitted by the NFIP or building codes for buildings in Zone V). The wall failure was likely due to both lateral flood loads and foundation undermining.

Figure 19:
Failure of a shore-perpendicular solid foundation wall that supported a low-rise building, which resulted in failure of the beam and floor system that were supported by the shore-perpendicular wall



6.9 Slabs

Concrete slabs are commonly used beneath elevated buildings in Zone V for vehicle parking and as floors of enclosed storage or building access areas. The vertical elements elevating the building should not rest on the slab to avoid an NFIP flood insurance rating of "non-elevated."

SLABS AND NFIP FLOOD INSURANCE

There is no difference in NFIP flood insurance premiums between having a frangible slab or a self-supporting structural slab for two otherwise identical elevated buildings.

Post-disaster assessments conducted by FEMA have concluded that unreinforced slabs less than 4 inches thick tend to break up into small pieces without causing adverse effects to elevated buildings (see Figure 20). Reinforced concrete slabs thicker than 4 inches tend not to break up into small pieces, can become dislodged and act as obstructions, and can transfer unanticipated loads to building foundations (see Figure 21).

Figure 20:
Damage to building foundation caused in part by failure of the reinforced slab undermined by erosion

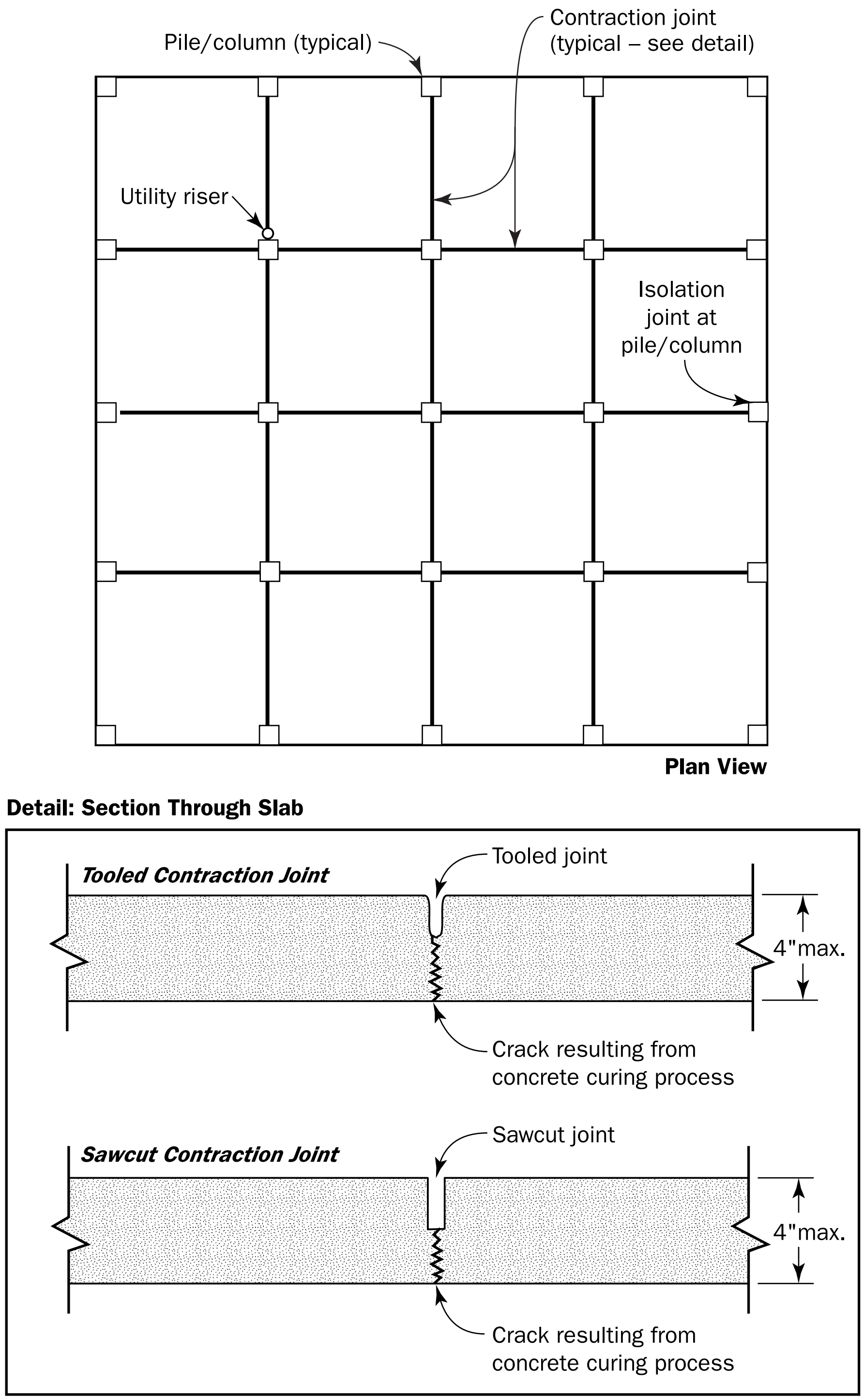
Figure 21:
Unreinforced slab that broke apart without imposing loads on the foundation

Post-disaster assessments have determined that slabs perform well if they meet the requirement in ASCE 24-14, Section 9.3, to either:

- Be frangible (break into small pieces), floating slabs supported by compacted soil, not attached to the building foundation, and designed and constructed with a maximum thickness (traditionally 4 inches), without reinforcement and without turned down edges, or
- Be designed and constructed as self-supporting structural slabs capable of remaining intact and functional during flooding up to and including base flood conditions, including expected erosion.

Building foundations must be capable of resisting any added loads and increase in local scour due to the presence of the slabs.

In most circumstances, and for low-rise buildings in Zone V (including residences), the best alternative is to use frangible slabs. This alternative is also appropriate for other uses of slabs, such as pool decks, sidewalks, and patios. Figure 22 illustrates one possible design for such a slab.



NOTE: Install expansion and isolation joints as appropriate in accordance with standard practice or as required by state and local codes.

Figure 22: Example of frangible slab design

Reinforced, self-supporting structural slabs below the BFE may be appropriate for large mid- and high-rise structures that are supported on deep piles because these structures are typically much heavier and less prone to damage from flood loads. If a frangible parking slab is constructed beneath such a structure, reoccupation of an otherwise intact and usable structure after a severe coastal storm event may be delayed due to loss of parking. A self-supporting structural slab could be considered in such situations.

Reinforced, self-supporting structural slabs and grade beams beneath large buildings should be designed to be only as thick as necessary to support vehicle loads and other design loads. The slabs and beams should be connected and integral to the foundations, and all below-BFE components should be designed to act together to resist flood loads and other design loads. Obstructive effects will be minimized as long as the slab systems remain intact and horizontal so floodwater and waves pass above and below the slabs.

7 Site Development: Practices and Issues

This section discusses common site development practices and issues that may significantly affect the free passage of flood flow and waves under or around elevated buildings. When these practices are undertaken in accordance with the guidance in this section, they will be deemed to satisfy the NFIP free-of-obstruction requirement, and the potential obstructive effects will be minimized.

7.1 Accessory Storage Structures

In Zone V, certain small accessories structures (as defined in a community's floodplain management ordinance, which has been approved by FEMA) may be permitted below the BFE. Small accessory structures include small storage structures such as metal, plastic, or wood sheds that are disposable. FEMA considers "small" to mean less than or equal to 100 square feet.

If accessory storage structures below the BFE do not meet the size considerations mentioned above, or if the structures are of significant size and made of material that is likely to create either damaging debris or flow and wave-diversion problems, communities could consider granting variances in accordance with their floodplain management ordinances and 44 CFR § 60.6. Alternatively, a best practice is to have accessory storage structures constructed and elevated in compliance with NFIP requirements.

ADDITIONAL ACCESSORY STRUCTURE CONSIDERATIONS

Some communities have FEMA-approved regulations that specify limitations on the size of accessory structures that are allowed in SFHAs without having to comply with elevation requirements. Other considerations for accessory structures are set forth in FEMA policies and guidance.

Local officials should consult NFIP State Coordinators or FEMA Regional Offices for additional guidance and for appropriate size limits and language to include in local regulations.

Small accessory storage structures that are not elevated must be anchored to resist wind loads (see Figure 23) and designed to resist flotation that may occur even under relatively shallow flood depths. However, because small accessory storage structures are unlikely to withstand wave loads, their loss should be anticipated during the base flood, and the effects that resultant debris may have on nearby structures must be considered.

Figure 23:
Small accessory structure that was moved by flood and wind forces

In addition, small accessory storage structures must be unfinished on the interior, constructed of flood damage-resistant materials, and used only for storage; moreover, if a structure is provided with electricity, the service must be above the BFE with all branch circuits descending below the BFE fed from ground-fault circuit interrupter breakers. Accessory storage structures must not be used for any habitable or other prohibited purpose.

Separate accessory storage structures must not be located directly under elevated buildings. An alternative is to create storage space below the elevated structure by enclosing an area with breakaway walls.

7.2 Detached Garages

Detached garages, such as those typically built for single-family homes or multi-family structures, are too large to qualify as accessory structures that are allowed below the BFE (see Section 7.1). Therefore, detached garages must be elevated on piles or columns and comply with other requirements for structures in Zone V.

Large, fully engineered, free-standing parking garages that satisfy Zone V design and construction requirements are permitted, even if portions lie below the BFE (e.g., vehicle ramps, stairwells, elevator shafts, parking spaces). These structures are not walled and roofed in the traditional sense and can be designed to allow the free passage of floodwater and waves.

ALTERNATIVE TO DETACHED GARAGES

Garages may be constructed under elevated buildings and enclosed with breakaway walls (see Technical Bulletin 9, *Design and Construction Guidance for Breakaway Walls*).

7.3 Erosion Control Structures

Erosion control structures, such as bulkheads, seawalls, retaining walls, and revetments, are obstructions when installed beneath elevated coastal buildings and are not permitted even if not attached to the building foundations. Erosion control structures can transfer damaging flood loads to building foundations and greatly increase the potential for redirecting flood flow and waves onto the elevated portions of coastal buildings). Figure 24 shows an example of waves running up and overtopping an erosion control structure. Figure 25 shows an example of timbers attached to a pile foundation (constituting a bulkhead), which is not permitted.

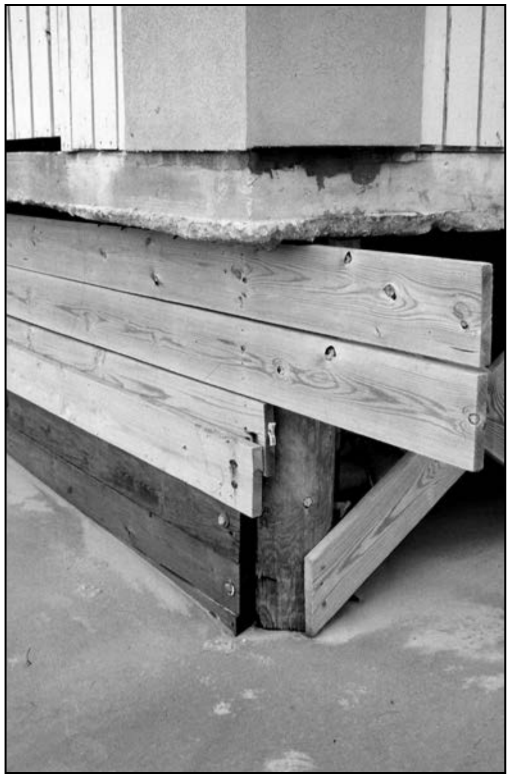
EFFECT OF EROSION CONTROL STRUCTURES ON WAVES

Guidance for evaluating potential effects of erosion control structures on waves is contained in the U.S. Army Corps of Engineers *Coastal Engineering Manual* (2002 and updates). Generally, erosion control structures with a steep face (1:2 [vertical to horizontal] or steeper) result in the greatest wave runup.

Figure 24: Wave runup and overtopping at an erosion control structure

Although the NFIP does not prohibit bulkheads, seawalls, retaining walls, or revetments outside a building's footprint, communities and design professionals must carefully consider the potentially significant effects of these structures. A general rule of thumb is the greater the horizontal distance between an erosion control structure and a building, the less likely that wave runup and overtopping will adversely affect the building. Although local or state regulations may prohibit the construction of erosion control structures until erosion is within a few feet of a building foundation (to maximize the recreational beach area seaward of the structure), the proximity of erosion control structures to buildings may contribute to wave runup and wave reflection damage.

Figure 25:
Shore-parallel timbers attached to a pile foundation that were intended to act as a bulkhead but constituted an obstruction and are not permitted



FEMA's coastal mapping guidance suggests that a 30-foot-wide "VE overtopping splash zone" (the area where waves breaking on or running up the seaward face of an erosion control structure land or splash down) be mapped landward of erosion control structures, but the guidance also contains site-specific calculations that can lead to a narrower splash zone. For floodplain management purposes, a 30-foot minimum splash zone width is desirable for new construction landward of existing erosion control structures, but this width may not be feasible for existing buildings situated close to erosion control structures. There is no established minimum distance between a building and an erosion control structure, but a reasonable minimum width is 10 to 15 feet. States and communities should take local conditions and observed building damage into account when establishing minimum distances.

7.4 Fences and Privacy Walls

Fences and privacy walls, including walls separating one property from another, may obstruct or divert flood flow and waves toward buildings. Their potential effects on buildings, including debris generation, should be evaluated. Open fences (e.g., wood, plastic, open masonry units, metal slat fencing with generous openings) are presumed to not cause harmful diversion of floodwater or wave runup and reflection. Fences with small openings and solid fences and walls may divert flow and waves and can trap debris.

Solid fences, privacy walls, and fences prone to trapping debris must be designed and constructed to fail under base flood conditions without causing harm to nearby buildings. Where building or fire codes require ground-level walls for tenant fire separation, designers should strive to satisfy code requirements while minimizing potential adverse effects from flood diversion.

Siting of new buildings near fences and privacy walls should be reviewed carefully given the impact that these structures could have on a building if they fail during a flood event. Figure 26 shows an example of a shore-perpendicular solid privacy wall that failed during a coastal flood event and damaged the pile foundation of an adjacent elevated building.

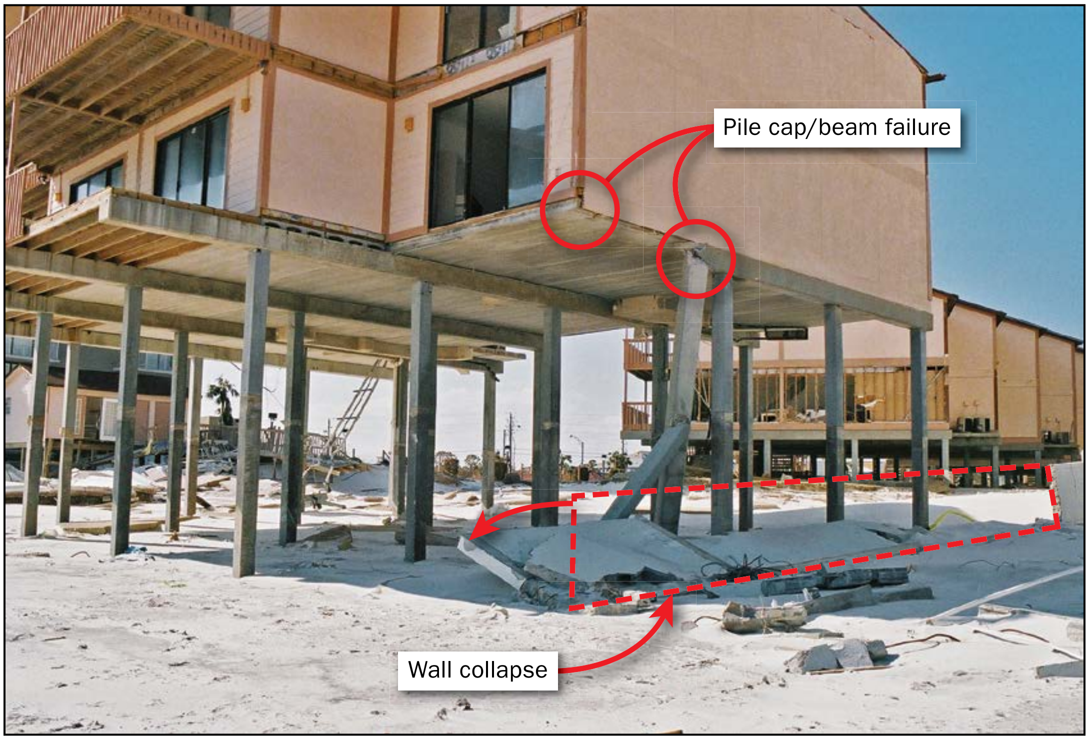


Figure 26: Shore-perpendicular reinforced masonry privacy wall that collapsed into the foundation of an adjacent building and contributed to failure of the corner foundation piling and pile cap/beam

7.5 Fill

NFIP regulations prohibit the use of fill for structural support of buildings in Zone V. Minor grading and the placement of minor quantities of nonstructural fill are allowed in Zone V but only for landscaping, drainage under and around buildings, and support of parking slabs, pool decks, patios, walkways, and similar site elements. Nonstructural fill should not prevent the free passage of floodwater and waves beneath elevated buildings, divert floodwater or waves such that building damage is exacerbated, or lead to damaging flood and wave conditions on a site or adjacent sites. Nonstructural fill should be assumed to wash away and should not be used in foundation design calculations.

Determining whether the placement and shaping of nonstructural fill will be detrimental is complicated. Therefore, some state and local

MINOR GRADING AND MINOR QUANTITIES OF NONSTRUCTURAL FILL

Minor grading: Minimum grading necessary to provide for landscaping and drainage purposes required or allowed by community regulations, subject to the limitations described in this Technical Bulletin.

Minor quantity of fill: Minimum quantity necessary to provide for adequate drainage of areas below and around elevated buildings; support of parking slabs, in-ground pool decks, decks, patios, walkways, and similar site elements; and for site landscaping, subject to the limitations described in this Technical Bulletin.

regulations essentially prohibit placement of any nonstructural fill in Zone V. However, such limits on nonstructural fill can also lead to problems such as ponding of rainfall around or under buildings. Other states and communities accept some (unspecified) amount of nonstructural fill provided an engineering analysis is performed and an engineer certifies that the fill will not lead to damaging flow diversion or wave runup and reflection. However, credible and defensible analyses are difficult to perform using current engineering methods and models for the small quantities of fill typically used on individual lots.

The placement of nonstructural fill in Zone V for landscaping, drainage, and slab support may be acceptable under certain circumstances using the evaluation criteria described below. Unless in conflict with state or local limitations, local officials are expected to apply these criteria using discretion to achieve the desired performance while giving deference to the general intent of the following criteria as described in the paragraphs that follow. Several criteria are listed, and they may not all agree, depending on specific circumstances.

7.5.1 Type of Fill

Fill placed on Zone V sites should be similar to natural soils in the area. In many coastal areas, natural soils are clean sand or sandy soils free of large quantities of clay, silt, and organic material. Nonstructural fill should not contain large rocks and debris. If the fill is similar to and compatible with natural soils, there is no need to require designers to investigate or certify whether the fill has a tendency for excessive natural compaction; an investigation or certification is a common requirement in many floodplain regulations. If the fill material is similar to natural soils, its behavior under flood conditions will be similar to the behavior of natural soils.

7.5.2 Fill Thickness

The addition of small thicknesses of site-compatible, nonstructural fill in Zone V is not likely to lead to adverse effects on buildings. There are no established rules as to what constitutes an acceptable fill thickness, so it must be addressed on a case-by-case basis and in some cases may require an engineering analysis of flow and wave effects of the fill. Designers should check with the community about fill thickness thresholds triggering engineering analyses.

Placement of up to 2 feet of fill under or around an elevated building can generally be assumed to comply with free-of-obstruction requirements and be acceptable without engineering analysis or certification, provided basic site drainage principles are not violated (see Section 7.5.4) and provided there are no other site-specific conditions or characteristics that would render the placement of the fill damaging to nearby buildings (e.g., if local officials have observed that the placement of similar quantities of fill has led to building damage during coastal storm events).

If fill is proposed for a site, the proposed final grade should be compared to local topography. If the proposed final fill configuration is below the threshold established by the community and the fill configuration is similar to grades and slopes in the immediate vicinity, a detailed analysis of the effects on flood flow and waves may not be needed. However, if the proposed fill configuration exceeds the community's configuration deemed to comply fill thickness threshold or the proposed fill configuration exceeds local grade heights and variations, an engineering analysis may be required by the community.

In cases where site development involves removing a layer of soil and fill is added to the site later, the fill thickness should be evaluated relative to the pre-removal soil elevation, not the removed soil elevation.

7.5.3 Prevention of Ponding

Most communities establish minimum floor elevations to ensure that water does not collect at or under buildings. Floor elevation requirements are frequently tied to nearby road elevations, and the quantity of fill required to raise building footprint areas typically falls within the fill height allowance mentioned in Section 7.5.2. There is no compelling reason to restrict the placement of site-compatible, nonstructural fill beneath buildings in Zone V if the fill will prevent ponding and saturated soil conditions, as long as other drainage requirements for grades and slopes can be satisfied.

7.5.4 Site Drainage Requirements

Most communities establish minimum slopes for building sites to facilitate drainage away from buildings (typically 1 unit vertical to 20 units horizontal [5 percent]). Slopes of 1 unit vertical to 3 units horizontal (or steeper) can produce appreciable wave runup. Conversely, slopes shallower than 1 unit vertical to 5 units horizontal (regardless of fill height) will probably not cause or worsen wave runup or wave reflection capable of damaging adjacent buildings. Figure 27 shows an example of fill placement that is considered acceptable because the fill depth is modest and the side slopes are gentle. FEMA's Hurricane Ivan Mitigation Assessment Team concluded that the presence and configuration of the fill did not cause additional flood or wave damage to either the elevated building or the nearby older non-elevated building (FEMA, 2005). The adjacent older, non-elevated building in Figure 27 would likely sustain structural damage during a coastal flood, even if the fill were not present. Swales and conventional site drainage practices should be used to mitigate potential effects of runoff from filled areas.

Figure 27: Post-hurricane photo showing an elevated building surrounded by gently sloping fill and an adjacent, damaged, older, non-elevated building

7.5.5 Vertical Clearance between Top of Fill and Bottom of Lowest Horizontal Structural Member of Lowest Floor

There are no established rules as to what constitutes acceptable vertical clearance, so it must be addressed on a case-by-case basis. Designers should check with the jurisdiction about minimum vertical clearance requirements.

When the BFE is above the existing ground, placement of nonstructural fill between the ground and the lowest horizontal structural member of the lowest floor may be permitted, but it is advisable to maintain some vertical clearance between the bottom of the lowest horizontal structural member and the top of the fill. Vertical clearance should be established to ensure that base flood flow and waves will pass beneath the elevated building and the fill will not contribute to wave runup and flood damage to the elevated building.

When the BFE is below the existing ground elevation (see Section 7.6), vertical clearance between the ground (including any nonstructural fill) and the lowest horizontal structural member of the lowest floor may not be needed as long as adequate site drainage is provided.

7.5.6 Fill Compaction

The NFIP regulations are explicit in that fill must not be used for structural support of buildings in Zone V. However, compaction of fill below and around elevated buildings used to support parking slabs, in-ground pool decks, patios, sidewalks, and similar site amenities is consistent with the intent of the regulations.

7.5.7 Dune Construction, Repair, and Reconstruction

Dunes are natural features in many coastal areas, and they can erode during storms and recover naturally over time. The natural recovery process can be accelerated by replacing the eroded dune with compatible sand, planting dune grasses, and installing sand fences (see Chapter 5 of *The Dune Book* [Rogers and Nash, 2003]). In general, these activities should not be considered detrimental even if part of the dune lies under a building's footprint. The addition of sand to restore a site to its pre-storm grades and stabilization with dune vegetation will likely do more good than harm in terms of flood damage reduction.

DUNE EXCAVATION MAY INCREASE POTENTIAL FLOOD DAMAGE

Communities must prohibit manmade alteration of sand dunes in Zone V if such alteration would increase potential flood damage (per 44 CFR § 60.3(e)(7)). Where the ground (dune) elevation is at or above the BFE, excavation to place the bottom of the lowest horizontal structural member of lowest floor at the BFE is not recommended and may in fact violate the limitation on alterations that increase potential flood damage.

Concerns about placement of nonstructural, clean sand under and around beachfront buildings should not be the basis for prohibiting dune maintenance and construction, beach nourishment, or similar activities. Dune construction, repair, and reconstruction under or around elevated buildings may be assumed to be acceptable as long as the scale and location of the dune work is consistent with local beach-dune morphology and reasonable vertical clearance is maintained between the top of the dune and the elevated building's floor system. ASCE 24-14 permits dune construction and reconstruction under and around elevated buildings but requires an engineering report documenting that the fill placement will not cause building damage by wave runup or reflection or deflection of floodwater.

7.5.8 Timing of Fill Placement

Sometimes fill is placed on a site months or years before building construction begins. This can be problematic unless the community tracks site improvements and fill placement. If the original natural grade elevation is unknown, borings or other site investigations may be required to determine the depth of fill and ensure adequate foundation depth.

7.6 Ground Elevations At or Above the Base Flood Elevation

In some Zone V areas, ground elevations are at or above the BFE, particularly along shorelines with well-developed dune fields. Mapped Zone V areas with ground above the BFE seem counterintuitive, but they are possible because of two Zone V mapping considerations:

- **Dune erosion.** Dunes can erode during the base flood (or lesser floods), resulting in a substantial lowering of the pre-storm grade to a level below the BFE. The BFE is mapped based on surge and waves passing over the eroded and inundated ground surface.
- **Presence of a primary frontal dune (PFD).** Zone V is mapped at a minimum to the inland extent (heel) of the PFD, even where the dune elevation is higher than the BFE (FEMA, 2014).

A ground elevation at or above the BFE may complicate the need to comply with Zone V design and construction requirements but does not eliminate it. It does raise the question of how the free-of-obstruction requirement applies in this situation: Because the soil at the site may erode during a coastal flood event, the area under the building will be exposed, and the exposed area must be free of obstructions.

The same free-of-obstruction considerations that apply to buildings elevated above grade apply to buildings where the BFE is below grade. Buildings must still be designed and constructed on pile or column foundations that are embedded deep into the ground, and the bottoms of the lowest horizontal structural members supporting the lowest floor must still be at or above the BFE. Vertical clearance between the bottom of the lowest horizontal structural member and the ground (see Section 7.5.5) is not required by the NFIP where ground elevations are at or above the BFE; however, communities should be contacted because they may have vertical clearance requirements. Any lowest horizontal structural members that come in contact with the fill must be composed of materials that can resist ground contact moisture levels. Minor site grading to drain water away from the foundation will also be necessary.

7.7 On-Site Septic Systems

On-site buried septic systems and mounded septic systems in Zone V are frequently exposed and/or displaced. In addition to compromising their subsequent use, damage can cause release of contents. Septic systems are often destroyed if they are near a shoreline. Therefore, septic systems should be located outside areas subject to erosion during the base flood or, if placed in an area subject to erosion, installed below the depth of expected erosion. The latter stipulation may conflict with septic system groundwater considerations, in which case an on-site septic system is not appropriate for the area, and alternate designs may be necessary.

On-site septic system tanks serving elevated buildings must not be structurally attached to building foundations. Plumbing and piping connections are required, and these items are allowed in Zone V. However, plumbing and piping components must not be attached to or pass through breakaway wall panels.

If mounded septic systems are used, they can require significant volumes of fill, which, if placed under or immediately adjacent to buildings, may constitute obstructions that divert flood flow and waves. An analysis of flow and wave effects should be undertaken. Mounded septic systems may be allowed in Zone V if they will not worsen flood and wave conditions for the buildings they serve or nearby buildings (see Section 7.5.2 for guidance on evaluating mounded systems near elevated buildings).

An additional consideration for on-site septic systems in Zone V is stated in 44 CFR § 60.3(a)(6)(ii) of the NFIP regulations, which requires "on-site waste disposal systems to be located to avoid impairment to them or contamination from them during flooding." FEMA P-348 provides additional guidance.

7.8 Restroom Buildings and Comfort Stations

Restroom buildings and comfort stations must be treated the same as other types of structures in Zone V and must meet the same elevation and design requirements as other buildings, even when the facilities are situated in public parks or recreation areas.

7.9 Swimming Pools and Spas

Three primary considerations relate to the placement of swimming pools and spas under or adjacent to buildings in Zone V:

- Whether the pool or spa will cause increased flood loads on buildings or exacerbate scour and erosion near buildings.
- Whether the pool or spa configuration is subject to NFIP use limitations for enclosed areas under elevated buildings.
- Whether a removable enclosure is placed around a pool or spa (usually in the winter) that will cause increased flood loads on buildings or exacerbate scour and erosion near buildings. NFIP flood insurance treats these enclosures as permanent enclosures even if they are only used seasonally or for short periods of time.

SWIMMING POOLS AND SPAS

Pools and spas adjacent to coastal buildings are allowed only if they will not act as obstructions that could lead to damage to nearby buildings. This effectively means that most pools and spas must be installed in-ground (either frangible or immovable) or completely elevated above the BFE. Swimming pools, spas, and related equipment are not covered by NFIP flood insurance.

Pools, pool decks, and walkways that are placed under or adjacent to coastal buildings must be structurally independent of the buildings and their foundations and must not contribute to building or foundation damage during the base flood. Three options, also recognized by ASCE 24-14, Section 9.6.2, satisfy this requirement:

- The pool can be elevated so the bottom of the lowest horizontal structural member supporting the pool (and the pool itself) is at or above the required flood elevation, or

- The pool can be designed and constructed to break away without producing debris capable of damaging nearby buildings, or
- The pool can be designed and constructed to remain in the ground and not divert flow or waves that can damage nearby buildings.

Registered design professionals must certify that pools or spas beneath or near buildings in Zone V will not be subject to flotation or displacement that will damage building foundations during a base flood or lesser event. In cases where pools are empty part of the year, flotation calculations should assume that pools are empty. Figure 28 shows a spa that was displaced and likely caused the failure of two piles that supported an elevated deck.

Figure 28:
Failure of two piles supporting an elevated deck that was likely caused by movement of a spa

The NFIP permits swimming pools and spas beneath elevated building only if the top of the pool or spa and accompanying deck or walkway are flush with the existing grade and the area around the pool or spa remains unenclosed. However, some states and communities may prohibit or restrict unenclosed pools and spas beneath elevated buildings. Designers should check with the local jurisdiction for any additional requirements.

The NFIP limits the use of enclosures under elevated buildings to parking of vehicles, building access, and storage. Because pools and spas do not satisfy these limitations, they are not allowed to be enclosed, even if enclosed by glass or breakaway walls. Use of lattice and insect screening is permitted around pools and spas below elevated buildings.

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This section lists the references cited in this Technical Bulletin. Additional resources related to NFIP requirements are provided in Technical Bulletin 0.

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Technical Bulletin 0, *User's Guide to Technical Bulletins*

Technical Bulletin 2, *Flood Damage-Resistant Materials Requirements for Buildings Located in Special Flood Hazard Areas*

Technical Bulletin 4, *Elevator Installation for Buildings Located in Special Flood Hazard Areas*

Technical Bulletin 9, *Design and Construction Guidance for Breakaway Walls Below Elevated Buildings Located in Coastal High Hazard Areas*

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Requirements for the Design and Certification of Dry Floodproofed Non-Residential and Mixed-Use Buildings

Located in Special Flood Hazard Areas in Accordance with the National Flood Insurance Program

NFIP Technical Bulletin 3 / January 2021

FEMA

Comments on the Technical Bulletins should be directed to:

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NFIP Technical Bulletin 3 (2021) replaces NFIP Technical Bulletin 3 (1993), *Non-Residential Floodproofing – Requirements and Certification for Buildings Located in Special Flood Hazard Areas in Accordance with the National Flood Insurance Program*.

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Acronyms

ACI	American Concrete Institute
ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
BFE	base flood elevation
CFR	Code of Federal Regulations
CMU	concrete masonry unit
DFE	design flood elevation
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
IBC®	International Building Code®
ICC®	International Code Council®
I-Codes®	International Codes®
IRC®	International Residential Code®
LiMWA	Limit of Moderate Wave Action
NFIP	National Flood Insurance Program
ORNL	Oak Ridge National Laboratory
SEI	Structural Engineers Institute
SERRI	Southeast Region Research Initiative
SFHA	Special Flood Hazard Area
USACE	U.S. Army Corps of Engineers

1 Introduction

This Technical Bulletin explains and provides guidance on the National Flood Insurance Program (NFIP) floodplain management requirements for the design and certification of dry floodproofing. This guidance applies to new and substantially improved non-residential buildings and mixed-use buildings in Special Flood Hazard Areas (SFHAs) identified as Zone A (A, AE, A1-30, AH, and AO) on Flood Insurance Rate Maps (FIRMs). This Technical Bulletin includes guidance for certification of dry floodproofed buildings for the purpose of obtaining NFIP flood insurance coverage with floodproofing credit.

The NFIP regulations do not permit the use of dry floodproofing for residential buildings in Zone A, and dry floodproofing is not permitted for any buildings in SFHAs that are subject to high velocity wave action, called coastal high hazard areas and identified on FIRMs as Zone V (V, VE, V1-30, and VO).

The design and certification of dry floodproofing measures involve engineering evaluations and calculations. FEMA P-936, *Floodproofing Non-Residential Buildings* (2013), contains detailed guidance that supplements this Technical Bulletin. ASCE 24, *Flood Resistant Design and Construction*, is referenced throughout this Technical Bulletin because it is the standard of practice for the design of dry floodproofed buildings. ASCE 24 is a referenced standard in the International Codes® (I-Codes®).

NFIP TECHNICAL BULLETIN 0

NFIP Technical Bulletin 0, *User's Guide to Technical Bulletins*, should be used as a reference with this Technical Bulletin. Technical Bulletin 0 describes the purpose and use of the Technical Bulletins. It includes common concepts and terms, lists useful resources, and includes a crosswalk of the sections of the NFIP regulations identifying the Technical Bulletin that addresses each section of the regulations and a subject index.

Readers are cautioned that the definitions of some of the terms that are used in the Technical Bulletins are not the same when used by the NFIP for the purpose of rating flood insurance policies.

FEMA P-936, *FLOODPROOFING NON-RESIDENTIAL BUILDINGS*

FEMA P-936 provides guidance on regulatory requirements, design considerations, design loads, site characteristics, and descriptions of dry floodproofing methods and equipment. Key information includes:

- Functional, operational, and economic factors to consider
- Tools such as a vulnerability checklist to help the designer or building owner determine the best dry floodproofing option for a particular building
- Case studies of applied dry floodproofing techniques
- Equations for determining flood forces and loads
- Summary of results from dry floodproofing research and testing for new construction

1.1 Definition of Floodproofing

The NFIP regulations define floodproofing as "any combination of structural and non-structural additions, changes, or adjustments to structures which reduce or eliminate flood damage to real estate or improved real property, water and sanitary facilities, structures and their contents" (Title 44 Code of Federal Regulations [CFR] § 59.1). In the NFIP regulations "floodproofing" is understood to refer to dry floodproofing. For the purposes of this Technical Bulletin, "dry floodproofing" means a combination of measures that make a building and attendant utilities and equipment watertight and substantially impermeable to floodwater, with structural components having the capacity to resist flood loads.

"Wet floodproofing" is not defined in the NFIP regulations. The term is used in FEMA guidance publications and by floodplain management professionals to mean the use of flood damage-resistant materials and construction techniques that intentionally allow floodwater to enter and flow through a structure without causing damage that requires more than cosmetic repairs. "Wet floodproofing" is sometimes used to refer to the requirements for enclosures below elevated building in Zone A when the enclosures are used only for parking of vehicles, storage, and building access.

Wet floodproofing measures are not covered in this Technical Bulletin. For more information on wet floodproofing, see FEMA P-936; NFIP Technical Bulletin 1, *Requirements for Flood Openings in Foundation Walls and Walls of Enclosures*; NFIP Technical Bulletin 2, *Flood Damage-Resistant Materials Requirements*; NFIP Technical Bulletin 7, *Wet Floodproofing Requirements*; and FEMA P-2140, *Floodplain Management Requirements for Agricultural Structures and Accessory Structures* (2020a). FEMA P-2140 describes wet floodproofing measures as they apply to specifically defined agricultural structures and small accessory structures.

TERMS USED IN THIS TECHNICAL BULLETIN

- **Active:** Dry floodproofing measures or system components that require human intervention or action before the onset of flooding to be effective (e.g., flood shields that must be installed, valves that must be closed).
- **Ancillary area:** Common area such as a lobby, foyer, office used by building management, exercise space, meeting room, and mail room (FEMA P-2037, *Flood Mitigation Measures for Multi-Family Buildings* [2019a]).
- **Basement:** "Any area of the building having its floor subgrade (below ground level) on all sides" (44 CFR § 59.1). The NFIP regulations do not allow basements to extend below the base flood elevation (BFE) except in dry floodproofed non-residential buildings.
- **Flood protection level:** Elevation to which flood protection measures are designed. The flood protection level is the most restrictive of (1) the BFE plus the prescribed amount of freeboard specified in ASCE 24, (2) the design flood elevation (DFE) if a different flood is used for regulatory purposes, and (3) the elevation relative to the BFE specified in local floodplain management regulations.
- **Flood shield:** Removable or permanent, substantially impermeable protective cover or panel for openings in the portions of a dry floodproofed building that are below the flood protection level (e.g., door, window, louver).
- **Floodproofing:** "Any combination of structural and non-structural additions, changes, or adjustments to structures which reduce or eliminate flood damage to real estate or improved real property, water and sanitary facilities, structures and their contents" (44 CFR § 59.1).
- **Mixed-use building:** Building that has both residential and commercial or other non-residential uses. The term does not include multi family residential buildings that have ancillary areas but no non-residential uses.
- **Non-residential building:** Building that has a commercial or other non-residential use.
- **Passive:** Dry floodproofing measures or system components that do not require human intervention or action before the onset of flooding to be effective (e.g., specially designed doors that are sealed when closed, designed window systems, flood shields that are designed to close automatically when triggered by rising floodwater).

(continued on page 3)

TERMS USED IN THIS TECHNICAL BULLETIN (continued)

- **Residential building:** Building designated for habitation. Ancillary areas of residential buildings that serve only residents are residential ancillary areas and include laundry facilities, storage rooms, mail rooms, recreational rooms, parking garages, and exercise facilities.
- **Substantially impermeable:** The use of materials and techniques that restrict the passage of water and seepage through pathways (joints, cracks, openings, channels) and points of entry and that limit the accumulation of water during flooding. According to ASCE 24 and the U.S. Army Corps of Engineers (USACE), a structure is considered substantially impermeable if the maximum accumulation of water is not more than 4 inches in a 24-hour period without relying on devices for the removal of the water (USACE, 1995).
- **Zone A:** Flood zones shown on FIRMs as Zone A, AE, A1-30, AH, AO, A99, and AR.
- **Zone V:** Flood zones shown on FIRMs as Zone V, VE, V1-30, and VO.

Other terms used in this Technical Bulletin are defined in the glossary in Technical Bulletin 0.

1.2 Floodproofing Certification

When a building owner proposes dry floodproofing measures for a non-residential building that is in an NFIP-participating community, the owner must provide certification that the structural designs, specifications, and plans for the construction of the dry floodproofing measures were developed and/or reviewed by registered professional engineers or architects (design professionals). The certification must state that the proposed dry floodproofing design and proposed methods of construction are in accordance with accepted standards of practice for achieving the required performance. Design professionals who sign and seal certifications must be licensed to practice in the state where projects are located.

FEMA Form 086-0-34, NFIP Floodproofing Certificate for Non-Residential Structures (FEMA, 2019b), provides information necessary for insurance underwriters to rate dry floodproofed buildings. The same form should be used to satisfy the requirement for design professionals to certify designs and as-built drawings and inspection. The certificate identifies ASCE 24-14 and ASCE 24-05 (or equivalent) as the accepted standard of practice.

The certificate requires the building owner's name and the address or other description of the building location. It has three sections:

- Section I: Site information from the FIRM.
- Section II: Certification of the elevation to which the building is floodproofed. The elevation (where BFEs are provided on FIRMs) or the height above the lowest adjacent grade (where BFEs are not provided) to which the building is floodproofed. Section II must be signed and sealed by a land surveyor, engineer, or architect authorized by law to certify elevation information.

ASCE 24 IS THE STANDARD OF PRACTICE FOR DRY FLOODPROOFING DESIGN

ASCE 24, *Flood Resistant Design and Construction*, is a consensus standard that was developed and is maintained by the American Society of Civil Engineers (ASCE). ASCE 24 is a referenced standard in the I-Codes, which means it is considered part of the requirements in these codes.

ASCE 24 represents the standard of practice for the design of buildings and structures in flood hazard areas, including the design of dry floodproofed buildings.

- Section III: Certification by a registered professional engineer or architect that "the structure, based upon development and/or review of the design, specifications, as-built drawings for construction and physical inspection" has been designed and constructed in accordance with "the accepted standards of practice (ASCE 24-05, ASCE 24-14, or their equivalent) and any alterations [of the structure]" meet these standards and specific listed provisions (i.e., are watertight and substantially impermeable and have structural components that are capable of resisting flood forces).

See Appendix A for further instructions on completing the certificate.

1.3 Limitations on the Use of Dry Floodproofing

Dry floodproofing is permitted for new and substantially improved non-residential and non-residential portions of mixed-use buildings in Zone A, but not for residential buildings in Zone A or any building in Zone V. The NFIP regulations and published FEMA guidance use "residential" and "non-residential" but do not define these terms. However, "residential" in general refers to dwelling units and the building systems and ancillary areas that support the units. Building systems include electrical, heating, ventilation, plumbing, and air conditioning equipment and other service equipment. Ancillary areas include areas that are designated or used by on premises guests. "Non-residential" refers to buildings with commercial or other non-residential uses. ASCE 24 has a more extensive definition of "residential" and defines "non-residential" as buildings that are not classified as residential. ASCE 24 commentary defines "mixed-use" and "residential portions of mixed-use buildings."

FEMA considers buildings with both non-residential and residential uses to be mixed-use buildings. The non-residential portions of mixed-use buildings are allowed to be dry floodproofed provided that all residential units, building systems and service equipment that serve residential units, and ancillary areas used by residents are elevated above the required elevation. See FEMA P-2037, *Flood Mitigation Measures for Multi-Family Buildings*, for more information.

In keeping with the requirements for enclosures below elevated residential buildings, lobbies that provide access to both residential and non-residential portions of mixed-use buildings are allowed to be dry floodproofed provided there are separate accesses to the residential portions. When an access to the residential portion of a mixed-use building is below the flood protection elevation and the access is enclosed by walls, the walls must comply with the requirements for enclosures below elevated buildings (sometimes called wet floodproofing).

HOTELS AND MOTELS

Hotels and motels are commercial buildings. For floodplain management purposes, guest rooms and the building systems and service equipment that serve guest rooms are considered residential and are not permitted to be located in areas of the building that are dry floodproofed. The requirements for building systems and service equipment that serve guest rooms and access to guest rooms are the same as the requirements for the residential portions of mixed-use buildings.

The NFIP regulations for dry floodproofing apply only in SFHAs identified on FIRMs as Zone A (A, AE, A1-30, AH, and AO). Dry floodproofing is not permitted in SFHAs identified as Zone V (V, VE, V1-30, and VO). For Zone A, the regulations do not specify limits on the use of dry floodproofing based on flood depth, flood velocity, or the presence of waves. However, FEMA does not recommend use of dry floodproofing systems in areas where:

- The depth of water under base flood conditions is greater than 3 feet.
- Base flood velocities exceed 5 feet per second.
- Moderate wave heights (1.5 to 3 feet) are present during base flood conditions.

1.4 Dry Floodproofing Measures

Dry floodproofing measures include but are not limited to the following:

- Portions of a building, including walls and slabs, reinforced to resist water pressure and floating debris impacts
- Doors and windows that are specially designed to be watertight when closed without flood shields
- Removable or permanently installed, substantially impermeable panels to cover doors, windows, and other openings
- Paints, membranes, gaskets, and other sealants that reduce water seepage
- Sump pumps or self-priming pumps that control the level of seepage water
- Backflow (non-return) valves or shutoff valves that prevent floodwater from entering through sewer and drainage pipes and/or sewage ejectors that pump sewage to above the flood protection level before the pipes connect to a vertical sewer line
- Seals that prevent the entrance of floodwater through joints and utility penetrations
- Electrical equipment and circuits that are protected to the flood protection level
- Backup or emergency power for sump pumps and other seepage control measures that is protected to the flood protection level

The planning considerations in Section 5 should be reviewed before determining which dry floodproofing measures or combination of measures are feasible for specific locations and before undertaking structural designs to ensure that the measures will provide the appropriate level of flood protection. Planning considerations include building location, flood characteristics (flood velocities, depths, duration of flooding, how quickly floodwater rises, and debris impacts), level of protection required, flood warning time, safety and access, flood emergency operations plan, and inspection and maintenance plans.

Questions about dry floodproofing requirements should be directed to the appropriate local official, National Flood Insurance Program State Coordinating Office, or FEMA Regional Office.

LEVEES AND FLOODWALLS

Levees and floodwalls are not considered dry floodproofing measures for buildings because they are separate structures and not part of the buildings. Levees and floodwalls that are designed and constructed to provide flood protection to a single building or a group of buildings are not addressed in this Technical Bulletin. Although levees and floodwalls can be used to mitigate flood damage, they may not be used to bring a building into compliance with NFIP requirements.

2 National Flood Insurance Program Regulations

An important NFIP objective is protecting buildings constructed in SFHAs from damage caused by flooding. The SFHA is the land area subject to flooding by the base flood. SFHAs are shown on FIRMs prepared by FEMA as Zones A and V. The base flood is the flood that has a 1 percent chance of being equaled or exceeded in any given year (commonly called the "100-year" flood). The NFIP floodplain management regulations include minimum building design criteria that apply to:

- New construction
- Work determined to be Substantial Improvements, including improvements, alterations, and additions
- Repair of buildings determined to have incurred Substantial Damage

A defining characteristic of the NFIP regulations applicable in any Zone A is the requirement for the lowest floor (including basement) of residential buildings to be elevated to or above the BFE. Non-residential buildings in Zone A must be elevated or dry floodproofed to or above the BFE. Dry floodproofing is not permitted in Zone V.

The NFIP regulations for dry floodproofing of non-residential buildings are codified in 44 CFR Part 60, Criteria for Land Management and Use. Specific to this Technical Bulletin, 44 CFR § 60.3(c)(3) states that a community shall:

> Require that all new construction and substantial improvements of non-residential structures within Zones A1–30, AE and AH zones on the community's firm [sic] (i) have the lowest floor (including basement) elevated to or above the base flood level, or (ii) together with attendant utility and sanitary facilities, be designed so that below the base flood level the structure is watertight with walls substantially impermeable to the passage of water and with structural components having the capability of resisting hydrostatic and hydrodynamic loads and effects of buoyancy.

Section 60.3(c)(8) states that in Zone AO (areas of sheet flow with depths of 1 to 3 feet), a community shall:

> Require within any AO zone on the community's FIRM that all new construction and substantial improvements of nonresidential structures (i) have the lowest floor (including basement) elevated above the highest adjacent grade at least as high as the depth number specified in feet on the community's FIRM (at least two feet if no depth number is specified), or (ii) together with attendant utility and sanitary facilities be completely floodproofed to that [base flood] level to meet the floodproofing standard specified in [44 CFR} § 60.3(c)(3)(ii).

Section 60.3(c)(4) requires that floodproofing designs be certified in the following manner:

> Provide that where a non-residential structure is intended to be made watertight below the base flood level, (i) a registered professional engineer or architect shall develop and/or review structural design, specifications, and plans for the construction, and shall certify that the design and methods of construction are in accordance with the accepted standards of practice for meeting the applicable provisions of paragraphs (c)(3)(ii) or (c)(8)(ii) of this section, and (ii) a record of such certificates which includes the specific elevation (in relation to mean sea level) to which such structures are floodproofed shall be maintained with the official designated by the community under [44 CFR] § 59.22(a)(9)(iii).

NFIP REQUIREMENTS AND HIGHER REGULATORY STANDARDS

State or Local Requirements. State or local floodplain management requirements that are more restrictive or stringent than the minimum requirements of the NFIP take precedence. The Technical Bulletins and other FEMA publications provide guidance on the minimum requirements of the NFIP and describe best practices. Design professionals, builders, and property owners should contact local officials to determine whether more restrictive provisions apply to buildings or sites in question. All other applicable requirements of the state or local building codes must also be met.

Substantial Improvement and Substantial Damage. As part of issuing permits, local officials must review not only proposals for new construction but also for work on existing buildings to determine whether the work constitutes Substantial Improvement or repair of Substantial Damage. If the work is determined to constitute Substantial Improvement or repair of Substantial Damage, the buildings must be brought into compliance with the NFIP requirements for new construction. Some communities modify the definitions of Substantial Improvement and/or Substantial Damage to be more restrictive than the NFIP minimum requirements. For more information on Substantial Improvement and Substantial Damage, see FEMA P-758, *Substantial Improvement/Substantial Damage Desk Reference* (2010a), and FEMA 213, *Answers to Questions About Substantially Improved/Substantially Damaged Buildings* (2018a).

Higher Building Elevation Requirements. Some states and communities require that non-residential buildings be elevated or dry floodproofed (allowed only in Zone A) above the NFIP minimum requirement. The additional elevation is called freeboard. Design professionals, builders, and property owners should check with local officials to determine whether a state or community has freeboard requirements. References to building elevations in the Technical Bulletin, including the required flood protection level, should be construed as references to the community's elevation requirement where freeboard is required.

3 Building Codes and Standards

In addition to complying with NFIP requirements, all new construction, Substantial Improvements, and repair of Substantial Damage must comply with the applicable building codes and standards adopted by states and communities.

The I-Codes, published by the International Code Council® (ICC®), are a family of codes that includes the International Residential Code® (IRC®), International Building Code® (IBC®), International Existing Building Code® (IEBC®), and codes that govern the installation of mechanical, plumbing, fuel gas service, and other aspects of building construction. FEMA has deemed that the latest published editions of the I-Codes generally meet or exceed NFIP requirements for buildings and structures in flood hazard areas. Excerpts of the flood provisions of the I-Codes are available on FEMA's Building Science – Flood Publications webpage (https://www.fema.gov/emergency-managers/risk-management/building-science/flood).

INTERNATIONAL BUILDING CODE AND ASCE 24 COMMENTARIES

The ICC publishes companion commentary for the IBC, and ASCE publishes a companion commentary for ASCE 24. Although not regulatory, the commentaries provide information and guidance that is useful for complying with, interpreting, and enforcing requirements.

3.1 International Residential Code

The International Residential Code (IRC) applies to one- and two-family dwellings and townhomes not more than three stories above grade plane. The IRC does not allow dry floodproofing of buildings within its scope.

3.2 International Building Code and ASCE 24

The International Building Code (IBC) applies to all applicable buildings and structures. While used primarily for buildings and structures other than dwellings within the scope of the IRC, the IBC may also be used to design dwellings.

The flood provisions of the latest published editions of the IBC generally meet or exceed NFIP requirements for buildings through reference to the standard ASCE 24, *Flood Resistant Design and Construction*.

ASCE 24 applies to structures that are subject to building code requirements. ASCE 24 requirements for dry floodproofing, summarized in Table 1, are similar to the NFIP requirements. Table 1 refers to selected dry floodproofing requirements of the 2018 IBC and ASCE 24-14 and notes changes from 2015 and 2012 IBC and ASCE 24-05 along with a comparison to the NFIP requirements. Subsequent editions of the IBC and ASCE 24 should include comparable requirements.

ASCE 24 AND NFIP DRY FLOODPROOFING REQUIREMENTS

FEMA interprets the NFIP regulations to be more restrictive than ASCE 24 in two respects:

- Temporary flood protection systems that cover exterior walls cannot be used in lieu of a substantially impermeable wall (see "ÁSCE Interpretation of ASCE 24-14 Flood Shield Requirements and FEMA Position on Whether a Flood Shield Configuration Meets NFIP Dry Floodproofing Requirements" at the end of Section 3.2 of this Technical Bulletin).
- Flood damage-resistant materials are required where seepage would collect inside dry floodproofed areas up to at least 4 inches above the floor.

Table 1: Comparison of Selected 2018 IBC and ASCE 24-14 Requirements with NFIP Requirements

Topic	Summary of Selected 2018 IBC / ASCE 24-14 Requirements and Changes from 2015 and 2012 IBC / ASCE 24-05	Comparison with NFIP Requirement
Definition of dry floodproofing	**2018 IBC Section 202 Definitions.** Defines dry floodproofing as a combination of design modifications resulting in a building, including the attendant utilities and equipment and sanitary facilities, being watertight with walls that are substantially impermeable and able to resist the loads required by ASCE 7, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*. Change from 2015 to 2018 IBC: No change. Change from 2012 to 2015 IBC: Added "and equipment." **ASCE 24-14 Section 1.2 Definitions.** Defines dry floodproofing as a combination of measures that results in making a structure and its utilities and equipment watertight with all elements substantially impermeable and with structural components having the capacity to resist flood loads. Change from ASCE 24-05: Expands the definition to require building and utilities and equipment serving the building to be watertight with walls substantially impermeable and able to resist flood loads rather than only requiring the building envelope to be substantially impermeable.	The definition of "dry floodproofing" (IBC and ASCE 24) is equivalent to the NFIP definition of "floodproofing" in NFIP 44 CFR § 59.1.

Table 1: Comparison of Selected 2018 IBC and ASCE 24-14 Requirements with NFIP Requirements (cont.)

Topic	Summary of Selected 2018 IBC / ASCE 24-14 Requirements and Changes from 2015 and 2012 IBC / ASCE 24-05	Comparison with NFIP Requirement
General flood hazard area requirements	**2018 IBC Section 1612.2 Design and construction.** Requires buildings and structures located in flood hazard areas to be designed and constructed in accordance with Chapter 5 of ASCE 7 and ASCE 24. Change from 2015 to 2018 IBC: Section renumbered from 1612.4 to 1612.2. Change from 2012 to 2015 IBC: Applies coastal high hazard area requirements in Coastal A Zones, if delineated.	Exceeds NFIP 44 CFR § 60.3(a)(3) with more specificity.
Flood hazard documentation	**2018 IBC Section 1612.4(1.3) Flood hazard documentation.** Requires submission of a certification statement prepared and sealed by a registered design professional that dry floodproofing is designed in accordance with ASCE 24. Change from 2015 to 2018 IBC: Section renumbered from 1612.5 to 1612.4. Change from 2012 to 2015 IBC: Applies coastal high hazard area requirements in Coastal A Zones, if delineated.	Equivalent to NFIP 44 CFR § 60.3(c)(4).
Elevation	**ASCE 24-14 Section 1.5.2 Elevation Requirements.** Allows for dry floodproofing of non-residential and the non-residential portions of mixed-use buildings below the BFE plus specified freeboard or the DFE, whichever is higher, provided the dry floodproofing measures meet the requirements in Chapter 6. **ASCE 24-14, Section 2.3, Elevation Requirements.** Allows for dry floodproofing of non-residential and the non-residential portions of mixed-use buildings below the BFE plus specified freeboard or DFE, whichever is higher, provided the dry floodproofing measures meet the requirements in Chapter 6. Change from ASCE 24-05: Requires Flood Design Class 4 buildings to be elevated or to be protected to BFE plus 2 feet, or DFE, or 500-year flood elevation, whichever is highest.	Exceeds NFIP 44 CFR § 60.3(c)(3) and (8) by requiring freeboard
Dry floodproofing	**ASCE 24-14 Section 6.2 Dry Floodproofing.** • Permits dry floodproofing of non-residential buildings and non-residential portions of mixed-use buildings when the buildings are located outside High Risk Flood Hazard Areas, Coastal High Hazard Areas, and Coastal A Zones • Requires techniques that make structures substantially impermeable and requires the use of flood damage-resistant materials, except on the interior of structures • Requires sump pumps to remove water that accumulates from the passage of vapor and seepage during flooding • Limits dry floodproofing to flood hazard areas with flood velocities that are less than or equal to 5 feet per second during the design flood • Requires walls below the minimum elevations of dry floodproofing specified in Table 6-1 to be substantially impermeable to passage of water	Exceeds NFIP 44 CFR § 60.3(c)(3) with more specificity, except (1) the NFIP requires the use of flood damage-resistant materials in areas where seepage can accumulate and (2) FEMA deems that temporarily installed means of flood protection that cover walls are inconsistent with the requirement that walls be substantially impermeable (see text box "ASCE Interpretation of ASCE 24-14 Flood Shield Requirements and FEMA Position on Whether a Flood Shield Configuration Meets NFIP Dry Floodproofing Requirements" on page 10).

Table 1: Comparison of Selected 2018 IBC and ASCE 24-14 Requirements with NFIP Requirements (cont.)

Topic	Summary of Selected 2018 IBC / ASCE 24-14 Requirements and Changes from 2015 and 2012 IBC / ASCE 24-05	Comparison with NFIP Requirement
Dry floodproofing (cont.)	• Requires walls, floors, and flood shields to resist hydrostatic, hydrodynamic, and other flood loads, including the effects of buoyancy • Specifies that soil or fill adjacent to a structure must be compacted and protected from erosion and scour • Requires that at least one door, window, or other opening for emergency escape and rescue be above the elevation specified in Table 6-1 • Specifies several limitations when human intervention is necessary to activate or implement dry floodproofing measures Change from ASCE 24-05: Does not require flood damage-resistant materials on the interior of dry floodproofed portions of buildings.	

ASCE INTERPRETATION OF ASCE 24-14 FLOOD SHIELD REQUIREMENTS AND FEMA POSITION ON WHETHER A FLOOD SHIELD CONFIGURATION MEETS NFIP DRY FLOODPROOFING REQUIREMENTS

In November 2016, ASCE issued a formal interpretation of whether a specific configuration of flood shields meets the dry floodproofing requirements of ASCE 24-14.[1] The configuration is described as a building that is supported by an impermeable reinforced concrete stem wall (foundation) with permeable exterior walls such as glass curtain walls. The question was whether the use of removable flood shields as a component of the exterior building façade would render the exterior walls impermeable along the entire length of the façade. Diagrams included in the request for the interpretation show flood shields attached at the base to the impermeable foundation stem wall and attached to vertical, structural columns between spans of the glass curtain wall system.

The ASCE interpretation determined that the flood shield configuration described and shown in the request meets the dry floodproofing requirements of ASCE 24-14 provided the building and shields meet all other dry floodproofing requirements, provided the flood shields are “close to and attached to the building façade,” and provided the shield attachment is “via guides, fasteners or supports that are permanent parts of the building façade.”[2]

The FEMA position is that the ASCE interpretation is contrary to the NFIP requirements because exterior wall sections that are neither substantially impermeable nor able to resist flood loads will not meet the intent of 44 CFR § 60.3(c)(3) that walls must be “substantially impermeable to the passage of water and with structural components having the capability of resisting hydrostatic and hydrodynamic loads and effects of buoyancy.” Therefore, any temporarily installed means of flood protection that cover such walls would not be considered compliant.

1 Jonathan C. Esslinger, Director, Technical Advancement and Codes & Standards, ASCE, written communication, November 29, 2016.

2 Ibid, Page 5.

3.3 ANSI/FM 2510, *American National Standard for Flood Mitigation Equipment*

ANSI/FM 2510, *American National Standard for Flood Mitigation Equipment* (ANSI/FM, 2020), describes performance and testing requirements that must be met for flood mitigation equipment and products, as defined in the standard, to be approved. Performance testing criteria are established for each type of equipment and products. The following types of equipment and products are addressed in the standard:

> **ANSI/FM 2510, AMERICAN NATIONAL STANDARD AND APPROVED EQUIPMENT AND PRODUCTS**
>
> ANSI/FM 2510: www.fmapprovals.com
>
> FM Approved equipment and products: https://nationalfloodbarrier.org

- Opening barriers (called flood shields in this Technical Bulletin)
- Flood glazing (permanent, passive barrier of reinforced glass material that is set and sealed within a structural frame)
- Flood mitigation valves (called backflow, non-return, or shutoff valves in this Technical Bulletin)
- Flood mitigation pumps (sump pumps, self-priming pumps, and other types of pumps used for seepage control)
- Penetration sealing devices
- Perimeter barriers (not applicable to this Technical Bulletin)

4 NFIP Flood Insurance Implications

Careful attention to compliance with the NFIP requirements, local building codes and standards, and floodplain management regulations is important during design, plan review, construction, and inspection. Compliance influences both vulnerability to flood damage and the cost of NFIP flood insurance.

> **NFIP FLOOD INSURANCE FOR DRY FLOODPROOFED BUILDINGS**
>
> While current owners and developers who are considering constructing dry floodproofed non-residential buildings may not intend to purchase NFIP flood insurance coverage, the cost of the coverage may be a factor for future owners.

An insurance agent with NFIP experience should be consulted during the design phase of buildings with dry floodproofing to estimate the cost of NFIP flood insurance. The consultation is particularly important when considering whether to include dry floodproofing of non-residential portions of mixed-use buildings or dry floodproofing of below-grade parking areas under non-residential and mixed-use buildings (see NFIP Technical Bulletin 6, *Requirements for Dry Floodproofed Below-Grade Parking Areas Under Non-Residential and Mixed-Use Buildings*).

Designers should pay particular attention to the flood protection level (level to which buildings will be dry floodproofed). The NFIP regulations applicable to non-residential structures in Zone A require the lowest floor (including basement) to be elevated to or above the BFE or the structures may be dry floodproofed below the

BFE. However, the NFIP flood insurance rating procedures provide credit for dry floodproofing only if the dry floodproofing measures are certified to be at least 1 foot above the BFE, even if that level of protection is not required by local floodplain management regulations. The NFIP also requires applications for insurance coverage for dry floodproofed buildings to include the NFIP Floodproofing Certificate (see Section 1.2 and Appendix A of this Technical Bulletin).

The methodology used by the NFIP to determine the NFIP flood insurance rate for dry floodproofed non-residential buildings and non-residential portions of mixed-use buildings is based on the "non-subsidized" rate with a credit (percentage discount) applied to that rate. The amount of credit is based on the information about the dry floodproofing components that must be included with NFIP flood insurance applications. Building owners and designers should consult with flood insurance providers before starting design work to understand how design decisions can impact NFIP flood insurance premiums.

5 Planning Considerations

Many factors and planning considerations influence the decision-making process when determining the feasibility of dry floodproofing options for specific buildings. Whether buildings are new construction designed to be dry floodproofed or existing buildings being considered for retrofitting with dry floodproofing measures, the dry floodproofing options that are examined and selected should:

- Comply with the applicable floodplain management and design requirements
- Reduce flood damage below the flood protection level
- Provide for the safety of personnel responsible for the deployment of components that require human intervention
- Be feasible to implement, maintain, and operate
- Be usable following recommended cleaning after flood events
- Result in a level of residual risk that is acceptable to the owner

Design professionals should assess the site during the planning phase to determine site-specific flood hazards that will influence the design of dry floodproofing measures, building vulnerability, and how well the building may perform during flood events (see Section 5.1). The assessment should include a flood vulnerability assessment to examine site conditions and, for existing buildings, the vulnerability of architectural and structural systems, building envelope, and utility systems (mechanical, plumbing, gas, electrical).

Other important planning considerations include determining the available warning time prior to the onset of flooding (see Section 5.2), functional use requirements (see Section 5.3), safety and access before and during flooding (see Section 5.4), and early consideration of required plans (Section 5.5), including flood emergency operations plans and maintenance and inspection plans.

The design professional should review the assessment findings with the building owner to determine whether dry floodproofing is appropriate and whether the results indicate any constraints on the design. Determining the flood warning time, described in Section 5.2 of this Technical Bulletin, is critical before deciding whether active dry floodproofing measures are feasible or appropriate, or whether passive measures or elevation should be considered.

Active dry floodproofing measures require human intervention or action before the onset of flooding and passive dry floodproofing measures do not require human intervention.

Building owners should also consider residual risk as part of determining whether dry floodproofing is an appropriate solution. Residual risk is the remaining exposure to loss after the designed floodproofing measures have been implemented. For example, losses could be higher than expected. Dry floodproofing systems are designed for a selected flood protection level, but during extreme events, floodwater may rise higher than the selected flood protection level and high water may affect some sites for longer than the anticipated periods of inundation. In addition, dry floodproofing systems can fail. Common causes of failure are unidentified points of entry for floodwater, poorly maintained components of a system, components with insufficient resistance to flood loads, and failure to implement active measures that require human intervention (especially for complex systems).

PLANNING, DESIGN, AND OPERATIONAL CONSIDERATIONS

For guidance on conducting a flood vulnerability assessment and designing dry floodproofing measures to reduce flood damage and interruption of building operations, see:

- FEMA P-936, Appendix C, "Checklist for Vulnerability of Flood-Prone Sites and Buildings"
- FEMA P-2022, *Mitigation Assessment Team Report: Hurricane Harvey in Texas*, Appendix C, "Dry Floodproofing: Planning and Design Considerations (Recovery Advisory 1)" (FEMA, 2018c)

For guidance on how to effectively implement dry floodproofing measures, see:

- FEMA P-2023, *Mitigation Assessment Team Report: Hurricane Irma in Florida*, Appendix C, "Dry Floodproofing: Operational Considerations (Recovery Advisory 1)" (FEMA, 2018b)

Designers and owners should evaluate the residual risks associated with dry floodproofing measures, and owners should consider the financial impacts if the dry floodproofing system fails. Added costs include down time, clean up, and repairs. Some financial risk can be offset by purchasing flood insurance.

5.1 Flood Hazards and Site Conditions

Selecting effective dry floodproofing measures requires evaluating the flood hazard conditions at the site for the flood used for design purposes, typically at least the base flood (1-percent-annual-chance flood). The assessment should determine flood velocity, depth of flooding, rate of floodwater rise and fall, frequency of flooding, duration of flooding, and possible debris impacts.

Design professionals and building owners should review Chapter 2 in FEMA P-936 for guidance on determining design loads and the site characteristics that need to be identified in order to determine whether dry floodproofing is feasible and to successfully design and construct a dry floodproofed building.

RESTRICTIONS BASED ON FLOOD ZONE AND CONDITIONS

The NFIP regulations do not allow dry floodproofing in Zone V. ASCE 24 restricts the use of dry floodproofing in Zone V and in Coastal A Zones if a Limit of Moderate Wave Action (LiMWA) is delineated on flood maps. Communities may have additional requirements, such as not allowing dry floodproofing to be used in floodways.

A factor that may influence the decision to use dry floodproofing is flood velocity. The USACE recommends in its *Flood Proofing Regulations* (1999) that dry floodproofing not be used where expected flood velocities exceed 5 feet per second. ASCE 24 limits the use of dry floodproofing to where expected flood velocities adjacent to a structure are less than or equal to 5 feet per second, although ASCE 24 commentary suggests that local officials may accept certified designs that demonstrate resistance to higher velocities. In this Technical Bulletin, see Section 6, Step 3B, for possible sources of data for determining expected flood velocities.

5.2 Flood Warning Time

Flood warning time is an important factor when considering active dry floodproofing measures. Flood warning time is the length of time between the recognition that flooding may occur and when floodwater begins to affect a site. Designers should determine whether warnings issued by credible sources would provide enough time to implement any active dry floodproofing measures.

The first step is to determine the flood warning time, which is site specific. The next step is to determine whether the flood warning time would be sufficient to implement the measures the designer is considering (see Section 5.5.1 of this Technical Bulletin) and to provide time to safely evacuate the site.

Flood warning time varies depending on the source of flooding and the capabilities of the entities that are responsible for monitoring flood conditions or issuing flood warnings. Flood warning times can vary widely:

- Small watersheds, especially those in mountain and hilly regions, may be subject to flash flooding with very little or no warning before the onset of flooding.
- Larger rivers and waterways may take hours, days, or weeks for floodwater to crest.
- Flooding in coastal areas usually has several days of warning, although storm paths can change abruptly, which can shorten or lengthen warning times.

SOURCES FOR ESTIMATES OF FLOOD WARNING TIME

Possible sources of information about flood warning time are state or local emergency management agencies, local floodplain managers, river basin authorities and drainage districts, state water resources agencies, National Weather Service, U.S. Geological Survey, and USACE District Offices.

Dry floodproofing measures are active or passive. Active measures require human intervention to install, deploy, or otherwise activate. When feasible, building owners and designers should consider passive measures because effectiveness does not depend on human intervention. Examples of passive measures are specially designed doors that are always sealed when closed, designed window systems, and flood shields that are designed to automatically close when triggered by rising floodwater on the site.

A key consideration for determining flood warning time is not the time it takes for floodwater to reach the flood protection level but the time it takes for flooding to begin to affect the site and reach the point where water enters the building if dry floodproofing measures have not been deployed. For example, if floodwater reaches the lowest point of entry

DESIGN LIMIT ON HUMAN INTERVENTION

Active dry floodproofing measures should be designed to meet the limit for human intervention specified in ASCE 24—a minimum of 12 hours of flood warning time unless the community operates a flood warning system, in which case the designer should determine how much time may be available.

during a 10-percent-annual-chance event, the flood warning time must be sufficient to allow the implementation of active measures prior to floodwater reaching the 10-percent-annual-chance elevation.

The amount of time needed to implement active dry floodproofing measures varies depending on factors such as the number and complexity of the measures that require timely action to function as designed. Determining whether the flood warning time would be adequate requires estimating the total time needed to:

- Recognize the threat, including whether anticipated storm conditions will have high winds that could hamper installation
- Notify persons or contractors responsible for installation or deployment
- Travel to building locations
- Locate, activate, deploy, and install the measures, which may require heavy equipment not typically on site, such as forklifts
- Evacuate people implementing the measures using predetermined evacuation routes, taking into account whether roads or bridges may be closed by state or local officials (e.g., when high winds or overtopping by floodwater are anticipated)

For more information on flood warning time, see FEMA P-936, Chapter 2.

5.3 Functional Use Requirements

The functional use of buildings and the spaces within them must be evaluated when considering dry floodproofing measures. If extended interruption of function would be detrimental, building owners should consider whether dry floodproofing is a viable option compared to elevating buildings. The location, purpose, and frequency of use of entrances may dictate the type of dry floodproofing measure that is selected. For example, doorways that are used often may not be suitable for special doors that are designed to seal when closed because the gaskets may wear more quickly. Another example is vehicle openings and delivery doors where accidental vehicle impact may damage permanently mounted brackets for flood shields.

Mixed-use buildings have additional functional use considerations because separate access must be provided to the elevated residential portions of these buildings when shared accesses (lobbies to residential and non-residential portions) are dry floodproofed. When the separate access to the residential portions of a mixed-use building is enclosed by walls, the walls must comply with the requirements for enclosures below elevated buildings (sometimes called wet floodproofing).

5.4 Safety and Access

For safety, dry floodproofed buildings should not be occupied during flood conditions. Safety and access considerations are especially important when evaluating mixed-use buildings and whether it is appropriate to design dry floodproofing measures for the non-residential portions of these buildings. Flooding may rise higher than the flood protection level or dry floodproofing system components may fail, endangering the occupants.

Flooding may limit access and timely response by emergency personnel. ASCE 24 requires an exit door, exterior door, or window at or above the flood protection level that can be used as an emergency escape and rescue opening. The opening must be capable of providing human ingress and egress during flooding.

5.5 Required Plans

Buildings that will be dry floodproofed should have both flood emergency operations plans and inspection and maintenance plans. When active dry floodproofing measures are specified (human intervention is required to implement), ASCE 24, Chapter 6, requires flood emergency plans that are approved by local officials. See Section 5.5.1 of this Technical Bulletin.

Communities are encouraged to require submission of these plans along with the construction documents and design certifications required as part of an application for a building permit. The required submission of a flood emergency operations plan and inspection and maintenance plan may be specified in local floodplain management regulations or building codes.

Emergency operations plans and inspection and maintenance plans are required to be submitted with applications for NFIP flood insurance coverage to receive credit for dry floodproofing measures (see Section 4 of this Technical Bulletin).

FACTORS THAT CONTRIBUTE TO THE FAILURE OF DRY FLOODPROOFING SYSTEMS

The Mitigation Assessment Teams that FEMA deploys after some major disasters issue reports that include observations of damage and factors that contributed to flood damage. The reports issued after Hurricane Harvey in Texas (FEMA, 2018c) and Hurricane Irma in Florida (FEMA, 2018b) identify the following factors that may have contributed to the failure of dry floodproofing systems:

- Lack of plans that detail installation requirements for active dry floodproofing measures or operations and inspection and maintenance plans with insufficient detail
- Occupants and building managers who were not aware of the dry floodproofing systems
- Missing, damaged, degraded, and leaking gaskets around flood shields
- Modification of dry floodproofing components by uninformed maintenance contractors

5.5.1 Flood Emergency Operations Plans

Flood emergency operations plans address the implementation of active dry floodproofing measures when flood events are anticipated. Design professionals engaged in designing dry floodproofed buildings should evaluate flood warning time and the estimated time and level of effort necessary to install and deploy various measures that require human intervention well in advance of the onset of flooding or high winds (see Section 5.2 of this Technical Bulletin). When there may be insufficient time to implement specific measures and evacuate, designers should re-examine the measures and specify those that can be installed safely within the available warning and evacuation time. If the entire dry floodproofing system cannot be implemented and personnel safely evacuated in the available time, designers should specify alternative dry floodproofing system components or advise owners to consider elevation when compliance is required.

PERIODIC PLAN REVIEWS, DRILLS, AND INSPECTIONS

An annual review of flood emergency operations plans, with exercises for personnel to practice installing and deploying measures that require human intervention, is critical for success when flooding occurs.

Some communities conduct periodic inspections of dry floodproofed buildings, and some require the submission of reports documenting third-party inspections.

Building owners, operators, and responsible personnel must be able to implement the plan and make sure that occupants are aware of what is required when plans are activated. Flood emergency operations plans must be tailored for each dry floodproofed building. At a minimum, plans should specify the following:

REQUIRED POSTING OF FLOOD EMERGENCY OPERATIONS PLANS IN VISIBLE LOCATIONS

ASCE 24, Chapter 6, requires flood emergency operations plans to be permanently posted in dry floodproofed buildings in at least two clearly visible locations.

- The personnel, equipment, tools, and supplies needed to deploy all dry floodproofing system components with sufficient time prior to the onset of flooding or conditions such as high winds that could interfere with efficient deployment of measures
- Clearly defined chain of command and assigned responsibilities for personnel involved in the installation of dry floodproofing measures
- Procedure for notifying personnel responsible for installing dry floodproofing measures, along with a list of duty requirements
- Decision tree that identifies the sequence, timeline, and responsible parties for installing the dry floodproofing components, including the triggers or benchmarks that will initiate procedures
- Written description and map of the storage locations and types of dry floodproofing measures to be installed or deployed, along with any equipment, tools, and materials required for installation
- Conditions that require the deployment of active dry floodproofing measures (e.g., installation of flood shields, closing of flood doors, closing of manual valves, staging of pumps)
- Instructions for installing or deploying each dry floodproofing measure and the order of installation if important for effectiveness
- Repair procedures and component maintenance procedures that may be necessary during a flooding event
- Instructions for connecting standby (emergency) power source (e.g., generator) for critical equipment such as sump pumps and egress lighting
- Contact information for the manufacturer and designer to expedite obtaining replacement parts and support as needed
- Evacuation plans for all personnel (see Section 5.2)
- Requirements for installation and deployment drills and training program (at least once a year)
- Requirement for regular review and update of the plan procedures

5.5.2 Inspection and Maintenance Plans

A comprehensive inspection and maintenance plan for the entire dry floodproofing system is needed to ensure that the system components, measures, materials, and equipment required for the system to function as intended are inspected and maintained periodically. The design professionals who design and certify dry floodproofing systems should prepare the inspection and maintenance plans. It is good practice for building owners or operators to engage design professionals to coordinate regular inspections and address significant deficiencies identified during inspections.

Observations by FEMA Mitigation Assessment Teams after significant flood events indicate that some dry floodproofing systems did not provide the intended level of protection in part because components of the systems were not regularly tested or properly maintained. For additional information, see Appendix C in FEMA P-2022 and Appendix C in FEMA P-2023.

Inspection and maintenance plans should include a schedule for regular inspection and maintenance of the components, materials, and equipment that are needed to activate dry floodproofing measures. Manufacturer manuals typically provide recommendations for the aspects that need to be checked during inspections and maintenance, the frequency of inspections, and ordering information for replacement parts.

FEMA Form 086-0-34, NFIP Floodproofing Certificate for Non-Residential Structures, lists the minimum information that maintenance plans must have in order to obtain NFIP flood insurance coverage (see Section 4 and Appendix A of this Technical Bulletin). The content of a comprehensive inspection and maintenance plan depends on the elements of the specific dry floodproofing system. At a minimum, the following should be addressed:

- Exterior envelope of the structure, such as wall and foundation systems, to identify possible structural and waterproofing deficiencies such as cracks, water staining, and penetrations
- Slabs and wall/slab joints, including structural and drainage deficiencies
- Flood shields, gates, panels, doors, glazing, and other components designed to provide dry floodproofing protection, including seals, gaskets, fasteners, and mounting hardware and tools
- Sump pumps (or self-priming pumps) and interior drain system
- Testing of emergency generators, sump pumps, and other drainage measures
- Backflow (non-return) valves or shutoff valves
- Location of all flood shields, gates, panels, and other components including all hardware along with any materials or tools needed to seal the dry floodproofed area
- Contact information for the manufacturer of the shields and other components to determine the availability of replacement gaskets, seals, and other parts and to ask questions
- Cadence of inspection and maintenance plan

Inspections should be performed regularly, usually once a year. Inspections can be coordinated with regular drills during which responsible personnel practice deploying measures that require human intervention and other actions specified in flood emergency operations plans. The inspection should identify items that are deficient, items in need of repair or replacement, and the materials and equipment needed to implement repairs. Building owners and operators should examine the inspection reports and promptly make repairs and address deficiencies.

ANNUAL INSPECTION AND MAINTENANCE

Performing annual inspections also helps increase personnel and occupant awareness of the presence and importance of the dry floodproofing systems.

6 Dry Floodproofing Design Process

Section 1.2 of this Technical Bulletin explains that communities must require dry floodproofing designs to be certified and that the NFIP Floodproofing Certificate for Non-Residential Structures (FEMA Form 086-0-34) should be used for this purpose (see Appendix A of this Technical Bulletin). The certificate requires registered design professionals to certify that dry floodproofing measures have been designed and constructed in accordance with ASCE 24 or its equivalent. The certificate requires certification of designs and "as-built drawings for construction and physical inspection." Certification of as-built dry floodproofed systems provides increased assurance to building owners and operators.

> **USE OF ANSI/FM 2510 APPROVED EQUIPMENT AND PRODUCTS**
>
> The use of equipment and products that are tested and approved in accordance with ANSI/FM 2510, *American National Standard for Flood Mitigation Equipment*, is not required for compliance with the NFIP or ASCE 24. However, specifying approved equipment and products may provide designers with more assurance when developing designs for dry floodproofing systems.
>
> ANSI/FM 2510, described in Section 3.3 of this Technical Bulletin, specifies the flood conditions for the testing of each type of equipment and product. Designers should verify applicability of approved equipment and products for site-specific flood conditions.

The accepted standard of practice for the design of dry floodproofing measures is ASCE 24. This section provides a step-by-step guide for developing dry floodproofing designs that comply with ASCE 24. Designers should first evaluate the planning considerations described in Section 5 of this Technical Bulletin and review additional guidance in FEMA P-936. The process is applicable to the design of new construction with dry floodproofing systems and retrofitting of existing buildings with dry floodproofing measures.

An overview of the design steps is shown in Figure 1.

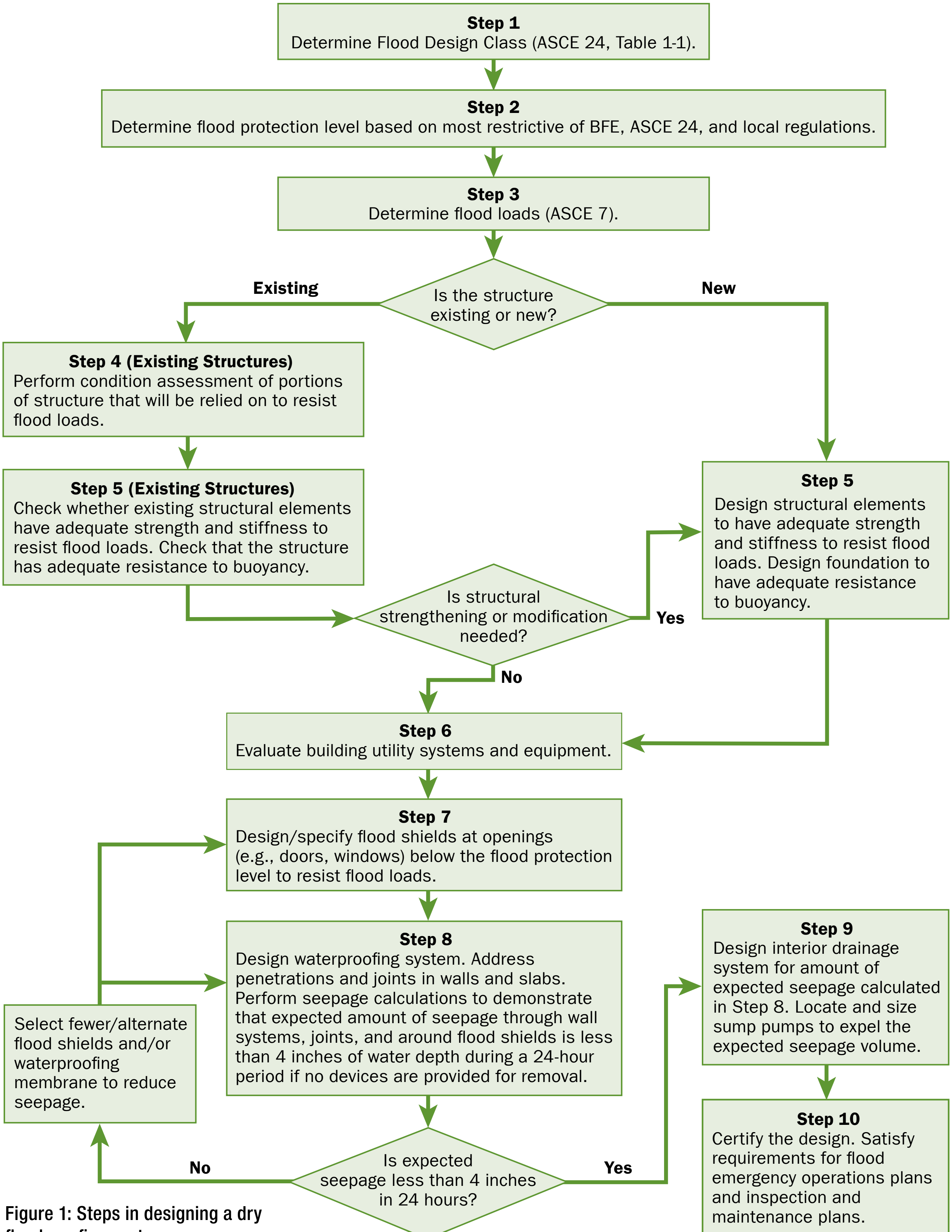

Figure 1: Steps in designing a dry floodproofing system

6.1 Step 1: Determine Flood Design Class

When designing in accordance with ASCE 24, the design professional begins the design process by determining the Flood Design Class (called "classification" in the 2005 edition). Flood Design Class is based on the use or occupancy of a building or structure, and the risk to the public should the building be damaged or the occupancy function be impaired by flooding. ASCE 24, Table 1-1, defines four Flood Design Classes.

6.2 Step 2: Determine the Flood Protection Level

The flood protection level is the elevation to which flood protection measures will be designed. The NFIP regulations specify that when non-residential buildings are dry floodproofed, the structures must be watertight and substantially impermeable below the base flood level or BFE.

ASCE 24 requires the minimum flood protection level to be the elevations listed in ASCE 24, Table 6-1, but state or local floodplain management regulations may require higher levels. ASCE 24 specifies flood protection levels based on the assignment of one of four Flood Design Classes (similar to risk categories).

> **"DESIGN FLOOD ELEVATION" IN ASCE 24**
>
> ASCE 24 defines and uses the terms "design flood" and "design flood elevation" (DFE) to account for communities that elect to adopt flood hazard maps based on floods that are higher than the base flood (the 1-percent-annual-chance flood) or to include additional areas not shown on FIRMs. Adding freeboard above the BFE as an additional factor of safety is also a common practice for establishing a minimum elevation requirement.
>
> When communities simply adopt FEMA FISs and FIRMs and use the base flood and BFE for regulatory purposes, the DFE is the same as the BFE.

The minimum flood protection level for Flood Design Class 2 and Class 3 buildings is the BFE plus 1 foot or the design flood elevation (DFE), whichever is higher. The minimum flood protection level for Flood Design Class 4, considered critical and essential facilities, is the highest of the BFE plus 2 feet, the DFE, or the 500 year flood elevation. Flood Design Class 1 includes temporary structures, accessory storage structures, small parking structures, and certain agricultural structures and also requires protection to BFE plus 1 foot or the DFE, whichever is higher. Local floodplain management officials should be consulted to determine whether local regulations require the flood protection level to be higher than the minimum elevations in ASCE 24.

The BFE is the computed water surface elevation for the 1-percent-annual-chance flood. When shown on FIRMs, the BFE is often rounded to the nearest whole number. Designers should also check elevations shown in Floodway Data Tables and Flood Profiles included in Flood Insurance Studies (FISs) when FEMA has developed engineering analyses. Figure 2 shows a sample FIRM marked to show a building location and applicable BFE.

Some FISs and FIRMs do not provide detailed information and/or BFEs for all sources of flooding, particularly smaller streams and tributaries. When a FIRM panel does not show a BFE or when detailed flood elevation information is not available, designers will need to take additional steps to determine the BFE. Local officials may have information from other sources or may direct designers to other sources, including USACE District Offices and FEMA Regional Offices. Additional steps may be necessary when 500-year flood elevations are not included in the FIS but are needed for the design of critical facilities. Statistical methods or engineering analyses may be required to identify critical flood characteristics.

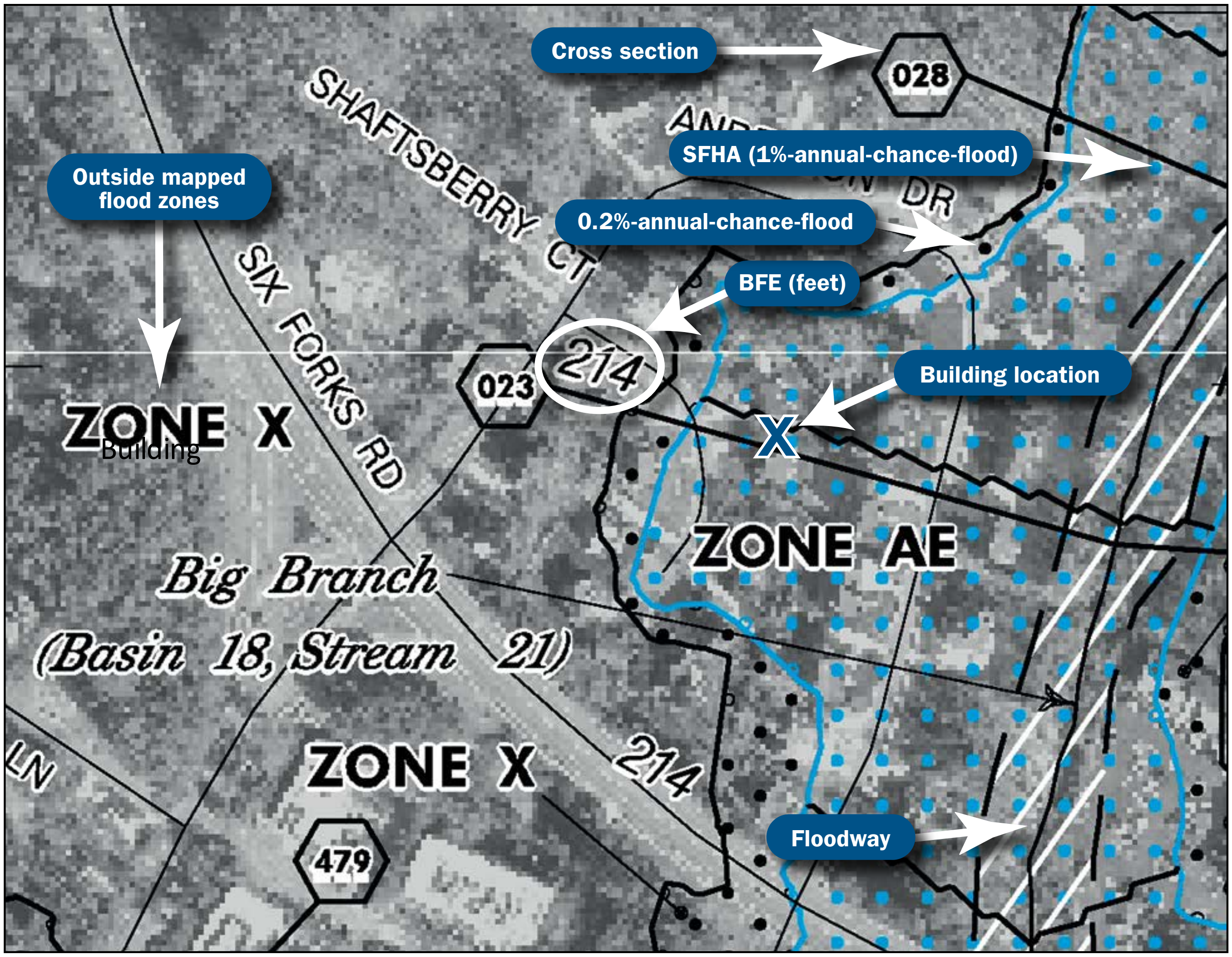

Figure 2: Example FIRM showing building location and BFE

An important consideration is that the flood protection level specified in ASCE 24 or local regulations is the minimum level to which buildings must be dry floodproofed. There is no restriction on designing dry floodproofing to provide protection for a higher flood elevation than what is required. Incorporating additional freeboard could help accommodate increases in future flood elevations, which may be caused by changes in storm intensity, increased development of surrounding areas, or ground subsidence. Owners and designers should discuss the acceptable level of protection given the value of the buildings, contents, occupancies, availability of replacement equipment, costs associated with business interruption and function, and cost-effectiveness of dry floodproofing. Owners may decide that a higher level of protection is appropriate.

6.3 Step 3: Determine Flood Loads

After the flood protection level has been determined, the next step is to determine the flood loads that would act on a building at the selected location. For design purposes, flood loads are the result of floodwater rising to the flood protection level and moving past an object such as a building or component of a building foundation. Flood loads are discussed in ASCE 7, which should be the primary source for calculating flood loads. Resources such as FEMA P-936 and FEMA P-55, *Coastal Construction Manual* (2010b), provide helpful information on determining site-specific loads. The four types of flood loads are:

- Hydrostatic loads, including buoyancy, which is the vertical hydrostatic force resulting from the displacement of a given volume of floodwater (Step 3A)
- Hydrodynamic loads (Step 3B)
- Wave loads (Step 3C)
- Impact loads (Step 3D)

Step 3E is load combinations, which are combinations of all types of loads, including flood loads.

All applicable flood loads must be considered over the entire dry floodproofing system below the flood protection level, including the portion above the BFE. Flood loads act on above-grade portions of buildings when floodwater is present and on below-grade foundation walls and slabs when saturated soil conditions may be present or may occur during flooding.

An overview of the types of flood loads is provided in Step 3A through Step 3E.

DETERMINING DEPTH OF FLOODING

The depth of flooding is critical in calculating flood loads. Designers of dry floodproofing systems should use the flood protection level elevation rather than the BFE or DFE when determining the depth of flooding for the calculation of flood loads.

6.3.1 Step 3A: Hydrostatic Loads

Hydrostatic loads are imposed by standing water on an object or building. Hydrostatic loads on specific buildings are determined using the flood protection level and must be applied to all building surfaces, both above and below the ground surface. Hydrostatic loads, also called pressures, are oriented horizontally on wall elements and increase linearly with depth of water (see Figure 3). For buildings with below-grade areas (basements), hydrostatic loads extend to the bottom of below-grade walls and are calculated using a saturated soil condition (see ASCE 7, Chapters 3 and 5).

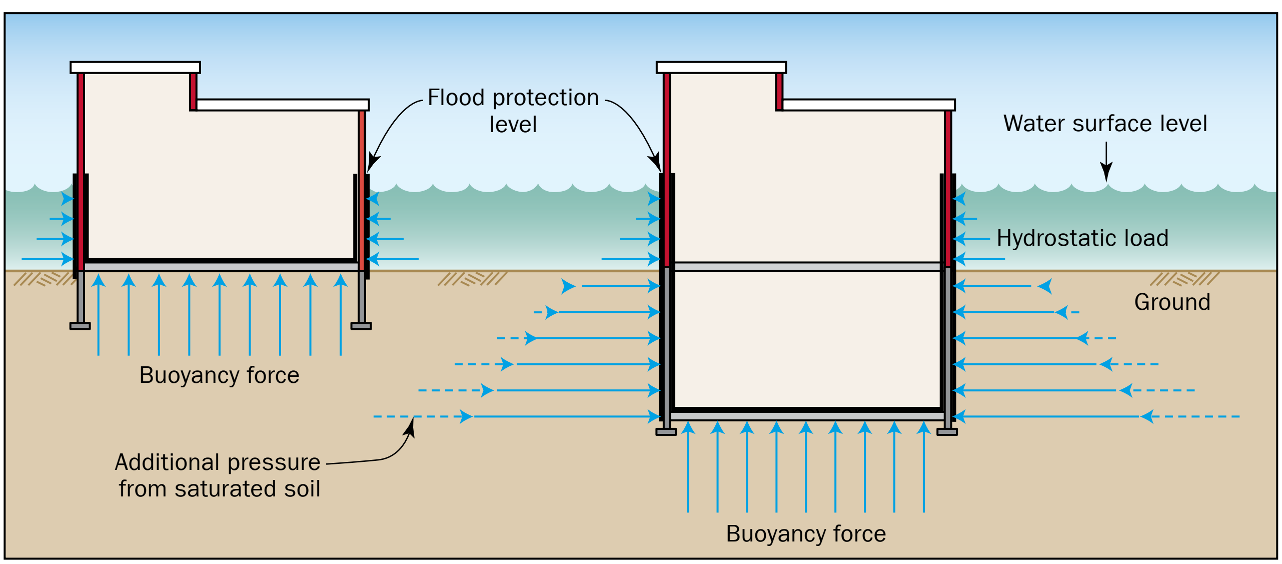

Figure 3: Hydrostatic loads

Vertical hydrostatic force (buoyancy) can be determined by multiplying the specific weight of water and the volume of floodwater displaced by a submerged object. Buoyant forces act upward on the bottom of foundation walls and base slabs and are resisted by the weight of the building and the structural capacity of the slab to resist uplift loads.

See FEMA P-936, Chapter 2, for information on determining hydrostatic loads and analyzing buoyancy forces.

When flood shields are included in dry floodproofing systems to prevent floodwater from entering openings in the building envelope (such as windows and doors), the shields must extend up to at least the flood protection level. A common practice is to extend flood shields an additional foot or more since even small amounts of splash or overtopping of a shield could result in a significant volume of floodwater entering the building. Flood shields must be designed to resist the hydrostatic load applied over the entire shield, and there must be a continuous load path through mounting systems to the walls and ultimately to foundations. See Step 7 for additional information on designing flood shields.

6.3.2 Step 3B: Hydrodynamic Loads

Hydrodynamic loads are imposed by water flowing around fixed objects such as buildings. These loads are a function of flow velocity and the geometry of the object or building. Upstream surfaces receive positive (frontal) pressures, side surfaces experience the effects of drag, and downstream surfaces have negative (suction) pressures (see Figure 4).

Hydrodynamic loads are determined by basic fluid mechanics. They increase as the size of the object around which the flow passes increases and with the square root of the flow velocity. Hydrodynamic loads vary with the shape of the object and associated drag coefficients.

ASCE 24, Chapter 6, limits the use of dry floodproofing to areas where flood velocities are less than or equal to 5 feet per second. ASCE 24 commentary acknowledges that effective designs may account for higher velocities and notes that it is the community's decision as to whether to accept dry floodproofing proposals in areas with velocities higher than 5 feet per second.

Determining the flood velocity can be a challenging part of estimating hydrodynamic loads on structures. Local, state, and federal government agencies and the Floodway Data Tables in FEMA FISs developed for waterways where FEMA performed detailed analyses are potential resources of velocity information.

ASCE 7 provides guidance on how to determine hydrodynamic loads and makes allowances for conditions when it is possible to calculate hydrodynamic loads as an equivalent hydrostatic load. FEMA P-936, Chapter 2, also describes hydrodynamic forces and how to determine a drag coefficient based on the shape of buildings and produce the total hydrodynamic force against a building or a given surface area.

DETERMINING FLOOD VELOCITY

Possible sources of data for determining expected flood velocity include studies by government agencies, hydraulic calculations, historical measurements, and Floodway Data Tables in FEMA FISs, among others. The Floodway Data Tables represent conditions during a 1-percent-annual-chance event. Where the flood protection level is higher, designers should consider that flood velocities for an event equaling the flood protection level may be higher. When data are not available for estimating flow velocities for a specific site, designers should contact experienced hydrologists or hydraulic or civil engineers to develop estimates.

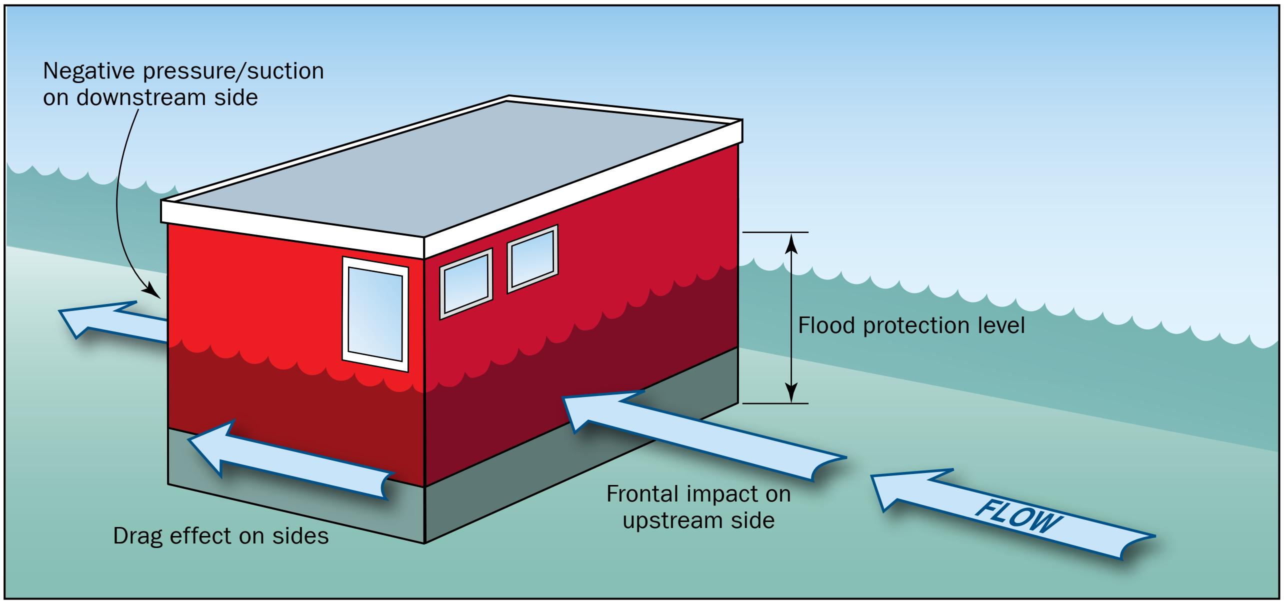

Figure 4: Hydrodynamic forces on a building

6.3.3 Step 3C: Wave Loads

The NFIP regulations do not permit the use of dry floodproofing in SFHAs that are subject to high velocity wave action, called coastal high hazard areas and identified on FIRMs as Zone V (V, VE, V1-30, and VO). FEMA does not identify other areas that may experience waves, including expansive riverine floodplains.

ASCE 24 does not permit dry floodproofing in Zone V or in Coastal A Zones when a Limit of Moderate Wave Action (LiMWA) is delineated on a FIRM. In addition, ASCE 24, Section 3.7.2, requires structures in noncoastal flood hazard areas subject to wind-driven waves that are equal to or greater than 3 feet high to be designed in accordance with the requirements for coastal high hazard areas. While wave loads are typically not considered in dry floodproofing designs, ASCE 24 commentary cautions that waves less than 3 feet in height can cause damage and should be considered in calculating flood loads. These waves may occur inland of the Zone V boundary where a LiMWA has not been delineated and in other floodplains where wind-driven waves may develop. Critical facilities could be located landward of Zone V and Coastal A Zones but under a design condition where the flood depth could support higher wave heights, which should be addressed in the design.

Design professionals should investigate historical flood damage near the site to determine whether wave forces could be present and could be significant enough to address in determining flood loads. Investigating historical flood damage is also appropriate for sites that are landward of Zone V boundaries if a LiMWA has not been delineated. Guidance on evaluating and determining appropriate wave loads and how to calculate the forces on various structural elements is included in ASCE 7, and additional information is provided in FEMA P-55.

6.3.4 Step 3D: Impact Loads

Impact loads result from debris that is transported by floodwater and strikes buildings. Such debris includes trees, boulders, ice floes, unsecured tanks and containers, vehicles, and material from damaged buildings. The magnitude of impact loads is difficult to predict due to the uncertainty of the size and weight of the objects. Determining the magnitude of debris impact loads should be based on a rational approach. The loads should be applied as a horizontal, concentrated load acting at the most critical location at or below the flood protection level.

ASCE 7 should be used as the source of how to calculate debris impact loads with FEMA P-936 as the source of helpful information and guidance on evaluating debris impact loads.

6.3.5 Step 3E. Load Combinations

Buildings need to be designed to resist all loads and load combinations. The applicable flood loads that are described above must be combined with other loads in accordance with ASCE 7. The design professional is permitted to combine loads by using Allowable Stress Design (ASD) or Strength Design (also known as Load Resistance Factor Design [LRFD]).

6.4 Step 4: Perform a Condition Assessment (Existing Structures)

When considering retrofitting an existing structure for dry floodproofing measures, design professionals must perform a condition assessment of the portions of the structures that will be relied on to resist the flood loads determined in Step 3. The assessment should be performed in two steps. The first step is a preliminary assessment consisting of a visual examination of the building and a review of available structural and architectural drawings.

If the preliminary assessment suggests that dry floodproofing may be possible, the second step is a more thorough assessment involving a review of as-built drawings (if available) and any plans or other documents related to any modifications of the structural elements after initial construction. Where adequate plans are not available, invasive testing to determine the structural aspects and condition of the building may be necessary. Cracks and penetrations through walls and slabs must be identified and examined to determine whether they would become pathways for seepage. The assessment results should be documented in written reports.

CONDITION ASSESSMENTS OF EXISTING STRUCTURES

See ASCE 11-99, *Guide for Structural Condition Assessment of Existing Buildings*, and Appendix C of FEMA P-936 for useful information on performing condition assessments of existing structures.

Design professionals use condition assessments to design modifications to existing structures that will satisfy dry floodproofing performance requirements. Modifications and key areas to identify include:

- Strengthening structural walls or floor systems
- Sealing wall penetrations
- Installing waterproofing membranes
- Locating where flood shields are needed
- Locating where seepage will accumulate and sump pumps are needed

If soil boring information for the site is not available, a geotechnical investigation may be necessary to determine lateral earth pressures and allowable soil-bearing capacities. Other geotechnical issues that may need to be considered include the presence of expansive or collapsible soils, potential for scour, permeability of soils, and compaction behavior of soils. See the discussion of site factors in FEMA P-936, Section 2.4, for additional information.

6.5 Step 5: Design or Check Structural Components for Resistance to Flood Loads

After flood loads have been determined in Step 3 and for existing buildings, the condition has assessed in Step 4, design professionals should next demonstrate that the structural elements (walls, foundations, and slabs) within areas to be dry floodproofed will have adequate strength to resist flood loads. To comply with ASCE 24, the structural components of new construction must be designed in accordance ASCE 7 to resist combined flood and other loads (e.g., dead load, live load, wind loads, seismic loads).

For existing buildings, the structural components that will resist flood loads need to be checked to determine whether they have adequate strength and stiffness. Structural components such as exterior walls, foundation elements, and diaphragms will likely experience substantial increases in loads after dry floodproofing measures are applied. Exterior walls commonly require strengthening with supplemental vertical or horizontal structural members to resist flood loads. Existing cracks and penetrations below the flood protection level must be sealed to limit seepage during flooding.

Another aspect of resistance to flood loads is whether building elements, such as slabs, have adequate resistance to uplift caused by buoyancy. ACI 350.4R-04, *Design Considerations for Environmental Engineering Concrete Structures* (ACI, 2004), is a helpful resource in determining the appropriate factor of safety to use to check uplift due to buoyancy. Some building elements may require strengthening or other modification to accommodate uplift pressures caused by buoyancy.

6.6 Step 6: Evaluate Building Utility Systems and Equipment

Designers must determine the needs of building utility systems and equipment in dry floodproofed buildings and identify the appropriate ways to satisfy floodplain management and building code requirements. The requirements apply to building utility systems (mechanical, electrical, and plumbing) and equipment (including fire controls and emergency power or generators).

The preferred solution is to locate building utility systems and equipment above the flood protection level. Building utility systems and equipment that serve non-residential buildings and non-residential portions of mixed-use buildings are allowed in dry floodproofed areas. If dry floodproofing systems fail or are overtopped by floodwater rising above the flood protection level, building utility systems and equipment may be damaged and not repairable, which could contribute to loss of building functionality. Backflow (non-return) valves or shutoff valves should be installed to prevent floodwater from entering through sewer and drainage pipes, and sewage ejectors should be installed to pump sewage to above the flood protection level before connecting to a vertical sewer line.

The NFIP regulations and ASCE 24 permit equipment and service facilities to be below the flood protection level when "designed … to prevent water from entering or accumulating within the components during conditions of flooding" (44 CFR § 60.3(a)(3)(iv)). The expectation is that after being submerged, equipment and facilities below the flood protection level will be able to be restored to functioning with minimal cleaning and repair. Unless equipment and service facilities are specifically designed to be submerged, they should be elevated on platforms or located on the roof, inside a freestanding engineered dry floodproofed walled area, or inside the dry floodproofed building. A good practice is to install connections for temporary equipment above the flood protection level or design interior core areas, as discussed in Section 3.3 of FEMA P-936. Additional guidance is available in FEMA P-348, *Protecting Building Utility Systems from Flood Damage* (2017).

When non-residential portions of mixed-use buildings are designed with dry floodproofing systems, the building utility systems and equipment that serve the residential uses are required to be elevated above the flood protection level and not located in areas that are protected with dry floodproofing (see Figure 5).

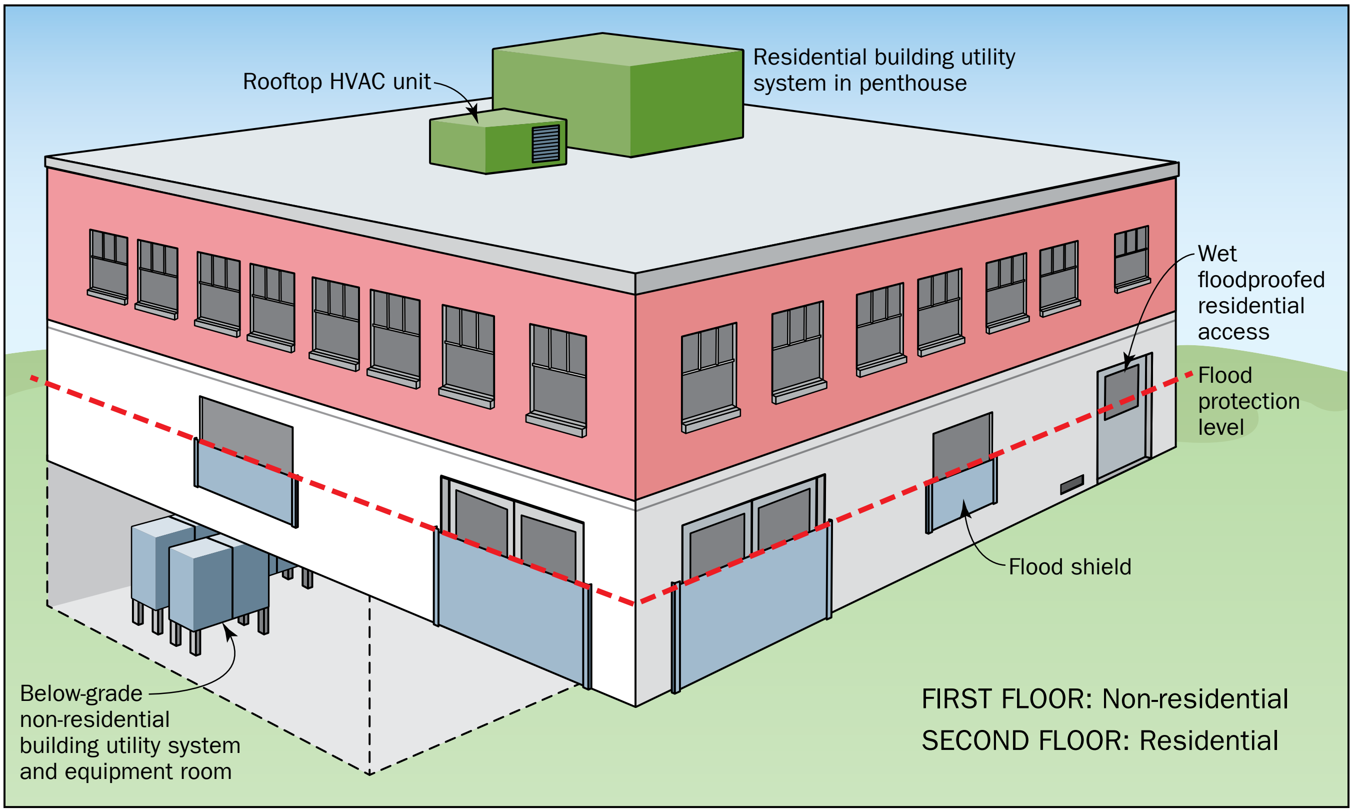

Figure 5: Mixed-use building with non-residential building utility systems and equipment in a dry floodproofed below-grade equipment room and elevated systems that serve the residential uses

6.7 Step 7: Design and Specify Flood Shields

When dry floodproofing systems are designed with doors, windows, or other openings below the flood protection level, design professionals must design or specify flood shields so the entire system performs as intended. Before finalizing designs, designers must determine the available warning time and the likely ability of personnel who would be responsible for deploying active dry floodproofing measures. Designers must also understand the requirements for installing different types of shields (see Section 5.2 of this Technical Bulletin).

Flood shields must be strong enough to resist all imposed flood loads. It is also critical to determine whether the shields will be mounted on structural elements of buildings or on door and window frames. When mounted on door and window frames, the frames must be capable of carrying the loads exerted on the shields. Designers should consider specifying flood shields that are tested and certified to the requirements of ANSI/FM 2510 (see Section 3.3 of this Technical Bulletin).

SPECIAL GLAZING SYSTEMS

Some manufacturers produce glazing (window) systems with laminated glass, seals, and frames designed to resist flood loads while meeting occupant needs for natural light. These window systems (sometimes called submarine or aquarium glass) are passive dry floodproofing measures because installing flood shields is not required when flooding is anticipated.

To limit seepage, flood shields typically have flexible gaskets around their perimeter. Various manufactured products are available. Figure 6 illustrates common types of shields, although other types may be available. Some permanent doors can be designed to function as flood shields when closed, although this may not be a viable option when doors are used frequently because of wear on gaskets and seals. Some flood shields are mounted next to openings to facilitate rapid deployment. Many flood shields are modular, can be stored nearby, and installed when needed.

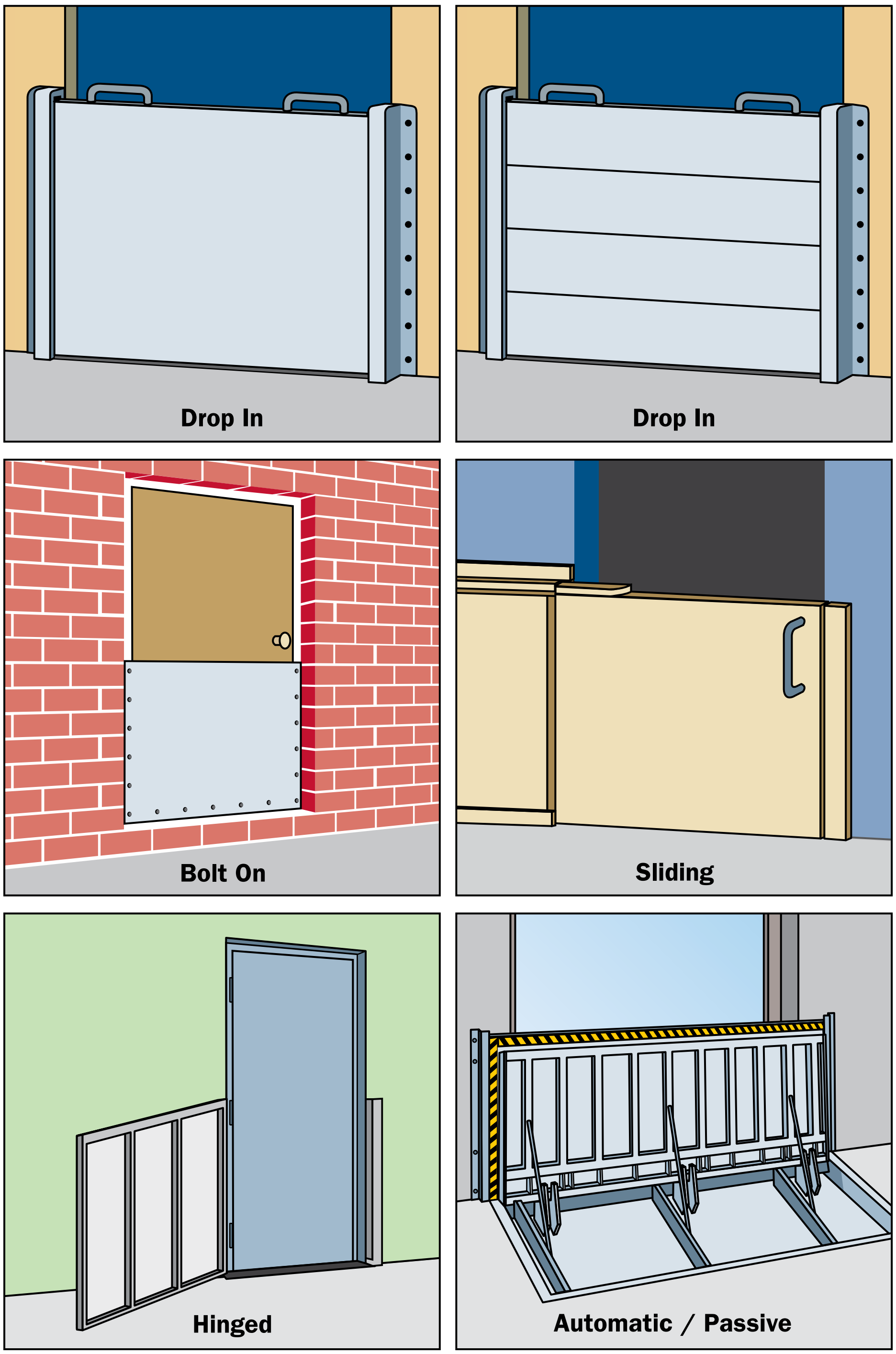

Figure 6: Common types of flood shields

Building owners and designers are cautioned that FEMA does not consider temporarily installed flood protection that covers walls, including glass curtain walls, to meet the NFIP minimum requirement that walls must be "substantially impermeable to the passage of water and with structural components having the capability of resisting hydrostatic and hydrodynamic loads and effects of buoyancy" (44 CFR § 60.3(c)(3)).

6.8 Step 8: Design Waterproofing System

In addition to ensuring that structures are capable of withstanding flood loads, design professionals need to ensure that areas below the flood protection level are watertight and substantially impermeable. To be considered substantially impermeable, the waterproofing system below the flood protection level must limit seepage through walls, floors, utility penetrations, joints, cracks, and around flood shields. The system must not allow more than 4 inches of water depth from seepage to accumulate during a 24-hour period without relying on devices to remove the water (e.g., sump pumps). Estimating seepage from each component of the waterproofing system is an important step because designers may need to alter designs to be able to certify that the designs stay within the accumulation limit.

6.8.1 Step 8A: Estimate Seepage through Wall Systems

Estimating the total seepage accumulation through a given wall system is challenging due to the many types of systems and the lack of available testing information for each type. However, in 2011, Oak Ridge National Laboratory (ORNL) tested 11 common wall assemblies under a simulated hydrostatic load for a 3-foot water depth to measure seepage when exposed to flooding over a 24-hour period. SERRI [Southeast Region Research Initiative] Report 80024-01, *Floodproof Construction: Working for Coastal Communities*, describes the test methodology and measured seepage accumulation for the 11 wall assemblies (ORNL, 2011).

The wall systems considered in the SERRI study included concrete masonry unit blocks with sprayed- and sheet-applied water-resistive membranes, insulated concrete formwork, and metal structural insulated panels. Designers should review the SERRI report to determine whether one of the tested wall systems could be considered similar enough to the wall system under consideration. If the wall systems are similar enough, the measured seepage accumulation results documented in the SERRI report could be used to derive approximate seepage values over a 24 hour period. Appendix B of this Technical Bulletin provides an example that illustrates the use of the SERRI results to estimate the seepage rate through a wall system to determine whether the dry floodproofed space is substantially impermeable.

The total seepage through a given wall system can be estimated by applying seepage rates to the area of wall exposed to floodwater. When using the SERRI report, the designer should recognize that the amount of seepage accumulation recorded in the study may not be fully representative of actual seepage volumes when there are differences in construction materials and methods from those described in the study and when flood conditions differ, such as flood depths other than 3 feet. When greater precision of wall seepage rates is desired, it may be necessary to construct a mockup for a particular wall assembly to test under hydrostatic load to measure seepage rates.

For an example calculation of seepage through walls, see Steps 1a and 1b in Appendix B.

6.8.2 Step 8B: Estimate Seepage through Joints and Penetrations

Various joints and gaps around utility penetrations are typically present in below-grade foundation systems and, in particular, the joints between foundations and lowest slabs. Because of the difficulty of sealing the joint between the exterior wall and slab, this joint is the most prone to allowing seepage into dry floodproofed areas (see Figure 7). In new construction, designers should specify and detail waterstops or joint seals that can resist the anticipated hydrostatic pressures.

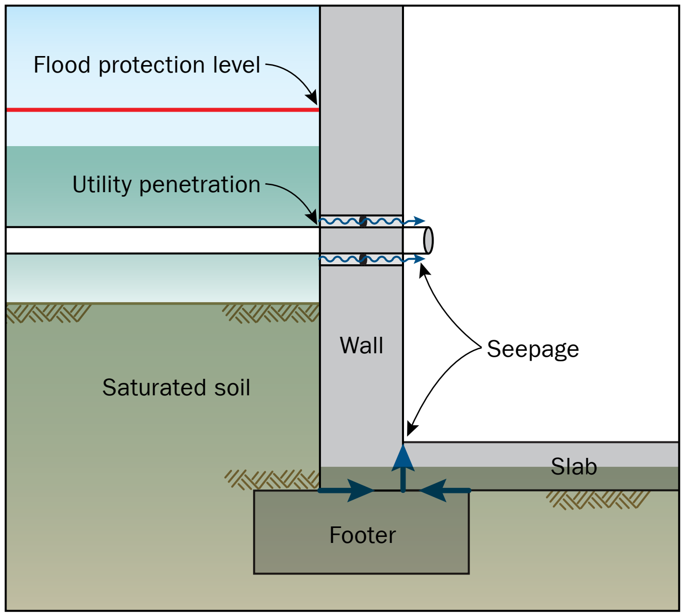

Figure 7: Typical seepage paths for water entering through joints between wall, footer, and slab

A common approach for existing buildings is to inject chemical grout into joints, wall penetrations, and cracks. The grout reacts with water and expands to form watertight, flexible seals. When determining whether this method is appropriate for expansion joints, the designer should evaluate whether the chemical grout would allow the joints to perform as intended. Alternative sealing products use a flexible material that fills the space between the utility penetration and the wall when fasteners are tightened. If known cracks or joints are not sealed, the designer will need to take these seepage sources into account when determining total seepage in a 24-hour period.

During the design of floodproofing systems for new buildings and when assessing the condition of existing buildings, designers should identify all joints and penetrations in the walls and slabs. Seepage through joints and penetrations must be estimated. An example of the calculation of seepage through expansion joints is shown in Appendix B. Manufacturers of some of the materials that are used to seal expansion joints and other penetrations may provide information that can be used to estimate seepage rates. When seepage rates under flood conditions are not provided or deemed inadequate for the purpose of dry floodproofing, designers may decide that it is necessary to perform mock-up testing of joints or penetration assemblies using the anticipated hydrostatic pressures.

For an example calculation of seepage through expansion joints, see Step 2 in Appendix B.

6.8.3 Step 8C: Estimate Seepage around Flood Shields

When flood shields are included in dry floodproofing systems, designers need to estimate the expected seepage around the wetted perimeter of each shield, which typically has a gasket that seals the shield to the building walls, frames around openings, or foundations. The amount of seepage depends on several factors, including the duration of flooding and integrity of the seal which, in turn, depends on maintenance and installation. Designers may need to adjust the initial designs, reduce the number of flood shields, or specify a different types of flood shield if the calculations indicate that the seepage will exceed the total allowed accumulation of seepage (4 inches over a 24-hour period).

GASKET AND SEAL MAINTENANCE: CRITICAL FOR PERFORMANCE

Post-disaster assessments have indicated that poorly maintained shield gaskets and seals are a common source of excessive water leakage. This situation can occur when gaskets and seals deteriorate due to weather or dry rot or are torn during handling or storage and are not replaced.

Manufacturers of various types of flood shields with gaskets and seals have tested some products under hydrostatic load to measure seepage rates (see Section 3.3 of this Technical Bulletin). Testing information should be obtained from manufacturers to estimate the volume of seepage, which may be provided as gallons per hour per linear foot of wetted perimeter.

For an example calculation of seepage around flood shields, see Step 3 in Appendix B.

6.8.4 Step 8D: Estimate Total Seepage through Waterproofing System

After estimates of seepage through wall systems, through joints and penetrations, and around flood shields are calculated, the total seepage can be estimated. For buildings to be certified as meeting the substantially impermeable requirement, the maximum accumulation in the dry floodproofed portion of the buildings must not exceed 4 inches of water depth over a 24-hour period without relying on devices for removal of water. If the total seepage estimate exceeds the 24-hour limit, the designer must adjust the design and selected components as necessary to satisfy the accumulation limit. Although sump pumps are required to handle seepage (see Step 9), sump pumps cannot be relied on to meet the maximum accumulation limit of 4 inches over a 24-hour period.

For an example calculation estimating total seepage, see Step 4 in Appendix B.

6.9 Step 9: Design Interior Drainage

Most spaces below the flood protection level of dry floodproofed buildings will not stay completely dry during flood events. Therefore, interior drainage systems should be designed to limit the accumulation of seepage. Designs must specify the paths along which seepage will flow and collect and where drains and sumps will be installed. ASCE 24 requires the use of sump pumps to remove water accumulation due to any passage of vapor and seepage of water during flooding events, described in Step 8.

If a building loses power, backup power fails to work properly, or sump pumps fail to operate, significant amounts of seepage could accumulate. For this reason, sump pumps cannot be relied on as the sole or primary means of meeting the dry floodproofing requirements. Sump pumps should only be relied on to address minor seepage and leaks that were not properly identified during condition assessments of existing buildings.

Sump pumps should be located at the point of lowest slab elevation, with the bottom of sump pits positioned well below the bottom of base slabs. A typical sump pump detail is shown in Figure 8. In large below-grade areas, it is common practice to install piping in gravel-filled trenches below the base slab at the perimeter of the foundation

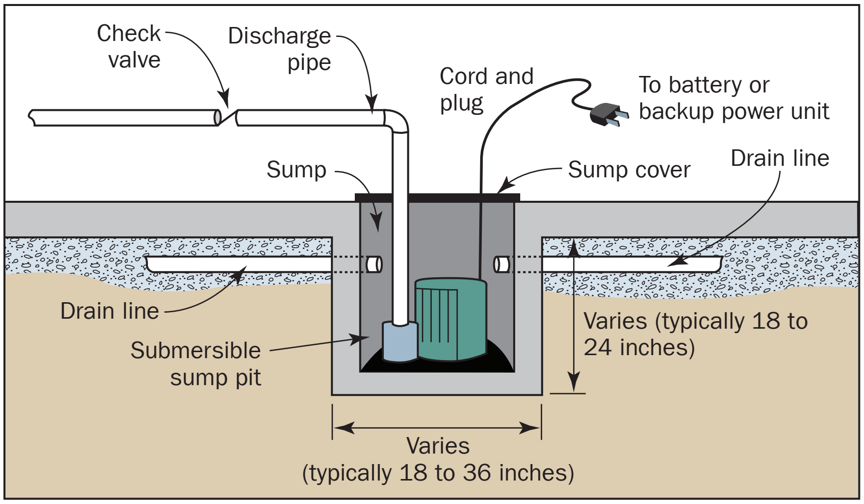

Figure 8: Typical sump pump detail

walls to provide a path for groundwater to access one or more sump pumps. A quickly rising water table or saturation from surface water, which occurs in many flood conditions, can produce enough seepage to overwhelm sump pumps if seepage rates into dry floodproofed spaces are high. Backup or emergency power for sump pumps is necessary due to the potential for power outages during flood events.

To select a sump pump as part of a dry floodproofing system, the designer should consider the advantages of each pump type and make the selection based on the estimate of total seepage rate (Step 8), pump capacity (gallons per minute), pump head, and electrical power required to operate the pump.

6.10 Step 10: Certify the Design and Satisfy Requirements for Plans

The final step in the dry floodproofing design process is for registered professional engineers or architects to certify designs. FEMA Form 086-0-34, NFIP Floodproofing Certificate for Non-Residential Structures, is used by most communities to meet the NFIP requirement that communities obtain certifications for dry floodproofing designs. See Section 1.2 of this Technical Bulletin for additional information on the certificate and Appendix A for instructions on completing the certificate.

REQUIRED DOCUMENTS FOR NFIP FLOOD INSURANCE POLICIES FOR DRY FLOODPROOFED BUILDINGS

When building owners apply for NFIP flood insurance policies for a dry floodproofed building, the NFIP requires a signed and sealed NFIP Floodproofing Certificate, flood emergency operations plan, and inspection and maintenance plan.

When human intervention is required to implement any component of dry floodproofing systems, ASCE 24 requires designers to meet specific requirements related to flood warning time (see Section 5.2 of this Technical Bulletin), flood shield design (Step 7, above), and flood emergency operations plans (see Section 5.5 of this Technical Bulletin). These requirements are also discussed in FEMA P-936. When dry floodproofing system designs are complete, designers should verify that flood emergency operations plans address all required elements and should review the plans with building owners.

Inspection and maintenance plans, described in Section 5.5 of this Technical Bulletin, are necessary for the long-term functioning of dry floodproofing systems. When dry floodproofing system designs are complete, designers should verify that inspection and maintenance plans address all required elements and should review the plans with building owners.

7 References

This section lists references cited in the Technical Bulletin. Additional resources related to NFIP requirements are provided in Technical Bulletin 0.

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- Technical Bulletin 0, *User's Guide to Technical Bulletins*
- Technical Bulletin 1, *Requirements for Flood Openings in Foundation Walls and Walls of Enclosures*
- Technical Bulletin 2, *Flood Damage-Resistant Materials Requirements*
- Technical Bulletin 6, *Requirements for Dry Floodproofed Below-Grade Parking Areas Under Non-Residential and Mixed-Use Buildings*
- Technical Bulletin 7, *Wet Floodproofing Requirements*

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Appendix A: FEMA Form 086-0-34, National Flood Insurance Program Floodproofing Certificate for Non-Residential Structures

Appendix A of the National Flood Insurance Program's Technical Bulletin 3, *Requirements for the Design and Certification of Dry Floodproofed Non-Residential and Mixed-Use Buildings*, includes guidance on completing FEMA Form 086-0-34, National Flood Insurance Program Floodproofing Certificate for Non Residential Structures. Communities that participate in the National Flood Insurance Program (NFIP) must require that designs for dry floodproofing be certified by a registered professional engineer or architect. The registered design professional must develop or review the structural designs, specifications, and plans for the construction of dry floodproofed buildings and must certify that the designs and methods of construction are in accordance with accepted standards of practice for achieving the required performance. Communities must maintain the certifications in their permanent records. These requirements are established in the Floodplain Management Criteria section of Title 44 Code of Federal Regulations (CFR) §§ 60.3(c)(3) and (4).

The following instructions are based on the NFIP Floodproofing Certificate that was issued in Dec. 2019, and that is scheduled to expire on Nov. 30, 2022. Design professionals must use the current NFIP Floodproofing Certificate or an equivalent statement to comply with the requirement.

TOP OF THE FORM

FLOODPROOFING CERTIFICATE FOR NON-RESIDENTIAL STRUCTURES

The floodproofing of non-residential buildings may be permitted as an alternative to elevating to or above the Base Flood Elevation; however, a floodproofing design certification is required. This form is to be used for that certification. Floodproofing of a residential building does not alter a community's floodplain management elevation requirements or affect the insurance rating unless the community has been issued an exception by FEMA to allow floodproofed residential basements. The permitting of a floodproofed residential basement requires a separate certification specifying that the design complies with the local floodplain management ordinance.

BUILDING OWNER'S NAME **A**		**FOR INSURANCE COMPANY USE** POLICY NUMBER
STREET ADDRESS (Including Apt., Unit, Suite, and/or Bldg. Number) OR P.O. ROUTE AND BOX NUMBER		COMPANY NAIC NUMBER
OTHER DESCRIPTION (Lot and Block Numbers, etc.)		
CITY	STATE	Zip Code

Instructions:

A Enter the building owner's name and the address of the building.

SECTION I

SECTION I – FLOOD INSURANCE RATE MAP (FIRM) INFORMATION					
Provide the following from the proper FIRM:					
COMMUNITY NUMBER	PANEL NUMBER	SUFFIX	DATE OF FIRM INDEX	FIRM ZONE	BASE FLOOD ELEVATION (in AO Zones, Use Depth)
B					C
D Indicate elevation datum used for Base Flood Elevation shown above: ☐ NGVD 1929 ☐ NAVD 1988 ☐ Other/Source:					

Instructions:

B Enter the following information from the Flood Insurance Rate Map (FIRM) and Map Index:

- Community Number – Six-digit identification number assigned to the community (also referred to as the community identification number or CID). Shown in the title block of the FIRM (see Figure A-1).
- Panel Number and Suffix –Identification of the FIRM panel that includes the subject property, shown in the title block of the FIRM (see Figure A-1).
- Date of FIRM Index – Most recent revision date for the community's FIRMs is the date on the FIRM Map Index, which may or may not be the date on the FIRM panel for the property (see Figure A-2).
- FIRM zone – The flood zone in which the building is located, obtained from the FIRM.

C Enter the base flood elevation (BFE) at the location of the building. Special Flood Hazard Areas (SFHAs) identified as Zone AO do not have BFEs; instead, a depth number may be shown (use depth of 2 feet if no depth number is shown).

D Select the elevation datum used for the BFE. The vertical datum is shown on the FIRM map legend or in "Notes to Users" on the FIRM.

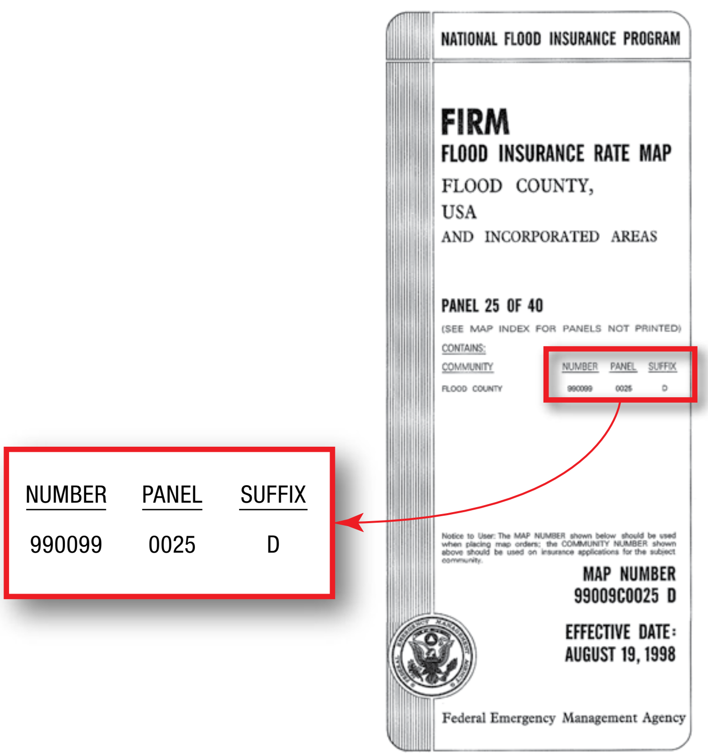

Figure A-1: Typical FIRM title block

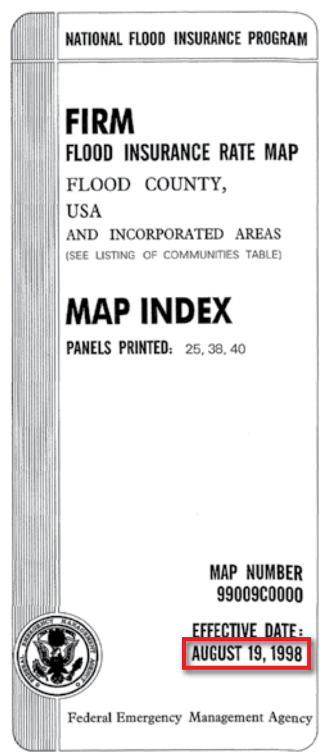

Figure A-2: Typical FIRM map index

SECTION II

Section II is used to certify the elevation (where BFEs are provided on FIRMs) or the height above the lowest adjacent grade (where BFEs are not provided) to which the building is floodproofed. Section II is to be signed and sealed by a land surveyor, engineer, or architect authorized by law to certify elevation information. Persons who sign and seal elevation information must be licensed or authorized to practice surveying in the state where projects are located.

SECTION II – FLOODPROOFED ELEVATION CERTIFICATION (By a Registered Professional Land Surveyor, Engineer, or Architect)

All elevations must be based on finished construction.

Floodproofing Elevation Information:

Building is floodproofed to an elevation of **E** . feet (In Puerto Rico only: . meters).

F ☐ NGVD 1929 ☐ NAVD 1988 ☐ Other/Source:

(Elevation datum used must be the same as that used for the Base Flood Elevation.)

Height of floodproofing on the building above the lowest adjacent grade is **G** feet (In Puerto Rico only: meters).

For Unnumbered A Zones Only:

Highest adjacent (finished) grade next to the building (HAG) **H** . feet (In Puerto Rico only: . meters).

I ☐ NGVD 1929 ☐ NAVD 1988 ☐ Other/Source:

(NOTE: For insurance rating purposes, the building's floodproofed design elevation must be at least 1 foot above the Base Flood Elevation to receive rating credit. If the building is floodproofed only to the Base Flood Elevation, then the building's insurance rating will result in a higher premium. See the Instructions section for information on documentation that must accompany this certificate if being submitted for flood insurance rating purposes.)

Instructions:

E Enter the floodproofing elevation in whole and decimal units. The floodproofing elevation is the top of the floodproofing measures ("height of floodproofing").

The floodproofing elevation must be referenced to the same vertical datum as the BFE identified in Section I.

F Enter the vertical datum the floodproofing elevation is referenced to (NGVD 1929, NAVD 1988, or a locally adopted vertical datum). For a locally used vertical datum, check "Other/Source" and describe the datum and provide the source.

G Enter the height of the floodproofing measures above the lowest adjacent grade. The lowest adjacent grade is the lowest ground next to the building.

H For unnumbered A Zones, enter the elevation of the highest finished grade adjacent (HAG) next to the building.

I Enter the vertical datum the HAG is referenced to (NGVD 1929, NAVD 1988, or a locally adopted vertical datum). For a local vertical datum, check "Other/Source" and describe the datum and provide the source.

SECTION II (cont.)

FLOODPROOFING CERTIFICATE FOR NON-RESIDENTIAL STRUCTURES

Non-Residential Floodproofed Elevation Information Certification:

Section II certification is to be signed and sealed by a land surveyor, engineer, or architect authorized by law to certify elevation information

I certify that the information in Section II on this Certificate represents a true and accurate interpretation and determination by the undersigned using the available information and data. I understand that any false statement may be punishable by fine or imprisonment under 18 U.S. Code, Section 1001.

CERTIFIER'S NAME J	LICENSE NUMBER (or Affix Seal)			PLACE SEAL HERE
TITLE	COMPANY NAME			
ADDRESS	CITY	STATE	ZIP CODE	
SIGNATURE	DATE	PHONE		

Instructions:

J Enter the name, license number, title, company name, and address and phone number of the individual completing Section II. Section II is to be completed (signed, dated, and sealed) by a land surveyor, engineer, or architect authorized by law to certify floodproofed elevation information.

SECTION III

Section III is used by a registered professional engineer or architect to certify that "the structure, based upon development and/or review of the design, specifications, as-build drawings for construction and physical inspection" has been designed and constructed in accordance with "the accepted standards of practice (ASCE 24-05, ASCE 24-14, or their equivalent) and any alterations [of the structure]" meet those standards, are watertight and substantially impermeable and will perform in accordance with 44 CFR § 60.3(c)(3). The designer also certifies the structure has structural components that are "capable of resisting hydrostatic and hydrodynamic flood forces, including the effects of buoyancy, and anticipated debris impact forces."

SECTION III – FLOODPROOFED CERTIFICATION (By a Registered Professional Engineer or Architect)

Non-Residential Floodproofed Construction Certification:

K

I certify the structure, based upon development and/or review of the design, specifications, as-built drawings for construction and physical inspection, has been designed and constructed in accordance with the accepted standards of practice (ASCE 24-05, ASCE 24-14 or their equivalent) and any alterations also meet those standards and the following provisions.

The structure, together with attendant utilities and sanitary facilities is watertight to the floodproofed design elevation indicated above, is substantially impermeable to the passage of water, and shall perform in accordance with the 44 Code of Federal Regulations (44 CFR 60.3(c)(3).

All structural components are capable of resisting hydrostatic and hydrodynamic flood forces, including the effects of buoyancy, and anticipated debris impact forces.

I certify that the information in Section III on this certificate represents a true and accurate determination by the undersigned using the available information and data. I understand that any false statement may be punishable by fine or imprisonment under 18 U.S. Code, Section 1001.

CERTIFIER'S NAME L	LICENSE NUMBER (or Affix Seal)			PLACE SEAL HERE
TITLE	COMPANY NAME			
ADDRESS	CITY	STATE	ZIP CODE	
SIGNATURE	DATE	PHONE		

Instructions:

K The signer of Section III certifies that floodproofing has been designed and constructed to meet accepted standards of practice. Accepted standards of practice must ensure that the criteria of the 2005 or 2014 editions of ASCE 24, *Flood Resistant Design and Construction* (or the equivalent), are met and that the two specific design statements are valid.

ASCE 24 contains several criteria for dry floodproofing. Design professionals who prepare designs for dry floodproofed buildings and certify NFIP Floodproofing Certificates should review all ASCE 24 criteria before completing and signing the certificate. Also see Technical Bulletin 3 and FEMA P-936, *Floodproofing Non-Residential Buildings*.

L Enter the name, license number, title, company name, and address and phone number of the individual completing Section III. Section III is to be completed (signed, dated, and sealed) by a registered professional engineer or architect authorized by law to certify structural designs.

END OF THE FORM

The end of the NFIP Floodproofing Certificate lists information that must be attached. The information is needed by the program's underwriters to provide credit for floodproofing. The information also helps to ensure compliance and provide reasonable assurance that due diligence has been applied in designing and constructing floodproofing measures. When the Floodproofing Certificate is used to obtain flood insurance coverage from the NFIP, building owners should consult with flood insurance providers to determine additional required documentation described in the *National Flood Insurance Program Flood Insurance Manual* (FEMA, 2020b).

FLOODPROOFING CERTIFICATE FOR NON-RESIDENTIAL STRUCTURES

Instructions for Completing the Floodproofing Certificate for Non-Residential Structures

To receive credit for floodproofing, a completed Floodproofing Certificate for Non-Residential Structures is required for non-residential and business buildings in the Regular Program communities, located in zones A1–A30, AE, AR, AR Dual, AO, AH, and A with BFE.

M In order to ensure compliance and provide reasonable assurance that due diligence had been applied in designing and constructing floodproofing measures, the following information must be provided with the completed Floodproofing Certificate:

- Photographs of shields, gates, barriers, or components designed to provide floodproofing protection to the structure.
- Written certification that all portions of the structure below the BFE that will render it watertight or substantially impermeable to the passage of water and must perform in accordance with Title 44 Code of Federal Regulations (44 CFR 60.3 (c)(3)).
- A comprehensive Maintenance Plan for the entire structure to include but not limited to:
    - Exterior envelope of the structure
    - All penetrations to the exterior of the structure
    - All shields, gates, barriers, or components designed to provide floodproofing protection to the structure
    - All seals or gaskets for shields, gates, barriers, or components
    - Location of all shields, gates, barriers, and components as well as all associated hardware, and any materials or specialized tools necessary to seal the structure.

Instructions:

M The additional information listed in the "Instructions for Completing the Floodproofing Certificate for Non-Residential Structures" at the end of the Floodproofing Certificate must be included.

Appendix B: Example Calculation for Estimating Total Seepage

Appendix B of the National Flood Insurance Program's Technical Bulletin 3, *Requirements for the Design and Certification of Dry Floodproofed Non-Residential and Mixed-Use Buildings*, contains an example calculation for estimating the total expected seepage into a dry floodproofed area. Total seepage is the combination of seepage through the wall system, seepage around flood shields (barriers), and seepage through joints and penetrations. A description of the calculation of seepage that is illustrated in this appendix is provided in the Technical Bulletin, Section 6.8, Step 8: Design Waterproofing System.

To be able to design and certify that a building is substantially impermeable, the design professional needs to estimate the total expected seepage into dry floodproofed areas. A dry floodproofed building that is made substantially impermeable through the use of materials and techniques allows limited accumulation of water to pass or seep through pathways (e.g., cracks, openings, channels) and points of entry during flooding. Water is allowed to accumulate to a depth of not more than 4 inches in a 24-hour period without relying on devices for removal of water.

The estimate of expected total seepage is used to determine whether the proposed dry floodproofing measures will meet the requirement (expected depth of accumulated water is not more than 4 inches). If the expected total seepage accumulation exceeds the maximum allowance, the designer must select one or more alternatives to meet the requirements, such as a different wall system, fewer openings that require flood shields, different types of shields, or relocating utility penetrations.

The example calculation in this appendix illustrates how to calculate seepage for an example building. To estimate the seepage through the wall system, the example applies the results of a seepage study by Oak Ridge National Laboratory, which were published in SERRI Report 80024-01, *Floodproof Construction: Working for Coastal Communities* (ORNL, 2011). The study tested a series of "pods" constructed of different materials using different methods by exposing them to 3 feet of water over more than 24 hours.

The wall system selected for the example calculation is identified in the SERRI report as "Test Pod H." Test Pod H was constructed of 8-inch concrete masonry unit (CMU) blocks with elastomeric weatherproofing membrane sprayed onto the exterior of the CMU block face. Excerpts from the SERRI report are included in this appendix, including a diagram of Test Pod H and observations from the flood simulation tests.

SERRI REPORT BASED ON 3-FOOT FLOOD DEPTH

It is important to note that the seepage accumulation in the SERRI report is based on a 3-foot flood depth (ORNL, 2011).

Designers should use caution when estimating total seepage rates for greater flood depths because the seepage rate may be higher because hydrostatic loads would be greater.

Calculation of Expected Seepage in an Example Building

Table B-1 and Calculation Steps 1 through 4 illustrate the calculation of the expected seepage for an example building with a wall system that is similar to the one used for Test Pod H in the SERRI report (CMU block with liquid membrane sprayed onto the exterior of the CMU face). Figure B-1 is the plan view of the example building.

Table B-1: Example Building Information

Description	Example Value	Notes
Flood depth Building length Building width	h = 3 feet L = 30 feet W = 40 feet	
Exterior doors Number Width	 n_{door} = 3 W_{door} = 6 feet	 Each door is 6 feet wide.
Length of joints in exterior wall through which seepage is expected	L_{EJ} = 48 feet	The assumption of 48 feet for the example building is based on the likely placement of expansion joints.

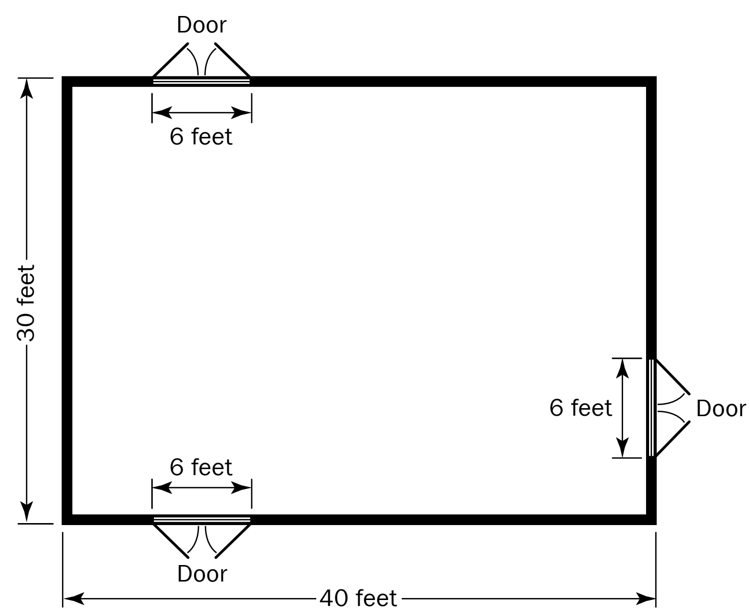

Figure B-1: Example building plan view

Calculation Step 1a. Estimate the seepage rate through the wall system.

This example uses the seepage rate through the wall system of Test Pod H from SERRI Report 80024-01. The seepage rate through the walls of Test Pod H is calculated using the volume of seepage that accumulated during a 24-hour period, divided by the area of the pod.

Area of test pod	$A_{pod} = 6\text{ ft} \times 6\text{ ft} = 36\text{ ft}^2$
Test pod wetted perimeter	$p_{pod\_w} = 6\text{ ft} + 6\text{ ft} + 6\text{ ft} + 6\text{ ft} = 24\text{ ft}$
Test pod wetted area (flood depth is 3 feet)	$A_{pod\_w} = 3\text{ ft} \times p_{pod\_w} = 72\text{ ft}^2$
Depth of water (inches) in test pod in 24 hours	$d_w = 15.5\text{ in} = 1.3\text{ ft}$ Note: Depth of water selected from the SERRI report, page A-5, Table A.2 (shown below)
Volume of seepage in test pod in 24 hours	$V_{pod\_s} = d_w \times A_{pod} = 46.8\text{ ft}^3$
Seepage rate through walls of test pod	$R_{wall} = V_{pod\_s} \div A_{pod\_w} = 0.65\text{ ft}^3/\text{ft}^2$ per 24 hours

Calculation Step 1b. Apply the estimated seepage rate to the example building to determine the volume of seepage through the walls of the example building in 24 hours

This example uses the seepage rate determined in Calculation Step 1 for the wall system of Test Pod H from the SERRI Report 80024-01.

Example building area	$A_{bldg} = L \times W = 1{,}200\text{ ft}^2$
Total width of doors	$L_{door} = n_{door} \times w_{door} = 18\text{ ft}$
Building wall wetted perimeter	$p_w = (2 \times L) + (2 \times W) - L_{door} = 122\text{ ft}$
Building wall wetted area	$A_{wall} = p_w \times h = 366\text{ ft}^2$
Seepage through wall system	$S_{wall} = A_{wall} \times R_{wall} = 238\text{ ft}^3$ per 24 hours

Calculation Step 2. Determine the volume of seepage around flood barriers (shields) installed over doors of the example building in 24 hours

Some manufacturers test flood shields and gaskets under varying conditions to determine seepage rates (see Section 3.3 in the Technical Bulletin). Seepage rates are often reported in the volume of seepage per length of gasket in a given period of time (ft^3/ft-hr or gal/ft-hr).

Door wetted length	$L_{door\_w} = n_{door} \times (h + h + w_{door}) = 36$ ft
Flood barrier (shield) seepage rate	$R_{FB} = 0.08$ gal/ft-hr $= 0.011$ ft^3/ft-hr Note: 0.08 gal/ft-hr is based on a manufacturer's technical specification. Designers must determine the actual rate based on specified flood shield(s).
Seepage through flood barriers (shields)	$S_{FB} = L_{door\_w} \times R_{FB} \times 24$ hr $= 10$ ft^3 per 24 hours

Calculation Step 3. Determine the seepage volume through expansion joints in the example building over 24 hours

Determination of the seepage rate through expansion joints may be difficult and may require more research than wall seepage estimates or flood shield gasket seepage rates. Some manufacturers may provide sufficient product information to allow the designer to estimate the amount of seepage through joint sealants under flood conditions. When seepage rates under flood conditions are not provided or are deemed inadequate for this purpose, designers may decide that it is necessary to perform mock-up testing of joints or penetration assemblies using the anticipated hydrostatic pressures (see Section 6, Step 8B, in the Technical Bulletin).

This example considers only seepage through expansion joints. Additional estimates must be made if there are penetrations and cracks below the flood protection level.

Seepage rate at expansion joints	$R_{EJ} = 0.80$ gal/ft-hr $= 0.107$ ft^3/ft-hr Note: 0.80 gal/ft-hr is based on testing of similar joint sealants. Designers must determine an appropriate seepage rate based on specified sealants.
Seepage through all expansion joints	$S_{EJ} = L_{EJ} \times R_{EJ} \times 24$ hr $= 123$ ft^3 per 24 hours

Calculation Step 4. Calculate the total estimated seepage for the example building

Seepage through walls, plus flood barriers (shields), plus expansion joints	$S_{Total} = S_{wall} \times S_{FB} + S_{EJ} = 371$ ft^3 per 24 hours
Depth of seepage per 24 hours	$d_{Seep} = S_{Total} \div A_{bldg} = 0.31$ feet or 3.72 inches per 24 hours

Conclusion

For the example building, the total estimated seepage is less than 4 inches in 24 hours, which means the example building meets the requirement to be considered substantially impermeable. The designer must also satisfy other requirements including determining where the seepage will accumulate and the paths along which seepage water will flow to get to the accumulation area. The interior drainage collection system must be designed to limit the accumulation of seepage (see Section 6, Step 9, of the Technical Bulletin).

4.2.8 Test Pod H: Weatherproofed Block

Test pod H: weatherproofed block (Fig. 4.15) was a CMU block structure with a liquid membrane sprayed onto the exterior of the CMU face.

- First course (8” in height) of CMU cells filled with mortar.
- Fully grouted CMU cells located at corners and at the middle of each wall.
- The flood resistive layer was an elastomeric waterproofing coating for masonry and concrete, applied in four thick coats.
- Design was developed as an inexpensive alternative to test pod A: sealed block which performed well with a high-end spray-applied water resistive layer.
- Elastomeric coating was applied with a residential sprayer.

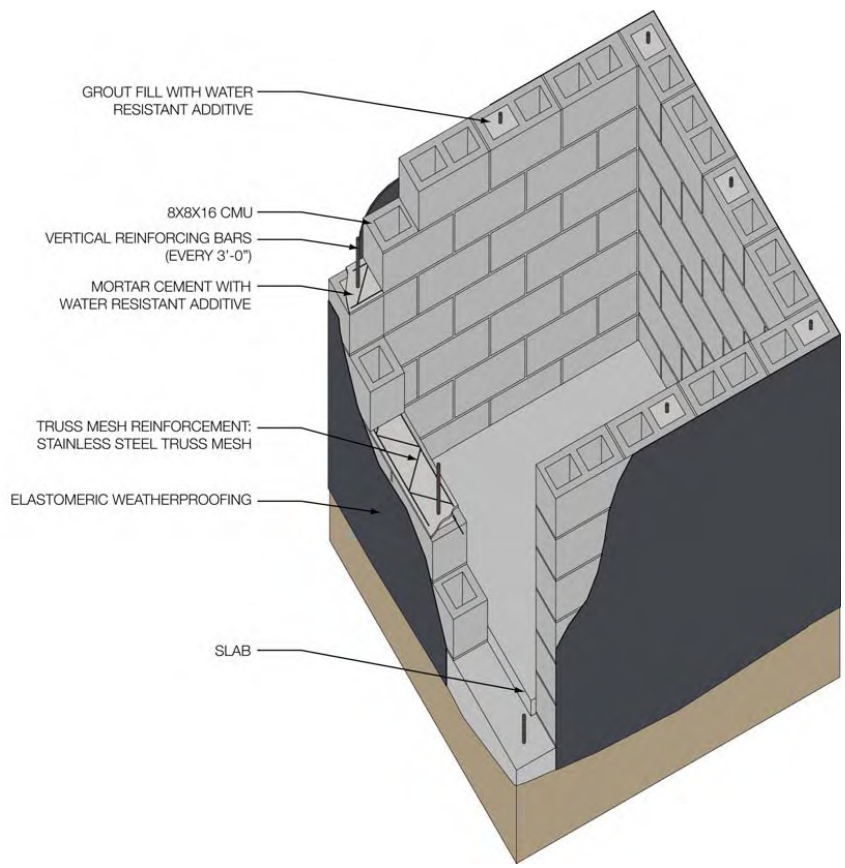

Fig. 4.15. DIAGRAM: test pod H: weatherproofed block.

A.2 Observations From Flood Simulation 2

Table A.2 is a log of the visual observations taken during flood simulation 1, which took place between June 28th, 2011 and June 29th, 2011. At specific time intervals, which are noted in the second column of this table, interior water depths were recorded for each test pod. Also, key observations regarding assembly changes are noted where applicable.

Table A.2. Observations from flood simulation 2.

Date	Time	Flooding Simulated Depth (in)	Test Pod G Interior Water Depth (in)	Test Pod H Interior Water Depth (in)	Test Pod A Interior Water Depth (in)	Test Pod B2 Interior Water Depth (in)	Test Pod D2 Interior Water Depth (in)	Test Pod F2 Interior Water Depth (in)
28-Jun	7:45 AM	0	0	0	0	0	0	0
	8:36 AM	10	*seepage south wall*	0	0	0	*seepage two corners*	*seepage two corners*
	8:50 AM	14	*more seepage, capillary action*	*seepage started*	0	0	*more seepeage*	*more seepage*
	9:45 AM	24	0	seepage	0	*seepage, early cells are seepaging more*	seepage	0.13
	10:45 AM	36	0.25	1.5	0	0.5	0.5	0.25
	11:45 AM	36	0.5	3.75	*corner seepage*	1.5	0.5	0.25
	12:45 PM	36	0.75	***6***	0	2.25	0.5	0.25
	1:45 PM	36	1	*6.5*	0	3	1	0.25
	2:45 PM	36	1	*8*	0	***4***	1.25	0.25
	3:45 PM	36	1.25	*9*	0	*5*	1.25	0.25
	5:45 PM	36	1.5	*10*	0	*7*	3	0.5
	7:45 PM	36	1.5	*12*	0.25	*8*	3	0.5
	9:45 PM	36	2.5	*12.5*	0.25	*9*	2.5	0.5
	11:45 PM	36	2.5	*14*	0.25	*10*	2.5	0.5
29-Jun	1:45 AM	36	3	*13.5*	0.25	*10*	3	0.5
	3:45 AM	36	3	*15*	0.25	*13.5*	3	0.5
	5:45 AM	36	3	*15.5*	0.25	*13.5*	3	0.5
	7:45 AM	36	3.5	*15.5*	0.25	*13.5*	3	0.5
	9:45 AM	36	3.5	*16*	0.25	*14*	3.5	0.5
	10:45 AM	36	3.75	*16.5*	0.25	*14.5*	3.75	0.5
	11:45 AM	31	3.75	*16.75*	0.25	*14.5*	3.75	0.5
	1:45 PM	12	3.75	*17*	0.25	*15.5*	3.75	0.5
	5:00 PM	0	**3.75**	*17*	**0.25**	*15.5*	**3.75**	**0.5**

Elevator Installation

for Buildings Located in Special Flood Hazard Areas in Accordance with the National Flood Insurance Program

NFIP Technical Bulletin 4 / June 2019

FEMA

Comments on the Technical Bulletins should be directed to:

DHS/FEMA
Federal Insurance and Mitigation Administration (FIMA) Risk Management Directorate
Building Science Branch
400 C Street, S.W., Sixth Floor
Washington, DC 20472-3020

NFIP Technical Bulletin 4 (2019) replaces NFIP Technical Bulletin 4 (2010) *Elevator Installation for Buildings Located in Special Flood Hazard Areas in accordance with the National Flood Insurance Program.*

Cover photograph: Looking down on a traction elevator system that sustained damage, including rusting and cab deterioration, from contact with floodwater.

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Revision History

May 2021 Made clarifying revisions to Sections 4.1 and 6.1 and Tables 3 and 4

Acronyms

ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
BFE	base flood elevation
CFR	Code of Federal Regulations
DHS	Department of Homeland Security
FEMA	Federal Emergency Management Agency
FIMA	Federal Insurance and Mitigation Administration
FIRM	Flood Insurance Rate Map
IBC	International Building Code®
ICC	International Code Council®
I-Codes	International Codes®
IRC	International Residential Code®
NEMA	National Electrical Manufacturers Association
NFIP	National Flood Insurance Program
NFPA	National Fire Protection Association
SEI	Structural Engineering Institute
SFHA	Special Flood Hazard Area
SFIP	Standard Flood Insurance Policy

1 Introduction

This Technical Bulletin provides guidance on the National Flood Insurance Program (NFIP) floodplain management requirements for installing elevators and associated equipment below the base flood elevation (BFE) in Special Flood Hazard Areas (SFHAs). This Technical Bulletin also discusses how the presence of elevators in buildings can affect flood insurance premiums.

Types of elevators and associated equipment are described, along with practical methods of protecting elevators from flood damage. Even when compliance is not required, application of these loss prevention measures can reduce the level of damage that can occur, the resultant repair costs, and the time elevators are out of service. If this guidance is followed, elevator service in buildings can be restored as quickly as possible once floodwater recedes and power is restored.

Questions about the NFIP floodplain management requirements pertaining to elevators should be directed to the appropriate local official, NFIP State Coordinating Office, or FEMA Regional Office.

NFIP TECHNICAL BULLETIN 0

NFIP Technical Bulletin 0, *User's Guide to Technical Bulletins,* should be used as a reference in conjunction with this Technical Bulletin. Technical Bulletin 0 describes the purpose and use of the Technical Bulletins, includes common concepts and terms, lists useful resources, and includes a crosswalk of the sections of the NFIP regulations identifying the Technical Bulletin that addresses each section of the regulations and a subject index.

Readers are cautioned that the definition of some of the terms that are used in the Technical Bulletins are not the same when used by the NFIP for the purpose of rating flood insurance policies.

2 NFIP Regulations

An important NFIP objective is protecting buildings constructed in SFHAs from damage caused by flood forces. The SFHA, composed of Zones A and V, is the areal extent of the base flood shown on Flood Insurance Rate Maps (FIRMs) prepared by FEMA. The base flood is the flood that has a 1 percent chance of being equaled or exceeded in any given year (commonly called the "100-year flood").

The NFIP floodplain management regulations include minimum building design criteria that apply to new construction and to improvements, alterations, and additions determined to be Substantial Improvements. The minimum criteria also apply to the repair of buildings determined to have incurred Substantial Damage. The NFIP regulations require the lowest floor (including basement) to be elevated to or above the BFE in new construction and for improvements determined to be Substantial Improvements (including

INCREASED USE OF ELEVATORS

Elevators have become more common in residential and nonresidential construction to facilitate access because of the requirements to elevate buildings and comply with the Americans with Disabilities Act of 1990.

repair of buildings determined to have incurred Substantial Damage). Non-residential buildings in Zone A must be elevated or dry floodproofed.

The NFIP regulations for utility systems, including elevator equipment, are codified in Title 44 of the Code of Federal Regulations (CFR) Part 60. Pertaining specifically to this Technical Bulletin, 44 CFR Section 60.3(a)(3) states that a community shall:

> Review all permit applications to determine whether proposed building sites will be reasonably safe from flooding. If a proposed building site is in a flood-prone area, all new construction and substantial improvements shall … (ii) be constructed with materials resistant to flood damage, (iii) be constructed by methods and practices that minimize flood damages, and (iv) be constructed with electrical, heating, ventilation, plumbing, and air conditioning equipment and other service facilities that are designed and/or located so as to prevent water from entering or accumulating within the components during conditions of flooding.

To comply with the NFIP regulations, measures must be taken to mitigate flood damage to service facilities, including elevators and associated equipment. Although in order to function, some components must be located below the lowest floor of an elevated building (i.e., below the BFE), most of the elevator components that are vulnerable to flooding can be located above the BFE or be designed so that flood damage is minimized.

NFIP REQUIREMENTS AND HIGHER REGULATORY STANDARDS

State and Local Requirements. State or local requirements that are more stringent than the minimum requirements of the NFIP take precedence. The Technical Bulletins and other FEMA publications provide guidance on the minimum requirements of the NFIP and describe best practices. Design professionals, builders, and property owners should contact local officials to determine whether more restrictive provisions apply to buildings or sites in question. All other applicable requirements of the State or local building codes must also be met for buildings in flood hazard areas.

Substantial Improvement and Substantial Damage. As part of issuing permits, local officials must review not only proposals for new construction but also for work on existing buildings to determine whether the work constitutes Substantial Improvement or repair of Substantial Damage. If the work is determined to constitute Substantial Improvement or repair of Substantial Damage, the buildings must be brought into compliance with NFIP requirements for new construction. Some communities modify the definitions of Substantial Improvements and/or Substantial Damage to be more restrictive than the NFIP minimum requirements. For more information on Substantial Improvement and Substantial Damage, see FEMA P-758, *Substantial Improvement/Substantial Damage Desk Reference* (2010), and FEMA 213, *Answers to Questions About Substantially Damaged/Substantially Damaged Buildings* (2018).

Higher Building Elevation Requirements. Some communities require that buildings be elevated above the NFIP minimum requirements. The additional elevation is called freeboard. Design professionals, builders, and property owners should check with local officials to determine whether a community has freeboard requirements. References to building elevations in this Technical Bulletin should be construed as references to the community's elevation requirement in areas where freeboard is required.

3 Other Regulations

In addition to complying with NFIP requirements, all new construction, Substantial Improvements, and repairs of Substantial Damage must comply with the applicable building codes and standards that have been adopted by States and communities.

The International Codes® (I-Codes®), published by the International Code Council® (ICC®) are a family of codes that include the International Residential Code® (IRC®), International Building Code® (IBC®), International Existing Building Code® (IEBC®), and codes that govern the installation of mechanical, plumbing, fuel gas service, and other aspects of building construction. FEMA has deemed that the latest published editions of the I-Codes meet or exceed NFIP requirements for buildings and structures. Excerpts of the flood provisions of the I-Codes are available on FEMA's Building Code Resource webpage (https://www.fema.gov/building-code-resources).

3.1 International Residential Code

The IRC applies to one- and two-family dwellings and townhomes not more than three stories above grade plane. IRC Section R321 requires that elevators comply with ASME A17.1/CSA B44, *Safety Code for Elevators and Escalators* (2016). The 2018 IRC requirements related to building utility and service equipment in dwellings in SFHAs (summarized in Table 1) are similar to, but generally exceed, NFIP requirements.

IRC COMMENTARY

ICC publishes companion commentary for the IRC. Although not regulatory, the commentary provides guidance that is useful in complying with, interpreting, and enforcing the requirements of the code.

Table 1. Comparison of Select 2018 IRC and NFIP Requirements

Topic	Summary of Select 2018 IRC Requirements and Changes from 2015 and 2012 Editions	Comparison with NFIP Requirements
Mechanical, plumbing, and electrical systems	**Section R322.1.6 Protection of mechanical, plumbing and electrical systems.** Specifies that protection of electrical systems, equipment, and components; heating, ventilating, air conditioning; plumbing appliances and plumbing fixtures; duct systems; and other service equipment should be located at or above the elevations required for buildings based on flood zone. In addition: • Equipment and components replaced as part of Substantial Improvement must meet the same requirements as new construction. • Systems, fixtures, equipment, and components must not be mounted on or penetrate through walls intended to break away under flood loads. • An exception allows equipment and components below the required elevation if designed and installed to prevent water from entering or accumulating within the components and to resist flood loads. • Electrical wiring systems that conform to requirements for wet locations are permitted below the required elevation. Change from 2015 to 2018 IRC: No change. Change from 2012 to 2015 IRC: No change.	Exceeds NFIP 44 CFR § 60.3(a)(3) with more specificity: Elevation must be to at least the same height as the elevation requirement for dwellings, and limitations related to breakaway walls, acknowledge that minimum electric service may be appropriate (e.g., for light switches).

Table 1. Comparison of Select 2018 IRC and NFIP Requirements (concluded)

Topic	Summary of Select 2018 IRC Requirements and Changes from 2015 and 2012 Editions	Comparison with NFIP Requirements
General mechanical systems	**Section M1301.1.1 [General Mechanical System Requirements] Flood-resistant installation.** Requires mechanical appliances, equipment, and systems to be located and installed in accordance with Section R322.1.6. Change from 2015 to 2018 IRC: No change. Change from 2012 to 2015 IRC: No change.	Exceeds NFIP 44 CFR § 60.3(a)(3) with more specificity.

Used with permission from ICC.

3.2 International Building Code and ASCE 24

The flood provisions of the latest published editions of the IBC meet or exceed the NFIP requirements for buildings, largely through reference to the standard ASCE 24, *Flood Resistant Design and Construction*, developed by the American Society of Civil Engineers (ASCE). The IBC applies to all applicable buildings and structures. While primarily used for buildings and structures other than dwellings within the scope of the IRC, the IBC may be used to design dwellings. Current (2018) IBC and current ASCE 24 (ASCE 24-14 [2014]) requirements for buildings in SFHAs are summarized in Table 2.

IBC AND ASCE COMMENTARIES

ICC publishes companion commentary for the IBC and ASCE publishes companion commentary for ASCE 24. Although not regulatory, the commentaries provide information and guidance that are useful in complying with, interpreting, and enforcing requirements.

Table 2. Comparison of Select 2018 IBC and ASCE 24-14 Requirements with NFIP Requirements

Topic	Summary of Select 2018 IBC/ASCE 24-14 Requirements and Changes from 2015 and 2012/ASCE 24-05	Comparison with NFIP Requirements
General flood hazard area requirements	**2018 IBC, Section 1612.2 Design and construction.** Requires buildings and structures located in flood hazard areas to be designed and constructed in accordance with Chapter 5 of ASCE 7, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures,* and ASCE 24. Change from 2015 to 2018 IBC: Section renumbered from 1612.4 to 1612.2. Change from 2012 to 2015 IBC: Applies Coastal High Hazard Area requirements in Coastal A Zones, if delineated.	Exceeds NFIP 44 CFR § 60.3(a)(3) with more specificity.
Elevators	**2018 IBC, Chapter 30, Elevators and Conveying Systems, Section 3001.3 Referenced standards.** Specifies the standards that govern the design, construction, installation, alteration, repair, and maintenance of elevators and conveying systems and components. Among other standards cited is ASME A17.1, *Safety Code for Elevators and Escalators,* issued by the American Society of Mechanical Engineers. ASCE 24 is cited for construction in flood hazard areas. Change from 2015 to 2018 IBC: Section renumbered from 3001.2 to 3001.3 and referenced standards, other than ASCE 24, provided in Table 3001.3. Change from 2012 to 2015 IBC: ASME A17.7/CSA B44.7 and ANSI MH29.1 added to Section 3001.2.	Exceeds NFIP 44 CFR § 60.3(a)(3) with more specificity.

Table 2. Comparison of Select 2018 IBC and ASCE 24-14 Requirements with NFIP Requirements (concluded)

Topic	Summary of Select 2018 IBC/ASCE 24-14 Requirements and Changes from 2015 and 2012/ASCE 24-05	Comparison with NFIP Requirements
Elevators	**ASCE 24-14, Section 7.5 Elevators** • Elevator components must be located above the elevations required for buildings unless specifically permitted by this section. • Components below the required elevations must be composed of flood damage-resistant materials and capable of resisting physical damage due to flooding. • Hydraulic elevators are permitted below the required elevation, but electrical control panels, hydraulic pumps, and tanks must be elevated; drainage must be provided for the elevator pit; hydraulic lines, hydraulic cylinders, and buffer springs must be located to prevent physical damage due to flooding or painted or coated with galvanic or rust-preventive paint. • Traction elevator systems must have elevated machine rooms, and components in hoistways below the required elevation must be protected from physical damage due to flooding. • Elevators must be equipped with controls that prevent cabs from descending into floodwater. • Elevator shafts must resist flood loads. In Zone A, shafts are not required to have flood openings; in Zone V and Coastal A Zones, shafts are not required to have breakaway walls. Change from ASCE 24-05: Added subsection on elevator shafts.	Exceeds NFIP 44 CFR § 60.3(a)(3) with more specificity.

4 How Elevators Affect NFIP Flood Insurance Rates

NFIP floodplain management regulations restrict use of enclosed areas below the lowest elevated floor of elevated buildings to parking of vehicles, building access, and storage. Elevators, just as stairs and ramps, are permitted for building access. Although elevators and elevator shafts are covered by NFIP flood insurance policies, their presence in a building, their size, and their manner of construction are factors used by insurance underwriters to determine a building's flood insurance premium.

4.1 Elevator Shafts

The NFIP treats elevator shafts as enclosures for the purposes of determining flood insurance premiums. For buildings located in Zone A (all zones shown on FIRMs as Zones A, AE, A1 through A30, AR, AO, and AH), where elevator shafts are not designed to automatically equalize hydrostatic flood forces on its exterior walls, a premium loading is added to the standard flood insurance building rate. The amount of premium loading depends on the square footage of the elevator shaft and the depth of the shaft in relation to the BFE. However, no premium loading is added to the standard building rate if the elevator shaft is designed to automatically equalize hydrostatic flood forces on exterior walls by allowing the entry and exit of floodwater, is unfinished, and used only for building access, parking of vehicles, or storage.

FLOOD INSURANCE TERMINOLOGY AND RATING OF ELEVATOR PITS

The NFIP and Standard Flood Insurance Policy (SFIP) define a **basement** as “any area of the building, including any sunken room or sunken portion of a room, having its floor below ground level (subgrade) on all sides.” Additionally, the NFIP and SFIP define the **lowest floor** as “the lowest enclosed area (including a basement). An unfinished or flood-resistant enclosure, usable solely for parking of vehicles, building access, or storage in an area other than a basement area, is not considered a building’s lowest floor provided that such enclosure is not built so as to render the structure in violation of requirements.” The SFIP defines an **elevated building** as “a building that has no basement and that has its lowest floor raised above ground level by foundation walls, posts, piers, pilings, or columns.”

Elevator Pits. A building that has its lowest elevated floor raised above ground level by foundation walls, posts, piers, pilings, or columns where the only area below grade is an elevator pit is classified as an elevated building for insurance rating purposes, even if the bottom of the elevator pit is below grade on all sides. There is a premium surcharge for elevators in an SFHA if the elevator pit is below the BFE, whether the pit is below grade or not. For non-elevated buildings with any area below grade, including an elevator pit, the below-grade portions are classified as basements for flood insurance rating purposes. Floodplain management regulations do not consider elevator pits that are the minimum size necessary as to be basements if they are designed in accordance with the requirements of this Technical Bulletin (i.e., the elevator pit is the minimum size required for the elevator to function, has no finishes, and contains no equipment).

For buildings located in Zone V (all zones shown on FIRMs as Zone V, VE, and V1 through V30), elevator shafts with walls surrounding the elevator cab are always considered building obstructions. If the elevator shaft exceeds 300 square feet and has breakaway walls, then a premium loading factor is added to the overall flood insurance building rate with obstruction. The amount of the premium loading depends on the actual square footage of the elevator shaft, and the depth of the shaft in relation to the BFE. However, no premium loading is added to the standard building with obstruction rate if the elevator shaft is less than 300 square feet, made with breakaway walls, is unfinished, and used only for building access, parking of vehicles, or storage.

4.2 Elevator Cabs and Equipment

The NFIP provides coverage for elevator cabs and their related equipment as building property. However, the NFIP does not cover elevator-related equipment located below the lowest floor of elevated buildings constructed after the community joined the NFIP or installed below the BFE after September 30, 1987. A separate premium loading is added to the cab and any permanent machinery and equipment servicing an elevator in a building that extends below the BFE in Zone A or Zone V.

5 Types of Elevators

> **ASME A17.1 TERMINOLOGY**
>
> For consistency with ASME A17.1, the industry standard, this Technical Bulletin refers to elevators as residential and commercial.

Elevators are vertical transports that move people or materials between the floors or levels of a structure. All elevators have a cab or platform in a shaft; the cab or platform moves along rails and is powered by one or more motors. Some of the differences between elevator systems are related to how the cab or platform is transported between levels.

The two primary types of elevators used in residential and commercial buildings are hydraulic elevators and traction elevators. A key difference between them is that hydraulic elevators lift the elevator cab using one or more pistons while traction elevators lift the elevator cab using steel cables and a traction motor.

Other conveyance systems include pneumatic elevators, chairlifts, and platform lifts.

5.1 Hydraulic Elevators

A hydraulic elevator consists of a cab attached directly or indirectly to a hydraulic jack that consists of a direct-acting piston inside a cylinder. Hydraulic elevators can be direct-acting (holed) or holeless. In direct-acting hydraulic elevators, the hydraulic jack assembly extends below the lowest floor and into the ground below the pit area (Figure 1). In contrast, for holeless hydraulic elevators, cylinders are placed in the shaft sides and do not extend below the pit floor (Figure 2). Both types of hydraulic elevators are operated by a hydraulic pump and reservoir for hydraulic fluid, both of which are usually located in a room adjacent to the elevator shaft. Both types of hydraulic elevators are generally used in buildings with fewer than five or six floors, including dwellings.

Table 3 provides a summary of hydraulic elevator system components, their typical location, and strategies to protect them from flood damage.

Table 3. Hydraulic Elevator System Components, Locations, and Flood-Protection Strategies

Elevator Component	Typical Component Location	Flood Protection Strategy	
		Elevation Above BFE	Flood Damage-Resistant Component
Elevator Shaft	Entire vertical limit of building	No	Yes Below the BFE
Cab	Hoistway	Yes	Yes
Cylinder	Pit	No	No Use holeless (see Table 5)
Hydraulic Jack Assembly	Pit	No	No Use holeless (see Table 5)
Buffer Springs and Stand	Pit	No	No Paint or coat (see Table 6)
Machine/Equipment Room (Enclosure)	1st or 2nd level of building	Yes	Yes
Hydraulic Pump	Above BFE	Yes	Yes
Hydraulic Reservoir	Above BFE	Yes	Yes
Electrical Control Panel	Above BFE	Yes	No

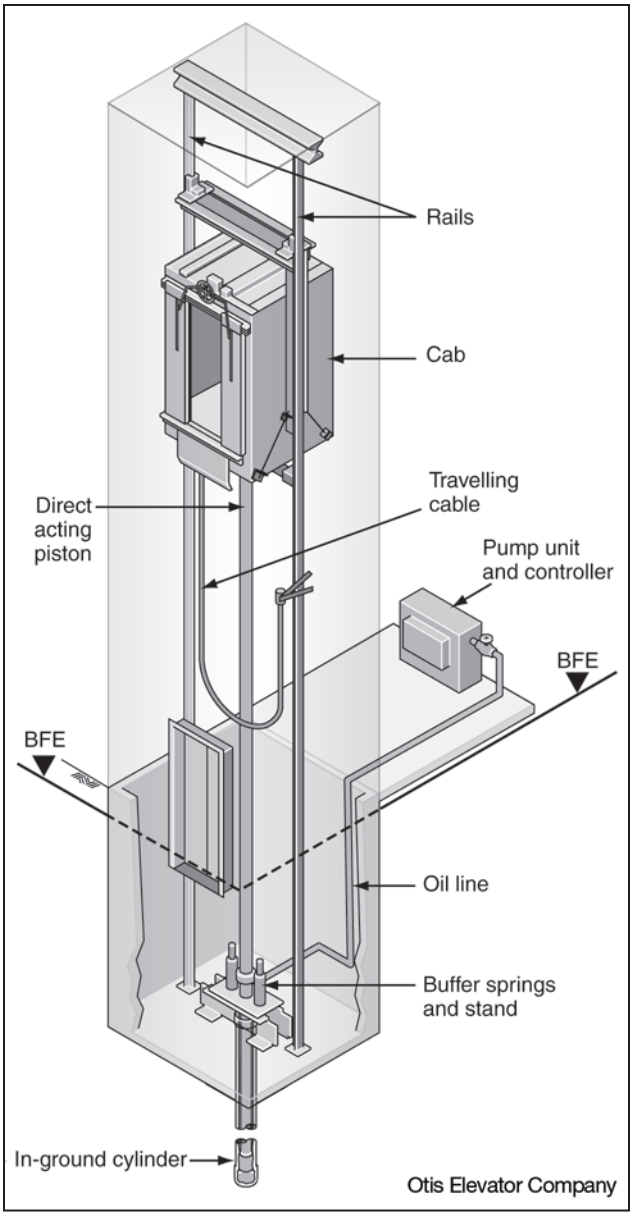

Figure 1. Direct-acting (holed) hydraulic elevator

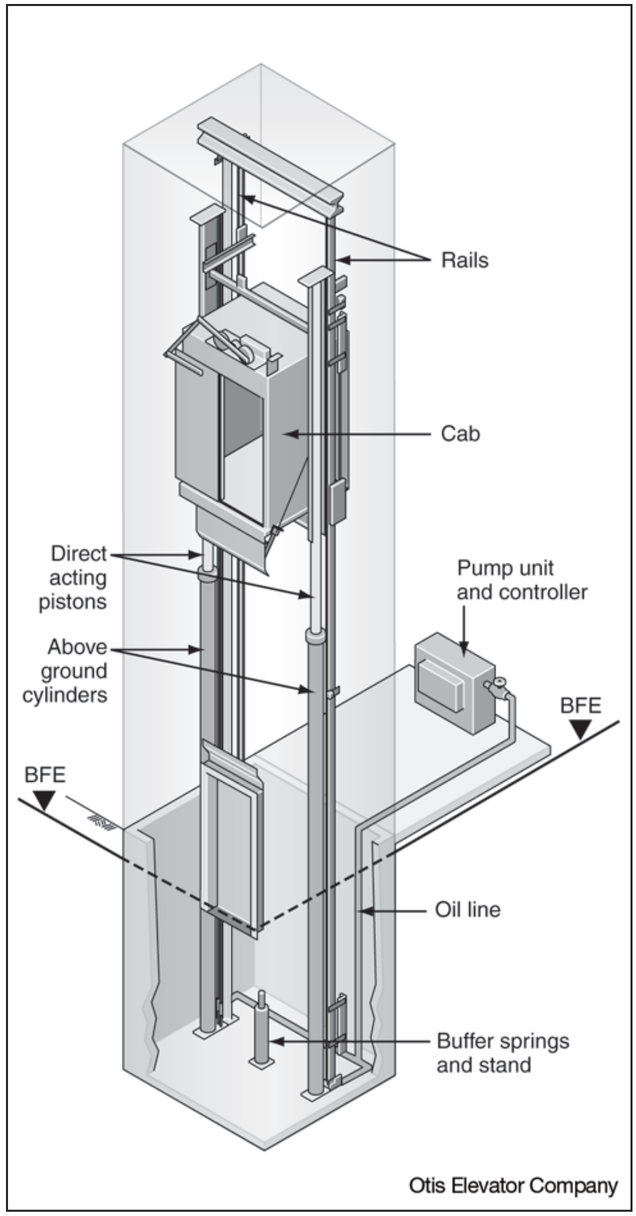

Figure 2. Holeless hydraulic elevator

5.2 Traction Elevators

Traditional geared traction elevator systems consist of cables connected to the top of the cab operated by an electric motor located in a penthouse above the elevator shaft, as shown in Figure 3. Traction elevators may be geared or gearless depending on building height, speed requirements, and cost considerations. Geared traction elevators are typically used for small low-rise structures, while more expensive gearless traction elevators tend to be used for larger high-rise structures, where speed is

LOW-RISE AND HIGH-RISE

For purposes of this Technical Bulletin, "low-rise" refers to dwellings within the scope of the IRC (one- and two-family homes and townhomes not more than three stories above grade plane) and other structures with a mean roof height of less than 75 feet. "High-rise" refers to structures with a mean roof height of 75 feet or more.

more critical. Machine room-less traction elevators employ a similar mechanical arrangement to geared traction elevators, with the machinery located in the elevator shaft at the top of the hoistway, as shown in Figure 4. Traction elevators are generally used in tall buildings.

Table 4 provides a summary of traction elevator system components, their typical location, and strategies to protect them from flood damage. Note that while nearly all traction elevator system components can be protected from flood damage, little can be done to protect governor cables, which typically must be replaced after flooding.

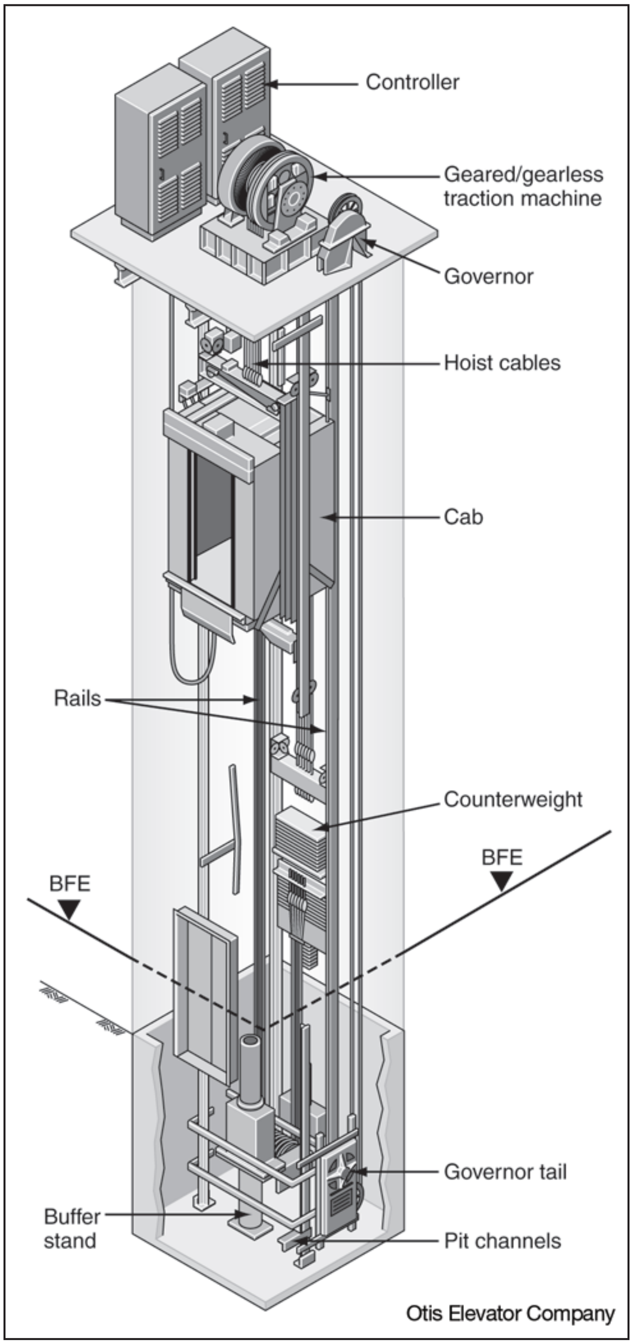

Figure 3. Traction elevator

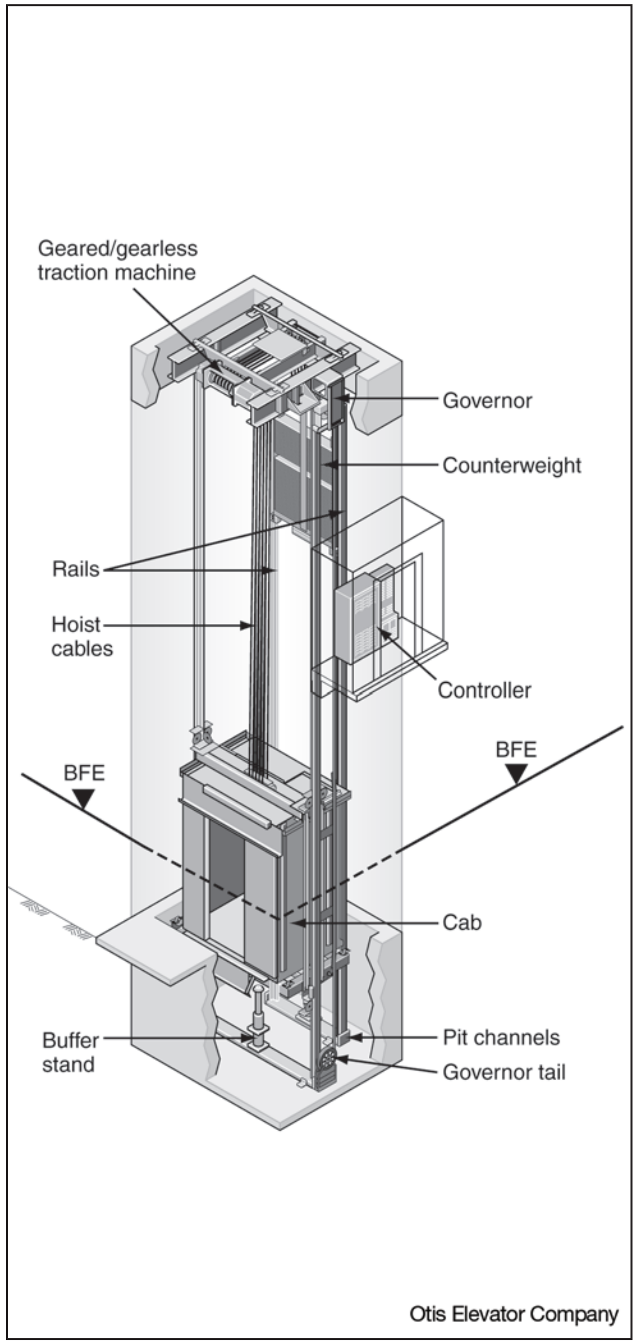

Figure 4. Machine room-less traction elevator

Table 4. Traction Elevator System Components, Locations, and Flood Protection Strategies

Elevator Component	Typical Component Location	Flood Protection Strategy	
		Elevation Above BFE	Flood Damage-Resistant Component
Elevator Shaft	Entire vertical limit of building	No	Yes Below the BFE
Cab	Hoistway	Yes	No
Counterweight and Roller Guides	Hoistway	Yes	No
Hoist Cable	Hoistway	Yes	No
Compensation Cables	Pit	No	Yes
Governor Cable	Pit	No	No
Buffers	Pit	No	No Paint or coat (see Table 6)
Limit Switches	Pit	Yes	No
Machine/Equipment Room (Enclosure)	Top of hoistway	Yes	No Replace with machine room-less
Electric Hoist Motor	Above BFE	Yes	No
Electrical Control Panel	Above BFE	Yes	No

5.3 Other Conveyance Mechanisms

In addition to hydraulic and traction elevators, other conveyance systems used include pneumatic elevators, chairlifts, and platform lifts.

Pneumatic elevators are small elevators with cabs controlled by a roof-mounted suction system. Pneumatic elevators are generally found in smaller buildings such as residences; they are not widely used in larger buildings because the cabs tend to be small. Other elevator types are roped hydraulic elevators and cable drum elevators, which are similar in function to the primary elevator types described in Sections 5.1 and 5.2.

ASCE 24 AND ELEVATORS

This section is based in part on the requirements of ASCE 24-14, Section 7.5, and the commentary that accompanies that section.

Chairlifts are conveyance mechanisms installed over or alongside a stairway to transport occupants between floors. Chairlifts are designed to operate both inside and outside of structures, while residential elevators are commonly placed inside if designed from the start, and outside the main structure footprint if the elevator is part of a renovation.

Platform lifts are designed to transport an individual in a wheelchair from one level to another. They are usually designed so that a wheelchair user can enter the lift on one side and exit on another (i.e., the lift has two doors).

6 Protecting Elevators from Flood Damage

This section describes measures to protect elevator components and equipment that are common to all elevator systems from flood damage, and specific guidance to protect hydraulic and traction elevators in accordance with NFIP regulations.

6.1 Elevator Shafts

Elevator shafts enclose the elevator cab and other equipment. Residential and commercial elevators, particularly those that are added as a post-construction retrofit, are usually installed in a shaft that is exterior to an original outside wall. Larger elevators are installed in shafts located in the interior of structures. In either case, elevator shafts must have landings, usually at the ground level, and cab platforms near the top of the shaft. Elevators that have a landing at the lower level almost always have pits below the BFE. Requirements for electrical service for sump pumps in elevator pits can be found in NFPA 70, *National Electrical Code* (2017).

The NFIP requires enclosed areas below elevated buildings in Zone A to have flood openings to minimize unequal hydrostatic loads (see NFIP Technical Bulletin 1, *Openings in Foundation Walls and Walls of Enclosures Below Elevated Buildings in Special Flood Hazard Areas)* and that walls that form enclosures below elevated buildings in Zone V be designed to break away under flood loads. However, elevator shafts that extend below the BFE are not required to include flood openings or breakaway walls because openings may conflict with fire safety protection or other code related requirements. Without openings or breakaway walls, the shafts may obstruct the flow of floodwater, impose more loads on building foundations, and are susceptible to damage from various flood forces, including erosion and scour. Even with breakaway walls, elevators extending below the BFE may be obstructions to the free passage of waves and water (see NFIP Technical Bulletin 5, *Free-of-Obstruction Requirements).*

ASCE 24: FLOOD OPENINGS IN BREAKAWAY WALLS AND ELEVATOR SHAFTS

ASCE 24-14 clarifies that flood openings are not required in elevator shafts, and in Coastal High Hazard Areas and Coastal A Zones, elevator shafts are not required to have breakaway walls.

ELEVATOR PITS

Although the NFIP defines a basement as any area below grade on all sides, elevator pits that are the minimum size necessary for the elevator to function are not considered to be basements. Elevator pits typically range between 4 and 5 feet deep for hydraulic elevators and between 6 and 8 feet deep for traction elevators. Additional information is contained in Section 4.

To minimize flood damage, elevator shafts must be designed to resist hydrostatic, hydrodynamic, and debris impact forces, as well as erosion, scour, and waves, particularly in Zone V. Foundation designs in both Zone A and Zone V should address potential flood loads acting on elevator shafts and elevator components and the resulting impacts on the building foundation and elevated structure. To reduce exposure of elevators to flood loads, elevator shafts can be located on the landward side of buildings in coastal areas and on the downstream side of buildings in riverine floodplains. Furthermore, designs for nearby or adjacent structural elements of the building should take into account the impacts of obstructed flow.

6.2 Elevator Equipment

Some equipment common to all elevators that extend below the BFE will be exposed to floodwater. The most obvious vulnerable component is the elevator cab. Depending on the size of the cab and the types of interior materials used, residential and commercial elevator cabs can be expensive to replace.

Flood damage-resistant materials can be used inside and outside the elevator cab to reduce flood damage (see NFIP Technical Bulletin 2, *Flood Damage-Resistant Materials Requirements for Buildings Located in Special Flood Hazard Areas*).

> **ASCE 24 AND EQUIPMENT**
>
> ASCE 24 requires electrical control panels, hydraulic pumps, and tanks to be located above the elevation required for buildings. ASCE 24 also requires drainage for elevator pits.

Cabs: Flood damage to cabs, which can range from superficial to significant, can be avoided by keeping cabs above floodwater when not in use. However, most elevator control systems automatically stop cabs upon loss of electrical power, which could result in a cab stopping below the BFE, making it vulnerable during flooding.

Float switches: Installing detection systems with one or more float switches in elevator shafts will prevent elevator cabs from descending into floodwater (Figure 5), providing a safer system while minimizing costly repairs or replacement. A float switch system or another system that provides the same level of safety is required, per ASME A17.1, for all elevators where there is a potential for the elevator cab to descend below the BFE during flood conditions.

Elevator equipment: Elevator equipment such as electrical controls and hydraulic pumps should be located above the BFE when possible. In some installations, it may be necessary to locate elevator equipment such as switches and controls below the BFE in the elevator pit. Some electrical equipment, such as electrical junction boxes and circuit and control panels, must be located at or above the elevation required for the building. Other elevator components, such as doors and pit switches, may be below that elevation. In these cases, damage can be minimized by using flood damage-resistant components or placing gear in water-resistant enclosures to reduce damage from floodwater.

Electrical equipment: Any electrical equipment installed in the hoistway below the BFE should be inside a National Electrical Manufacturers Association (NEMA) 4-rated enclosure for water resistance. Some elevator equipment manufacturers offer water-resistant components. Therefore, design professionals should contact suppliers to determine the availability of these components.

All elevator equipment and components should be maintained and tested in accordance with the manufacturer's requirements and maintenance schedules. This is especially true for safety components such as high-water sensors and switches and their associated alarms. If these elements are found to be inoperative or out of specified tolerances, the elevator should be repaired by a qualified technician.

> **ELEVATOR EQUIPMENT AND CORROSION IN COASTAL AREAS**
>
> In coastal areas, building equipment, connectors, and other metal parts are regularly corroded by air-borne salts. Some protection for elevator equipment can be provided by constructing a small foyer to enclose the area around the elevator door. The NFIP has requirements for such enclosures that are based on whether the flood zone is Zone A or Zone V. See Technical Bulletin 8, *Corrosion Protection for Metal Connectors and Fasteners in Coastal Areas,* for additional information on corrosion in coastal areas.

6.3 Fire Recall Switches and Backup Power

For safety reasons, commercial elevators are designed with “fire recall” circuitry, which sends elevators to a designated floor when fire alarms are activated so that emergency services personnel can use the elevators. However, during flooding, this feature may expose the cab and occupants directly to floodwater. ASME A17.1 requires that, for elevators in SFHAs, the designated floor must be located above the BFE. If an elevator is intended to serve areas that may be flooded, it should be equipped with a float switch system that will activate during flooding and send the elevator cab to a floor above the BFE (Figure 5).

Emergency power circuitry is provided for elevators when buildings have emergency generators. In general, when emergency power starts up, all elevator cars return to the designated floor, and then one car returns to normal operation. Emergency power generators are required for elevators in buildings of four or more stories but are not commonly found in low-rise buildings. If there is no emergency power, some hydraulic elevators can employ a battery descent feature. Upon power loss, batteries release the hydraulic controls, and the car descends to the lowest landing. If this feature is employed, care should be taken to integrate a float switch system into the operation of the controller to prevent the car from descending into floodwater.

If elevators have no emergency power operation or battery descent feature, upon loss of power the elevators will cease to function, resulting in possible entrapment or damage. Therefore, building owners should have emergency plans that provide for safe occupant evacuations, having elevator cabs move to upper floors (above the BFE) and shutting down power to the elevator machinery well before any flooding occurs.

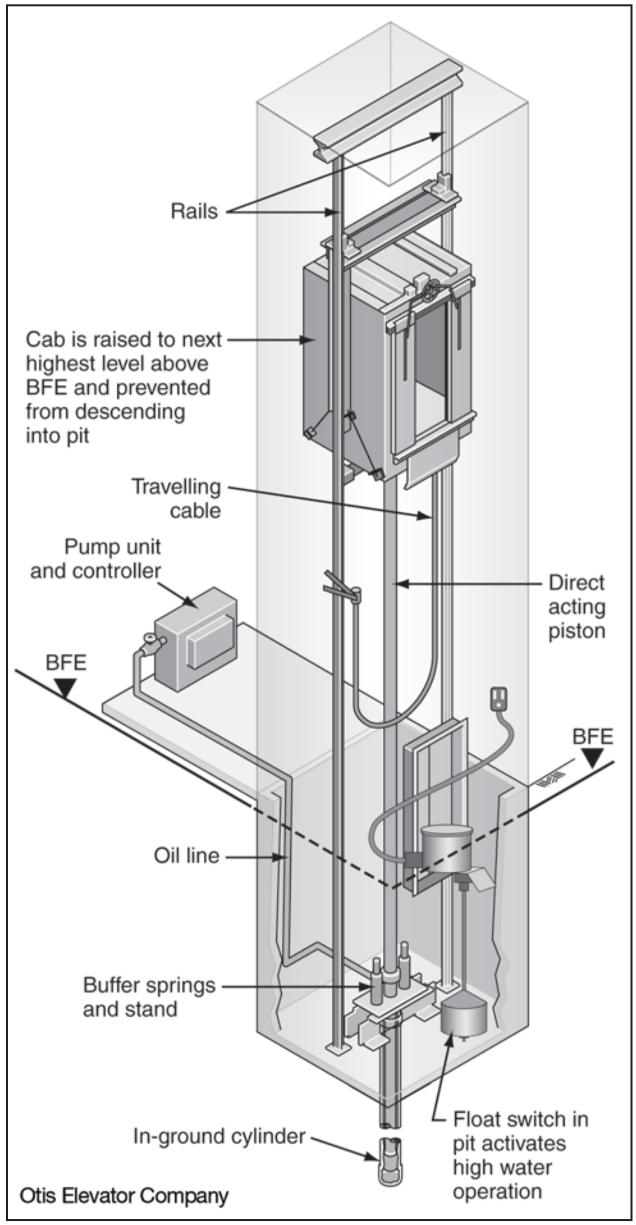

Figure 5. Float switch to control cab descent

6.4 Hydraulic Elevators

The hydraulic jack assembly for a direct-acting (holed) hydraulic elevator (Figure 1) will, by necessity, be located below the lowest floor and, therefore, likely below the BFE. The jack is located in a casing that can resist damage from small amounts of water seepage, although corrosive saline water is particularly damaging. However, total inundation by floodwater will usually result in contamination of the hydraulic fluid and possible damage to jack cylinders and seals. For this reason, holeless hydraulic elevators are recommended for low-rise buildings.

When hydraulic elevators are used, jacks should be installed inside the elevator shaft, with critical seals and components located above BFE as shown in Figure 2. Hydraulic pumps and fluid reservoirs should be located above the BFE. In addition, hydraulic lines connecting the assembly should be located where the lines are protected from physical damage or coated with galvanic or rust-preventive paint. Additional guidance based on post-disaster observations is included in Section 6.7.

6.5 Traction Elevators

Electric motors and most other traction elevator equipment used for traction elevators are normally located above the elevator shaft and are, therefore, not usually susceptible to flood damage (Figure 5). However, some equipment such as the counterweight roller guides, compensation cable assemblies, limit switches, selector tape, governor rope assemblies, and oil buffers are usually located at the bottom of the shaft. When these components cannot be located above the BFE, they must be constructed of flood damage-resistant materials where possible. Additional guidance based on post-disaster observations is included in Section 6.7.

While nearly all traction elevator system components can be protected from flood damage, little can be done to protect governor tail cables, which typically must be replaced after flooding.

6.6 Other Conveyance Mechanisms

Pneumatic elevators, chairlifts, and platform lifts are usually located inside buildings where the components of these systems can be located above the BFE to protect them from flood damage. However, when platform lifts are installed outdoors, it can be more difficult to elevate equipment above the BFE, making it susceptible to flood damage.

6.7 Mitigation Guidance Based on Post-Disaster Observations

The following guidance is based on observations made following Hurricane Katrina (2005), Hurricane Ike (2008), and Hurricane Sandy (2013). Some recommendations could apply to new installations, and some apply when building owners and managers consider retrofitting and replacing existing elevator systems.

Table 5. General Guidance

Topic	General Guidance	Comments
Holeless Hydraulics	For hydraulic elevators, explore hoistway conditions for the use of holeless hydraulics. Note that holeless hydraulic elevators are typically used in low-rise construction with only two or three floors.	—
Raised Elevators	In an effort to maintain the operational capacity of critical facilities with multiple elevators during flood events, consider installing one or more raised elevators with no components or floor stops below the BFE. Ramps can be provided to access the higher elevation. This will allow some of the building's vertical transportation systems to be isolated above the BFE, helping to ensure some access to upper levels. While FEMA recommends that people evacuate when authorities at State and local levels advise or mandate it, emergencies and disasters can create circumstances that require robust elevator systems to be operational before, during, and after flood events, such as with approved shelter-in-place plans.	—
Increased Resilience	Consider raising elevator mechanical, electrical, and other equipment vital to operations to levels above the BFE to reduce exposure when flooding is more severe than the base flood.	Refer to FEMA P-942, Recovery Advisory 4, *Reducing Interruptions to Mid- and High-Rise Buildings During Floods,* for details (2013)
Continuity of Operations	Consider sizing emergency generator capacity to enable critical elevator operations in accordance with recommendations from FEMA P-1019. In some situations, power serving critical facilities may be disrupted by nearby flooding, even if the facility is not flooded.	FEMA P-1019, *Emergency Power Systems for Critical Facilities: A Best Practices Approach to Improving Reliability* (2014)
Other Protection Considerations – Protection from High Winds	While elevating equipment will protect it from flooding, elevating equipment can introduce other risks. Equipment mounted in mechanical penthouses can be damaged by the high winds that accompany storms, and equipment that services exterior-mounted elevators in coastal areas can be damaged by storm surge generated by high winds. Penthouses have failed in storm events and allowed rainwater to enter from the top, rendering equipment inoperable. Designers are advised to account for the increased high wind risks associated with elevation as they reduce risks from flooding.	—

Table 6. Guidance for Specific Components

Topic	Guidance for Specific Components
Doors and Door Frames	Use stainless steel doors and door frames below the BFE.
Limit Switches	Relocate switches above the BFE using small brackets. Modern controllers use selector tape for landing control systems and require a short length of selector cam for switch activation.
Selector Tape	Use stainless steel selector tape, which is available for most controllers.
Slide and Roller Guides	For hydraulic elevators, use Teflon®-impregnated inserts on slide guides or convert to roller guides to reduce leakage of oil-based products into pits.
Compensation Cables	For traction elevators, remove compensation cables and replace with encapsulated chain systems.
Electrical	Use NEMA 4-rated enclosures, galvanized conduits, and watertight conduits and fittings below the BFE. Locate controls and equipment above the BFE where possible.
Hardware	Use galvanized sill angles and hardware at floors below the BFE.
Maintenance	Paint or coat buffers and all pit steel and hardware with galvanic or rust-preventive paint.

7 References

This section lists the references that are cited in this Technical Bulletin. Additional resources related to NFIP requirements are provided in Technical Bulletin 0.

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- *User's Guide to Technical Bulletins.* Technical Bulletin 0.
- *Requirements for Flood Openings in Foundation Walls and Walls of Enclosures Below Elevated Buildings in Special Flood Hazard Areas.* Technical Bulletin 1.
- *Flood Damage-Resistant Materials Requirements for Buildings Located in Special Flood Hazard Areas.* Technical Bulletin 2.
- *Free-of-Obstruction Requirements for Buildings Located in Coastal High Hazard Areas.* Technical Bulletin 5.
- *Corrosion Protection for Metal Connectors and Fasteners in Coastal Areas.* Technical Bulletin 8.

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U.S. DEPARTMENT OF HOMELAND SECURITY

FEMA

Free-of-Obstruction Requirements

For Buildings Located in Coastal High Hazard Areas in Accordance with the National Flood Insurance Program

NFIP Technical Bulletin 5 / March 2020

FEMA

Comments on the Technical Bulletins should be directed to:

DHS/FEMA
Federal Insurance and Mitigation Administration (FIMA) Risk Management Directorate
Building Science Branch
400 C Street, S.W., Sixth Floor
Washington, DC 20472-3020

NFIP Technical Bulletin 5 (2020) replaces NFIP Technical Bulletin 5 (2008), *Free-of-Obstruction Requirements.*

Cover photograph: Area beneath an elevated building that is free of obstruction.

For more information, see the FEMA Building Science Frequently Asked Questions website at https://www.fema.gov/frequently-asked-questions-building-science.

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Revision History

April 2020 Added 44 CFR citation for swimming pools and spas topic in Table 1 (page 8)

April 2020 Corrected caption for Figure 1 (page 16)

Acronyms

ASCE	American Society of Civil Engineers
BFE	base flood elevation
CFR	Code of Federal Regulations
DFE	design flood elevation
DHS	Department of Homeland Security
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
IBC	International Building Code®
ICC	International Code Council®
I-Codes	International Codes®
IRC	International Residential Code®
ISPSC	International Swimming Pool and Spa Code®
NFIP	National Flood Insurance Program
PFD	primary frontal dune
SEI	Structural Engineering Institute
SFHA	Special Flood Hazard Area

1 Introduction

> **NFIP TECHNICAL BULLETIN 0**
>
> NFIP Technical Bulletin 0, *User's Guide to Technical Bulletins*, should be used as a reference in conjunction with this Technical Bulletin. Technical Bulletin 0 describes the purpose and use of the Technical Bulletins, includes common concepts and terms, lists useful resources, and includes a crosswalk of the sections of the NFIP regulations identifying the Technical Bulletin that addresses each section of the regulations and a subject index.
>
> Readers are cautioned that the definitions of some of the terms that are used in the Technical Bulletins are not the same when used by the NFIP for the purpose of rating flood insurance policies.

This Technical Bulletin provides guidance on the National Flood Insurance Program (NFIP) free-of-obstruction requirements in Coastal High Hazard Areas, which are designated as Zone V (V, VE, V1-30, and/or VO) on a community's Flood Insurance Rate Map (FIRM), as well as the NFIP requirements for construction in Zone V to minimize flood damage potential that is applicable to construction in Zone V. The free-of-obstruction requirements were instituted to minimize the transfer of flood forces to an elevated building's foundation and also to minimize the diversion or deflection of floodwater or waves that could damage the elevated building or neighboring buildings.

This Technical Bulletin also discusses how the presence or absence of obstructions can affect NFIP flood insurance premiums.

Coastal waves and flooding can exert strong hydrodynamic forces on building elements in their path. Therefore, the NFIP requires that all new and Substantially Improved structures in Coastal High Hazard Areas (Zone V) be elevated on pilings or columns with the bottom of the lowest horizontal structural members of the lowest floor elevated to or above the base flood elevation (BFE). These open foundations allow floodwater and waves to pass beneath the elevated structure.

> **EFFECTS OF OBSTRUCTIONS**
>
> The NFIP requires the area beneath elevated structures in Zone V to remain *free of any obstructions that would prevent the free flow of coastal floodwater and waves* during a base flood event. An area beneath a structure elevated on an open foundation is considered to be free of obstructions if flood flow and waves can pass through the area without significant ***flow diversion, wave reflection, or wave runup.***
>
> - **Flow diversion.** Change in the course of flood flow when it encounters an object or structure. Diversion can be accompanied by an increase in the local flood level and/or flood velocity when the blockage is large relative to the area through which the flow would otherwise pass.
> - **Wave reflection.** Return or redirection of a wave striking an object.
> - **Wave runup.** Rush of water up a slope or structure following wave breaking.
>
> Some flow diversion, wave reflection, and wave runup can occur even with open foundations, but if the guidance in this Technical Bulletin is followed, the effects should be minimized during flood conditions up to the base flood event.

Any element constructed below the BFE that is attached to a building in Zone V is considered part of the building and must meet the free-of-obstruction requirements.

Standard solid foundation walls, such as masonry, concrete, and wood-frame walls, are not permitted in Zone V because they would obstruct flow and be at risk of damage from high-velocity flood forces. In addition, solid foundations and other obstructions could cause wave runup or reflection or divert floodwater into the elevated portion of the building or nearby buildings.

The NFIP interprets the free-of-obstruction requirements to apply to certain site development practices that prevent the free flow of coastal floodwater and waves under or around buildings or increase flood loads on nearby buildings. Construction elements outside the perimeter (footprint) of and not attached to a coastal building (e.g., bulkheads, retaining walls, decks, swimming pools, accessory structures) and site development practices (e.g., addition of fill) may alter the physical characteristics of flooding or significantly increase wave or flood forces affecting nearby buildings. As part of the design certification process for a building in Zone V, the registered design professional must consider the effects these elements and practices will have on the building and on nearby buildings.

The NFIP requires buildings to be constructed using methods and materials that minimize the potential for flood damage. Therefore, any construction element placed on a building site in Zone V (see Sections 6 and 7) has the potential to affect the building and nearby buildings, which must be taken into account. In addition to potential wave and floodwater diversion effects, obstructions can break free and become floodborne debris that may strike and damage other buildings.

The building elements and site development issues in regard to obstruction that are discussed in this Technical Bulletin include:

Building elements below the BFE

- Access stairs and ramps
- Decks, porches, and patios
- Elevators
- Enclosed areas
  - Below elevated structures
  - Above-grade (elevated)
  - Two levels
- Equipment and tanks
- Foundation bracing
- Grade beams
- Shear walls
- Slabs

Site development: Practices and issues

- Accessory storage structures
- Detached garages
- Erosion control structures
- Fences and privacy walls
- Fill
- Ground elevations at or above the BFE
- On-site septic systems
- Restroom buildings and comfort stations
- Swimming pools and spas

Building elements and site development practices that are not specifically prohibited by the NFIP may be used as long as they will not adversely affect other structures. However, some building elements and site development practices may increase flood-related loading on the building where those practices are proposed. In such cases, the building must be designed to withstand the additional flood-related loading and the registered design professional must provide the required Zone V certification for the building.

Questions about free-of-obstruction requirements should be directed to the appropriate local official, NFIP State Coordinating Office, or Federal Emergency Management Agency (FEMA) Regional Office.

NFIP TERMS USED IN THIS TECHNICAL BULLETIN

- **Special Flood Hazard Area (SFHA):** Area subject to flooding by the base flood (1-percent-annual-chance flood) and shown on FIRMs as Zone A or Zone V.
- **Zone A:** Flood zones shown on FIRMs as Zone A, AE, A1-30, AH, AO, A99, and AR.
- **Zone V:** Flood zones shown on FIRMs as Zone V, VE, V1-30, and VO.
- **Coastal High Hazard Area:** Area shown on FIRMs and other flood hazard maps as Zone V, VO, VE, or V1-30.

2 National Flood Insurance Program Regulations

An important NFIP objective is protecting buildings constructed in Special Flood Hazard Areas (SFHAs) from damage caused by flooding. The SFHA is the land area subject to flooding by the base flood. SFHAs are shown on Flood Insurance Rate Maps (FIRMs) prepared by FEMA as Zones A and V. The base flood is the flood that has a 1 percent chance of being equaled or exceeded in any given year (commonly called the "100-year" flood).

The NFIP floodplain management regulations include minimum building design criteria that apply to:

- New construction
- Work determined to be Substantial Improvements such as improvements, alterations, and additions
- Repair of buildings determined to have incurred Substantial Damage

A defining characteristic of the NFIP regulations applicable in Zone V is the requirement for the lowest horizontal structural member of the lowest floor to be elevated to or above the BFE. This requirement applies to both residential and non-residential buildings. Furthermore, the area beneath elevated structures must be free of obstructions that would prevent the free flow of coastal floodwater and waves during a base flood event.

ZONE V CERTIFICATION OF STRUCTURAL DESIGN AND METHODS OF CONSTRUCTION

The NFIP regulations require communities to ensure that construction meets Zone V requirements, including the free-of-obstruction requirement. Registered professional engineers or architects must develop or review structural designs, specifications, and plans for new construction and Substantial Improvements and certify that designs and methods of construction are in accordance with the accepted standards of practice. Building engineers and architects should consult with communities on their certification requirements before starting design, and communities must obtain and retain the certifications.

Satisfying the NFIP free-of-obstruction requirement is part of the certification. Local officials should determine that construction and/or site plans show all proposed site improvement elements described in this Technical Bulletin. The NFIP requires Zone V certification prior to construction. The community must ensure that what is constructed is compliant; some jurisdictions may require post-construction certification by the registered design professional.

See Technical Fact Sheet 1.5 in the *Home Builder's Guide to Coastal Construction* (FEMA P-499) (2010a) for a discussion of Zone V certification requirements.

The NFIP regulations for Zone V construction are codified in Title 44 Code of Federal Regulations (44 CFR) Part 60 Criteria for Land Management and Use. Specific to this Technical Bulletin, Section 60.3(a)(3) of the NFIP regulations states:

> If a proposed building site is in a flood-prone area, all new construction and substantial improvements shall … (iii) be constructed by methods and practices that minimize flood damages …

Section 60.3(e)(4) states that a community shall require (emphasis added):

> … that **all new construction and substantial improvements** in Zones V1 V30, VE, and also Zone V if base flood elevation data is available, on the community's **FIRM, are elevated on pilings and columns so that (i) the bottom of the lowest horizontal structural member of the lowest floor (excluding the pilings or columns) is elevated to or above the base flood level; and (ii) the pile or column foundation and structure attached thereto is anchored to resist flotation, collapse, and lateral movement due to the effects of wind and water loads acting simultaneously on all building components.** Water loading values used shall be those associated with the base flood. Wind loading values used shall be those required by applicable State or local building standards. A registered professional engineer or architect shall develop or review the structural design, specifications and plans for the construction, and shall certify that the design and methods of construction to be used are in accordance with accepted standards of practice for meeting the provisions of paragraphs (e)(4)(i) and (ii) of this section.

Section 60.3(e)(5) further states that a community shall require (emphasis added):

> **… that all new construction and substantial improvements within Zones V1-V30, VE, and V on the community's FIRM have the space below the lowest floor either free of obstruction or constructed with non-supporting breakaway walls, open wood lattice-work, or insect screening intended to collapse under wind and water loads without causing collapse,**

displacement, or other structural damage to the elevated portion of the building or supporting foundation system. For the purpose of this section, a breakaway wall shall have a design safe loading resistance of not less than 10 and no more than 20 pounds per square foot. Use of breakaway walls which exceed a design safe loading resistance of 20 pounds per square foot (either by design or when so required by local or State codes) may be permitted only if a registered professional engineer or architect certifies that the designs proposed meet the following conditions: (i) Breakaway wall collapse shall result from a water load less than that which would occur during the base flood; and (ii) The elevated portion of the building and supporting foundation system shall not be subject to collapse, displacement, or other structural damage due to the effects of wind and water loads acting simultaneously on all building components (structural and non-structural). Water loading values used shall be those associated with the base flood. Wind loading values used shall be those required by applicable State or local building standards. Such enclosed space shall be useable solely for parking of vehicles, building access, or storage.

Section 60.3(e)(6) states that a community shall "prohibit the use of fill for structural support of buildings within Zones V1-30, VE, and V on the community's FIRM."

Section 60.3(e)(7) states that a community shall "prohibit man-made alteration of sand dunes and mangrove stands within Zones V1–30, VE, and V on the community's FIRM which would increase potential flood damage."

For more information on NFIP regulations, refer to the following for:

- Guidance on coastal construction in the *Coastal Construction Manual* (FEMA P-55) (2011) and in the *Home Builder's Guide to Coastal Construction* (FEMA P-499) (2010a)
- Guidance on design considerations, buildings codes and regulations, and best practices for coastal communities in *Local Officials Guide for Coastal Construction* (FEMA P-762) (2009)
- Guidance on the breakaway wall requirements of Section 60.3(e)(5) of the NFIP regulations in NFIP Technical Bulletin 9, *Design and Construction Guidance for Breakaway Walls Below Elevated Buildings Located in Coastal High Hazard Areas*
- Guidance on the requirement that building materials used below the BFE must meet the flood damage-resistant materials requirement of Section 60.3(a)(3) of the NFIP regulations in NFIP Technical Bulletin 2, *Flood Damage-Resistant Materials Requirements for Buildings Located in Special Flood Hazard Areas*

NFIP REQUIREMENTS AND HIGHER REGULATORY STANDARDS

State and Local Requirements. State or local requirements that are more restrictive or stringent than the minimum requirements of the NFIP take precedence. The Technical Bulletins and other FEMA publications provide guidance on the minimum requirements of the NFIP and describe best practices. Design professionals, builders, and property owners should contact local officials to determine whether more restrictive provisions apply to buildings or sites in question. All other applicable requirements of the state or local building codes must also be met for buildings in flood hazard areas.

Substantial Improvement and Substantial Damage. As part of issuing permits, local officials must review not only proposals for new construction but also for work on existing buildings to determine whether the work constitutes Substantial Improvement or repair of Substantial Damage. If the work is determined to constitute Substantial Improvement or repair of Substantial Damage, the buildings must be brought into compliance with NFIP requirements for new construction. Some communities modify the definitions of Substantial Improvements and/or Substantial Damage to be more restrictive than the NFIP minimum requirements. For more information on Substantial Improvement and Substantial Damage, see FEMA P-758, *Substantial Improvement/Substantial Damage Desk Reference* (2010b), and FEMA 213, *Answers to Questions About Substantially Damaged/Substantially Damaged Buildings* (2018a).

Higher Building Elevation Requirements. Some communities require that buildings be elevated above the NFIP minimum requirements. The additional elevation is called freeboard. Design professionals, builders, and property owners should check with local officials to determine whether a community has freeboard requirements. References to building elevations in this Technical Bulletin should be construed as references to the community's elevation requirement in areas where freeboard is required.

3 Building Codes and Standards

In addition to complying with the NFIP requirements, all new construction, Substantial Improvements, and repair of Substantial Damage must comply with applicable building codes and standards that have been adopted by states and communities.

The International Codes® (I-Codes®), published by the International Code Council® (ICC®), are a family of codes that includes the International Residential Code® (IRC®), International Building Code® (IBC®), International Existing Building Code® (IEBC®), and codes that govern the installation of mechanical, plumbing, fuel gas service, and other aspects of building construction. FEMA has deemed that the latest published editions of the I-Codes meet or exceed NFIP requirements for buildings and structures in flood hazard areas. Excerpts of the flood

I-CODES AND COASTAL A ZONES

The 2018 International Codes (I-Codes) treat Coastal A Zones like Zone V if a Limit of Moderate Wave Action (LiMWA) is delineated on FIRMs. If a community designates an area as a Coastal A Zone through its building code or floodplain management regulations, buildings in that area are required to comply with the Zone V requirements for foundations, including the free-of-obstruction requirement, with an exception that permits filled stem wall foundations.

Note: Per the I-Codes and ASCE 24-14, breakaway walls in the Coastal A Zone and Zone V must have flood openings.

provisions of the I-Codes are available on FEMA's Building Code Resource webpage (https://www.fema.gov/building-code-resources).

3.1 International Residential Code

The IRC applies to one- and two-family dwellings and townhomes not more than three stories above grade plane. The IRC's free-of-obstruction requirements are summarized in Table 1 and compared to NFIP requirements.

Table 1 refers to selected requirements of the 2018 IRC and notes changes from the 2015 and 2012 editions.

IRC COMMENTARY

ICC publishes companion commentary for the IRC. Although not regulatory, the commentary provides guidance that is useful in complying with, interpreting, and enforcing the requirements of the code.

Table 1: Comparison of Selected 2018 IRC Requirements and NFIP Requirements

Topic	Summary of Selected 2018 IRC Requirements and Changes from 2015 and 2012 Editions	Comparison with NFIP Requirements
Free of obstruction	**Section R322.3.3 Foundations.** Requires in Coastal High Hazard Areas (Zone V) and Coastal A Zones that areas below elevated buildings be either free of obstructions or constructed of breakaway walls. In Coastal A Zones, filled stem wall foundations must be designed to resist flood loads, erosion, and scour. <u>Change from 2015 to 2018 IRC:</u> Changes to subsection numbering due to insertion of new subsections expanding requirements for 322.3.4, Concrete slabs; R322.3.7, Stairways and ramps; and R322.3.8, Decks and porches. <u>Change from 2012 to 2015 IRC:</u> Applies Zone V requirements in Coastal A Zone, if delineated, with an exception that permits stem wall foundations.	Equivalent to NFIP 44 CFR §§ 60.3(e)(4) and (5), except that 2018 IRC applies in both Zone V and Coastal A Zones, with an exception that permits stem wall foundations in Coastal A Zones.
Use of fill	**Section R322.3.2 Elevation requirements [excerpt].** Prohibits the use of fill for structural support in Coastal High Hazard Areas (Zone V) and Coastal A Zones, while allowing minor quantities of nonstructural fill to be used for drainage and landscaping purposes under and around buildings and for support of parking slabs, pool decks, patios, and walkways. <u>Change from 2015 to 2018 IRC:</u> No change. <u>Change from 2012 to 2015 IRC:</u> No change.	Equivalent to NFIP 44 CFR § 60.3(e)(6), with more specificity for use of fill for specific, nonstructural purposes.
Enclosed areas	**Section R322.3.5 Walls below design flood elevation.** In Coastal High Hazard Areas (Zone V) and Coastal A Zones, (1) requires that enclosures below elevated buildings be designed to break away under certain wind and flood loads without damaging the elevated building or the building foundation and (2) prohibits mounting of electrical, mechanical, and plumbing system components on breakaway walls or penetration of the breakaway walls. <u>Change from 2015 to 2018 IRC:</u> No change. <u>Change from 2012 to 2015 IRC:</u> Clarifies that attachment or penetration by electrical, mechanical or plumbing systems to breakaway walls is not permitted.	Exceeds NFIP 44 CFR § 60.3(e)(5) by specifying components that are not to be mounted on or penetrate through breakaway walls and by requiring flood openings in breakaway walls.

Table 1: Comparison of Selected 2018 IRC Requirements and NFIP Requirements (continued)

Topic	Summary of Selected 2018 IRC Requirements and Changes from 2015 and 2012 Editions	Comparison with NFIP Requirements
Equipment and tanks	**Section R322.1.6 Protection of mechanical, plumbing, and electrical systems.** Requires that new electrical, plumbing, and mechanical system elements, along with replacements due to Substantial Improvements, be elevated to the design flood elevation (DFE) or if below the DFE, to be designed and installed to prevent water from entering or accumulating within the element and be able to withstand certain loads and stresses. <u>Change from 2015 to 2018 IRC:</u> No change. <u>Change from 2012 to 2015 IRC:</u> No change. **Section R322.3.7 Tanks.** Requires tanks to either be located underground or elevated to the DFE. When located underground, tanks must be anchored to resist flotation, collapse, and lateral movement during the base flood. If elevated, tanks must be on platforms that are cantilevered or knee-braced against the building or on a platform with a foundation that resists certain wind and flood loads. <u>Change from 2015 to 2018 IRC:</u> No change. <u>Change from 2012 to 2015 IRC:</u> Added requirements for tanks.	Equivalent to NFIP 44 CFR § 60.3(a)(3)(iv) but with more specificity: components are not to be mounted on or penetrate through breakaway walls and there are explicit requirements for tanks.
Concrete slabs	**Section R322.3.4 Concrete slabs.** Requires that slabs used for parking, floors of enclosures, landings, decks, walkways, patios, and similar uses that are beneath buildings or located such that they could be undermined or displaced and could cause damage be either (1) structurally independent of foundations and no more than 4 inches thick, have no turn-downed edges, have no reinforcing, and have isolation joints at pilings and columns and control or construction joints in both directions no more than 4 feet apart or (2) self-supporting and will remain intact under base flood conditions, taking into account scour and erosion, and have building foundations capable of resisting any added loads due to the presence of the slabs. <u>Change from 2015 to 2018 IRC:</u> Moved specifications for slabs from R322.3.3. to separate subsection. <u>Change from 2012 to 2015 IRC:</u> No change.	Exceeds NFIP 44 CFR § 60.3(e)(5) by specifying requirements for concrete slabs.
Swimming pools and spas	**Section R326.1 [Swimming Pools, Spas and Hot Tubs] General.** Requires pools and spas to comply with the *International Swimming Pool and Spa Code®* (ISPSC), which requires compliance with American Society of Civil Engineers (ASCE) 24. <u>Change from 2015 to 2018 IRC:</u> No change. <u>Change from 2012 to 2015 IRC:</u> Added requirement to comply with the ISPSC.	Exceeds NFIP 44 CFR § 60.3(e)(5) by specifying requirements for pools and spas.
Building envelope	**Section R322.3.6.1 Protection of building envelope.** Requires an exterior door at the top of stairs that provides access to the building. <u>Change from 2015 to 2018 IRC:</u> No change. <u>Change from 2012 to 2015 IRC:</u> Added requirement for door.	Exceeds NFIP 44 CFR § 60.3(e)(5) by specifying requirements for door at top of stairway.

Table 1: Comparison of Selected 2018 IRC Requirements and NFIP Requirements (continued)

Topic	Summary of Selected 2018 IRC Requirements and Changes from 2015 and 2012 Editions	Comparison with NFIP Requirements
Stairways and ramps	**Section R322.3.7 Stairways and ramps.** Provides four options for stairs and ramps located below the lowest floor elevation: (1) open or partially open risers and guards, (2) breakaway, (3) retractable, or (4) designed to resist flood loads. In all cases, the area below stairs and ramps must not be enclosed with walls unless the walls are designed to break away. Change from 2015 to 2018 IRC: New section for stairways and ramps incorporating language from R322.3.3.	Exceeds NFIP 44 CFR § 60.3(e)(5) by specifying requirements for stairways and ramps.
Decks and porches	**Section R322.3.8 Decks and porches.** Requires attached decks and porches to meet lowest floor elevation requirement and either have compliant foundations or be cantilevered from or knee-braced to the building. Self-supporting decks and porches must be designed to remain in place or break away and may be below the BFE if not enclosed by solid walls (including breakaway walls). Change from 2015 to 2018 IRC: New section for decks and porches incorporating language from R322.3.3.	Exceeds NFIP 44 CFR § 60.3(e)(5) by specifying requirements for decks and porches.
Elevators and foundation bracing	No explicit provisions; see free-of-obstruction requirement in the first row of this table (Table 1).	Meets NFIP 44 CFR § 60.3(e)(5), which has no specific requirements.

3.2 International Building Code and ASCE 24

The flood provisions of the International Building Code® (IBC®) meet or exceed the NFIP requirements for buildings largely through reference to the ASCE 24, *Flood Resistant Design and Construction*. The IBC applies to all applicable buildings and structures. While primarily used for buildings and structures other than dwellings within the scope of the IRC, the IBC may be used to design dwellings. ASCE 24 applies to structures subject to building code requirements. The ASCE 24 requirements, summarized in Table 2, are more specific than the NFIP free-of-obstruction requirements.

IBC AND ASCE COMMENTARIES

ICC publishes companion commentary for the IBC, and ASCE publishes companion commentary for ASCE 24. Although not regulatory, the commentaries provide information and guidance that are useful in complying with, interpreting, and enforcing requirements.

Table 2: Comparison of Selected 2018 IBC and ASCE 24-14 Requirements with NFIP Requirements

Topic	Summary of Selected 2018 IBC / ASCE 24-14 Requirements and Changes from 2015 and 2012 IBC / ASCE 24-05	Comparison with NFIP Requirements
General design requirement	**2018 IBC Section 1612.2 Design and construction.** Requires design and construction of buildings and structures located in Coastal High Hazard Areas (Zone V) and Coastal A Zones to comply with Chapter 5 of ASCE 7 and ASCE 24. Change from 2015 to 2018 IBC: No change except renumbering of section. Change from 2012 to 2015 IBC: Applies Coastal High Hazard Area requirements in Coastal A Zones if delineated.	Exceeds NFIP 44 CFR § 60.3(e) by referring to ASCE 24, which has more specificity for some foundation elements and higher minimum building elevations, and which requires meeting Zone V design and construction standards in Coastal A Zones (which are not defined in the NFIP).
Obstruction	**ASCE 24-14 Section 1.2 Definitions.** "Obstruction – Any object or structural component attached to a structure below the DFE that can cause an increase in flood elevation, deflect floodwaters, or transfer flood loads to any structure." The DFE in the definition of obstruction is the Design Flood Elevation, which will be equal to or higher than the BFE. Change from ASCE 24-05: No change.	The NFIP does not define "obstruction."
Free of obstruction	**ASCE 24-14 Section 4.5.1 Foundation Requirements, General.** • Applies to foundation systems in Coastal High Hazard Areas (Zone V) and Coastal A Zones. • Requires foundations to be designed to minimize forces acting on foundations, to minimize damage to the foundations and the elevated structures, and to adequately transfer all loads imposed on the foundations and elevated structures to the supporting soils. With the exception of certain bracing and shear walls, requires foundation system to be free of obstructions that will restrict or eliminate free passage of high-velocity flood waters and waves during design flood conditions. Change from ASCE 24-05: No change.	Equivalent to NFIP 44 CFR § 60.3(e)(5).

Table 2: Comparison of Selected 2018 IBC and ASCE 24-14 Requirements with NFIP Requirements (continued)

Topic	Summary of Selected 2018 IBC / ASCE 24-14 Requirements and Changes from 2015 and 2012 IBC / ASCE 24-05	Comparison with NFIP Requirements
Use of fill	**2018 IBC Section 1804.5 Grading and fill in flood hazard areas.** Specifies that fill is only allowed where constructed and placed to avoid diversion of water and waves toward any building or structure. Where allowed, fill is required to be stable under conditions of flooding, including rapid rise and drawdown and wave action. Change from 2015 to 2018 IBC: Clarifies that fill where allowed must be stable under conditions of flooding. Change from 2012 to 2015 IBC: No change. **ASCE 24-14 Section 4.5.4 Use of Fill.** • Specifies that placement of nonstructural fill for minimal site grading and landscaping and to meet local drainage requirements is permitted. • Specifies that placement of nonstructural fill under and around a structure for dune construction or reconstruction is permitted if an engineering report documents that the fill will not result in wave runup, ramping, or deflection of floodwaters that can cause damage to structures. Change from ASCE 24-05: Clarifies that an engineering report is necessary to document the effect of fill, and the commentary clarifies that the intent is to allow minor amounts of nonstructural fill for specific purposes.	Equivalent to NFIP 44 CFR § 60.3(e)(6), with more specificity for use of fill for specific, nonstructural purposes.
Enclosed areas	**ASCE 24-14 Section 4.6 Enclosed Areas Below Design Flood Elevation.** Requires enclosed areas below DFE to be designed and constructed with breakaway walls, with flood openings in those walls, and requires stairways within the enclosed area to have an exterior door at the top of the stairs. Change from ASCE 24-05: Modified to refer to subsections for requirements and adds the requirement for an exterior door at the top of the stairs. **ASCE 24-14 Section 4.6.1 Breakaway Walls.** Change from ASCE 24-05: No change. **ASCE 24-14 Section 4.6.2 Openings in Breakaway Walls.** Change from ASCE 24-05: Modified to require flood openings in breakaway walls forming an enclosure.	Exceeds NFIP 44 CFR § 60.3(e)(5) by requiring flood openings in breakaway walls and a door at the top of stairways within enclosures.
Utilities and equipment	**ASCE 24-14 Section 7.1 General.** Requires attendant utilities and equipment to be at or above specified elevations or be specifically designed, constructed, and installed to prevent floodwaters from entering or accumulating within components. Change from ASCE 24-05: No change	Exceeds NFIP 44 CFR § 60.3(a)(3)(iv) with freeboard requirements for utility system platforms and equipment for most buildings.
Tanks	**ASCE 24-14 Section 9.7 Tanks.** Requires tanks in Coastal High Hazard Areas (Zone V) and Coastal A Zones to be (1) elevated on platforms meeting certain requirements or (2) installed and anchored below the eroded ground surface. Change from ASCE 24-05: Consolidated requirements for tanks in Section 9.7.	Exceeds NFIP 44 CFR § 60.3(a)(3)(iv) with specificity for platforms and requirements for tanks.

Table 2: Comparison of Selected 2018 IBC and ASCE 24-14 Requirements with NFIP Requirements (continued)

Topic	Summary of Selected 2018 IBC / ASCE 24-14 Requirements and Changes from 2015 and 2012 IBC / ASCE 24-05	Comparison with NFIP Requirements
Slabs	**ASCE 24-14 Section 9.3 Concrete Slabs.** Requires in Coastal High Hazard Areas (Zone V) and Coastal A Zones that concrete slabs be either (1) designed as frangible, not structurally connected to structure, and not capable of creating debris that would cause significant damage to other structures or (2) be self-supporting and remain in place and functional after the design flood. Change from ASCE 24-05: Slabs were moved from Section 4.8 to Section 9.3. New text permits (non-building-foundation) self-supporting structural slabs for parking/enclosure/deck/patio in Zone V and Coastal A Zone.	Exceeds NFIP 44 CFR § 60.3(e)(5) with requirements for concrete slabs.
Swimming pools and spas	**2018 IBC Section 3109.1 General.** Requires, within Coastal High Hazard Areas (Zone V) and Coastal A Zones, that the design and construction of swimming pools, spas, and hot tubs comply with the ISPSC, which requires pools to be designed in accordance with ASCE 24. Change from 2015 to 2018 IBC: No change Change from 2012 to 2015 IBC: Replaces specific requirements with reference to the ISPSC. **ASCE 24-14 Section 9.6.2 Pools in Coastal High Hazard Areas, Coastal A Zones and Other Flood Hazard Areas.** Requires pools to be (1) elevated, (2) designed to break away without producing damaging debris, or (3) designed to remain in the ground without obstructing flow that could cause damage. Pools must be structurally independent of buildings and structures unless located in or on elevated floors or roofs that are above the DFE. Change from ASCE 24-05: Clarifies pool requirements for pools within Coastal High Hazard Areas, Coastal A Zones, and other flood hazard zones.	Exceeds NFIP 44 CFR § 60.3(e)(5) with requirements for swimming pools and spas.
Elevators	**2018 IBC Section 3001.3 Referenced standards.** Requires the design, construction, installation, alteration, repair, and maintenance of elevators and conveying systems and their components to comply with the standard specified in 2018 IBC Section 3001.3, Table 3001.3, and ASCE 24 unless the code states otherwise. Change from 2015 to 2018 IBC: Standards moved to Table 3001.3. Change from 2012 to 2015 IBC: No change.	Exceeds NFIP 44 CFR § 60.3(e)(5) with requirements for elevators.
Access stairs and ramps	**ASCE 24-14 Section 8.1 General.** In Coastal High Hazard Areas (Zone V) and Coastal A Zones provides four options for the design and construction of stairways and ramps below the required elevation. Change from ASCE 24-05: Adds option for retractable stairways and ramps.	Exceeds NFIP 44 CFR § 60.3(e)(5) with requirements and alternatives for stairways and ramps.

Table 2: Comparison of Selected 2018 IBC and ASCE 24-14 Requirements with NFIP Requirements (continued)

Topic	Summary of Selected 2018 IBC / ASCE 24-14 Requirements and Changes from 2015 and 2012 IBC / ASCE 24-05	Comparison with NFIP Requirements
Decks and porches	**ASCE 24-14 Section 9.2 Decks and Porches** **9.2.1 Attached Decks and Porches.** In coastal high hazard areas (Zone V) and Coastal A Zones, specifies that attached decks and porches be elevated on certain foundations or cantilevered from the main structure. **ASCE 24-14 Section 9.2.2 Detached Decks and Porches.** In Coastal High Hazard Areas (Zone V) and Coastal A Zones, specifies that detached decks and porches be (1) designed and constructed to remain intact and in place during the base flood or (2) be designed to be frangible, minimizing debris capable of causing significant damage to any structure. Change from ASCE 24-05: Clarifications with no new requirements or limitations.	Exceeds NFIP 44 CFR § 60.3(e)(5) with requirements for decks and porches.
Foundation bracing	**ASCE 24-14 Section 4.5.11 Bracing.** Change from ASCE 24-05: No change.	Exceeds NFIP 44 CFR § 60.3(e)(5) with requirements for bracing.

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4 NFIP Flood Insurance Implications

Meeting the minimum NFIP floodplain management requirements does not necessarily result in the lowest NFIP flood insurance premium. NFIP flood insurance premiums depend on the presence, location, construction, size, age, and use of enclosures and other building components and equipment. Floodplain management regulations allow enclosures greater than 300 square feet, but structures with these enclosures have higher NFIP flood insurance premiums. Designers should consult a qualified insurance agent and review FEMA's *NFIP Flood Insurance Manual* to determine insurance implications of design and construction decisions.

EFFECT OF CONSTRUCTION BELOW THE BFE

Any construction or site development practice below the BFE (even piles and columns permitted by the NFIP) will cause a localized disruption of flow and waves during the base flood. The question is whether the localized disruption will be great enough to harm the elevated building or surrounding buildings.

NFIP floodplain management regulations allow certain construction elements below the BFE that may or may not break away during the base flood (e.g., stairwells, elevator shafts, shear walls). These elements may or may not be considered obstructions for NFIP flood insurance rating purposes. For example:

- The NFIP floodplain management regulations in 44 CFR § 60.3(e) allow open wood lattice, insect screening, and solid, non-load-bearing, breakaway walls below elevated buildings in Coastal High Hazard Areas. Even though floodplain management regulations permit solid breakaway walls, garage doors, and slats or lattice (with less than 40 percent of the area open), building designers and owners should be aware that these elements can result in higher NFIP flood insurance premiums. See the text box "NFIP Flood Insurance Free-of-Obstruction Rate" below for details.

- The NFIP floodplain management regulations in 44 CFR § 60.3(e) restrict uses of space below the BFE to parking of vehicles, building access, and storage. Stairs, ramps, and elevators are permitted. However, depending on how stairs, ramps, and elevators are constructed, they may be considered obstructions for NFIP flood insurance rating purposes and could result in higher premiums.

DETERMINING FLOOD INSURANCE IMPLICATIONS BEFORE THE DESIGN

Design professionals and property owners may wish to contact a qualified insurance agent or the NFIP regarding the flood insurance rating and premium implications of obstructions before a building is designed.

NFIP FLOOD INSURANCE FREE-OF-OBSTRUCTION RATE

In order for a structure to qualify for the NFIP flood insurance free-of-obstruction rate, the space below the lowest elevated floor must be free of obstructions with the following exceptions:

- Insect screening provided that no additional supports are required for the screening
- Wooden or plastic lattice with at least 40 percent of its area open and constructed of material no thicker than ½ inch
- Wooden or plastic slats or shutters with at least 40 percent of their area open and constructed of material no thicker than 1 inch
- One solid breakaway wall or garage door with the remaining sides of the enclosure constructed of the above-mentioned insect screening, wooden or plastic lattice, slats, or shutters

5 Free-of-Obstruction Requirement Considerations

Some NFIP flood-resistant design and construction requirements, including free-of-obstruction requirements, are performance related and are not prescriptive. In other words, the expected building performance is stated, but how to achieve the performance is not specified. It is up to the design professional to create a design that complies with the free-of-obstruction performance requirements and up to the local official to determine whether the design satisfies the community's requirements.

It is not always clear whether a particular building element or a site development practice would create a significant obstruction that would prevent the free passage of floodwater and waves. "Significant" is used because *any* construction element or site development practice below the flood level would cause a localized disruption of flow and waves during the base flood. Determining whether the disruption would be significant is not always easy because in most cases, there are no analytical or readily usable numerical tools to answer the question with certainty. Local experience, results of post-disaster assessments, and application of coastal processes and building science principles must be relied on to reach a conclusion.

Some local floodplain management regulations require potential obstructions below or near a building to be evaluated to determine their effects on flow and waves. Fluid mechanics and coastal engineering references, such as the U.S. Army Corps of Engineers *Coastal Engineering Manual* (2002), provide some guidance, but the methods in these references are not generally capable of evaluating the potential effects of small building elements or small amounts of fill on flooding and waves during a base flood. Numerical coastal storm surge and wave models used in Flood Insurance Studies do not have sufficiently detailed resolution to discern building-sized disruptions to flow and wave fields.

Currently, developing models with fine enough resolution is technically challenging, time consuming, and cost prohibitive. And although recently developed, sophisticated numerical models show some promise in analyzing flow around buildings, their use is not economically feasible for most communities, owners, or designers interested in examining the potential obstructions discussed in this Technical Bulletin.

6 Building Elements Below the Base Flood Elevation

This section discusses common building elements under elevated buildings that can impede the free passage of flood flow and waves. Following the guidance in this section will minimize potential obstructive effects and satisfy the NFIP free-of-obstruction requirement.

6.1 Access Stairs and Ramps

Access stairs and ramps that are attached to or beneath an elevated building may be enclosed with breakaway walls or unenclosed. However, like foundation bracing (see Section 6.8), stairs and ramps can impede breakaway walls from breaking away cleanly as intended. To minimize this possibility, unenclosed stairs and ramps are preferred, but if enclosures are used, the design should be such that the stairs and

ENTRY DOOR AT TOP OF ACCESS STAIRS

Access stairs to elevated buildings are often constructed inside a breakaway enclosure with an entry door at the bottom of the enclosure but no entry door into the building at the top of the stairs. The lack of an entry door at the top results in a large opening in the building envelope when enclosures break away. Numerous post-disaster damage assessments have shown that loss of breakaway enclosures exposes building interiors to higher internal wind pressures and wind-driven rain. Loss of breakaway enclosures can also provide an easy path for floodwater to enter buildings, resulting in damage that can be avoided when doors are provided at the top of the access stairs.

Beginning with the 2015 IRC and ASCE 24-14, solid entry doors capable of resisting all design loads are required to be installed at the top of access stairs inside breakaway enclosures.

ramps do not interfere with breakaway wall performance. Enclosing stairways also affects NFIP flood insurance rates.

Stairs and ramps are not required to break away, but it is a design option. Stairs and ramps must be designed and constructed to either:

- Resist flood loads and remain in place during floods up to and including the base flood. If this option is selected, the elevated building and its foundation must be designed to resist any flood loads that are transferred from the stairs or ramp to the building, or
- Break away during base flood conditions without causing damage to the building or its foundation.

Figure 1 shows an example of an elevated building that was damaged as a result of stairs that did not break away cleanly; the stairway pulled out the exterior wall of the elevated building as the stairway failed.

Figure 1:
Damage to an elevated building as a result of stairs that did not break away cleanly

Constructing access stairs with open sides (open guards and railings) and risers, to the extent allowed by building codes, minimizes the potential for flood loads acting on the stairs, thereby minimizing flood damage and also minimizing transfer of flood loads to the elevated building. Open stairs should be considered whenever possible (see Figure 2). Note that building codes may have maximum opening size limits on stair risers and railings, necessitating a longer run. Check with the local jurisdiction for requirements.

Ramps must be designed and constructed to minimize the obstruction of floodwater and waves and configured so that floodwater and waves cannot flow directly up the ramp toward the elevated building. This means that ramps should be positioned to avoid a straight alignment from the elevated building to the likely direction of wave and surge approach.

Figure 2:
Open stairs, which minimize transfer of flood and wave forces

Massive exterior stairs are not permitted because they are inconsistent with the free-of-obstruction requirement and because other types of stairs can provide access. Figure 3 shows massive stairs that are attached to an elevated coastal home. These massive stairs will act as an obstruction and increase the likelihood of trapping or reflecting waves and flood flow beneath the elevated building.

In some cases, life-safety code requirements dictate that stairs and stairwells in structures of certain occupancy categories be constructed to be fire resistant and structurally stable even if portions of the adjacent structure fail. Stairs and stairwells that meet these requirements are usually constructed of some combination of steel, reinforced masonry, and reinforced concrete and will not break away under

Figure 3:
Massive stairs attached to an elevated coastal home, which act as an obstruction

expected base flood loads and conditions. These stairs and stairwells, typically found in mid- and high-rise buildings, must be designed to withstand all base flood loads, including flow, waves, and floodborne debris impacts.

6.2 Decks, Porches, and Patios

Decks, porches, and patios are typically outside the footprint of elevated residential and commercial buildings and may be constructed at grade, above grade but below the BFE, at the BFE, or above the BFE.

In Coastal High Hazard Areas, decks and porches outside the building footprint must meet one of the following conditions:

- If structurally attached to a structure, the bottom of the lowest horizontal structural member of the deck or porch must be at or above the BFE. Deck and porch supports that extend below the BFE (e.g., pilings, bracing) must comply with Zone V design and construction requirements, and the structure must be designed to accommodate any increased loads resulting from the attached deck or porch.
- If an attached deck or porch is located above the BFE but relies on support elements (posts, columns, braces) that extend below the BFE, the supports must comply with Zone V design and construction requirements.
- If a deck, porch, or patio (not counting its supports) lies in whole or in part below the BFE, it must be structurally independent from the structure and its foundation system.

Decks that are constructed within the building footprint between the ground and the elevated building are sometimes referred to as mezzanine decks. In Coastal High Hazard Areas, mezzanine decks should be treated similar to the floors of above-grade (elevated) enclosures (see Section 6.5). If directly below the footprint, a mezzanine deck that is structurally attached to the host building is treated as the lowest floor elevation for NFIP flood insurance rating purposes.

From a floodplain management perspective, mezzanine decks must meet building code requirements for dead, live, and other applicable loads and must be designed to either:

1) Break apart into small pieces without causing collapse, displacement, or other structural damage to the elevated building or the supporting foundation under flood loads less than those that occur during the base flood or
2) Along with the building foundation, accommodate flood loads transferred from the mezzanine deck to the building foundation during flooding up to and including base flood conditions.

Mezzanine decks may be independently supported on an open foundation and must be designed to either withstand flooding up to and including the base flood or break apart into small pieces under base flood or lesser conditions. Structurally independent decks below the BFE and below a structure's footprint are not considered the lowest floor for NFIP flood insurance purposes.

Decks, porches, and patios must not adversely affect the structure with which they are associated, or nearby structures, by diverting floodwater and waves during flood conditions up to and including the base flood. Some decks and patios, such as low-profile decks and patios constructed at natural grade or on minor quantities of fill necessary to level the site (see the textbox in Section 7.5), are deemed to comply by minimizing harmful diversion of floodwater or wave runup and reflection. A low-profile deck or patio, as used here, has a floor system depth of 12 inches or less, some of which may be below the adjacent finished grade. The depth does not include railings, which should be open to allow water to flow through. Attaching seats, benches, tables, planters, or similar features will cause a deck or patio to lose its deemed-to-comply low-profile classification. These features may or may not be obstructions (depending on size, number, and configuration) and should be evaluated for potential effects on flow and waves.

Decks, porches, and patios must be designed and constructed so that when subject to flooding up to and including base flood conditions, they do not create debris capable of causing significant damage to nearby structures. This means that decks, porches, and patios must remain intact and in place during base flood conditions or break apart into small pieces so the resulting debris does not lead to structural damage to nearby structures.

Decks and porches that are structurally attached to structures in Zone V must be supported to resist the simultaneous action of design wind loads and base flood loads. Most attached decks and porches are supported on piles or columns embedded in the ground and are capable of surviving anticipated erosion and scour. Post-storm assessments frequently identify decks and porches that were elevated on posts whose diameters were too small or on structural elements without sufficient embedment into the ground. The result of inadequate support is loss of decks and porches and sometimes damage to elevated structures. Unless the building code or local community prescribes otherwise, the foundation for an elevated deck or porch attached to a structure in Zone V should be similar to the structure's foundation. Attached decks and porches may be cantilevered from main structures instead of supported on piles or columns.

6.3 Elevators

Elevators attached to or beneath elevated structures in Zone V must comply with building, fire, electrical, and mechanical code requirements. Elevators and elevator shafts are not required to break away but must meet flood damage-resistant material and equipment requirements.

Flood loads acting on elevator components, any non-breakaway shaft walls, and potential wave runup and reflection effects must be accounted for in the design of the elevated structure and its foundation system. Therefore, it is advantageous to minimize the size of elevators, especially residential elevators in one- and two-family structures. Elevators should be designed and installed to satisfy the requirements of ASCE 24, which FEMA has determined meets or exceeds the minimum NFIP requirements. Additional guidance can be found in NFIP Technical Bulletin 4, *Elevator Installation for Buildings Located in Special Flood Hazard Areas.*

NFIP FLOOD INSURANCE AND ELEVATOR SHAFTS AND ELEVATOR EQUIPMENT

Elevator shafts and elevator equipment below the BFE will result in higher NFIP flood insurance premiums. The presence of elevators always increases the premium, regardless of how the shafts are constructed.

6.4 Enclosed Areas

The types of enclosed areas that are discussed in this section are:

- Enclosed areas below elevated structures
- Above grade (elevated) enclosures
- Two-level enclosures

6.4.1 Enclosed Areas Below Elevated Structures

The use of enclosed areas below elevated structures is restricted to parking of vehicles, building access, and storage. Enclosed areas must not be used for habitable purposes. Enclosed areas, including foyers, must be constructed of flood damage-resistant materials and not be finished. All enclosed areas below elevated buildings will be considered when the NFIP flood insurance premium is determined.

The NFIP regulations in 44 CFR § 60.3(e)(5) state that the area beneath the elevated portion of a structure in Zone V may be enclosed only with open lattice, insect screening, or non-supporting breakaway walls (see NFIP Technical Bulletin 9, *Design and Construction Guidance for Breakaway Walls Below Elevated Buildings in Coastal High Hazard Areas*). However, while NFIP regulations permit all enclosure walls to be solid breakaway walls, construction of such will lead to a With-Obstruction rating by the NFIP.

FEMA guidance states that the following lattice and slats are acceptable:

- Wood or plastic lattice no thicker than ½ inch with at least 40 percent of its area open
- Wood or plastic slats or fixed louvers no thicker than 1 inch that, when installed, have at least 40 percent of their area open

Figure 4 and Figure 5 show examples of compliant slats, which are typically installed flat against foundation pilings (see Figure 4) or angled like louvers between the pilings (see Figure 5). Percent open area of a lattice or louver wall should be calculated based on the area through which water can flow through lattice or louvers, divided by the total area of the enclosure wall (see Figure 6).

PRIVACY SCREENING

Privacy screening around outdoor shower areas is permitted if the sides are open at top and bottom and the screening will break away under base flood or lesser conditions. If a space under the building footprint is enclosed with privacy screening, there will be an NFIP flood insurance premium increase.

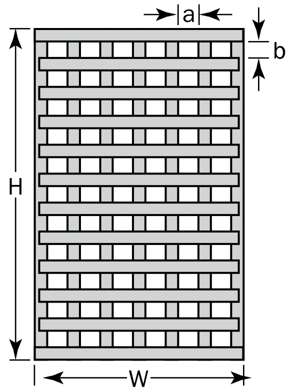
SIZE OF ENCLOSURES AND NFIP FLOOD INSURANCE

The NFIP does not limit the size of enclosures under elevated structures. However, higher NFIP flood insurance premiums will generally be assessed for structures in Zone V with enclosed areas of any size (including stairwells and elevator enclosures), even if enclosed by breakaway walls. Annual NFIP premiums can be even higher when buildings have enclosures that are 300 square feet or larger. Some communities have adopted restrictions or prohibitions on enclosures. Designers, contractors, and owners should check local requirements prior to construction.

The NFIP does not require flood openings in the walls of enclosures in Zone V. However, beginning with ASCE 24-14 and the 2015 IRC and IBC, enclosures in Zone V require flood openings.

Figure 4:
Compliant wood slats installed flat against foundation pilings

Figure 5:
Compliant, fixed, wood louvers installed between pilings

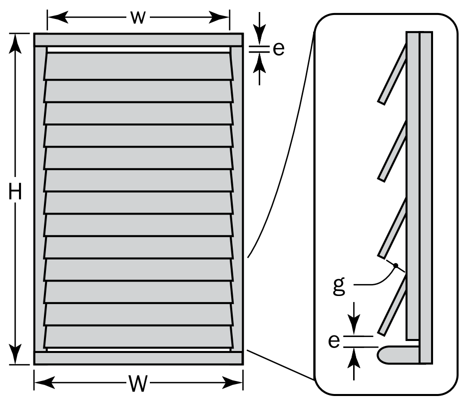


Lattice wall

Percent open area is the sum of all individual open areas, divided by the overall panel area, times 100.

Measure the height and width of the opening, multiply by the total number of openings, and divide by the total panel area (height times width). To get a percentage, multiply the result by 100.

$$\% \text{ open area} = \frac{\Sigma (ab) \times 100}{HW}$$



Louver wall

Percent open area is the sum of all individual open areas in gaps between louvers, plus top and bottom edge opening areas, divided by the overall panel area, times 100.

The individual open areas are calculated as the distance between louvers multiplied by the panel width. Multiply that area by the total number of gaps, add the edge opening areas, and divide by the total panel area (height times width). To get a percentage, multiply the result by 100.

$$\% \text{ open area} = \frac{(\Sigma (gw) + (2ew)) \times 100}{HW}$$

Figure 6: Determination of the percentage of open area for a lattice or louver wall

Figure 7 shows an elevated building in which a portion of a solid breakaway wall enclosure did not break away. Waves were not able to pass beneath the elevated structure, and wave runup against the enclosure wall likely caused damage above the elevated floor.

Figure 7:
Breakaway wall that did not break away, which led to wave runup and contributed to flood damage on the side of the elevated building

6.4.2 Above-Grade Enclosed Areas (Elevated)

Another enclosure option is to construct enclosures with floor systems that are elevated above grade and are not in contact with the ground (see Figure 8). Placing the enclosure floor above grade minimizes the potential for damage to the enclosure and contents during frequent, low-level flood events.

Figure 8: Above-grade enclosure

An above-grade enclosed area (sometimes referred to as a hanging enclosure) is any enclosure with its floor system above grade. The enclosure may be supported by a foundation beneath the enclosure or by the elevated building and/or building foundation. A hanging floor is the lowest floor elevation for NFIP flood insurance rating purposes.

Above-grade enclosures may be used only for storage and building access and must meet all other requirements applicable to enclosures, including the use of breakaway walls and flood damage-resistant materials below the BFE. Additionally, mechanical and electrical systems in the enclosure must be elevated to or above the BFE. A floor grate should be installed in the enclosure floor, and flood openings should be installed in breakaway enclosure walls. The grate will reduce vertical uplift (buoyancy) loads on the enclosure floor before water flows through the openings in the enclosure walls and allow the elevated enclosure to drain fully, reducing the downward load caused by water that would otherwise be trapped above the enclosure floor.

ABOVE-GRADE ENCLOSURES AND NFIP FLOOD INSURANCE

NFIP flood insurance policies for elevated buildings with above-grade enclosures are rated assuming the floor of the above-grade enclosure is the lowest floor (or based on the elevation of the lowest horizontal structural member of the enclosure instead of the lowest horizontal structural member of the lowest floor of the elevated building). Owners should ask their insurance companies to submit requests to the NFIP for a special rating for buildings with above-grade enclosures.

The design of the foundation and enclosure floor system for above-grade enclosures that are in Zone V must meet one of the following conditions:

- The floor system is designed to break away under flood loads less than those that occur during the base flood without causing collapse, displacement, or other structural damage to the elevated building or the supporting foundation (see Figure 9), or
- The floor system is designed to remain in place and intact, and the building foundation is designed to accommodate flood loads transferred from the enclosure floor system to the foundation during flood conditions up to and including the base flood (see Figure 9), or
- The enclosure floor system is independently supported on an open foundation (see Figure 10).

Flood openings in above-grade enclosure walls are required by the building code but do not reduce NFIP flood insurance premiums for the enclosure.

6.4.3 Two-Level Enclosed Areas

In flood hazard areas where the BFE is very high above the ground or where owners elect to elevate buildings very high, some owners opt to build two-level enclosures (see Figure 11 and Figure 12). Two-level enclosures are permitted but not recommended due to their more complicated construction and increased potential for

TWO-LEVEL ENCLOSURES

Two-level enclosures are also known as two-story enclosures, double enclosures, and stacked enclosures.

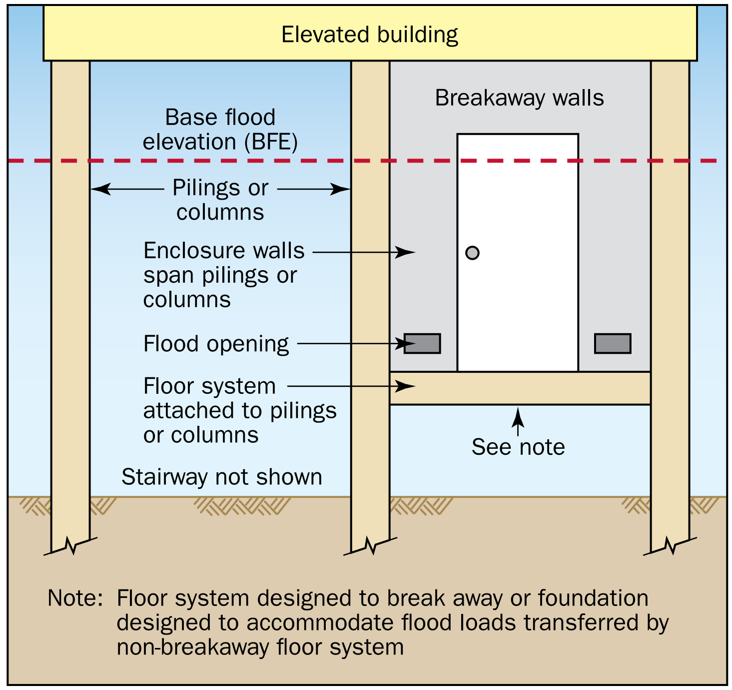


Figure 9: Above-grade enclosure floor system attached to building foundation

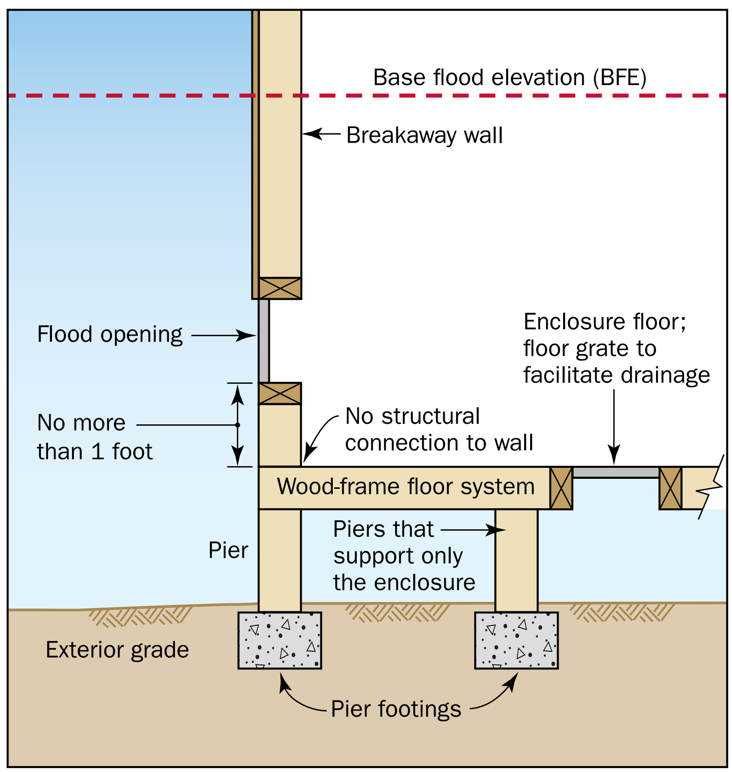


Figure 10: Above-grade enclosure supported by independent foundation

Figure 11:
Two-level enclosure

floodborne debris. Two-level enclosures could also result in the floor of the upper level being considered the lowest floor for NFIP flood insurance rating purposes.

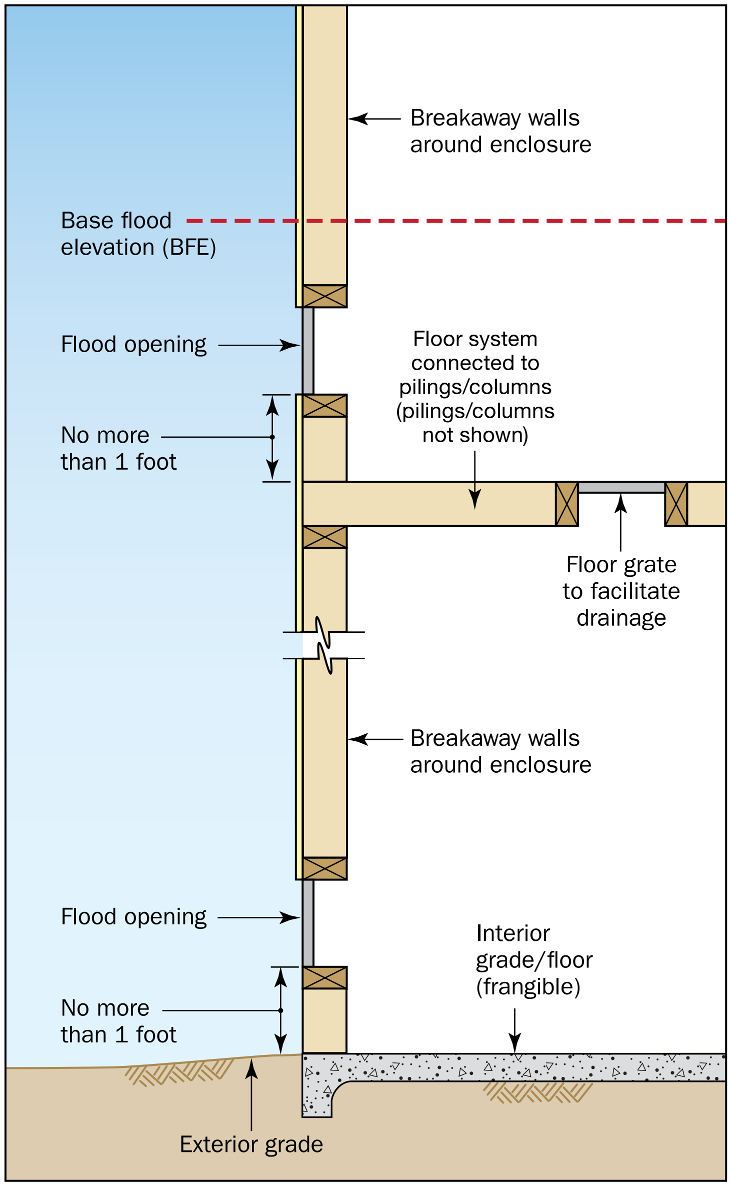
Both levels of the enclosure must meet all of the floodplain management and building code requirements for enclosed areas, including breakaway walls, elevated utilities, flood damage-resistant materials, and limitations on use (parking of vehicles, building access, and storage). The floor system of the upper enclosure level must be designed to meet one of the options for above-grade (elevated) enclosed areas (see Section 6.4.2).

Openings with grates should be installed in the floor to facilitate drainage from the upper level enclosure. In the event that floodwater enters the upper level but does not cause failure of the breakaway walls, the floor grates will allow trapped water to drain to the lower level and not overload the upper level floor system.

TWO-LEVEL ENCLOSURES AND NFIP FLOOD INSURANCE

Designers and owners should be aware that a building with a two-level enclosure, even if allowed by permit, could result in higher NFIP flood insurance premiums than if the building has a one-level enclosure. Even if a two-level enclosure complies with building code and floodplain management requirements for enclosures, the upper floor of the two-level enclosure could be deemed the lowest floor for NFIP flood insurance rating purposes (the lowest floor elevation for flood insurance purposes is the first floor elevated above ground). Owners should ask their insurance companies to submit requests to the NFIP for a special rating for buildings with two-level enclosures.

Figure 12:
Two-level enclosure schematic



6.5 Mechanical, Electrical, and Plumbing Equipment, Ducts, Tanks, and Fixtures

Mechanical, electrical, and plumbing equipment, ducts, tanks, and fixtures serving elevated buildings are required to be elevated to or above the BFE or protected from water entry during the base flood.

There are exceptions for elevator equipment that cannot be elevated (see NFIP Technical Bulletin 4, *Elevator Installation for Buildings Located in Special Flood Hazard Areas*, and ASCE 24).

EQUIPMENT BELOW AN ELEVATED BUILDING AND NFIP FLOOD INSURANCE

Designers and owners should be aware that elevator equipment and other equipment below an elevated building will result in higher NFIP flood insurance premiums, even if the equipment is allowed by permit.

Utility lines, pipes, risers, and chases may need to extend below the BFE but should be installed to minimize potential damage from flooding (some utility companies place meters below the BFE so they can be easily accessed). The following help minimize potential damage:

- Utility lines, pipes, risers, and chases are not allowed to be attached to or penetrate through breakaway walls (see Figure 13).
- Utility lines, pipes, risers, and chases should be located on the sides of piles and columns that are opposite the anticipated direction of flood flow and wave approach, where possible.

Fuel tanks and other tanks serving elevated buildings and located under or adjacent to the buildings must be in-ground or elevated above the BFE. In both cases, tanks should be anchored to prevent flotation or lateral movement during base flood conditions. Platforms supporting elevated tanks should resist flooding up to and including base flood conditions.

To satisfy free-of-obstruction requirements, above-ground tanks must not be located beneath elevated buildings or attached to elevated buildings below the BFE. This requirement also applies to permanently

UTILITY CHASES

For floodplain management and NFIP flood insurance purposes, utility chases designed to protect utility lines from freezing are not considered enclosures. Utility chases must be small and not allow access for a person to enter the space (access panels for servicing the lines are appropriate).

Because a utility chase is not considered an enclosure, it does not have to meet the requirement of breakaway walls, louvers, or open latticework; however, the chase may be breakaway under flood conditions.

The utility chase must be constructed of flood damage-resistant materials below the BFE, and the enclosed utility lines must meet the requirement to be watertight and capable of withstanding flood loads (hydrostatic, hydrodynamic, wave). Additionally, the portions of the utility system located below the BFE and the utility chase should not be attached to, mounted on, pass through, or be located along breakaway walls.

Figure 13:
Utilities mounted on wall, which prevented the wall from breaking away cleanly

installed fuel tanks for outdoor kitchens. Portable gas grills and associated propane fuel tanks and similar devices for which building permits are not required are not subject to these requirements. However, communities may have other fire and life-safety requirements that must be met. In addition, when flooding is anticipated, owners should move portable grills and propane fuel tanks to a safe location where they will not pose a hazard or become floodborne debris.

Additional guidance can be found in FEMA P-348, *Protecting Building Utilities from Flood Damage* (2017), and FEMA P-259, *Engineering Principles and Practices for Retrofitting Flood-Prone Residential Structures* (2012).

6.6 Foundation Bracing

Foundation bracing is often used to stiffen pile foundations and/or improve comfort and reduce sway in elevated buildings. However, foundation designs without bracing are preferred in coastal areas because they minimize obstructions to flow and waves.

Free-of-obstruction considerations call for using only the minimum amount of foundation bracing necessary to achieve a stable design, and such bracing should be designed to withstand flood conditions up to and including the base flood. Additional bracing may be used to improve the comfort of building occupants (i.e., reduce building sway under non-flood conditions), but the additional bracing should not be as strong as that required for structural stability and should not be relied on to yield a stable design, as it may be lost during a flood.

Many coastal construction experts and design references advise relying on shore-perpendicular bracing and minimizing the use of shore-parallel bracing. However, because wind and seismic loads can act in any direction, this alternative may not always provide the structural stability that is required in some locations. Increasing the number of piles (by decreasing horizontal spacing), detailing moment connections at the tops of the piles (in the case of concrete piles and beams), and using grade beams are accepted ways of eliminating or reducing the need for foundation bracing. Designers may determine other ways to minimize the amount and type of bracing.

Diagonal timber cross-bracing is the most common type of bracing used on foundations under coastal homes. Unfortunately, timber braces frequently fail during severe flood events as a result of wave or debris impacts. If they survive, they can interfere with breakaway wall failure, trap debris, and transfer lateral flood loads to the foundation. Metal rod braces, while less susceptible to failure, can also trap floating debris (see Figure 14). Knee braces at the tops of pilings are sometimes preferred (Figure 15) because their position higher up on the pilings will present less obstruction to flow and waves.

When foundation bracing below the BFE is used, it must be placed so as not to interfere with the intended failure of breakaway wall panels (see Figure 16). Avoiding interference may require eliminating breakaway walls, shifting the location of breakaway walls, or redesigning the foundation so the need for certain braces is eliminated. Breakaway walls and foundation bracing should not be placed close to each other if either could adversely affect the intended performance of the other.

Figure 14:
Floating debris trapped by metal rod cross bracing

Figure 15: Knee bracing

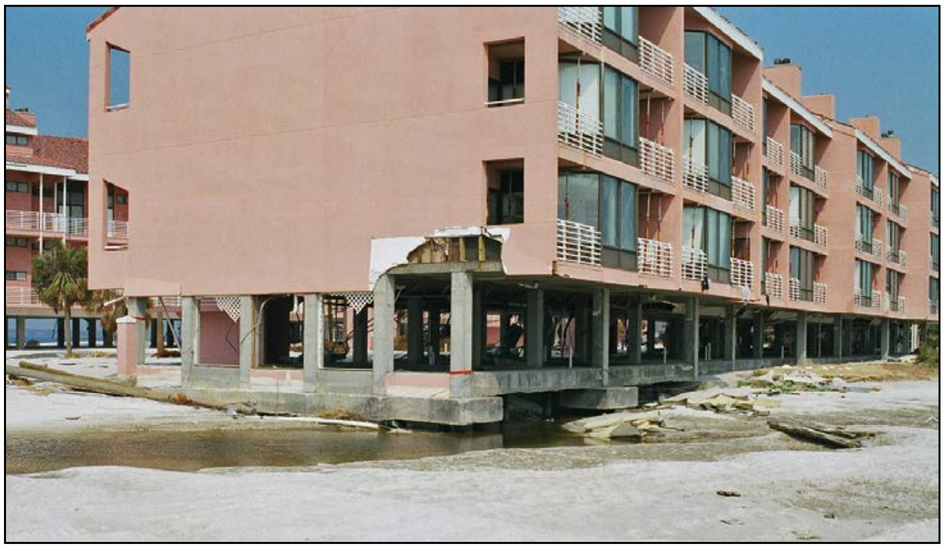
Figure 16: Cross bracing that interfered with the failure of a breakaway wall

6.7 Grade Beams

Grade beams are horizontal elements at or below the ground surface that tie the foundation piles or columns together and provide additional lateral support. They are typically reinforced concrete or wood.

Grade beams that are placed with their upper surfaces flush with or below the natural grade (the grade before the site is altered by fill or grading, if any) are not considered obstructions and are allowed by NFIP. However, storm erosion and local scour can expose and undermine grade beams, sometimes leaving them suspended above the post-storm ground profile. Designers must anticipate this circumstance and design grade beams to resist flood, wave, and debris loads and to remain in place and functional when undermined by scour and erosion (see Figure 17). Grade beams must also be designed and constructed so the vertical thickness is minimized, thereby reducing the lateral flood, wave, and debris loads acting on the beam and minimizing the transfer of these loads to the foundation.

Figure 17:
Grade beams that were exposed to flood forces during hurricane-induced scour; grade beams must resist flood, wave, and debris loads when undermined



6.8 Shear Walls

The NFIP regulations in 44 CFR § 60.3(e) state that only pile and column foundations are permitted in Zone V. In practice, this requirement has been relaxed by the NFIP and building codes for mid- and high-rise structures to allow certain types of solid walls, called shear walls, if detailed engineering calculations demonstrate that such walls are required to transfer lateral loads acting on upper stories to the ground, particularly in extreme-wind zones (see Figure 18). Even in these cases, shear walls should be used only if foundations and buildings are designed to resist all base flood conditions, all other design loads, and all appropriate load combinations.

SHEAR WALLS

ASCE 24 contains flood-related requirements and limitations for shear walls used to support buildings in Zone V. Contact your local building department for rules and building code requirements for shear walls in Zone V.

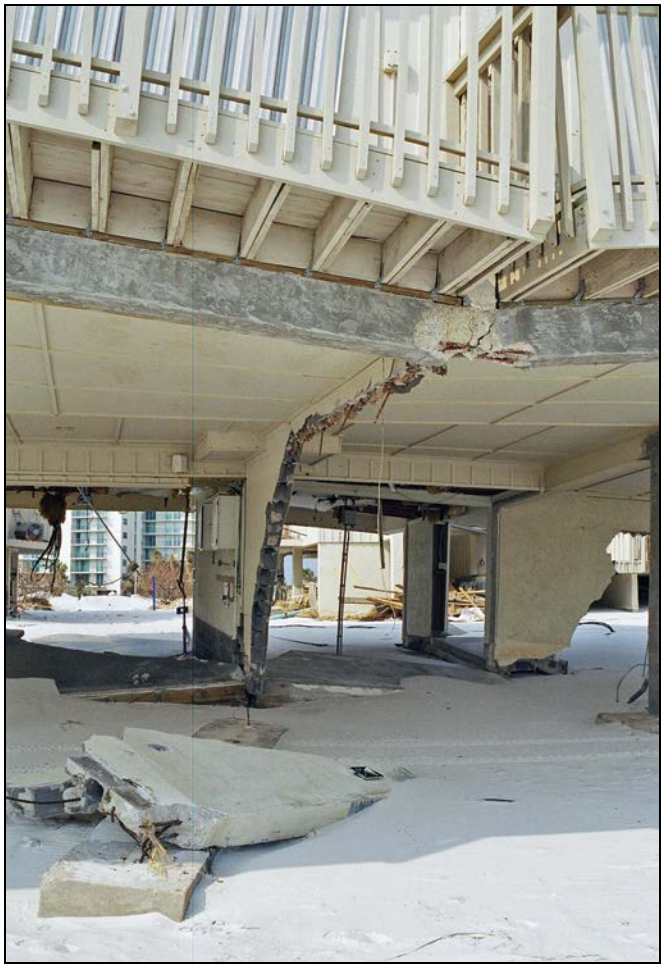
Shear walls should be constructed parallel to the anticipated direction of flood flow and wave attack (typically perpendicular to the shoreline) to allow floodwater and waves to pass freely. In some cases, building designs require both shore-perpendicular and shore-parallel shear walls. Use of shore-parallel shear wall segments should be limited to the minimum length required to transfer upper-story loads to

Figure 18:
High-rise buildings elevated on shore-perpendicular shear walls

the foundation. Shore-parallel shear walls should be designed with openings in the walls or gaps between shear wall segments to minimize trapping of floodwater, waves, and debris and minimize the total flood loads acting on the building. In any case, designs of these walls must be certified by registered design professionals as part of the requirement for certification of foundation designs.

Low-rise buildings in Zone V should be designed with pile or column foundations that are consistent with the NFIP regulations. Post-flood assessments have found that shear walls supporting older low-rise buildings often do not survive severe storm events. See Figure 19, which shows the failure of a wall section of a building supported on columns and shore-perpendicular walls. Wall failure led to failure of the elevated floor beam and floor. In this instance, the building was an older non-conforming building, and the solid walls rested on shallow footings (a means of support not permitted by the NFIP or building codes for buildings in Zone V). The wall failure was likely due to both lateral flood loads and foundation undermining.

Figure 19:
Failure of a shore-perpendicular solid foundation wall that supported a low-rise building, which resulted in failure of the beam and floor system that were supported by the shore-perpendicular wall



6.9 Slabs

Concrete slabs are commonly used beneath elevated buildings in Zone V for vehicle parking and as floors of enclosed storage or building access areas. The vertical elements elevating the building should not rest on the slab to avoid an NFIP flood insurance rating of "non-elevated."

SLABS AND NFIP FLOOD INSURANCE

There is no difference in NFIP flood insurance premiums between having a frangible slab or a self-supporting structural slab for two otherwise identical elevated buildings.

Post-disaster assessments conducted by FEMA have concluded that unreinforced slabs less than 4 inches thick tend to break up into small pieces without causing adverse effects to elevated buildings (see Figure 20). Reinforced concrete slabs thicker than 4 inches tend not to break up into small pieces, can become dislodged and act as obstructions, and can transfer unanticipated loads to building foundations (see Figure 21).

Figure 20:
Damage to building foundation caused in part by failure of the reinforced slab undermined by erosion

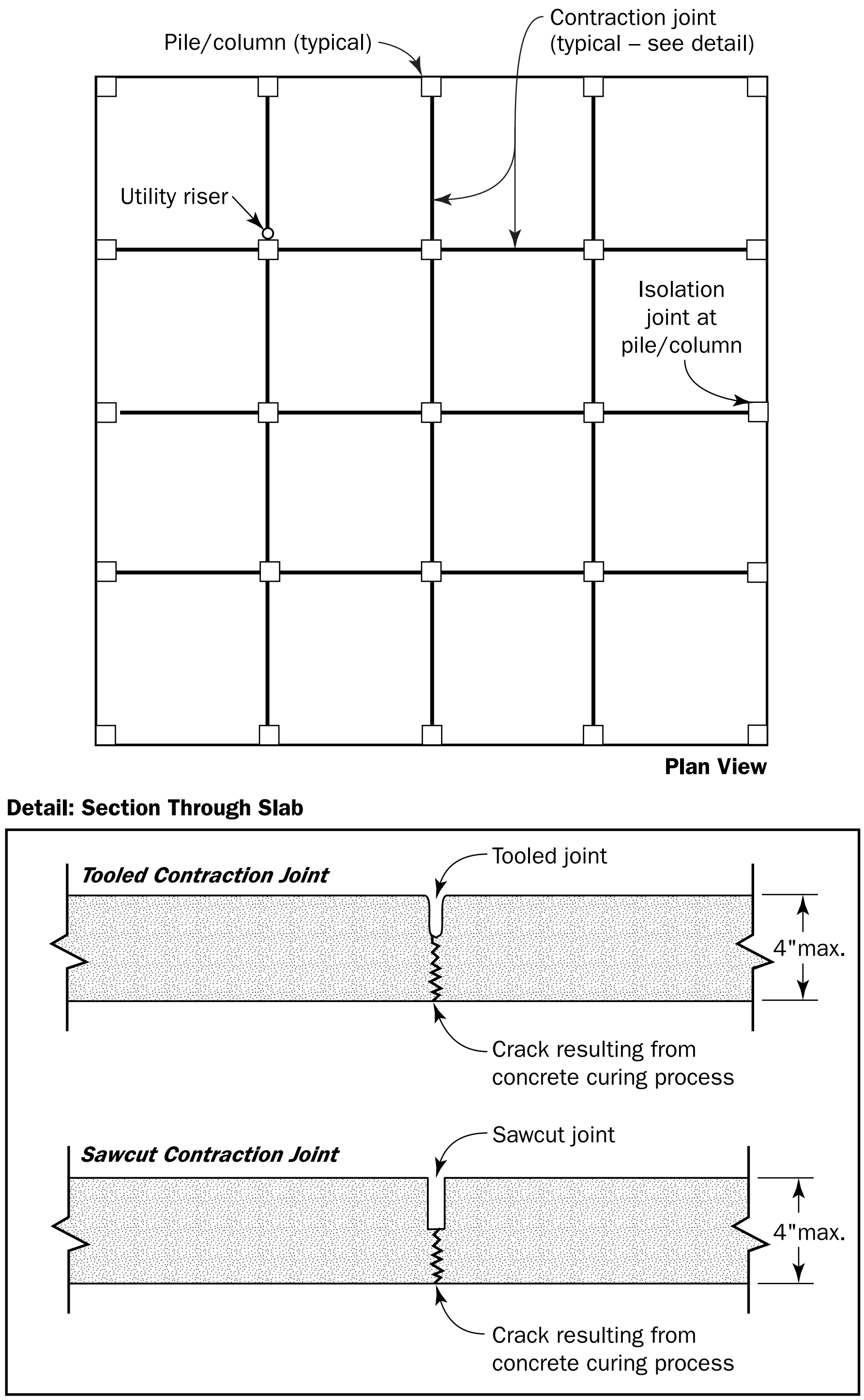
Figure 21:
Unreinforced slab that broke apart without imposing loads on the foundation

Post-disaster assessments have determined that slabs perform well if they meet the requirement in ASCE 24-14, Section 9.3, to either:

- Be frangible (break into small pieces), floating slabs supported by compacted soil, not attached to the building foundation, and designed and constructed with a maximum thickness (traditionally 4 inches), without reinforcement and without turned down edges, or
- Be designed and constructed as self-supporting structural slabs capable of remaining intact and functional during flooding up to and including base flood conditions, including expected erosion.

Building foundations must be capable of resisting any added loads and increase in local scour due to the presence of the slabs.

In most circumstances, and for low-rise buildings in Zone V (including residences), the best alternative is to use frangible slabs. This alternative is also appropriate for other uses of slabs, such as pool decks, sidewalks, and patios. Figure 22 illustrates one possible design for such a slab.



NOTE: Install expansion and isolation joints as appropriate in accordance with standard practice or as required by state and local codes.

Figure 22: Example of frangible slab design

Reinforced, self-supporting structural slabs below the BFE may be appropriate for large mid- and high-rise structures that are supported on deep piles because these structures are typically much heavier and less prone to damage from flood loads. If a frangible parking slab is constructed beneath such a structure, reoccupation of an otherwise intact and usable structure after a severe coastal storm event may be delayed due to loss of parking. A self-supporting structural slab could be considered in such situations.

Reinforced, self-supporting structural slabs and grade beams beneath large buildings should be designed to be only as thick as necessary to support vehicle loads and other design loads. The slabs and beams should be connected and integral to the foundations, and all below-BFE components should be designed to act together to resist flood loads and other design loads. Obstructive effects will be minimized as long as the slab systems remain intact and horizontal so floodwater and waves pass above and below the slabs.

7 Site Development: Practices and Issues

This section discusses common site development practices and issues that may significantly affect the free passage of flood flow and waves under or around elevated buildings. When these practices are undertaken in accordance with the guidance in this section, they will be deemed to satisfy the NFIP free-of-obstruction requirement, and the potential obstructive effects will be minimized.

7.1 Accessory Storage Structures

In Zone V, certain small accessories structures (as defined in a community's floodplain management ordinance, which has been approved by FEMA) may be permitted below the BFE. Small accessory structures include small storage structures such as metal, plastic, or wood sheds that are disposable. FEMA considers "small" to mean less than or equal to 100 square feet.

If accessory storage structures below the BFE do not meet the size considerations mentioned above, or if the structures are of significant size and made of material that is likely to create either damaging debris or flow and wave-diversion problems, communities could consider granting variances in accordance with their floodplain management ordinances and 44 CFR § 60.6. Alternatively, a best practice is to have accessory storage structures constructed and elevated in compliance with NFIP requirements.

ADDITIONAL ACCESSORY STRUCTURE CONSIDERATIONS

Some communities have FEMA-approved regulations that specify limitations on the size of accessory structures that are allowed in SFHAs without having to comply with elevation requirements. Other considerations for accessory structures are set forth in FEMA policies and guidance.

Local officials should consult NFIP State Coordinators or FEMA Regional Offices for additional guidance and for appropriate size limits and language to include in local regulations.

Small accessory storage structures that are not elevated must be anchored to resist wind loads (see Figure 23) and designed to resist flotation that may occur even under relatively shallow flood depths. However, because small accessory storage structures are unlikely to withstand wave loads, their loss should be anticipated during the base flood, and the effects that resultant debris may have on nearby structures must be considered.

Figure 23:
Small accessory structure that was moved by flood and wind forces

In addition, small accessory storage structures must be unfinished on the interior, constructed of flood damage-resistant materials, and used only for storage; moreover, if a structure is provided with electricity, the service must be above the BFE with all branch circuits descending below the BFE fed from ground-fault circuit interrupter breakers. Accessory storage structures must not be used for any habitable or other prohibited purpose.

Separate accessory storage structures must not be located directly under elevated buildings. An alternative is to create storage space below the elevated structure by enclosing an area with breakaway walls.

7.2 Detached Garages

Detached garages, such as those typically built for single-family homes or multi-family structures, are too large to qualify as accessory structures that are allowed below the BFE (see Section 7.1). Therefore, detached garages must be elevated on piles or columns and comply with other requirements for structures in Zone V.

Large, fully engineered, free-standing parking garages that satisfy Zone V design and construction requirements are permitted, even if portions lie below the BFE (e.g., vehicle ramps, stairwells, elevator shafts, parking spaces). These structures are not walled and roofed in the traditional sense and can be designed to allow the free passage of floodwater and waves.

ALTERNATIVE TO DETACHED GARAGES

Garages may be constructed under elevated buildings and enclosed with breakaway walls (see Technical Bulletin 9, *Design and Construction Guidance for Breakaway Walls*).

7.3 Erosion Control Structures

Erosion control structures, such as bulkheads, seawalls, retaining walls, and revetments, are obstructions when installed beneath elevated coastal buildings and are not permitted even if not attached to the building foundations. Erosion control structures can transfer damaging flood loads to building foundations and greatly increase the potential for redirecting flood flow and waves onto the elevated portions of coastal buildings). Figure 24 shows an example of waves running up and overtopping an erosion control structure. Figure 25 shows an example of timbers attached to a pile foundation (constituting a bulkhead), which is not permitted.

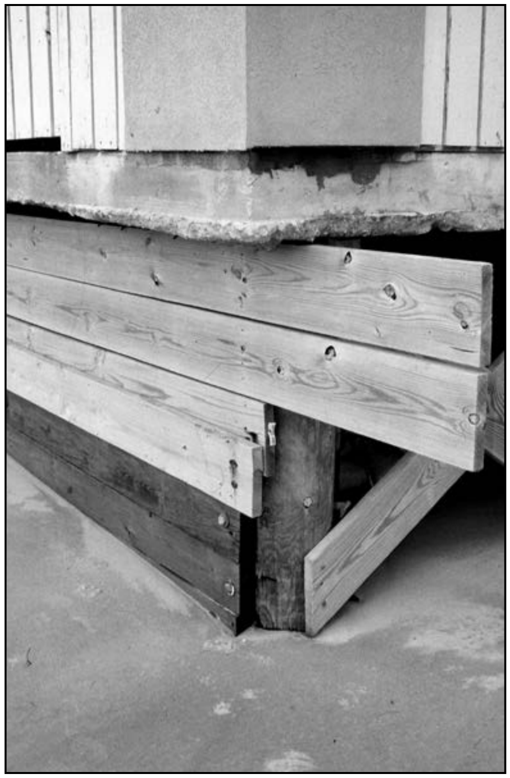
EFFECT OF EROSION CONTROL STRUCTURES ON WAVES

Guidance for evaluating potential effects of erosion control structures on waves is contained in the U.S. Army Corps of Engineers *Coastal Engineering Manual* (2002 and updates). Generally, erosion control structures with a steep face (1:2 [vertical to horizontal] or steeper) result in the greatest wave runup.

Figure 24: Wave runup and overtopping at an erosion control structure

Although the NFIP does not prohibit bulkheads, seawalls, retaining walls, or revetments outside a building's footprint, communities and design professionals must carefully consider the potentially significant effects of these structures. A general rule of thumb is the greater the horizontal distance between an erosion control structure and a building, the less likely that wave runup and overtopping will adversely affect the building. Although local or state regulations may prohibit the construction of erosion control structures until erosion is within a few feet of a building foundation (to maximize the recreational beach area seaward of the structure), the proximity of erosion control structures to buildings may contribute to wave runup and wave reflection damage.

Figure 25:
Shore-parallel timbers attached to a pile foundation that were intended to act as a bulkhead but constituted an obstruction and are not permitted



FEMA's coastal mapping guidance suggests that a 30-foot-wide "VE overtopping splash zone" (the area where waves breaking on or running up the seaward face of an erosion control structure land or splash down) be mapped landward of erosion control structures, but the guidance also contains site-specific calculations that can lead to a narrower splash zone. For floodplain management purposes, a 30-foot minimum splash zone width is desirable for new construction landward of existing erosion control structures, but this width may not be feasible for existing buildings situated close to erosion control structures. There is no established minimum distance between a building and an erosion control structure, but a reasonable minimum width is 10 to 15 feet. States and communities should take local conditions and observed building damage into account when establishing minimum distances.

7.4 Fences and Privacy Walls

Fences and privacy walls, including walls separating one property from another, may obstruct or divert flood flow and waves toward buildings. Their potential effects on buildings, including debris generation, should be evaluated. Open fences (e.g., wood, plastic, open masonry units, metal slat fencing with generous openings) are presumed to not cause harmful diversion of floodwater or wave runup and reflection. Fences with small openings and solid fences and walls may divert flow and waves and can trap debris.

Solid fences, privacy walls, and fences prone to trapping debris must be designed and constructed to fail under base flood conditions without causing harm to nearby buildings. Where building or fire codes require ground-level walls for tenant fire separation, designers should strive to satisfy code requirements while minimizing potential adverse effects from flood diversion.

Siting of new buildings near fences and privacy walls should be reviewed carefully given the impact that these structures could have on a building if they fail during a flood event. Figure 26 shows an example of a shore-perpendicular solid privacy wall that failed during a coastal flood event and damaged the pile foundation of an adjacent elevated building.

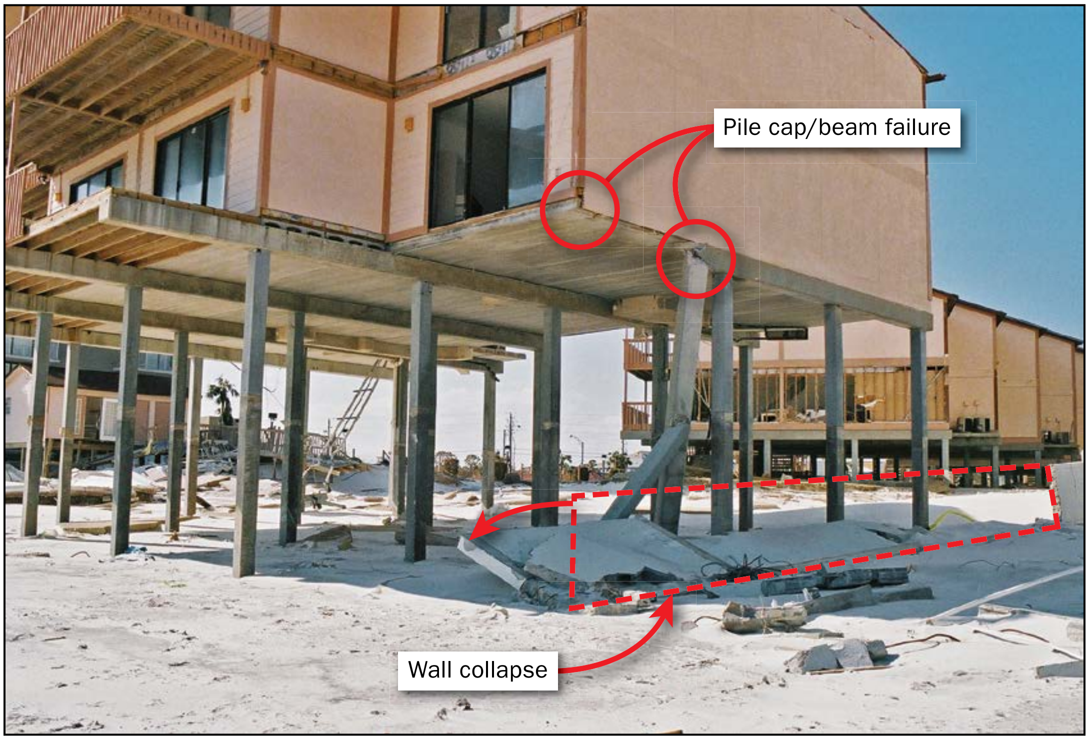


Figure 26: Shore-perpendicular reinforced masonry privacy wall that collapsed into the foundation of an adjacent building and contributed to failure of the corner foundation piling and pile cap/beam

7.5 Fill

NFIP regulations prohibit the use of fill for structural support of buildings in Zone V. Minor grading and the placement of minor quantities of nonstructural fill are allowed in Zone V but only for landscaping, drainage under and around buildings, and support of parking slabs, pool decks, patios, walkways, and similar site elements. Nonstructural fill should not prevent the free passage of floodwater and waves beneath elevated buildings, divert floodwater or waves such that building damage is exacerbated, or lead to damaging flood and wave conditions on a site or adjacent sites. Nonstructural fill should be assumed to wash away and should not be used in foundation design calculations.

Determining whether the placement and shaping of nonstructural fill will be detrimental is complicated. Therefore, some state and local

MINOR GRADING AND MINOR QUANTITIES OF NONSTRUCTURAL FILL

Minor grading: Minimum grading necessary to provide for landscaping and drainage purposes required or allowed by community regulations, subject to the limitations described in this Technical Bulletin.

Minor quantity of fill: Minimum quantity necessary to provide for adequate drainage of areas below and around elevated buildings; support of parking slabs, in-ground pool decks, decks, patios, walkways, and similar site elements; and for site landscaping, subject to the limitations described in this Technical Bulletin.

regulations essentially prohibit placement of any nonstructural fill in Zone V. However, such limits on nonstructural fill can also lead to problems such as ponding of rainfall around or under buildings. Other states and communities accept some (unspecified) amount of nonstructural fill provided an engineering analysis is performed and an engineer certifies that the fill will not lead to damaging flow diversion or wave runup and reflection. However, credible and defensible analyses are difficult to perform using current engineering methods and models for the small quantities of fill typically used on individual lots.

The placement of nonstructural fill in Zone V for landscaping, drainage, and slab support may be acceptable under certain circumstances using the evaluation criteria described below. Unless in conflict with state or local limitations, local officials are expected to apply these criteria using discretion to achieve the desired performance while giving deference to the general intent of the following criteria as described in the paragraphs that follow. Several criteria are listed, and they may not all agree, depending on specific circumstances.

7.5.1 Type of Fill

Fill placed on Zone V sites should be similar to natural soils in the area. In many coastal areas, natural soils are clean sand or sandy soils free of large quantities of clay, silt, and organic material. Nonstructural fill should not contain large rocks and debris. If the fill is similar to and compatible with natural soils, there is no need to require designers to investigate or certify whether the fill has a tendency for excessive natural compaction; an investigation or certification is a common requirement in many floodplain regulations. If the fill material is similar to natural soils, its behavior under flood conditions will be similar to the behavior of natural soils.

7.5.2 Fill Thickness

The addition of small thicknesses of site-compatible, nonstructural fill in Zone V is not likely to lead to adverse effects on buildings. There are no established rules as to what constitutes an acceptable fill thickness, so it must be addressed on a case-by-case basis and in some cases may require an engineering analysis of flow and wave effects of the fill. Designers should check with the community about fill thickness thresholds triggering engineering analyses.

Placement of up to 2 feet of fill under or around an elevated building can generally be assumed to comply with free-of-obstruction requirements and be acceptable without engineering analysis or certification, provided basic site drainage principles are not violated (see Section 7.5.4) and provided there are no other site-specific conditions or characteristics that would render the placement of the fill damaging to nearby buildings (e.g., if local officials have observed that the placement of similar quantities of fill has led to building damage during coastal storm events).

If fill is proposed for a site, the proposed final grade should be compared to local topography. If the proposed final fill configuration is below the threshold established by the community and the fill configuration is similar to grades and slopes in the immediate vicinity, a detailed analysis of the effects on flood flow and waves may not be needed. However, if the proposed fill configuration exceeds the community's configuration deemed to comply fill thickness threshold or the proposed fill configuration exceeds local grade heights and variations, an engineering analysis may be required by the community.

In cases where site development involves removing a layer of soil and fill is added to the site later, the fill thickness should be evaluated relative to the pre-removal soil elevation, not the removed soil elevation.

7.5.3 Prevention of Ponding

Most communities establish minimum floor elevations to ensure that water does not collect at or under buildings. Floor elevation requirements are frequently tied to nearby road elevations, and the quantity of fill required to raise building footprint areas typically falls within the fill height allowance mentioned in Section 7.5.2. There is no compelling reason to restrict the placement of site-compatible, nonstructural fill beneath buildings in Zone V if the fill will prevent ponding and saturated soil conditions, as long as other drainage requirements for grades and slopes can be satisfied.

7.5.4 Site Drainage Requirements

Most communities establish minimum slopes for building sites to facilitate drainage away from buildings (typically 1 unit vertical to 20 units horizontal [5 percent]). Slopes of 1 unit vertical to 3 units horizontal (or steeper) can produce appreciable wave runup. Conversely, slopes shallower than 1 unit vertical to 5 units horizontal (regardless of fill height) will probably not cause or worsen wave runup or wave reflection capable of damaging adjacent buildings. Figure 27 shows an example of fill placement that is considered acceptable because the fill depth is modest and the side slopes are gentle. FEMA's Hurricane Ivan Mitigation Assessment Team concluded that the presence and configuration of the fill did not cause additional flood or wave damage to either the elevated building or the nearby older non-elevated building (FEMA, 2005). The adjacent older, non-elevated building in Figure 27 would likely sustain structural damage during a coastal flood, even if the fill were not present. Swales and conventional site drainage practices should be used to mitigate potential effects of runoff from filled areas.

Figure 27:
Post-hurricane photo showing an elevated building surrounded by gently sloping fill and an adjacent, damaged, older, non-elevated building

7.5.5 Vertical Clearance between Top of Fill and Bottom of Lowest Horizontal Structural Member of Lowest Floor

There are no established rules as to what constitutes acceptable vertical clearance, so it must be addressed on a case-by-case basis. Designers should check with the jurisdiction about minimum vertical clearance requirements.

When the BFE is above the existing ground, placement of nonstructural fill between the ground and the lowest horizontal structural member of the lowest floor may be permitted, but it is advisable to maintain some vertical clearance between the bottom of the lowest horizontal structural member and the top of the fill. Vertical clearance should be established to ensure that base flood flow and waves will pass beneath the elevated building and the fill will not contribute to wave runup and flood damage to the elevated building.

When the BFE is below the existing ground elevation (see Section 7.6), vertical clearance between the ground (including any nonstructural fill) and the lowest horizontal structural member of the lowest floor may not be needed as long as adequate site drainage is provided.

7.5.6 Fill Compaction

The NFIP regulations are explicit in that fill must not be used for structural support of buildings in Zone V. However, compaction of fill below and around elevated buildings used to support parking slabs, in-ground pool decks, patios, sidewalks, and similar site amenities is consistent with the intent of the regulations.

7.5.7 Dune Construction, Repair, and Reconstruction

Dunes are natural features in many coastal areas, and they can erode during storms and recover naturally over time. The natural recovery process can be accelerated by replacing the eroded dune with compatible sand, planting dune grasses, and installing sand fences (see Chapter 5 of *The Dune Book* [Rogers and Nash, 2003]). In general, these activities should not be considered detrimental even if part of the dune lies under a building's footprint. The addition of sand to restore a site to its pre-storm grades and stabilization with dune vegetation will likely do more good than harm in terms of flood damage reduction.

> **DUNE EXCAVATION MAY INCREASE POTENTIAL FLOOD DAMAGE**
>
> Communities must prohibit manmade alteration of sand dunes in Zone V if such alteration would increase potential flood damage (per 44 CFR § 60.3(e)(7)). Where the ground (dune) elevation is at or above the BFE, excavation to place the bottom of the lowest horizontal structural member of lowest floor at the BFE is not recommended and may in fact violate the limitation on alterations that increase potential flood damage.

Concerns about placement of nonstructural, clean sand under and around beachfront buildings should not be the basis for prohibiting dune maintenance and construction, beach nourishment, or similar activities. Dune construction, repair, and reconstruction under or around elevated buildings may be assumed to be acceptable as long as the scale and location of the dune work is consistent with local beach-dune morphology and reasonable vertical clearance is maintained between the top of the dune and the elevated building's floor system. ASCE 24-14 permits dune construction and reconstruction under and around elevated buildings but requires an engineering report documenting that the fill placement will not cause building damage by wave runup or reflection or deflection of floodwater.

7.5.8 Timing of Fill Placement

Sometimes fill is placed on a site months or years before building construction begins. This can be problematic unless the community tracks site improvements and fill placement. If the original natural grade elevation is unknown, borings or other site investigations may be required to determine the depth of fill and ensure adequate foundation depth.

7.6 Ground Elevations At or Above the Base Flood Elevation

In some Zone V areas, ground elevations are at or above the BFE, particularly along shorelines with well-developed dune fields. Mapped Zone V areas with ground above the BFE seem counterintuitive, but they are possible because of two Zone V mapping considerations:

- **Dune erosion.** Dunes can erode during the base flood (or lesser floods), resulting in a substantial lowering of the pre-storm grade to a level below the BFE. The BFE is mapped based on surge and waves passing over the eroded and inundated ground surface.
- **Presence of a primary frontal dune (PFD).** Zone V is mapped at a minimum to the inland extent (heel) of the PFD, even where the dune elevation is higher than the BFE (FEMA, 2014).

A ground elevation at or above the BFE may complicate the need to comply with Zone V design and construction requirements but does not eliminate it. It does raise the question of how the free-of-obstruction requirement applies in this situation: Because the soil at the site may erode during a coastal flood event, the area under the building will be exposed, and the exposed area must be free of obstructions.

The same free-of-obstruction considerations that apply to buildings elevated above grade apply to buildings where the BFE is below grade. Buildings must still be designed and constructed on pile or column foundations that are embedded deep into the ground, and the bottoms of the lowest horizontal structural members supporting the lowest floor must still be at or above the BFE. Vertical clearance between the bottom of the lowest horizontal structural member and the ground (see Section 7.5.5) is not required by the NFIP where ground elevations are at or above the BFE; however, communities should be contacted because they may have vertical clearance requirements. Any lowest horizontal structural members that come in contact with the fill must be composed of materials that can resist ground contact moisture levels. Minor site grading to drain water away from the foundation will also be necessary.

7.7 On-Site Septic Systems

On-site buried septic systems and mounded septic systems in Zone V are frequently exposed and/or displaced. In addition to compromising their subsequent use, damage can cause release of contents. Septic systems are often destroyed if they are near a shoreline. Therefore, septic systems should be located outside areas subject to erosion during the base flood or, if placed in an area subject to erosion, installed below the depth of expected erosion. The latter stipulation may conflict with septic system groundwater considerations, in which case an on-site septic system is not appropriate for the area, and alternate designs may be necessary.

On-site septic system tanks serving elevated buildings must not be structurally attached to building foundations. Plumbing and piping connections are required, and these items are allowed in Zone V. However, plumbing and piping components must not be attached to or pass through breakaway wall panels.

If mounded septic systems are used, they can require significant volumes of fill, which, if placed under or immediately adjacent to buildings, may constitute obstructions that divert flood flow and waves. An analysis of flow and wave effects should be undertaken. Mounded septic systems may be allowed in Zone V if they will not worsen flood and wave conditions for the buildings they serve or nearby buildings (see Section 7.5.2 for guidance on evaluating mounded systems near elevated buildings).

An additional consideration for on-site septic systems in Zone V is stated in 44 CFR § 60.3(a)(6)(ii) of the NFIP regulations, which requires "on-site waste disposal systems to be located to avoid impairment to them or contamination from them during flooding." FEMA P-348 provides additional guidance.

7.8 Restroom Buildings and Comfort Stations

Restroom buildings and comfort stations must be treated the same as other types of structures in Zone V and must meet the same elevation and design requirements as other buildings, even when the facilities are situated in public parks or recreation areas.

7.9 Swimming Pools and Spas

Three primary considerations relate to the placement of swimming pools and spas under or adjacent to buildings in Zone V:

- Whether the pool or spa will cause increased flood loads on buildings or exacerbate scour and erosion near buildings.
- Whether the pool or spa configuration is subject to NFIP use limitations for enclosed areas under elevated buildings.
- Whether a removable enclosure is placed around a pool or spa (usually in the winter) that will cause increased flood loads on buildings or exacerbate scour and erosion near buildings. NFIP flood insurance treats these enclosures as permanent enclosures even if they are only used seasonally or for short periods of time.

SWIMMING POOLS AND SPAS

Pools and spas adjacent to coastal buildings are allowed only if they will not act as obstructions that could lead to damage to nearby buildings. This effectively means that most pools and spas must be installed in-ground (either frangible or immovable) or completely elevated above the BFE. Swimming pools, spas, and related equipment are not covered by NFIP flood insurance.

Pools, pool decks, and walkways that are placed under or adjacent to coastal buildings must be structurally independent of the buildings and their foundations and must not contribute to building or foundation damage during the base flood. Three options, also recognized by ASCE 24-14, Section 9.6.2, satisfy this requirement:

- The pool can be elevated so the bottom of the lowest horizontal structural member supporting the pool (and the pool itself) is at or above the required flood elevation, or

- The pool can be designed and constructed to break away without producing debris capable of damaging nearby buildings, or
- The pool can be designed and constructed to remain in the ground and not divert flow or waves that can damage nearby buildings.

Registered design professionals must certify that pools or spas beneath or near buildings in Zone V will not be subject to flotation or displacement that will damage building foundations during a base flood or lesser event. In cases where pools are empty part of the year, flotation calculations should assume that pools are empty. Figure 28 shows a spa that was displaced and likely caused the failure of two piles that supported an elevated deck.

Figure 28:
Failure of two piles supporting an elevated deck that was likely caused by movement of a spa

The NFIP permits swimming pools and spas beneath elevated building only if the top of the pool or spa and accompanying deck or walkway are flush with the existing grade and the area around the pool or spa remains unenclosed. However, some states and communities may prohibit or restrict unenclosed pools and spas beneath elevated buildings. Designers should check with the local jurisdiction for any additional requirements.

The NFIP limits the use of enclosures under elevated buildings to parking of vehicles, building access, and storage. Because pools and spas do not satisfy these limitations, they are not allowed to be enclosed, even if enclosed by glass or breakaway walls. Use of lattice and insect screening is permitted around pools and spas below elevated buildings.

8 References

This section lists the references cited in this Technical Bulletin. Additional resources related to NFIP requirements are provided in Technical Bulletin 0.

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Technical Bulletin 0, *User's Guide to Technical Bulletins*

Technical Bulletin 2, *Flood Damage-Resistant Materials Requirements for Buildings Located in Special Flood Hazard Areas*

Technical Bulletin 4, *Elevator Installation for Buildings Located in Special Flood Hazard Areas*

Technical Bulletin 9, *Design and Construction Guidance for Breakaway Walls Below Elevated Buildings Located in Coastal High Hazard Areas*

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Requirements for Dry Floodproofed Below-Grade Parking Areas Under Non-Residential and Mixed-Use Buildings

Located in Special Flood Hazard Areas in Accordance with the National Flood Insurance Program

NFIP Technical Bulletin 6 / January 2021

FEMA

Comments on the Technical Bulletins should be directed to:

Department of Homeland Security / Federal Emergency Management Agency
Federal Insurance and Mitigation Administration (FIMA) Risk Management Directorate
Building Science Branch
400 C Street, S.W., Sixth Floor
Washington, DC 20472-3020

NFIP Technical Bulletin 6 (2021) replaces NFIP Technical Bulletin 6 (1993), *Below-Grade Parking Requirements in Special Flood Hazard Areas in Accordance with the National Flood Insurance Program*.

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Cover. Mixed-use building in Hoboken, NJ, with dry floodproofed below-grade parking, A. Holtzman, CFM

Figure 3. Stop logs inside building, Eugene Henry, Hillsborough County, FL, Retired Hazard Mitigation Manager and Floodplain Manager

Figure 5. Manually deployed panel, Savannah Trims, Inc.

Figure 6. Automatic gate, Andrew H. Hoyns

For more information, see the FEMA Building Science Frequently Asked Questions website at https://www.fema.gov/emergency-managers/risk-management/building-science/faq.

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Acronyms

ASCE	American Society of Civil Engineers
BFE	base flood elevation
CFR	Code of Federal Regulations
DFE	design flood elevation
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
IBC®	International Building Code®
ICC®	International Code Council®
I-Codes®	International Codes®
IRC®	International Residential Code®
LiMWA	Limit of Moderate Wave Action
NFIP	National Flood Insurance Program
SFHA	Special Flood Hazard Area

1 Introduction

This Technical Bulletin provides guidance on the National Flood Insurance Program (NFIP) floodplain management requirements for the design and certification of dry floodproofed below-grade parking areas. This guidance applies to new and substantially improved non-residential buildings and mixed-use buildings in Special Flood Hazard Areas (SFHAs) identified as Zone A (A, AE, A1-30, AH, and AO) on Flood Insurance Rate Maps (FIRMs).

Below-grade areas, including areas used for parking, are not permitted under residential buildings in SFHAs identified as Zone A. In addition, below-grade areas are not permitted under any building in SFHAs identified as Zone V (V, VE, V1-30, and VO), and dry floodproofing is not permitted for any buildings in coastal high hazard areas identified on FIRMs as Zone V.

NFIP TECHNICAL BULLETIN 0

NFIP Technical Bulletin 0, *User's Guide to Technical Bulletins*, should be used as a reference with this Technical Bulletin. Technical Bulletin 0 describes the purpose and use of the Technical Bulletins. It includes common concepts and terms, lists useful resources, and includes a crosswalk of the sections of the NFIP regulations identifying the Technical Bulletin that addresses each section of the regulations and a subject index.

Readers are cautioned that the definitions of some of the terms that are used in the Technical Bulletins are not the same when used by the NFIP for the purpose of rating flood insurance policies.

Many large, fully engineered, non-residential and mixed-use buildings are designed with below-grade parking areas. These areas are used for parking of vehicles, access to the above-grade floors, and equipment and machinery servicing the buildings. Buildings in SFHAs designed with dry floodproofed below-grade parking areas may sustain significant structural damage if floodwater rises higher than anticipated in the designs. Such flooding may also damage parked vehicles, stored contents, and service equipment and machinery.

This Technical Bulletin highlights issues specific to dry floodproofing below-grade parking areas. It does not provide detailed guidance on the planning and design of dry floodproofing systems. Extensive guidance is available in FEMA P-936, *Floodproofing Non-Residential Buildings* (2013), and NFIP Technical Bulletin 3, *Requirements for the Design and Certification of Dry Floodproofed Non-Residential and Mixed-Use Buildings.*

ASCE 24: STANDARD OF PRACTICE FOR DRY FLOODPROOFING DESIGN

ASCE 24, *Flood Resistant Design and Construction,* is a consensus standard that is developed and maintained by the American Society of Civil Engineers (ASCE). ASCE 24 is a referenced standard in the International Codes (I-Codes), which means it is considered part of the requirements in these codes.

ASCE 24 represents the standard of practice for the design of buildings and structures in flood hazard areas, including the design of dry floodproofed buildings.

When a building owner proposes dry floodproofing measures for a non-residential building that is in an NFIP-participating community, the owner must provide certification that the structural designs, specifications, and plans for the construction of the dry floodproofing measures were developed and/or reviewed by registered professional engineers or architects (design professionals). The certification must state that the proposed dry floodproofing design and proposed methods of construction are in accordance with accepted standards of practice for achieving the required performance. Design professionals who sign and seal certifications must be licensed to practice in the state where projects are located.

Technical Bulletin 3 describes FEMA Form 086-0-34, NFIP Floodproofing Certificate for Non-Residential Structures, and includes instructions on completing the certificate. FEMA developed the Floodproofing Certificate to provide the information that insurance underwriters require to rate dry floodproofed buildings. The certificate identifies ASCE 24-14 and ASCE 24-05 (or equivalent) as the accepted standard of practice.

Parking areas that are at grade or above grade (i.e., not below grade on all sides) are permitted under elevated buildings provided all other NFIP requirements are met. At-grade and above-grade parking areas are not addressed in this Technical Bulletin.

Questions about dry floodproofing requirements for below-grade parking areas should be directed to the appropriate local official, National Flood Insurance Program State Coordinating Office, or FEMA Regional Office.

TERMS USED IN THIS TECHNICAL BULLETIN

- **Ancillary area:** Common area such as a lobby, foyer, office used by building management, exercise space, meeting room, and mail room (FEMA P-2037, *Flood Mitigation Measures for Multi-Family Buildings* [2019]).
- **Basement:** “Any area of the building having its floor subgrade (below ground level) on all sides” (Title 44 Code of Federal Regulations [CFR] § 59.1). The NFIP regulations do not allow basements to extend below the base flood elevation (BFE) except in dry floodproofed non-residential buildings.
- **Dry floodproofing:** Combination of measures that makes a building and attendant utilities and equipment watertight and substantially impermeable to floodwater, with structural components having the capacity to resist flood loads.
- **Flood protection level:** Elevation to which flood protection measures are designed. The flood protection level is the most restrictive of (1) the BFE plus the prescribed amount of freeboard specified in ASCE 24, (2) the design flood elevation (DFE) if a different flood is used for regulatory purposes, and (3) the elevation relative to the BFE specified in local floodplain management regulations.
- **Floodproofing:** “Any combination of structural and non-structural additions, changes, or adjustments to structures which reduce or eliminate flood damage to real estate or improved real property, water and sanitary facilities, structures and their contents” (44 CFR § 59.1).
- **Mixed-use building:** Building that has both residential and commercial or other non-residential uses. The term does not include multi-family residential buildings that have ancillary areas but no non-residential uses.

(continued on page 3)

TERMS USED IN THIS TECHNICAL BULLETIN (continued)

- **Non-residential building:** Building that has a commercial or other non-residential use.
- **Residential building:** Building designated for habitation. Ancillary areas of residential buildings that serve only residents are residential ancillary areas and include laundry facilities, storage rooms, mail rooms, recreational rooms, parking garages, and exercise facilities.
- **Substantially impermeable:** The use of materials and techniques that restrict the passage of water and seepage through pathways (joints, cracks, openings, channels) and points of entry and that limit the accumulation of water during flooding. According to ASCE 24 and the U.S. Army Corps of Engineers (USACE), a structure is considered substantially impermeable if the maximum accumulation is not more than 4 inches in a 24-hour period without relying on devices for the removal of the water (USACE, 1995).
- **Zone A:** Flood zones shown on FIRMs as Zone A, AE, A1-30, AH, AO, A99, and AR.
- **Zone V:** Flood zones shown on FIRMs as Zone V, VE, V1-30, and VO.

Other terms used in this Technical Bulletin are defined in the glossary in Technical Bulletin 0.

2 National Flood Insurance Program Regulations

An important NFIP objective is protecting buildings constructed in SFHAs from damage caused by flooding. The SFHA is the land area subject to flooding by the base flood. SFHAs are shown on FIRMs prepared by FEMA as Zones A and V. The base flood is the flood that has a 1 percent chance of being equaled or exceeded in any given year (commonly called the "100-year" flood).

The NFIP floodplain management regulations include minimum building design criteria that apply to:

- New construction
- Work determined to be Substantial Improvements, including improvements, alterations, and additions
- Repair of buildings determined to have incurred Substantial Damage

The NFIP regulations for non-residential buildings in SFHAs, including requirements when those buildings are elevated or dry floodproofed, are codified in Title 44 Code of Federal Regulations (CFR) Part 60, Criteria for Land Management and Use. The subsections below provide excerpts of the regulations that are applicable to dry floodproofed below-grade parking areas under non-residential and mixed-use buildings in SFHAs identified as Zone A.

For floodplain management purposes, a basement is "any area of the building having its floor subgrade (below ground level) on all sides" (44 CFR § 59.1). Therefore, parking areas that are below grade on all sides are subject to the requirements for basements that are cited in the excerpts.

NFIP REQUIREMENTS AND HIGHER REGULATORY STANDARDS

State or Local Requirements. State or local floodplain management requirements that are more restrictive or stringent than the minimum requirements of the NFIP take precedence. The Technical Bulletins and other FEMA publications provide guidance on the minimum requirements of the NFIP and describe best practices. Design professionals, builders, and property owners should contact local officials to determine whether more restrictive provisions apply to buildings or sites in question. All other applicable requirements of the state or local building codes must also be met.

Substantial Improvement and Substantial Damage. As part of issuing permits, local officials must review not only proposals for new construction but also for work on existing buildings to determine whether the work constitutes Substantial Improvement or repair of Substantial Damage. If the work is determined to constitute Substantial Improvement or repair of Substantial Damage, the buildings must be brought into compliance with the NFIP requirements for new construction. Some communities modify the definitions of Substantial Improvement and/or Substantial Damage to be more restrictive than the NFIP minimum requirements. For more information on Substantial Improvement and Substantial Damage, see FEMA P-758, *Substantial Improvement/Substantial Damage Desk Reference* (2010), and FEMA 213, *Answers to Questions About Substantially Improved/Substantially Damaged Buildings* (2018).

Higher Building Elevation Requirements. Some states and communities require that non-residential buildings be elevated or dry floodproofed (allowed only in Zone A) above the NFIP minimum requirement. The additional elevation is called freeboard. Design professionals, builders, and property owners should check with local officials to determine whether a state or community has freeboard requirements. References to building elevations in this Technical Bulletin, including the required flood protection level, should be construed as references to the community's elevation requirement where freeboard is required.

2.1 Dry Floodproofed Below-Grade Parking Areas: Permitted Under Non-Residential Buildings in Zone A

Parking areas that are below grade on all sides are permitted under non-residential buildings and mixed-use buildings in any Zone A provided that the buildings (including parking areas) are dry floodproofed to or above the BFE in accordance with the design requirements in 44 CFR Section 60.3(c)(3)(ii) and the structural designs, specifications, and plans are certified.

Section 60.3(c)(3) of the NFIP regulations states that a community shall:

> Require that all new construction and substantial improvements of non-residential structures within Zones A1-30, AE and AH zones on the community's firm [sic] (i) have the lowest floor (including basement) elevated to or above the base flood level or, (ii) together with attendant utility and sanitary facilities, be designed so that below the base flood level the structure is watertight with walls substantially impermeable to the passage of water and with structural components having the capability of resisting hydrostatic and hydrodynamic loads and effects of buoyancy.

Section 60.3(c)(8) states that in Zone AO (areas of sheet flow with depths of 1 to 3 feet), a community shall:

> Require within any AO zone on the community's FIRM that all new construction and substantial improvements of nonresidential structures (i) have the lowest floor (including

> basement) elevated above the highest adjacent grade at least as high as the depth number specified in feet on the community's FIRM (at least two feet if no depth number is specified), or (ii) together with attendant utility and sanitary facilities be completely floodproofed to that level to meet the floodproofing standard specified in [44 CFR] § 60.3(c)(3)(ii).

Section 60.3(c)(4) requires that floodproofing designs be certified in the following manner:

> Provide that where a non-residential structure is intended to be made watertight below the base flood level, (i) a registered professional engineer or architect shall develop and/or review structural design, specifications, and plans for the construction, and shall certify that the design and methods of construction are in accordance with accepted standards of practice for meeting the applicable provisions of paragraph (c)(3)(ii) or (c)(8)(ii) of this section, and (ii) a record of such certificates which includes the specific elevation (in relation to mean sea level) to which such structures are floodproofed shall be maintained with the official designated by the community under [44 CFR] § 59.22(a)(9)(iii).

2.2 Dry Floodproofed Below-Grade Parking Areas: Permitted Under Mixed-Use Buildings in Zone A

The NFIP regulations and published FEMA guidance use, but do not define, the terms "non-residential" and "residential" and do not use or define the term "mixed-use." In general, "residential" refers to dwelling units and the building systems and ancillary areas that support the residential units. Building systems include electrical, heating, ventilation, plumbing, and air conditioning equipment and other service equipment. Ancillary areas include areas that are designated or used by on-premises guests. "Non-residential" refers to buildings with commercial or other non-residential uses. ASCE 24 has a more extensive definition of "residential" and defines "non-residential" as buildings that are not classified as residential. ASCE 24 commentary defines "mixed-use" and "residential portions of mixed-use buildings."

FEMA considers buildings with both non-residential and residential uses to be mixed-use buildings. Fully engineered mixed-use buildings may be designed with below-grade parking areas. The non-residential portions of mixed-use buildings are allowed to be dry floodproofed provided that all residential units, the building systems and service equipment that serve residential units, and the ancillary areas for use by residents are elevated above the required elevation. See FEMA P-2037 for more information.

In keeping with the requirements for enclosures below elevated residential buildings, lobbies that provide access to both residential and non-residential portions of mixed-use buildings are allowed to be dry floodproofed, provided there also is separate access to the residential spaces that, if enclosed by walls, complies with the requirements for enclosures below elevated buildings (sometimes called wet floodproofing).

2.3 Dry Floodproofed Below-Grade Parking Areas: Not Permitted Under Residential Buildings in Zone A

A defining characteristic of the NFIP regulations applicable in any Zone A is the requirement for the lowest floor of residential buildings to be elevated to or above the BFE. Any area that is below grade on all sides is a basement, and basements are not permitted under residential buildings. The regulations do not include provisions to allow residential buildings to be dry floodproofed. Areas under elevated residential buildings may be enclosed and used solely for parking of vehicles, building access, or storage, provided the enclosures comply with the relevant requirements.

Section 60.3(c)(2) of the NFIP regulations states that a community shall:

> Require that all new construction and substantial improvements of residential structures within Zones A1-30, AE and AH zones on the community's FIRM have the lowest floor (including basement) elevated to or above the base flood level …

Section 60.3(c)(7) of the NFIP regulations states that a community shall:

> Require within any AO zone on the community's FIRM that all new construction and substantial improvements of residential structures have the lowest floor (including basement) elevated above the highest adjacent grade at least as high as the depth number specified in feet on the community's FIRM (at least two feet if no depth number is specified).

3 Building Codes and Standards

In addition to complying with NFIP requirements, all new construction, Substantial Improvements, and repair of Substantial Damage must comply with the applicable building codes and standards adopted by states and communities.

The International Codes® (I-Codes®), published by the International Code Council® (ICC®), are a family of codes that includes the International Residential Code® (IRC®), International Building Code® (IBC®), International Existing Building Code® (IEBC®), and codes that govern the installation of mechanical, plumbing, fuel gas service, and other aspects of building construction. FEMA has deemed that the latest published editions of the I-Codes generally meet or exceed the NFIP requirements for buildings and structures in flood hazard areas. Excerpts of the flood provisions of the I-Codes are available on FEMA's Building Science – Flood Publications webpage (https://www.fema.gov/emergency-managers/risk-management/building-science/flood).

HOTELS AND MOTELS

Hotels and motels are commercial buildings. For floodplain management purposes, guest rooms and the building systems and service equipment that serve guest rooms are residential and are not permitted to be located in areas of the buildings that are dry floodproofed. The requirements for building systems and service equipment that serve guest rooms and access to guest rooms are the same as the requirements for the residential portions of mixed-use buildings.

3.1 International Residential Code

The International Residential Code (IRC) applies to one- and two-family dwellings and townhomes not more than three stories above grade plane. The IRC does not allow basements or enclosed areas under elevated dwellings to be below grade on all sides. The IRC does not allow dry floodproofing of buildings within its scope.

3.2 International Building Code and ASCE 24

The International Building Code (IBC) applies to all applicable buildings and structures. While used primarily for buildings and structures other than dwellings within the scope of the IRC, the IBC may also be used to design dwellings.

The flood provisions of the latest published editions of the IBC generally meet or exceed NFIP requirements for buildings through reference to the standard ASCE 24, *Flood Resistant Design and Construction*.

> **INTERNATIONAL BUILDING CODE AND ASCE 24 COMMENTARIES**
>
> The ICC publishes companion commentary for the IBC, and ASCE publishes a companion commentary for ASCE 24. Although not regulatory, the commentaries provide information and guidance that is useful for complying with, interpreting, and enforcing requirements.

ASCE 24 applies to structures that are subject to building code requirements. ASCE 24 requirements for dry floodproofing, summarized in Table 1, are similar to the NFIP requirements. Table 1 refers to selected dry floodproofing requirements of the 2018 IBC and ASCE 24-14 and notes changes from 2015 and 2012 IBC and ASCE 24-05, along with a comparison to the NFIP requirements. Subsequent editions of the IBC and ASCE 24 should include comparable requirements.

Table 1: Comparison of Selected 2018 IBC and ASCE 24-14 Requirements with NFIP Requirements

Topic	Summary of Selected 2018 IBC / ASCE 24-14 Requirements and Changes from 2015 and 2012 IBC / ASCE 24-05	Comparison with NFIP Requirements
Definition of dry floodproofing	**2018 IBC Section 202 Definitions.** Defines dry floodproofing as a combination of design modifications resulting in a building, including the attendant utilities and equipment and sanitary facilities, being watertight with walls that are substantially impermeable and able to resist the loads required by ASCE 7, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*. Change from 2015 to 2018 IBC: No change. Change from 2012 to 2015 IBC: Added "and equipment." **ASCE 24-14 Section 1.2 Definitions.** Defines dry floodproofing as a combination of measures that result in making a structure and its utilities and equipment watertight with all elements substantially impermeable and with structural components having the capacity to resist flood loads. Change from ASCE 24-05: Expands the definition to require building and utilities and equipment serving the building to be watertight with walls substantially impermeable and able to resist flood loads rather than only requiring the building envelope to be substantially impermeable.	The definition of "dry floodproofing" (IBC and ASCE 24) is equivalent to the NFIP definition of "floodproofing" in NFIP 44 CFR § 59.1.
General flood hazard area requirements	**2018 IBC Section 1612.2 Design and construction.** Requires buildings and structures located in flood hazard areas to be designed and constructed in accordance with Chapter 5 of ASCE 7 and ASCE 24. Change from 2015 to 2018 IBC: Section renumbered from 1612.4 to 1612.2. Change from 2012 to 2015 IBC: Applies coastal high hazard area requirements in Coastal A Zones, if delineated.	Exceeds NFIP 44 CFR § 60.3(a)(3) with more specificity.

Table 1: Comparison of Select 2018 IBC and ASCE 24-14 Requirements with NFIP Requirements (continued)

<table>
<tr><th>Topic</th><th>Summary of Selected 2018 IBC / ASCE 24-14 Requirements and Changes from 2015 and 2012 IBC / ASCE 24-05</th><th>Comparison with NFIP Requirements</th></tr>
<tr><td>Flood hazard documentation</td><td>2018 IBC Section 1612.4(1.3) Flood hazard documentation.
Requires submission of a certification statement prepared and sealed by a registered design professional that dry floodproofing is designed in accordance with ASCE 24.
<u>Change from 2015 to 2018 IBC</u>: Section renumbered from 1612.5 to 1612.4.
<u>Change from 2012 to 2015 IBC</u>: Applies coastal high hazard area requirements in Coastal A Zones, if delineated.</td><td>Equivalent to NFIP 44 CFR § 60.3(c)(4).</td></tr>
<tr><td>Elevation</td><td>ASCE 24-14 Section 1.5.2 Elevation Requirements.
Allows for dry floodproofing of non-residential and the non-residential portions of mixed-use buildings below the BFE plus specified freeboard or the design flood elevation (DFE), whichever is higher, provided the dry floodproofing measures meet the requirements in Chapter 6.
ASCE 24-14 Section 2.3 Elevation Requirements.
Allows for dry floodproofing of non-residential and the non-residential portions of mixed-use buildings below the BFE plus specified freeboard or DFE, whichever is higher, provided the dry floodproofing measures meet the requirements in Chapter 6.
<u>Change from ASCE 24-05</u>: Requires Flood Design Class 4 buildings to be elevated to or protect to BFE plus 2 feet, or DFE, or 500-year flood elevation, whichever is highest.</td><td>Exceeds NFIP 44 CFR § 60.3(c)(3) and (8) by requiring freeboard.</td></tr>
<tr><td>Dry floodproofing</td><td>ASCE 24-14 Section 6.2 Dry Floodproofing.
• Permits dry floodproofing of non-residential buildings and non-residential portions of mixed-use buildings when the buildings are located outside High Risk Flood Hazard Areas, Coastal High Hazard Areas, and Coastal A Zones
• Requires techniques that make structures substantially impermeable and requires the use of flood damage-resistant materials, except on the interior of structures
• Requires sump pumps to remove water that accumulates from the passage of vapor and seepage during flooding
• Limits dry floodproofing to flood hazard areas with flood velocities that are less than or equal to 5 feet per second during the design flood
• Requires walls below the minimum elevations of dry floodproofing specified in Table 6-1 to be substantially impermeable to passage of water
• Requires walls, floors, and flood shields to resist hydrostatic, hydrodynamic, and other flood loads, including the effects of buoyancy
• Specifies that soil or fill adjacent to a structure must be compacted and protected from erosion and scour
• Requires that at least one door, window, or other opening for emergency escape and rescue be above the elevation specified in Table 6-1
• Specifies several limitations when human intervention is necessary to activate or implement dry floodproofing measures</td><td>Exceeds NFIP 44 CFR § 60.3(c)(3) and (8) with more specificity, except (1) the NFIP requires the use of flood damage-resistant materials in areas where seepage will accumulate and (2) FEMA deems that temporarily installed means of flood protection that cover walls are inconsistent with the requirement that walls be substantially impermeable (see Section 3.2 of Technical Bulletin 3).</td></tr>
</table>

Table 1: Comparison of Select 2018 IBC and ASCE 24-14 Requirements with NFIP Requirements (continued)

Topic	Summary of Selected 2018 IBC / ASCE 24-14 Requirements and Changes from 2015 and 2012 IBC / ASCE 24-05	Comparison with NFIP Requirements
Dry floodproofing (continued)	Change from ASCE 24-05: Does not require flood damage-resistant materials on the interior of dry floodproofed portions of buildings.	
Garages	**ASCE 24-14 Section 9.4 Garages, Carports, and Accessory Storage Structures.** Specifies that floodproofed, below-grade parking, where allowed, shall meet the requirements of Section 6. Change from ASCE 24-05: Section renumbered from 9.3 to 9.4 and expanded to include accessory storage structures.	Exceeds NFIP 44 CFR § 60.3(c)(3) and (8) with more specificity.

4 NFIP Flood Insurance Implications

> **NFIP FLOOD INSURANCE FOR DRY FLOODPROOFED BUILDINGS**
>
> While current owners and developers who are considering constructing dry floodproofed non-residential buildings may not intend to purchase NFIP flood insurance coverage, the cost of the coverage may be a factor for future owners.

Careful attention to compliance with the NFIP requirements, local building codes and standards, and floodplain management regulations is important during design, plan review, construction, and inspection. Compliance influences both vulnerability to flood damage and the cost of NFIP flood insurance.

An insurance agent with NFIP experience should be consulted during the design phase of buildings with dry floodproofing to estimate the cost of NFIP flood insurance, especially if the design includes dry floodproofed below-grade levels. This consultation is particularly important when considering whether to include dry floodproofing of non-residential portions of mixed-use buildings or dry floodproofing of below-grade parking areas under non-residential and mixed-use buildings.

Designers should pay particular attention to the flood protection level (level to which buildings will be dry floodproofed). The NFIP regulations for non-residential structures in Zone A require the lowest floor (including basement) to be elevated to or above the BFE, or the structures may be dry floodproofed below the BFE. However, the NFIP flood insurance rating procedures provide credit for dry floodproofing only if the dry floodproofing measures are certified to be at least 1 foot above the BFE, even if that level of protection is not required by local floodplain management regulations. The NFIP also requires applications for insurance coverage for dry floodproofed buildings to include the NFIP Floodproofing Certificate described in Technical Bulletin 3.

The methodology used by the NFIP to determine the NFIP flood insurance rate for dry floodproofed non-residential buildings and non-residential portions of mixed-use buildings is based on the "non-subsidized" rate with a credit (percentage discount) applied to that rate. The amount of credit is based on the information about the dry floodproofing components that must be included with NFIP flood insurance applications. Building owners and designers should consult with flood insurance providers before starting design work to understand how design decisions can impact NFIP flood insurance premiums.

5 Planning Considerations

Technical Bulletin 3 describes several planning considerations that building owners and design professionals should examine before determining which floodproofing measures or combination of measures are feasible for specific locations and before undertaking structural designs. Section 5 of Technical Bulletin 3 includes guidance on the following planning considerations:

- Site-specific flood hazards and site conditions (flood velocities, depths, duration of flooding, how quickly floodwater rises, and debris impacts)
- Flood warning time (length of time between recognition that flooding may occur and when floodwater begins to affect a site)
- Functional use requirements (access and interruption while dry floodproofing is deployed)
- Safety and access; also see Section 5.1 of this Technical Bulletin
- Required plans (emergency operations plans and inspection and maintenance plans); also see Section 5.1 of this Technical Bulletin

5.1 Occupant Safety and Required Plans

Dry floodproofed below-grade parking areas present potential safety risks to people who use these areas. For example, there is a high probability that some people may not move vehicles out of the parking areas when flood conditions threaten. When considering below-grade parking areas, building owners and designers should evaluate the following safety factors:

- Dry floodproofed buildings should not be occupied during flooding. Therefore, safety and access considerations are especially important when evaluating mixed-use buildings and whether it is appropriate to design dry floodproofing measures for the non-residential portions of these buildings and below-grade parking areas. Flooding may rise higher than the flood protection level, or dry floodproofing system components may fail, resulting in failure that could endanger occupants who do not evacuate.
- Flood emergency operations plans are necessary. The plans should be developed during the planning

RELIANCE ON HUMAN INTERVENTION

The potential for loss of life and property damage is high if the people who are responsible for buildings fail to maintain, inspect, and deploy measures that rely on human intervention such as flood shields and gates.

Measures that require human intervention should be specified only for buildings that have facility maintenance and operations personnel who are responsible for conducting routine maintenance and inspection and responsible for and capable of deploying flood protection measures well in advance of the onset of flooding.

phase when designers identify site-specific characteristics of flooding. The plans should take into account how quickly floodwater may affect a site and the level of effort and the time necessary to activate or deploy dry floodproofing measures that may require human intervention.

- Time available to implement measures may be insufficient. Designers should investigate alternatives if a proposed dry floodproofing system cannot be implemented and personnel safely evacuated from the area in the available time before the onset of flooding or high winds, taking into account whether roads or bridges may be closed by state or local officials. Alternatives may include eliminating below-grade parking or selecting alternative dry floodproofing system components that require less effort. The plans must specify the location of flood shields and other measures that require installation or deployment and the required tools and hardware, along with step-by-step deployment instructions. The plans should be tested and ready to implement when flooding threatens.

- Inspection and maintenance plans are also necessary. These plans should specify a schedule and instructions for regular inspections and maintenance of all materials and measures that are necessary for the successful functioning of the dry floodproofing systems. Building owners and managers should conduct periodic exercises to ensure that facility operations and maintenance personnel are familiar with installation requirements.

OBSERVATIONS OF DRY FLOODPROOFING FAILURES

Numerous observations by FEMA Mitigation Assessment Teams after significant flood events indicate that many dry floodproofing systems did not provide the intended level of protection in part because deployments were not adequately exercised or system components were not properly maintained.

Communities are encouraged to require the submission of flood emergency operations plans and inspection and maintenance plans along with the construction documents and design certifications that are required as part of applications for building permits. Some communities specify this requirement in local floodplain management regulations or building codes.

5.2 Limitations on the Use of Dry Floodproofing

The NFIP regulations for dry floodproofing apply only in SFHAs identified on FIRMs as Zone A (A, AE, A1-30, AH, and AO). Dry floodproofing is not permitted in SFHAs identified as Zone V (V, VE, V1-30, and VO). For Zone A, the regulations do not specify limitations on the use of dry floodproofing based on flood depth, flood velocity, or the presence of waves. However, FEMA does not recommend use of dry floodproofing systems in areas where:

- The depth of water under base flood conditions is greater than 3 feet
- Base flood velocities exceed 5 feet per second
- Moderate wave heights (1.5 to 3 feet) are present during base flood conditions

ASCE 24, Chapter 6, limits the use of dry floodproofing to areas where flood velocities at building sites are less than or equal to 5 feet per second, although commentary suggests that local officials may accept certified designs that demonstrate resistance to higher velocities. In addition, ASCE 24 does not permit the use of dry floodproofing in coastal areas where breaking wave heights during base flood conditions are expected to be between 1.5 and 3 feet, called Coastal A Zones.

ASCE 24 permits the use of dry floodproofing measures that require human intervention to activate or implement only when certain conditions are satisfied, including (1) there is a minimum of 12 hours warning time (unless a community has a warning system that can ensure sufficient warning to implement measures), (2) flood shields and covers for openings are designed to resist flood loads, and (3) flood emergency plans, approved by community officials, specify certain information that is critical for installation, maintenance, and inspection. For safety, all buildings that rely on dry floodproofing should have emergency plans, including those with only passive measures, which do not rely on human intervention. Technical Bulletin 3 includes guidance on warning time and required plans.

COASTAL A ZONE

FEMA delineates a Limit of Moderate Wave Action (LiMWA) on FIRMs when analyses indicate the inland extent of 1.5-foot waves. The Coastal A Zone is the area between the LiMWA and Zone V boundary or between the LiMWA and shoreline if Zone V is not designated. FIRMs do not label these areas as Coastal A Zone.

6 Designing Dry Floodproofed Below-Grade Parking Areas

When designing non-residential structures and mixed-use buildings with dry floodproofed below-grade parking areas, design professionals must determine the flood protection level. Designers must also evaluate other flood conditions to determine site-specific flood loads. Structural designs must account for flood loads, described briefly in Section 6.2 of this Technical Bulletin and in more detail in Technical Bulletin 3. Designers also must determine the requirements for the design and installation of building utility systems and equipment, identify where seepage may occur, and identify other points where water may enter and the paths that seepage flow will take to accumulate at collection points.

6.1 Flood Protection Level

The flood protection level is the elevation to which flood protection measures will be designed. The NFIP regulations specify that when non-residential buildings are dry floodproofed, the structures must be watertight and substantially impermeable below the BFE.

ASCE 24 requires the minimum flood protection level to be the elevations listed in ASCE 24, Table 6-1, but state or local floodplain management regulations may require higher levels. ASCE 24 specifies flood protection levels based on the assignment of one of four Flood Design Classes (similar to risk categories). The minimum flood protection level for

"DESIGN FLOOD ELEVATION" IN ASCE 24

ASCE 24 defines and uses the terms "design flood" and "design flood elevation" (DFE) to account for communities that elect to adopt flood hazard maps based on floods that are higher than the base flood (the 1-percent-annual-chance flood) or to include additional areas not shown on FIRMs.

When communities adopt FEMA Flood Insurance Studies and FIRMs and use the base flood and BFE for regulatory purposes, the DFE is the same as the BFE.

Flood Design Class 2 and Class 3 buildings is the BFE plus 1 foot or the design flood elevation (DFE), whichever is higher. The minimum flood protection level for Flood Design Class 4, considered critical and essential facilities, is the highest of BFE plus 2 feet, the DFE, or the 500-year flood elevation. Flood Design Class 1 includes temporary structures, accessory storage structures, small parking structures, and certain agricultural structures. Local floodplain management officials should be consulted to determine whether local regulations require the flood protection level to be set higher than the minimum elevations in ASCE 24.

For NFIP flood insurance purposes, the flood protection level must be at least 1 foot above the BFE for the building to receive premium credits for dry floodproofing (see Section 4 of this Technical Bulletin). Thus, design professionals should design dry floodproofing measures to extend to at least BFE plus 1 foot unless a higher level of flood protection is required by the community or building owner.

6.2 Flood Loads

Flood loads are the result of floodwater rising to the flood protection level and moving past an object such as a building or component of a building foundation. The four types of flood loads are hydrostatic (including buoyancy), hydrodynamic, wave, and debris impact. Flood loads and the methods of calculating them are discussed in FEMA P-936 and Technical Bulletin 3.

While designers must evaluate all types of flood loads, particular attention must be given to hydrostatic loads when below-grade spaces will be dry floodproofed. Hydrostatic loads (pressures) are imposed on an object or building by standing water. The pressures are oriented horizontally on wall elements and increase linearly with the depth of water (see Figure 1). During conditions of flooding, hydrostatic loads are exerted above the ground and below the ground surface as soils become saturated. Vertical hydrostatic force (buoyancy) is a function of the volume of displaced floodwater. In most designs, loads on the above-grade portions of a building are transferred to below-grade structural elements, including the structural elements of below-grade parking areas. Consequently, any structural failure in below-grade areas could result in partial or complete failure of a building.

Determining the hydrostatic loads on a specific building requires identifying the BFE, the elevation of adjacent grades, the duration of flooding, the nature of soils and saturation potential, and the flood protection level. Flood protection level is discussed in Section 6.1 of this Technical Bulletin.

ASCE 7 AND FLOOD LOADS

For the calculation of flood loads, ASCE 24 refers to ASCE 7, *Minimum Design Loads and Associated Criteria* (2010). ASCE 7 addresses hydrostatic loads, hydrodynamic loads, wave loads, and impact loads from floodborne debris and ice.

CONSEQUENCES OF NOT MOVING CARS

After Hurricane Sandy inundated several buildings with below-grade parking areas, damage investigations noted minor structural damage caused by floating cars impinging on decks and structural columns. Trapped cars can exert uplift loads on submerged parking decks.

Some communities reported that efforts to remove disabled cars took weeks or months because low ceiling heights hindered access by tow trucks. When there is a chance that some cars may not be moved before the onset of flooding, designers should consider factoring into the design the potential for floating cars in below-grade parking decks and increasing ceiling heights to facilitate tow truck access.

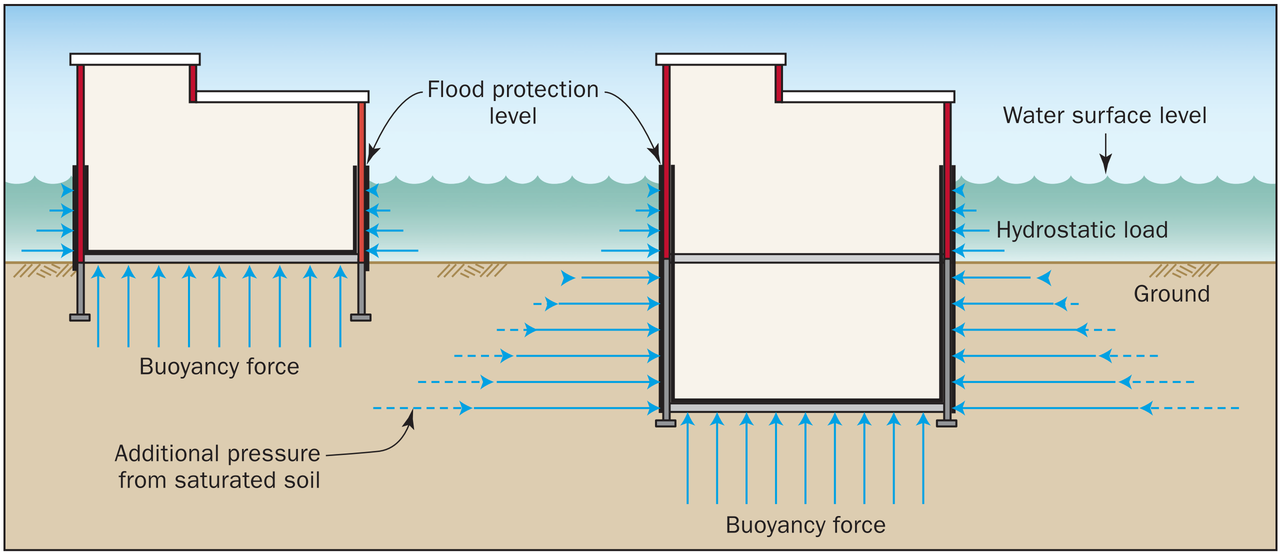

Figure 1: Hydrostatic loads

When water is kept out of a building, the water levels on opposite sides of walls (inside and outside) can be substantially different, which means hydrostatic pressures are unbalanced. Unbalanced hydrostatic loads can cause severe deflection, displacement, or collapse. The sum of the hydrostatic pressures over a surface represents the load acting on that surface.

In structural analysis, hydrostatic forces act vertically upward on the underside of all submerged members such as floor slabs, walls, and footings, and they act laterally on perimeter and foundation walls (see Figure 1). The vertical hydrostatic force (buoyancy) must be resisted by various building elements through the weight of the building elements themselves or by anchoring through the load path. The design of anchoring to resist buoyancy should account for changes in soil capacity caused by saturation. Floor slabs may crack or fail due to shear or bending caused by the buildup of hydrostatic loads underneath slabs, allowing water to enter.

6.3 Building Utility Systems and Equipment

Floodplain management requirements apply to building utility systems (mechanical, electrical and plumbing) and equipment (including fire controls and emergency power or generators). The preferred solution is to locate building utility systems and equipment above the flood protection level. Building utility systems and equipment that serve non-residential buildings and non-residential portions of mixed-use buildings are allowed in dry floodproofed areas, including below-grade parking areas. If dry floodproofing systems fail or are overtopped by floodwater rising above the flood protection level, utility systems and equipment may be damaged and not repairable, which could contribute to loss of building functionality.

The NFIP regulations and ASCE 24 permit equipment and service facilities to be below the flood protection level when "designed … to prevent water from entering or accumulating within the components during conditions of flooding" (44 CFR § 60.3(a)(3)(iv)). The expectation is that equipment and facilities installed below the flood protection level, after being submerged, will be able to be restored to functioning with minimal cleaning and repair. Additional guidance is available in Technical Bulletin 3 and FEMA P-348, *Protecting Building Utility Systems from Flood Damage* (2017).

When non-residential portions of mixed-use buildings are designed with dry floodproofing systems, the building utility systems and equipment that serve the residential uses are required to be elevated above the flood protection level and not located in areas that are protected with dry floodproofing.

6.4 Managing Points of Entry and Seepage

Critical elements in the design of below-grade parking areas are openings and points of entry where floodwater could enter dry floodproofed areas. Designers who prepare structural designs for dry floodproofed buildings should avoid specifying points of entry through exterior walls and slabs below the flood protection level. Possible points of entry are penetrations through walls and slabs for utility conduits, pedestrian entrances, stairwells, elevators, connections with adjacent buildings, and vehicle ramps. When points of entry cannot be avoided, designers should minimize the number of penetrations. All openings and points of entry below the flood protection level must be protected. Technical Bulletin 3 contains guidance for the design and specification of flood shields.

USE OF EQUIPMENT AND PRODUCTS APPROVED ACCORDING TO ANSI/FM 2510

Use of equipment and products that are tested and approved in accordance with ANSI/FM 2510, *American National Standard for Flood Mitigation Equipment* (2020), is not required for compliance with the NFIP or ASCE 24. However, specifying FM Approved equipment and products may provide designers more assurance when developing designs for dry floodproofing systems.

The ANSI/FM 2510 standard, described in Technical Bulletin 3, specifies the flood conditions for testing each type of equipment and product. Designers should verify the applicability of approved equipment and products for site-specific flood conditions.

To be considered “substantially impermeable,” the dry floodproofing system below the flood protection level must limit seepage through walls, through joints and utility penetrations, and around flood shields. The system must not allow more than 4 inches of water depth from seepage during a 24-hour period. If the designer determines that the total seepage of a proposed system will exceed the limitation, the design must be modified to satisfy the accumulation limit. Although sump pumps are required to handle seepage, sump pumps cannot be relied on to meet the maximum accumulation limit. Guidance on estimating total seepage through an example dry floodproofing system is provided in Technical Bulletin 3.

Designers must plan the paths along which seepage will flow in order to determine where collection points, drains, and sumps will be installed. For buildings with below-grade parking areas, collection points are usually at the lowest point of the lowest parking level. Flood damage-resistant materials must be used in areas where seepage collects to minimize damage and downtime. When designing buildings with more than one below-grade level, designers should consider the flow path of floodwater between below-grade levels in the event that the floodproofing systems are overtopped or fail. Water should be able to easily flow between levels to prevent a hydrostatic or standing water load from exceeding the capacity of the concrete parking slab or deck as it travels to the lowest point.

FLOW PATH OF FLOODWATER

Failure to address the flow path of floodwater between below-grade levels could result in the accumulation of water and unanticipated loading, which could cause structural damage.

Particular attention must be paid when adjacent buildings share below-grade components such as utility chases and pedestrian corridors that could allow floodwater from an unprotected building to enter a building that is supposed to be dry floodproofed. Dry floodproofed below-grade parking areas should not be shared by two buildings unless both buildings are permitted to have dry floodproofed below-grade parking areas and both buildings are dry floodproofed to the same flood protection level.

Vehicle ramps and methods to prevent floodwater from entering through vehicle ramps must be considered carefully. The best method of protection is to design the ramps to be above the elevation of the dry floodproofing measures. For example, if dry floodproofing extends to the BFE plus 2 feet, the lowest point on the ramp should be at least the same elevation, and the ramp and surrounding site must be configured to prevent water from overtopping that elevation at any point (see Figure 2). If it is not possible to configure vehicle ramps to provide this level of protection, the ramps must be designed to accommodate flood shields, gates, stop logs, or other components that are designed to span the garage entry, withstand the hydrostatic pressure, and keep floodwater out of dry floodproofed below-grade parking areas (examples shown in Figures 3 through 6).

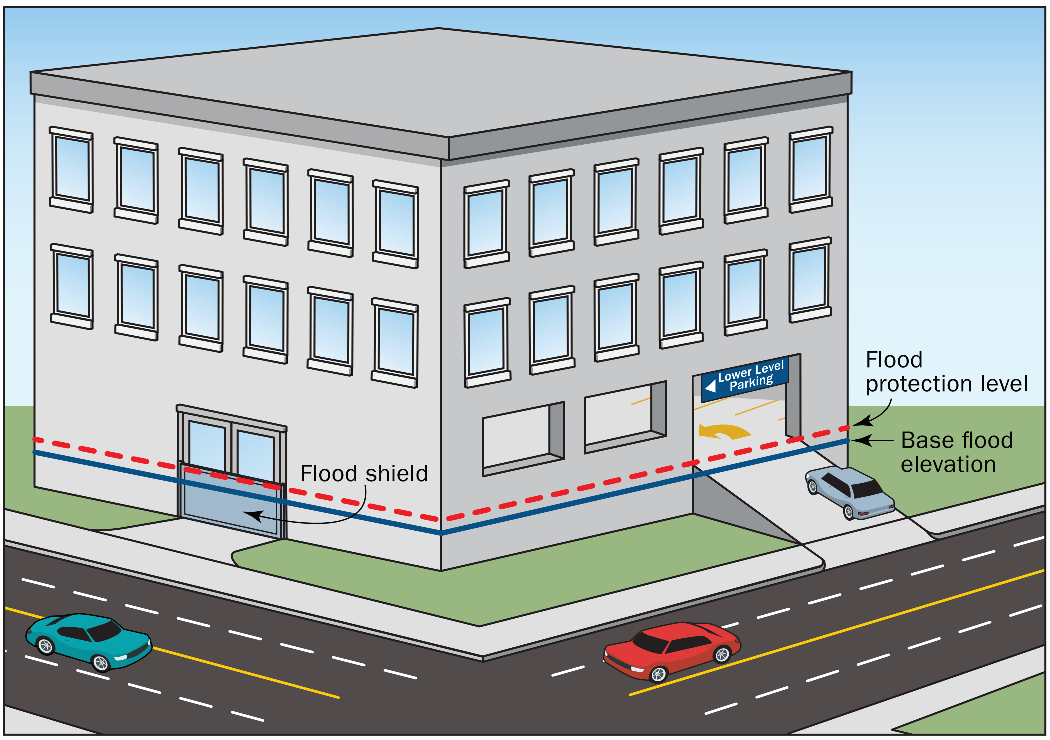

Figure 2: Raised vehicle ramp for dry floodproofed below-grade parking

Figure 3: Stop logs deployed inside the building to trap seepage around the garage door and avoid accumulation of rainfall

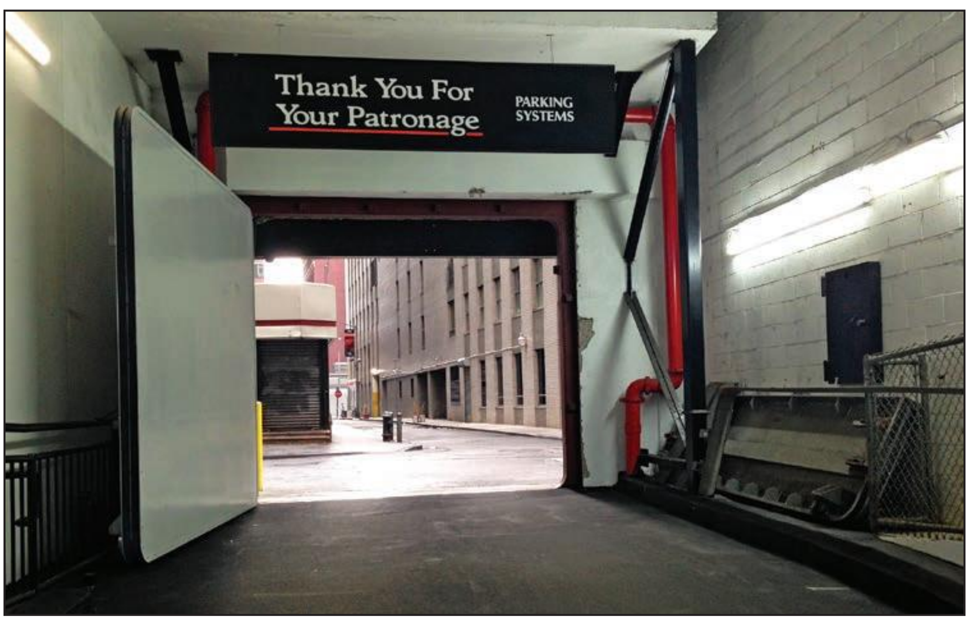

Figure 4: Permanent swing door (deployment requires closing and securing the door)

Figure 5: Manually deployed panel

Figure 6: Automatic gate (deploys automatically when triggered by rising floodwater)

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Wet Floodproofing Requirements and Limitations

For Buildings and Structures Located in Special Flood Hazard Areas in Accordance with the National Flood Insurance Program

NFIP Technical Bulletin 7 / May 2022

FEMA

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Acronyms

ASCE	American Society of Civil Engineers
BFE	base flood elevation
CFR	Code of Federal Regulations
CRS	Community Rating System
DFE	design flood elevation
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
HVAC	heating, ventilation, and air conditioning
IBC®	International Building Code®
ICC®	International Code Council®
I-Codes®	International Codes®
IEBC®	International Existing Building Code®
IRC®	International Residential Code®
NFIP	National Flood Insurance Program
SEI	Structural Engineers Institute
SFHA	Special Flood Hazard Area

1. Introduction

This Technical Bulletin provides guidance on the National Flood Insurance Program (NFIP) floodplain management requirements for the design and construction of wet floodproofed buildings and structures in Special Flood Hazard Areas (SFHAs). The SFHA is identified as Zone A (A, AE, A1-30, AH, AO, A99, and AR) and Zone V (V, VE, V1-30, and VO) on a community's Flood Insurance Rate Map (FIRM) prepared by the Federal Emergency Management Agency (FEMA).

This Technical Bulletin also describes limitations on the use of wet floodproofing and how to evaluate the feasibility of using wet floodproofing measures for historic structures, agricultural structures, and functionally dependent uses.

1.1. Definition of Floodproofing

The NFIP regulations define floodproofing as "any combination of structural and non-structural additions, changes, or adjustments to structures which reduce or eliminate flood damage to real estate or improved real property, water and sanitary facilities, structures and their contents" (Title 44 Code of Federal Regulations [CFR] § 59.1). Measures taken to make a building and attendant utilities and equipment watertight and substantially impermeable to floodwater, with structural components having the capacity to resist flood loads are dry floodproofing measures. "Floodproofing" in the NFIP regulations is understood to refer to "dry floodproofing."

The term "wet floodproofing" is used in FEMA guidance publications and by floodplain management professionals to mean the use of flood damage-resistant materials and construction techniques to minimize flood damage to structures by intentionally allowing floodwater to enter and exit automatically, which means without human intervention.

Dry floodproofing measures are not covered in this Technical Bulletin. For more information on dry floodproofing, see FEMA P-936, *Floodproofing Non-Residential Buildings* (FEMA, 2013); NFIP Technical Bulletin 3, *Requirements for the Design and Certification of Dry Floodproofed Non-Residential and Mixed-Use Buildings;* and NFIP Technical Bulletin 6, *Requirements for Dry Floodproofed Below-Grade Parking Areas Under Non-Residential and Mixed-Use Buildings*.

NFIP Technical Bulletin 0

NFIP Technical Bulletin 0, *User's Guide to Technical Bulletins*, should be used as a reference with this Technical Bulletin. Technical Bulletin 0 describes the purpose and use of the Technical Bulletins. It includes common concepts and terms, lists useful resources, and includes a crosswalk of the sections of the NFIP regulations identifying the Technical Bulletin that addresses each section of the regulations and a subject index.

Readers are cautioned that the definitions of some of the terms that are used in the Technical Bulletins are not the same when used by the NFIP for the purpose of rating flood insurance policies.

Terms Used in This Technical Bulletin

Accessory structure: A structure on the same parcel of property as a principal structure, the use of which is incidental to the use of the principal structure. For floodplain management purposes, accessory structures must be used for parking or storage, be small, represent minimal investment by owners, and have low damage potential. Under the NFIP regulations, accessory structures are non-residential structures.

Agricultural structure: For floodplain management purposes, agricultural structures are structures that are used exclusively for agricultural purposes or uses in connection with the production, harvesting, storage, raising, or drying of agricultural commodities and livestock. Structures that house tools or equipment used in connection with these purposes or uses are also considered to have agricultural purposes or uses. Some structures used for aquaculture are considered agricultural structures. Under the NFIP regulations, agricultural structures are non-residential structures.

Basement: "Any area of the building having its floor subgrade (below ground level) on all sides" (44 CFR § 59.1). The NFIP regulations do not allow basements to extend below the base flood elevation (BFE) except in dry-floodproofed, non-residential buildings.

Enclosed area (enclosure): An area below an elevated building that is enclosed by walls on all sides.

Existing building (existing structure): Buildings and structures that were constructed before a community joined the NFIP.

Flood damage-resistant materials: Any building product (material, component, or system) capable of withstanding direct and prolonged contact with floodwater without sustaining significant damage, in which "prolonged contact" means at least 72 hours and "significant damage" means any damage requiring more than cosmetic repair. "Cosmetic repair" includes cleaning, sanitizing, and resurfacing the material (e.g., sanding, repair of joints, repainting).

Human intervention: "Required presence and active involvement of people to implement a floodproofing measure prior to the onset of flooding" (ASCE 24).

Legal non-conforming building (legal non-conforming structure): Buildings and structures that were built after a community joined the NFIP but do not conform to a community's current floodplain management requirements.

Lowest floor: Lowest floor of the lowest enclosed area of a building, including basement. An unfinished or flood-resistant enclosure that is used solely for parking of vehicles, building access, or storage in an area other than a basement area is not considered a building's lowest floor, provided the enclosure is built in compliance with applicable requirements (44 CFR § 59.1).

Special Flood Hazard Area (SFHA): Area subject to flooding by the base flood (1-percent-annual-chance flood) and shown on Flood Insurance Rate Maps (FIRMs) as Zone A or Zone V.

Variance: Grant of relief by a community from the terms of a floodplain management regulation (44 CFR § 59.1).

Wet floodproofing: Use of flood damage-resistant materials and construction techniques to minimize flood damage to structures by intentionally allowing floodwater to enter and exit automatically (without human intervention) to minimize unequal pressure of water on walls (called hydrostatic load or pressure).

Zone A: Flood zones shown on FIRMs as Zone A, AE, A1-30, AH, AO, A99, and AR.

Zone V: Flood zones shown on FIRMs as Zone V, VE, V1-30, and VO; also known as the Coastal High Hazard Area.

Other terms used in this Technical Bulletin are defined in the glossary in Technical Bulletin 0.

1.2. Limitations on the Use of Wet Floodproofing

The use of wet floodproofing measures for flood protection is limited to:

- Enclosures below elevated buildings when the enclosures are used solely for parking of vehicles, building access, or storage
- Attached garages
- Certain accessory structures used for parking of vehicles or storage
- Certain agricultural structures when communities authorize the structures in accordance with FEMA P-2140, *Floodplain Management Bulletin: Floodplain Management Requirements for Agricultural Structures and Accessory Structure*s, (Version 1.1, 2021a)
- Historic structures when authorized by variances
- Functionally dependent uses when authorized by variances

The authority to allow the use of wet floodproofing measures in specific circumstances is established in FEMA Policy #104-008-03, *Floodplain Management Requirements for Agricultural Structures and Accessory Structures* (2020). The situations and conditions in which communities may authorize wet floodproofing are detailed in Section 5 of this Technical Bulletin.

Section 8 of this Technical Bulletin describes additional measures that may be used to retrofit buildings and structures when NFIP compliance is not required but owners want to reduce damage to at-risk existing and legal non-conforming buildings and structures in SFHAs.

1.3. Construction Requirements for Wet Floodproofing

Figure 1 illustrates the following typical wet floodproofing measures:

- Anchoring to resist flotation, collapse, and lateral movement
- Using flood damage-resistant materials below the base flood elevation (BFE)
- Installing flood openings to automatically equalize hydrostatic forces (loads or pressure caused by standing or slow-moving water) on exterior walls
- Protecting mechanical and utility equipment by elevating or by installing and configuring the equipment components to minimize damage (e.g., elevated water heater, elevated outlet)
- Anchoring fuel tanks to resist flotation and lateral movement

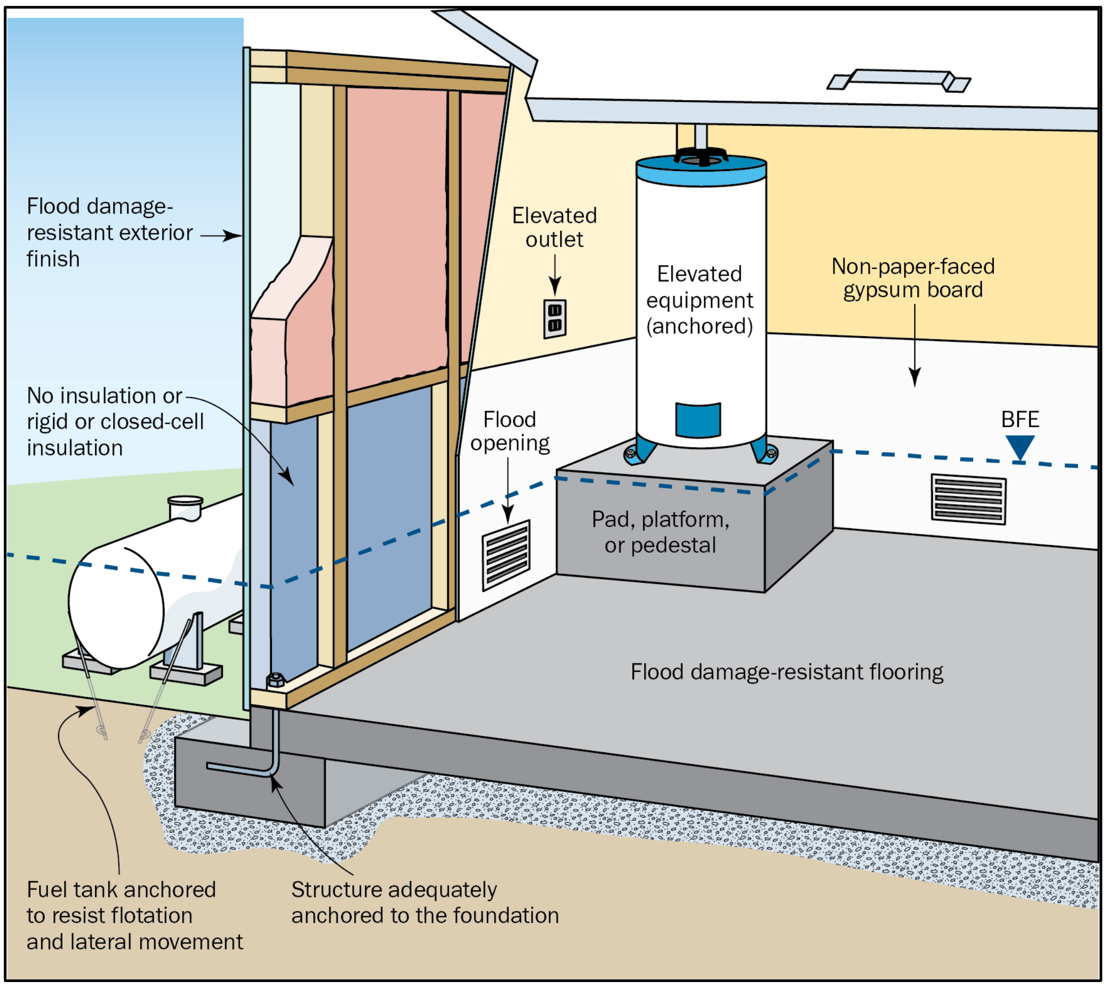

Figure 1: Typical wet floodproofing measures

Other measures that reduce the potential for flood damage may be considered wet floodproofing but should be used only when NFIP compliance is not required or when communities grant variances to the elevation or dry floodproofing requirements.

See Section 8 of this Technical Bulletin for more information on retrofit measures when NFIP compliance is not required. Those measures should also be considered when communities grant variances to the elevation or dry floodproofing requirements. Section 9 of this Technical Bulletin describes best practices to consider when evaluating the use of wet floodproofing measures.

Questions about wet floodproofing should be directed to the appropriate local official, NFIP State Coordinating Office, or FEMA Regional Office.

2. NFIP Regulations and FEMA Policy

An important NFIP objective is protecting buildings constructed in SFHAs from damage caused by flooding. The SFHA is the land area subject to flooding by the base flood. SFHAs are shown on FIRMs prepared by FEMA as Zones A and V. The base flood is the flood that has a 1 percent chance of being equaled or exceeded in any given year (commonly called the "100-year" flood). The NFIP floodplain management regulations include minimum building design criteria that apply to:

- New construction
- Work determined to be substantial improvements, including improvements, alterations, and additions
- Repair of buildings determined to have incurred substantial damage

A defining characteristic of the NFIP regulations applicable in Zone A is the requirement for the lowest floor (including basement) of residential buildings to be elevated to or above the BFE. Non-residential buildings in Zone A must be elevated or dry floodproofed to or above the BFE. The NFIP requirements in Zone V also specify building elevation, foundation, and enclosure requirements. Dry floodproofing is not permitted in Zone V.

2.1. NFIP Regulations

The NFIP regulations are codified in 44 CFR Part 60, Criteria for Land Management and Use. Specific to this Technical Bulletin, 44 CFR § 60.3(a)(3) requires that a community:

> *Review all permit applications to determine whether proposed building sites will be reasonably safe from flooding. If a proposed building site is in a flood-prone area, all new construction and substantial improvements shall (i) be designed (or modified) and adequately anchored to prevent flotation, collapse, or lateral movement of the structure resulting from hydrodynamic and hydrostatic loads, including the effects of buoyancy, (ii) be constructed with materials resistant to flood damage, (iii) be constructed by methods and practices that minimize flood damages, and (iv) be*

> *constructed with electrical, heating, ventilation, plumbing, and air conditioning equipment and other service facilities that are designed and/or located so as to prevent water from entering or accumulating within the components during conditions of flooding.*

The NFIP regulations for enclosures below the lowest floor of buildings in Zone A are in 44 CFR § 60.3(c)(5), which requires that a community shall:

> *Require, for all new construction and substantial improvements, that fully enclosed areas below the lowest floor that are usable solely for parking of vehicles, building access or storage in an area other than a basement and which are subject to flooding shall be designed to automatically equalize hydrostatic flood forces on exterior walls by allowing for the entry and exit of floodwaters. Designs for meeting this requirement must either be certified by a registered professional engineer or architect or meet or exceed the following minimum criteria: A minimum of two openings having a total net area of not less than one square inch for every square foot of enclosed area subject to flooding shall be provided. The bottom of all openings shall be no higher than one foot above grade. Openings may be equipped with screens, louvers, valves, or other coverings or devices provided that they permit the automatic entry and exit of floodwaters.*

2.2. FEMA Policy

The NFIP regulations do not provide explicit requirements for agricultural structures or accessory structures. Therefore, these structures are regulated as non-residential structures, and the elevation and dry floodproofing requirements for non-residential structures apply to them.

In 2020, FEMA issued FEMA Policy #104-008-03 to provide clarification and technical guidance on the implementation of NFIP design and performance standards for agricultural structures and accessory structures. FEMA recognizes that the inherent design and function of certain agricultural structures and accessory structures may mean that the structures have low damage potential, which allows the use of flood protection methods other than elevation and dry floodproofing. These methods are the wet floodproofing measures that are described in this Technical Bulletin.

In 2021, FEMA issued FEMA P-2140, *Floodplain Management Bulletin: Floodplain Management Requirements for Agricultural Structures and Accessory Structures*, to clarify and refine the wet floodproofing measures that are applicable to certain agricultural structures and accessory structures described in FEMA Policy #104-008-03. FEMA P-2140 and Section 5 of this Technical Bulletin describe the circumstances under which communities may authorize wet floodproofed accessory structures by permit (based on size) and when communities must use variances to authorize wet floodproofing measures for larger accessory structures and agricultural structures. FEMA P-2140 includes decision charts that can be used to determine whether proposed projects qualify as agricultural structures or accessory structures and whether those structures may be wet floodproofed.

NFIP Requirements and Higher Regulatory Standards

Federal, State, and Local Requirements. Federal, state, or local requirements that are more restrictive or stringent than the minimum requirements of the NFIP take precedence. The Technical Bulletins and other FEMA publications provide guidance on the minimum requirements of the NFIP and describe best practices. Design professionals, builders, and property owners should contact local officials to determine whether more restrictive provisions apply to buildings or sites in question. All other applicable requirements of state or local building codes must also be met for buildings in flood hazard areas.

Substantial Improvement and Substantial Damage. As part of issuing permits, local officials must review not only proposals for new construction but also for work on existing and legal non-conforming buildings to determine whether the work constitutes substantial improvement or repair of substantial damage. If the work is determined to constitute substantial improvement or repair of substantial damage, the buildings must be brought into compliance with NFIP requirements for new construction. Some communities modify the definitions of substantial improvement and/or substantial damage to be more restrictive than the NFIP minimum requirements. For more information on substantial improvement and substantial damage, see FEMA P-758, *Substantial Improvement/Substantial Damage Desk Reference* (2010) and FEMA 213, *Answers to Questions About Substantially Improved/Substantially Damaged Buildings* (2018).

Elevation Above Minimum NFIP Requirements. Some states and communities require that buildings be elevated above the NFIP minimum requirement. The additional elevation is called freeboard. Design professionals, builders, and property owners should check with local officials to determine whether a community has freeboard requirements. References to building elevations in this Technical Bulletin should be construed as references to the community's elevation requirement where freeboard is required.

3. Building Codes and Standards

In addition to complying with NFIP requirements, all new construction, substantial improvements, and repair of substantial damage must comply with the applicable building codes and standards that are adopted and enforced by states and communities.

The International Codes® (I-Codes®), published by the International Code Council® (ICC®), are a family of codes that includes the International Residential Code® (IRC®), International Building Code® (IBC®), International Existing Building Code® (IEBC®), and codes that govern the installation of mechanical, plumbing, fuel gas, and other aspects of building construction. FEMA has deemed that the latest published editions of the I-Codes generally meet or exceed NFIP requirements for buildings and structures. Excerpts of the flood provisions of the I-Codes are available on the FEMA Building Science webpage at https://www.fema.gov/emergency-managers/risk-management/building-science/building-codes.

3.1. International Residential Code

The International Residential Code (IRC) applies to one- and two-family dwellings and townhomes not more than three stories above grade plane.

International Residential Code Commentary

The ICC publishes companion commentary for the IRC. Although not regulatory, the commentary provides guidance that is useful in complying with, interpreting, and enforcing the requirements of the code.

Table 1 summarizes the 2021 IRC requirements related to wet floodproofing; notes changes from the 2018, 2015, and 2012 editions; and compares the IRC provisions to the NFIP requirements. Subsequent editions of the IRC should include comparable requirements.

Table 1: Comparison of Selected 2021 IRC Requirements with NFIP Requirements

Topic	Summary of Selected 2021 IRC Requirement and Changes from 2018, 2015, and 2012 Editions	Comparison with NFIP Requirements
Variance/ modification	**Section R104.10.1 [Modifications] Flood hazard areas.** Limits granting modifications to the flood hazard area requirements unless a determination is made that certain conditions are satisfied. Change from 2018 to 2021: No change. Change from 2015 to 2018: No change. Change from 2012 to 2015: Provisions moved from Board of Appeals to duties and powers of the building official.	Equivalent to NFIP 44 CFR § 60.6 requirements for variances.
Garages and carports	**Section R309.3 [Garages and carports] Flood hazard areas.** Requires garages and carports in flood hazard areas to meet requirements of R322. Change from 2018 to 2021: Details of requirements for garages and carports moved from R309 to R322. Change from 2015 to 2018: No change. Change from 2012 to 2015: No change.	Exceeds NFIP 44 CFR § 60.3 by specifying requirements for garages and carports.

Topic	Summary of Selected 2021 IRC Requirement and Changes from 2018, 2015, and 2012 Editions	Comparison with NFIP Requirements
Elevation (garages and carports)	**Section R322.2.1 (Zone A) and R322.3.2 (Zone V and Coastal A Zone) Elevation requirements.** Requires garages and carport floors to (1) be elevated to the BFE plus 1 foot or the design flood elevation (DFE), whichever is higher or (2) be at or above grade on at least one side and meet the same requirements for enclosures below elevated dwellings. Change from 2018 to 2021: Details of requirements for garages and carports moved from R309 to R322. Change from 2015 to 2018: No change. Change from 2012 to 2015: One foot of freeboard added. Modified to require dwellings in Coastal A Zones to comply with R322.3.	Exceeds NFIP 44 CFR § 60.3 by specifying requirements for garages and carports and by requiring a minimum elevation higher than the BFE.
Enclosed areas (walls)	**Sections R322.2.2 (Zone A) and R322.3.6 (Zone V and Coastal A Zone) Enclosed area below required elevation and Section R322.3.5 (Zone V and Coastal A Zone) Walls below required elevation.** Provides requirements for enclosed areas below the required elevation, including flood openings in Zone A and breakaway walls with flood openings in Zone V and the Coastal A Zone. The required elevation is the BFE plus 1 foot or DFE, whichever is higher. Change from 2018 to 2021: Modified to apply requirements below the elevation required by R322, rather than the DFE. Change from 2015 to 2018: Section numbers changed from R322.3.4 and R322.3.5 to R322.3.5 and R322.3.6, respectively. Change from 2012 to 2015: Flood opening installation requirements moved to a new section. Requirement for flood openings in all breakaway walls added.	Exceeds NFIP 44 CFR § 60.3(c)(5) and (e)(5) by requiring (1) flood openings in walls of each enclosed area, (2) flood openings on different sides of each enclosed area, (3) breakaway walls for enclosures in Coastal A Zones, and (4) flood openings in breakaway walls (Zone V and Coastal A Zone).

Topic	Summary of Selected 2021 IRC Requirement and Changes from 2018, 2015, and 2012 Editions	Comparison with NFIP Requirements
Enclosed areas (use limitations)	**Sections R322.2.2 (Zone A) and R322.3.6 (Zone V and Coastal A Zone) Enclosed areas below required elevation.** Requires enclosed areas below the required elevation to be used solely for parking of vehicles, building access, or storage. Change from 2018 to 2021 IRC: Applies requirements below the elevation required in Section R322 rather than the DFE. Change from 2015 to 2018 IRC: No change. Change from 2012 to 2015 IRC: No change.	Equivalent to NFIP 44 CFR § 60.3(c)(5) and (e)(5) regarding the use of enclosed areas.
Equipment (electrical, plumbing, and mechanical systems)	**Section R322.1.6 Protection of mechanical, plumbing, and electrical systems.** Requires that systems, equipment, and components be located at or above the required elevation, which is the BFE plus 1 foot or DFE, whichever is higher. Alternatively, those elements may be permitted below the required elevation if designed and installed to meet certain performance requirements. Change from 2018 to 2021: Modified to apply flood load requirements during the occurrence of flooding to the elevation required by R322, rather than the DFE. Change from 2015 to 2018: No change. Change from 2012 to 2015: No change.	Exceeds NFIP 44 CFR § 60.3(a)(3) by requiring a minimum elevation higher than the BFE.
Flood damage-resistant materials	**Section R322.1.8 Flood-resistant materials.** Requires flood damage-resistant materials below the required elevation to conform to the requirements of NFIP Technical Bulletin 2, *Flood Damage-Resistant Materials Requirements*. The required elevation is BFE plus 1 foot or DFE, whichever is higher. Change from 2018 to 2021: No change. Change from 2015 to 2018: No change. Change from 2012 to 2015: Modified to refer only to Technical Bulletin 2 instead of listing pressure-preservative-treated wood requirements.	Exceeds NFIP 44 CFR § 60.3(a)(3) by requiring that flood damage-resistant materials extend higher than the BFE.

3.2. International Building Code and ASCE 24

The International Building Code (IBC) applies to all applicable buildings and structures. While used primarily for buildings and structures other than dwellings within the scope of the IRC, the IBC may also be used to design dwellings.

The flood provisions of the latest published editions of the IBC generally meet or exceed NFIP requirements for buildings through reference to the standard ASCE 24, *Flood Resistant Design and Construction*. ASCE 24 is developed by the American Society of Civil Engineers (ASCE). ASCE 24 applies to structures that are subject to building code requirements. ASCE 24 requirements for wet floodproofing are similar to the NFIP requirements for enclosures below elevated buildings.

International Building Code and ASCE 24 Commentaries

The ICC publishes companion commentary for the IBC, and ASCE publishes companion commentary for ASCE 24. Although not regulatory, the commentaries provide information and guidance that are useful for complying with, interpreting, and enforcing requirements.

Table 2 summarizes the 2021 IBC and ASCE 24-14 requirements related to wet floodproofing; notes changes from 2018, 2015, and 2012 IBC editions and ASCE 24-05; and compares those provisions to the NFIP requirements. Subsequent editions of the IBC and ASCE 24 should include comparable requirements.

Table 2: Comparison of Selected 2021 IBC and ASCE 24-14 Requirements with NFIP Requirements

Topic	Summary of Selected 2021 IBC / ASCE 24-14 Requirements and Changes from 2018, 2015, and 2012 IBC / ASCE 24-05	Comparison with NFIP Requirements
Variance/ Modification	**IBC Section 104.10.1 [Modifications] Flood hazard areas.** Limits granting modifications to the flood hazard area requirements unless a determination is made that certain conditions are satisfied. IBC Appendix G, Flood-Resistant Construction, which is not applicable unless specifically adopted, allows variances for historic structures and functionally dependent facilities. Change from 2018 to 2021 IBC: No change. Change from 2015 to 2018 IBC: No change. Change from 2012 to 2015 IBC: No change.	Equivalent to NFIP 44 CFR § 60.6 requirements for variances.

Topic	Summary of Selected 2021 IBC / ASCE 24-14 Requirements and Changes from 2018, 2015, and 2012 IBC / ASCE 24-05	Comparison with NFIP Requirements
Enclosed areas	**ASCE 24-14 Section 2.7 Enclosures Below the Design Flood Elevation (Zone A) and Section 4.6 Enclosed Areas Below Design Flood Elevation (Zone V and Coastal A Zone)** Specify requirements for enclosed areas below the DFE, including flood openings in Zone A and breakaway walls with flood openings in Coastal High Hazard Areas (Zone V) and Coastal A Zone. Change from ASCE 24-05: New requirement for openings in breakaway walls in Coastal High Hazard Areas and Coastal A Zones. Specifies measurement of enclosed areas to determine square footage. Consolidates installation requirements, which apply to both non-engineered and engineered openings, and clarifies that the position is relative to the higher of the interior and exterior grade or floor.	Exceeds NFIP 44 CFR § 60.3(c)(5) and (e)(5) by requiring (1) flood openings in each enclosed area, (2) flood openings on different sides of each enclosed area, (3) breakaway walls for enclosures in Coastal A Zones, and (4) flood openings in breakaway walls (Zone V and Coastal A Zone).
Flood damage-resistant materials	**ASCE 24-14 Chapter 5 Materials** Requires use of flood damage-resistant materials below the required elevation and includes additional detailed requirements for specific materials. The required elevation depends on the Flood Design Class assigned to buildings. Change from ASCE 24-05: Modified requirements for wood; preservative-treated wood required only when specified, instead of for all wood.	Exceeds NFIP 44 CFR § 60.3(a)(3) by requiring that flood damage-resistant materials extend higher than the BFE.
Wet floodproofing limitations on use	**ASCE 24-14 Section 6.3 Wet Floodproofing** Limits the use of wet floodproofing to Flood Design Class 1 structures; enclosures used solely for parking of vehicles, building access, or storage; structures that are functionally dependent on their close proximity to water; and certain agricultural structures. Change from ASCE 24-05: No change. However, small parking structures were added to the Flood Design Class 1 category and specificity was added to the description of temporary structures in Flood Design Class 1.	Equivalent to NFIP 44 CFR § 60.3(c)(5) for enclosures and § 60.6 for functionally dependent use. Flood Design Class 1 is more specific than the NFIP by specifying temporary structures, storage buildings, small garages, and certain agricultural structures.

Topic	Summary of Selected 2021 IBC / ASCE 24-14 Requirements and Changes from 2018, 2015, and 2012 IBC / ASCE 24-05	Comparison with NFIP Requirements
Wet floodproofing requirements	**ASCE 24-14 Section 6.3 Wet Floodproofing** Requires that wet floodproofing be accomplished by use of flood damage-resistant materials and techniques that minimize damage to the structure associated with flood loads by meeting the requirements for enclosures in Section 2.7 or Section 4.6, and by installing utilities in conformance with Chapter 7. The elevation requirement for Flood Design Class 1 structures is BFE + 1 foot or DFE, whichever is higher. Change from ASCE 24-05: No change.	Exceeds NFIP 44 CFR § 60.3(a)(3) by requiring that flood damage-resistant materials extend higher than the BFE.
Utility systems and equipment	**ASCE 24-14 Chapter 7 Attendant Utilities and Equipment** Specifies utility elevation requirements and also requirements for equipment and utility systems that are below the required elevations, including elevators. The required elevation depends on Flood Design Class and is the BFE or higher. Change from ASCE 24-05: Requirements for tanks moved to Section 9.7.	Exceeds NFIP 44 CFR § 60.3(a)(3) by having specific requirements for system elements and by requiring a minimum elevation higher than the BFE.
Garages, carports, and accessory storage structures	**ASCE 24-14 Section 9.4 Garages, Carports, and Accessory Storage Structures** Includes requirements and allows the use of wet floodproofing in conformance with Section 6.3 in flood hazard areas other than Coastal High Hazard Areas and the Coastal A Zone. Change from ASCE 24-05: Added accessory storage structures, defined as used only for storage that is incidental to dwellings.	Equivalent to NFIP 44 CFR § 60.3(a)(3).

3.3. International Existing Building Code

The International Existing Building Code (IEBC) applies to the repair, alteration, change of occupancy, addition to, or relocation of existing buildings and structures. The I-Codes define an existing building as "a building [or structure] erected prior to the date of adoption of the appropriate code, or one for which a legal building permit has been issued." The NFIP regulations allow communities to issue variances for the repair or rehabilitation of historic structures provided the variance is the minimum necessary and the structures retain their designation as historic structures (44 CFR § 60.6(a)).

International Existing Building Code Commentary

The ICC publishes companion commentary for the IEBC. Although not regulatory, the commentary provides guidance that is useful in complying with, interpreting, and enforcing the requirements of the code.

Table 3 summarizes the 2021 IEBC requirements related to historic structures; notes changes from the 2018, 2015, and 2012 editions; and compares those provision to the NFIP requirements. Subsequent editions of the IEBC should include comparable requirements.

Table 3: Comparison of Selected 2021 IEBC Requirements with NFIP Requirements

Topic	Summary of Selected 2021 IEBC Requirements and Changes from 2018, 2015, and 2012 Editions	Comparison with NFIP Requirements
Definition	**Section 202 Definitions; Historic Buildings.** Defines buildings as historic buildings if they meet at least one of three criteria. Change from 2018 to 2021 IEBC: No change. Change from 2015 to 2018 IEBC: No change. Change from 2012 to 2015 IEBC: Definition of historic building added.	Differs from the definition in NFIP 44 CFR § 59.1 by including local community historic registers.
Repairs	**Section 507.3 [Prescriptive Compliance Historic Buildings] Flood hazard areas.** Provides an exception to bringing historic buildings that are substantially improved into compliance with the flood requirements of the IBC provided the buildings retain their historic designation. Change from 2018 to 2021 IEBC: No change. Change from 2015 to 2018 IEBC: No change. Change from 2012 to 2015 IEBC: Section 507.3 added.	Equivalent to the exclusion in the definition of Substantial Improvement in NFIP 44 CFR § 59.1.

Topic	Summary of Selected 2021 IEBC Requirements and Changes from 2018, 2015, and 2012 Editions	Comparison with NFIP Requirements
Preservation of historic structures	**Section 1201.4 [Historic Buildings] Flood hazard areas.** Provides an exception to bringing historic buildings that are substantially improved into compliance with the flood requirements of the IBC provided the buildings meet specific criteria and retain their historic designation. Change from 2018 to 2021 IEBC: No change. Change from 2015 to 2018 IEBC: No change. Change from 2012 to 2015 IEBC: Compliance requirements with flood provisions in Section 1612 of the IBC and Section R322 of the IRC added.	Equivalent to the exclusion in the definition of Substantial Improvement in NFIP 44 CFR § 59.1.

4. NFIP Flood Insurance Implications

NFIP flood insurance premiums for new construction and buildings that are substantially improved or repaired after incurring substantial damage are based on a number of factors such as flood risk, distance to flooding sources, elevation relative to flooding sources, type of building and foundation, number of floors, and whether a basement or enclosure is below elevated buildings. Designers, builders, and owners may wish to contact a qualified insurance agent with NFIP experience for more information on policy coverage, coverage limits, and premium costs.

The NFIP regulations for variances require communities to provide a written notice to applicants when a variance to allow a structure below the BFE is requested (44 CFR § 60.6(a)(5)). The notice requirement applies even when wet floodproofing measures are included in the building design. The notice must state that issuance of the variance will result in increased premium rates for NFIP flood insurance and that construction below the BFE increases risks to life and property.

5. Options for Communities to Authorize Wet Floodproofing

Communities have the following options to authorize wet floodproofing depending in part on the type of structure:

- Issue permits for the following:
  - Elevated buildings with enclosures below the lowest floor (see Section 5.1.1 of this Technical Bulletin)

  - Buildings with attached garages (see Section 5.1.2 of this Technical Bulletin)
  - Accessory structures that are not elevated or dry floodproofed, provided the structures are not larger than specific sizes (see Section 5.1.3 of this Technical Bulletin)
  - Agricultural structures or accessory structures, but only when FEMA approves a community's request for a community-wide exception (see Section 5.3 of this Technical Bulletin)

- Consider issuing variances for the following:
  - Historic structures (see Section 5.2.1 of this Technical Bulletin)
  - Functionally dependent uses (see Section 5.2.1 of this Technical Bulletin)
  - Accessory structures that are larger than the specified size limits established for authorization by permit (see Section 5.2.2 of this Technical Bulletin)
  - Certain agricultural structures (see Section 5.2.2 of this Technical Bulletin)

Section 5.4 of this Technical Bulletin covers the implications for NFIP Community Rating System (CRS) communities that approve wet floodproofing.

Modifying Community Floodplain Management Regulations

FEMA P-2140 has model ordinance language for some authorization options for wet floodproofing of agricultural structures and accessory structures.

Communities considering making any modifications to floodplain management regulations should check with NFIP State Coordinating Offices or FEMA Regional Offices to ensure consistency with the NFIP and state requirements.

5.1. When Wet Floodproofing May Be Authorized by Permit

Wet floodproofing may be authorized by permit for enclosures below elevated buildings, attached garages, and non-elevated accessory structures.

5.1.1. ENCLOSURES BELOW ELEVATED BUILDINGS

The NFIP regulations provide criteria that must be satisfied when communities issue permits for elevated buildings with enclosures below the lowest floor. Enclosures below elevated buildings must be used solely for parking of vehicles, building access, or storage.

The criteria for enclosures below elevated buildings in Zone A are equivalent to wet floodproofing measures that do not require human intervention (e.g., flood openings, flood damage-resistant materials, elevated mechanical and utility equipment). Enclosures below elevated buildings in

Zone V must have breakaway walls, but breakaway walls are not considered wet floodproofing measures.

5.1.2. ATTACHED GARAGES

Attached garages without a story above are allowed to have the garage floors below the BFE provided the garages are designed and constructed to meet the same requirements as enclosures below elevated buildings. Attached garages with floors below the BFE must have flood openings and use flood damage-resistant materials, and mechanical and utility equipment must be elevated.

5.1.3. NON-ELEVATED ACCESSORY STRUCTURES

FEMA P-2140 describes the requirements that communities should adopt in order to issue permits for non-elevated accessory structures that may be wet floodproofed. FEMA P-2140 includes model ordinance language.

Before issuing permits for wet floodproofed accessory structures, communities must verify:

- Use is limited to parking of vehicles or storage.
- Size is less than or equal to the limits based on flood zone:
  - Zone A: Not larger than a one-story, two-car garage (600 square feet)
  - Zone V: Not larger than 100 square feet (breakaway walls are not required)
- The structures have low damage potential (see FEMA P-2140, Section 2.1.5).
- The structures comply with wet floodproofing requirements.

5.2. When Wet Floodproofing Must Be Authorized by Variance

The NFIP regulations and FEMA guidance address when communities may issue variances to the strict application of the floodplain management requirements, including the elevation and dry floodproofing requirements. To properly issue variances, communities should have a designated reviewing body and procedures for hearings and evaluating variance requests. FEMA P-993, *Floodplain Management Bulletin: Variances and the National Flood Insurance Program* (2014), provides guidance on variance procedures in accordance with 44 CFR § 60.6.

When considering requests for variances, communities must determine whether variances meet the NFIP criteria for issuance. To do so, the community must, at a minimum, apply the variance criteria in 44 CFR § 60.6, including determining that variances are the minimum necessary to afford relief, considering the flood conditions at a site. This means that when a community considers a variance from elevation or dry floodproofing requirements, consideration must be given to whether wet floodproofing is an appropriate alternative that minimizes potential damage.

"Minimum Necessary" and "Mixed Mitigation"

The NFIP regulations state that variances must be issued only after a determination that variances are the "minimum necessary, considering the flood hazard, to afford relief" (44 CFR § 60.6(a)(4)).

"Mixed mitigation" refers to combining partial elevation with wet or dry floodproofing. FEMA P-2140 describes and illustrates mixed mitigation measures.

5.2.1. ALLOWABLE VARIANCES IDENTIFIED IN 44 CFR § 60.6

The NFIP regulations in 44 CFR § 60.6 state that variances from the minimum requirements for buildings in SFHAs may be issued for the repair and rehabilitation of historic structures and for functionally dependent uses.

Historic Structures

The NFIP regulation in 44 CFR § 60.6(a) states that variances may be issued for the repair and rehabilitation of historic structures. The term "historic structure" is defined in 44 CFR § 59.1 and in local floodplain management regulations. FEMA P-467-2, *Floodplain Management Bulletin: Historic Structures* (2008), provides guidance on how the NFIP treats historic structures and identifies mitigation measures that can be taken to minimize the effects of flooding.

"Historic Structure" Defined in NFIP Regulations

Historic structure is defined in 44 CFR § 59.1 as any structure that is:

(a) Listed individually in the National Register of Historic Places (a listing maintained by the Department of Interior) or preliminarily determined by the Secretary of the Interior as meeting the requirements for individual listing on the National Register;

(b) Certified or preliminarily determined by the Secretary of the Interior as contributing to the historical significance of a registered historic district or a district preliminarily determined by the Secretary to qualify as a registered historic district;

(c) Individually listed on a state inventory of historic places in states with historic preservation programs which have been approved by the Secretary of the Interior; or

(d) Individually listed on a local inventory of historic places in communities with historic preservation programs that have been certified either:

    (1) By an approved state program as determined by the Secretary of the Interior or

    (2) Directly by the Secretary of the Interior in states without approved programs.

Communities may issue a variance for repairs to or rehabilitation of historic structures that would otherwise constitute substantial improvement or repair of substantial damage as long as the work is determined not to preclude the structure's continued designation as a historic structure. Communities must also determine that the variance is the minimum necessary to preserve the historic character and design of the structure. Consideration of wet floodproofing measures should be part of determining whether a variance is the minimum necessary because wet floodproofing may reduce the potential for damage.

Functionally Dependent Uses

For floodplain management purposes, "functionally dependent uses" are uses that cannot perform their intended purposes unless located or carried out in close proximity to water. The NFIP definition includes only docking facilities, port facilities that are necessary for the loading and unloading of cargo or passengers, and ship building and ship repair facilities and does not include long-term storage or related manufacturing facilities (44 CFR § 59.1). Other structures and uses may be commonly located near water, but that does not qualify them as functionally dependent uses.

Communities may grant variances to allow new construction or substantial improvement of functionally dependent uses without requiring compliance with elevation or dry floodproofing requirements. Variances should be issued only after determining whether inclusion of wet floodproofed measures satisfies the requirement that variances be the minimum necessary.

In addition to general criteria for variances, the NFIP regulations at 44 CFR § 60.6(a)(7) provide that functionally dependent uses must be protected by methods that minimize flood damage during the base flood and must create no additional threat to public safety. Wet floodproofing measures may reduce the potential for damage.

5.2.2. ALLOWABLE VARIANCES NOT IDENTIFIED IN 44 CFR § 60.6

Communities may consider requests for variances to floodplain management regulations even when those variances are not explicitly identified in the NFIP regulations for variances. FEMA policy and guidance explicitly state that communities must use variances to approve accessory structures that are larger than the size limits established in FEMA P-2140 and for certain agricultural structures defined in FEMA P-2140.

Accessory Structures Larger than Specified Size Limits

Accessory structures that are larger than the size limits established in FEMA P-2140 and Section 5.1.3 of this Technical Bulletin must be elevated or dry floodproofed. Alternatively, communities may consider variances for wet floodproofed accessory structures that are larger than those size limits when the structures represent minimum investment and have low damage potential. Communities should also consider implementing the suggested best practices described in Section 9 of this Technical Bulletin, especially limiting what can be stored and requiring nonconversion agreements. Some communities require that owners execute and record a nonconversion agreement to stipulate that they will not modify wet floodproofing measures and will not convert at-grade accessory structures to uses other than approved uses.

Communities that choose to issue variances for accessory structures larger than the specified size limits should adopt specific provisions in the variance section of their floodplain management regulations. FEMA P-2140 includes model ordinance language.

Certain Agricultural Structures

FEMA recognizes that wet floodproofing may be appropriate for certain types of agricultural structures. Variances may be issued for wet floodproofed agricultural structures only if the structures are used solely for agricultural purposes and the use is exclusively connected to the production, harvesting, storage, raising, or drying of agricultural commodities and livestock. Communities should grant variances only when it can be demonstrated that structures have low damage potential and can be designed using methods that minimize flood damage during the base flood and that no additional threats to public safety are created. Wet floodproofing measures may reduce the potential for damage.

Because wet floodproofing a new agricultural structure with the lowest floor below the BFE is not in compliance with NFIP requirements, variances must address both the non-conforming flood protection measures and the restriction of use to the designated agricultural purposes. Refer to FEMA P-2140 for requirements and procedures related to variances for agricultural structures. FEMA P-2140 includes model ordinance language.

When variances to allow wet floodproofing are considered, a best practice is to require flood emergency operations plans and inspection and maintenance plans to ensure that wet floodproofing measures remain functional (see Section 6.5 of this Technical Bulletin).

State Agricultural Structure Exemptions

Some states exempt agricultural structures or structures on farms from state and local building and zoning codes. State exemptions do not exempt those structures from floodplain management regulations administered by communities that participate in the NFIP.

5.3. Community-Wide Exception

Consistent with FEMA Policy #104-008-03, FEMA P-2140 notes that FEMA recognizes that complying with the NFIP requirements for the elevation or dry floodproofing of agricultural structures or accessory structures could cause hardship or inequity due to extraordinary circumstances or local conditions. In these cases, and in accordance with 44 CFR § 60.6(b) and FEMA Policy #104-008-03, communities may apply to FEMA for approval of a community-wide exception to issue permits for wet floodproofed agricultural structures or accessory structures. Approved community-wide exceptions allow communities to deviate from the NFIP requirements under specified conditions without having to process individual variance requests. FEMA P-2140 provides guidance on submitting a community-wide exception request for agricultural structures and accessory structures. Communities should contact FEMA Regional Offices for assistance.

5.4. Implications for NFIP Community Rating System Communities That Approve Wet Floodproofing

Communities that participate in the NFIP Community Rating System (CRS) must maintain all required floodplain-related construction certificates listed in Section 301.b of the *Addendum to the 2017 CRS Coordinator's Manual* (FEMA, 2021b) that are applicable to the community's situation, including Elevation Certificates, V Zone design certificates, and Floodproofing Certificates. These certificates must be collected and maintained for all buildings that are constructed, substantially improved, and/or repaired after incurring substantial damage in SFHAs. Elevation Certificates are not required for accessory structures.

CRS communities periodically submit construction certificates to FEMA for review. Communities should be aware of how the CRS will respond when reviewing construction certifications for wet floodproofed structures. CRS participation and credits are not affected when CRS communities adopt ordinance language in accordance with FEMA P-2140 to allow wet floodproofed accessory structures and agricultural structures.

CRS credits for freeboard or other higher standards could be reduced if CRS communities opt to no longer require freeboard (or other higher standards) for wet floodproofed agricultural structures, historic structures, or functionally dependent uses, all of which require construction certificates.

6. Planning Considerations

This section describes the planning considerations that may influence owners and designers when they evaluate the feasibility of using wet floodproofing measures for historic structures, agricultural structures, and functionally dependent uses. Some of the considerations should be evaluated as part of deciding whether to wet floodproof accessory structures and whether to enclose areas under elevated buildings.

When identifying sites and developing plans for buildings, owners and developers should have design professionals assess building sites to determine the site-specific flood hazards and conditions that are described in this section. The hazards and conditions may influence the feasibility and selection of wet floodproofing measures. The assessment should include not only flood hazards and site conditions but also available flood warning time prior to the onset of flooding, functional use requirements, safety and access before and during flooding, and the possible need for flood emergency operations plans and inspection and maintenance plans. Designers should review the assessment findings with building owners to determine whether wet floodproofing is appropriate and whether the assessment results indicate any constraints on designs.

6.1. Flood Hazards and Site Conditions

Site assessments should determine whether sites are located in a mapped floodway, the depth of flooding, rate of floodwater rise and fall, frequency of flooding, duration of flooding, presence of ice, and likelihood of flood-borne contaminants.

6.1.1. LOCATION IN MAPPED FLOODWAY

The NFIP regulations place restrictions on construction in floodways. The floodway is the “channel of a river or other watercourse and the adjacent land areas that must be reserved to discharge the base flood without cumulatively increasing the water surface elevation by more than a designated height” (44 CFR § 59.1).

Communities must prohibit floodway encroachments unless engineering analyses demonstrate that the encroachments would not result in any increase in flood levels during base flood events (44 CFR § 60.3(d)(3)). The floodway encroachment restriction applies whether communities authorize proposed development by permit or variance.

6.1.2. DEPTH OF FLOODING

In general, the amount of physical damage that a structure incurs increases as the depth of flooding increases. Establishing a reasonable range of flood depths for wet floodproofing measures is difficult in part because of how wet floodproofed structures or parts of structures may be used. For example, wet floodproofing may involve permanent or contingent elevation of contents, equipment, and machinery. Based on local conditions and to address safety concerns, communities could establish a maximum depth of water under base flood conditions (BFE minus ground elevation) as a depth that would preclude approving the use of wet floodproofing by variance. The depth limit would not constrain the use of wet floodproofing when allowed by permit, including when used for enclosures below elevated buildings and accessory structures.

6.1.3. RATE OF FLOODWATER RISE AND FALL

A primary requirement when wet floodproofing is specified is the installation of flood openings in exterior walls to allow the automatic entry and exit of floodwater. Automatic entry and exit allow the exterior and interior flood levels to be approximately the same as floodwater rises and falls, which balances hydrostatic pressure. See Section 7.2 of this Technical Bulletin for more information on flood openings.

6.1.4. FREQUENCY OF FLOODING

Frequent flooding may render wet floodproofing impractical, depending on how structures are used. Factors that should be assessed to determine whether wet floodproofing is a viable option in areas that experience frequent flooding include the cumulative wear and tear of recurring inundation and the costs associated with repeated interruption of use, frequent removal (or inundation) of contents, and frequent cleanup activities.

6.1.5. DURATION OF FLOODING

Duration of flooding is the amount of time floodwater is expected to affect a site, starting with the onset of flooding and ending when floodwater recedes. The following two impacts associated with duration of flooding should be considered when structures are wet floodproofed:

- The longer the duration, the more likely structural components, interior materials and finishes, equipment and machinery, and contents will deteriorate because of saturation.

- Because use and occupancy are disrupted during flooding, disruption combined with the time necessary to clean up and repair may result in significant economic losses for long duration times.

6.1.6. PRESENCE OF ICE

In colder regions, the impact of large, water-borne chunks of ice can damage or destroy portions of structures that are not elevated, including wet floodproofed enclosures and structures. Water that freezes inside wet floodproofed structures can exert expansive forces that may damage both structural and non-structural components of the buildings.

6.1.7. FLOOD-BORNE CONTAMINANTS

Floodwater may contain numerous contaminants that are caustic, toxic, or putrid. Floodwater in urbanized and industrialized areas may contain salts, alkalis, oils, wastes, chemicals, and debris in higher amounts than in other areas. In agricultural areas, floodwater often contains herbicides, pesticides, fertilizers, animal waste, and dead and decaying animals. Some flooding sources contain higher concentrates of suspended sediment than others. Inundated construction materials and contents of wet floodproofed areas may be coated with sediment, debris, and contaminants.

6.2. Flood Warning Time

Flood warning time is important to consider when owners plan to relocate contents and machinery or when wet floodproofing measures that require human intervention are allowed by variance. In both cases, advance notice and time are necessary to perform the appropriate actions before the onset of flooding. When wet floodproofing measures that require human intervention are proposed as part of requests for variances, designers should determine whether warnings issued by credible sources would provide enough time to implement those measures. Determining whether the flood warning time is adequate requires estimating the total time needed to:

- Recognize the threat, including whether anticipated storm conditions will have high winds that could hamper installation

- Notify persons or contractors responsible for activation or deployment

- Travel to the site if key personnel are not located on site

- Relocate contents and machinery
- Implement the measures
- Evacuate the personnel implementing the measures using predetermined evacuation routes, taking into account whether roads or bridges may be closed by state or local officials (e.g., when high winds or overtopping by floodwater are anticipated)
- Allow for unanticipated factors that may require additional time

Additional information about flood warning time may be available from state and local emergency management agencies, local floodplain managers, river basin authorities and drainage districts, state water resources agencies, National Weather Service, U.S. Geological Survey, and the U.S. Army Corps of Engineers District Offices.

6.3. Functional Use of Wet Floodproofed Areas

Owners should evaluate the use of buildings and portions of buildings proposed to be wet floodproofed when considering the feasibility of intentionally allowing these areas to flood. Daily operations and use of these areas may need to be modified to reduce vulnerability when flooding occurs. If extended interruption of function would be detrimental, building owners should consider whether wet floodproofing is a viable option compared to elevation or dry floodproofing.

6.4. Safety and Access as Flooding Threatens

For safety, wet floodproofed buildings should not be occupied during flood conditions because floodwater may rise quickly or rise to a higher level than anticipated. In addition, muddy floodwater can obscure scour holes, washed-out paved surfaces, and tripping hazards. Safe access should be considered if an owner expects to need access to a wet floodproofed structure as flooding begins to affect a site or during flooding. See Section 6.2 of this Technical Bulletin for guidance on flood warning time.

In general, fast flowing floodwater is more dangerous than slow moving or standing water. Even shallow floodwater less than a few feet deep can be dangerous if the velocities are high. Rather than locate a new structure with wet floodproofing in an area where safe access is not assured, owners should consider sites where water depths will be shallower and velocities are not high. Some information about water depth and velocities may be available in Flood Insurance Studies or other studies by government agencies.

6.5. Recommended Plans

Flood emergency operations plans and inspection and maintenance plans should be prepared when wet floodproofing is proposed for historic structures and functionally dependent uses and when wet floodproofing is authorized by variance for other buildings.

6.5.1. FLOOD EMERGENCY OPERATIONS PLANS

Flood emergency operations plans should be required when wet floodproofing measures or a combination of wet and dry floodproofing measures that require human intervention are authorized by variance. Building owners, operators, and responsible personnel must be able to implement the plan and then safely leave the area in advance of the onset of flooding (see Section 6.2 of this Technical Bulletin). In addition, there must be sufficient time to notify and evacuate occupants when flood conditions are anticipated.

Annual review of flood emergency operations plans, with exercises for personnel, is critical to the success of the measures when flooding occurs. At a minimum, plans should:

- Identify the personnel, equipment, tools, and supplies needed to implement the measures
- Detail procedures for notifying persons responsible for implementing the measures, including chain of command
- Lay out in detail the sequence, timeline, and personnel responsible for implementing the measures
- Describe and illustrate the storage locations of equipment and deployable components
- Provide step-by-step instructions for implementing the measures
- Specify the requirements for regular review, deployment drills and training, and updating the plan

6.5.2. INSPECTION AND MAINTENANCE PLANS

Floodproofing measures require periodic inspection and maintenance plans to ensure that the measures are kept in working order so all components will function properly under flood conditions. An inspection and maintenance plan should be prepared to ensure that the components are inspected and properly maintained on a regular basis. Inspections and maintenance should be performed annually in accordance with the plans. At a minimum, plans should:

- Identify the personnel or service contractors responsible for conducting the inspections and any required maintenance
- Describe and illustrate the floodproofing measures
- Specify the requirements for regular inspections, routine maintenance, and corrective actions
- Verify that flood openings are not blocked or modified
- Verify that flood damage-resistant materials have not been replaced with materials that would be damaged by contact with floodwater

- List contact information for the manufacturer of any product, such as flood damage-resistant materials and flood openings

7. Design Requirements

Understanding the design considerations and requirements associated with wet floodproofing measures will help owners, builders, and design professionals develop strategies to meet the requirements when buildings are allowed to be wet floodproofed. Owners and designers should also consider the measures described in Section 8 of this Technical Bulletin and the suggested best practices described in Section 9 of this Technical Bulletin.

7.1. Foundations

The failure of foundations inundated by floodwater can cause structural damage. Foundation design is a site-specific process and must account for combined building loads, flood loads, and the flood hazard and site conditions described in Section 6.1 of this Technical Bulletin. Foundation design should also consider the effects of moving water, which may erode supporting soil, scour foundation material, or undermine footings.

The NFIP regulations require buildings to be anchored to foundations to prevent flotation, collapse, or lateral movement of the structure resulting from hydrodynamic and hydrostatic loads, including the effects of buoyancy. During flood events, uplift forces are often great enough to separate an improperly anchored building from its foundation. Structures that become dislodged can cause damage to other buildings or block downstream drainageways, culverts, and bridges.

7.2. Flood Openings

A primary requirement for wet floodproofing is to intentionally allow floodwater to enter and exit automatically (without human intervention). Allowing floodwater to enter and exit automatically minimizes unequal hydrostatic loads on walls. Hydrostatic loads are forces that are associated with standing or slow-moving floodwater. Unequal hydrostatic loads can cause foundation or wall collapse and flood-induced uplift.

Equalizing hydrostatic loads is achieved by installing flood openings in walls to allow water to automatically enter and exit (see Figure 2). In addition, provisions should be made to prevent air from becoming trapped during periods of inundation, which can pressurize the interior of wet floodproofed buildings and damage walls and roofs. The NFIP requirements and guidance for flood openings are discussed in NFIP Technical Bulletin 1, *Requirements for Flood Openings in Foundation Walls and Walls of Enclosures*.

Measures not Acceptable as Flood Openings

Doors, panels, and covers that must be opened before the onset of flooding do not satisy the automatic entry and exit requirement because human intervention is required.

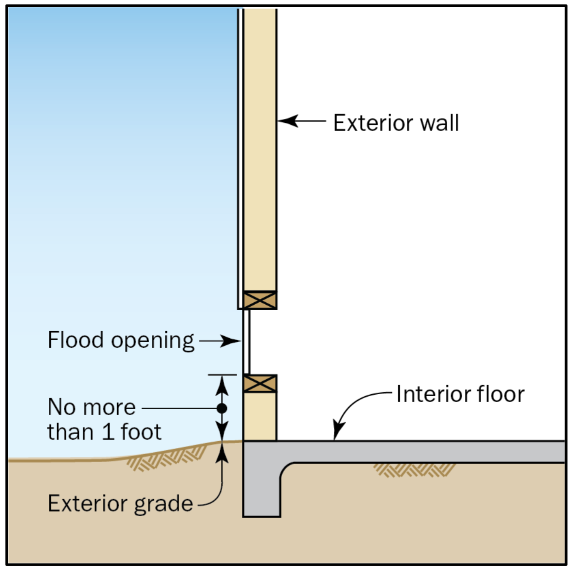

Figure 2: Typical flood opening configuration

7.3. Wall Construction

Walls of wet floodproofed buildings are subject to damage by floodwater if the walls are not properly constructed. Measures should be taken to reduce the absorption of floodwater into walls and finishes.

7.3.1. SOLID WALLS

Solid walls are walls without internal spaces that could retain floodwater. Typical solid walls are made with cast-in-place concrete or fully grouted concrete masonry units. Because the surfaces of walls made of these materials are somewhat porous, they can absorb moisture and to a limited degree, flood-borne contaminants. The intrusion of moisture can lead to damage, particularly in colder climates with freeze-thaw cycles. Sealants and waterproof paints can reduce the absorption of moisture and contaminants and facilitate cleanup.

7.3.2. CAVITY WALLS

Cavity walls are walls with internal spaces that could retain floodwater. Typical cavity walls are wood-framed walls with interior sheathing and walls made with ungrouted concrete masonry units.

Using unfinished wood-framed walls without interior sheathing and solid masonry or grouted concrete masonry units avoids difficulties with draining and cleaning cavity walls. When cavity walls are used, the walls should be constructed to enable the cavities to adequately drain as floodwaters recede. Wall cavities inundated by floodwater will be exposed to contaminants and should have clean-out access panels or other means to allow the internal air spaces to be flushed with water or cleaning agents and to allow fresh air to circulate in the cavities to facilitate drying. If the walls are insulated, foam and closed cell types of insulation should be used because they have flood damage-resistant characteristics.

7.4. Flood Damage-Resistant Materials

The NFIP regulations require that construction materials below the BFE be resistant to flood damage. Materials that are not flood damage-resistant materials may be used when necessary to address life safety and fire code requirements.

NFIP Technical Bulletin 2, *Flood Damage-Resistant Materials Requirements,* describes five classes of materials ranging from highly resistant to flood damage to no resistance. Materials are broadly described as structural materials and finish materials based on how the materials are used in normal construction practices:

- **Structural materials** include all elements necessary to provide structural support, rigidity, and integrity to a building or building component. Structural materials include floor slabs, beams, subfloors, framing, and structural components, such as trusses, wall panels, I-joists and headers, and interior/exterior sheathing.

- **Finish materials** include all coverings, finishes, and elements that do not provide structural support or rigidity to a building or building component. Finish materials include floor coverings, wall and ceiling surface treatments, insulation, cabinets, and materials used to fabricate doors, partitions, and windows.

Technical Bulletin 2 includes guidance on fasteners and connectors used below the BFE. “Fastener” refers to nails, screws, bolts, and anchors. “Connector” refers to manufactured devices used to connect two or more building components. The performance of buildings can be compromised when fasteners and connectors are rusted or otherwise weakened by inundation. Fasteners and connectors must be made of flood damage-resistant materials.

Metal Buildings

Metal cladding and metal buildings used for agricultural structures and accessory structures must be made of corrosion-resistant materials, such as galvanized steel.

7.5. Protection of Mechanical, Plumbing, and Electrical Systems

The NFIP regulations require mechanical, plumbing, and electrical systems to be “designed and/or located so as to prevent water from entering or accumulating within the components during conditions of flooding” (44 CFR § 60.3(a)(3)(iv)). The preferred method of meeting this requirement is elevating the system components above the BFE because most mechanical, plumbing, and electrical equipment is not specifically designed to prevent water from entering or accumulating within the components during flooding and thus must not be installed below the BFE. Systems that serve non-residential buildings may use techniques called “component protection” or “in-place protection” to protect non-elevated equipment and systems (see Section 8.2 of this Technical Bulletin).

Guidance for Mechanical, Plumbing, Electrical, and Other Building Utilities and Systems

FEMA P-348, *Protecting Building Utilities From Flood Damage* (2017), provides guidance on mitigation measures to protect mechanical, plumbing, electrical, and other building utilities and systems, including new installations, replacement systems, and retrofit measures for existing systems.

7.5.1. HEATING, VENTILATION, AND AIR CONDITIONING

In general, heating, ventilation, and air conditioning (HVAC) equipment is not designed to withstand inundation and will be damaged when flooded. When structures are allowed to be wet floodproofed, HVAC equipment should be elevated or have component protection measures to minimize inundation of system components and to be serviceable after floodwater recedes.

As part of proposals for wet floodproofing, especially retrofit wet floodproofing, an option may be considered when permit applicants demonstrate that elevating, using component protection, or permanently relocating HVAC equipment is not practical. The option allows the use of quick-release or disconnect mechanisms so equipment can be easily moved prior to the onset of flooding. When this option is considered, the available flood warning time should be determined (see Section 6.2 of this Technical Bulletin), and the flood emergency operations plan should include this action (see Section 6.5.1 of this Technical Bulletin).

7.5.2. ELECTRICAL SYSTEMS

Electrical systems that serve wet floodproofed buildings must be designed to minimize exposure to flooding as follows:

- Electrical service provided from poles or other overhead sources should enter buildings at a point above the BFE.
- Underground service cables may be feasible provided they are waterproofed, located where not exposed to direct contact with floodwater, and able to resist flood loads.
- Elevation of all electrical system components is required, including transformers, switchboards, and branch panels.
- An alternative to elevating components and equipment may be to enclose them in watertight panels, conduits, or chases that are insulated, rigid, and designed to withstand flood and debris impact forces.
- A minimum number of light switches and receptacles necessary to meet life safety requirements may be located below the BFE, provided they are intended for use in wet locations.
- Ground-fault circuit interrupters should be used for all electrical circuits that serve areas below the BFE.

Post-Flood Safety Inspections

Electrical system components that have been flooded must have a safety inspection before power is restored to ensure that the electrical components are completely dry and clean.

7.6. Fuel, Gas, and Liquid Storage Tanks

Fuel, gas, and liquid storage tanks are subject to hydrostatic loads (buoyancy) during inundation. When allowed above ground in Zone A, tanks can be installed and anchored on grade or elevated on platforms or fill. In Zone V, above-ground tanks must be elevated on platforms to satisfy the requirement that buildings be free of obstructions. Underground tanks must be installed and adequately anchored to account for buoyancy loads and reduced soil capacity when surrounding soils become saturated and to account for scour and erosion during flooding. Fill openings, outlets, vents, and cleanouts must be elevated above the BFE or designed to prevent the entry of floodwater and loss of contents during flooding. FEMA P-348 and FEMA P-2140 provide illustrations and descriptions of designs and options for installation of tanks.

Tanks should have labels that identify the contents. Labeling enables emergency personnel to identify the contents if a tank breaks loose and floats away. Empty tanks, whether above ground and anchored or underground, should be “topped off” (filled) when feasible prior to the onset of flooding to help resist buoyancy loads. After flooding, tank contents must be disposed of in accordance with all applicable federal, state, and local requirements.

8. Retrofit Measures When NFIP Compliance Is Not Required

The retrofit measures described in this section can be used to reduce damage to at-risk, existing and legal non-conforming buildings and structures in SFHAs when compliance with the NFIP requirements for new construction and substantial improvement is not required. These measures should also be considered when communities grant variances to the elevation or dry floodproofing requirements to satisfy the expectation that variances are the minimum necessary to afford relief.

For floodplain management purposes, existing buildings and structures are those constructed before a community joined the NFIP. Legal non-conforming buildings and structures are structures built after a community joined the NFIP but do not conform to a community’s current floodplain management requirements. Non-conformance may result from changes in requirements for buildings or changes in FIRMs that alter SFHAs, flood zones, and BFEs. In general, work on an existing or non-conforming building should not be allowed to increase the building’s non-conformity. Specifically, proposed work on legal non-conforming buildings must not be allowed if the work does not conform to the floodplain management requirements in effect at the time the building was constructed, even if the proposed work does not constitute substantial improvement.

8.1. Relocation or Elevation of Machinery and Equipment

When existing and legal non-conforming buildings and structures are not required to be brought into compliance with the NFIP minimum requirements, a degree of protection can be achieved by permanently relocating or elevating machinery and equipment. Depending on the function of the machinery and equipment, it may be able to continue service if relocated to a higher floor, or the machinery and equipment can be elevated in place. Relocated or elevated equipment will be functional when flooding does not rise higher than the height of the bottom of the equipment. This method of protection can be used for HVAC equipment that, when functional after flooding, will facilitate drying and recovery. See FEMA P-348 for guidance.

Machinery and equipment inside buildings can be elevated by permanently mounting on pads, platforms, or pedestals (see Figure 3) or by using hoists or some type of overhead suspension system when flooding is predicted. A wide range of objects can be elevated such as machinery, utility system components (particularly electrical equipment), fuel and storage containers, and building contents. Pads, platforms, and pedestals should be anchored to the floor system or slab, and the equipment should be anchored to the supporting structure.

Machinery and equipment installed outside buildings can usually be elevated on pedestals, pads, or platforms.

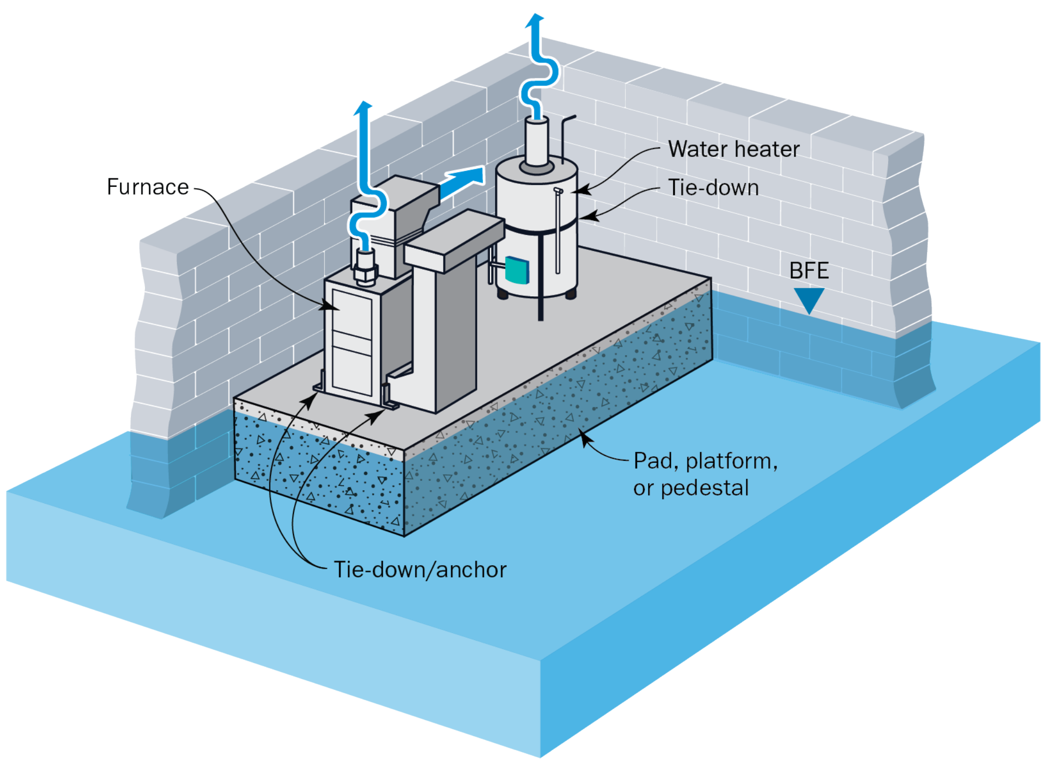

Figure 3: Elevation of equipment on a pad, platform, or pedestal in an area in which the floor slab is below the BFE

8.2. Component Protection of Machinery and Equipment

When existing and legal non-conforming buildings and structures are not required to be brought into compliance with the NFIP minimum requirements, a degree of protection can be achieved by using component protection measures (also called "in-place protection") to protect machinery and equipment. When protected, the equipment will be functional when flooding does not rise higher than the height of the protection measure. This method of protection can be used for HVAC equipment that, when functional, will facilitate drying and recovery. See FEMA P-348 for guidance.

Component protection involves protective permanent or temporary waterproof barriers (see Figure 4), especially when components are difficult to elevate or move. Access doors in permanent barriers should be watertight when closed or protected with mountable flood shields. Tanks and storage containers can be retrofitted with anchors and tie-downs to resist flotation and movement during flooding.

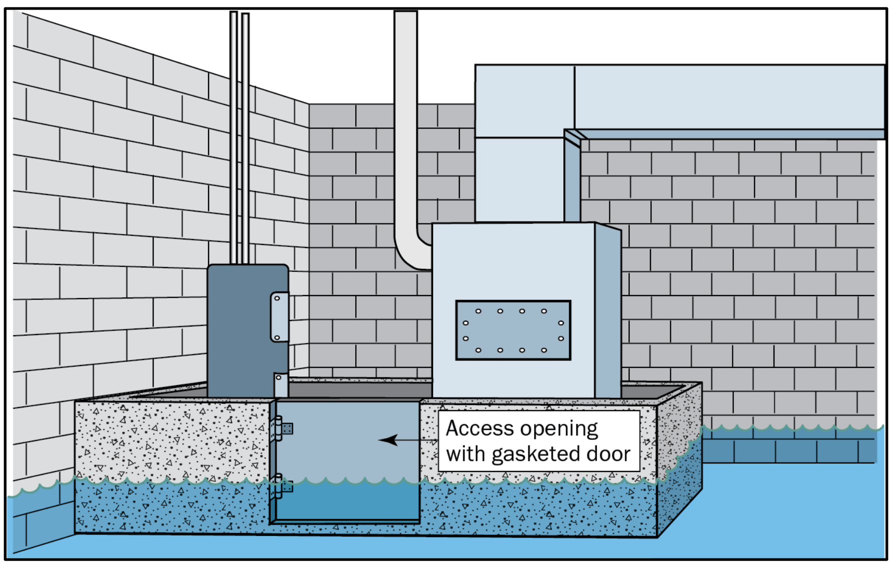

Figure 4: Water heater and furnace protected by a concrete floodwall with access protected by gasketed door or shield

8.3. Interior Drain Systems

Existing and legal non-conforming buildings and structures may have below-grade areas that are subject to flooding. If interior drain systems are not already present, retrofitting below-grade areas with measures to facilitate drainage after floodwaters recede may reduce damage. Interior drain systems also keep seepage from accumulating in interior areas of buildings but are not intended to prevent water from entering buildings during flooding. Sump pumps are commonly used for dewatering below-grade areas and facilitating recovery after floodwaters recede. Gradual dewatering is necessary to avoid creating unequal saturated soil loads on basement walls that can lead to wall failure. Sump pits generally are constructed with the bottom well below the base of the floor slab, and the floor is sloped to drain water to the sump (see Figure 5). See FEMA P-348 for guidance.

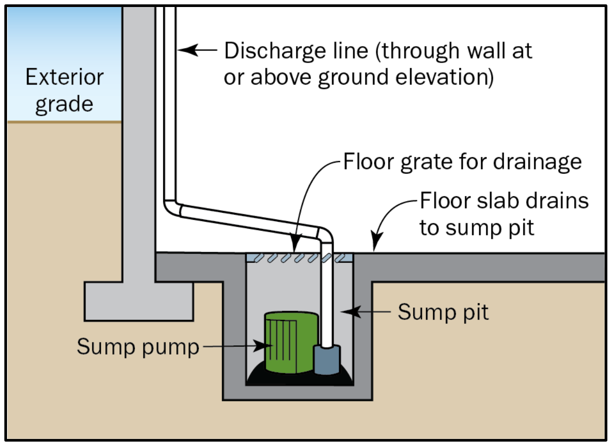

Figure 5: Typical interior drain system

8.4. Dry Floodproofing

Retrofitting some existing and legal non-conforming buildings and structures with dry floodproofing measures by sealing the perimeter walls and creating watertight structures may be technically feasible but not advisable. For guidance on dry floodproofing, refer to FEMA P-936 and Technical Bulletin 3. The likelihood that retrofit floodproofing measures will fail can be high for buildings that were not originally designed to be substantially impermeable and resistant to flood loads. In these cases, and when compliance is not required, it may be technically and economically feasible to consider wet floodproofing to minimize the potential for structural damage.

8.5. Other Considerations

When considering work on existing and legal non-conforming buildings and structures when NFIP compliance is not required, owners and designers should consider the following flood damage reduction retrofit measures:

- Walls, insulation, wall coverings, and finishes can be replaced with flood damage-resistant materials to facilitate cleanup and recovery.
- Quick-disconnect type plugs and receptacles can be used for standard electrical motors and other electrical connections to enable rapid shutdown, reinstallation and restart.
- Equipment and inventory can be mounted on skids or pallets to facilitate relocation, elevation, or removal.
- Large machinery that can be lifted from overhead can be permanently fitted with lifting bars or lugs.
- Buildings should be organized for easy access and to facilitate temporary relocation of contents.

- Contents can be moved to other areas of the building above the anticipated flood level or offsite.
- Vehicles can be moved to locations outside the flood hazard area.

9. Suggested Best Practices

Owners and designers should consider the following best practices when evaluating the use of wet floodproofing measures:

- Consider combining partial elevation or partial dry floodproofing with wet floodproofing (sometimes called “mixed mitigation”). Although written specifically for agricultural structures and accessory structures, the mixed mitigation measures described and illustrated in FEMA P-2140 are applicable to other types of structures for which wet floodproofing is authorized.
- Consider damage reduction practices such as wet floodproofing for areas known to experience flooding that are outside the mapped SFHA.
- Install and configure electrical and mechanical systems to minimize disruptions and facilitate repairs:
  - Elevate the electrical system by running wiring along the top of the walls, down to each outlet.
  - Locate outlets well above the anticipated flood level.
  - Fit appliances with quick disconnections.
- For retrofitting existing floodprone buildings with below-grade areas, install pumps to gradually remove floodwater. Gradual removal is necessary to avoid creating unequal saturated soil loads on basement walls that can lead to wall failure.
- When windows are located below the BFE, use glass block or impact-resistant plastic, wire-reinforced glass, or heavy screens to minimize damage by flood-borne debris impacts.
- Develop flood emergency operations and inspection and maintenance plans.
- Locate furniture and equipment so they can be moved quickly.
- Limit what is stored in wet floodproofed areas, including hazardous materials and pollutants.
- Require applicants and owners to sign nonconversion agreements that stipulate that wet floodproofing measures will not be modified and that wet floodproofed areas will not be converted to uses other than approved uses. Some communities require nonconversion agreements to be recorded in land records.

10. References

This section lists references cited in the Technical Bulletin. Additional resources related to NFIP requirements are provided in Technical Bulletin 0.

ASCE/SEI. 2005. ASCE 24-05, *Flood Resistant Design and Construction.* Available at https://www.asce.org/.

ASCE/SEI. 2014. ASCE 24-14, *Flood Resistant Design and Construction.* Available at https://www.asce.org/.

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- Technical Bulletin 0, User's Guide to Technical Bulletins
- Technical Bulletin 1, Requirements for Flood Openings in Foundation Walls and Walls of Enclosures
- Technical Bulletin 2, Flood Damage-Resistant Materials Requirements
- Technical Bulletin 3, Requirements for the Design and Certification of Dry Floodproofed Non-Residential and Mixed-Use Buildings
- Technical Bulletin 6, Requirements for Dry Floodproofed Below-Grade Parking Areas Under Non-Residential and Mixed-Use Buildings

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- FEMA. 2008. FEMA P-467-2, NFIP Floodplain Management Bulletin: Historic Structures
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ICC. 2021. International Residential Code for One- and Two-Family Dwellings. ICC: Country Club Hills, IL. Earlier editions published in 2000, 20003, 2006, 2009, 2012, 2015, and 2018. Available at https://www.iccsafe.org/.

Corrosion Protection for Metal Connectors and Fasteners in Coastal Areas

in Accordance with the National Flood Insurance Program

NFIP Technical Bulletin 8 / June 2019

FEMA

Comments on the Technical Bulletins should be directed to:

DHS/FEMA
Federal Insurance and Mitigation Administration (FIMA) Risk Management Directorate
Building Science Branch
400 C Street, S.W., Sixth Floor
Washington, DC 20472-3020

Technical Bulletin 8 (2019) replaces Technical Bulletin 8 (1996), *Corrosion Protection for Metal Connectors in Coastal Areas for Structures Located in Special Flood Hazard Areas in accordance with the National Flood Insurance Program.*

Cover photographs: Inset photo: Corrosion of galvanized connectors (FEMA, Fire Island, NY, after Hurricane Sandy). Outset photo: Longer strap connectors helped maintain the connection between the beam and floor joists (FEMA, Seaside Heights, NJ, after Hurricane Sandy)..

For more information, see the FEMA Building Science Frequently Asked Questions website at http://www.fema.gov/frequently-asked-questions-building-science.

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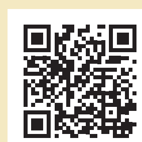

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Acronyms

ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
ASTM	ASTM International
AWC	American Wood Council
BFE	base flood elevation
CCA	chromated copper arsenate
CFR	Code of Federal Regulations
DHS	Department of Homeland Security
FEMA	Federal Emergency Management Agency
FIRM	Federal Insurance Rate Map
IBC	International Building Code®
ICC	International Code Council®
ICC-ES	ICC Evaluation Service
I-Codes	International Codes®
IMOA	International Molybdenum Association
IRC	International Residential Code®
NDS	National Design Specification
NFIP	National Flood Insurance Program
oz/ft^2	ounces per square foot
PWF	Permanent Wood Foundation
SEI	Structural Engineering Institute
SFHA	Special Flood Hazard Area
SSPC	Society for Protective Coatings
TPI	Truss Plate Institute

1 Introduction

This Technical Bulletin explains the importance of using corrosion-resistant metal connectors and fasteners in the construction of coastal structures, areas using preservative-treated lumber, and any locations subject to contact with floodwater or windblown rain.

Post-disaster assessments of wood-framed buildings following natural hazard events such as high winds, floods, and earthquakes have revealed that structural failures frequently occur at connections rather than in framing members. In coastal areas, where higher moisture and humidity levels exist and buildings are exposed to salt spray, corroded metal connectors and fasteners have been observed to contribute to the loss of an adequate load path. The loss of an adequate load path often results in damage to or failure of the structure. This Technical Bulletin presents guidance on addressing and avoiding the corrosion of connectors and fasteners.

Questions pertaining to minimizing or avoiding corrosion of connectors and fasteners should be directed to the appropriate product manufacturers, local official, NFIP State Coordinating Office, or the Federal Emergency Management Agency (FEMA) Regional Office.

NFIP TECHNICAL BULLETIN 0

NFIP Technical Bulletin 0, *User's Guide to Technical Bulletins,* should be used as a reference in conjunction with this Technical Bulletin. Technical Bulletin 0 describes the purpose and use of the Technical Bulletins, includes common concepts and terms, lists useful resources, and includes a crosswalk of the sections of the NFIP regulations identifying the Technical Bulletin that addresses each section of the regulations and a subject index.

Readers are cautioned that the definition of some of the terms that are used in the Technical Bulletins are not the same when used by the NFIP for the purpose of rating flood insurance policies.

2 NFIP Regulations

An important National Flood Insurance Program (NFIP) objective is protecting buildings constructed in Special Flood Hazard Areas (SFHAs) from damage caused by flood forces. The SFHA, composed of Zones A and V, is the areal extent of the base flood shown on Flood Insurance Rate Maps (FIRMs) prepared by FEMA. The base flood is the flood that has a 1 percent chance of being equaled or exceeded in any given year (commonly called the "100-year flood").

The NFIP regulations are codified in Title 44 of the Code of Federal Regulations (CFR) Part 60. Specific to this Technical Bulletin, in coastal regions, corrosion-resistant connectors and fasteners are essential to maintaining a building's load paths and demonstrating compliance with 44 CFR Sections 60.3(a)(3) and 60.3(e)(4).

I-CODES AND ASCE

The International Codes (I-Codes) and the standard, ASCE 24, *Flood Resistant Design and Construction*, include requirements for metal connectors and fasteners used in coastal areas that are susceptible to salt spray to address metal corrosion.

Section 60.3(a)(3) is applicable to all SFHAs:

> If a proposed building site is in a flood-prone area, all new construction and substantial improvements shall (i) be designed (or modified) and adequately anchored to prevent flotation, collapse, or lateral movement of the structure resulting from hydrodynamic and hydrostatic loads, including the effects of buoyancy, (ii) be constructed with materials resistant to flood damage, (iii) be constructed by methods and practices that minimize flood damages …

Section 60.3(e)(4) is applicable to Coastal High Hazard Areas (Zone V):

> … new construction and substantial improvements… [shall be] elevated on pilings and columns so that …(ii) the pile or column foundation and structure attached thereto is anchored to resist flotation, collapse and lateral movement due to the effects of wind and water loads acting simultaneously on all building components. Water loading values used shall be those associated with the base flood. Wind loading values used shall be those required by applicable State or local building standards.

NFIP REQUIREMENTS AND HIGHER REGULATORY STANDARDS

State and Local Requirements. State or local requirements that are more stringent than the minimum requirements of the NFIP take precedence. The Technical Bulletins and other FEMA publications provide guidance on the minimum requirements of the NFIP and describe best practices. Design professionals, builders, and property owners should contact local officials to determine whether more restrictive provisions apply to buildings or sites in question. All other applicable requirements of the State or local building codes must also be met for buildings in flood hazard areas.

Substantial Improvement and Substantial Damage. As part of issuing permits, local officials must review not only proposals for new construction but also for work on existing buildings to determine whether the work constitutes Substantial Improvement or repair of Substantial Damage. If the work is determined to constitute Substantial Improvement or repair of Substantial Damage, the buildings must be brought into compliance with NFIP requirements for new construction. Some communities modify the definitions of Substantial Improvements and/or Substantial Damage to be more restrictive than the NFIP minimum requirements.

For more information on Substantial Improvement and Substantial Damage, see FEMA P-758, *Substantial Improvement/Substantial Damage Desk Reference* (2010b), and FEMA 213, *Answers to Questions About Substantially Improved/ Substantially Damaged Buildings* (2018a).

Flood Damage-Resistant Materials. Guidance on the NFIP requirement regarding the use of building materials resistant to flood damage can be found in Technical Bulletin 2, *Flood Damage-Resistant Materials Requirements.*

3 Other Regulations

In addition to complying with NFIP requirements, all new construction, Substantial Improvements, and repair of Substantial Damage must comply with applicable building codes and standards that have been adopted by States and communities.

The International Codes® (I-Codes®), published by the International Code Council® (ICC®) are a family of codes that includes the International Residential Code® (IRC®), International Building Code® (IBC®), International Existing Building Code® (IEBC®), and codes that govern the installation of mechanical, plumbing, fuel gas service, and other aspects of building construction. FEMA has deemed that the latest published editions of the I-Codes meet or exceed NFIP requirements for buildings and structures. Excerpts of the flood provisions of the I-Codes are available on FEMA's Building Code Resource webpage (http://www.fema.gov/building-code-resources).

3.1 International Residential Code

The IRC applies to one- and two-family dwellings and townhomes not more than three stories above grade plane, with certain limitations for high wind, high seismic, and high snow regions. The IRC requirements that are related to connectors and fasteners in coastal areas are summarized in Table 1.

Although Table 1 refers to selected requirements of the 2018 IRC and notes changes from the 2015 and 2012 editions, subsequent editions should include comparable requirements.

Table 1: Comparison of Select 2018 IRC and NFIP Requirements

Topic	Summary of Select 2018 IRC Requirements and Changes from 2015 and 2012 Editions	Comparison with NFIP Requirement
Fasteners and connectors	**Section R317.3.1 Fasteners for preservative-treated wood.** Requires all fasteners used for pressure-treated wood to be corrosion resistant. Specific requirements for connectors are outlined in the IRC. The coating type and weights of connectors shall either be as specified by the manufacturer or meet the minimum requirements as specified in the IRC. Exceptions to this requirement are outlined in the IRC. <u>Change from 2015 to 2018 IRC:</u> The need for staples to be stainless steel was added. <u>Change from 2012 to 2015 IRC:</u> No changes.	No NFIP requirement
Flood-resistant construction	**Section R322.1.2 Structural systems.** Requires that buildings and structures be designed and constructed to resist flood forces during a design flood event. This includes connecting structural systems and anchoring the building to resist flotation, collapse or permanent lateral movement during a design flood. <u>Changes from 2015 to 2018 IRC:</u> No change. <u>Changes from 2012 to 2015 IRC:</u> No change.	Equivalent to NFIP regulation in 44 CFR §§ 60.3(a)(3)(i) and (iii), and § 60.3(e)(4)

Table 1: Comparison of Select 2018 IRC and NFIP Requirements (concluded)

Topic	Summary of Select 2018 IRC Requirements and Changes from 2015 and 2012 Editions	Comparison with NFIP Requirement
Flood damage-resistant materials	**Section R322.1.8 Flood-resistant materials.** Requires materials used below the required design flood elevation to be flood damage resistant in conformance with NFIP Technical Bulletin 2. Change from 2015 to 2018 IRC: No change. Change from 2012 to 2015 IRC: The need for wood to be pressure-treated, preservative-treated, or decay-resistant heartwood was deleted to clarify that the guidance in NFIP Technical Bulletin 2 is adequate to meet flood damage-resistant material requirements.	Equivalent to NFIP regulation in 44 CFR § 60.3(a)(3)(ii)

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3.2 International Building Code and ASCE 24

The flood provisions in the latest published editions of the IBC meet or exceed the NFIP requirements for buildings largely through reference to the standard ASCE 24, *Flood Resistant Design and Construction,* developed by the American Society of Civil Engineers (ASCE). The IBC applies to all applicable buildings and structures. While primarily used for buildings and structures other than dwellings within the scope of the IRC, the IBC may be used to design dwellings. The IBC and ASCE 24 requirements related to the use of corrosion-resistant fasteners (often used for maintaining a building load path), which are summarized in Table 2, are more specific than NFIP regulations and also apply to areas where the minimum elevation requirements are above the base flood elevation (BFE) by the incorporation of freeboard.

IBC AND ASCE COMMENTARIES

ICC publishes companion commentary for the IBC and ASCE publishes companion commentary for ASCE 24. Although not regulatory, the commentaries provide information and guidance that are useful in complying with, interpreting, and enforcing requirements.

Although Table 2 refers to selected requirements of the 2018 IBC and ASCE 24-14 (noting changes from 2015 and 2012 IBC and ASCE 24-05), subsequent editions should include comparable requirements.

Table 2: Comparison of Select 2018 IBC and ASCE 24-14 Requirements with NFIP Requirements

Topic	Summary of Select 2018 IBC/ASCE 24-14 Requirements and Changes from 2015 and 2012 IBC/ASCE 24-05	Comparison with NFIP Requirement
General design requirement	**2018 IBC, Section 1612.2 Design and construction.** Requires buildings and structures located in all delineated flood hazard areas to be designed and constructed in accordance with Chapter 5 of ASCE 7 *(Minimum Design Loads and Associated Criteria for Buildings and Other Structures)* and ASCE 24. Change from 2015 to 2018 IBC: Section renumber from 1612.4 to 1612.2. Change from 2012 to 2015 IBC: Applies to coastal high hazard area requirements in Coastal A Zones, if delineated.	For Zones A and V, equivalent to NFIP 44 CFR § 60.3 For Coastal A Zones, more restrictive than the NFIP since the NFIP does not define Coastal A Zones

Table 2: Comparison of Select 2018 IBC and ASCE 24-14 Requirements with NFIP Requirements (continued)

Topic	Summary of Select 2018 IBC/ASCE 24-14 Requirements and Changes from 2015 and 2012 IBC/ASCE 24-05	Comparison with NFIP Requirement
Fasteners and connectors for preservative-treated wood	**2018 IBC, Section 2304.10.5 Fasteners and connectors in contact with preservative-treated and fire-retardant-treated wood.** Requires all fasteners used for pressure-treated and fire-retardant-treated wood to be corrosion resistant and shall be compliant with Sections 2004.10.5.1 through 2304.10.5.4. Coating requirements for zinc coatings and stainless steel fasteners are specified in the IBC.	No NFIP requirement
Fasteners and connectors for preservative-treated wood (cont.)	**2018 IBC, 2304.10.5.1 Fasteners and connectors for preservative-treated wood.** Requires all fasteners used for pressure-treated wood to be corrosion resistant. Specific requirements for connectors are outlined in the IBC. The coating type and weights of connectors shall either be as specified by the manufacturer or meet the minimum requirements as specified in the IBC. An exception for carbon steel fasteners is outlined in the IBC. **2018 IBC, 2304.10.5.2 Fastenings for wood foundations.** Requires all fasteners used for wood foundations to be compliant with the American Wood Council's *Permanent Wood Foundation Design Specification with Commentary,* 2015 Edition (ANSI/AWC PWF-2015 [2014b]). **2018 IBC, 2304.10.5.3 Fasteners for fire-retardant-treated wood used in exterior applications or wet or damp locations.** Requires all fasteners used for fire-retardant-treated wood in exterior applications or wet or damp locations to be corrosion resistant. Specific requirements for fasteners are outlined in the IBC. **2018 IBC, 2304.10.5.4 Fasteners for fire-retardant-treated wood used in interior applications.** Requires all fasteners used for fire-retardant-treated wood in interior locations to be as specified by the manufacturer, or if those specifications do not exist, the fasteners meet the requirements of Section 2304.9.5.3. Changes from 2015 to 2018 IBC: Standards for driven fasteners and the need for staples to be stainless steel were added. Changes from 2012 to 2015 IBC: Section 2304.9.5 was renumbered to 2304.10.5.	No NFIP requirement
Flood damage-resistant materials	**ASCE 24-14, Section 5.1 General** Requires that, in flood hazard areas, all materials used in new construction and substantial improvaements be constructed of flood damage-resistant materials below the required elevations specified in Table 5-1 of ASCE 24-14. Also requires materials to be of sufficient strength, rigidity, and durability to adequately resist all flood-related and other loads or to be designed as breakaway or as otherwise permitted in the standard. Change from ASCE 24-05: Duplicative statement at the end of the section on the need for materials to have sufficient strength, rigidity, and durability to resist flood loads was removed.	Equivalent to NFIP 44 CFR § 60.3(a)(3) with more specificity on requirements for connectors and fasteners

Table 2: Comparison of Select 2018 IBC and ASCE 24-14 Requirements with NFIP Requirements (concluded)

Topic	Summary of Select 2018 IBC/ASCE 24-14 Requirements and Changes from 2015 and 2012 IBC/ASCE 24-05	Comparison with NFIP Requirement
Metal connectors and fasteners	**ASCE 24-14, Section 5.2.1 Metal Connectors and Fasteners** Requires that metal connectors and fasteners exposed to floodwater, precipitation, or wind-driven water meet specific standards as outlined in ASCE 24-14 for corrosion resistance. Change from ASCE 24-05: Updated references to materials standards. **ASCE 24-14, Section 5.2.2.1 Corrosive Environments** Requires structural steel exposed to saltwater, salt spray, or other corrosive materials be hot-dipped galvanized after fabrication and other secondary components to meet the requirements of Section 5.2.1. Change from ASCE 24-05: No change.	No NFIP requirement

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4 Importance of Selecting Proper Connectors and Fasteners for a Continuous Load Path

Buildings are exposed to numerous forces (loads), including those associated with wind events, floods, snow accumulation, and earthquakes. For a building to survive exposure to such forces, loads must be transferred through the building's structure to the soils that support the building along what are typically referred to as load paths. Load paths consist of structural elements (e.g., beams, columns, bearing walls) and the components that connect these elements. In light-frame construction, structural elements are often connected with metal connectors and fasteners (fasteners include screws, bolts, and nails). Examples are shown in Figure 1.

Metal connectors are premanufactured components that are usually cut from flat steel sheets and formed into a shape to efficiently transfer loads from one structural element to another. The load capacities of metal connectors, often determined by the manufacturer through testing or analysis, are published for use by design professionals and contractors to meet the load requirements for their project.

Metal connectors and fasteners are important elements in transferring loads from natural hazards (e.g., flood, wind, seismic) through a building. Corrosion rates for metal are dramatically higher in coastal environments than in less harsh, non-coastal environments. Therefore, it is important to increase the corrosion protection for metal connectors and fasteners in coastal environments. See Section 6 for information on the causes of corrosion in coastal areas. Studies have shown that stainless steel and thick hot-dip galvanized (G185 or higher) metal connectors and fasteners improve corrosion protection. Selecting metal connectors and fasteners made of the same metal and either hot-dip galvanized or stainless steel will improve performance. See Section 8 for information on improving corrosion resistance.

Regardless of the metal that is selected, routine inspection is important to identify when replacement is necessary. See Section 9.2 for information on inspections.

Preservative-treated lumber, which is commonly used in many buildings, requires special attention when selecting connectors and fasteners. See Section 5.1.1.

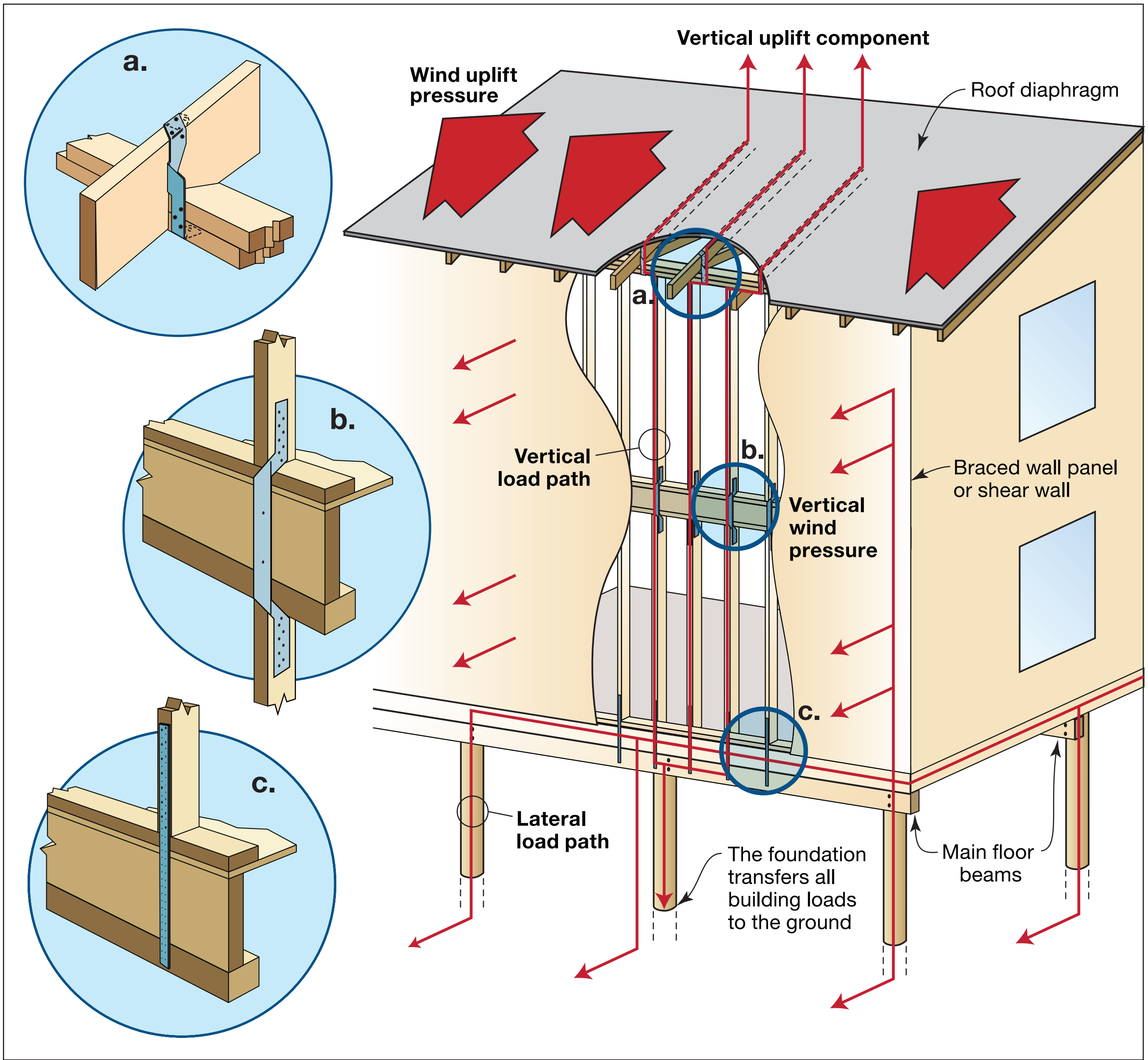


Figure 1: Example of using metal connectors and fasteners to create a continuous load path

5 Light Gauge Metal Connectors and Corrosion

The term "light gauge metal connectors" is used in this Technical Bulletin to highlight the importance of corrosion protection for lighter gauge connectors such as the prefabricated connectors that are used to facilitate wood connections. However, metal connectors fabricated from thicker steel will also benefit from this guidance.

Light gauge metal connectors are commonly used in several locations throughout wood-framed buildings. Concrete and masonry structures may also use them. Although light gauge metal connectors are not unique to wood-framed buildings, this Technical Bulletin highlights aspects of using them in wood-framed buildings in areas where corrosion can occur.

Light gauge metal connectors are often used to create a load path by securing roof framing to the tops of load-bearing walls, connecting walls of upper floors to lower floors, and connecting walls to foundations. The selection of the type of metal connector to use for specific applications may be dictated by the building code or may be based on the relative ease a type of connector offers in making complex framing connections. Metal connectors such as wind anchors may be used instead of toe-nailed connections to increase the strength of connections of a roof truss to a top plate (see Figure 2). In some cases, such as when attaching floor joists to floor band joists, metal connectors can both improve the connection and also reduce labor costs (see Figure 3). In some portions of a building's load path, light gauge metal connectors can make the connection several times stronger than a connection that is readily achievable by nails alone.

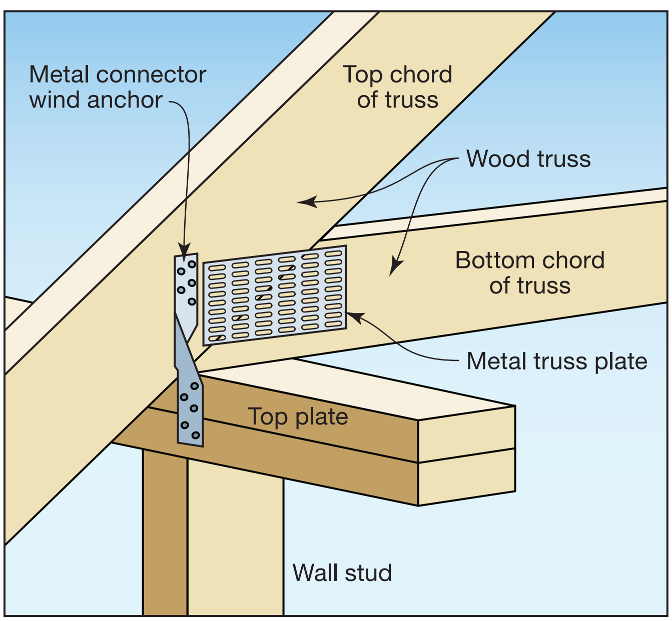


Figure 2: Common wind anchor and metal truss plate

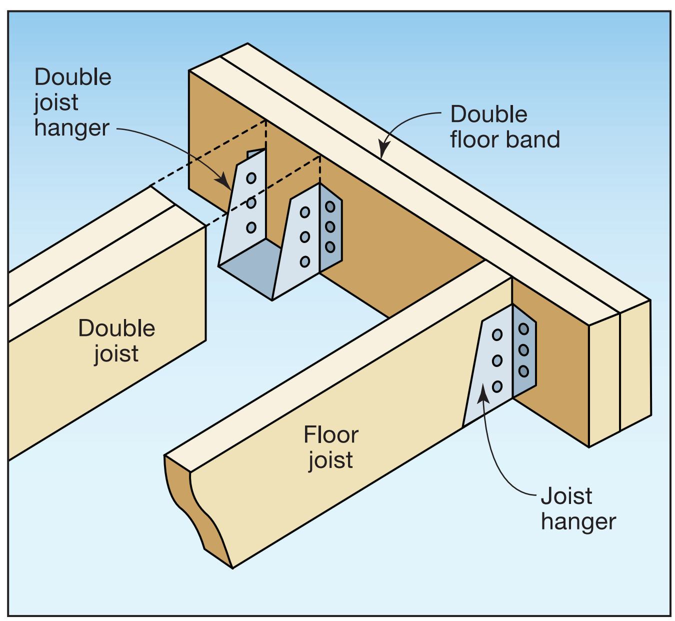


Figure 3: Common single- and double-joist hangers

Despite the benefit of being stronger than nails alone, light gauge metal connectors have drawbacks in coastal environments. Metal connectors that are prone to corrosion can lead to load path failures and structural damage during natural hazard events. The following are examples of important metal connectors potentially subject to corrosion:

- Hurricane straps and wind anchors used to connect roofs to walls (see Figure 2)
- Truss plates that connect the members of pre-manufactured roof and floor framing systems
- Joist hangers used on floor joists (see Figure 3), beams, and rafters
- Other metal connectors such as those used to improve lateral load resistance

5.1 Known Concerns Related to Nominally Galvanized Metal Connectors

In this Technical Bulletin, the term "nominally galvanized metal connectors" refers to connectors that have the minimum galvanization provided by the manufacturer and that do not have corrosion resistance beyond the minimum.

Nominally galvanized metal connectors should be upgraded when enhanced corrosion resistance or greater strength in the connection is needed or desired.

5.1.1 Chemicals in Preservative-Treated Wood

Salt spray in coastal environments and the chemicals in the preservatives that are used to treat wood can both contribute to the corrosion of metal fasteners. One of the chemicals in preservatives, chromated copper arsenate (CCA), was removed in 2004 from formulations for preservative-treated wood for most building applications. Several formulations to replace CCA were developed, including some that are more chemically reactive and therefore more corrosive to metal connectors and fasteners. As a result, manufacturers of several of the new formulations specified that all fasteners used with preservative-treated framing be stainless steel or hot-dip galvanized metal with a defined minimum amount of galvanizing.

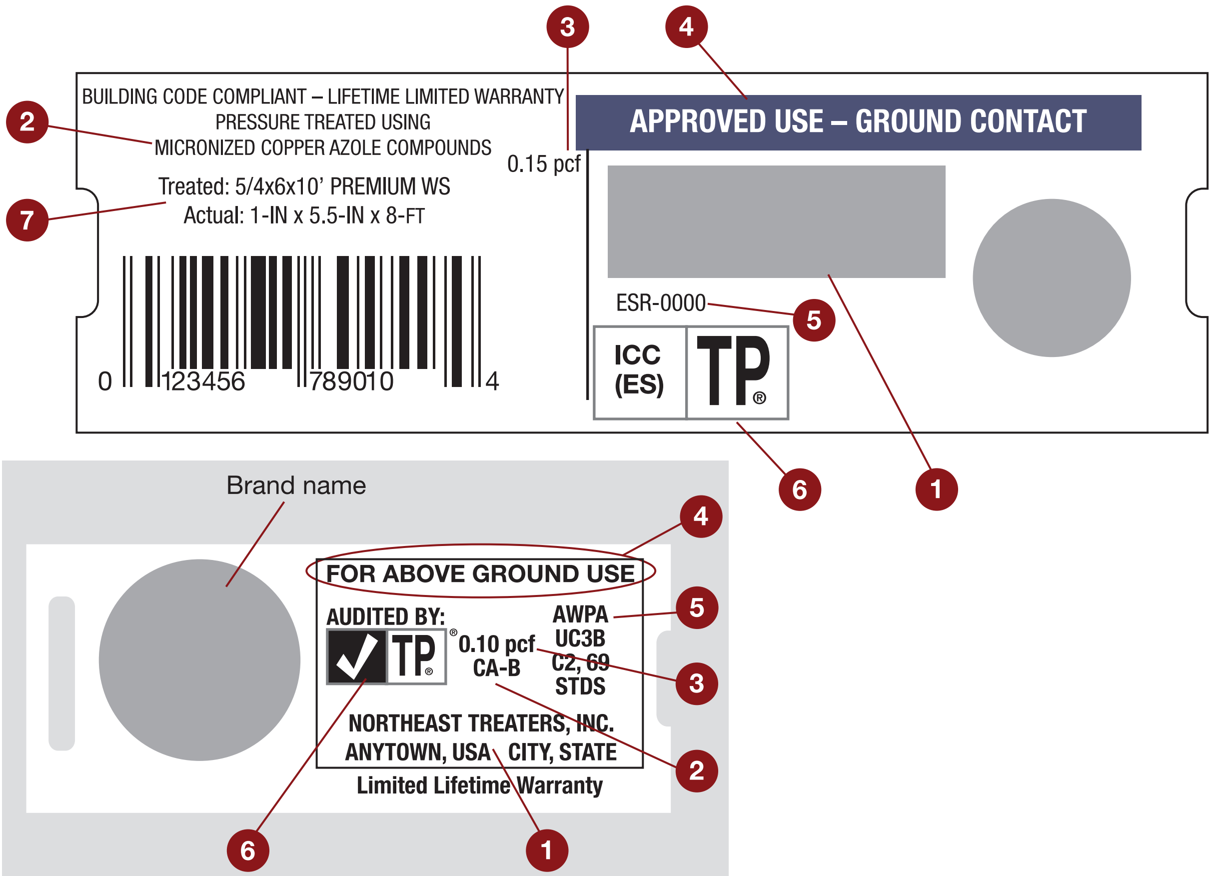
Which chemical is used in the treatment and the amount of chemical in the wood after treatment, referred to as retention, can both influence the corrosion rate. Wood treated for use in more severe environments, such as in direct contact with the ground, has higher chemical retention than wood treated for use in less severe environments. Higher retention can increase the corrosion rate. Connector manufacturers may have recommendations on selecting connectors and fasteners that will be in contact with treated wood.

Lumber manufacturers attach identification tags to treated wood products to indicate the type of preservative that was used (see Figure 4). The tags allow designers and builders to select connectors and fasteners that are compatible with the amount and type of preservative in the wood and its intended environment.

5.1.2 Galvanic Corrosion

Galvanic corrosion is the corrosion that results when two metals with different electrical potential are in contact with each other and are in the presence of an electrolyte such as saltwater. Galvanic corrosion is an electrochemical process in which one of the metals corrodes and the other one is protected.

Metals can be protected from galvanic corrosion by applying a sacrificial metal to a metal surface (see Section 8). The metals involved in galvanic corrosion can be (1) the metallic compounds in wood preservatives and the metal connectors the compounds are in contact with or (2) metal connectors and adjoining fasteners if they are made of dissimilar metals such as stainless steel and aluminum. *It is important that fasteners and connectors be made of similar metals to prevent galvanic corrosion.* Galvanic corrosion can occur anywhere but can occur more quickly in coastal environments.



Preservative-treated wood is commonly referred to as "pressure treated" lumber and has an identification tag attached to the lumber. The tag contains the following information:

1 Identification of treating manufacturer
2 Type of preservative
3 Minimum preservative retention (pcf)
4 End use for which the product is treated
5 Standard to which the product was treated or ICC-ES Evaluation Report Number
6 Identity of the approved inspection agency
7 Size, Length, Grade, Species (Optional)

Figure 4: Wood product identification tag

5.2 Metal Connector and Fastener Materials and Fabrication

Most light gauge metal connectors are made from thin, flat sheets of steel that has been galvanized (has a zinc coating that was applied during fabrication). In flat sheet form, steel is sufficiently strong for connectors and is readily workable and relatively inexpensive, all of which make it well suited for connectors. Most fasteners (e.g., screws, bolts, nails) are also made of steel.

Unprotected (ungalvanized) steel is subject to corrosion, even in inland areas, and corrodes rapidly in salt air. To protect against corrosion, most light gauge metal connectors and fasteners are galvanized.

CORROSION OF BRICK TIES

Metal brick ties and their fasteners are also subject to corrosion. Fact Sheet 5.4, "Attachment of Brick Veneer in High-Wind Regions" in FEMA P-499, *Home Builder's Guide to Coastal Construction* (2010a), contains recommendations on improving the attachment of brick veneers to buildings. The recommendations in this Technical Bulletin for corrosion-resistant connectors and fasteners also apply to the proper selection of corrosion-resistant brick ties and fasteners.

5.2.1 Galvanizing

Galvanizing is the process of coating steel with zinc.

In hot-dip galvanizing, the steel is carefully cleaned and then dipped into a vat of molten zinc. The high temperature melts the surface of the steel and forms several steel/zinc alloys that tightly bond the zinc coating to the steel base metal; various thicknesses of zinc coatings are achievable. The protective zinc coating still corrodes, but the corrosion of the zinc protects the steel base metal. Galvanized steel can degrade up to more than 50 times slower than ungalvanized steel in the same coastal environment.

Zinc can also be applied mechanically. The method typically involves tumbling the metal parts in acid and copper to mechanically weld a zinc coating onto a steel surface. This method is preferred for applying zinc to threaded parts, such as machine screws, because it creates a uniform thickness of the coating. As with hot-dip galvanizing, various thicknesses of zinc coatings are achievable.

Mechanically galvanized fasteners are appropriate for some applications, but mechanically applied galvanized coatings are typically thinner and more brittle than hot-dip galvanized coatings, so mechanically galvanized fasteners are discouraged for exterior applications, particularly in coastal environments. The IBC and IRC prohibit mechanical galvanizing for driven fasteners such as nails and timber rivets because mechanically galvanized coatings may deteriorate during installation. For these applications, hot-dip galvanized coated steel or stainless steel fasteners are recommended.

HOT-DIP GALVANIZING COATING DESIGNATION SYSTEM

ASTM A653 (2015a) uses a coating designation for hot-dip galvanizing that indicates the amount of galvanizing in ounces per square foot (oz/ft^2) of surface area. For example, hardware designated as G185 has a galvanized coating that weighs 1.85 oz/ft^2 (the weight includes both surfaces of the coated material) and a minimum of 0.64 oz/ft^2 on one side because coatings are not always evenly distributed on both sides. Metal connectors are often stamped with the coating designation, but fasteners generally are not, so it is necessary to look at the packaging to determine the amount of galvanizing for fasteners.

5.2.2 Protective Properties of Zinc

Galvanizing is particularly effective for steel because, unlike most other coatings, zinc sacrificially protects bare steel edges and scratches. The zinc surface near a scratch corrodes slightly faster than the zinc surrounding it and fills small scratches with zinc corrosion products, preventing the steel from rusting until the nearby zinc is consumed. The protection of bare edges and scratches offered by galvanizing is important because many connectors are fabricated after the steel sheet metal has been galvanized, and fabrication can remove the zinc and expose the base metal.

Zinc also differs from other coatings (or paints) and most metals by corroding at a relatively steady rate in most atmospheric exposures. Therefore, doubling the thickness of the zinc coating approximately doubles the protection period.

5.2.3 Standards and Codes

ASTM International (ASTM) has established national standards for galvanizing that are referenced by the I Codes, ASCE 24, and most local building codes. The standards are contained in the following:

- Hot-dip galvanized steel sheets used in the manufacture of metal connectors are covered in ASTM A653, *Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process* (2015a).
- Metal connectors that are hot-dip galvanized after fabrication are covered in ASTM A153/A153M, *Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware* (2016).
- Hot-dip galvanizing of most fasteners is covered by ASTM A123, *Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products* (2015b).
- Mechanically applied galvanizing is covered in ASTM B695-04, *Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel* (2004), which states that Class 55 is the minimum thickness allowed to be in contact with preservative-treated lumber.

The I-Codes require that treated wood or the connector manufacturer's recommendations be followed when connectors are in contact with preservative-treated lumber. In the absence of direction, the I-Codes require that a minimum G185 zinc-coated steel be used (some exceptions are provided). Use of Type 304 or Type 316 stainless steel is regarded as exceeding the minimum G185 zinc-coated steel code requirement for corrosion protection. Stainless steel types are explained in Section 8.2 of this Technical Bulletin.

5.2.4 Proprietary Coatings

For some types of fasteners, particularly screws, manufacturers use a proprietary coating rather than simple galvanization. One advantage of using a proprietary coating is that the coating can be more uniform to allow the threads to function normally. Manufacturers may have a building code evaluation report to show that their coating is equivalent to one of the prescriptive corrosion-resistant coatings required by the codes.

6 Causes of Corrosion in Coastal Areas

Corrosion of metal fasteners and connectors is accelerated when a certain level of surface wetness is exceeded, initiating electrochemical reactions among the metal, salts, and air. The conditions that accelerate the rate of corrosion near the coast have been studied at a few field stations and in research laboratories. The studies identified the major factors that contribute to accelerated corrosion rates as including proximity to the shoreline, high temperature, high humidity, elevation, exposure class (see text box) including sheltering, and certain airborne pollutants. While it may be infeasible to determine the rate of corrosion at specific sites, it is helpful to understand the factors that contribute to corrosion so that appropriate design, construction, and maintenance activities can be implemented.

EXPOSURE CLASS

As used in this Technical Bulletin, the term "exposure class" relates to areas of buildings exposed to different conditions that affect corrosion. It is different from the term "Exposure Category," which is used in the wind load requirements of the I-Codes.

Exposure classes are outlined in Section 7 of this Technical Bulletin.

6.1 Salt Spray from Breaking Waves and Onshore Winds

Salt spray from breaking waves and onshore winds significantly accelerates the rate of corrosion of metal connectors and fasteners. Ocean salts, which are primarily sodium chloride but include other chlorides and compounds, accumulate on metal surfaces and accelerate the electrochemical reactions that cause rusting and other forms of corrosion. The combination of salt accumulation on the surface and the high humidity common in many coastal areas further accelerates the corrosion rate of untreated steel and other metals commonly used in connectors, fasteners, and other building materials. The longer a surface remains damp during the normal daily fluctuations in humidity, the higher the corrosion rate. Onshore winds carry both salt and moisture inland from the ocean. Therefore, corrosion rates are higher along shorelines with predominantly onshore winds than along shorelines with predominantly offshore winds.

6.2 Distance from Ocean

When waves break, salt water is aerosolized, and the wind tends to distribute the salt spray to inland areas. The amount of salt spray in the air is greatest near breaking waves and declines rapidly in the first 300 to 3,000 feet landward of the shoreline. Despite the inland reduction, studies have shown accelerated corrosion rates as far inland as 5 to 10 miles (IMOA, 2009). Farther landward, corrosion can be similar to the rates that occur in milder, inland conditions.

Although the width of high-corrosion areas varies along the shoreline, it is appropriate to assume that oceanfront and nearshore buildings can be more severely affected than buildings farther inland. Tests in North Carolina in the 1940s found that samples of iron corroded 10 times faster 80 feet landward of the shoreline than samples of the same material 800 feet landward of the shoreline (LaQue, 1975). Similar results have been noted around the world.

6.3 Elevation Above Ground

LaQue (1975) determined that elevation above the ground, in addition to distance from the ocean, affected rates of corrosion in tests at Kure Beach, NC. The tests showed that the rate of corrosion reached a peak at approximately 12 feet above the ground near the shoreline (see Figure 5), approximately equal to the lowest floor elevation of an elevated building with parking underneath. In several rows of buildings farther inland, the corrosion rate was found to be lower, but the rate was highest at an elevation above the roofs of small buildings. The tests also indicated that the highest corrosion rate near the ocean was more than twice the corrosion rate farther inland.

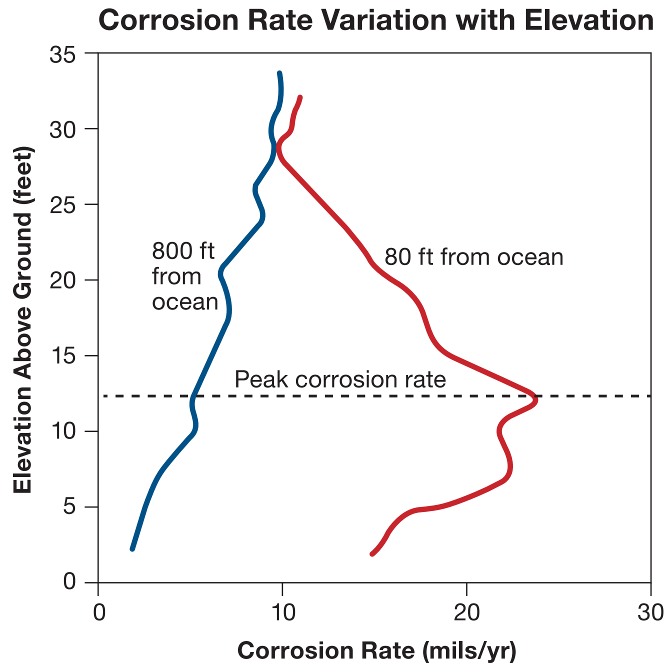


Figure 5: Variation in the corrosion rate of steel with elevation at two distances from the ocean for Kure Beach, NC (LaQue, 1975)

6.4 Exposure to Corrosion and Building Orientation

Both exposure and building orientation affect corrosion rates (exposure classes are described in Section 7 of this Technical Bulletin). Exposed areas such as building exteriors are often coated with large amounts of salt spray and can be expected to suffer high corrosion rates. LaQue (1975) found that the metals on the side of a building facing the ocean corrode much faster than those facing away from the ocean.

Perhaps less obvious is LaQue's finding that partially sheltered exposures, such as areas under piling-supported buildings or under decks and walkways, can experience even greater corrosion than open exposures. Tests showed that portions of buildings exposed to rain may undergo lower corrosion rates than sheltered areas because rain can periodically wash away salt accumulations. Sheltered or covered areas, on the other hand, do not benefit from occasional rinsing from rain and therefore accumulate more salt, resulting in higher corrosion rates.

Another effect of exposure and building orientation is related to the duration of surface wetness. Open exposures dry more readily because they are exposed to sunlight, and rapid drying slows the corrosion rate. Partially sheltered exposures stay damp longer and therefore may corrode faster.

6.5 Weather and Rates of Corrosion

Weather affects the rate of corrosion of metal in both coastal and inland locations. Most chemical reactions, including corrosion, are affected by temperature, humidity, wind speed, and other factors. Higher temperatures and higher humidity increase corrosion rates. Like any weather-driven condition, corrosion rates can vary considerably from year to year.

Short-term measurements of corrosion rates at specific locations can be misleading unless compared to long-term averages for nearby locations because average weather conditions for factors such as rainfall seldom occur. In any given year, measured rainfall can be much higher or lower than the average rainfall.

As a result, the corrosion rate for a given area in an individual year may be significantly higher or lower than the long-term average rate. Because corrosion rates vary, inspections and maintenance should be done at least annually, and preferably more often, to identify connectors and fasteners that need to be replaced. See Section 9.2 for more information on maintenance and replacement.

6.6 Identifying Areas with Increased Corrosion Rates

Corrosion tests can help define the coastal areas where corrosion is most severe, and extra precautions should be taken to minimize corrosion of metal connectors and fasteners. Unfortunately, corrosion data are not available for most coastal communities, and building professionals must rely on local experience to estimate the areas where corrosion-resistant materials and methods are needed.

Areas of increased corrosion concern can be identified by observing the state of corrosion of metal connectors and fasteners in older buildings located at various distances from the shoreline. The observations can be documented and used to delineate areas with higher corrosion rates. Alternatively, communities or builders can conduct field tests using a test kit or laboratory to determine areas where increased corrosion protection should be used.

7 Exposure Classes for Connectors and Fasteners

Corrosion exposure types for metal connectors and fasteners in most buildings can be grouped into five classes, which are discussed in this section. The five classes and their locations in a building are shown in Figure 6.

Exposure classes should be considered when determining which connectors and fasteners are appropriate for a given application. The use of corrosion-resistant fasteners and connectors, such as those that are made of stainless steel or incorporate thicker zinc galvanizing (G185 or thicker), will reduce corrosion rates or extend the period that the zinc coating protects the base metal. Using corrosion-resistant fasteners and connectors will maintain the designed load path longer than nominally galvanized connectors and fasteners. In areas where corrosion is the most

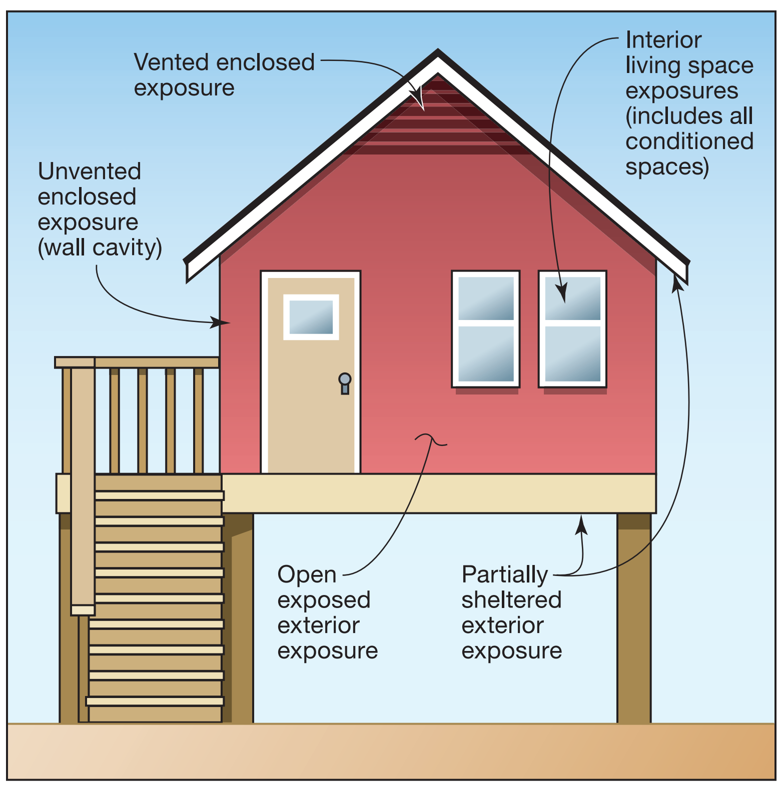


Figure 6: Corrosion exposure classes and their locations

problematic, the most corrosion-resistant metal connectors and fasteners, such as Type 304 or Type 316 stainless steel, should be used.

SELECTING FASTENERS AND CONNECTORS

Before selecting fasteners and connectors, consult the locally applicable code and relevant design standards for requirements to determine the minimum level of corrosion protection necessary.

7.1 Partially Sheltered Exterior Exposure

Examples of *partially sheltered exterior exposures* are open, under-house storage; parking areas below a piling-, column-, or post-supported buildings; and areas under roof overhangs, decks, screened-in porches, and walkways.

In partially sheltered areas, corrosion can significantly weaken nominally galvanized light gauge metal connectors in 5 to 10 years or sooner. When not concealed by exterior finishes, these areas can often be inspected to evaluate the condition of the connectors and determine when maintenance or replacement is necessary.

7.2 Open Exposed Exterior Exposure

Open exposed exterior exposures are areas such as exterior walls where metal connectors and fasteners are exposed to the elements.

If metal connectors and fasteners are exposed to rainwater and usually dry fully between wettings from ocean spray, as can occur in open exposed exterior exposures, the corrosion rates will likely be lower than in partially sheltered exterior exposures. However, if fasteners and connectors in open exposed exterior exposures do not benefit from rainwater washes or remain wet for extended periods, the corrosion rates in these exposures can match the rates in partially sheltered exterior exposures.

Connectors in open exposed exterior exposures can usually be inspected to evaluate their condition, and if access is sufficient to remove the fasteners, connectors can often be replaced if found to be weakened by corrosion.

REGULAR INSPECTION AND MAINTENANCE

Owners may not be aware that maintenance is necessary for connectors and fasteners and may not be able to inspect some areas where corrosion can occur. Owners should be advised to regularly inspect connections and that replacement of metal connectors and fasteners may be necessary to maintain the structural integrity of their buildings. In areas where inspections or replacements are difficult and corrosion is possible, designers and builders should use materials with higher degrees of corrosion resistance, such as stainless steel.

7.3 Vented Enclosed Exposures

Examples of *vented enclosed exposures* are attics, which must be vented to release excess heat and moisture, and rafter and floor cavities if vents are installed.

Corrosion of metal connectors and fasteners in vented enclosed exposures depends on the location of the metal connectors in the enclosed space. Corrosion rates near vents, where outside airflow is concentrated, are often similar to the rates in partially sheltered exterior exposures (see Section 7.1). Corrosion rates for metal connectors that are not near vents or that are covered by insulation are expected to be much lower.

Some vented enclosed areas can be hard to access, complicating inspections to evaluate the condition of the metal connectors and replace them when needed. In these locations, it is worth considering a more corrosion-resistant metal connector since its condition will rarely be evaluated.

7.4 Unvented Enclosed Exposures

Examples of *unvented enclosed exposures* are enclosed areas such as wall cavities, enclosures surrounded by breakaway walls under elevated buildings, and floor framing cavities created when finishes are installed on the underside of floor joists.

Because of the limited airflow and incoming salt spray, corrosion rates for connectors in these exposures are expected to be lower than the rates in partially sheltered exterior exposures, open exposed exterior exposures, or vented enclosed exposures. However, since many connectors and fasteners installed in unvented enclosed exposures are concealed by finishes and would require removing building materials to gain access to the fasteners, inspection to evaluate their condition is generally impractical. Therefore, installing corrosion-resistant (or more corrosion-resistant) fasteners and metal connectors in these areas should be considered a responsible construction practice.

7.5 Interior Living Space Exposures

Interior living space exposures are the areas within a building that are usually heated or air conditioned.

These spaces are sealed from most salt spray, and the humidity control provided in most conditioned spaces generally reduces humidity levels below those that contribute to accelerated corrosion rates.

In coastal areas, using more corrosion-resistant fasteners such as mechanically galvanized fasteners will better protect connections in the interior portions of exterior walls and wall connections to attic spaces as long as they do not receive salt spray. These areas typically have a relatively low chance of corrosion and are free of preservative-treated lumber. Fasteners for interior walls can be uncoated or electroplated galvanized fasteners.

8 Improving Corrosion-Resistant Materials and Coatings

The durability of metal connectors can be improved by using more corrosion-resistant materials such as Type 304 or Type 316 stainless steel or by treating metal connectors after fabrication with hot-dip or mechanical galvanizing. Improving corrosion resistance is discussed in this section.

Materials with improved corrosion resistance may cost more initially, but reduced maintenance over the life of a building can partially or completely offset the cost.

Another important consideration in selecting connectors and fasteners is accessibility of the connections. Fasteners and metal connectors located in areas that cannot be readily inspected or where the fasteners and metal connectors cannot be easily replaced should be made of materials with higher corrosion resistance. Since corrosion not only reduces the strength of a connection, but more importantly, can result in a load path failure, it is important to use durable connectors in building areas that are difficult to access.

Metals may be selected because of their strength, temperature resistance, durability, availability, cost, and other reasons. As mentioned in Section 5.1.2, dissimilar metals can undergo a process called galvanic corrosion if they come into contact with an electrolyte such as saltwater. When in contact with an electrolyte, charged particles flow between the dissimilar metals, which causes one of them to corrode and the other to be protected. Which metal corrodes and which one is protected depends on the relative affinity to attract or repel electrical changes. The reactivity, the rate of corrosion that occurs, which metal will corrode, and which one will be protected can be evaluated using a galvanic corrosion chart such as the one shown in Figure 7.

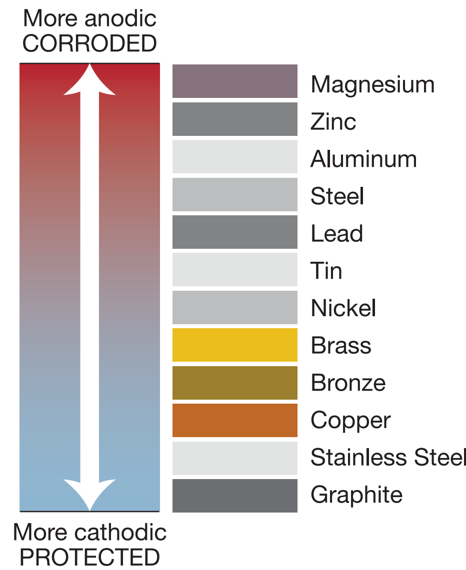


Figure 7: Galvanic chart of common metals

The chart shown in Figure 7 is simplified, but it shows individual metals' relative affinity for attracting or repelling electrical charges. Metals closer to the top of the chart tend to function as anodes and undergo galvanic corrosion. Metals closer to the bottom tend to function as cathodes and are protected. Metals function as anodes or cathodes depending on the metal they are paired with. For example, nickel will function as a cathode and be protected when in contact with zinc or aluminum but will function as an anode and corrode when in contact with copper. Metals not affected by galvanic corrosion can still corrode through exposure to compounds like salt.

In addition to depicting which metals will function as anodes and cathodes, a galvanic chart can also depict the relative rate of corrosion that two metals may experience. Metals that are relatively close to each other on the chart will have low rates of corrosion, while those that are more widely separated will corrode more quickly. For example, when exposed to copper, bronze, which is relatively close to copper on the galvanic chart, will have a lower corrosion rate than steel, which is more widely separated from copper on the chart.

The strength of the electrolyte also comes into play. For any two dissimilar metals, the anodic metal will corrode more rapidly in an electrolyte that easily conducts electrical charges compared to a weaker electrolyte that does not easily conduct charges. Because of this, dissimilar metals in dryer environments, which tend to retard the flow of electrical charges, have lower corrosion rates than the same metals in areas with high moisture levels.

As shown by its location near the "Protected" end of the chart, stainless steel is more resistant to galvanic corrosion than most metals and is therefore the preferred metal in harsh environments and in areas where connector replacement will be difficult.

The galvanizing zinc protects steel in two ways: it acts as a physical barrier, and it slows the corrosion process because the zinc layer corrodes first, even protecting adjacent scratches in the coating. It should be noted that if a galvanized fastener is used in conjunction with steel plates, the galvanizing on the fastener will corrode much faster than when used in conjunction with galvanized plates.

8.1 Thicker Galvanizing

The galvanizing process does not eliminate the need for maintenance, but proper material selection can prolong the lifespan of the material and increase the potential for the fastener or metal connector to maintain its design strength. Increasing the thickness of the galvanized coating extends the length of time before the zinc corrodes to the point where the steel base metal begins to corrode.

The two methods of producing thicker galvanized coating on connectors are:

- Fabricating connectors from steel sheet with thicker initial galvanized coating
- Galvanizing connectors after fabrication

Galvanized sheet steel is available in a variety of coating thicknesses. Several manufacturers now market common connectors in various designs fabricated with G185 to G200 grades of galvanized protection, which, compared to standard G60 or G90 grades, have zinc coatings that are two to three times thicker. Since the corrosion resistance of zinc is proportional to the thickness of the zinc, G185 to G200 connectors should last approximately two to three times longer than G60 or G90 connectors.

Thicker galvanized coatings can also be attained by using the hot-dip process after connector fabrication. Several variables can affect the thickness of hot-dip galvanizing, but the result is typically a coating of zinc similar to the coating on a G185 connector. A few types of connectors with thicker galvanized coatings are regularly available. Other connector designs are available by special order.

Figure 8 illustrates that increasing the thickness of galvanizing results in a longer service life. The extent to which service life is increased depends on the location and the amount of salt in the air, as well as pollutants such as sulfur dioxide.

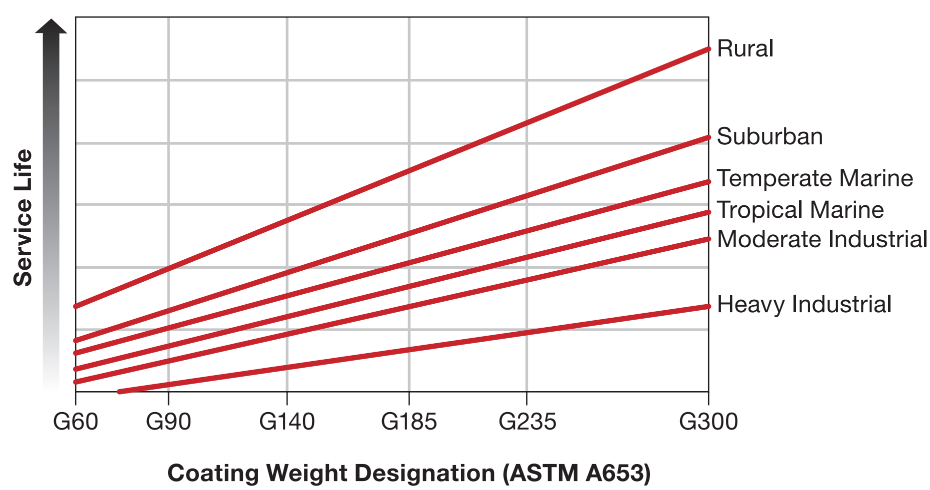


Figure 8: Approximate service life improvement from increasing galvanization thickness
SOURCE: ADAPTED FROM ZHANG (2002)

Applying an additional outer coating in the factory or painting light gauge metal connectors fabricated from galvanized steel can enhance corrosion protection (see Section 8.3), and manufacturers can provide data on appropriate applications and compatible fasteners. However, paint should be used with caution because if it is scratched, it does not provide any corrosion resistance at that location.

8.2 Stainless Steel

Stainless steel is created when other metals are added to steel to make an alloy. The composition of the alloy determines its corrosion resistance, temperature resistance, and hardness and denotes the stainless steel type. Not all types of stainless steel have the same corrosion resistance, and some types are preferred over others in saltwater applications. Several connector manufacturers produce the most commonly used connectors in a stainless steel option. Stainless steel is resistant to corrosion in salt air, and it usually lasts longer than most other materials, even in the most corrosive oceanfront situations.

To eliminate the potential for galvanic corrosion, stainless steel connectors must be attached with stainless steel nails when separate fasteners are needed; otherwise, corrosion will be accelerated on the less corrosion-resistant metal and can dramatically reduce its lifespan (see Figure 7). In coastal applications, stainless steel should be Type 304 or Type 316. Type 316 is more resistant to corrosion and should be used for stainless steel metal connectors. Some fasteners are fabricated from Type 410 stainless steel, which has more corrosion resistance than galvanized bare steel but less than Type 316 stainless steel.

Stainless steel is tougher than normal carbon steel, which means that stainless steel connectors are more difficult to fabricate. Also, stainless steel tends to be more expensive than carbon steel and galvanized steel. When considering upgrading from galvanized fasteners and connectors to stainless steel, designers, contractors, and building owners in coastal areas should compare the cost of stainless steel connectors to G185 galvanized connectors, not to G60 and G90 galvanized connectors, which are not recommended in coastal areas. Furthermore, the reduced maintenance/replacement/labor life-cycle costs when using stainless steel should be considered when specifying connectors. See Section 9.2.2 for further details.

8.3 Applied Coatings and Paint

Coatings and paint applied to galvanized steel connectors can improve corrosion resistance, but many coatings and paints commonly used for buildings do not adhere well to galvanized surfaces. The Truss Plate Institute (TPI) has evaluated the use of truss plates in corrosive environments. If specified by the registered design professional or building designer, ANSI/TPI 1-2014 design specifications, which are referenced in the I-Codes, recommend that one of two industrial paint systems be applied by brush to embedded plates after delivery of the completed truss to the job site or after truss installation (ANSI/TPI, 2014). Alternatively, using truss plates with a thicker hot-dip galvanized coating is also recommended. The three industrial coating options for increasing corrosion resistance are:

- Epoxy-polyamide primer (SSPC-Paint 22)
- Coal tar epoxy-polyamide black or dark red paint (SSPC-Paint 16)
- Post-plate manufacture hot-dip galvanizing (zinc-based) per ASTM A153/A153M (ASTM, 2016)

The degree of improvement in corrosion resistance that the recommended applied coatings provide is difficult to estimate. Unlike differences in galvanized coating thickness, differences in paint system coating thickness do not proportionally change the corrosion resistance of the connector. Coating lifetimes are significantly affected by salt spray, but exposure conditions can affect coatings and galvanizing differently. Surface preparation and care in application are critical for improving corrosion resistance with coatings. The added cost of these coatings varies with local labor costs.

In general, other types of coatings and paints should not be assumed to significantly improve the corrosion resistance of nominally galvanized connectors and truss plates. For other types of connectors, the alternatives described previously are recommended over any other type of painting. However, for maintenance, zinc-based coatings may offer some benefits over standard coatings because zinc-based coatings can increase protection somewhat in areas where the coating is damaged. Stainless steel metal connectors should not be painted because the coating can prevent the protective oxide film that forms on the surface of stainless steel from developing. This oxide film is how the stainless steel resists corrosion.

8.4 Other Corrosion-Resistant Fasteners

Manufacturers supply some fasteners with coatings other than galvanization and should be evaluated to ensure their corrosion resistance. ICC Evaluation Service (ICC-ES) produces acceptance criteria that manufacturers use to demonstrate that product performance is consistent with I Code requirements. ICC-ES published AC257, *Acceptance Criteria for Corrosion-Resistant Fasteners and Evaluation of Corrosion Effects of Wood Treatment Chemicals* (ICC ES, 2015), which provides criteria for alternative fasteners. The criteria outline requirements for testing fasteners in preservative-treated lumber in various types of accelerated corrosion environments. There are also evaluation reports regarding this acceptance criterion that provide information so that fasteners that are not galvanized or stainless steel can be considered for applicability in coastal environments. Without an evaluation report, manufacturers can often provide some information to allow comparisons with other more common methods of fabricating corrosion-resistant fasteners.

ADDITIONAL INFORMATION ON CONNECTORS

Additional information on properly making connections between the foundation and the building can be found in FEMA's Hurricane Sandy Recovery Advisory RA1, *Improving Connections in Elevated Coastal Residential Buildings* (2013). The recovery advisory also discusses corrosion protection and lists resources for strengthening connections in wood-framed buildings.

9 Guidance for Connector and Fastener Corrosion Control

In corrosive environments, most construction materials deteriorate with time and eventually need to be repaired or replaced. In the United States, the service life of a wood-frame building could be approximately 70 years or more. With continued maintenance and periodic upgrades, buildings can remain serviceable well beyond that time. However, lack of maintenance and repairs can cause buildings to deteriorate much sooner than the average service life. Buildings located in coastal environments where steel components can corrode at a high rate are particularly susceptible to deterioration if not maintained regularly. Continued use of a building over its service life requires that:

- The original materials are durable enough to last the expected lifetime
- Periodic maintenance is conducted to extend the life of original materials
- Materials that have deteriorated are replaced

9.1 Reducing Corrosion Rates

Standard connectors are intended for inland uses, and under normal conditions, they last as long or longer than other materials in a building. Although components of some buildings in coastal communities may have only slightly increased corrosion rates, buildings close to the ocean are likely to have drastically higher corrosion rates. In nearshore areas, the use of more corrosion-resistant materials and coatings is recommended in *partially sheltered exterior exposures, open exposed exterior exposures, vented enclosed exposures,* and *unvented enclosed exposures* (see Figure 6). Use of nominally galvanized metal connectors should be limited to interior areas that can be protected from corrosion (interior living space exposures).

Additional considerations in reducing corrosion rates are as follows:

- Consider changing the exposure class where connectors are used. For some uses, corrosion rates can be reduced by altering the exposure of the connectors. For example:
  - Connectors typically found on building exteriors should be fully covered if possible or otherwise protected from salt spray and moisture. Applying exterior siding to fully cover the connections is one way to change the exposure from *open exposed exterior exposure* to an *unvented enclosed exposure condition*.
  - An easy way to protect joist hangers and truss plates in the floors of piling-supported buildings is to sheath the underside of the floor joists to reduce the exposure to salt air. Adding such sheathing transforms one of the worst exposures, *partially sheltered exterior exposure,* into the less corrosive *unvented enclosed exposure condition*. However, when corrosion occurs, it can go undetected, so screws or some other removable fastening mechanism should be used to allow periodic inspection.
- Consider using alternate materials or connection methods. For some connections, such as floor joist-to-floor beam connections, corrosion may be minimized by not using light gauge metal connectors, especially in *partially sheltered exterior exposures* and *open exposed exterior exposures*. Construction practices that were commonplace before the advent of light gauge metal connectors can be used to connect wood framing. With many of those practices, metal fasteners (nails, wood screws, lag screws, and bolts) are used with wood framing, and the metal fasteners are nearly fully concealed and protected from the elements by the wood components. In many connections, only the head of the fasteners remain exposed to salt spray. When used with preservative-treated lumber, stainless steel nails and other corrosion-resistant fasteners should be used. See Section 9.2 for more guidance on maintenance and replacement. See the applicable building code for information on when these alternate methods are permitted and the size and number of fasteners that are required.

  Figure 9 and Figure 10 show common methods of connecting wood framing members with only nails, screws, lag screws, and bolts. In both methods, the shafts of the fasteners are not exposed to salt spray.

The drawback of these methods is that their capacity to resist loads is not readily known since their strength depends greatly on fastener sizes and even more on the species of wood used. The design of wood framing connections is complex, and prescriptive methods are somewhat limited. The IRC and the *Wood Frame Construction Manual* (AWC, 2015) both contain nailing schedules, but neither contain prescriptive methods for connections such as those shown in Figure 10 and Figure 11. In contrast, the capacities of light gauge metal connectors are published by the manufacturers and verified by third-party testing. See the textbox below for more information.

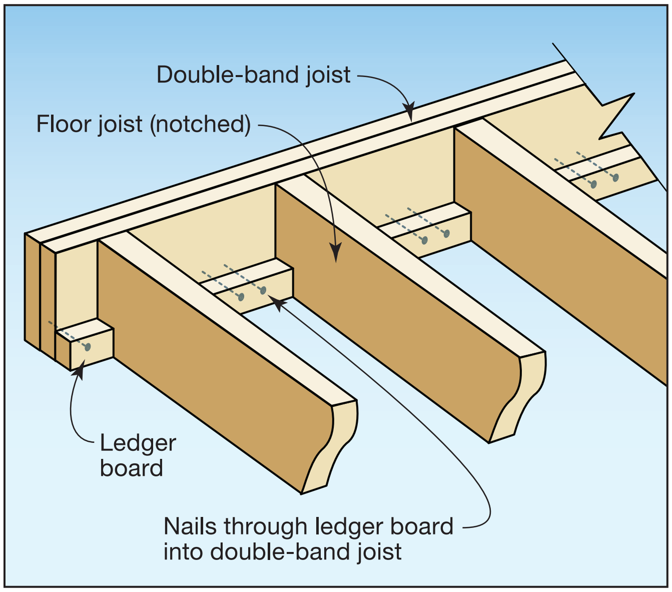


Figure 9: Traditional wooden ledger boards used in place of joist hangers in high corrosion areas

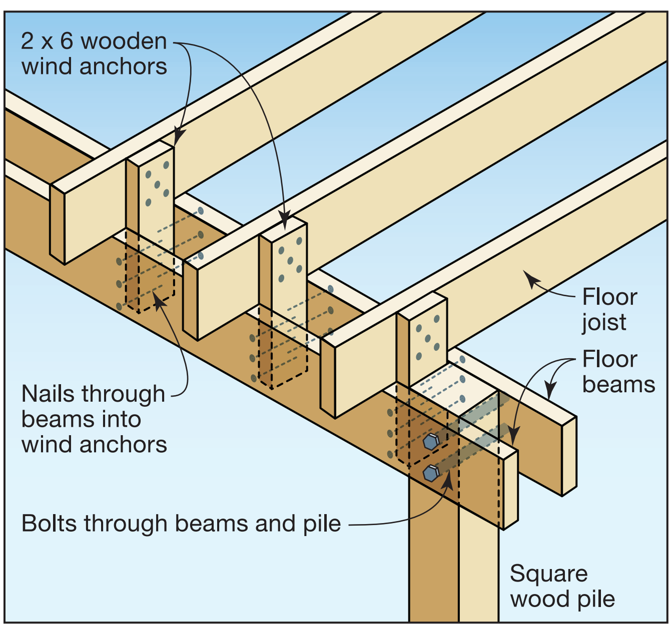


Figure 11: Wooden wind anchors used to connect floor joists to floor beams

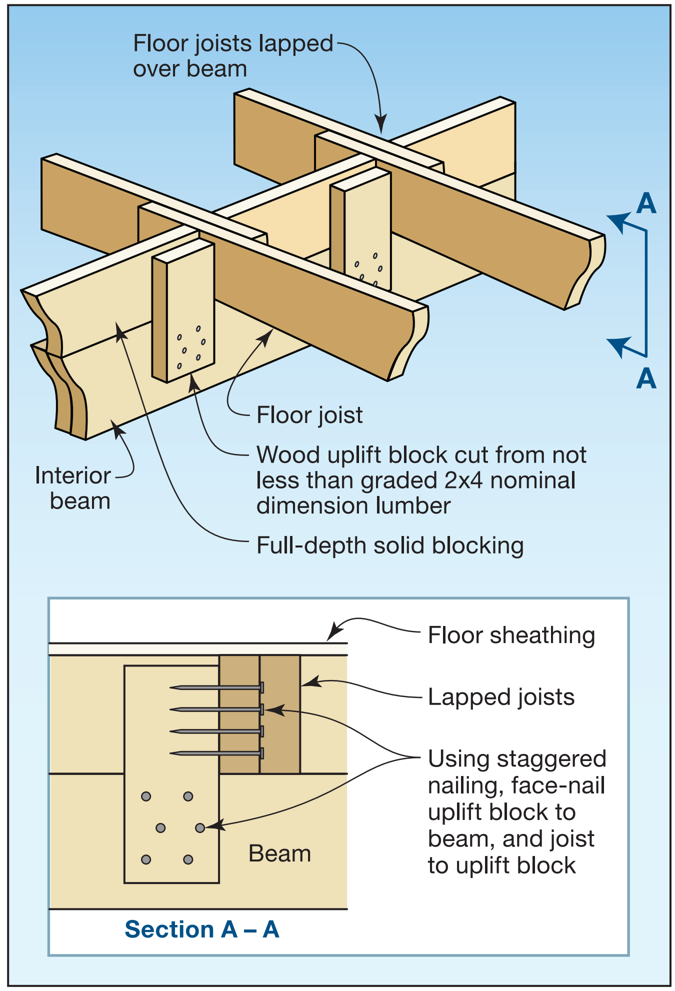


Figure 10: Detail of an elevated floor-to-beam connection using wood uplift blocking and full-depth solid blocking

STRENGTHS OF NAILED, SCREWED, LAGGED, AND BOLTED CONNECTIONS

The strength of connections made with dowel-type fasteners (nails, screws, lag screws, bolts, split ring connectors, shear plate connections, and timber rivets) is specified by ANSI/AWC NDS-15, *National Design Specification for Wood Construction* (2014a).

Allowable loads are determined by multiplying reference design values by all applicable adjustment factors. The reference design values are tabulated in NDS-15, Chapter 12; adjustment factors are contained in Chapters 11 and 12. Most adjustment factors are less than 1.0 (they lower the reference design values); several adjustment factors that account for load duration are greater than 1.0.

Reference design withdrawal values (W) for lag screws, wood screws, nails, and ring shank nails are listed in NDS-15, Tables 12.2A through 12.2D. Adjusted withdrawal values (W') are determined by applying all adjustment factors to those reference withdrawal values. Reference design withdrawal values and adjusted withdrawal values are measured per inch of fastener penetration or the depth of thread penetration for threaded fasteners.

Reference design lateral values (Z) for bolts, lag screws, wood screws, nails, and ring shank nails are tabulated in NDS, Tables 12A through 12T. Like withdrawal values, adjusted lateral design values (Z') are obtained by multiplying reference values by all adjustment factors.

The design values in the NDS are only for fasteners meeting the generic specification for that particular type of fastener. Fastener manufacturers have recently begun developing improved proprietary fasteners with higher design values. These design values can typically be found in the fastener's evaluation report.

9.2 Maintenance and Replacement Considerations

Inspection of fasteners and metal connectors is important and should be a regular maintenance activity undertaken by owners of buildings located in nearshore coastal environments. *Since many homeowners may not be aware of the effects of corrosion on the fasteners in their homes, communities in coastal areas should consider communicating to their citizens the importance of routine inspection and maintenance of connectors and fasteners.*

In some applications, connectors may be located where they are accessible and easily maintained. In areas where corrosion is less aggressive, such as locations farther from the coast, applying a coat of exterior house paint to exposed connectors may be enough to extend the life of the connectors. In areas with more aggressive corrosion, even annual painting is unlikely to prolong the life of connectors. In these areas, accessible connectors should be inspected for corrosion and replaced when necessary. Galvanized light gauge metal connectors should be replaced as soon as corrosion extends into the base metal (see Figure 12). The presence of more than thin rusty edges indicates that the zinc coating has been consumed and the sacrificial effects have been lost. Corrosion of the thin, steel sheet will occur quickly and rapidly affect the structural integrity of the connector.

Figure 12: Zinc galvanizing on connectors that has corroded

9.2.1 Replacing Corroded Connectors

Replacement is the only option in existing buildings where connectors have already been damaged by corrosion. It is recommended that replacement connectors have different sizes or shapes or be fastened in different locations so that connections are to undisturbed wood. Since the availability of locations to attach replacement connectors into undisturbed wood may be limited, it is imperative that the most corrosion-resistant connectors and fasteners possible be used to minimize replacements over the life of the structure. Inspections may also indicate a need to install connectors where they were not previously installed. For example, adding roof uplift connectors (hurricane clips) can significantly improve wind resistance and is generally worthwhile, even if some dismantling is needed to gain access. Wind retrofits are described for various levels of wind performance improvement in FEMA P-804, *Wind Retrofit Guide for Residential Buildings* (2010c).

9.2.2 Reducing Connection Maintenance for New and Existing Buildings

When evaluating the option of whether to initially install more corrosion-resistant metal connectors or replace them more frequently, the cost over the life of the building should be considered. Enhanced corrosion-resistant metal connectors, available for a moderately higher price, can have significantly longer lifetimes than nominally galvanized connectors. The cost of labor for initial installation is often the same for either option. The material and labor cost for even one replacement is typically many times more than the added cost of initially installing more corrosion-resistant materials. Using more corrosion-resistant materials during construction can avoid or reduce the cost of future repairs.

In areas where conditions foster aggressive corrosion and nominally galvanized connectors may have to be replaced as often as every 5 years, using more expensive materials such as stainless steel connectors and fasteners will likely prove less costly over the long run. Repeated replacement of metal connectors can be difficult since previously used fastener holes should not be reused. Different styles of metal connectors may provide different and faster locations to facilitate replacement, but eventually damage from fastener holes may result in the need for more extensive repairs such as replacing structural members to maintain a continuous load path. Replacing structural members would be more expensive than upgrading to a more corrosion-resistant metal connector that would reduce the number of necessary connector replacements over the life of the building.

Given the difficulty of inspecting many connections after construction and the impossibility of inspecting others without invasive actions, using nominally galvanized fasteners and metal connectors in corrosive areas is fraught with potential problems and higher maintenance costs. There is a low likelihood that effective regular inspections to identify deterioration before the structural integrity is compromised would or could be performed. Even when problems with more vulnerable connectors can be identified, replacing damaged connections in existing buildings is usually costly and difficult. Furthermore, many connectors are hidden structural components that will go unseen and are difficult or impossible to maintain or replace. In such cases, replacement is rarely an option, and more corrosion-resistant materials should be selected during initial construction.

10 Summary of Best Practices for Corrosion Resistance

For many connector applications in corrosion-prone buildings, using materials with enhanced corrosion resistance is the best solution for new construction, and is also recommended for replacement connectors during maintenance or repair/renovation of existing construction. The choice of alternative connector material or coating specification should be guided by the following criteria:

- Location of the building relative to the observed corrosion hazards (primarily distance from the coast), as noted in Section 6
- Where the connectors will be used, as noted in Section 7
- Importance of the connection to the structure's load path, as noted in Section 4
- Life-cycle cost-effectiveness of the connector for the structure's service life, as noted in Section 9
- Long-term viability of the structure based on its potential service life and the need to maintain a proper load path throughout the life of the structure

Recommended materials for typical residential buildings are listed in Table 3.

In Table 3, building locations are identified as oceanfront buildings, intermediate rows of buildings in corrosion-prone areas, and buildings near the coast but far enough away from the ocean that excessive corrosion is not anticipated or has not been observed. Metal connectors with minimal galvanizing on oceanfront buildings are expected to corrode at high rates. In most communities, as buildings are constructed farther from the oceanfront, the rate at which corrosion occurs should decrease significantly at distances of 300 to 3,000 feet landward of the ocean. FEMA's Mitigation Assessment Team deployed to Puerto Rico following Hurricanes Irma and Maria and identified areas farther inland than 3,000 feet landward of the ocean where significant corrosion was noted on exposed structural connection that would be more consistent with the corrosion experienced by buildings closer to the shoreline (FEMA, 2018b). This finding suggests that in some areas, building owners may want to consider using hot-dip galvanized or stainless steel connectors farther inland than the 3,000 feet landward of the ocean guideline.

A site survey of surrounding buildings and structures may provide information on the severity of corrosion in specific areas, which will affect the useful life of connectors and fasteners. Another key factor for material selection is the exposure class of the connectors and fasteners; exposure classes are listed in Table 3 in order of decreasing severity of corrosion at particular locations. Since access to inspect or replace connectors and fasteners is a key consideration in whether to use more corrosion-resistant materials, an assessment of the severity of corrosion in the area and exposure class may provide additional insight into whether to use upgraded fasteners and connectors.

Table 3 also includes notes on truss plate treatments based on TPI recommendations for corrosive environments. Some of the recommendations in Table 3 are based on limited research. When the severity of the exposure is unknown, selecting more corrosion-resistant materials is prudent. In most cases, a Type 304 or Type 316 stainless steel connection or fastener will provide superior corrosion resistance, as shown in the galvanic corrosion chart in Figure 7.

Table 3: Recommendations on Corrosion-Resistant Materials and Methods

Exposure Class(1)	Accessibility(2)	Oceanfront, Second Row, and Third Row Buildings(3)	Intermediate Rows of Buildings in Corrosion-Prone Areas(3)	Buildings Farther Landward(4)
Partially Sheltered Exterior Enclosures	Easy	• Avoid light gauge metal connectors • Use stainless steel connectors and fasteners • Use connectors with thicker galvanizing and replace when necessary	• Use connectors with thicker galvanized coating • **Best practice:** Use stainless steel connectors and fasteners	• Use connectors with code-required galvanizing • **Best practice:** Use connectors with thicker galvanizing than required by code or use stainless steel
Open Exposed Exterior Enclosures	Easy	• Avoid light gauge metal connectors • Use stainless steel connectors and fasteners • Use connectors with thicker galvanizing	• Use connectors with a thicker galvanized coating • **Best practice:** Use stainless steel connectors and fasteners	• Use connectors with code-required galvanizing • **Best practice:** Use connectors with thicker galvanizing than required by code or use stainless steel

Table 3: Recommendations on Corrosion-Resistant Materials and Methods (concluded)

Exposure Class(1)	Accessibility(2)	Oceanfront, Second Row, and Third Row Buildings(3)	Intermediate Rows of Buildings in Corrosion-Prone Areas(3)	Buildings Farther Landward(4)
Vented Enclosed Exposures	Difficult	• Use connectors with thicker galvanizing • **Best practice:** Use stainless steel connectors and fasteners • Use TPI-specified coatings or paints on truss plates • **Best practice for truss plates:** Use TPI-specified coatings over thicker galvanizing, or use stainless steel	• Use connectors with a thicker galvanized coating • Use TPI-specified coatings on truss plates near vents • **Best practice:** Use thicker galvanizing for all connectors; use stainless steel near vents or where salt accumulation is anticipated	• Use connectors with code-required galvanizing • **Best practice:** Use connectors with thicker galvanizing than required by code or use stainless steel
Unvented Enclosed Exposures	Difficult	• Use connectors with thicker galvanizing • Use TPI-specified coatings or paints on truss plates • **Best practice for truss plates:** Use thicker galvanizing or use stainless steel.	• Use galvanized connectors • **Best practice:** Use connectors with thicker galvanizing than required by code or use stainless steel	• Use connectors with code-required galvanizing • **Best practice:** Use connectors with thicker galvanizing than required by code or use stainless steel
Interior Living Space Enclosures	Difficult	• Use galvanized connectors • **Best practice:** Use thicker galvanizing than required by code or use stainless steel	• Use galvanized connectors • **Best practice:** Use connectors with thicker galvanizing than required by code or use stainless steel	• Use galvanized connectors • **Best practice:** Use connectors with thicker galvanizing than required by code or use stainless steel

The recommendations in this table are based on available research and are subject to change in future Technical Bulletins. Stainless steel connectors should also be considered a best practice in many of the areas listed in the table. However, due to practical and cost reasons, this guidance does not prescribe its use, although the galvanic corrosion chart (Figure 7) clearly shows that stainless steel (especially Types 304 and 316) is a superior performer for corrosion resistance compared to many other metals.

(1) See Section 7 for information on exposure classes.

(2) Ability to inspect/replace fasteners and connectors.

(3) 300 feet or less from the shoreline. Distances may vary depending on local climate. The width of corrosion-prone areas relative to the ocean should be determined from field observations, existing corrosion studies, and consultation with local building departments.

(4) Greater than 3,000 feet from the shoreline. Distances may vary depending on local climate and can extend much farther inland as identified by FEMA's Mitigation Assessment Team in Puerto Rico (FEMA, 2018b). The width of corrosion-prone areas relative to the ocean should be determined from field observations, existing corrosion studies, and consultation with local building departments.

11 References and Resources

This section lists the references that are cited in this Technical Bulletin (Section 11.1) and additional resources on wood-framed building connection requirements (Section 11.2). Additional resources are listed in Technical Bulletin 0.

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11.2 Resources

The following sources have additional information on wood-framed building connection requirements.

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Design and Construction Guidance for Breakaway Walls

Below Elevated Buildings Located in Coastal High Hazard Areas in Accordance with the National Flood Insurance Program

NFIP Technical Bulletin 9 / September 2021

FEMA

Comments on the Technical Bulletins should be directed to:

Department of Homeland Security / Federal Emergency Management Agency
Federal Insurance and Mitigation Administration (FIMA) Risk Management Directorate
– Building Science Branch
400 C Street SW, Sixth Floor
Washington, DC 20472-3020

NFIP Technical Bulletin 9 (2021) replaces NFIP Technical Bulletin 9 (2008), *Design and Construction Guidance for Breakaway Walls*.

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Cover photo: Underside of an elevated building in Zone V post-Hurricane Ivan (2004). The breakaway walls under the building were removed by waves as intended during the hurricane.

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1.1.1 List of Figures

1.1.1 List of Tables

Acronyms

APA	The Engineered Wood Association (formerly American Plywood Association)
ASCE	American Society of Civil Engineers
ASTM	ASTM International (formerly American Society for Testing and Materials)
AWC	American Wood Council
BFE	base flood elevation
CFR	Code of Federal Regulations
CMU	concrete masonry unit
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
IBC®	International Building Code®
ICC®	International Code Council®
I-Codes®	International Codes®
IRC®	International Residential Code®
LiMWA	Limit of Moderate Wave Action
MAT	Mitigation Assessment Team
NFIP	National Flood Insurance Program
o.c.	on center
psf	pounds per square foot
psi	pounds per square inch
SAE	SAE International (formerly Society of Automotive Engineers)
SEI	Structural Engineering Institute
SFHA	Special Flood Hazard Area

1 Introduction

This Technical Bulletin provides guidance on the National Flood Insurance Program (NFIP) requirements for the design and construction of breakaway walls that are used to create enclosures below the lowest floor of elevated structures in Coastal High Hazard Areas. A breakaway wall is a wall that is not part of the structural support of a building and is intended through its design and construction to collapse under specific lateral loading forces without causing damage to the elevated portion of the building or supporting foundation system (see Figure 1). Coastal High Hazard Areas are designated as Zone V (V, VE, V1-30, and VO) on a community's Flood Insurance Rate Map (FIRM).

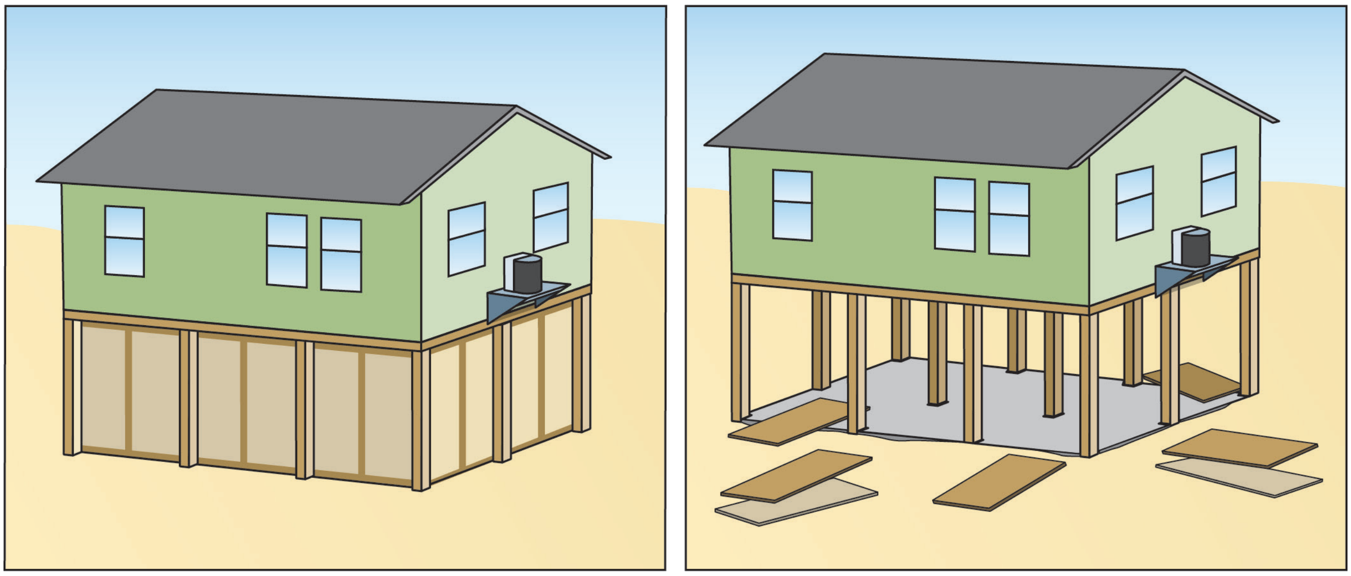


Figure 1: Breakaway walls enclosing an area below an elevated building in Zone V (left); breakaway wall enclosures that have broken away as a result of lateral flood loads (right)

This Technical Bulletin presents three methods of designing breakaway walls that are consistent with the NFIP regulations:

- Prescriptive design method
- Simplified design method
- Performance-based design method

Breakaway walls that are designed using the simplified and performance-based design methods must be certified by a registered professional engineer or architect as meeting the NFIP requirements. Breakaway walls designed using the prescriptive design method do not require certification by a registered professional engineer or architect, although state or local governments may require certification. Regardless of which method is used,

NFIP TECHNICAL BULLETIN 0

NFIP Technical Bulletin 0, *User's Guide to Technical Bulletins*, should be used as a reference with this Technical Bulletin. Technical Bulletin 0 describes the purpose and use of the Technical Bulletins. It includes common concepts and terms, lists useful resources, and includes a crosswalk of the sections of the NFIP regulations identifying the Technical Bulletin that addresses each section of the regulations and a subject index.

Readers are cautioned that the definitions of some of the terms that are used in the Technical Bulletins are not the same when used by the NFIP for the purpose of rating flood insurance policies.

breakaway walls must be designed and constructed to meet the applicable building codes and standards adopted by states and communities.

The three design methods are described further in Sections 1.2, 8, 9, and 10 of this Technical Bulletin.

1.1 Alternatives to Breakaway Walls

The NFIP regulations permit areas below elevated buildings in Zone V to be enclosed in one of three ways: open lattice-work, insect screening, and non-supporting breakaway walls (44 CFR § 60.3(e)(5)).

Open lattice-work and insect screening are not considered walls or obstructions. These materials are assumed to collapse under wind and base flood loads without causing the elevated portion of the building or supporting foundation system to collapse, be displaced, or sustain other structural damage. To increase the likelihood that these materials will collapse as intended, the vertical framing members (such as 2x4s) on which the open lattice-work or insect screening is mounted should be spaced at least 2 feet apart. Metal and synthetic mesh insect screening are both acceptable.

Although the NFIP regulations explicitly identify wood lattice, the Federal Emergency Management Agency (FEMA) considers plastic lattice acceptable provided the material that is used to fabricate the lattice is no thicker than ½ inch and the finished sheet has at least 40 percent of its area open (see NFIP Technical Bulletin 5, *Free-of-Obstruction Requirements*). Wood and plastic lattices are usually available in 4-foot by 8-foot sheets.

Although not specified in the NFIP regulations, areas below elevated buildings may also be surrounded by plastic or wood shutters, slats, or louvers (see Technical Bulletin 5). These materials must:

- Be cosmetic only and not provide structural support to the building
- Have at least 40 percent of the area open
- Be no thicker than 1 inch

1.2 Design Safe Loading Resistance (Ultimate Load)

Previous editions of this Technical Bulletin refer to breakaway walls as having a design safe loading resistance (referred to in ASCE 7 as allowable load) of 20 psf or less. To make the calculation of wind loads consistent with the approach used for seismic design, the standard approach to wind design introduced in ASCE 7-10, *Minimum Design Loads for Buildings and Other Structures*, uses a design methodology applying ultimate loads. Therefore, this Technical Bulletin uses the conversion of the allowable load of not less than 10 psf and no more than 20 psf into the ultimate load of not less than 17 psf and no more than 33 psf for the prescriptive design method. This approach is consistent with the wind design procedures in ASCE 7-10. Although there have been changes to design methods for breakaway walls, the revised values that express the design safe loading resistance as ultimate loads are equivalent to the allowable loads provided in the NFIP requirements for breakaway walls.

Although there have been changes to design methods for breakaway walls, the revised values that express the design safe loading resistance as ultimate loads are equivalent to the allowable loads provided in the NFIP requirements for breakaway walls.

1.3 Breakaway Wall Design Methods Provided in This Technical Bulletin

The designer may select one of three design methods for breakaway walls: prescriptive, simplified, or performance-based. The methods are consistent with the NFIP regulations.

1.3.1 Prescriptive Design Method

The NFIP design requirements for breakaway walls were the subject of research performed for FEMA and the National Science Foundation by North Carolina State University and Oregon State University (Tung et al., 1999). The research evaluated failure mechanisms in full-scale, laboratory wave-tank tests of breakaway wall panels. The results influenced the prescriptive design method that is described in this Technical Bulletin.

The **prescriptive design method** for the design and construction of a compliant breakaway wall system that is within the load parameters provided in Section 7 of this Technical Bulletin uses common materials and detailing practices, which allow the designer to use the prescriptive details provided in Section 8.3 of this Technical Bulletin. Although certification is not required by the NFIP for breakaway walls that conform to the specifications in the prescriptive design method, state or local governments may require certification.

See Section 8 of this Technical Bulletin for more information on the prescriptive design method.

1.3.2 Simplified Design Method

The **simplified design method** uses the common materials and detailing practices that are similar to those in the prescriptive design method. The method is simplified because breakaway walls are designed to minimize flood loads to the elevated structure and foundation system. The method is permitted for walls that are designed to have a design safe loading resistance (ultimate load) of more than 33 psf but no more than 70 psf for wood-framed and steel stud-framed breakaway walls and more than 33 psf but no more than 55 psf for unreinforced masonry breakaway walls. A design certification is required for breakaway walls designed using the simplified design method.

See Section 9 of this Technical Bulletin for more information on the simplified design method.

1.3.3 Performance-Based Method

The **performance-based design method** allows more detailing freedom for breakaway walls than the other two methods but requires the designer to consider the combined effect of wind forces acting on the elevated portion of the structure and wind and flood loads acting on the foundation system and breakaway walls. A design certification is required for breakaway walls designed using the performance-based design method.

See Section 10 of this Technical Bulletin for more information on the performance-based design method.

Questions about breakaway wall system requirements should be directed to the appropriate local official, NFIP State Coordinating Office, or FEMA Regional Office.

TERMS USED IN THIS TECHNICAL BULLETIN

Breakaway wall: “A wall that is not part of the structural support of the building and is intended through its design and construction to collapse under specific lateral loading forces, without causing damage to the elevated portion of the building or supporting foundation system” (44 CFR § 59.1).

Coastal A Zone: “Area within *a special flood hazard area*, landward of a V Zone or landward of an open coast without mapped V Zones. In a Coastal A Zone, the principal source of flooding must be astronomical tides, storm surges, seiches, or tsunamis, not riverine flooding. During the base flood conditions, the potential for breaking *wave heights* shall be greater than or equal to 1.5 feet. The inland limit of the Coastal A Zone is (1) the *Limit of Moderate Wave Action* if delineated on a *FIRM*, or (2) designated by the authority having jurisdiction” (ASCE 24-14, used with permission from ASCE).

Coastal High Hazard Area: “An area of special flood hazard extending from offshore to the inland limit of a primary frontal dune along an open coast and any other area subject to high velocity wave action from storms or seismic sources” (44 CFR § 59.1). The coastal high hazard area is shown on the FIRMs or other flood hazard maps as Zone V, VO, VE, or V1-30.

Enclosed area (enclosure): An area below an elevated building that is enclosed by walls on all sides.

Flood damage-resistant material: Any building product (material, component, or system) capable of withstanding direct and prolonged contact with floodwaters without sustaining significant damage. “Prolonged contact” means at least 72 hours, and “significant damage” means any damage requiring more than cosmetic repair, which includes cleaning, sanitizing, and resurfacing (e.g., sanding, repair of joints, repainting).

Freeboard: “Factor of safety usually expressed in feet above a flood level for purposes of flood plain management” (44 CFR § 59.1).

Limit of Moderate Wave Action (LiMWA): The LiMWA marks the inland limit of the Coastal A Zone—the part of the coastal SFHA referenced by building codes and standards where wave heights can be between 1.5 and 3 feet during a base flood event (FEMA, 2019). FEMA began delineating the LiMWA on coastal FIRMs in 2009.

Lowest floor: Lowest floor of the lowest enclosed area of a building, including basement. An unfinished or flood-resistant enclosure that is used solely for parking of vehicles, building access, or storage in an area other than a basement area is not considered the lowest floor, provided the enclosure is built in compliance with applicable requirements.

Special Flood Hazard Area (SFHA): Area subject to flooding by the base flood (1-percent-annual-chance flood) and shown on FIRMs as Zone A or V.

Zone A: Flood zones shown on FIRMs as Zones A, AE, A1-30, AH, AO, A99, and AR.

Zone V: Flood zones shown on FIRMs as Zones V, VE, V1-30, and VO.

Other terms used in this Technical Bulletin are defined in the glossary in Technical Bulletin 0.

2 NFIP Regulations

An important NFIP objective is protecting buildings constructed in Special Flood Hazard Areas (SFHAs) from damage caused by flooding. The SFHA is the land area subject to flooding by the base flood. SFHAs are shown on FIRMs prepared by FEMA as Zones A and V. The base flood is the flood that has a 1 percent chance of being equaled or exceeded in any given year (commonly called the “100-year” flood). The NFIP floodplain management regulations include minimum building design criteria that apply to:

- New construction
- Work determined to be Substantial Improvement, including improvements, alterations, and additions
- Repair of buildings determined to have incurred Substantial Damage

The NFIP regulations that are applicable in SFHAs identified as Coastal High Hazard Areas (Zones V, VE, V1-30, and VO) require the bottom of the lowest horizontal structural member of the lowest floor to be elevated to or above the base flood elevation (BFE) on an open foundation system (pilings or columns) to allow waves and water moving at high velocity to flow beneath buildings. Coastal waves and flooding can exert strong hydrodynamic and potential debris impact loads on any building element that is exposed to the waves or flow of water. Obstructions below an elevated building can significantly increase the potential for flood damage by increasing the surface area subject to wave or potential debris impacts and velocity flow.

The NFIP regulations also require that unenclosed areas below the lowest floor of elevated buildings be free of obstructions and that enclosed areas be enclosed by non-supporting breakaway walls, open lattice-work, or insect screening. The walls, lattice, or screening must collapse under wave loads without causing the elevated building or supporting foundation system to collapse, be displaced, or sustain other structural damage. Enclosed areas are allowed to be used only for parking of vehicles, building access, or storage.

All materials used below the BFE, including materials used to construct enclosures, must be flood damage-resistant, and enclosures must be constructed using methods and practices that minimize the potential for flood damage.

ZONE V CERTIFICATION OF STRUCTURAL DESIGN AND METHODS OF CONSTRUCTION

The NFIP regulations require communities to ensure that design and construction meet Zone V requirements, including breakaway wall requirements. Registered professional engineers or architects must develop or review structural designs, specifications, and plans for new construction and Substantial Improvements and certify that designs and methods of construction are in accordance with the accepted standards of practice. Registered professional engineers and architects should consult with communities on their certification requirements before starting the design. Communities must obtain and retain the certifications.

Satisfying the NFIP breakaway wall requirements is part of the certification. The community must ensure that construction is compliant with the NFIP regulations. Jurisdictions may require post-construction certification by a registered professional engineer or architect.

See Technical Fact Sheet 1.5 in FEMA P-499, *Home Builder’s Guide to Coastal Construction Technical Fact Sheet Series* (FEMA, 2010a), for a discussion of Zone V certification requirements and a sample form that can be used. If the sample form is used, Section IV should be modified to reflect the ultimate load as the design safe loading resistance.

The terms that are used by the NFIP that are relevant to breakaway walls are defined in Title 44 of the Code of Federal Regulations (CFR) Section 59.1, Definitions, and the NFIP regulations for breakaway walls are codified in 44 CFR Part 60, Criteria for Land Management and Use.

Section 59.1 defines breakaway walls as follows:

> Breakaway wall means a wall that is not part of the structural support of the building and is intended through its design and construction to collapse under specific lateral loading forces, without causing damage to the elevated portion of the building or supporting foundation system.

Section 60.3(e)(4) states that a community shall:

> Provide that all new construction and substantial improvements in Zones V1-30 and VE, and also Zone V if base flood elevation data is available, on the community's FIRM, are elevated on pilings and columns so that (i) the bottom of the lowest horizontal structural member of the lowest floor (excluding the pilings or columns) is elevated to or above the base flood level; and (ii) the pile or column foundation and structure attached thereto is anchored to resist flotation, collapse and lateral movement due to the effects of wind and water loads acting simultaneously on all building components. Water loading values shall be those associated with the base flood. Wind loading values used shall be those required by applicable State or local building standards. A registered professional engineer or architect shall develop or review the structural design, specifications and plans for the construction, and shall certify that the design and methods of construction to be used are in accordance with accepted standards of practice for meeting the provisions of paragraphs (e)(4)(i) and (ii) of this section.

Section 60.3(e)(5) states that a community shall require:

> ... that all new construction and substantial improvements within Zones V1-30, VE, and V on the community's FIRM have the space below the lowest floor either free of obstruction or constructed with non-supporting breakaway walls, open wood lattice-work, or insect screening intended to collapse under wind and water loads without causing collapse, displacement, or other structural damage to the elevated portion of the building or supporting foundation system. For the purposes of this section, a breakaway wall shall have a design safe loading resistance of not less than 10 and no more than 20 pounds per square foot.[1] Use of breakaway walls which exceed a design safe loading resistance of 20 pounds per square foot (either by design or when so required by local or State codes) may be permitted only if a registered professional engineer or architect certifies that the designs proposed meet the following conditions: (i) Breakaway wall collapse shall result from a water load less than that which would occur during the base flood; and (ii) The elevated portion of the building and supporting foundation system shall not be subject to collapse, displacement, or other structural damage due to the effects of wind and water loads acting simultaneously on all building components (structural and non-structural). Water loading values used shall be those associated with the base flood. Wind loading values used shall be those required by applicable State or local building standards. Such enclosed space shall be useable solely for parking of vehicles, building access, or storage.

1 Footnote added for this Technical Bulletin. Because the wind design approach changed in ASCE 7-10, this Technical Bulletin uses 33 psf ultimate load as the requirement, which is the calculated equivalent of the 20 psf allowable load that is specified in this section of the NFIP regulation (44 CFR § 60.3(e)(5)).

NFIP REQUIREMENTS AND HIGHER REGULATORY STANDARDS

Federal, State, or Local Requirements. Federal, state, or local requirements that are more restrictive or stringent than the minimum requirements of the NFIP take precedence. The Technical Bulletins and other FEMA publications provide guidance on the minimum requirements of the NFIP and describe best practices. Design professionals, builders, and property owners should contact local officials to determine whether more restrictive provisions apply to buildings or sites in question. All other applicable requirements of state or local building codes must also be met.

Substantial Improvement and Substantial Damage. As part of issuing permits, local officials must review not only proposals for new construction but also for work on existing buildings to determine whether the work constitutes Substantial Improvement or repair of Substantial Damage. If the work is determined to constitute Substantial Improvement or repair of Substantial Damage, the buildings must be brought into compliance with the NFIP requirements for new construction. Some communities modify the definitions of Substantial Improvement and/or Substantial Damage to be more restrictive than the NFIP minimum requirements. For more information on Substantial Improvement and Substantial Damage, see FEMA P 758, *Substantial Improvement/Substantial Damage Desk Reference* (2010b) and FEMA 213, *Answers to Questions About Substantially Improved/Substantially Damaged Buildings* (2018a).

Higher Building Elevation Requirements. Some states and communities require that buildings be elevated above the NFIP minimum required elevation. The additional elevation is called freeboard. Design professionals, builders, and property owners should check with local officials to determine whether a community has a freeboard requirement. The guidance in this Technical Bulletin is that freeboard should only be applied when determining the minimum required elevation for the lowest horizontal structural member of the lowest flood and the height that flood damage-resistant materials are required to extend to. Loading requirements are only to the BFE in breakaway wall designs.

3 Building Codes and Standards

In addition to complying with NFIP requirements, all new construction, Substantial Improvements, and repair of Substantial Damage must comply with applicable building codes and standards that have been adopted by states and communities.

The International Codes® (I-Codes®), published by the International Code Council® (ICC®), are a family of codes that includes the International Residential Code® (IRC®), International Building Code® (IBC®), International Existing Building Code® (IEBC®), and codes that govern the installation of mechanical, plumbing, fuel gas service, and other aspects of building construction. FEMA has deemed that the latest published editions of the I-Codes generally meet or exceed NFIP requirements for buildings

I-CODES AND COASTAL A ZONE

The 2015 and later editions of the International Codes (I-Codes) treat Coastal A Zones like Zone V if a Limit of Moderate Wave Action (LiMWA) is delineated on FIRMs. The 2015 and later editions of the I-Codes also require flood openings in breakaway walls (see Section 3.3 of this Technical Bulletin).

If a community designates an area as a Coastal A Zone in its building code or floodplain management regulations, buildings in that area are required to comply with Zone V requirements, including for breakaway walls.

and structures. Excerpts of the flood provisions in the I-Codes are available on the FEMA Building Science – Flood Publications webpage at https://www.fema.gov/emergency-managers/risk-management/building-science/flood.

3.1 International Residential Code

The International Residential Code (IRC) applies to one- and two-family dwellings and townhomes not more than three stories above grade plane.

Depending on location, the design wind speeds may exceed the prescriptive limits specified in the IRC. The prescriptive design provisions of the 2018 and later editions of the IRC are applicable only to locations as defined in IRC Section R301.2.1. Thus, one- and two-family dwellings in areas where ultimate design wind speeds exceed these minimum values must be designed in accordance with the wind design requirements of the IBC or other standard referenced in the IRC (see IRC Section R301.2.1.1).

INTERNATIONAL RESIDENTIAL CODE COMMENTARY

The ICC publishes companion commentary for the IRC. Although not regulatory, the commentary provides guidance that is useful in complying with, interpreting, and enforcing the requirements of the code.

The primary reference for wind and seismic loading in the 2018 and 2021 editions of the IBC and IRC is ASCE 7-16, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures.*

The IRC requirements related to breakaway walls are summarized in Table 1, with a comparison to NFIP requirements. Table 1 refers to selected requirements of the 2021 IRC, noting changes from the 2018, 2015, and 2012 editions. Subsequent editions of the IRC should include comparable requirements.

Table 1: Comparison of Selected 2021 IRC and NFIP Requirements

Topic	Summary of Selected 2021 IRC Requirements and Changes from 2018, 2015, and 2012 Editions	Comparison with NFIP Requirements
Equipment (electrical, plumbing, and mechanical systems)	**Section R322.1.6 Protection of mechanical, plumbing, and electrical systems.** Requires new electrical, plumbing, and mechanical system elements and replacement systems that are part of Substantial Improvements to be elevated to or above the elevations required for buildings or, if below these elevations, to be designed and installed to prevent water from entering or accumulating within the components and able to withstand certain loads and stresses. Specifies that systems, fixtures, and equipment components must not be mounted on or penetrate through walls intended to break away. Change from 2018 to 2021 IRC: Applies requirements below the elevation required in Section R322.3.2 for the lowest horizontal structural member of the lowest floor. Change from 2015 to 2018 IRC: No change. Change from 2012 to 2015 IRC: No change.	Equivalent to NFIP 44 CFR § 60.3(a)(3)(iv), with more specificity (components are not to be mounted on or penetrate through breakaway walls).

Table 1: Comparison of Selected 2021 IRC and NFIP Requirements (cont.)

Topic	Summary of Selected 2021 IRC Requirements and Changes from 2018, 2015, and 2012 Editions	Comparison with NFIP Requirements
Free of obstruction	**Section R322.3.3 Foundations.** Requires that areas below elevated buildings in Coastal High Hazard Areas (Zone V) and Coastal A Zones be free of obstructions or enclosed by breakaway walls. In Coastal A Zones, filled stem wall foundations that are designed to resist flood loads, erosion, and scour are allowed as an exception. Change from 2018 to 2021 IRC: Requirements are in a numbered list, and requirements are more clearly applied to column foundations. Change from 2015 to 2018 IRC: Subsection numbering is changed due to the addition of subsections that expand requirements for concrete slabs (322.3.4); stairways and ramps (R322.3.7), and decks and porches (R322.3.8). Change from 2012 to 2015 IRC: Applies Zone V requirements in Coastal A Zones, if delineated, with an exception that permits stem wall foundations.	Equivalent to NFIP 44 CFR § 60.3(e)(4) and (5), except that the 2015 and later editions of IRC apply requirements in both Zone V and Coastal A Zones, with an exception that permits stem wall foundations in Coastal A Zones.
Enclosed areas (walls)	**Section R322.3.5 Walls below required elevation.** Requires that enclosures below elevated buildings in Coastal High Hazard Areas (Zone V) and Coastal A Zones: 1. Be constructed with insect screening or open lattice or designed to break away under certain wind and flood loads without damaging the elevated building or the building foundation 2. Do not have electrical, mechanical, and plumbing system components mounted on or penetrate through breakaway walls 3. Have flood openings that meet the criteria in Section R322.2.2, Item 2 Change from 2018 to 2021 IRC: Applies requirements below the elevation required in Section R322.3.2 to the lowest horizontal structural member of the lowest floor. Change from 2015 to 2018 IRC: No change. Change from 2012 to 2015 IRC: Clarifies that attachment or penetration by electrical, mechanical, or plumbing systems to breakaway walls is not permitted.	Exceeds NFIP 44 CFR § 60.3(e)(5) by specifying that components must not to be mounted on or penetrate through breakaway walls and by requiring flood openings in breakaway walls (see Section 3.3 of this Technical Bulletin).
Enclosed areas (use limitations)	**Section R322.3.6 Enclosed areas below required elevation.** Requires enclosed areas below the required elevation to be used solely for parking of vehicles, building access, or storage. Change from 2018 to 2021 IRC: Applies requirements below the elevation required in Section R322.3.2 for the lowest horizontal structural member of the lowest floor. Change from 2015 to 2018 IRC: No change. Change from 2012 to 2015 IRC: No change.	Equivalent to NFIP 44 CFR § 60.3(e)(5) regarding use of enclosed areas.

Table 1: Comparison of Selected 2021 IRC and NFIP Requirements (cont.)

Topic	Summary of Selected 2021 IRC Requirements and Changes from 2018, 2015, and 2012 Editions	Comparison with NFIP Requirements
Stairways and ramps	**Section R322.3.7 Stairways and ramps.** Requires areas below stairways and ramps, if enclosed by walls, to be enclosed by breakaway walls. Change from 2018 to 2021 IRC: Applies requirements below the elevation required in Section R322.3.2 to the lowest horizontal structural member of the lowest floor. Change from 2015 to 2018 IRC: New section for stairways and ramps incorporating language from R322.3.3.	Exceeds NFIP 44 CFR § 60.3(e)(5) by specifying requirements for stairways and ramps, including breakaway walls when areas under stairways and ramps are enclosed by walls.
Decks and porches	**Section R322.3.8 Decks and porches.** Requires attached decks and porches to meet the lowest floor elevation requirement and have compliant foundations or be cantilevered from or knee-braced to the building. Self-supporting decks and porches must be designed to remain in place or break away and may be below the required elevation if not enclosed by solid walls (including breakaway walls). Change from 2018 to 2021 IRC: Applies requirements below the elevation required in Section R322.3.2 to the lowest horizontal structural member of the lowest floor. Change from 2015 to 2018 IRC: New section for decks and porches incorporating language from R322.3.3.	Exceeds NFIP 44 CFR § 60.3(e)(5) by specifying requirements for decks and porches.

IRC WIND PROVISION FOR PROTECTION OF THE BUILDING ENVELOPE ON BUILDINGS WITH BREAKAWAY WALLS

Since the 2015 edition of the IRC, Section R322.3.6.1 (Protection of building envelope), has required an exterior door at the top of stairs that provide access to the building when the area below the lowest floor is enclosed by walls that are designed to break away. This provision is to ensure that the building is protected from the effects of wind when the breakaway walls have failed (i.e., perform as intended). A similar requirement is provided in ASCE 24-14, Section 4.6 (Enclosed areas below design flood elevation).

3.2 International Building Code and ASCE 24

The flood provisions of the latest published editions of the IBC generally meet or exceed NFIP requirements for buildings largely through reference to the standard ASCE 24, *Flood Resistant Design and Construction*. ASCE 24 is developed by the American Society of Civil Engineers (ASCE). The IBC applies to all applicable buildings and structures. While primarily used for buildings and structures other than dwellings within the scope of the IRC, the IBC may be used to design dwellings.

The IBC and ASCE 24 requirements related to breakaway walls are summarized in Table 2 with a comparison to NFIP requirements. Table 2 refers to selected requirements of the 2021 IBC and ASCE 24-14 (noting changes from 2018, 2015, and 2012 IBC and ASCE 24-05). Subsequent editions of the IBC and ASCE 24 should include comparable requirements.

INTERNATIONAL BUILDING CODE AND ASCE 24 COMMENTARIES

The ICC publishes companion commentary for the IBC, and ASCE publishes companion commentary for ASCE 24. Although not regulatory, the commentaries provide information and guidance that are useful in complying with, interpreting, and enforcing requirements.

Table 2: Comparison of Selected 2021 IBC and ASCE 24-14 Requirements with NFIP Requirements

Topic	Summary of Selected 2021 IBC / ASCE 24-14 Requirements and Changes from 2018, 2015, and 2012 IBC / ASCE 24-05	Comparison with NFIP Requirements
General design requirement	**2021 IBC Section 1612.2 Design and construction.** Requires design and construction of buildings and structures located in Coastal High Hazard Areas (Zone V) and Coastal A Zones to comply with ASCE 24 and Chapter 5 of ASCE 7. Change from 2015 to 2018 IBC: No change. Change from 2015 to 2018 IBC: Sections renumbered. Change from 2012 to 2015 IBC: Applies Coastal High Hazard Area requirements to Coastal A Zones if Limit of Moderate Wave Action (LiMWA) is delineated on FIRMs.	Exceeds NFIP 44 CFR § 60.3(e) by referring to ASCE 24, which has more specificity for some foundation elements and higher minimum building elevations and requires meeting Zone V design and construction standards in Coastal A Zones (which are not defined in the NFIP regulations).
Definition	**ASCE 24-14, Section 1.2 Definitions.** "Breakaway Wall – Any type of wall subject to flooding that is not required to provide structural support to a building or other structure and that is designed and constructed such that, under base flood or lesser flood conditions, it will collapse under specific lateral loads in such a way that (1) it allows the free passage of floodwaters and (2) it does not damage the structure or supporting foundation system" (used with permission from ASCE). Change from ASCE 24-05: No change.	Equivalent to NFIP 44 CFR § 59.1 definition.
Breakaway walls	**ASCE 24-14, Section 4.6.1 Breakaway Walls.** Requires breakaway walls to fail before or during base flood conditions without imparting loads on foundations and without producing damaging debris. Specifies that utilities and equipment must not be mounted on, pass through, or be located along breakaway walls. Change from ASCE 24-05: No change.	Exceeds NFIP 44 CFR § 60.3(e)(5) by specifying that utilities and equipment must not to be mounted on, penetrate, or be located on breakaway walls in Zone V or Coastal A Zones.

Table 2: Comparison of Selected 2021 IBC and ASCE 24-14 Requirements with NFIP Requirements (cont.)

Topic	Summary of Selected 2021 IBC / ASCE 24-14 Requirements and Changes from 2018, 2015, and 2012 IBC / ASCE 24-05	Comparison with NFIP Requirements
Openings	**ASCE 24-14, Section 4.6.2 Openings in Breakaway Walls.** Requires flood openings in breakaway walls to allow the automatic entry and exit of floodwater. Refers to flood opening requirements in ASCE 24, Section 2.7. Change from ASCE 24-05: Modified to require flood openings in breakaway walls, replacing a permissive statement.	Exceeds NFIP 44 CFR § 60.3(e)(5) by requiring flood openings in all breakaway walls in Zone V and Coastal A Zones (see Section 3.3 of this Technical Bulletin).
Access stairways and ramps	**ASCE 24-14, Chapter 8.1, General.** Requires walls enclosing stairways and ramps to meet the requirements for enclosures in ASCE 24, Section 4.6. Change from ASCE 24-05: No change to enclosure requirements.	Exceeds NFIP 44 CFR § 60.3(e)(5) by specifying requirements for stairways and ramps in both Zone V and Coastal A Zones.
Equipment (attendant utilities)	**ASCE 24-14, Section 7.1 General.** Specifies requirements for elevation or design of building equipment and utilities. Requires attendant utilities and equipment to not be mounted on, pass through, or be located along breakaway walls. Change from ASCE 24-05: No change.	Exceeds NFIP 44 CFR § 60.3(e)(5) by specifying that components must not be mounted on or penetrate through breakaway walls in Zone V or Coastal A Zones.
Equipment electrical, mechanical, plumbing)	**2021 IBC Section 1402.7 Flood resistance for coastal high-hazard areas and coastal A zones.** Specifies that electrical, mechanical, and plumbing system components must not be mounted on or penetrate through exterior walls that are designed to break away. Change from 2018 to 2021 IBC: No change. Change from 2015 to 2018 IBC: No change. Change from 2012 to 2015 IBC: No change.	Exceeds NFIP 44 CFR § 60.3(e)(5) by specifying that components are not to be mounted on or penetrate through breakaway walls.

3.3 Flood Openings in Breakaway Walls

Observations after flood events indicate that breakaway walls with flood openings (see Figure 2) help minimize wall failure in frequent, shallow flood events. Flood openings allow the automatic inflow and outflow of floodwater, which equalizes hydrostatic forces on enclosure walls. Avoiding frequent wall failure reduces the amount of flood-borne debris and protects enclosure interiors and stored items from wind-driven rain and sand. In addition, owners avoid the cost and inconvenience of replacing walls.

The 2015 and later editions of the IRC and the 2014 edition of ASCE 24 require flood openings in breakaway walls in both Zone A (including Coastal A Zones) and Zone V. Breakaway walls with flood openings must be designed to fail under the base flood specified by the NFIP regulations and building codes and standards.

The NFIP regulations do not require flood openings in breakaway walls of enclosures below elevated buildings in Zone V but require flood openings in walls of enclosures below elevated buildings in Zone A, even when breakaway walls are specified. See NFIP Technical Bulletin 1, *Requirements for Flood Openings in Foundation Walls and Walls of Enclosures.*

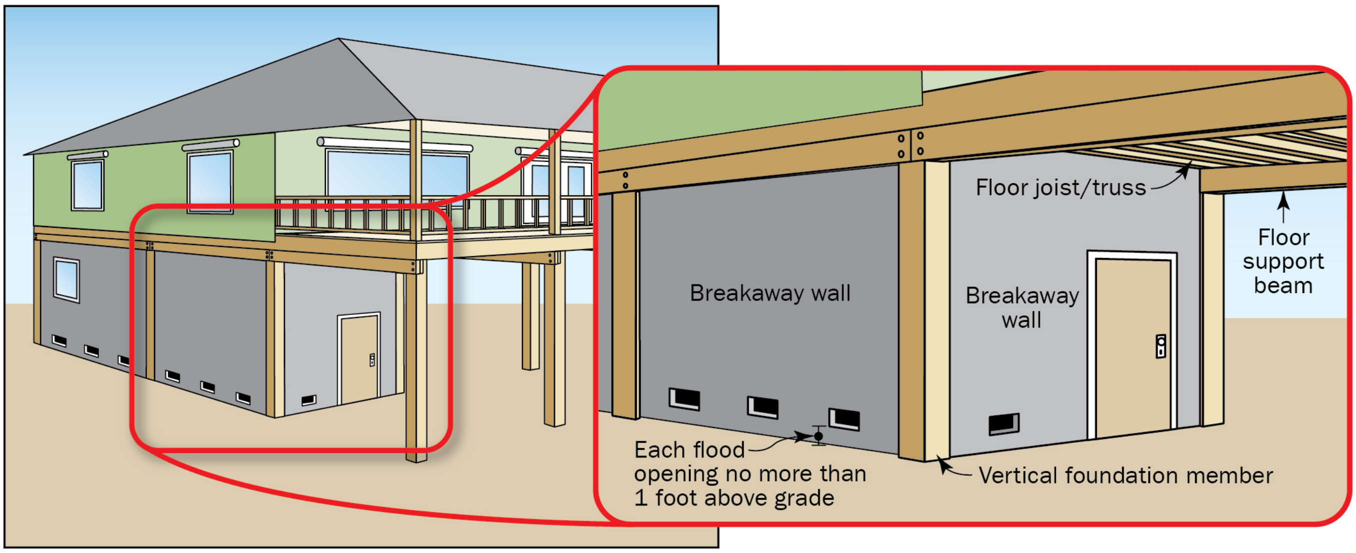


Figure 2: Flood openings in breakaway walls

4 NFIP Flood Insurance Implications

Careful attention to compliance with the NFIP requirements for enclosures below elevated lowest floors is important during the design, plan review, construction, and inspection of buildings in Zone V (Coastal High Hazard Areas). Compliance influences vulnerability to flood damage and the cost of NFIP flood insurance premiums. Meeting the minimum NFIP floodplain management requirements for enclosures does not necessarily result in the lowest NFIP flood insurance premium. Designers and owners should consult an insurance agent familiar with NFIP flood insurance to determine the insurance implications of design and construction decisions.

The NFIP floodplain management regulations in 44 CFR § 60.3(e) allow open wood lattice-work, insect screening, and solid, non-load-bearing, breakaway walls below elevated buildings in Coastal High Hazard Areas. For NFIP flood insurance purposes, breakaway walls below elevated buildings do not qualify a structure to be classified as "without enclosure." See NFIP Technical Bulletin 5, *Free-of-Obstruction Requirements*, for more information on the NFIP free-of-obstruction requirements.

Designers and owners should be aware of the following regarding NFIP flood insurance premiums for buildings in Zone V with enclosures:

- Premiums for elevated buildings with enclosure, with or without breakaway walls, are higher than premiums for elevated buildings that have no enclosed areas underneath.
- Buildings may be classified as without enclosure and may have lower premiums if the space below the lowest elevated floor is enclosed in one of the following ways:
  - Insect screening, provided that no additional supports are required for the screening
  - Wooden or plastic lattice with at least 40 percent of its area open and made of material no thicker than ½ inch
  - Wooden or plastic slats or shutters with at least 40 percent of the area open and the slats or shutters made of material no thicker than 1 inch

– One solid breakaway wall or garage door with the remaining sides of the enclosure constructed of the above-mentioned insect screening, wooden or plastic lattice, slats, or shutters

- NFIP flood insurance policies have coverage limitations for enclosures and for contents below the lowest elevated floor for post-FIRM buildings in most SFHAs.

5 Wave Loads on Building Elements

Buildings in areas where conditions produce breaking waves are exposed to different and more severe loads than are imposed on buildings in flood hazard areas without breaking waves. As a breaking wave passes a pile foundation or other element of an open foundation, the structure is subject to an oscillating, high-velocity water flow that peaks at the wave crest just as the wave breaks. Drag forces are imposed on the relatively narrow vertical surfaces of open foundations as water moves under the building and past the foundation elements, while most of the flow is relatively undisturbed. Water flows past pilings and columns supporting elevated buildings in much the same way that rivers flow past the piles and piers that support bridges. These forces are why open foundations are required in Zone V, which is subject to high-velocity wave action. Open foundations are recommended in other flood hazard areas where waves occur or that are exposed to high-velocity flows.

The effects of waves on buildings and foundations are quite different when a breaking wave hits a continuous, vertical surface such as a wall that is wider than a column or piling. When the crest of a breaking wave impacts a wall, the wave traps and compresses a pocket of air (see Figure 3). As the air pocket collapses, an exceedingly high-pressure burst (i.e., shock wave) impacts the wall with the force centered around the stillwater level. Peak pressures from a 5-foot breaking wave can be 100 times greater than the maximum design safe loading resistance (ultimate load) of 33 psf that is used in the prescriptive design method (see Sections 7 and 8 in this Technical Bulletin). Waves can also "run up" the vertical face of the building above the BFE until the breakaway wall breaks away. The impact of waves running up breakaway walls underneath buildings until the breakaway walls fail is discussed in Section 11.6 of this Technical Bulletin.

Non-breaking and broken waves, which are waves that move along the surface of the water, represent an additional design consideration for coastal structures. The effect of non-breaking and broken waves should be a design consideration inland from the open shore where breaking waves are less frequent. Though less powerful than breaking waves, non-breaking and broken waves can cause significant damage when impacting a vertical surface such as a wall. When non-breaking and broken waves impact a vertical surface, the wave can "run up" the surface, dramatically increasing the flood load on the surface.

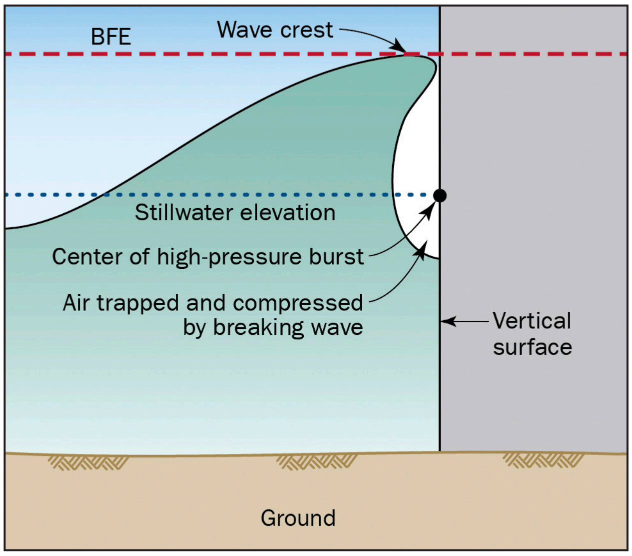


Figure 3: Impact of a breaking wave on a vertical surface

6 Breakaway Wall Performance

Breakaway wall performance has been evaluated by observing the condition of buildings in areas affected by coastal storms (see Section 6.1 of this Technical Bulletin) and by testing performance in a laboratory (see Section 6.2 of this Technical Bulletin). Conclusions from the observations are that most breakaway walls performed as intended when designed and constructed in compliance with the NFIP regulations and that many elevated structures were damaged or collapsed when the breakaway walls that surround areas under the building did not comply with the breakaway wall requirements (FEMA, 2018b). The laboratory tests showed that wood-framed breakaway walls that are designed to resist extreme wind conditions fail reliably at the connection between the bottom plate of the wall and the floor (Tung et al., 1999).

6.1 Observations of Breakaway Wall Performance

FEMA deploys Mitigation Assessment Teams (MATs) after some disasters to evaluate the performance of buildings and related infrastructure. MAT reports prepared after significant coastal storms have consistently concluded that breakaway wall systems perform as intended when they are designed and constructed to break away without damaging the elevated building (FEMA, 2018b[2]). Additionally, properly constructed breakaway walls have not been observed to become sufficient debris that causes significant foundation damage when trapped under buildings. Figure 4 and Figure 5 are examples of successful breakaway wall performance.

Figure 4: Breakaway walls under an elevated building that were removed by waves (i.e., performed as intended) during Hurricane Ivan in 2004 (Gulf Shores, AL)

2 For additional MAT reports with observations of breakaway wall performance, see the FEMA Mitigation Assessment Team webpage at https://www.fema.gov/emergency-managers/risk-management/building-science/mitigation-assessment-team.

Figure 5: Unreinforced masonry breakaway walls removed by waves (i.e., performed as intended) during Hurricane Irma in 2017 (Monroe County, FL)

MAT reports also show that many of the breakaway walls that were designed, constructed, or modified in ways that conflicted with the NFIP regulations led to unnecessary damage to, or collapse of, elevated structures. The most commonly observed problems in breakaway wall systems were caused by poor detailing, inappropriately constructed additions, and problems with other construction features. Such practices do not comply with the NFIP regulations, which require structures to be "constructed by methods and practices that minimize flood damage" (44 CFR § 60.3(a)(3)).

Figure 6 through Figure 10 are examples of non-compliant construction practices identified during field assessments for MAT reports.

Figure 6 shows damage associated with wave runup on walls that were not sufficiently detailed to break away from the structure. To be compliant with the NFIP regulations, the breakaway wall that forms the enclosure must be designed to break away cleanly from the structure and avoid continuous exterior sheathing spanning the breakaway walls and the structure. See Section 8.3 of this Technical Bulletin for more information on appropriate separation joints.

Figure 7 shows propagation of damage to the building exterior above the lowest floor system, which was likely caused by a lack of a horizontal separation joint between the breakaway wall and the wall above.

Figure 6: Damage caused by waves running up the exterior wall prior to dislodging of breakaway walls during Hurricane Ivan in 2004 (Pensacola Beach, FL)

Figure 7: Non-compliant joint detailing, resulting in the propagation of damage above the lowest floor when the breakaway walls broke away during Hurricane Ike in 2008 (Seabrook, TX)

Figure 8 illustrates what is likely to be the most common practice that contributes to damage: poor detailing. In this example, utilities attached to breakaway walls may have prevented the walls from breaking away. Similar damage is caused when utility lines are run through improperly placed access holes (blockouts). All utility components that must be installed below the elevated structure must be flood damage-resistant, designed for flood forces, and attached to permanent structural elements. When utilities must be located below an elevated structure, the components should be placed on the protected side of a foundation member on the side opposite to the anticipated direction of flow and wave approach.

Figure 8: Utilities attached to breakaway walls that may have prevented the walls from breaking away, resulting in additional damage to the structure during Hurricane Ike in 2008 (Galveston Island, TX)

Figure 9 shows cross bracing that had been installed inside breakaway walls and that may have prevented the walls from performing as intended and as required. When bracing is required by the structural design, it must be located and installed so it does not interfere with the intended performance of breakaway walls (see Technical Bulletin 5).

Figure 10 shows a detailing practice in which the breakaway walls spanned vertical foundation members, which unintentionally strengthened the breakaway walls and prevented them from performing as intended.

Figure 9: Cross bracing that interfered with the failure of a breakaway wall

Figure 10: Non-compliant breakaway walls that were nailed over the piles and floor beam, preventing a clean break during Hurricane Ike in 2008 (Gulf Shores, AL)

6.2 Research on Breakaway Wall Performance

Early analyses of breakaway walls assumed base flood conditions and oscillating (non-breaking) wave conditions. The assumptions in research conducted by North Carolina State University and Oregon State University differed in two significant ways to better model coastal storm conditions: rising water levels with time and breaking wave conditions (Tung et al., 1999). In addition to the modeling, full-scale wall panels were tested in a wave tank to confirm the theoretical results of the modeling.

Tung et al. (1999) found that walls constructed using standard wood studs and structural wood sheathing failed after being hit by several breaking waves averaging less than 2 feet in height. Equivalent wave conditions usually occur early in coastal storms when the stillwater depth is approximately 2 feet above ground. Although the flood forces acting on walls are significant, when the stillwater depth is shallow, the forces are expected to act close to the ground where much of the force is transferred into the ground or to the foundation near the ground. Since the loads experienced prior to failure of a properly designed and constructed breakaway wall are applied near the bottom of the wall, the forces that are transferred upward to the elevated building are minimized.

The tests on full-scale wall panels showed that wood-framed breakaway walls that are designed to resist extreme wind conditions fail reliably at the connection between the bottom plate of the wall and the concrete slab depending on fastening (see Figure 11). The tests showed that the failure begins with bowing and gradual displacement of the bottom plate and that a similar secondary failure occurs beginning with the central studs of the breakaway wall (Tung et al., 1999).

The tests determined that another secondary failure mode can occur if the bottom plate of the wall does not break away. In this case, with only a slight increase in the applied load, failure occurs at the connection between the bottom plate of the wall and the bottom of each wall stud (see Figure 12). The researchers concluded that properly detailed and fastened wood-framed breakaway walls will effectively fail before the excessive loads imposed by greater wave forces are transferred to the elevated building or foundation (Tung et al., 1999).

Figure 11: Expected failure mode of wood-framed breakaway wall based on full-scale testing

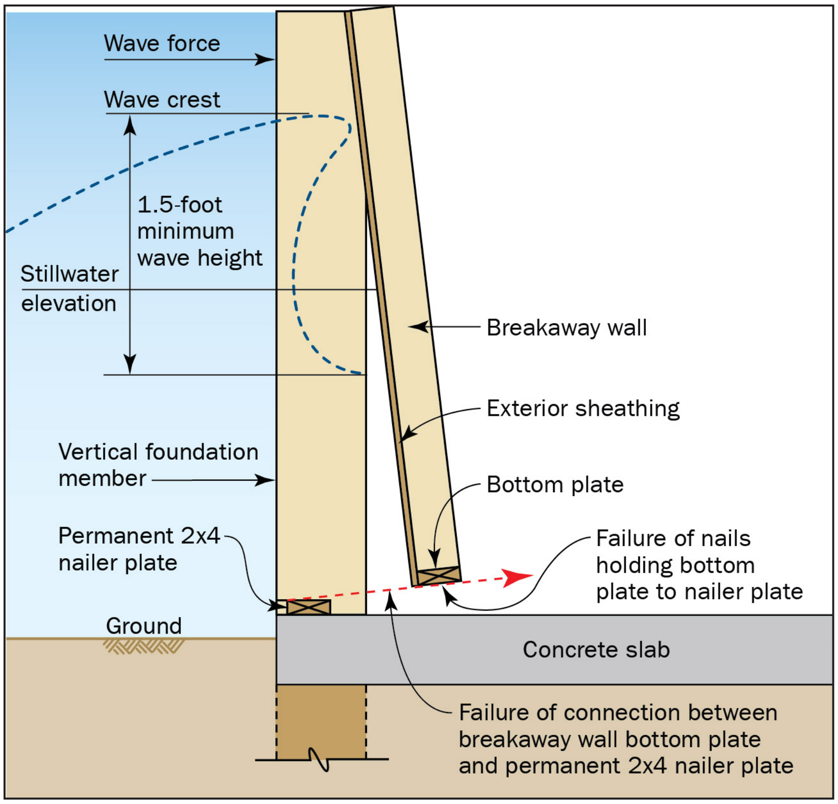
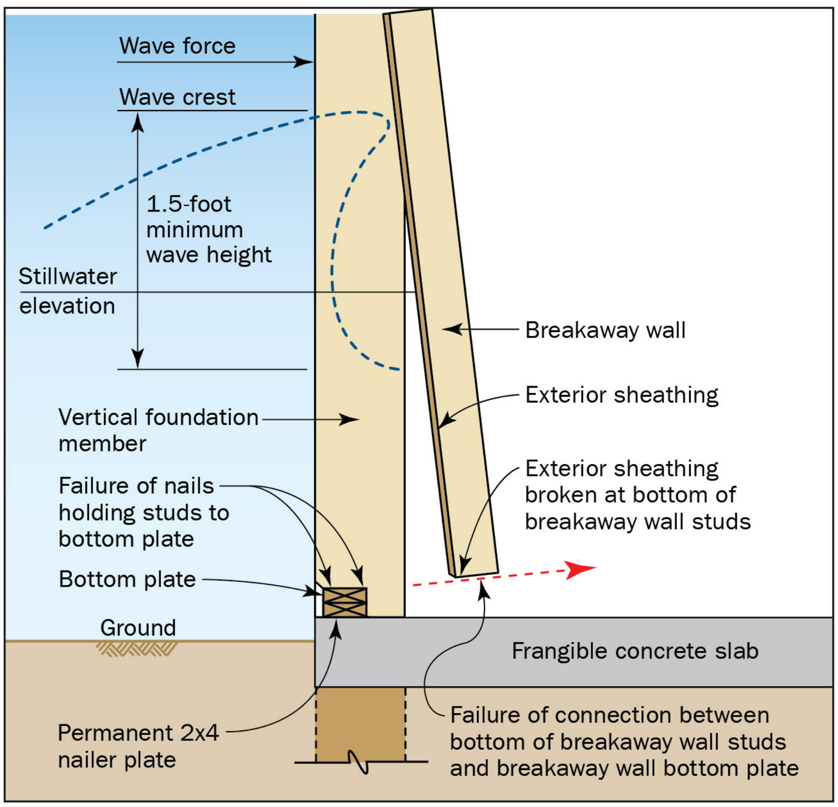


Figure 12: Secondary failure mode of wood-framed breakaway wall as determined from full-scale testing



Similar research on the performance of steel stud-framed breakaway walls and unreinforced masonry breakaway walls has not been conducted. If detailed properly, steel stud-framed breakaway walls are expected to fail in a manner that is similar to wood-framed breakaway walls. Unreinforced masonry breakaway walls are expected to fail at the mortar joints between the unreinforced ungrouted masonry units. Failure is expected to begin near the stillwater level where the pressure on the wall is assumed to be greatest (see Figure 13).

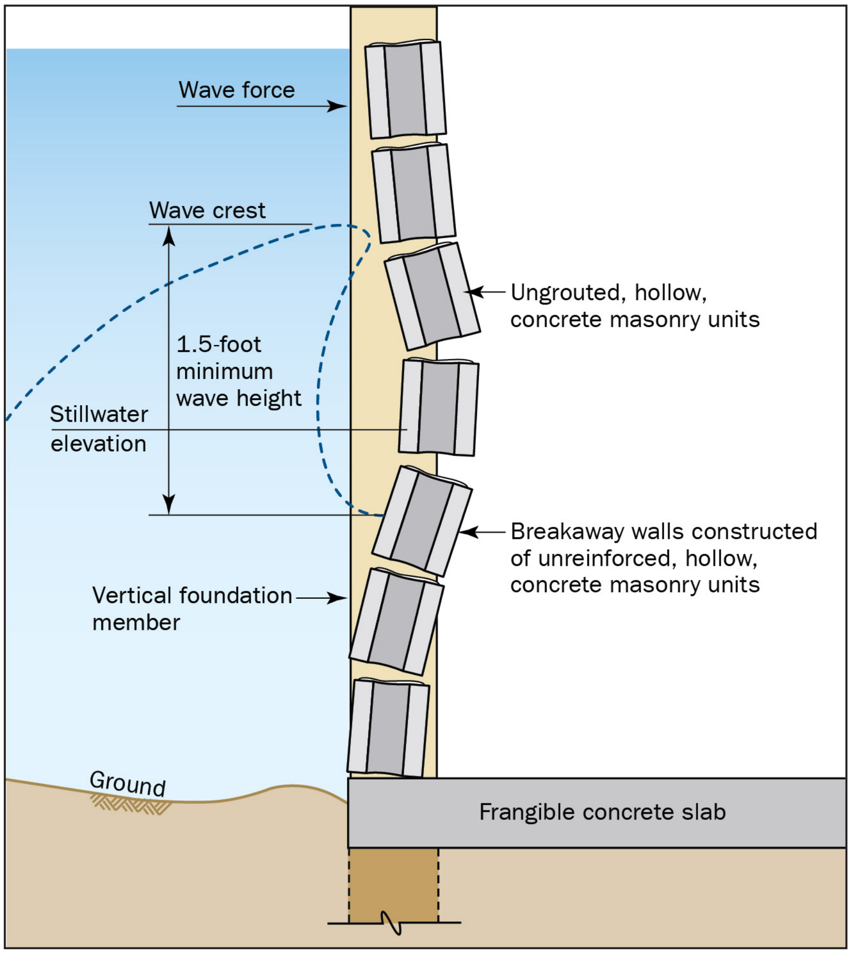


Figure 13: Expected failure mode of unreinforced masonry breakaway wall

7 Design Methods for Breakaway Walls

The NFIP regulations specify that buildings in Zone V must resist the effects of wind and water loads acting simultaneously on all building components (where applicable, seismic loads must also be addressed).

The NFIP regulations further specify that breakaway walls may be designed and constructed with either:

- A design safe loading resistance (ultimate load) of not less than 17 psf and no more than 33 psf,[3] in which case a registered professional engineer or architect is not required to certify the design. This method is the prescriptive design method that is described in Section 8 of this Technical Bulletin.
- A design safe loading resistance (ultimate load) that exceeds 33 psf, provided a registered professional engineer or architect certifies that the design meets certain conditions. To help the registered professional engineer or architect certify the conditions, the simplified and performance-based design methods are described in Sections 9 and 10 of this Technical Bulletin, respectively.

> **FLOOD OPENINGS IN BREAKAWAY WALLS**
>
> The NFIP does not require flood openings in breakaway walls under elevated buildings in Zone V, but state or local governments may. ASCE 24-14 and the 2015 and later editions of the I-Codes require flood openings in all breakaway walls, including in Coastal A Zones and Zone V. See Section 3.3 of this Technical Bulletin.

The intent of the breakaway wall requirements is to minimize loads on the foundation and the elevated building during a base flood or larger event. The loading requirements for the design of breakaway walls are those that would occur during the base flood. Even in communities that require buildings to be elevated higher than the minimum elevation (with freeboard), the loads associated with the base flood must be used for breakaway wall design. If the loads associated with a higher flood elevation are used, breakaway walls may not fail under a base flood conditions, which could transfer additional loads to the foundation and would not comply with the NFIP requirements.

The placement of non-structural fill below and around elevated buildings should comply with Technical Bulletin 5. Nonstructural fill material is not allowed to be placed against breakaway walls that are designed and constructed using the prescriptive and simplified design methods. If non-structural fill material is placed against breakaway walls, the walls must comply with the performance-based design method.

Table 3 summarizes the differences between and the limitations of the prescriptive, simplified, and performance-based design methods for breakaway walls.

Careful plan review and inspection by local officials are paramount when the prescriptive and simplified design methods are used. Plan reviewers must ensure that the proper number and type of connectors are specified for both the top and the bottom plate connections, and inspectors should pay close attention that the installation complies with the approved plans. Some jurisdictions may require a registered professional engineer or architect to verify the number and type of connectors for the breakaway wall design prior to plan submittal.

3 These values reflect the adjustment that is necessary to reflect the current wind design approach and are equivalent to the NFIP regulations of not less than 10 psf and no more than 20 psf. See Section 1.2 of this Technical Bulletin.

Table 3: Parameters for Breakaway Wall Design Methods

Design Method	3-second Gust Design Wind Speed	Range of Design Safe Loading Resistance (Wind Pressure – Ultimate Load)	Pile Spacing	Breakaway Wall Height
Prescriptive	Not to exceed 120 mph	Not less than 17 psf and no more than 33 psf	8 to 12 feet	6 to 9 feet
Simplified	120 to 170 mph for wood and steel-stud	More than 33 psf but no more than 70 psf	8 to 12 feet	6 to 9 feet
	120 to 150 mph for unreinforced masonry	More than 33 psf but no more than 55 psf	8 to 12 feet	6 feet to 8 feet 8 inches
Performance-based	Based on project location	Based on project location	Specified by designer	Specified by designer

WINDOWS AND DOORS IN BREAKAWAY WALLS

Windows and doors are allowed in breakaway walls provided they do not interfere with the performance of the walls and meet applicable building code requirements.

Any glazed openings in breakaway walls must meet the same windborne debris protection requirements that apply to the building because buildings can be affected by high-wind events without flooding.

Windows and doors in breakaway walls are allowed when using the prescriptive and simplified design methods provided the following requirements are met:

- For framed (wood or steel-stud) breakaway walls, windows and doors do not interfere with the ability of the breakaway wall to break away during a flood event.
- The opening framing is not attached to the permanent nailers and is located such that the framing does not need to be attached to foundation piles or columns.
- The bottom permanent nailer for the doorway opening is optional, and the door framing needs to be attached to the breakaway bottom framing, not the permanent bottom nailer.

Windows and doors may be incorporated into the performance-based design method provided all of the other design requirements are met.

8 Prescriptive Design Method for Breakaway Walls

Walls with a design safe loading resistance (ultimate load) of not less than 17 psf and no more than 33 psf meet the NFIP requirements and can be designed and constructed using the prescriptive breakaway wall method. They do not require certification by a registered professional engineer or architect. The intent of the prescriptive design method is that when designing the foundation elements to resist flood loads, designers consider the loads associated with breakaway walls until the breakaway walls fail during a base flood event at which point the breakaway walls are no longer considered.

Tung et al. (1999) shows that breakaway walls with a design safe loading resistance (ultimate load) of no more than 33 psf will fail at very low flood loads (i.e., 1.5-foot wave height). Failure at no more than 33 psf ensures that the foundation and building can be designed to accommodate wind, flood, and debris impact loads transferred from breakaway walls up to the point of wall failure and that beyond this threshold, the foundation loads will be reduced by the elimination of loads from the breakaway wall. However, the 33 psf restriction may not accommodate all of the necessary loading requirements on a breakaway wall from wind, seismic, or debris impact loads. It was never the intent to allow breakaway walls to be designed for less than the building and residential code-mandated wind and seismic loads. The applicability of this prescriptive design method is based on a combination of the site characteristics and pile spacings outlined in Section 8.1 of this Technical Bulletin.

Breakaway walls that are built in accordance with the prescriptive design method are considered to have a design safe loading resistance (ultimate load) of not less than 17 psf and no more than 33 psf. Modern building and residential codes used along the Gulf and Atlantic Coasts are likely to require unfactored design wind pressures that exceed 33 psf, which prohibit the use of the prescriptive design method. Designers may not use the prescriptive design method in areas where design wind pressures exceed 33 psf and should evaluate the applicability of the simplified design method and the performance-based design method.

8.1 Applicability

Wood-framed, steel stud-framed, and unreinforced masonry breakaway walls that use the prescriptive design method do not require certification by a registered professional engineer or architect and are permitted if all of the following conditions are satisfied:

- Breakaway wall heights are between 6 and 9 feet, and piles or columns are spaced between 8 and 12 feet apart. (The performance-based design method must be used when the conditions fall outside these parameters; see Section 10 of this Technical Bulletin.)
- The 3-second gust design wind speed for all parts of breakaway walls does not exceed 120 mph per the basic wind speed maps in ASCE 7-16. The 3 second gust design wind speeds for a specific location can also be obtained from the Applied Technology Council website https://hazards.atcouncil.org/. As with any design, the enforced design wind speeds for specific locations should be verified with local officials.

WIND LOADS

The prescriptive design method for breakaway walls may not be used in areas where the wind loads exceed base flood loads for breakaway walls. The prescriptive design method is applicable only when wind loads do not exceed base flood loads.

- The prescriptive design method for wood-framed and steel stud-framed walls is permitted for all Seismic Design Categories in ASCE 7-16. Unreinforced masonry breakaway walls are permitted only in Seismic Design Category A as identified in ASCE 7-16.
- Breakaway walls serving as backup for brick veneer or other material that may be damaged by excessive deflections may not be designed using the prescriptive design method.

8.2 Design Methodology

Wood-framed breakaway walls must be constructed in accordance with Figure 14. Nail requirements for wood-framed breakaway walls are listed in Table 4. Wood-framed breakaway walls must be constructed using flood damage-resistant, No. 2 Grade Spruce-Pine-Fir or better grade/species (e.g., No. 2 Southern Pine has a greater allowable bending stress).

Steel stud-framed breakaway walls must be constructed in accordance with Figure 15. Screw requirements for steel stud-framed breakaway walls are listed in Table 5. Interpolation for different pile spacings and wall heights is permitted when using Table 4 and Table 5. Utility blockouts should be located in the upper corners of breakaway wall panel sections and sized to allow clear passage of the utility based on building material sizing (e.g., masonry block sizes). A 4-inch by 4-inch utility blockout is shown in Figure 14 for wood-framed breakaway walls and in Figure 15 for steel stud-framed breakaway walls, and an 8-inch by 8-inch utility blockout is shown for unreinforced masonry breakaway walls in Figure 20. The size of utility blockouts should be as small as possible to minimize the impact to the performance of the breakaway wall.

STEEL STUD-FRAMED BREAKAWAY WALLS

The section designation (type, gauge, and size) for steel stud-framed breakaway walls in the prescriptive and simplified design methods is provided in Figure 14 and Section 9.2 of this Technical Bulletin.

PRESCRIPTIVE AND SIMPLIFIED BREAKAWAY WALL DESIGN METHOD ASSUMPTIONS

In both the prescriptive and simplified design methods, breakaway wall panels are designed to fail under a non-breaking or broken wave loading condition. A stillwater depth of 1.9 feet and a 1.5-foot-tall non-breaking wave are assumed to ensure that the panels could be incorporated into Coastal A Zone buildings. The wall is assumed to have flood openings that equalize hydrostatic loads, and a flood velocity of 4.9 feet per second is assumed. The conditions also assume wave runup on the breakaway wall exterior surface.

Figure 14: Typical wood-framed breakaway wall construction (prescriptive design method); see Table 4 for nail requirements for top and bottom (no nails along panel sides)

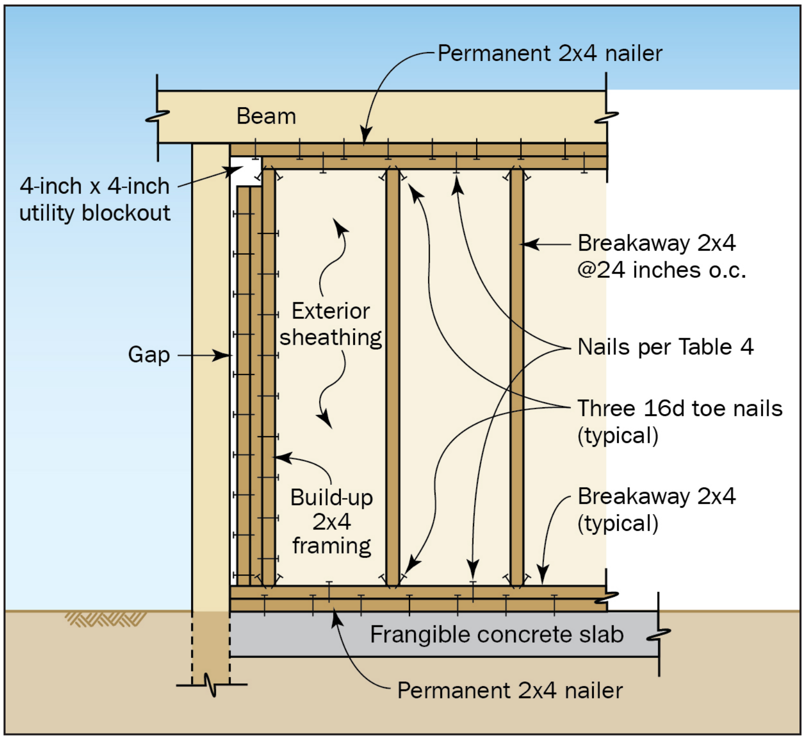


Table 4: Required Size and Number of Galvanized Common Nails for Wood-Framed Breakaway Walls with Different Heights and Pile Spacings

Breakaway Wall Height (feet)	Pile Spacing (feet)	Nail Size	Number of Nails(1)
6	8	8d	18
		10d	12
	10	8d	24
		10d	16
	12	8d	28
		10d	18
7	8	8d	22
		10d	14
	10	8d	28
		10d	18
	12	8d	32
		10d	22
8	8	8d	24
		10d	16
	10	8d	32
		10d	20
	12	8d	38
		10d	24
9	8	8d	28
		10d	18
	10	8d	34
		10d	24
	12	8d	42
		10d	28

(1) Divided equally between top and bottom and evenly spaced; nails must not be used along panel sides

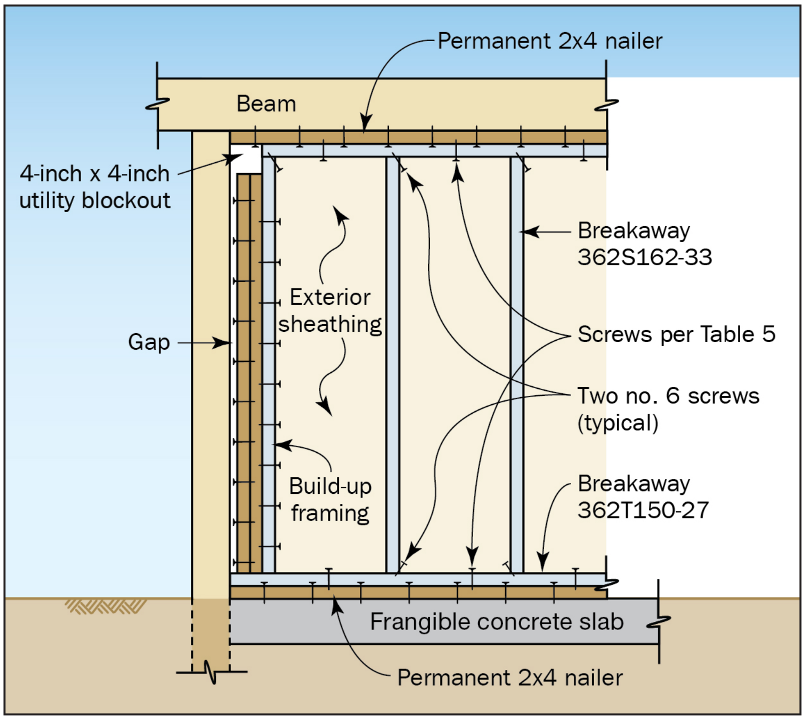


Figure 15: Typical steel stud-framed breakaway wall construction with designated section type, gauge, and size (prescriptive design method); see Table 5 for screw requirements. Note that two no. 6 screws are shown as a diagonal connection for clarity; the typical connection location is between the flanges of the steel stud and steel track.

Table 5: Required Number of 1-inch-long No. 6 Self-Tapping Screws for Steel Stud-Framed Breakaway Walls with Different Heights and Pile Spacings

Breakaway Wall Height (feet)	Pile Spacing (feet)	Number of Screws(1)
6	8	22
	10	28
	12	32
7	8	26
	10	32
	12	38
8	8	30
	10	36
	12	44
9	8	32
	10	42
	12	50

(1) Divided equally between top and bottom and evenly spaced and conforming to SAE J78 with a Type II coating in accordance with ASTM B 633 (screws must not be used along panel sides)

8.2.1 Unreinforced Masonry Design Option

The prescriptive design method for unreinforced masonry breakaway walls is the same as the simplified design method (see Section 9 of this Technical Bulletin). The unreinforced masonry wall failure mode is such that it will fail under a base flood condition and resist a wind load of up to 55 psf or a wind speed of 150 mph. Unreinforced masonry breakaway walls were developed to be used only in Seismic Design Category A, as defined in ASCE 7-16.

Unreinforced masonry infill breakaway walls must be constructed in accordance with the following building configurations:

- Lowest horizontal structural member is a concrete beam (see Figure 16)
- Lowest horizontal structural member is a timber structural beam with floor joists bearing on the structural beam (see Figure 17)
- Lowest horizontal structural member is a timber structural beam with floor joists hanging from the face of the structural beam (see Figure 18).

Note that the sheathing material shown in Figure 16, Figure 17, and Figure 18 incorporates a 4-inch overlap of the top of the masonry breakaway wall to help restrain the wall until it is knocked free by a base flood event. This section of sheathing is detailed to terminate at the top with a watertight seal at the midpoint of the rim joist of the elevated building. This overlap detail prevents damage to the elevated building but provides sufficient attachment surface for the sheathing during construction.

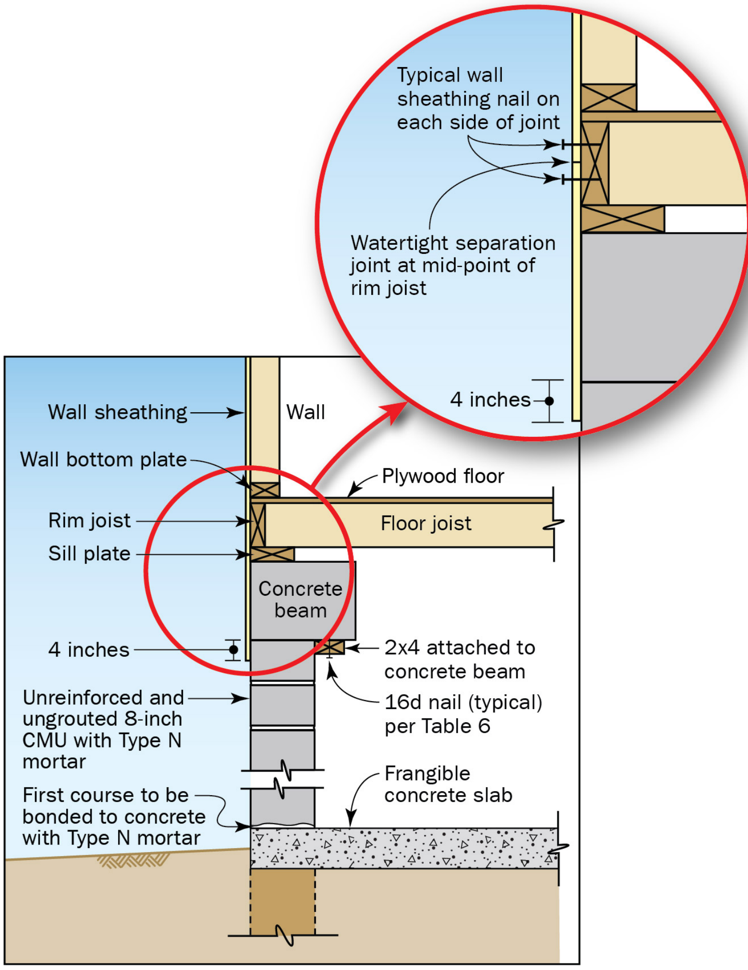


Figure 16: Typical breakaway masonry wall where the lowest horizontal structural member is a concrete beam (prescriptive design method); see Table 6 for nailing requirements

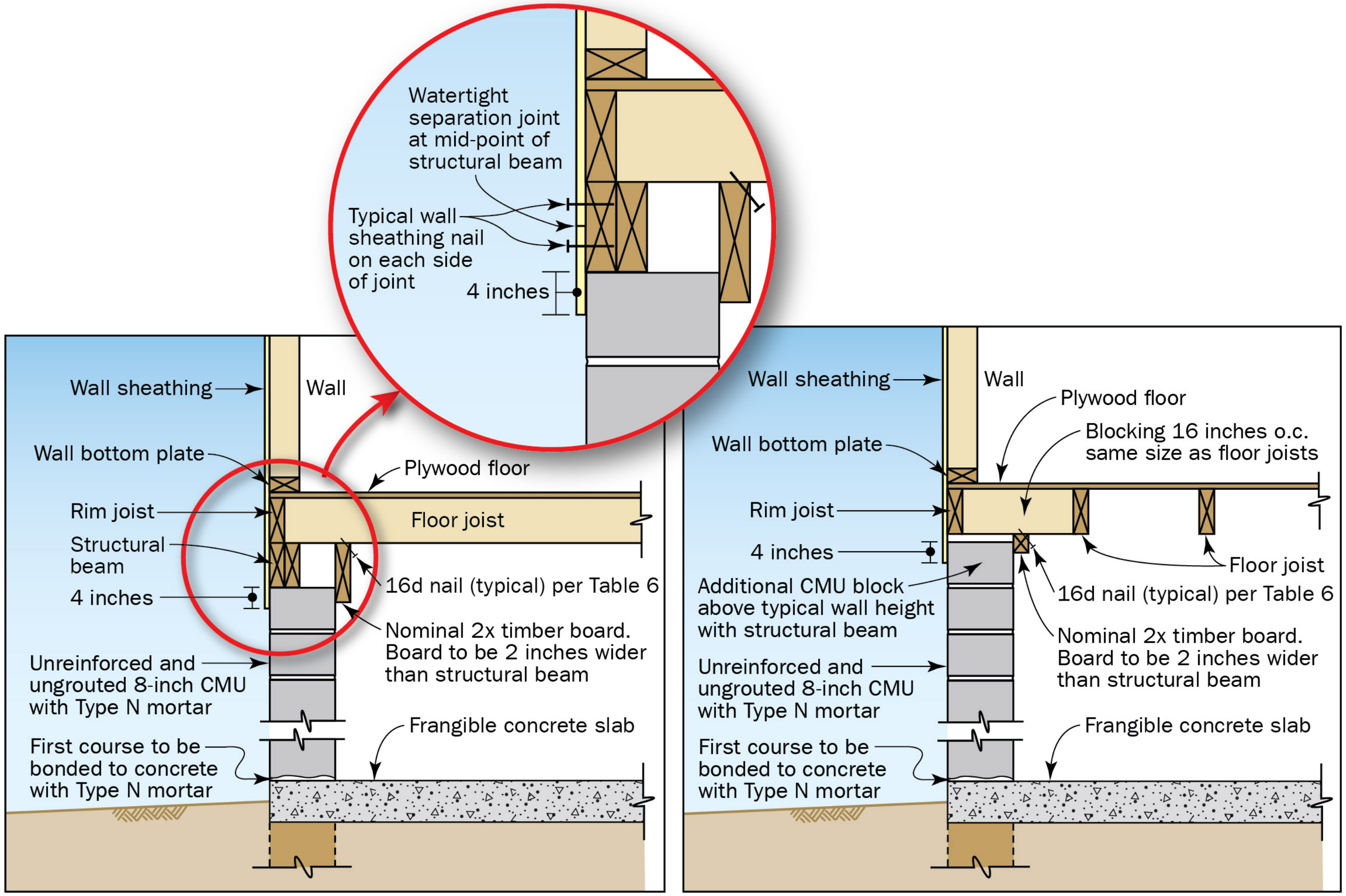


Figure 17: Typical breakaway masonry wall where the lowest horizontal structural member is a timber structural beam with floor joists bearing on the structural beam (prescriptive design method). Left image is perpendicular to the floor joists, and the right image is normal to the floor joists; see Table 6 for nailing requirements.

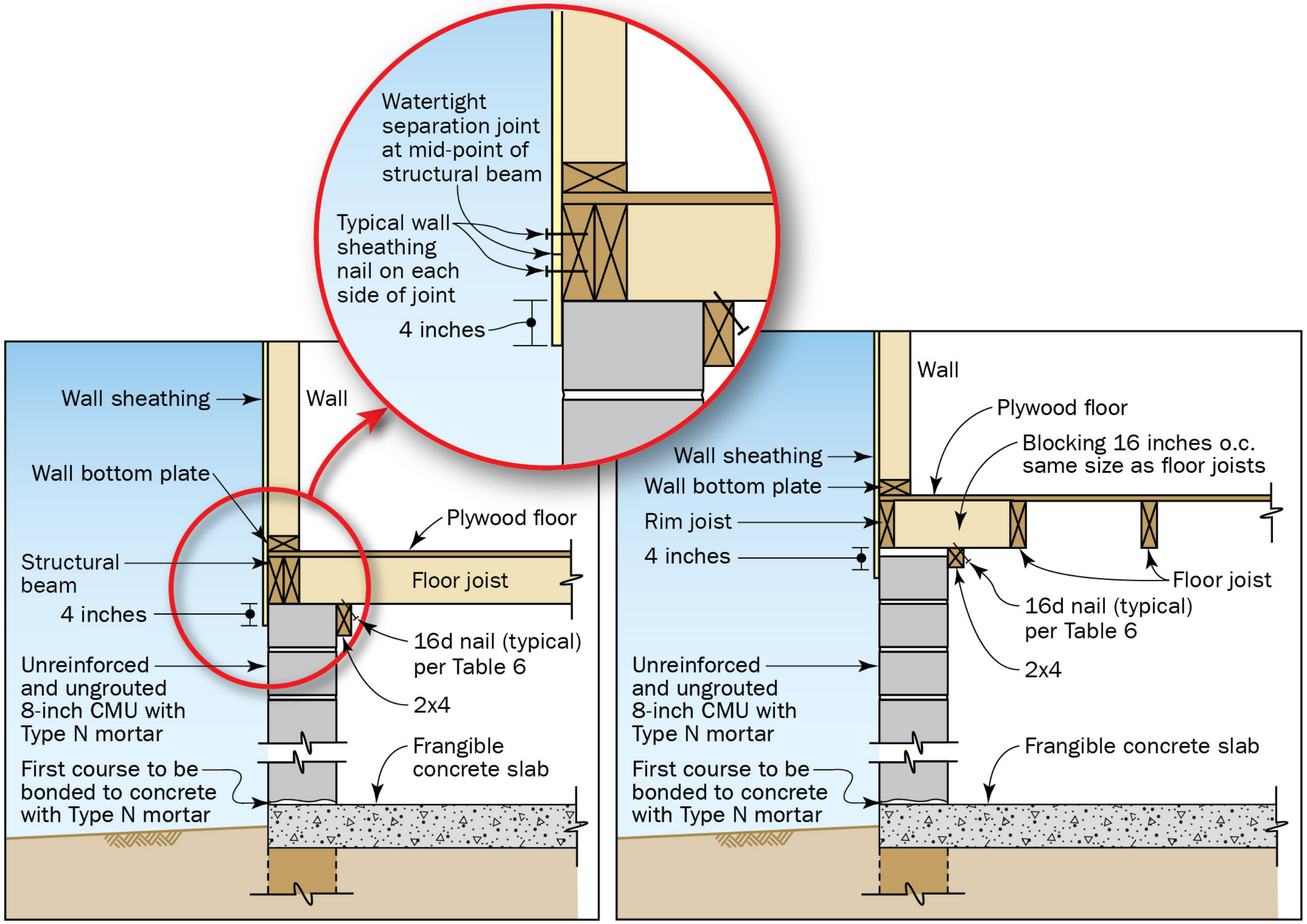


Figure 18: Typical breakaway masonry wall where the lowest horizontal structural member is a timber structural beam with floor joists hanging from the face of the structural beam (prescriptive design method). Left image is perpendicular to the floor joists, and the right image is normal to the floor joists; see Table 6 for nailing requirements.

Unreinforced masonry infill walls may be used in the prescriptive and simplified design methods only when the dimensions of the openings align with masonry modular dimensions (i.e., the opening size is an even multiple of 8 inches). The configuration of the structural framing may impact the timber framing that is used to restrain the masonry units. Table 6 indicates the nailing requirements for securing timber sections to the structure (interpolation is allowed). Timber framing used as part of these breakaway wall systems must be constructed using flood damage-resistant, No. 2 Grade Spruce-Pine-Fir or better grade/species (e.g., No. 2 Southern Pine has a greater allowable bending stress).

Table 6: Required Number of Galvanized 16d Common Nails for Restraining 2x4s on Unreinforced Masonry Breakaway Walls with Different Pile Spacings

Breakaway Wall Height	Pile Spacing (feet)	Number of Screws(1)
6 feet 0 inch	8	7
	10	9
	12	10
7 feet 4 inches	8	7
	10	9
	12	10
8 feet 0 inch	8	7
	10	9
	12	10
8 feet 8 inches	8	7
	10	9
	12	10

(1) Divided equally along the top framing elements

8.3 Design Details

When using Section 8.3 of this Technical Bulletin for the prescriptive design method, designers should also reference the tables and figures in Section 9.2 of this Technical Bulletin.

All breakaway walls designed using the prescriptive design method must be designed and detailed in accordance with the following:

- Breakaway walls are designed to meet all applicable state and local building codes or other requirements.
- The material specifications match the material specifications shown in the figures and tables in this Technical Bulletin (if not, the performance-based design method must be used)
- Per Figure 14 and Figure 15, wood-framed and steel stud-framed breakaway wall panels are not attached to the pilings or other vertical foundation members. Only the tops and bottoms of wall panels may be connected to permanent 2x4 nailer plates. High-capacity connectors such as bolts, lag screws, metal straps, and hurricane fasteners (e.g., clips, straps) are not used to secure breakaway wall panels.
- Unreinforced masonry breakaway walls were developed to be used only in Seismic Design Category A, as defined in ASCE 7-16. The following assumptions apply to the designs shown in Figure 16, Figure 17, and Figure 18.
  - Unreinforced masonry blocks are bonded to the frangible concrete slab or grade beam and to each other using Type N mortar conforming to ASTM C270.
  - Concrete masonry units (CMUs) are 8-inch nominal units with a compressive strength of 2,000 psi.
  - Masonry infill walls are used only when the dimensions of the openings align with masonry modular dimensions.
  - There are no fasteners attaching the masonry to timber framing or connection to the concrete slab, grade beam, or columns.
  - Where a concrete beam is used to support the elevated structure shown in Figure 16, mortar is not required in the gap between the top masonry block in the wall and the bottom of the concrete beam.
- The exterior structure's wall siding/sheathing does not extend below the lowest horizontal structural member and overlaps with breakaway wall panels (except as shown to comply with Figure 16, Figure 17, and Figure 18), and breakaway wall panels do not overlap and are not attached to the vertical foundation members.
- Breakaway wall sheathing and siding are discontinuous at the lowest horizontal structural member; horizontal separation joints are provided to prevent damage to the sheathing or siding above the lowest horizontal structural member (see Figure 19). As shown in Figure 19, a watertight seal is provided for separation joints to prevent wind-driven rain and sea spray from entering the building envelope. A similar vertical sealed joint may be needed in front of the piling.

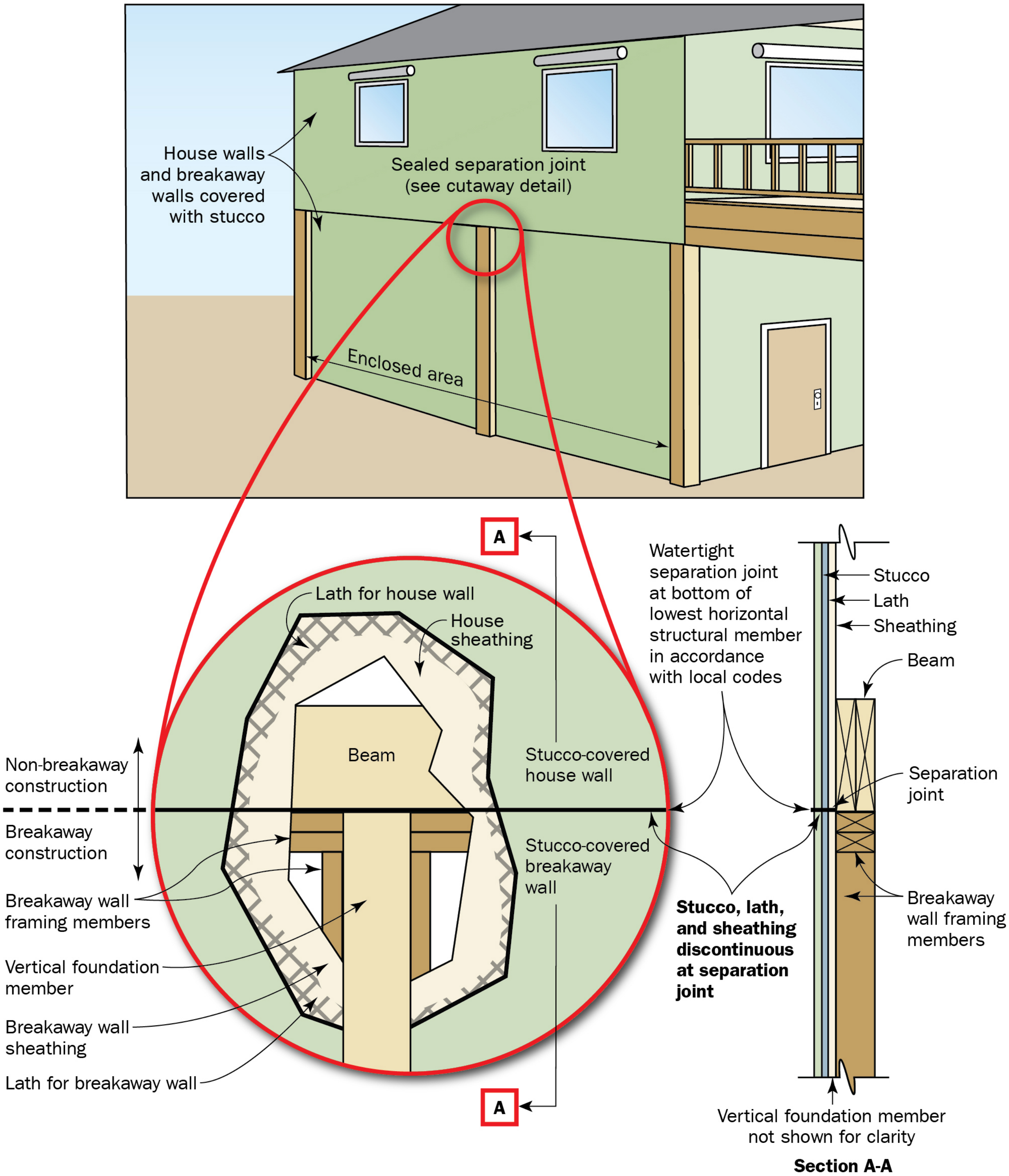


Figure 19: Separation joint between sheathing and wall covering (e.g., stucco, siding) on house walls and breakaway walls

- Utilities, including electrical wiring, switches, outlets, breaker boxes, power meters, plumbing, conduits, and ventilation ducts, are not mounted on or attached to breakaway wall panels. Building supply lines and other utility fixtures, such as light switches and electrical outlets, may be attached to the sheltered side of vertical foundation members as allowed by applicable building codes and floodplain management regulations (which generally require utilities to be elevated above the BFE). If utility lines must be routed into or out of an enclosure, one or more of the walls are constructed with a utility blockout (see Figure 14 and Figure 15). For unreinforced masonry breakaway walls, the utility openings are 8 inches by 8 inches based on standard masonry block sizes (see Figure 20) but as small as possible. Utility lines that pass through the blockout are independent of the walls and are therefore not subject to damage if the wall panels break away.
- Breakaway wall panels are positioned such that, on failure, they do not collapse against cross-bracing or threaten other foundation components (for more information, see Technical Bulletin 5).
- Partial-height breakaway wall systems using the prescriptive design method are not permitted. (Other methods can be used, as described in Section 11.4 of this Technical Bulletin.)

When using the prescriptive design method for unreinforced masonry, designers should reference the tables and figures in Section 9.2 of this Technical Bulletin.

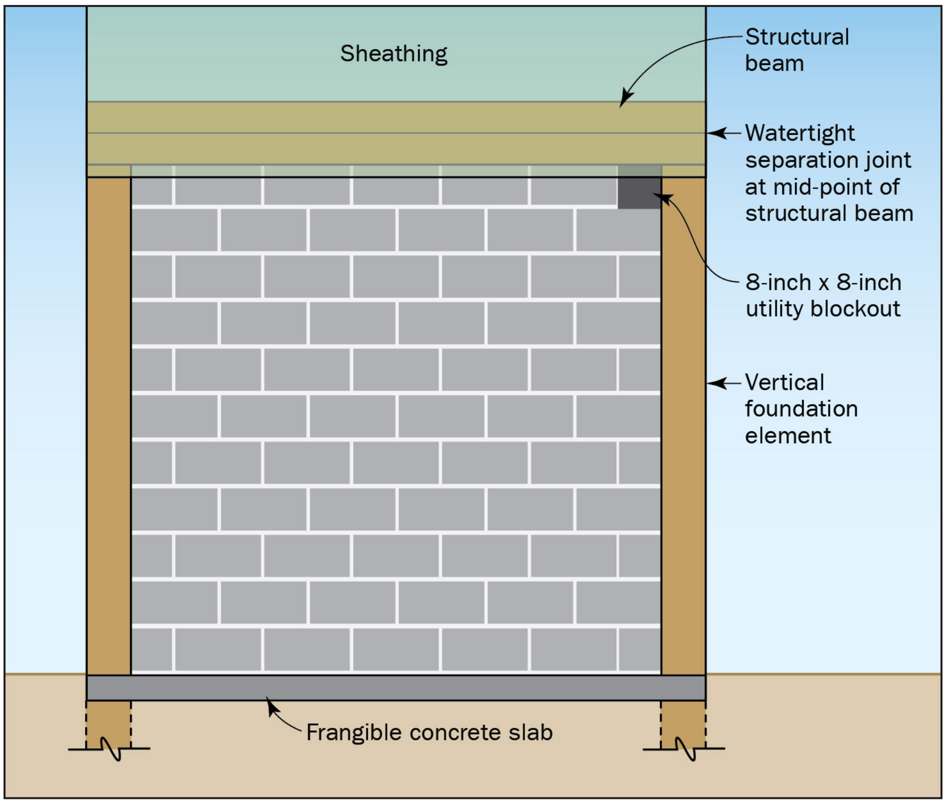


Figure 20: Utility blockout for an unreinforced masonry breakaway wall

8.4 Example

Problem: Design a 10-foot-wide by 9-foot-tall wood-framed breakaway wall for a 3-second gust design wind speed of 120 mph. The Seismic Design Category is D, and deflection of the wall is not important. Wood framing must be constructed using flood damage-resistant material such as No. 2 Grade Spruce-Pine-Fir 2x4s or better grade/species.

Solution: The described problem clearly allows the use of the prescriptive design method. Due to the Seismic Design Category, unreinforced masonry breakaway walls are not permitted, and wood-framed breakaway walls could therefore be considered. Figure 14 shows that 2x4 studs at 24 inches on center (o.c.) must be toe nailed to the top and bottom plates using three 16d nails. According to Table 4, 24 10d nails (12 top and 12 bottom) could be used to connect the breakaway top and bottom plates to permanent 2x4 nailer plates.

9 Simplified Design Method for Breakaway Walls

In most coastal areas, the applicable building codes include wind and/or seismic design requirements that exceed the maximum allowed design safe loading resistance (ultimate load) of 33 psf in the prescriptive design method for breakaway walls. NFIP performance criteria allow breakaway walls that meet a design safe loading resistance (ultimate load) that is more than 33 psf if a registered professional engineer or architect certifies that (1) the wall will collapse before base flood conditions are reached and (2) the elevated building will not be damaged by combined wind and flood loads acting simultaneously on all building components. The above performance criteria comprise the simplified design method.

Breakaway walls designed in accordance with the simplified design method have a design safe loading resistance (ultimate load) that exceeds 33 psf, yet they still comply with NFIP performance criteria. Tung et al. (1999) shows that wave loads do not exceed the design capacity of elevated structures or their supporting foundations if breakaway walls are designed to resist wind loads of up to 55 psf. Therefore, walls designed using the simplified design method meet NFIP performance criteria. Stud, nail, and screw requirements in Table 7 through Table 10 meet the stringent design conditions described in Section 9.1 of this Technical Bulletin. The quantity or size of fasteners may be reduced as long as the designer ensures that the breakaway wall satisfies the adopted building code's wind and/or seismic requirements.

When wind pressures exceed 70 psf for wood-framed and steel stud-framed breakaway walls or 55 psf for unreinforced masonry breakaway walls, the performance-based design method must be used (see Section 10 of this Technical Bulletin).

9.1 Applicability

The simplified design method for wood-framed and steel stud-framed breakaway walls requires certification by a registered professional engineer or architect. The method may be used in all Seismic Design Categories identified in ASCE 7-16 when all of the following conditions are satisfied:

- Breakaway wall heights are between 6 and 9 feet, and piles or columns are between 8 and 12 feet apart. The performance-based design method must be used for configurations that are outside these limitations.

- The 3-second gust design wind speed for all parts of breakaway walls is between 120 and 170 mph per the basic wind speed maps in ASCE 7-16. Wind pressures shall not exceed 70 psf.
- Breakaway walls do not serve as support for brick veneer or other materials that may be damaged by excessive deflections.

The simplified design method for unreinforced masonry walls requires certification by a registered professional engineer or architect. The method is permitted in all Seismic Design Categories identified in ASCE 7-16 when all of the following conditions are satisfied:

- Breakaway wall heights are between 6 feet and 8 feet 8 inches, and piles or columns are between 8 and 12 feet apart. The performance-based design method must be used for configurations that are outside these limitations.
- The 3-second gust design wind speed is between 120 and 150 mph in accordance with the basic wind speed maps in ASCE 7-16. Wind pressures shall not exceed 55 psf.
- Breakaway walls do not serve as support for brick veneer or other materials that may be damaged by excessive deflections.

9.2 Design Methodology

Wood-framed walls must be constructed using flood damage-resistant Spruce-Pine-Fir or better species (e.g., No. 2 Southern Pine has a higher allowable bending stress). Wood-framed breakaway walls must be constructed in accordance with Figure 21. Table 7 provides the required spacing for No. 2 Grade studs as a function of wind speed and wall height. Stud spacing values may not be interpolated (e.g., use a 150-mph design wind speed if the actual design wind speed is greater than 140 mph but less than or equal to 150 mph). Table 8 provides the required number of nails for different design wind speeds as a function of wall height and pile spacing (interpolation is allowed).

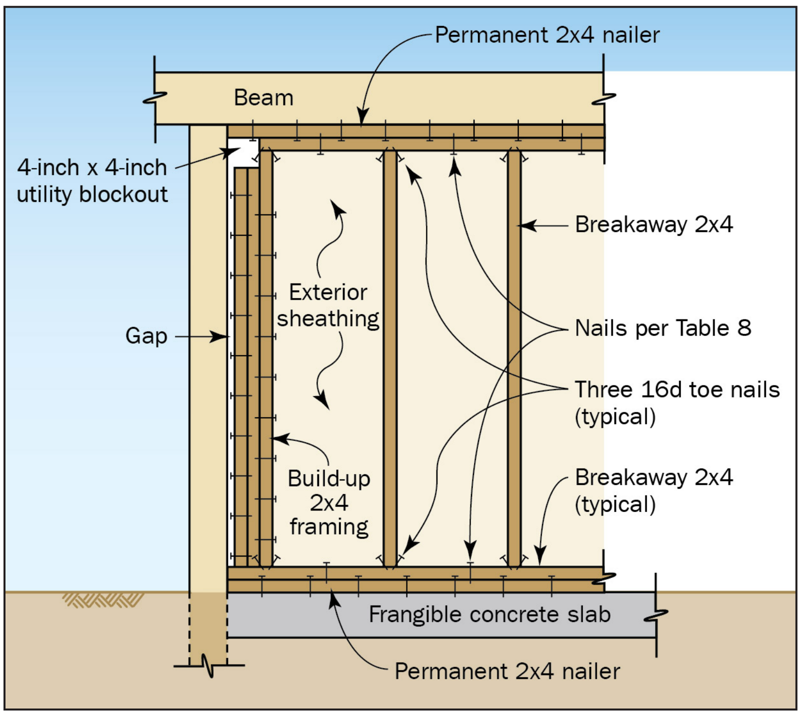


Figure 21: Typical wood-framed breakaway wall construction (simplified design method)

EDGE DISTANCE, END DISTANCES, AND SPACING FOR TOE NAILS

Figure 21 shows that three 16d (3 1/2-inch) toe nails are required for all wall geometries. Although no specific pattern of toe nailing is required in this Technical Bulletin, the *National Design Specification (NDS) for Wood Construction* (AWC, 2018) requires that edge distances, end distances, and spacing be sufficient to prevent splitting the wood. If horizontal construction is preferred by the contractor, one 16d nail installed end grain to the stud may be used with two 16d toe nails installed in alternate directions once the wall is placed vertically (see Figure 21). Likewise, two 40d nails installed end grain to the stud may be used so the breakaway wall can be assembled horizontally and then nailed in place to the permanent top and bottom nailer plates. Pre-drilling may be required.

Table 7: Required 2x4 (No. 2 Grade) Stud Spacing for Wood-Framed Breakaway Walls of Different Heights and Design Wind Speeds

Breakaway Wall Height (feet)	Design Wind Speed per ASCE 7-16 (mph)	Stud Spacing (inches)
6	140	24
	150	24
	160	24
	170	24
7	140	24
	150	24
	160	16
	170	16
8	140	16
	150	16
	160	16
	170	12
9	140	16
	150	12
	160	12
	170	Not permitted(1)

(1) Where not permitted, performance-based design method must be used for breakaway wall design

Table 8: Required Number of 10d Galvanized Common Nails for Wood-Framed Breakaway Walls with Different Wall Heights and Design Wind Speeds

Breakaway Wall Height (feet)	Design Wind Speed per ASCE 7-16 (mph)	Pile Spacing (feet)	Number of Nails(1)
6	140	8	18
		10	20
		12	24
	150	8	20
		10	24
		12	30
	160	8	22
		10	28
		12	34
	170	8	26
		10	32
		12	38
7	140	8	20
		10	24
		12	30
	150	8	22
		10	28
		12	34
	160	8	26
		10	32
		12	40
	170	8	30
		10	38
		12	44

Table 8: Required Number of 10d Galvanized Common Nails for Wood-Framed Breakaway Walls with Different Wall Heights and Design Wind Speeds (cont.)

Breakaway Wall Height (feet)	Design Wind Speed per ASCE 7-16 (mph)	Pile Spacing (feet)	Number of Nails[1]
8	140	8	22
		10	28
		12	34
	150	8	26
		10	32
		12	38
	160	8	30
		10	38
		12	44
	170	8	34
		10	42
		12	52
9	140	8	24
		10	32
		12	38
	150	8	30
		10	36
		12	44
	160	8	34
		10	42
		12	50
	170	8	Not permitted[2]
		10	
		12	

(1) Divided equally between top and bottom and evenly spaced (nails must not be used along panel sides)

(2) Where not permitted, performance-based design method must be used for breakaway wall design.

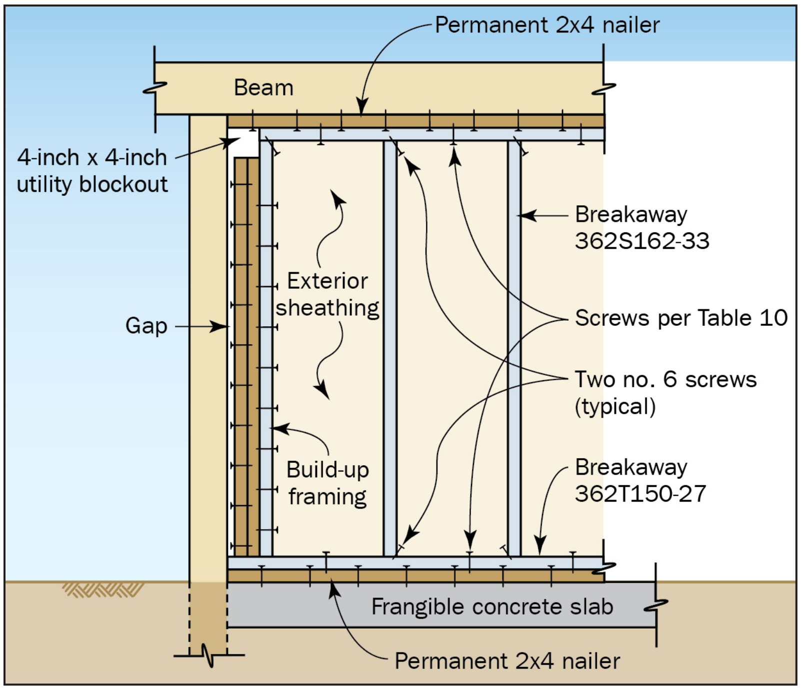


Figure 22: Typical steel stud-framed breakaway wall construction (simplified design method)

Steel stud-framed breakaway walls must be constructed in accordance with Figure 22. Table 9 provides the required spacing for steel studs as a function of wind speed and wall height. Stud spacing values may not be interpolated (e.g., use 150 mph design wind speed if actual design wind speed is greater than 140 mph but less than 150 mph). Table 10 provides the required number of self-tapping screws for different design wind speeds as a function of wall height and pile spacing (interpolation is allowed).

Table 9: Required 362S162-33 Stud Spacing for Steel Stud-Framed Breakaway Walls with Different Heights and Design Wind Speeds

Breakaway Wall Height (feet)	Design Wind Speed per ASCE 7-16 (mph)	Stud Spacing (inches)
6	140	24
	150	24
	160	24
	170	24
7	140	24
	150	24
	160	24
	170	16
8	140	24
	150	16
	160	16
	170	12
9	140	16
	150	12
	160	12
	170	Not permitted(1)

(1) Where not permitted, performance-based design method must be used for breakaway wall design.

Table 10: Required Number of 1-inch long No. 6 Self-Tapping Screws for Steel-Stud Framed Breakaway Walls with Different Heights and Design Wind Speeds

Breakaway Wall Height (feet)	Design Wind Speed per ASCE 7-16 (mph)	Pile Spacing (feet)	Number of Nails[(1)]
6	140	8	30
		10	36
		12	44
	150	8	34
		10	42
		12	50
	160	8	40
		10	50
		12	60
	170	8	46
		10	56
		12	68
7	140	8	34
		10	42
		12	50
	150	8	40
		10	50
		12	60
	160	8	46
		10	58
		12	70
	170	8	52
		10	66
		12	78

Table 10: Required Number of 1-inch long No. 6 Self-Tapping Screws for Steel-Stud Framed Breakaway Walls with Different Heights and Design Wind Speeds (cont.)

Breakaway Wall Height (feet)	Design Wind Speed per ASCE 7-16 (mph)	Pile Spacing (feet)	Number of Nails[1]
8	140	8	38
		10	48
		12	58
	150	8	46
		10	56
		12	68
	160	8	52
		10	66
		12	78
	170	8	60
		10	76
		12	90
9	140	8	44
		10	54
		12	66
	150	8	50
		10	64
		12	76
	160	8	60
		10	74
		12	88
	170	8	Not permitted[2]
		10	
		12	

(1) Divided equally between top and bottom and evenly spaced and conforming to SAE J78 with a Type II Coating in accordance with ASTM B 633

(2) Where not permitted, performance-based design method must be used for breakaway wall design.

9.3 Design Details

The design details in the prescriptive design method (see Section 8.3 of this Technical Bulletin) also apply to the simplified design method.

9.4 Example

Problem: Design a 10-foot-wide by 9-foot-tall wood-framed breakaway wall for a 3-second gust design wind speed of 160 mph. The Seismic Design Category is D, and deflection of the wall is not important. Wood framing is flood damage-resistant No. 2 Grade Spruce-Pine-Fir or better grade/species.

Solution: The described problem allows the use of the simplified design method. According to Table 7, 2x4 studs at 12 inches o.c. must be toe nailed to breakaway 2x4 top and bottom plates using three 16d nails (Figure 21). According to Table 8, 42 10d nails (21 top and 21 bottom) must be used to connect the breakaway top and bottom plates to permanent 2x4 nailer plates.

10 Performance-Based Design Method for Breakaway Walls

Breakaway walls designed in accordance with the performance-based design method will normally have a design safe loading resistance (ultimate load) of greater than 33 psf. Flood loads (i.e., wave loads, hydrodynamic loads, and impact loads) must be calculated and taken into account when designing the breakaway wall system, and once a design condition is met, the designer should verify that the walls do not impart an additional load on the elevated structure and the supporting foundation system. However, as described below, the designer has slightly more flexibility when detailing breakaway wall systems using the performance-based design method than in the prescriptive design method.

10.1 Applicability

The performance-based design method is always permitted, and the walls may be designed and constructed using wood studs, steel studs, unreinforced masonry, or alternative materials. However, the anticipation is that the performance-based design method will be used primarily when the applicability criteria (e.g., taller walls, wider spans, higher design wind speeds, greater seismic design category) for the prescriptive and simplified design methods cannot be satisfied. The performance-based design method for breakaway walls must be performed and certified by a registered professional engineer or architect.

10.2 Design Methodology

Breakaway walls must be capable of resisting the design wind loads on the building while still failing under base flood conditions. The performance-based design method for breakaway walls consists of designing the breakaway wall to resist the largest out-of-plane load of (1) the design wind pressure in accordance with ASCE 7, (2) the design seismic out-of-plane load in accordance with ASCE 7, or (3) demonstrating a minimum resistance of 17 psf (ultimate load). For masonry design, building codes and material standards no longer permit a one-third allowable stress increase for resisting wind and seismic forces. As a result, the one-third allowable stress increase is prohibited when designing unreinforced masonry breakaway walls.

Although breakaway walls are permitted by the NFIP regulations, the effects of flood loads on these walls (and any other building components that are below the BFE) must be included in the design of the elevated structure and its supporting foundation. Designers must evaluate two conditions when designing the building foundation: (1) a design flood event on the foundation during a design event once the breakaway walls have failed and (2) just prior to the breakaway walls' failing during a base flood event while breakaway walls are still attached to the building. The foundation must be capable of resisting both of these loading conditions. It should be noted that more resistant breakaway walls increase the potential forces from debris impact loading on foundation elements and possibly on neighboring structures. Wave heights during both the design condition and the base flood condition should be calculated based on the site conditions using a method such as the one outlined in FEMA P-55, *Coastal Construction Manual* (2011).

An evaluation of buildings for base flood conditions should include whether exposure to non-breaking or broken waves is expected because the design assumptions for non-breaking and broken waves are different from the assumptions for breaking waves. While flood maps do not adequately indicate whether waves are breaking, non-breaking, or broken, buildings along the shoreline without obstructions such as other buildings could be assumed to be exposed to breaking waves. Buildings that are shielded by buildings or other significant obstructions should be assumed to be exposed to waves that are either non-breaking or broken.

ASCE 7, Chapter 5, provides guidance on calculating breaking waves on vertical walls to address breaking wave conditions. Non-breaking waves and broken waves must be addressed differently. A recommended approach when designing for non-breaking and broken waves is to consider that hydrostatic loads and hydrodynamic loads will cause the proposed breakaway wall to fail. Since a debris load cannot be relied upon to cause the wall to fail, a debris load should not be considered in the design of breakaway walls. The hydrostatic load should consider that the exterior wall face will experience a wave runup height of 1.5 times the wave height above the stillwater depth. The interior face of the breakaway wall will likely experience a hydrostatic load of approximately the stillwater depth due to the potential for flood openings on some buildings, but breakaway walls are often open enough along the sides of the wall that equalization of the floodwaters to the stillwater depth is likely. The hydrodynamic load should be calculated using the stillwater depth and follow the guidance in the commentary for ASCE 7, Chapter 5, to calculate flood velocities and the associated loads.

Using non-breaking or broken waves for analysis yields a wall system that will fail under lower loading and reduces loads on the foundation system during the evaluation of the condition when breakaway walls are still in place and fully loaded by the base flood condition just prior to the walls' failing. Even when breaking waves are expected, if breakaway walls are designed using non-breaking or broken waves, the foundation is more likely to experience reduced flood loading during a base flood event.

10.3 Segmented Breakaway Walls

A segmented breakaway wall that is designed using the performance-based design method can minimize the need to replace an entire breakaway wall after a less than base flood event. As shown in Figure 23, a segmented breakaway wall allows horizontal segments or sections of the wall to fail as floodwaters rise. Vertical segments are also allowed provided they meet all other breakaway wall requirements. Each segment must meet the loading requirements outlined in Section 10.2 of this Technical Bulletin in order to ensure that during a base flood condition, the wall segments will fail and will not increase the loads on the foundation elements. Configuration details for segmented breakaway walls are based on segment height, foundation element spacing, and loading requirements. Review Section 11.4 of this Technical Bulletin on partial-height breakaway walls to make sure that a proposed wall configuration is compliant with the minimum requirements for breakaway walls.

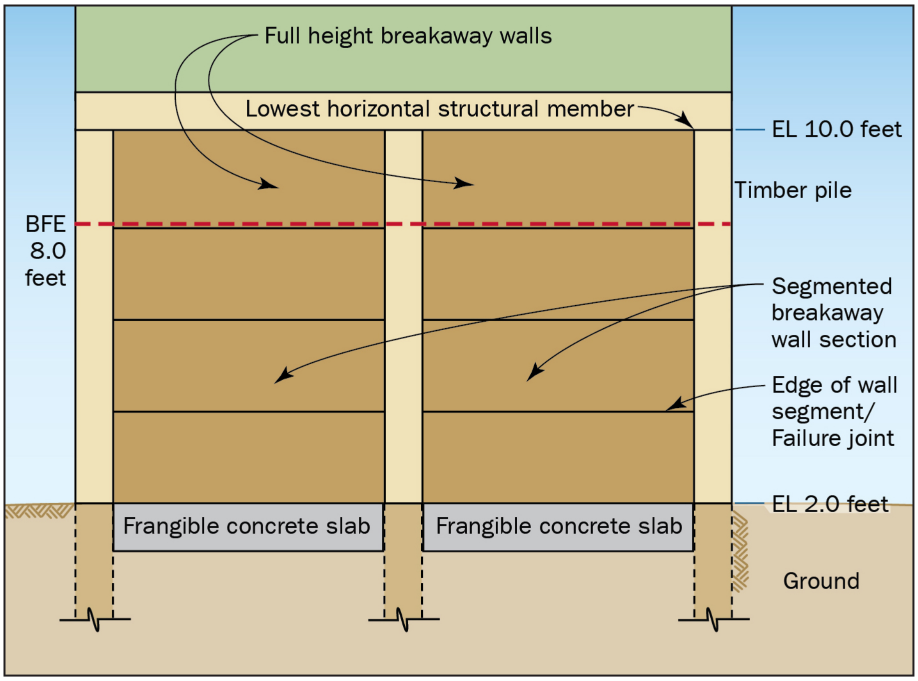


Figure 23: Example of a segmented breakaway wall using horizontal segments. Example elevations are provided for clarity.

10.4 Design Details

All breakaway walls designed using the performance-based design method must be designed and detailed in accordance with the following:

> **WIND LOADS THAT EXCEED FLOOD LOADS**
>
> When breakaway walls are designed using the performance-based design method, tall or large wall panels may result in wind loads that exceed flood loads. To meet the NFIP requirements, the wall geometry may need to be modified to reduce the tributary area for the wind load. If this is not possible, louvered or open lattice-work should be used in lieu of breakaway walls.

- Breakaway walls are designed to meet all applicable state and local floodplain management and building code requirements.
- Breakaway wall sheathing and siding are discontinuous at the lowest horizontal structural member; horizontal separation joints are provided to prevent damage to the sheathing or siding above the lowest floor of the elevated building (see Figure 19). As shown in Figure 19, a watertight seal is provided for separation joints to prevent wind-driven rain and sea spray from entering the building envelope. A similar vertical sealed joint may be needed in front of the piling.
- Utilities, including electrical wiring, switches, outlets, breaker boxes, power meters, plumbing, conduits, and ventilation ducts, are not placed in or attached to breakaway wall panels. Building supply lines and other utility fixtures, such as light switches or electrical outlets, may be attached to the sheltered side of vertical foundation members as allowed by applicable building codes and floodplain management regulations (which generally require that utilities be elevated above the BFE). If utility lines must be routed into or out of an enclosure, one or more of the walls are constructed with a utility blockout (see Figure 14, Figure 15, and Figure 20). Utility lines that pass through the blockout are independent of the walls to avoid being subject to damage if the wall panels break away.
- Breakaway wall panels are positioned such that, on failure, they do not collapse against cross-bracing or threaten other foundation components (see Technical Bulletin 5).

- The configurations of partial-height breakaway wall systems that are not permitted are not used (see Section 11.4 of this Technical Bulletin).
- Wood-framed and steel stud-framed breakaway wall panels may be attached to pilings or other vertical foundation members (i.e., all four sides of the panel may be attached) as accounted for in the design of the wall and foundation elements.
- Masonry units are not attached to floor beams or to vertical foundation members with standard mortars.
- Continuous breakaway wall systems that span or overlap pilings or columns are not used.

11 Breakaway Walls and Other Building Elements

Breakaway walls that form enclosures under elevated buildings can have direct impacts on the other building elements, and some of the elements may impact the performance of breakaway walls.

11.1 Attendant Utilities and Equipment

Attendant utilities and equipment must not be mounted on, pass through, or be located along breakaway walls. This Technical Bulletin describes the proper placement of access holes (blockouts) to allow clear passage of utility piping and wiring to minimize the possibility of impairing the performance of breakaway walls (see Section 8.2 of this Technical Bulletin).

FREE-OF-OBSTRUCTION CONSIDERATIONS

For more information on building elements such as elevator shafts, shear walls, utility chases, and stairwell enclosures, see Technical Bulletin 5.

Only the minimum lighting circuits, switches, receptacles, and similar elements that are required to be installed below the BFE to address life safety and electric code requirements should be installed, but they must not be installed on breakaway walls. These elements should be mounted on the sheltered or landward side of foundation members.

As discussed in Technical Bulletin 5, utility chases designed to protect utility lines from weather are not considered enclosures for floodplain management or NFIP flood insurance purposes. Utility chases must be small and sized such that they do not allow a person to enter the space (access panels for servicing the lines are appropriate). Because a utility chase is not considered an enclosure, it does not have to meet the enclosure requirements (breakaway walls/louvres/open lattice-work in Zone V and flood openings in Zone A). However, the utility chase must still meet the requirement to be constructed of flood damage-resistant materials below the BFE. Additionally, the portions of the utility systems below the BFE and the utility chase must be able to withstand anticipated wind, flood, and debris impact loads (ASCE 7 provides the methodology for flood load calculation) and must not be attached to, be mounted on, pass through, or be located along breakaway walls. Utility lines within the chase must meet all of the NFIP requirements related to proper anchoring, resisting flood loads, and preventing floodwater intrusion and accumulation.

11.2 Equipment (Tanks)

Tanks serving elevated buildings are covered in Technical Bulletin 5. Above-ground tanks must be mounted on a platform supported on a foundation that is anchored to prevent flotation and lateral movement during a base flood event or on a platform that is cantilevered from the building above the BFE. Tanks installed on the ground are obstructions to the free passage of waves and water under elevated buildings. Tanks must not be mounted on breakaway walls. Piping and wires must pass through utility blockouts and must not penetrate through breakaway walls.

11.3 Garage Doors

Garage doors are subject to the NFIP requirements to break away under base flood conditions. Standard residential garage doors may be considered breakaway panels, and flood loads acting on these doors need not be calculated explicitly. Although garage doors have not been tested under wave loads, the I-Codes require the use of doors that are rated for wind loads. Experience has shown that rated doors fail under low wave loading without significantly affecting elevated homes and foundations. Designers must meet all wind load requirements for the building when specifying garage doors. Garage doors and framing may be designed and detailed using the performance-based design method provisions described in Section 10 of this Technical Bulletin. The performance-based design method is required because the garage door frame does not match the layouts in the prescriptive or simplified design method.

11.4 Partial-Height Breakaway Wall Systems

A partial-height breakaway wall is a wall system in which only a portion of a wall panel is designed to break away and a portion above the minimum required elevation is designed to remain in place (see Figure 24). Some configurations of partial-height breakaway walls do not satisfy the NFIP requirements in 44 CFR § 60.3(e)(5) and are therefore not permitted. A partial-height breakaway wall configuration occurs when the bottom of the lowest horizontal structural member of the lowest floor of the building is above the minimum required elevation. In the prohibited configuration shown in Figure 24, a wall panel is split between a section that is above the minimum required elevation (below the lowest horizontal structural member) and is not designed to break away while the other wall panel section is below the minimum required elevation and is designed to break away. Any wall system below the lowest horizontal structural member of the lowest floor must be designed to break away regardless of the minimum required elevation.

When the floor system of an elevated building consists of different floor levels, the structural member for the lowest floor area is considered the lowest horizontal structural member. For example, if a house is constructed in Zone V with Room 1 recessed 18 inches below the rest of the first floor, the lowest horizontal structural member of the lowest floor (Room 1) is used to determine the maximum elevation that the breakaway walls would be required to extend up to (see Figure 25). The configuration shown in Figure 25 is considered allowable.

Figure 24: Prohibited partial-height breakaway wall showing a breakaway portion that extends only up to the minimum required elevation and permanent walls that extend from the top of the breakaway wall up to the lowest horizontal structural member supporting the lowest floor. Example elevations are provided for clarity.

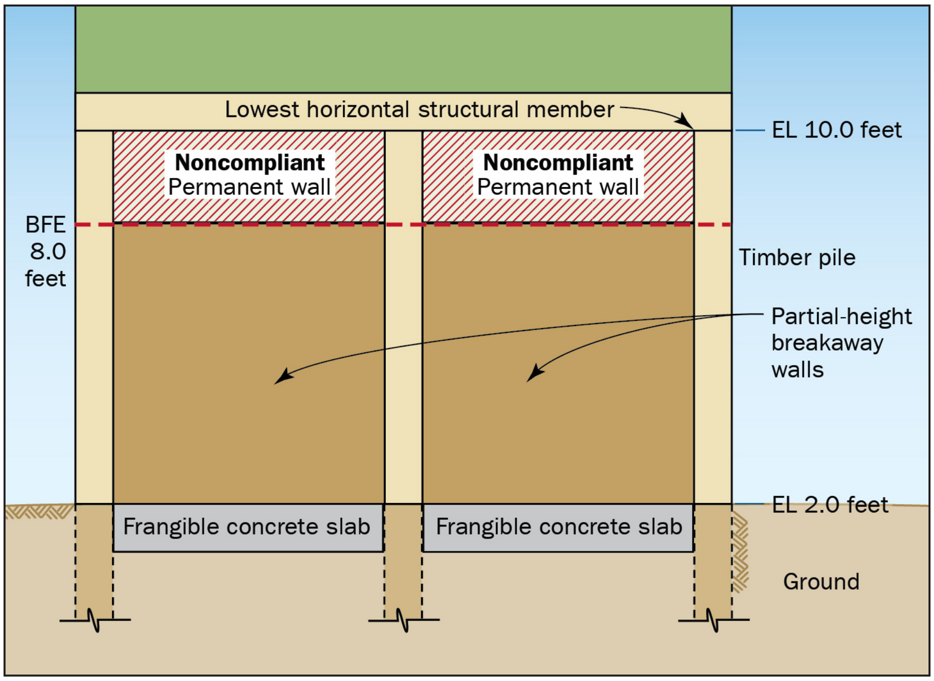
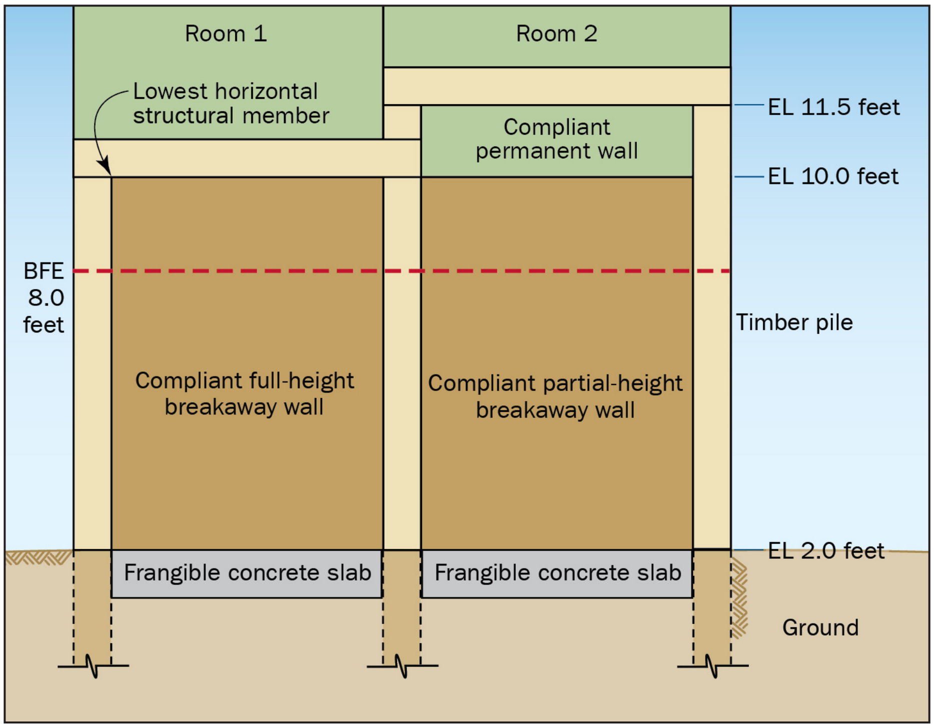


Figure 25: Breakaway walls that extend up to the lowest horizontal structural member of the lowest floor, which are considered full-height breakaway walls. The section of the permanent wall above the right section of a breakaway wall is compliant since the lowest horizontal structural member of the lowest floor for the building is located above the breakaway wall in the left section. Example elevations are provided for clarity.



Breakaway walls are not the only option. The space between the top of the breakaway wall and the lowest horizontal structural member of the lowest floor could be open or covered with open lattice-work or insect screening (see Section 1.1 of this Technical Bulletin). Any wall section that is placed in the area below the lowest horizontal structural member of the lowest floor must break away up to this elevation (see Figure 26). The configuration shown in Figure 26 is an allowable partial-height breakaway wall provided it is designed using the performance-based design method.

Breakaway walls are not required to extend to the ground or parking slab (see Figure 27). Since such a design conflicts with the assumptions in the prescriptive and the simplified design methods, the design requires the performance-based design method and a registered professional engineer or architect to demonstrate compliance with the requirements that are described in this Technical Bulletin.

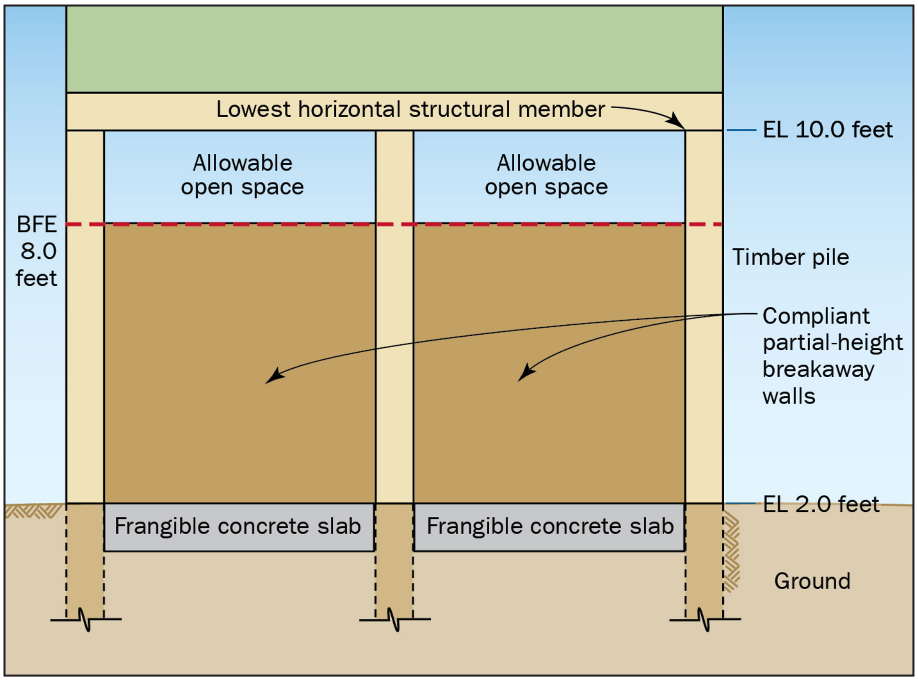
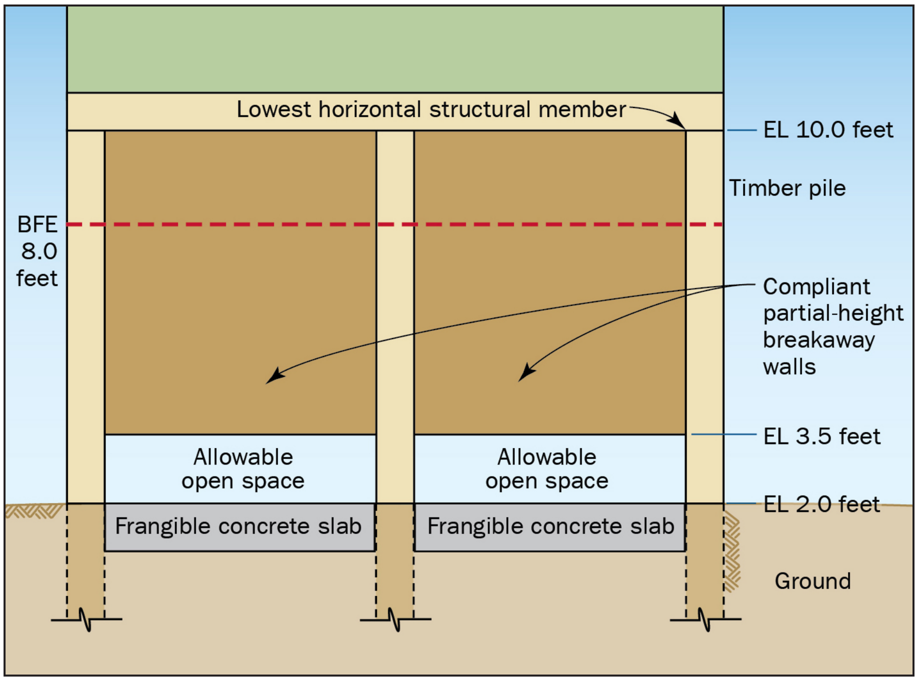


Figure 26: Breakaway walls that do not extend up to the lowest horizontal structural member of the lowest floor, which are allowable if the space between the top of the breakaway wall and the lowest horizontal structural member is open or covered with open lattice-work or insect screening and the performance-based design method is used. Example elevations are provided for clarity.

Figure 27: Breakaway walls that do not extend to the bottom of the ground or parking slab, which are allowable if a registered professional engineer or architect verifies that the breakaway walls will break away during a base flood event and the performance-based design method is used. Example elevations are provided for clarity.



11.5 Firewalls between Townhomes, Rowhomes, and Multi-family Housing

Firewalls are required between townhomes, rowhomes, and multi-family housing units. Mid- and high-rise structures in Coastal High Hazard Areas may be allowed to use shear walls that function as firewalls (see Technical Bulletin 5). For low-rise buildings that require breakaway walls, special considerations in both firewall and breakaway wall requirements must be satisfied. Design professionals should work with local officials and floodplain managers to determine the most appropriate materials and detailing necessary to comply with fire safety requirements and meet the intent of the breakaway wall requirements. When using a gypsum product is necessary, flood damage-resistant non-paper-faced gypsum products that are compliant with NFIP Technical Bulletin 2, *Flood Damage-Resistant Materials Requirements*, should be specified.

The NFIP does not require flood openings in breakaway walls in Zone V. ASCE 24 and some editions of the IRC require flood openings in breakaway walls in Zone V and Coastal A Zones (see Section 3 of this Technical Bulletin). Designers and local officials should determine whether flood opening requirements can be satisfied without flood openings being placed in firewalls (see Technical Bulletin 1) or by using flood opening devices that are designed for fire separation purposes.

11.6 Soffits under Elevated Buildings with Breakaway Walls

Coverings for soffits and the underside of the floor system of elevated buildings can be damaged when waves are reflected up from breakaway walls that have not yet failed. When breakaway walls are subjected to waves, the walls on the side of the building that is closest to the source of flooding typically fail first. The wave energy may be insufficient to cause the breakaway walls on the landward side of the building to fail at the same time. In these situations, water often runs up against the backside breakaway wall and splashes against the soffit covering under the floor system. The water can damage or destroy the soffit covering and saturate the floor system. As a best practice to minimize potential damage, more rigid soffit material should be used, and gaps and joints in the covering material should be sealed. The soffits should be removed after a storm event to allow the floor system to properly dry.

11.7 Exterior Finishes

Exterior finishes such as brick veneer, concrete plank, stucco, and other unreinforced non-load-bearing elements may be attached to breakaway walls if the finishes do not inhibit the breakaway characteristics of the walls, which can be accomplished by connecting the finishes only to the supporting breakaway wall panel and not across joints between the walls and vertical foundation members. Designers should consider that these exterior finishes should be designed/detailed to meet building code requirements for wind and seismic loading. Horizontal separation joints must be used at the top of the breakaway wall sections to minimize damage to the elevated structure when the wall fails under flood loads. The separation joint must ensure that the exterior finish of the elevated building is not damaged or compromised when the breakaway wall fails.

11.8 Interior Finishes

Enclosures below elevated buildings are allowed to be used solely for parking of vehicles, building access, or storage. Installing utility stub-outs (i.e., purposely placed utility access points for future connections) is inconsistent with the NFIP regulations for the allowable uses of an unfinished enclosure. Likewise, enclosures should be unfinished or, if any interior finishes are used, the finishing materials must be flood damage-resistant (see Technical Bulletin 2). Other materials may be used if required to address life safety and fire code requirements.

An exception exists for steel stud-framed breakaway walls when structural performance under wind loads requires continuous lateral bracing of both stud flanges. When using a gypsum product is necessary, flood damage-resistant non-paper-faced gypsum products compliant with Technical Bulletin 2 should be specified.

12 Construction Materials

The NFIP floodplain management regulations require that construction materials used below the BFE be resistant to flood damage. Flood damage-resistant materials are those that are capable of withstanding direct and prolonged contact with floodwater (i.e., at least 72 hours) without sustaining significant damage. Significant damage means damage that requires more than cosmetic repair, which allows for cleaning, sanitizing, and resurfacing. See Technical Bulletin 2.

Unless other materials are required to address life safety and fire code requirements, flood damage-resistant materials must be used for breakaway walls and wall panels, as described in the following subsections. See Section 11.8 of this Technical Bulletin for an exception for interior finishes of steel stud-framed breakaway walls.

12.1 Wood Materials

Materials used in wood-framed breakaway walls must meet the following requirements.

- Standard dimensional lumber can be used because it is considered flood damage-resistant, but lumber is preservative treated or decay resistant (e.g., redwood, cedar, some oaks, bald cypress) if required by building code provisions.
- Exterior siding is exterior grade and no thicker than ½-inch plywood, APA 32/16 rated sheathing, or other equivalent sheathing material.

- Wall studs are no larger than 2x4 inches (nominal dimensions) unless designed using the performance-based design method provisions described in this Technical Bulletin.
- Interior wall sheathing is not used in wood-framed breakaway walls.

12.2 Metal Connectors and Fasteners

Metal connectors and fasteners must be corrosion resistant (see NFIP Technical Bulletin 8, *Corrosion Protection for Metal Connectors and Fasteners in Coastal Areas*).

12.3 Masonry Materials

The following recommendations or requirements apply to materials used for unreinforced masonry materials in breakaway walls using the prescriptive and simplified design methods:

- As indicated in Section 8.3 of this Technical Bulletin, masonry units must be 8-inch nominal units that conform to ASTM C90 with a compressive strength of 2,000 psi.
- Mortar for walls must be Type N conforming to ASTM C270.
- Walls must be unreinforced including not having any horizontal joint reinforcement.
- Walls must be ungrouted cells.
- Any wood-framing materials used with masonry must comply with Section 12.1 of this Technical Bulletin.

12.4 Other Materials

All other materials that may be used to construct breakaway walls must be flood damage-resistant, including:

- Light-gauge steel framing, such as steel studs, must be coated to resist corrosion.
- Stucco, exterior insulation finishing system (EIFS) walls, and other lightweight exterior sheathing material may be applied as long as a separation joint is provided where the material is attached at or near the bottom of the elevated floor beam or joists to avoid damage to the building finish when walls break away (see Figure 19).
- Insulation must be installed with a separation joint at or near the bottom of the elevated floor beam so that it does not hinder performance. Only sprayed polyurethane foam or closed-cell plastic foams are identified as acceptable in Technical Bulletin 2.
- Foam sheathed walls may be designed and used as breakaway walls in accordance with the performance-based design method provisions in Section 10 of this Technical Bulletin.

Materials and products that are not listed in this Technical Bulletin may be used if reviewed and accepted by the local official.

13 Existing Buildings: Repairs, Remodeling, Additions, and Retrofitting

Work that is determined to be Substantial Improvement of an existing building (including additions and repair of substantial damage) must comply with the NFIP regulations for new construction, and the entire structure must be brought into compliance. Work on any building that was constructed in compliance with the NFIP requirements that is determined to not be Substantial Improvement must comply with the requirements in place at the time of construction and must not jeopardize the continued compliance of the building. Therefore, if enclosures are added below compliant Substantially Improved buildings in Zone V, breakaway walls must be used. For more information about the requirements for Substantially Improved and Substantially Damaged buildings, see FEMA P-758, *Substantial Improvement/Substantial Damage Desk Reference* (FEMA, 2010b).

14 Best Practices in Coastal A Zones

Mitigation Assessment Team (MAT) reports published by FEMA after numerous significant flood events have consistently documented that buildings in areas mapped as Zone A and subject to tidal flooding, wave forces, scour, and debris impacts are often severely damaged. The landward boundary of Zone V is where the depth of water can no longer support a 3-foot breaking wave for the base flood. Zone A is mapped inland of Zone V (or the shoreline if there is no Zone V) to the landward boundary of the SFHA.

In the portions of the SFHA that are mapped as Zone A, where the depth of flooding can support wave heights between 3 and 1.5 feet (which only requires approximately 2 feet of water depth), there is more significant wave-related damage than in the areas of the SFHA without waves. NFIP coastal Flood Insurance Studies since 2009 have examined wave conditions in Zone A and mapped an informational layer on the Flood Insurance Rate Map (FIRM) called the Limit of Moderate Wave Action (LiMWA). The LiMWA is delineated on FIRMs to indicate the inland limit of the 1.5-foot breaking wave height during the base flood event.

The term "Coastal A Zone" is used to refer to areas seaward of the LiMWA and landward of the Zone V boundary or landward of the shoreline where Zone V is not identified. Because of the increased risk of erosion, scour, and damage from "moderate" waves in the Coastal A Zone, the I-Codes and referenced standards require higher construction standards within these areas than in the rest of the Zone A (see Section 3 of this Technical Bulletin). However, Coastal A Zones are not labeled on FIRMs, and the NFIP regulations for development in SFHAs and the NFIP regulations that govern the identification of SFHAs on maps do not use the term "Coastal A Zone."

The NFIP floodplain management requirements regulate areas identified as Coastal A Zones to Zone A standards. However, Coastal A Zones are subject to conditions similar to those in Zone V (Coastal High Hazard Areas), including breaking waves, erosion, and scour. Because of the increased risks associated with moderate wave action, FEMA strongly recommends that structures in Coastal A Zones be designed and constructed to meet the requirements that apply in Zone V, including the requirements for breakaway walls. The NFIP Community Rating System awards credits to communities that regulate Coastal A Zones to Zone V standards. Figure 28 shows a home in

Figure 28: Home elevated above the BFE in Zone AE showing successful failure of breakaway walls.

Zone AE that was elevated above the BFE, and the breakaway walls failed as intended without damaging the elevated structure.

Because the Coastal A Zone is designated Zone A on FIRMs, the NFIP regulations (and I-Codes) require that flood openings be provided in walls surrounding enclosures below elevated buildings (see Technical Bulletin 1). Breakaway walls in Coastal A Zones must have flood openings that allow for the automatic entry and exit of floodwater to minimize damage caused by hydrostatic loads. Openings also function to minimize damage during flooding that is shallower than base flood events or if anticipated wave loading does not occur with the base flood.

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Reasonably Safe from Flooding Requirement for Building on Filled Land

Removed From the Special Flood Hazard Area

in Accordance with the National Flood Insurance Program

NFIP Technical Bulletin 10 / March 2023

FEMA

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Comments on the Technical Bulletins should be directed to:

Department of Homeland Security / Federal Emergency Management Agency
Federal Insurance and Mitigation Administration (FIMA) Risk Management Directorate
Building Science Branch
400 C Street, S.W., Sixth Floor
Washington, DC 20472-3020

NFIP Technical Bulletin 10 (2023) replaces NFIP Technical Bulletin 10, *Ensuring That Structures Built on Fill In or Near Special Flood Hazard Areas Are Reasonably Safe From Flooding* (2001).

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Cover photo: New development elevated on fill and removed from the floodplain through a Letter of Map Revision based on Fill, Oak Creek, WI. Credit: Korndoerfer Homes

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Acronyms

ASCE	American Society of Civil Engineers
ASTM	ASTM International
BFE	base flood elevation
CFR	Code of Federal Regulations
CLOMR-F	Conditional Letter of Map Revision Based on Fill
DHS	Department of Homeland Security
ESA	Endangered Species Act
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
IBC®	International Building Code®
ICC®	International Code Council®
I-Codes®	International Codes®
IEBC®	International Existing Building Code®
IRC®	International Residential Code®
LiMWA	Limit of Moderate Wave Action
LOMR	Letter of Map Revision
LOMR-F	Letter of Map Revision Based on Fill
NFIP	National Flood Insurance Program
SFHA	Special Flood Hazard Area

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1. Introduction

This Technical Bulletin provides guidance on the National Flood Insurance Program (NFIP) requirements related to determining that buildings constructed on fill will be reasonably safe from flooding during the occurrence of the base flood. Guidance is provided for the placement of fill and the parameters for the design and construction of buildings on filled land that has been removed from the Special Flood Hazard Area (SFHA) through the flood map revision process managed by the Federal Emergency Management Agency (FEMA). The SFHA is identified as Zone A (A, AE, A1-30, AH, AO, A99, and AR) and Zone V (V, VE, V1-30, and VO) on a community's Flood Insurance Rate Map (FIRM) prepared by FEMA. When permitted under applicable federal, state, and local laws, ordinances, and regulations, earthen fill is sometimes placed to reduce flood risk to structures located in Zone A. In Zone V, fill for the purpose of elevating buildings is not permitted, and use of fill for other purposes is limited because fill may obstruct the flow of floodwater and divert waves.

Under certain conditions, when structural fill (also called engineered fill) is placed to raise the surface of the ground to or above the base flood elevation (BFE), property owners and developers may submit requests to FEMA to revise FIRMs to remove filled land from the SFHA (see Figure 1). When a revision is warranted, after reviewing an application, FEMA may revise a FIRM by issuing a Letter of Map Revision Based on Fill (LOMR-F). The NFIP requirements include, as part of the LOMR-F application, that written assurance from the participating community include a determination that the site (filled area) and any existing, proposed or future development (buildings and structures on the filled land) to be removed from the SFHA are or will be "reasonably safe from flooding" as defined in Title 44 of the Code of Federal Regulations (CFR) Part 65, Identification and Mapping of Special Flood Hazard Areas (see Section 2 of this Technical Bulletin).

NFIP Technical Bulletin 0

NFIP Technical Bulletin 0, *User's Guide to Technical Bulletins*, should be used as a reference with this Technical Bulletin. Technical Bulletin 0 describes the purpose and use of the Technical Bulletins. It includes common concepts and terms, lists useful resources, and includes a crosswalk of the NFIP regulations by section and the applicable Technical Bulletin, as well as a subject index.

Readers are cautioned that the definitions of some of the terms that are used in the Technical Bulletins are not the same when used by the NFIP for the purpose of rating flood insurance policies.

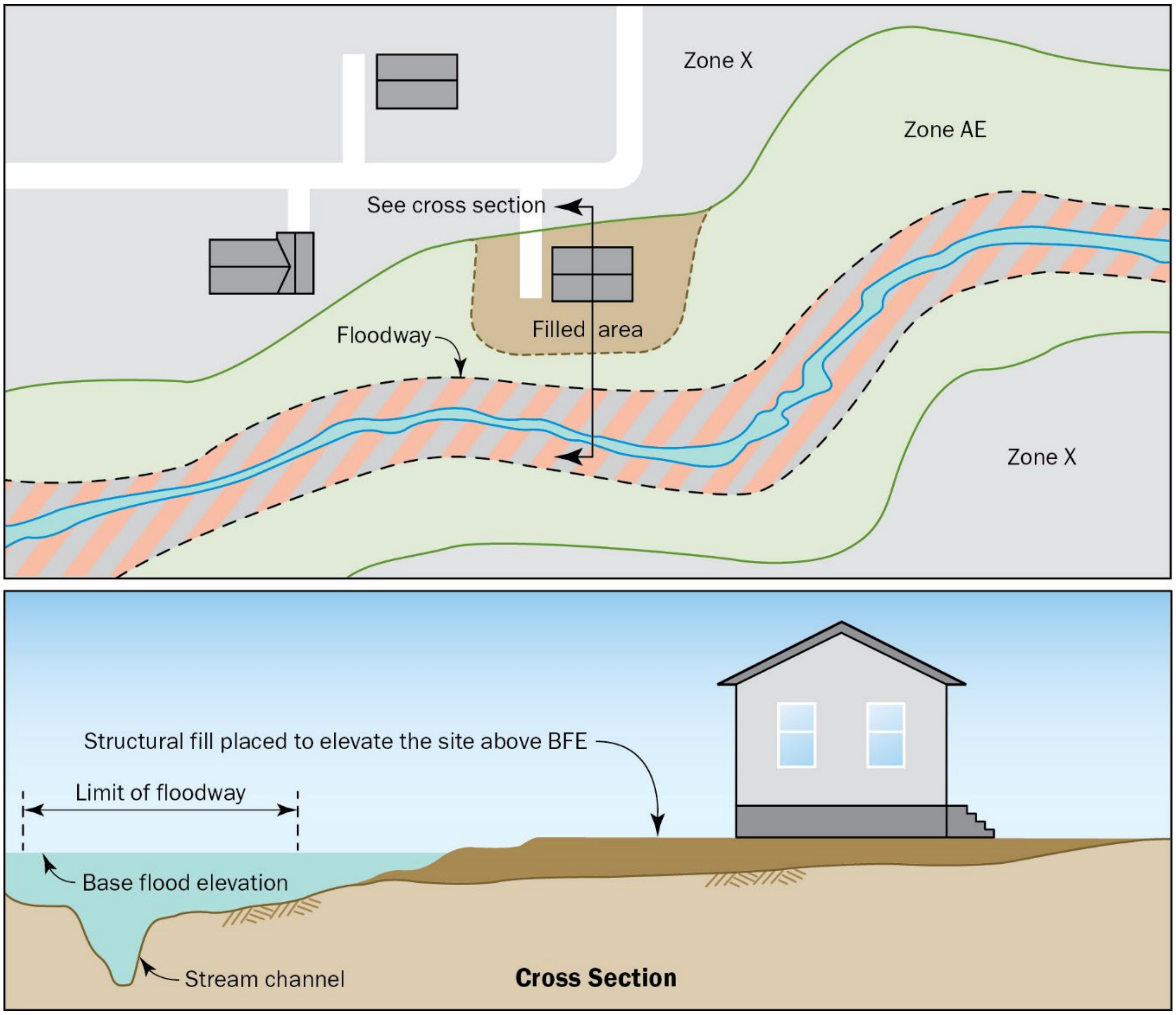

Figure 1: Building on site elevated by fill

1.1. History and Update of Technical Bulletin 10

In 2001, FEMA revised the NFIP regulations and the Letter of Map Revision (LOMR) and LOMR-F procedures, including the addition of the reasonably safe from flooding requirements to address concerns regarding the inconsistent and potentially hazardous practice of constructing on land removed from the SFHA. The additional requirements emphasized the long-standing requirement that NFIP communities must review all permit applications to determine whether proposed building sites will be reasonably safe from flooding [44 CFR 60.3(a)(3)]. FEMA issued the first edition of this Technical Bulletin in 2001 to provide guidance on how to make the determination that an area is reasonably safe from flooding. This updated Technical Bulletin reorganizes and clarifies the previous guidance but does not change any requirements or design approaches.

1.2. Letter of Map Revision Based on Fill

When fill has been placed **and a property owner wishes to have a structure or property removed from the SFHA**, the owner must submit a map revision request to FEMA for consideration. When fill is proposed but not yet placed, a Conditional Letter of Map Revision Based on Fill (CLOMR-F) can be requested from FEMA. A CLOMR-F is used to request FEMA's comments on a proposed project; it does not revise a FIRM and is not a permit or approval to perform the proposed filling. When FEMA approves a CLOMR-F, a subsequent as-built LOMR-F must be requested after construction before FEMA will officially revise the FIRM to remove the land from the SFHA. The FEMA MT-1 application is used to support a request for a LOMR-F or CLOMR-F. The application includes a Property Information Form (Form 1), Elevation Form (Form 2), and Community Acknowledgement Form (Form 3). By signing the Community Acknowledgement Form, the local official responsible for floodplain management in the community is acknowledging that they have reviewed the LOMR-F request and asserting that the project is reasonably safe from flooding. Additional guidance on the MT-1 application and supporting documentation to make this assertion is provided in this Technical Bulletin.

Performing Work After a CLOMR-F

If the scope of an as-built LOMR-F follow up to an approved CLOMR-F differs from the approved CLOMR-F, the LOMR-F application may be reviewed as a brand new application and may not result in an approval. Additionally, if the review determines that the as-built project is in violation of the floodplain management regulations, a potential violation memorandum may be issued by FEMA to the community.

1.3. Residual Risks

Constructing a building to the minimum NFIP requirements—or constructing a building on land adjacent to the SFHA—is no guarantee the building will be undamaged by flooding. To make informed decisions during planning, siting, and design of buildings, owners, design professionals, and local officials should understand the following:

- FIRMs are based on modeling of the best available topographic, hydrologic, hydraulic, and climate conditions data at the time of the Flood Insurance Study (FIS). There are inherent uncertainties in the modeling and analyses of BFEs and delineation of flood hazard zones. Some FIRMs, particularly older FIRMs, may no longer reasonably reflect the land characteristics and actual flood risk during base flood events. Current effective FIRMs do not convey the potential impacts of future conditions.

- Floods can and do exceed the BFE and can extend beyond the SFHA delineated on FIRMs. During notable flood events such as Hurricane Sandy in 2012, riverine flooding in Louisiana in 2017, and Hurricane Michael in 2018, flood elevations exceeded the BFEs by several feet in some areas and extended far beyond the SFHAs shown on the effective FIRMs.

- NFIP flood insurance premiums based on current flood modeling data and methodologies may change in the future if revised or newly acquired flood data indicate different flood risk.

Residual Risks

Residual risks associated with flooding may exist in areas elevated above the BFE by the placement of structural fill. Residual risks in these areas include subsurface flooding caused by saturated soils and surface flooding that exceeds base flood conditions.

Areas adjacent to SFHAs may have residual risks of flood damage like areas removed from SFHAs by the placement of fill. The guidance in Sections 8 and 9 of this Technical Bulletin should also be used when buildings with basements are constructed in areas adjacent to SFHAs.

1.4. Guidance in Technical Bulletin 10

This Technical Bulletin includes guidance on:

- NFIP regulations related to determining that buildings constructed on fill will be reasonably safe from flooding during the occurrence of the base flood (see Section 2 of this Technical Bulletin).
- Building codes and standards provisions related to the placement of fill in SFHAs (see Section 3 of this Technical Bulletin).
- NFIP flood insurance for buildings on land removed from SFHAs through the LOMR-F process (see Section 4 of this Technical Bulletin).
- Documentation and certification requirements to determine that buildings constructed on fill are reasonably safe from flooding (see Section 5 of this Technical Bulletin).
- Best practices for administrative procedures and more restrictive, higher regulatory standards (see Section 6 of this Technical Bulletin).
- Proper design and placement of fill (see Section 7 of this Technical Bulletin).
- Several types of foundations that are used for buildings on fill and the residual risk associated with non-basement foundations (see Section 8.1 of this Technical Bulletin) and basement foundations (see Section 8.2 of this Technical Bulletin).

Technical approaches to analyzing seepage into basements constructed into fill to satisfy the requirement that buildings on fill with basements are reasonably safe from flooding (see Section 9 of this Technical Bulletin).

Best Practice: Avoid Basements Below BFE

In some parts of the country, basements are a standard construction feature. Some owners may wish to construct basements into filled land after the site is removed from the SFHA. Buildings with basements have a higher risk of damage caused by subsurface flooding compared to buildings built on foundations that do not have below-grade areas. As a best practice to minimize risk of future flooding during base flood conditions, FEMA recommends that buildings constructed on land officially removed from SFHAs by issuance of LOMR-Fs be designed with the lowest floor (including basement) at or above the elevation of the BFE associated with the adjacent SFHA. Any basement with the lowest floor below the elevation of the BFE associated with the adjacent SFHA should only be used for parking of vehicles, building access, or storage, and not as living space.

This Technical Bulletin **does not apply** to situations in which other requirements or restrictions apply, including the following:

- Construction and filling in floodways with an increase in flood levels. The NFIP regulations prohibit encroachments in floodways that would result in an increase in flood levels [44 CFR § 60.3(d)(3)]. The LOMR-F process (MT-1) cannot be used for requests involving property and/or structures that have been elevated by fill placed within the regulatory floodway [44 CFR § 65.5(a)]. All Letter of Map Change requests involving the placement of fill in floodways must go through the CLOMR and LOMR processes using the MT-2 application [44 CFR § 65.7].

  This Technical Bulletin applies to proposed fill or grading in the floodway, and the CLOMR application review determines that the proposed encroachment will not result in any increase in flood levels. The community must ensure that the fill and any structures built or proposed in the filled area will be reasonably safe from flooding [44 CFR § 65.6(a)(14)].

- Construction in Coastal High Hazard Areas (Zone V). The NFIP regulations prohibit the use of structural fill for support of buildings in Coastal High Hazard Areas [44 CFR § 60.3(e)(6)]. While nonstructural fill for landscaping and drainage may be placed in Zone V, fill for those purposes does not qualify for a map revision. The LOMR-F process is not used to determine the acceptability of the placement of fill in Zone V [44 CFR § 65.5(a)].

- Construction in SFHAs subject to alluvial fan flooding, which are typically designated on FIRMs as Zone AO with depths and velocities [44 CFR § 65.13(b)]. Elevating a parcel of land or a structure by fill or other means will not serve as a basis for removing areas subject to alluvial fan flooding from the SFHA. Revision requests involving alluvial fans will only be considered through the LOMR (MT-2) process if a structural flood control measure is designed and/or constructed to provide protection against the base flood in compliance with 44 CFR § 65.13.

- Placement of fill around an existing residential or non-residential building where the lowest floor is below the BFE with the intent of changing the lowest adjacent grade to remove the building from the SFHA.
- Analysis of an existing residential or non-residential building with a basement that has its lowest floor below the BFE with the intent of using the analysis to determine that a building is "reasonably safe from flooding" in order to obtain a LOMR-F. Basements excavated into fill with the basement floor below the BFE are prohibited unless the land has been removed from the SFHA through the LOMR-F process prior to construction or the building is in an approved basement exception community.[1] In addition, post-construction testing to confirm geotechnical conditions beneath the building would likely involve testing that is destructive to the building.

Questions about requirements for placement of fill in SFHAs and LOMR-Fs should be directed to the appropriate local official, NFIP State Coordinating Office, or FEMA Regional Office.

Terms Used in This Technical Bulletin

Basement: "Any area of a building having its floor subgrade (below ground level) on all sides" (44 CFR § 59.1). The NFIP regulations do not allow basements to extend below the base flood elevation (BFE) except in dry-floodproofed, non-residential buildings.

Fill or earthen fill: Material from any source, such as soil, gravel, or crushed stone, that is placed to increase or raise ground elevations to or above the BFE.

Conditional Letter of Map Revision Based on Fill (CLOMR-F): An official letter issued by FEMA stating that a parcel of land or proposed structure that will be elevated by fill would not be inundated by the base flood if the fill is placed on the parcel as proposed or the structure is built as proposed. A CLOMR-F provides comment on the proposed plan and does not revise or amend the Flood Insurance Rate Map (FIRM).

Development: "Any manmade change to improved or unimproved real estate, including but not limited to buildings or other structures, mining, dredging, filling, grading, paving, excavation or drilling operation or storage of equipment or materials" (44 CFR § 59.1).

Existing (Non NFIP definition): As used in this Technical Bulletin, existing building or existing fill refers to buildings or fill where construction or placement occurred prior to the date of the preparation of LOMR-F or LOMR application.

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[1] Approximately 50 NFIP communities have obtained an exception from FEMA to allow residential buildings with floodproofed basements below the BFE (https://www.fema.gov/floodplain-management/manage-risk/residential-buildings-basements). This Technical Bulletin does not address the dry floodproofing requirements for basements in excepted communities [44 CFR § 60.6(b) or (c)].

Terms Used in This Technical Bulletin (continued)

Land removed from SFHA by placement of fill: Land that has been elevated by fill where an official determination (LOMR-F) has been issued by FEMA that the parcel of land will not be inundated by the base flood and the site or parcel is subsequently designated as being outside the SFHA.

Letter of Map Revision Based on Fill (LOMR-F): An official determination (letter) issued by FEMA stating that an existing structure or parcel of land that has been elevated by fill would not be inundated by the base flood. A LOMR-F revises the FIRM by designating filled land as being removed from the SFHA.

Reasonably safe from flooding: "Base flood waters will not inundate the land or damage structures to be removed from the SFHA and any subsurface waters related to the base flood will not damage existing or proposed buildings or structures" [44 CFR § 65.2(c)].

Special Flood Hazard Area (SFHA): Area subject to flooding by the base flood (1-%-annual-chance flood) and shown on FIRMs as Zones A or V.

Structural fill or engineered fill: Fill placed and compacted to a specified density to provide structural support or protection for buildings and structures as authorized by local officials.

Zone A: Flood zones shown on FIRMs as Zone A, AE, A1-30, AH, AO, A99, and AR.

Zone V: Flood zones shown on FIRMs as Zone V, VE, V1-30, and VO; also known as the Coastal High Hazard Area.

Other terms in this Technical Bulletin are defined in a glossary in Technical Bulletin 0.

2. National Flood Insurance Program Regulations

An important NFIP objective is protecting buildings constructed in SFHAs from damage caused by flooding. The SFHA is the land area subject to flooding by the base flood. SFHAs are shown on FIRMs prepared by FEMA as Zones A and V. The base flood is the flood that has a 1 % chance of being equaled or exceeded in any given year (commonly called the "100-year" flood). The NFIP floodplain management regulations include minimum building design criteria that apply to:

- New construction
- Work determined to be substantial improvements, including improvements, alterations, and additions
- Repair of buildings determined to have incurred substantial damage

The NFIP regulations for development in SFHAs, including filling, grading, excavation, and buildings and structures, are codified in 44 CFR Part 60, Criteria for Land Management and Use.

Section 59.1 defines “development” to mean (emphasis added):

> *… any manmade change to improved or unimproved real estate, including but not limited to **buildings or other structures**, mining, dredging, **filling**, **grading**, paving, **excavation** or drilling operation or storage of equipment or materials.*

The NFIP regulations for identification and mapping of SFHAs are set forth in 44 CFR Part 65, Identification and Mapping of Special Hazard Areas. Specific to revisions to SFHAs in accordance with the FEMA map revision process, Section 65.2(c) defines “reasonably safe from flooding” to mean:

> *… base flood waters will not inundate the land or damage structures to be removed from the SFHA and that any subsurface waters related to the base flood will not damage existing or proposed buildings.*

Section 60.3(a)(3) states that a community shall (emphasis added):

> *Review **all permit applications** to determine whether the proposed building sites will be **reasonably safe from flooding**. If a proposed building site is in a flood-prone area, all new construction and substantial improvements shall … [meet specific listed performance requirements]*

Section 60.3(a)(4) states that a community shall (emphasis added):

> *Review subdivision proposals and other proposed new development, including manufactured home parks or subdivisions, to determine whether such proposals will be **reasonably safe from flooding**.*

When property owners submit requests to FEMA for map revisions that involve topographic changes by placement of engineered earthen fill (structural fill) but that do not change BFEs, Section 65.5(a)(4)(ii) requires that the request include written assurance from the community that they have (emphasis added):

> *… determined that the land and any existing or proposed structures removed from the SFHA are **“reasonably safe from flooding,”** and that they have on file, available upon request by FEMA, all supporting analyses and documentation used to make that determination.*

When property owners submit requests to FEMA for map revisions, including those that involve the placement of fill in floodways, that result in changes to BFEs, Section 65.6(a)(14)(ii) requires that the request include written assurance from the community that they have (emphasis added):

> *… determined that the land and any existing or proposed structures to be removed from the SFHA are **“reasonably safe from flooding,”** and that they have on file, available upon request by FEMA, all supporting analyses and documentation used to make that determination.*

When a regulatory floodway has not been identified, communities must review permit applications to evaluate cumulative effects of proposed development as specified in Section 60.3(c)(10):

> *Require until a regulatory floodway is designated, that no new construction, substantial improvements, or other development (including fill) shall be permitted within Zones A1-30 and AE on the community's FIRM, unless it is demonstrated that the cumulative effect of the proposed development, when combined with all other existing and anticipated development, will not increase the water surface elevation of the base flood more than one foot at any point within the community.*

NFIP Requirements and More Restrictive Regulatory Standards

Federal, State, and Local Requirements. Federal, state, or local requirements that are more restrictive or stringent than the minimum requirements of the NFIP take precedence. The Technical Bulletins and other FEMA publications provide guidance on the minimum requirements of the NFIP and describe best practices. Design professionals, builders, and property owners should contact local officials to determine whether more restrictive provisions apply to buildings or sites in question. All other applicable requirements of state or local building codes must also be met for buildings in flood hazard areas.

Substantial Improvement and Substantial Damage. As part of issuing permits, local officials must review not only proposals for new construction but also for work on existing and legal non-conforming buildings to determine whether the work constitutes substantial improvement or repair of substantial damage. If the work is determined to constitute substantial improvement or repair of substantial damage, the buildings must be brought into compliance with NFIP requirements for new construction. Some communities modify the definitions of substantial improvement and/or substantial damage to be more restrictive than the NFIP minimum requirements. For more information on substantial improvement and substantial damage, see FEMA P-758, *Substantial Improvement/Substantial Damage Desk Reference* (2010), and FEMA 213, *Answers to Questions About Substantially Improved/Substantially Damaged Buildings* (2018).

Elevation Above Minimum NFIP Requirements. Some states and communities require that buildings be elevated above the NFIP minimum requirement. The additional elevation is called freeboard. Design professionals, builders, and property owners should check with local officials to determine whether a community has freeboard requirements. References to building elevations in this Technical Bulletin should be construed as references to the community's elevation requirement where freeboard is required.

3. Building Codes and Standards

In addition to complying with NFIP requirements, all new construction, substantial improvements, and repair of substantial damage must comply with applicable building codes and standards that are adopted and enforced by states and communities.

The International Codes® (I-Codes®), published by the International Code Council® (ICC®), are a family of codes that includes the International Residential Code® (IRC®), International Building Code® (IBC®), International Existing Building Code® (IEBC®), and codes that govern the installation of mechanical, plumbing, fuel gas, and other aspects of building construction. FEMA has deemed that the latest published editions of the I-Codes generally meet or exceed NFIP requirements for buildings and structures. Excerpts of the flood provisions of the I-Codes are available on the FEMA Building Code webpage at https://www.fema.gov/emergency-managers/risk-management/building-science/building-codes.

3.1. International Residential Code

The International Residential Code (IRC) applies to one- and two-family dwellings and townhomes not more than three stories above grade plane.

International Residential Code Commentary

The ICC publishes companion commentary for the IRC. Although not regulatory, the commentary provides guidance that is useful in complying with, interpreting, and enforcing the requirements of the code.

Table 1 summarizes the 2021 IRC requirements related to fill in flood hazard areas, notes changes from the 2015 and 2018 editions, and compares the IRC provisions to the NFIP requirements. Subsequent editions of the IRC should include comparable requirements.

Table 1: Comparison of Selected 2021 IRC Requirements with NFIP Requirements

Topic	Summary of Selected 2021 IRC Requirements and Changes from 2015 and 2018 Editions	Comparison with NFIP Requirements
Fill supporting foundations and nonstructural fill (Zone V and Coastal A Zones)	**Section R322.3.2 [Coastal high-hazard areas (including V Zones and Coastal A Zones, where designated)] Elevation requirements.** Prohibits the use of fill for structural support. Allows minor quantities of nonstructural fill for grading, landscaping, drainage, and to support parking slabs, pool decks, patios, and walkways. Change from 2018 to 2021: No change. Change from 2015 to 2018: No change.	Equivalent to NFIP 44 CFR § 60.3(e)(6) in Zone V and exceeds NFIP by prohibiting structural fill in Coastal A Zones. More specific than NFIP by specifying allowed uses of nonstructural fill.

Topic	Summary of Selected 2021 IRC Requirements and Changes from 2015 and 2018 Editions	Comparison with NFIP Requirements
Fill supporting foundations (in and out of FHA)	**Section R401.2 [Foundations] Requirements.** Requires fill soils supporting foundations to be designed, installed, and tested in accordance with accepted engineering practice. **Section R506.2.1 [Concrete Floors (on Ground)] Fill.** Requires fill material to be free of vegetation and foreign material and compacted to ensure support of slabs. Unless otherwise approved, specific maximum fill depths apply. <u>Change from 2018 to 2021</u>: No change. <u>Change from 2015 to 2018</u>: No change.	Equivalent to NFIP 44 CFR § 60.3(a)(3)(i) requirements for stability, with specific requirements for design, placement, content, and compaction of fill.
Site drainage (in and out of FHA)	**Section R401.3 [Foundations] Drainage.** Requires surface drainage to be diverted away from foundation walls to a collection point and specifies a minimum grade of 6 inches of fall within the first 10 feet, with exceptions. <u>Change from 2018 to 2021</u>: No change. <u>Change from 2015 to 2018</u>: No change.	Exceeds NFIP 44 CFR § 60.3(c)(11) by requiring drainage away from all dwellings, instead of only those in Zone AO and Zone AH, and by specifying minimum slopes for drainage.
Foundations (in and out of FHA)	**Section R404 Foundations and Retaining Walls.** Requires concrete and masonry foundation walls to be designed in accordance with accepted engineering practice where walls are subject to hydrostatic pressure from groundwater or where walls supporting more than 48 inches of unbalanced backfill do not have permanent lateral support. Foundation requirements are based on height of unbalanced backfill. **Section R405 Foundation Drainage.** Specifies requirements for foundation drainage for foundations that enclose habitable or usable space located below grade based on foundation material. **Section R406 Foundation Waterproofing and Dampproofing.** Specifies requirements for waterproofing and dampproofing of interior spaces and floors below grade based on foundation material. <u>Change from 2018 to 2021</u>: Requirements in Section R404 based on maximum unsupported wall height rather than maximum wall height. <u>Change from 2015 to 2018</u>: No significant changes.	Equivalent to NFIP 44 CFR § 60.3(a)(3)(i) requirements for stability, with specific requirements for foundation design. Equivalent to 44 CFR § 60.3(a)(3)(iii) with specific requirements for drainage and waterproofing.

3.2. International Building Code and ASCE 24

The International Building Code (IBC) applies to all applicable buildings and structures. While used primarily for buildings and structures other than dwellings within the scope of the IRC, the IBC may also be used to design dwellings.

The flood provisions of the latest published editions of the IBC generally meet or exceed NFIP requirements for buildings through reference to the standard ASCE 24, *Flood Resistant Design and Construction*. ASCE 24 is developed by the American Society of Civil Engineers (ASCE) and applies to structures that are subject to building code requirements.

International Building Code and ASCE 24 Commentaries

The ICC publishes companion commentary for the IBC, and ASCE publishes companion commentary for ASCE 24. Although not regulatory, the commentaries provide information and guidance that are useful in complying with, interpreting, and enforcing requirements of the code.

Table 2 summarizes the 2021 IBC and ASCE 24-14 requirements related to fill in flood hazard areas, notes changes from 2015 and 2018 IBC editions, and compares those provisions to the NFIP requirements. Subsequent editions of the IBC and ASCE 24 should include comparable requirements.

Table 2: Comparison of Selected 2021 IBC and ASCE 24-14 Requirements with NFIP Requirements

Topic	Summary of Selected 2021 IBC / ASCE 24-14 Requirements and Changes from 2015 and 2018 IBC	Comparison with NFIP Requirements
Testing of site soils and fill (in and out of FHA)	**IBC Section 1705.6 [Required Special Inspections and Tests] Soils.** Requires special inspections and tests of existing site soil conditions, fill placement, and load-bearing requirements, including continuous inspection of fill density and lift thickness during fill placement. Change from 2018 to 2021 IBC: Added specificity to fill inspection. Change from 2015 to 2018 IBC: No change.	Exceeds NFIP by requiring inspections and testing during placement of fill.

Topic	Summary of Selected 2021 IBC / ASCE 24-14 Requirements and Changes from 2015 and 2018 IBC	Comparison with NFIP Requirements
Soils and foundations (in and out of FHA)	**IBC Chapter 18 Soils and Foundations.** Specifies requirements for geotechnical investigations (Sec. 1803); excavation, grading, and fill (Sec. 1804); dampproofing and waterproofing (Sec. 1805); and unsupported height of backfilled foundation walls (Sec. 1807). Change from 2018 to 2021 IBC: No significant changes. Change from 2015 to 2018 IBC: See "Site grading" in this table.	Equivalent to NFIP 44 CFR § 60.3(a)(3)(i) requirements for stability, with specific requirements for foundation design. Equivalent to NFIP 44 CFR § 60.3(a)(3)(iii) with specific requirements for drainage and waterproofing.
Site grading (in and out of FHA)	**IBC Section 1804.4 [Excavation, Grading and Fill] Site grading.** Requires ground to be sloped away from foundations at a minimum 5% slope, with exceptions. Change from 2018 to 2021 IBC: No change. Change from 2015 to 2018 IBC: Added exception for certain door landings and ramps.	Exceeds NFIP 44 CFR § 60.3(c)(11) by requiring drainage away from all buildings, instead of only those in Zone AO and Zone AH, and by specifying minimum slopes for drainage.
Fill (in FHA)	**IBC Section 1804.5 [Excavation, Grading and Fill] Grading and fill in flood hazard areas.** Requires fill to be placed, compacted, and sloped to minimize shifting, slumping, and erosion during the rise and fall of floodwater and, as applicable, wave action. Prohibits fill in floodways unless analysis shows the fill will not cause any increase in flood levels. Prohibits fill in coastal high hazard areas unless fill is placed to avoid diverting water and waves toward buildings. [See "Fill in Zone V and Coastal A Zones" in this table] Change from 2018 to 2021 IBC: No change. Change from 2015 to 2018 IBC: No change.	Equivalent to NFIP 44 CFR § 60.3(a)(3)(i) with more specific requirements for performance under flood conditions. Equivalent to NFIP 44 CFR § 60.3(c)(10) and § 60.3(d)(3) floodway encroachment requirements. Equivalent to NFIP 44 CFR § 60.3(e)(6) prohibiting structural fill in Zone V.

Topic	Summary of Selected 2021 IBC / ASCE 24-14 Requirements and Changes from 2015 and 2018 IBC	Comparison with NFIP Requirements
Definition of fill	**ASCE 24 Section 1.2 Definitions.** Defines fill as "material such as soil, gravel, or crushed stone that is placed in an area to increase ground elevations." Defines structural fill as "fill placed and compacted to a specified density to provide structural support or protection to a structure."	Exceeds NFIP 44 CFR § 59.1 by defining fill and structural fill.
Geotechnical considerations and stability of fill (in all FHA)	**ASCE 24 Section 1.5.3.1 Geotechnical Considerations.** Requires foundation designs to be based on geotechnical characteristics of the soils and strata below the structure. **ASCE 24 Section 1.5.4 Use of Fill.** Requires fill to be stable under flood conditions, including rapid rise and rapid drawdown of floodwaters, prolonged inundation, and flood-related erosion and scour.	Equivalent to NFIP 44 CFR § 60.3(a)(3)(i) requirements for stability, with more specific requirements for performance under flood conditions.
Fill in floodways	**ASCE 24 Section 2.2 Development in Floodways.** Prohibits fill in floodways unless analysis shows the fill will not cause any increase in flood levels.	Equivalent to NFIP 44 CFR § 60.3(d)(3) and § 60.3(c)(10) floodway encroachment requirements.
Fill in Zone A	**ASCE 24 Section 2.4.1 Structural Fill.** In flood hazard areas other than Coastal High Hazard Areas and Coastal A Zones (i.e., in Zone A), permits structural fill if designed to account for soil consolidation and settlement, slope stability, and erosion control. Specifies maximum 12-inch lifts, compaction densities, and maximum side slope ratio of 1:1.5.	Equivalent to NFIP 44 CFR § 60.3(a)(3)(i) requirements for stability, with specific requirements for design, placement, content, and compaction of fill.
Fill in Zone V and Coastal A Zones	**ASCE 24 Section 4.5.4 Use of Fill.** Prohibits structural fill in Coastal High Hazard Areas and Coastal A Zones. Allows nonstructural fill for minimal site grading, landscaping, local drainage, and limited dune construction/reconstruction.	Equivalent to NFIP 44 CFR § 60.3(e)(6) in Zone V and exceeds by requiring prohibition in Coastal A Zones. More specific than NFIP by specifying allowed uses of nonstructural fill.

4. NFIP Flood Insurance Implications

NFIP flood insurance coverage is available for all eligible buildings in participating communities, including buildings located outside the SFHA. NFIP flood insurance rates are based on several flood risk factors, such as distance and elevation relative to flooding sources, first floor height above grade, building occupancy (residential, non-residential, other residential), foundation type, number of floors, and whether a basement or enclosure is below elevated buildings. In general, buildings with basements will have a higher premium due to an increase in risk than buildings on other foundation types if all other rating variables are the same.

The purchase of flood insurance is mandatory for federally backed mortgages on buildings in SFHAs in NFIP participating communities. The mandatory purchase requirement does not apply after FEMA officially removes filled land from the SFHA through the LOMR-F process. However, removal of filled land from the SFHA does not mean all risk of flooding is eliminated. Historically, approximately 25% of all claims paid by the NFIP have been for buildings located outside the SFHA. It is the lending institution’s prerogative to require flood insurance as a condition of a loan if it deems such action appropriate. FEMA encourages property owners and tenants to purchase flood insurance even when not required by mortgage lenders.

Designers, builders, and owners may wish to contact a qualified insurance agent or carrier with flood insurance experience for more information about policy coverage, coverage limits, and premium costs.

5. Documentation and Certification Requirements

Communities that participate in the NFIP are required to make a determination that applications for development in SFHAs comply with local floodplain management regulations. Permit applicants submit site plans, building plans, required documentation, analyses, and certifications. Local officials are responsible for reviewing applications for compliance.

To request a LOMR-F or CLOMR-F, permit applicants must prepare the MT-1 application forms, which help applicants gather the information that FEMA needs to determine whether the land or structures are likely to be flooded during a base flood event. The MT-1 application forms include a Community Acknowledgement Form to be signed by the local official responsible for floodplain management (Section 5.1 of this Technical Bulletin). To support the application review, local officials typically require permit applicants to submit supporting documentation, including a signed statement or certificate that the filled land and existing or proposed structures are or will be reasonably safe from flooding (Section 5.2 of this Technical Bulletin). At minimum, permit applicants must submit professionally certified elevation information (Section 5.3 of this Technical Bulletin).

Only FEMA can revise or amend FIRMs by issuing Letters of Map Change, including LOMR-Fs. Although a local official may conclude that a proposal to fill land is reasonably safe from flooding, the filled area must continue to be regulated as an SFHA until and unless FEMA issues a LOMR-F for the project. When fill is proposed but not yet placed, a CLOMR-F should be requested. A CLOMR-F does not revise the FIRM, nor does it suggest that FEMA has determined that the proposed building on fill will be reasonably safe from flooding. Therefore, issuance of a LOMR-F subsequent to an approved CLOMR-F to remove a building built in the SFHA with the lowest floor below the BFE is not guaranteed. To revise the FIRM, after construction is completed, the property owner must submit a subsequent LOMR-F application to document the as-built conditions. A basement with the basement floor below the BFE must not be excavated into fill where only a CLOMR-F has been issued, unless the building is in an approved basement exception community.

Local Permits Required

Communities that participate in the NFIP are responsible for regulating development in SFHAs by requiring and reviewing permit applications for compliance and issuing permits when in compliance with the permit requirements. Submission of an MT-1 application to FEMA is not an application for a permit, and FEMA's issuance of a LOMR-F or CLOMR-F is not authorization to perform the work described in the MT-1 application.

5.1. Community Acknowledgement Form (Signed by Local Official)

Property owners and developers seeking LOMR-Fs and CLOMR-Fs must ask local officials to sign the MT-1 Community Acknowledgement Form (Form 3). The Community Acknowledgement Form statement for requests involving the placement of fill includes the following:

> *As the community official responsible for floodplain management, I hereby acknowledge that we have received and reviewed this Letter of Map Revision Based on Fill (LOMR-F) or Conditional LOMR-F request. Based upon the community's review, we find the completed or proposed project meets or is designed to meet all of the community floodplain management requirements, including the requirement that no fill be placed in the regulatory floodway, and that all necessary Federal, State, and local permits have been, or in the case of a Conditional LOMR-F, will be obtained. … In addition, we have determined that the land and any existing or proposed structures to be removed from the SFHA are or will be reasonably safe from flooding as defined in 44 CFR 65.2(c), and that we have available upon request by DHS-FEMA, all analyses and documentation used to make this determination. For LOMR-F requests, we understand that this request is being forwarded to DHS-FEMA for a possible map revision.*

Environmental Compliance

In some areas, the placement of fill has been identified as a contributor to loss of habitat critical to endangered species. The Community Acknowledgement Form includes a statement about meeting the federal Endangered Species Act (ESA) requirements. Documentation of compliance with the ESA requirements is required to be submitted to FEMA prior to issuance of a CLOMR-F, or the local official must acknowledge that the ESA requirements were complied with independently of the FEMA process for LOMR-F requests. In addition, the local official must acknowledge that all necessary federal, state, and local permits have been or will be obtained, which may include environmental impacts such as wetlands development permits or local tree removal permits.

In order to complete the Community Acknowledgment Form, the local official must review the MT-1 application and accompanying documentation. If the local official can attest that the applicant has met or will meet the local floodplain management requirements including that the land and any existing or proposed structures to be removed from the SFHA are or will be reasonably safe from flooding, the local official should sign the Community Acknowledgement Form. If the local official is unable to sign the statement, for example if a proposal does not meet local requirements, the applicant's supporting documentation is insufficient to make a reasonably safe from flooding determination, or the local official concludes that a structure on filled land is not, or will not be, reasonably safe from flooding, the local official should not sign the Community Acknowledgement Form. MT-1 applications submitted for CLOMR-Fs/LOMR-Fs without the local official's signed Community Acknowledgement Form are incomplete and FEMA will suspend processing of the request. The permit applicant can then work with the local official to modify the project or submit additional documentation to achieve compliance.

5.2. Reasonably Safe from Flooding Documentation (Signed by Design Professional)

Local officials who have the authority to make determinations as to whether filled sites are reasonably safe from flooding should require permit applicants to submit appropriate information such as that described in this Technical Bulletin to review and to make the determination. A common practice is to require a signed statement or certificate by a qualified design professional to indicate that all land and existing or proposed structures to be removed from the SFHA, are or will be reasonably safe from flooding, according to the criteria described in this Technical Bulletin. An example certificate is shown in Figure 2.

NFIP Community Identification Number and Name

Project Name and Location (address, parcel number, lot and plat)

I, ______________________ certify that the plans and design for the aforementioned development is reasonably safe from flooding in accordance with the requirements of the community in which the project is located and the guidance provided in the latest edition of NFIP Technical Bulletin 10 related to ensuring that structures built on fill in or near SFHAs are reasonably safe from flooding.

I certify that the design and specifications for the placement of fill are in accordance with accepted professional practices.

The foundation type is: ☐ non-basement or ☐ basement

For basements, the determination is based on: ☐ simplified approach, or
☐ engineered analysis, or
☐ basement floor at or above BFE

Documents attached are: ______________________

Certifier's Name | License Number

Title

Company Name

Address

PLACE SEAL HERE

City | State | Zip Code

Signature | Date | Telephone | Ext

Figure 2: Example certification for reasonably safe from flooding

Certifications may be provided by professional engineers, professional geologists, professional soil scientists, or other design professionals qualified to make such evaluations. Local officials should have the certification and its supporting documentation submitted with permit applications to be able to make reasonably safe from flooding determinations before issuing building or floodplain development permits. When developers propose fill in SFHAs in all or part of subdivisions, certifications by appropriate professionals should be required for each individually filled lot or proposed structure location. After reviewing MT-1 applications for LOMR-Fs/CLOMR-Fs, FEMA may require additional supporting data that supports the reasonably safe from flooding determination, such as the information outlined in this Technical Bulletin. The local official charged with reviewing the application and signing the Community Acknowledgement form should not sign the form unless the applicant provides sufficient documentation of the assumptions, analyses, and approaches used.

5.3. Elevation Form (Signed by Surveyor or Design Professional)

MT-1 applications must include elevation information certified by a licensed land surveyor, registered professional engineer, or architect authorized by state law to certify elevation information. The MT-1 application includes the Elevation Form (Form 2) to provide information that local officials can use in making the reasonably safe from flooding determination. The Elevation Form may be used for one property or multiple lots in subdivisions. If the LOMR-F request is to make a determination on a structure and the NFIP Elevation Certificate has already been completed, it can be submitted in lieu of the Elevation Form.

The local official can request additional elevation information, such as that provided on the NFIP Elevation Certificate, to use in making the reasonably safe from flooding determination. For requests that involve the proposed construction of buildings elevated on fill, the local official should use the elevation information to make sure that both the lowest adjacent grade elevation and the lowest floor elevation (including basement and crawlspace floors) are at or above the regulated BFE.

6. Best Practices for Administrative Procedures and Higher Regulatory Standards

Communities may choose to implement administrative procedures and adopt regulations to assist with gathering information to increase flood resistance of proposed development and to determine whether a proposed development is reasonably safe from flooding. Administrative procedures can help to alert plan reviewers of sites that have been removed from the SFHA by a LOMR-F so that proposed development on the site is reasonably safe from flooding and conforms to the LOMR-F application. Communities may also adopt higher regulatory standards to further reduce flood risk to buildings on land removed from the SFHA through the LOMR-F process, or to restrict development on or involving fill.

Regulatory Requirements May Exceed NFIP Requirements

Communities are encouraged to adopt local floodplain management regulations to reduce flood risk associated with development on filled areas removed from the SFHA by LOMR-Fs. The NFIP regulations specifically acknowledge that communities are encouraged to exceed the minimum criteria by adopting more comprehensive or higher standards [44 CFR § 60.1(d)] than the minimum criteria [44 CFR § 60.3]. In particular, the regulations note that local officials may have access to information or knowledge of conditions that warrant higher standards and encourage communities to adopt more restrictive criteria. The regulations explicitly state that any floodplain management regulations adopted by a state or community that are more restrictive than NFIP requirements shall take precedence.

The following are examples of administrative procedures and more restrictive or more specific requirements related to placement of fill in SFHAs:

- Stipulate that LOMR-Fs do not remove the land from the regulated flood hazard area for the purposes of floodplain management regulations. The mandatory flood insurance purchase requirement would be removed, but buildings would have to meet all building performance requirements, including that the lowest floor (including basement) be at or above the BFE.

- Develop a checklist of permit application submittals that are necessary when applicants propose placing fill in SFHAs and a checklist of plan review requirements to facilitate a thorough review of the submitted materials.

- When issuing permits for the placement of fill only (no building or structures), stipulate that no buildings can be built on the filled area without a subsequent building permit or floodplain development permit that includes consideration of residual risk, described in Section 1.4 of this Technical Bulletin and ensuring that the lowest floor elevation is at or above the elevation of the BFE that existed at the site prior to the LOMR-F.

- Require building sites that have been or will be filled to have building footprints identified on construction plans and on preliminary and final plats for subdivisions and other developments, and then evaluate those sites using the guidance described in this Technical Bulletin.

- Require grading plans that delineate filled building sites and building footprints as a condition of issuing fill permits and evaluate those building sites using the guidance described in this Technical Bulletin.

- Where building codes are not adopted, modify local floodplain management regulations to incorporate the design and placement of fill requirements of the I-Codes, summarized in Section 3 of this Technical Bulletin.

- Adopt buffer zones or setback zones around the perimeter of fill pads or at the edge of the floodplain and establish limits on construction in these zones.

- Require pilings or columns rather than fill, for the elevation of structures in the SFHA, in order to maintain the storage capacity of the floodplain and to minimize the potential for negative impacts to sensitive ecological areas [44 CFR § 60.22(c)(17)].

- Require applicants to demonstrate that the quantity of fill and area to be filled are the minimum necessary to achieve the intended objective. Limiting the quantity and area of fill limits environmental impacts by minimizing tree and vegetation removal and alteration of natural drainage and infiltration processes.

Floodplain Fill and Loss of Storage and Conveyance

Placing fill in SFHAs along riverine waterways can cause increases in BFEs by reducing the ability of the floodplain to store and convey floodwater. This can result in increased flood damage to both upstream and downstream properties. To reduce the risk of increased damage, some communities prohibit fill, require compensatory storage volume to offset the impact of filled areas, or identify a more restrictive floodway than is shown on FIRMs. At a minimum, the NFIP regulations regarding cumulative development in the SFHA and encroachment in the regulatory floodway must be met. Details of these requirements can be found in 44 CFR §§ 60.3(c)(10) and 60.3(d).

- Control development of filled areas and land that is immediately adjacent to floodplains but higher than the BFE to satisfy the requirement that future buildings in these areas are reasonably safe from flooding by adopting regulations to require permit applicants to sign legally binding agreements before the local official signs the MT-1 Community Acknowledgement Form. Communities may adopt higher standards to further reduce the risk of flooding. Conditions that can be included in binding agreements include:
    - Require, as a condition of final subdivision plat approval, that no basements can be built into filled lots or filled building sites
    - Specifically require that construction be designed, permitted, and constructed in accordance with the guidance in this Technical Bulletin
    - Prohibit excavation of fill for basements with floors below the BFE that existed prior to the placement of fill and the issuance of the LOMR-F
    - Require an agreement prohibiting basement apartments, or limiting basement use to parking of vehicles, building access, and storage
    - Prohibit locating critical facilities on land removed from the SFHA by LOMR-F

- Adopt requirements for areas proposed to be filled for building sites to be designed to have the top grade of the fill (after compaction and settlement) to be above the BFE (not “at the BFE”), especially when communities already require buildings to be elevated higher than the BFE (see Figure 3). Reasons for requiring additional elevation (called freeboard) above the BFE include:

- To better protect buildings when flooding rises higher than the BFE
- When newly available technical information indicates higher flood risk than what is shown in the effective FIRM or FIS or when existing conditions have changed that could increase flooding
- When an increase in upland development and the addition of impervious surfaces results in greater runoff that increases flood risk
- To account for future changes that may increase the BFE, including sea level rise and increased rainfall intensity or duration

- For communities that adopt freeboard above the BFE for lowest floor elevation, stipulate that the top grade of the fill must be at or above the elevation required for lowest floors.
- Adopt regulations to limit or prohibit the use of fill in Coastal A Zones, which are areas seaward of the Limit of Moderate Wave Action (LiMWA) delineated by FEMA on FIRMs. The LiMWA delineates where waves associated with coastal flooding are expected to be between 1.5 and 3 feet high during base flood conditions.
- Adopt regulations to limit or prohibit the use of fill in high risk flood hazard areas (e.g., areas prone to flooding from alluvial fans, flash floods, erosion, ice jams, debris, mudslides, high velocity flow, and wave action).
- Modify the sample Reasonably Safe From Flooding Certificate (Figure 2 in Section 5.2 of this Technical Bulletin) to stipulate that the design is reasonably safe from future flooding to a specific year (such as sea level or rainfall projections 50 years from the date of the application) or flooding associated with a higher mean recurrence interval, such as the 500-year flood.

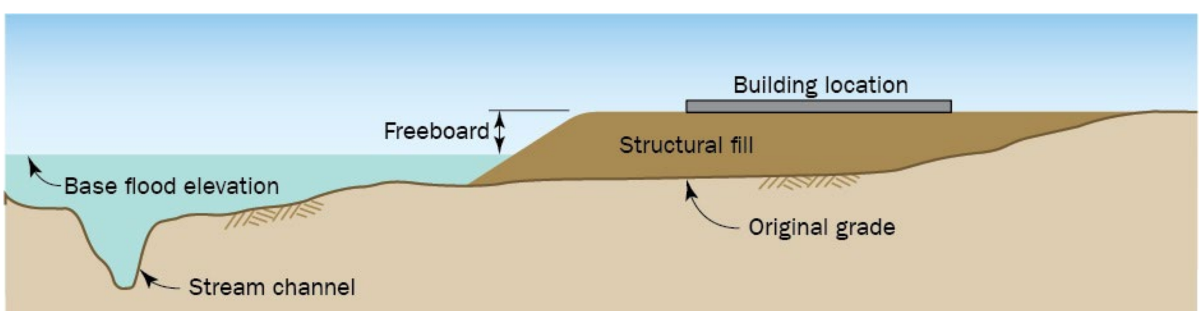


Figure 3: Filled site with freeboard above BFE

7. Proper Design and Placement of Fill

Proper design and placement of fill requires an understanding of soil mechanics, local site conditions, the specific characteristics of the earthen materials being placed, methods to place and compact the fill to achieve the desired characteristics, and soil testing procedures. Standard engineering and soil mechanics texts cover these subjects in detail.

Communities, property owners, designers, and builders should follow best practices when specifying the design and placement of structural fill. The NFIP does not specify requirements for the design and placement of fill in SFHAs, but the general performance requirements of the NFIP must be satisfied. The I-Codes and ASCE 24 have specifications for site grading, fill compaction, side slopes, protection of slopes from erosion during flooding, and design and performance of structural fill (see Section 3 of this Technical Bulletin). Where building codes are not adopted, the fill provisions of the I-Codes and ASCE 24 should be used as best practices or adopted into local floodplain management regulations.

Qualified professionals may be required to design the placement of fill in SFHAs intended to support buildings, and communities may require submission of the signed and sealed certification form described in Section 5.2 of this Technical Bulletin. Property owners should work with a licensed professional engineer, geotechnical engineer, engineering geologist, or other qualified professional licensed in the state in which the building is located to design the fill. The performance of filled areas should consider, but is not limited to, the following fill material characteristics:

- Engineering properties of existing and proposed fill material—soil classification, shear strength, compressive strength, maximum density, permeability, erodibility, liquefaction potential, etc.
- Geotechnical conditions at the site before placement of fill—bearing capacity, groundwater levels, presence of expansive soils or sinkholes, etc.
- Stratification between fill material and underlying soil
- Potential consolidation over time of the existing soil under the weight of added fill
- Effect of consolidation, settlement, or differential settlement of the fill
- Ability of the fill material and side slopes to resist flood-related erosion and scour, especially in SFHAs where base flood velocities exceed 5 feet per second (side slopes should be protected from erosion)
- Ability of fill material and side slopes to withstand rapid drawdown, which could alter the stability of the remaining fill
- How the permeability of fill material and underlying soil affects water infiltration into the fill, which may affect structures built on the site, especially buildings with below-grade basements

Permit application documents should include specifications for the placement of fill, including:

- Proper preparation of the site before fill placement (e.g., grading and compacting, moisture control)
- Thickness of lifts (layers of soil after compaction) and compaction densities
- Side slope ratios and slope stabilization methods
- Placement of fill such that the final top surface of the fill (after compaction and settlement) is at or above the BFE, or higher if freeboard is required, illustrated in Figure 3
- Final grading to drain surface runoff away from buildings

8. Constructing on Land Removed from SFHAs by Placement of Fill

Buildings that are constructed on land removed from the SFHA by the placement of fill have the lowest residual risk of flooding when the entire building (excluding subsurface foundation elements) is elevated above the BFE that existed prior to the placement of fill. Designs that place the lowest floor and below-grade areas at, rather than above, the BFE have a greater degree of residual risk even when flooding rises only slightly higher than the BFE. Designs that place the lowest floor (including a basement floor) below the BFE have the highest degree of risk, with an increased risk of subsurface flooding and damage from flooding that exceeds the BFE. Residual risks of flooding are described in Section 1.3 of this Technical Bulletin and relative residual risks by foundation type are summarized in Section 8.3 of this Technical Bulletin.

8.1. Non-Basement Foundations

Non-basement foundations do not have any enclosed area that extends below grade on all sides. Non-basement foundations consist of open, stem wall, perimeter walls (crawlspace), and slab-on-grade foundations. Non-basement foundations on fill are illustrated in Figure 4:

- **Open foundations (piles, columns, piers).** Open foundations provide a high degree of flood protection because the piles/columns/piers are used to raise the lowest floor above the surrounding grade and the area under the elevated building allows free flow of floodwater when flooding rises higher than the top surface of the fill. Unless footings extend into undisturbed soil, the fill must be placed to support the more concentrated loads under footings, which may need to be larger than footings that bear on undisturbed soil. This approach can provide freeboard and less resistance to flood forces when the area below the lowest floor is not enclosed. Constructing an open foundation and raising the lowest floor above the BFE provides the highest degree of flood protection especially in areas subject to coastal flooding and areas with high velocity floodwater.

- **Backfilled stem walls.** Stem walls backfilled with fill or gravel raise a floor above the surrounding grade. Backfilled stem wall foundations on fill provide a high degree of flood protection even when the top surface of the fill is at the BFE. Placing fill on the site prior to constructing a backfilled stem wall can provide freeboard for an additional degree of flood protection.

- **Perimeter walls.** Perimeter walls that form crawlspaces raise the floor above the surrounding grade. Perimeter wall foundations on fill provide a high degree of protection when flooding rises above the top surface of the fill. Installing flood openings in the perimeter walls is recommended to allow floodwater to enter the enclosed area to equalize hydrostatic pressure on foundation walls in the event of flooding that exceeds the BFE (see NFIP Technical Bulletin 1, *Requirements for Flood Openings in Foundation Walls and Walls of Enclosu*res). Perimeter wall construction is less preferred than the backfilled stem wall construction as an enclosure is created.

- **Slab-on-grade.** Slab-on-grade foundations constructed on fill provide the least flood protection of the non-basement foundations because the floor of the building typically is not elevated above the adjacent grade more than a few inches. Water will enter slab-on-grade buildings when flooding rises higher than a few inches above the top surface of the fill. Placing additional structural fill beneath the building footprint to a level above the BFE increases flood protection.

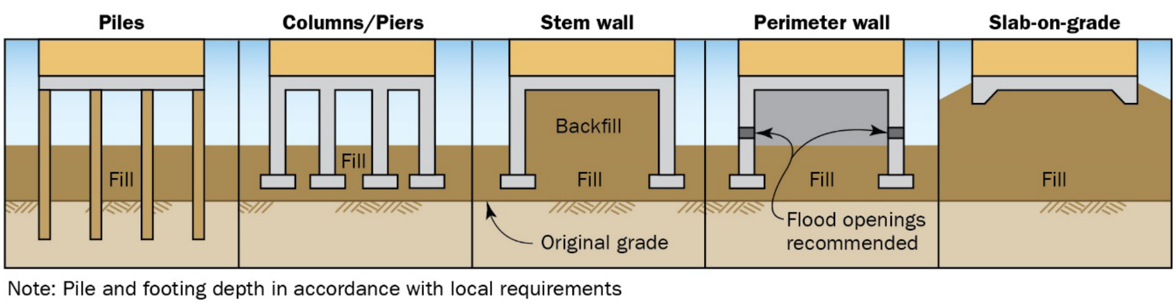


Figure 4: Non-basement foundation types

8.2. Basement Foundations

NFIP minimum floodplain management requirements generally do not allow basements (any areas that are below-grade on all sides) in SFHAs because of the increased risk of flood damage. However, if FEMA approves the removal of land from the SFHA by the LOMR-F process, floodplain management requirements for buildings in SFHAs no longer apply. Although not recommended, builders and property owners who build on land removed from the SFHA through the LOMR-F process sometimes elect to construct basements. Basements excavated in fill are at higher risk of flood damage than the non-basement foundation types described in Section 8.1 of this Technical Bulletin.

Regulating Excavated Basements for Buildings Elevated on Fill

Filled areas must be regulated as being in the SFHA unless or until FEMA issues the LOMR-F or LOMR, which will remove the filled area from the SFHA. That means that LOMR-F applications involving constructing buildings with basements and simultaneously placing fill (where the land has not yet been removed from the SFHA) are a violation and will not be approved unless the basement floor is at or above the BFE.

In other words, basements with the lowest floor below the BFE, excavated into fill, are prohibited unless the land is first removed from the SFHA through the LOMR-F process prior to construction commencing (or in an approved basement exception community). Additionally, basements that are part of engineered, dry floodproofed non-residential buildings (in Zone A only) are allowed in the SFHA.

Basement foundations enclose areas that extend below grade on all sides. The scenarios described in this section are listed in order of increasing risk of flood damage. Basement foundations in fill are illustrated in Figure 5:

- **Basement floor at or above BFE.** Placing the floor of a basement in fill at or above the BFE effectively eliminates risk of damage when flooding rises to the BFE. In general, the higher the basement floor is relative to the BFE, the lower the risk of damage from seepage and hydrostatic pressure caused by saturated soils.

- **Basement floor below BFE.** Placing the floor of a basement in fill below the BFE may expose the basement walls and floor to damage from seepage and hydrostatic pressure caused by saturated soils when flooding rises up to or higher than the BFE.

- **Lowest opening above BFE.** Regardless of where the floor of a basement in fill is placed, risk of flood damage is increased when an opening (window well or exterior doorway) is located below-grade, even when positioned above the BFE. When below-grade openings are located above the BFE, then seepage associated with soils saturated by flood up to the BFE would not enter the basement through those openings. However, below-grade openings would allow surface water into the basement when flooding rises higher than the top of the fill.

- **Lowest opening at or below BFE.** Placing the floor of a basement in fill below the BFE with a below-grade opening (window well or exterior door) also located below the BFE increases the risk of damage. If the fill becomes saturated when flooding rises up to or higher than the BFE, the below-grade openings could allow seepage to enter the basement. Below-grade openings would also allow surface water into the basement when flooding rises higher than the top of the fill.

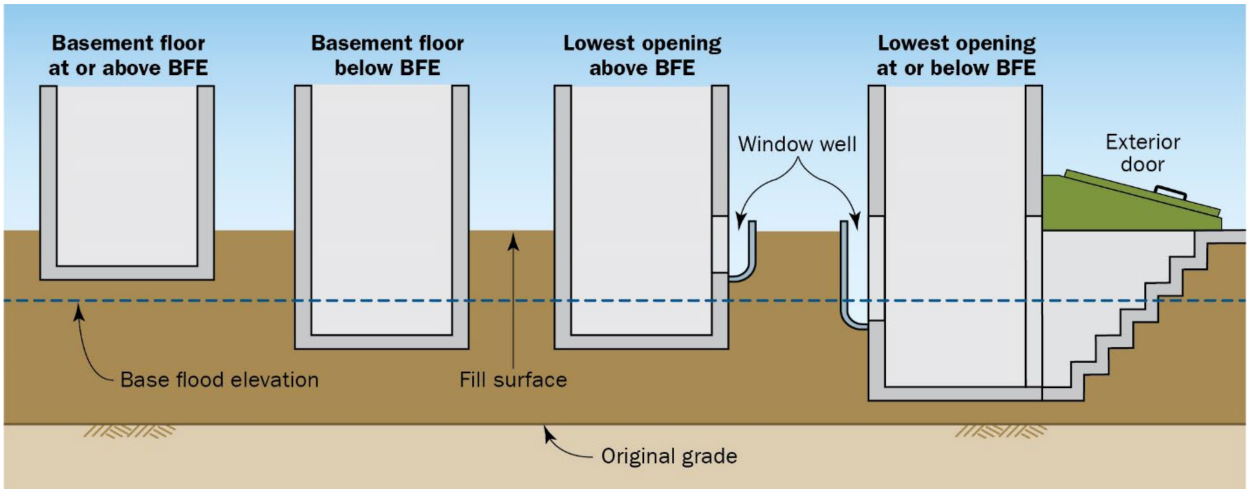


Figure 5: Four scenarios of basements built into fill

Number of Sides Below Grade

An enclosure that is below the exterior ground level on all sides is a basement regardless of the depth below grade or the height of the enclosure (headroom). An area of a building that is below grade on two or three sides (i.e., the floor or interior grade is at or above the exterior grade along at least one entire side) is not a basement, although the area may be called a walkout basement, daylight basement, or terrace or garden level.

8.2.1. RISK OF SUBSURFACE FLOODING

Constructing a basement foundation in filled land is not recommended because the basement floor and portions of the basement walls can be subject to subsurface flooding. High groundwater at a site with a basement can result in water infiltrating the basement or significantly increasing hydrostatic pressures on the walls and basement slab, which can cause failure or permanent deformation of the walls (see Figure 6). Approaches to analyzing seepage (saturation and infiltration) of water into filled soils are described in Section 9 of this Technical Bulletin. Even when surface floodwater has not reached buildings with basements, FEMA has seen numerous examples of flooded basements, bowed basement floors, and collapsed basement walls caused by high groundwater associated with nearby flooding.

Figure 6: Unreinforced masonry walls of a basement that failed because of the pressure exerted by water and saturated soil

Another reason why constructing basement foundations in filled land is not recommended is because when flooding rises higher than the top of the filled area, the basement area may be completely inundated, especially if the basement has window wells or an exterior entrance. When builders and building owners decide to accept the additional risk associated with basement construction on filled land, they need to satisfy the requirement that the basement and the rest of the building are reasonably safe from flooding.

8.2.2. RECOMMENDATIONS TO REDUCE RISK OF SUBSURFACE FLOODING

To be reasonably safe from flooding during base flood conditions, proposed or existing structures on filled land must not be vulnerable to damage by subsurface flooding. This means that during base flood conditions, the basements are dry, structurally sound, and not exposed to lateral hydrostatic and uplift pressure (buoyancy loads) and saturated soil loads that either exceed the structural capacity of walls and floors or that cause unacceptable deflections.

This Technical Bulletin does not address the structural design of foundations and basement walls, nor does it address the design of drainage systems. Floors, slabs, and walls should be designed for the hydrostatic pressures that can occur during conditions of flooding. For structural design, it is recommended that the full hydrostatic pressures be assumed as unrelieved by a subsurface drainage system. Foundation walls that are not designed for full hydrostatic pressures should not be used. Soils around the basement should have low permeability to minimize or stop water infiltration into the basement walls and floor. Regardless of the permeability of the fill soils, water that infiltrates to the basement should be removed by a drainage system on the outside (soil side) of the basement. Sump pumps to remove seepage into below-grade areas should also be considered.

To minimize the additional risk of subsurface flooding, the following site planning and construction practices are recommended:

- Locate structures as far from the SFHA as possible (farther back from the edge of the fill closest to the flooding source).
- Elevate basement floors as much as possible, preferably to or above the BFE. As the elevation of the basement floor increases, the risk of subsurface flooding decreases.
- For below-grade areas, implement flood-resistant construction practices, including fill material specifications and compaction, and use of flood damage-resistant materials, properly sized sump pumps, and foundation drainage.
- For below-grade areas, to stop the capillary transmission of water from soil to concrete, provide a capillary break (a physical gap between the water or wet soil and the foundation wall). This can be a waterproof membrane, a layer of granular fill (gravel or crushed stone), or a manufactured drainage membrane against the basement wall.
- Grade the surrounding area to slope away from the structure.
- Implement construction practices or requirements based on local knowledge of conditions and the risk of subsurface flooding.

Warning about Pumping Basements

Owners and occupants should take precautions before pumping out water from flooded basements. When floodwater is rapidly pumped from basements and the soil surrounding the basement walls is still saturated, the walls can collapse, and the floor can be pushed up or cracked. As the water level in the basement drops, the outside pressure on the basement walls and floor can become greater than the inside pressure.

When basements are flooded, owners should contact experienced contractors to determine when and how best to safely pump out basements.

8.3. Relative Residual Risk by Foundation Type

Residual risks are described in Section 1.3 of this Technical Bulletin. The degree of residual risk that a foundation built on or in fill is exposed to depends on the proper design and placement of fill (see Section 7 of this Technical Bulletin), site-specific conditions (such as soil mechanics, hydrology, and topography), and the following building-related factors:

- The foundation type
- The elevation of the foundation or floor relative to the BFE

- The elevation of fill relative to the BFE
- The location of windows, window wells, doors, or other openings (basement foundations only)

Table 3 and Table 4 summarize the features of non-basement foundations (see Figure 4) and basement foundations (see Figure 5) that are described in Sections 8.1 and 8.2 of this Technical Bulletin and rank the combinations of elevation and foundation types in terms of relative residual risk compared with open foundations, which have the lowest degree of risk. The tables indicate whether each combination results in buildings that are reasonably safe from flooding. Where noted in Table 4, some combinations are reasonably safe from flooding only when seepage analyses are prepared by a qualified professional as described in Section 9 of this Technical Bulletin.

Table 3: Non-Basement Foundations: Relative Residual Risk Based on Foundation Type and Elevations

Relative Residual Risk	Foundation Type	Fill Elevation	Lowest Floor Elevation	Reasonably Safe from Flooding?
None	Piles, columns, piers	Above BFE	Above BFE	Yes
		At BFE	Above BFE	Yes
Minor	Backfilled stem wall	Above BFE	Above BFE	Yes
		At BFE	Above BFE	Yes(1)
Minor	Perimeter wall (crawlspace)	Above BFE	Above BFE	Yes
		At BFE	Above BFE	Yes(1)
Moderate	Slab-on-grade	Above BFE	Above BFE	Yes
		At BFE	At BFE	Yes(1)

(1) Non-basement foundations with fill elevation at the BFE are not recommended because buildings are vulnerable when flooding rises higher than BFE

Table 4: Basement Foundations: Relative Residual Risk Based on Elevations

Relative Residual Risk	Fill Elevation	Basement Floor Elevation	Opening Location	Reasonably Safe from Flooding?
Minor	Above BFE	Above BFE	Above BFE	Yes
	Above BFE	At BFE	Above BFE	Yes
Moderate	Above BFE	Below BFE	Above BFE	Only when using simplified approach or verified by engineering analysis (see Section 9 of this Technical Bulletin).

Relative Residual Risk	Fill Elevation	Basement Floor Elevation	Opening Location	Reasonably Safe from Flooding?
High	At BFE	Below BFE	Above BFE	Only when using simplified approach or verified by engineering analysis (see Section 9 of this Technical Bulletin).
	At BFE	Below BFE	At BFE	Only when using simplified approach or verified by engineering analysis (see Section 9 of this Technical Bulletin).
	Above BFE	Below BFE	Below BFE	No
	At BFE	Below BFE	Below BFE	No

Note: Basement foundations are not recommended because buildings are vulnerable when flooding rises higher than the BFE. Basements excavated into fill are prohibited below the BFE, unless the land has been removed from the SFHA by LOMR-Fs or LOMRs prior to construction (or in an approved basement exception community).

Elevator Pits Below Grade on All Sides

NFIP Technical Bulletin 4, *Elevator Installation*, provides guidance for construction of elevator pits. When elevator pits are the minimum size necessary and are designed in accordance with the guidance, the pits are not considered basements.

9. Basement Foundations: Technical Approaches to Seepage Analysis to Determine Reasonably Safe from Flooding

This section provides guidance on seepage analysis and measures that can be taken when building owners desire to construct basements in land that has been filled and removed from the SFHA by a LOMR-F. The guidance will help protect and satisfy the requirement that the basements are reasonably safe from flooding. Local officials should be cautious about allowing excavation for basements in filled areas without consideration of seepage during flood events, even when the filled areas are officially removed from the SFHA.

The guidance in this section is not to be used to make a determination that existing structures with the lowest floor (basement) below the BFE are reasonably safe from flooding.

Communities must regulate filled areas as SFHAs, unless the filled areas are officially removed from the SFHA by FEMA. Non-basement foundations (open foundations, backfilled stem wall, perimeter wall, slab-on-grade) and basement foundations with basement floors at or above the BFE can be used and are assumed to be reasonably safe from flooding (see Section 8.3 of this Technical

Bulletin). However, basements with floors proposed below the BFE are not permitted for residential buildings if the filled areas are still in the SFHAs. Non-residential buildings in SFHAs may have basements provided the floodplain management requirements for dry floodproofing are satisfied.

Limitations

The guidance in this section does not apply to:

- New construction or substantially improved buildings in SFHAs (not removed through the LOMR-F process). The NFIP regulations require buildings and structures in SFHAs to have the lowest floors, including basements, at or above the BFE. In effect, areas that are below grade on all sides (basements) are not permitted (unless authorized as part of dry floodproofed non-residential buildings).
- Placement of fill around existing residential or non-residential buildings where the lowest floor is below the BFE with the intent of changing the lowest adjacent grade to remove the building from the SFHA.

The first step in determining whether a basement will be reasonably safe from flooding is to analyze seepage that may occur during base flood conditions. For a local official to deem a building reasonably safe from flooding, the analysis must show that base floodwater will not inundate the land or damage structures and that any subsurface waters related to the base flood will not damage buildings.

The two approaches to seepage analysis described in this section—the simplified approach and the engineered analysis approach—may be used to evaluate proposed buildings with basement floors below the BFE in filled areas. The simplified approach is presented first. When the design requirements, limitations, and assumptions for the simplified approach are not met or are not applicable, the engineered analysis approach must be used.

Some possible means for evaluating whether the limitations and requirements of the approaches are met may require soil tests and investigations, including soil borings and hand augers; field records from the time the fill was placed; and soil surveys. If the standards of practice, design requirements, and conditions for use of the simplified approach are not met, a licensed professional engineer, geotechnical engineer, engineering geologist, or other qualified professional must perform the more detailed analysis described for the engineered analysis approach. More extensive soil investigations and testing will likely be necessary to complete the analysis and demonstrate that buildings will be reasonably safe from flooding.

Documentation to Submit

Documentation of the approach used, including assumptions and analysis performed, should be submitted to the local official so the local official can make the reasonably safe from flooding determination. Local officials responsible for signing the Community Acknowledgment Form can use the requirements and limitations of the simplified and engineered analysis approaches as an aid to determine whether sufficient analyses and documentation are provided (see Section 5.1 of this Technical Bulletin).

9.1. Simplified Approach

The simplified approach is a set of design requirements and limitations (see Section 9.1.1 of this Technical Bulletin) for basement foundations excavated in fill with basement floors below the BFE. If the design requirements and limitations are satisfied, the buildings are reasonably safe from flooding. Section 9.1.2 of this Technical Bulletin outlines the assumptions for the simplified approach.

If any one of the design requirements, limitations, or assumptions of the simplified approach are not satisfied, the more detailed engineered analysis approach described in Section 9.2 of this Technical Bulletin must be performed to determine whether a building with a basement floor below the BFE can be considered reasonably safe from flooding.

9.1.1. DESIGN REQUIREMENTS AND LIMITATIONS

The simplified approach does not eliminate the need for soil tests and investigations, which will likely require a licensed professional engineer, geotechnical engineer, engineering geologist, or other qualified professional. A qualified professional should consider the proposed building design and should investigate and document proposed fill material characteristics and the site conditions. The design requirements and limitations of the simplified approach are presented in this section and grouped as building design, fill placement, fill material characteristics, and site conditions. Figure 7 illustrates these requirements and limitations.

Limiting Assumption for the Simplified Approach

The simplified approach assumes there will be no hydrostatic pressure on the foundation because a standard drainage system is provided. The drainage system must include a sump pump that discharges above the BFE and has backup power to function during floods.

Building Design

To use the simplified approach:

- The footprint of the basement must be less than or equal to 1,200 square feet.

- The basement must have no open penetration through the wall or floor.

- The basement floor must be less than 5 feet below the BFE. The depth of the basement floor can be shallower to achieve more favorable conditions.

- There must be a granular drainage layer beneath the floor slab. If a granular soil (typically gravel or sand) is used as the drainage layer below the slab, the gradation of the drainage material should be designed to be compatible with the gradation of the fill material to reduce movement of fines. Crushed stone wrapped with filter fabric below the slab and around the perimeter of the foundation may be an option.

- A minimum of at least one single ¼-horsepower sump pump with a backup power supply must be provided to remove seepage from the drainage layer. More than one sump pump or a sump pump with higher capacity (the horsepower requirement, also called "size") may be necessary. The total pump capacity must be calculated based on the quantity of seepage flow, which depends on soil permeability and other site conditions (see Figure 8 and Equation 1 in Section 9.1.2 of this Technical Bulletin). The pump must be rated at four times the estimated seepage rate and must discharge above the BFE and away from the building. This arrangement is essential to prevent build-up of hydrostatic pressure against the basement walls and uplift of the floor under the effect of the seepage pressure.

- The drainage system must be equipped with a positive means of preventing backflow.

I-Code Exception for Foundation Drainage

The I-Codes generally allow foundation drains to discharge through either mechanical means or gravity drains and do not require drainage systems in well-drained soils (gravel or sand/gravel mixture). In or near floodplains, well-drained soils can increase groundwater flow toward the building foundation during conditions of flooding. Therefore, this exception should not apply in or near floodplains.

Fill Placement

To use the simplified approach:

- The filled ground surface around the building and within a defined setback distance from the new edge of the SFHA must be at or above the BFE. The setback distance is measured from the new edge of the SFHA to the nearest wall of the basement. The minimum allowable setback distance is 20 feet.

- The fill material—or existing underlying soil of similar classification and degree of permeability as the fill material—must extend to at least 5 feet below the bottom of the basement floor slab.

- The fill material must be compacted to at least 95% of its maximum standard proctor density according to ASTM International (ASTM) Standard D698, *Standard Test Methods for Laboratory*

Compaction Characteristics of Soil Using Standard Effort (ASTM 2021a). Alternatively, the fill material must be compacted to at least 90% of its maximum modified proctor density according to ASTM Standard D1557, *Standard Text Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort* (ASTM 2021b).

Fill Material Characteristics

To use the simplified approach:

- The fill material must be homogeneous and isotropic, which means the fill material must be all of one material, and the engineering properties must be the same in all directions.
- Fill soils must be fine-grained soils of low permeability, such as those classified as CH, CL, SC, or ML according to ASTM Standard D2487, *Standard Practice for Classification of Soils for Engineering Purposes* (ASTM 2020). See IRC Table R405.1 for descriptions of these soil types.

Site Conditions

To use the simplified approach:

- The normal and seasonal high water table (including perched water table) must be lower than the proposed floor of the basement.
- There must be a constant soil type and density over the seepage flow zone (measured horizontally by the setback distance between the building and the edge of the SFHA and vertically from the BFE to the base of the seepage flow zone). The underlying soils at the site must not have stratified soil layers.
- The depth of the base of the seepage flow zone must be able to be defined (see Figure 8 in Section 9.1.2 of this Technical Bulletin). This depth is needed in the calculation of the quantity of seepage flow, which is necessary to determine the total quantity of seepage that determines the required sump pump capacity.
    - If the base of the seepage flow zone is not known, its depth below the bottom of the basement floor slab can be conservatively approximated as one-half of the building width most nearly perpendicular to the shoreline or bank of the source of flooding. This would approximate the boundary effects of the three-dimensional seepage flow in that it would represent the flow coming in from all sides and meeting in the center beneath the floor slab.

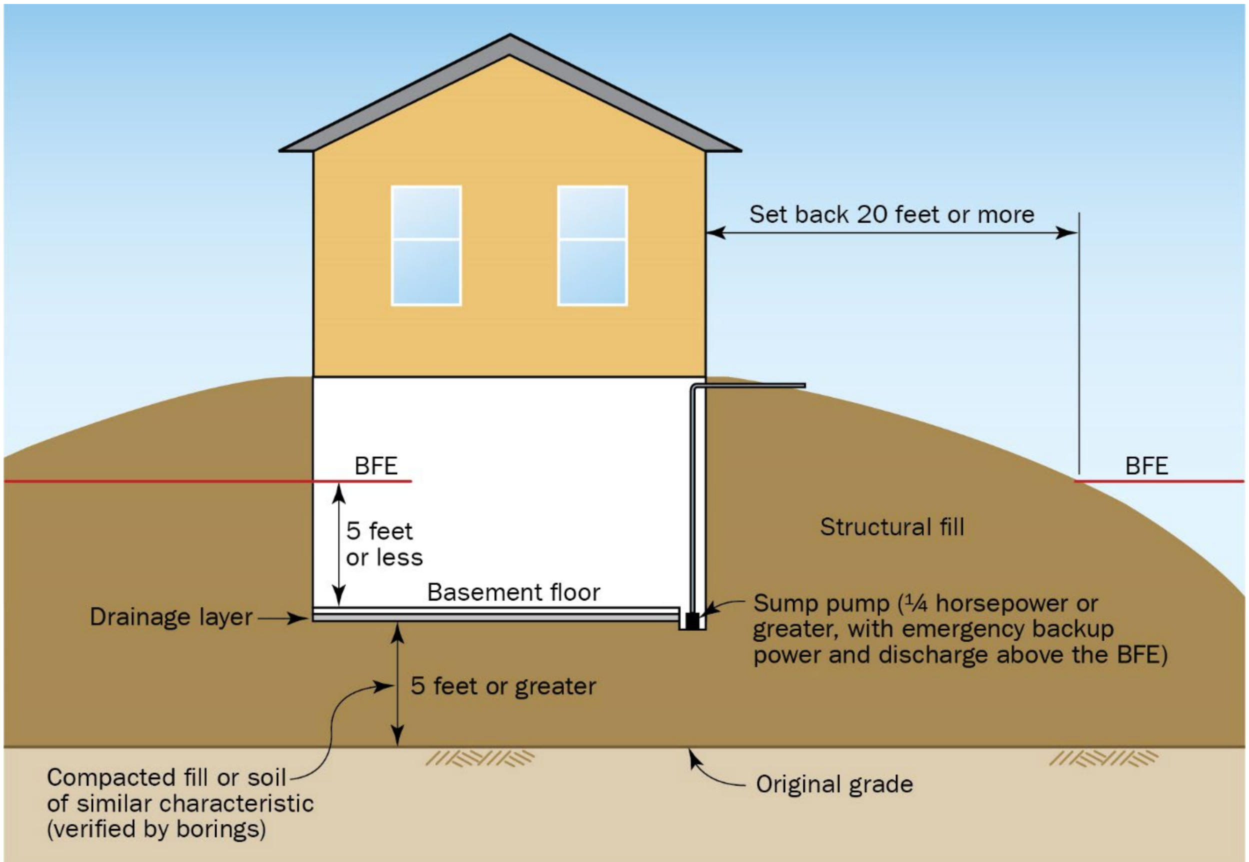


Figure 7: Limitations on the use of the simplified approach to basement construction

9.1.2. ASSUMPTIONS FOR THE SIMPLIFIED APPROACH

The simplified approach is based on the following assumptions:

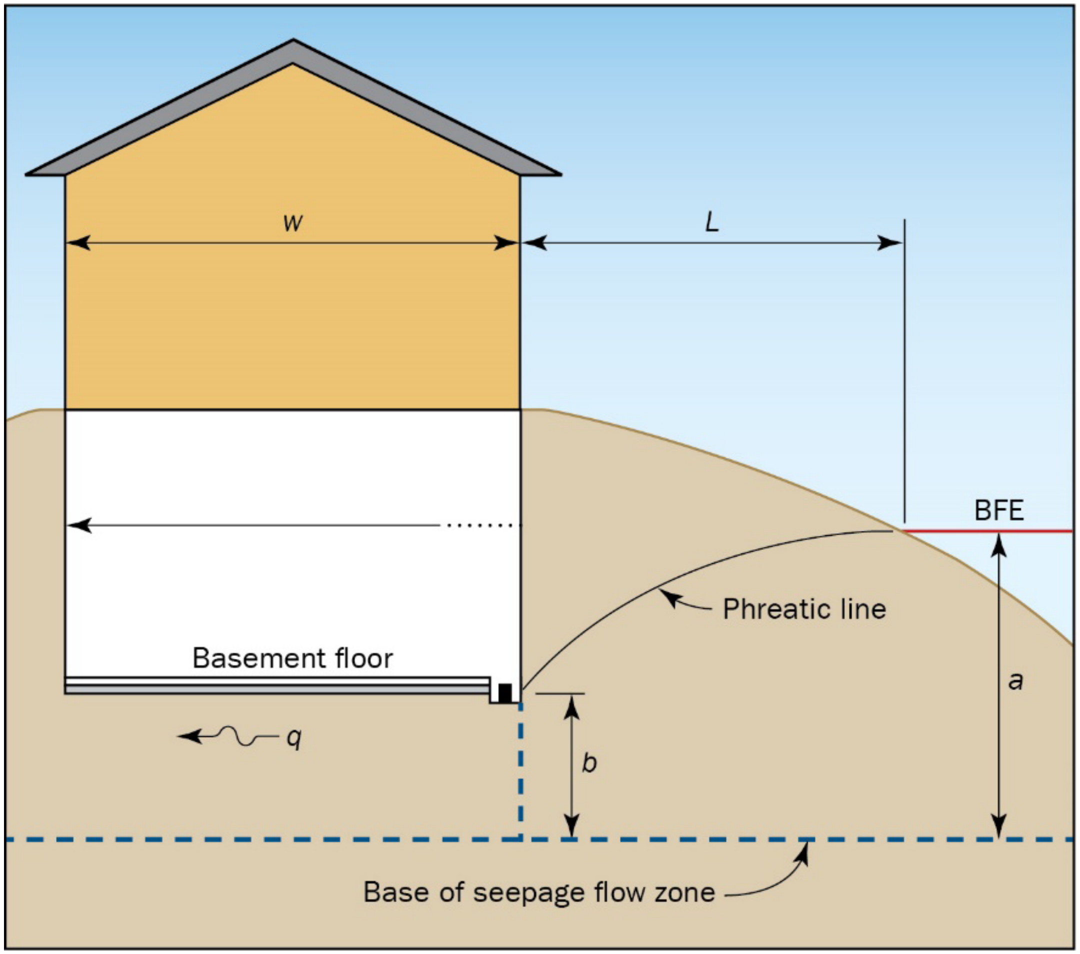
- The soil is saturated. Using this assumption means there will be no time lag in the development of the seepage pattern with a change in flood levels. The groundwater table in many floodplains is shallow and fine-grained soils have a substantial potential for maintaining saturation above the water table by capillary rise.

- The tailwater level is at the elevation of the BFE. For this Technical Bulletin, "tailwater" is defined as the groundwater level on the side of the building away from the flooding source. This is a reasonably conservative assumption because the groundwater level is expected to rise during flooding conditions. In some cases, the tailwater level can be higher than the flood level because there is higher ground, such as a valley wall, that drains groundwater into the floodplain soils.

- The quantity of seepage flow can be calculated by the Dupuit equation for flow in an unconfined aquifer, in this case for flow in fill. The Dupuit equation uses Darcy's law with specific physical characteristics. A more detailed description of these equations and their application can be found in standard references for soil mechanics and groundwater hydrology. The Dupuit equation and the values used in the Dupuit equation are illustrated in Figure 8.

- The entry surface, with hydraulic head "*a*," is a vertical line measured beginning where the BFE intersects the fill, extending down to the base of seepage flow zone.
- The exit surface, with hydraulic head "*b*," is a vertical line measured beginning from the basement floor closest to the fill slope, extending down to the base of seepage flow zone.
- The length of the flow path, "*L*," is the setback distance.
- Flow is assumed to be horizontal. For simplicity, the small, inclined entry zone at the edge of the water source and the exit zone below the basement floor are ignored. This is a reasonably conservative measure.
- The soil permeability, "*k*," is based on the type of fill soils. Because the soils must be homogeneous and seepage flow is assumed to be horizontal, only one value for "*k*" is used.
- The phreatic line (the line below which the seepage flow occurs), extends from the edge of the fill in contact with floodwater to the bottom of the basement floor slab. If the exit zone below the basement floor was included, the hydraulic head at "*b*" would be higher. As shown in Figure 8, the phreatic line is not a straight line, but within the limits of the boundary values assumed for the simplified approach, it is close to a straight line.
- To obtain the total quantity seepage flow in cubic feet per second, the value "*Q*," the unit quantity of seepage, "*q*," is multiplied by the length around the perimeter of the below-grade portion of the building, "*P*."

Soil permeability, "*k*," has a significant effect on the quantity of seepage that must be collected and discharged by the drainage layer and sump pump. The calculation of "*Q*" determines the number and capacity of sump pumps (the horsepower requirement, also called "size"). To allow for possible errors in the estimation of soil permeability, the pump or pumps should have a capacity of at least four times the calculated value of "*Q*." As noted in Section 9.1.1 of this Technical Bulletin, a minimum of at least one standard sump pump of ¼ horsepower is needed to satisfy the requirements of seepage removal for the conditions described in this section for use of the simplified approach. Equation 1 shows an example calculation of sump pump capacity.



The Dupuit equation for the quantity of seepage flow is:

$q = k(a^2 - b^2)/2L$

where: q = flow in cubic feet per second for a 1-foot width of seepage zone

k = soil permeability in feet per second (fps) (maximum value of k is $1x10^{-3}$ fps)

a = hydraulic head at entry surface in feet ($a < b + 5$)

b = hydraulic head at drain surface in feet

L = length of the seepage zone (setback distance) in feet ($L > 20$ feet)

The equation for the total seepage flow is:

$Q = Pq$

Q = total seepage flow in cubic feet per second

P = length around the perimeter of the below-grade portion of the structure

Required sump pump capacity is:

Capacity = $4Q$

Figure 8: Method of calculating quantity of seepage flow using the Dupuit equation

The following is an example calculation of sump pump capacity within the limits of the simplified approach. The variables are defined in Figure 8.

Equation 1:

$$q = \frac{k\left(a^2 - b^2\right)}{2L} = 1 \times 10^{-3} \times \frac{81 - 25}{40} = 0.0014 \text{ cubic feet per second per linear foot}$$

$$Q = P \times q = 140 \times 0.0014 = 0.196 \text{ cubic feet per second}$$

$$\text{Capacity} = 4Q = 4(0.196) = 0.784 \text{ cubic feet per second}$$

Where:

k = 1×10^{-3} feet per second

a = 9 feet

b = 5 feet

L = 20 feet

P = 140 feet (length = 40 feet; width = 30 feet)

9.2. Engineered Analysis Approach

The engineered analysis approach is an evaluation of proposed fill soils and seepage when basements are excavated into fill. When the design requirements, limitations, and assumptions described for the simplified approach (Section 9.1 of this Technical Bulletin) cannot be satisfied, detailed engineering analyses must be prepared by a licensed professional engineer, geotechnical engineer, engineering geologist, or other qualified professional. Reports of the results of the analyses help local officials to determine whether proposed buildings with basements constructed in fill with the basement floor below the BFE will be reasonably safe from flooding, which is needed for the local official to be able to sign the MT-1 Community Acknowledgement Form. Detailed engineering analyses should consider, but are not limited to, the issues described in the following sections.

9.2.1. DEPTH, TYPE, AND STRATIFICATION OF SOILS

The combination of depth of soil, soil type, and stratification of soils at specific sites may be complex, whether the soils are natural soils or fill material. An engineering analysis of whether a basement will be reasonably safe from flooding must account for variations in soils as part of applying the Dupuit equation to estimate the total amount of seepage that must be collected and discharged by the drainage layer and sump pump (see Figure 8 and Equation 1). The total amount of seepage determines the number and size (or capacity) of sump pumps necessary.

Terminology: Pervious and Impervious Soils

In the Dupuit equation, soil permeability, “k,” varies based on the characteristics of the soils:

- Pervious soils, also called well drained soils, allow relatively free movement of water.
- Impervious soils have low infiltration rates and offer resistance to the movement of water.

It is common for natural floodplain soils to be stratified in layers of different soil compositions. Four general cases illustrating how soil types and stratification affect seepage into basements are shown in Figure 9. Case A and Case B show homogeneous soils and Case C and Case D show simple stratified soils:

- Case A illustrates impervious clayey soils, either fill or natural deposits or a combination, which are more or less homogeneous and have similar engineering properties, including low permeability. If an adequate setback distance is provided (see “L” in Figure 8), the quantity of seepage flow (“*q*”) into a basement would be relatively low, and uplift pressure beneath the slab could be controlled by a drainage layer and adequately sized sump pump.

- Case B illustrates pervious sandy soils, either fill or natural soil deposits or a combination, which are more or less homogeneous and have similar engineering properties, including high permeability. The quantity of seepage flow (“*q*”) into a basement could be fairly large, in which case attention would have to be given to the setback distance and to the design of the drainage layer and an adequately sized sump pump to prevent excessive uplift pressure beneath the floor slab.

- Case C illustrates stratified soils with the contact between the two strata at some distance below a proposed basement floor. The quantity of seepage flow would be moderate, depending on the thickness (“*d*”) of the layer of impervious soils below the basement floor. There is also potential for uplift pressure beneath the floor slab, at the level of the bottom of the impervious stratum. These factors must be considered when specifying the drainage layer and when determining an adequate number and size (capacity) of sump pumps.

- Case D shows impervious soils overlying pervious soils, with the contact between the soil strata at some distance above the basement floor. Depending on how deep into the pervious layer the basement extends, there could be a large quantity of seepage (“*q*”) and potential for excessive uplift beneath the basement floor, which must be controlled by installing a drainage layer and an adequate number and size (capacity) of sump pumps.

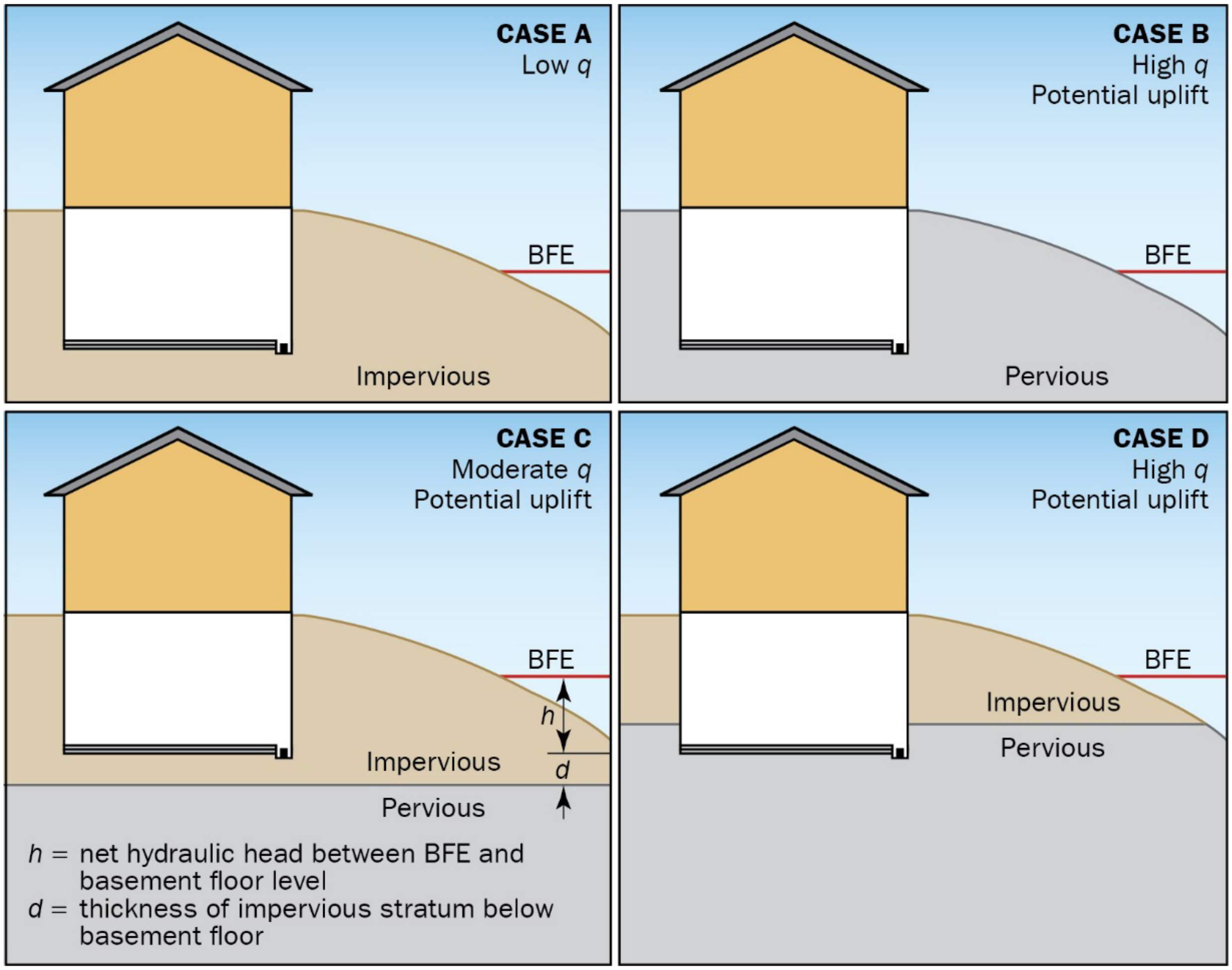


Figure 9: Generalized scenarios with homogeneous (Cases A and B) and stratified (Cases C and D) soils affecting quantity of seepage ("q") into basements

9.2.2. GEOTECHNICAL INVESTIGATIONS FOR ENGINEERING ANALYSES

In addition to the engineering design of regular foundations, the design professional who prepares an engineering analysis may require geotechnical investigations to determine whether a building with a basement in fill, with the basement floor below the BFE, will be reasonably safe from flooding. Information that is needed to prepare an engineering analysis includes:

- A flow net that accounts for all boundary conditions may be required for analysis of uplift pressures. Uplift pressures may be more significant in stratified soils than in homogeneous soils.
- The BFE, which is to be used as the floodwater entry surface for calculating expected seepage. The entry surface, with hydraulic head, "a," is a vertical line measured beginning where the BFE intersects the fill, extending down to the base of seepage flow zone (see Figure 8).
- The depth below grade of the bottom of the basement floor, which is to be used as the exit or drainage surface. The foundation design should be adjusted as needed to decrease the depth of the basement floor to achieve more suitable conditions. The exit surface, with hydraulic head,

"b," is a vertical line measured beginning from the basement floor closest to the fill slope, extending down to the base of seepage flow zone (see Figure 8).

- The setback distance from the edge of the SFHA to the nearest wall of the basement, shown as "L" in Figure 8. The location of the building can be moved farther away from the flooding source to achieve more suitable seepage control. The design professional will determine the length of the flow path which, at a minimum, is the setback distance. Figure 8

- The elevation of the groundwater table and its seasonal variations. It may not be feasible to have basements when sites have normally high water tables, even without the added seepage that may occur during flood events.

- The stratification of the subsurface materials, for both natural and fill soils (see Section 9.2.1 of this Technical Bulletin). In general, borings should be drilled to a depth below the proposed bottom of the basement floor slab, extending at least two times the depth of the floor slab below the BFE.

- The engineering classification of the soils, for both the natural underlying soils and the fill soils. The classification should be determined in accordance with ASTM D2487, *Standard Practice for Classification of Soils for Engineering Purposes* (Unified Soil Classification System), which is used throughout the United States. Typical local or county agricultural soil survey maps may not be sufficient because they do not give site-specific information at a small enough scale to provide detailed location and depth of soils, and their designations are not pertinent to use for engineering designs.

- Subsurface conditions landward from the building, away from the source of flooding. Conditions of interest include the location of the groundwater table (whether it is higher or lower than the BFE) and whether there is any penetration of soil layers, such as ponds, that are sources of subsurface water. Attention should be given to the possibility that higher ground, such as valley walls, could contribute to the groundwater level in the floodplain, either perennially or during periods of heavy rain.

- Whether a proposed basement will have penetrations through the basement walls, such as utility lines and other openings. Unless specifically sealed to prevent infiltration, penetrations may allow seepage that is not accounted for when determining the number and size (capacity) of sump pumps.

10. References

This section lists references cited in the Technical Bulletin. Additional resources related to NFIP requirements are provided in Technical Bulletin 0.

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- Technical Bulletin 0, *User's Guide to Technical Bulletins*
- Technical Bulletin 1, *Requirements for Flood Openings in Foundation Walls and Walls of Enclosures*
- Technical Bulletin 4, *Elevator Installation*

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Technical Bulletin

Crawlspace Construction

for Buildings Located in Special Flood Hazard Areas
National Flood Insurance Program Interim Guidance

FEMA TB-11 / November 2001

FEMA

Key Word/Subject Index

This index allows the user to locate key words and subjects in this Technical Bulletin. The Technical Bulletin User's Guide (printed separately) provides references to key words and subjects throughout the Technical Bulletins. For definitions of selected terms, refer to the Glossary at the end of this bulletin.

Any comments on the Technical Bulletins should be directed to:

Federal Emergency Management Agency
Federal Insurance and Mitigation Administration
500 C Street, SW.
Washington, DC 20472

Wave design on cover based on the Japanese print *The Great Wave Off Kanagawa*, by Katsuchika Hokussai (1760–1849), Asiatic Museum of Fine Arts, Boston.

TECHNICAL BULLETIN 11-01

Crawlspace Construction for Buildings Located in Special Flood Hazard Areas National Flood Insurance Program Interim Guidance

Introduction

Crawlspace foundations are commonly used to elevate the lowest floors of residential buildings located in Special Flood Hazard Areas (SFHAs) above the Base Flood Elevation (BFE). This Technical Bulletin provides guidance on crawlspace construction and supports a recent policy decision to allow construction of crawlspaces with interior grades up to 2 feet below the lowest adjacent exterior grade (LAG), referred to as below-grade crawlspaces, provided that other requirements are met. Prior to that decision, below-grade crawlspaces were considered basements under the National Flood Insurance Program (NFIP) Floodplain Management Regulation definitions at 44 CFR 59.1 and were not permitted below the BFE. This requirement had been established because below-grade crawlspace foundation walls are exposed to increased forces during flood conditions, such as hydrostatic and saturated soil forces.

In many parts of the country, a common practice is to construct crawlspaces with the interior floor 1 or 2 feet below-grade by either (1) backfilling against the exterior of the foundation wall or (2) excavating the crawlspace area to construct footings that result in a below-grade crawlspace floor. Because FEMA wishes to recognize common construction practices that do not increase flood damage, FEMA recently completed a review of the policy for residential crawlspace construction. In this review, the construction practices for below-grade crawlspaces were examined to determine whether a crawlspace that was 1 or 2 feet below grade would increase the flood damage potential to the foundation walls or result in additional damages to the building.

The review included (1) an engineering analysis that assessed the damage potential of floodwaters acting upon below-grade crawlspace foundation walls, (2) a review of available NFIP claims history for crawlspaces, and (3) input from FEMA Regional staff and NFIP General Adjusters of any firsthand knowledge of crawlspace damage during flood events. A review of NFIP claims history and staff input did not reveal evidence of structural damage or failure of crawlspace foundation walls during flood events. The engineering analysis indicates that below-grade foundation walls, when constructed according to common practice, have sufficient capacity to resist flood-related forces from standing and low-velocity floodwaters, subject to the requirements outlined in this bulletin.

This Technical Bulletin presents NFIP minimum requirements for crawlspace construction in the SFHA, including (1) requirements for all crawlspace construction and (2) requirements for below-grade crawlspace construction that may extend 1 or 2 feet below grade in the SFHA. This Technical Bulletin also provides a best practices approach for preferred and below-grade crawlspace construction, illustrated in Figures 1 and 2, including design limitations, water accumulation and drainage considerations, and use of flood-resistant materials. While communities may now allow below-grade crawlspace construction in the SFHA, this type of construction is not the recommended construction method, because of the increased likelihood of problems with water accumulation, moisture damage, and drainage. The use of crawlspace construction with the interior grade at or above the LAG minimizes the occurrence of these problems. This interim guidance on residential crawlspace construction is based on conclusions from the recently completed review and analyses.

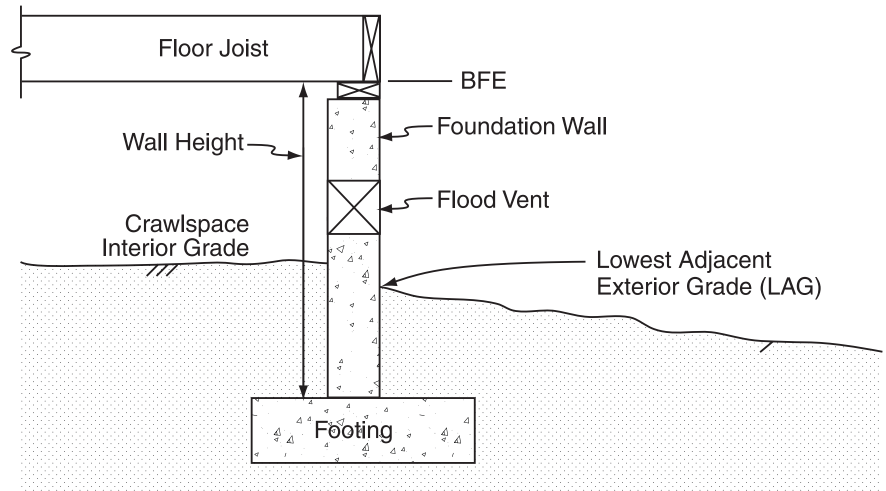

Figure 1 Preferred crawlspace construction.

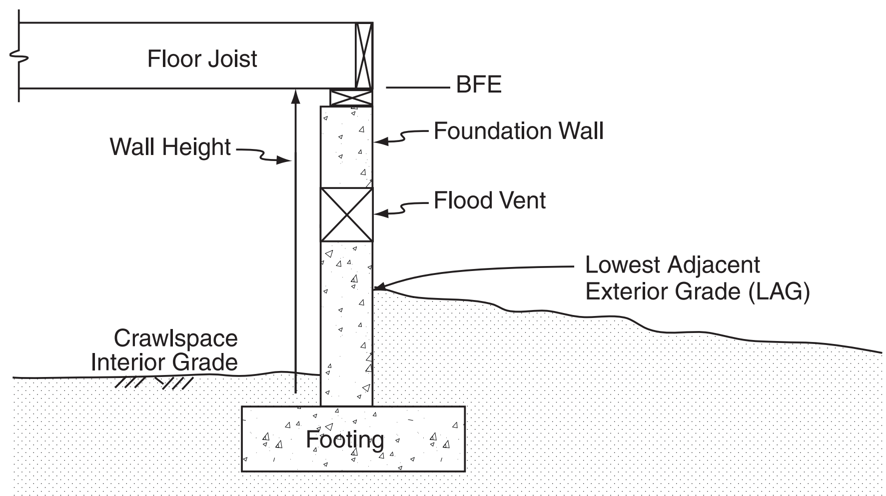

Figure 2 Below-grade crawlspace construction.

This Technical Bulletin provides **interim** guidance. The decision whether or not to allow below-grade crawlspace construction will be left to each community. Communities should review applicable state laws, regulations, and building codes, and consult with their State NFIP Coordinator to determine whether below-grade crawlspace construction is permitted in their state. Communities that choose to allow below-grade crawlspace construction will be required to amend their floodplain management ordinance to include the provisions outlined in the following sections on below-grade crawlspace construction. Please note that communities that choose to amend their ordinance to allow for below-grade crawlspaces in response to this interim guidance may also be required at some later date to amend their ordinance if FEMA adopts revised regulations that differ from the interim guidance.

Note

Any building utility systems within the crawlspace must be elevated above the BFE or designed so that floodwaters cannot enter or accumulate within system components during flood conditions. Ductwork, in particular, must either be placed above the BFE or sealed to prevent the entry of floodwaters. FEMA 348, *Protecting Building Utilities from Flood Damage*, provides detailed guidance on designing and constructing flood-resistant utility systems.

NFIP Requirements

NFIP requirements that apply to crawlspace construction are found in sections 44 CFR 60.3(a)(3) and 60.3(c)(2) and (c)(5) of the NFIP regulations. NFIP requirements that apply to all crawlspaces are discussed in the first section below. The second section lists additional requirements that must be applied to crawlspaces that have interior grades below the LAG. The additional requirements are intended to ensure that these crawlspaces are not subject to flood-related loads that would exceed the strength of the crawlspace wall and lead to failure and significant damage to the building or to other damage related to poor drainage in the below-grade crawlspace.

NFIP Requirements for All Crawlspace Construction

Crawlspaces are commonly used as a method of elevating buildings in SFHAs to or above the BFE. General NFIP requirements that apply to all crawlspaces that have enclosed areas or floors below the BFE include the following:

- The building must be designed and adequately anchored to resist flotation, collapse, and lateral movement of the structure resulting from hydrodynamic and hydrostatic loads, including the effects of buoyancy. Hydrostatic loads and the effects of buoyancy can usually be addressed though the required openings discussed in the next bullet. Because of hydrodynamic loads, crawlspace construction is not recommended in areas with flood velocities greater than 5 feet per second unless the design is reviewed by a qualified design professional, such as a registered architect or professional engineer. Other types of foundations are recommended for these areas.
- The crawlspace is an enclosed area below the BFE and, as such, must have openings that equalize hydrostatic pressures by allowing for the automatic entry and exit of floodwaters. The bottom of each flood vent opening can be no more than 1 foot above the lowest adjacent exterior grade. For guidance on flood openings, see Technical Bulletin 1-93, *Openings in Foundation Walls*.

- Crawlspace construction is not permitted in V zones. Open pile or column foundations that withstand storm surge and wave forces are required in V zones.
- Portions of the building below the BFE must be constructed with materials resistant to flood damage. This includes not only the foundation walls of the crawlspace used to elevate the building, but also any joists, insulation, or other materials that extend below the BFE. The recommended construction practice is to elevate the bottom of joists and all insulation above BFE. Insulation is not a flood-resistant material. When insulation becomes saturated with floodwater, the additional weight often pulls it away from the joists and flooring. Ductwork or other utility systems located below the insulation may also pull away from their supports. See the section Flood-Resistant Materials, on page 8 this bulletin. For more detailed guidance on flood-resistant materials see Technical Bulletin 2-93, *Flood-Resistant Materials Requirements*.
- Any building utility systems within the crawlspace must be elevated above BFE or designed so that floodwaters cannot enter or accumulate within the system components during flood conditions. Ductwork, in particular, must either be placed above the BFE or sealed from floodwaters. For further guidance on the placement of building utility systems in crawlspaces, see FEMA 348, *Protecting Building Utilities From Flood Damage.*

Flood-resistant materials and utilities, access, and ventilation openings in crawlspaces are further addressed in this bulletin.

Additional Requirements for Below-Grade Crawlspaces

If a community chooses to amend its floodplain management ordinance to allow for the construction of below-grade crawlspaces, the ordinance must include the following provisions in addition to the above requirements:

- The interior grade of a crawlspace below the BFE must not be more than 2 feet below the lowest adjacent exterior grade (LAG), shown as D in Figure 3.
- The height of the below-grade crawlspace, measured from the interior grade of the crawlspace to the top of the crawlspace foundation wall must not exceed 4 feet (shown as L in Figure 3) at any point. The height limitation is the maximum allowable unsupported wall height according to the engineering analyses and building code requirements for flood hazard areas (see the section Guidance for Pre-Engineered Crawlspaces, on page 7 of this bulletin). This limitation will also prevent these crawlspaces from being converted into habitable spaces.
- There must be an adequate drainage system that removes floodwaters from the interior area of the crawlspace. The enclosed area should be drained within a reasonable time after a flood event. The type of drainage system will vary because of the site gradient and other drainage characteristics, such as soil types. Possible options include natural drainage through porous, well-drained soils and drainage systems such as perforated pipes, drainage tiles, or gravel or crushed stone drainage by gravity or mechanical means.
- The velocity of floodwaters at the site should not exceed 5 feet per second for any crawlspace. For velocities in excess of 5 feet per second, other foundation types should be used.

• Below-grade crawlspace construction in accordance with the requirements listed above will not be considered basements.

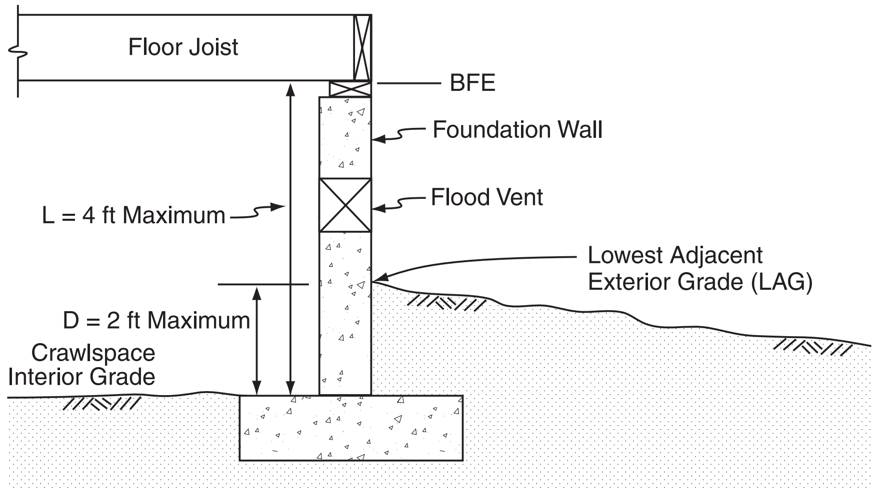

Figure 3 Requirements regarding below-grade crawlspace construction.

Drainage considerations for below-grade crawlspaces are further addressed in this bulletin. For additional information regarding this interim guidance, please contact the FEMA Regional Office or State NFIP Coordinator. Local FEMA regional offices are listed in the separately printed *User's Guide to Technical Bulletins* and may be found at the www.fema.gov website.

Flood Forces on Buildings

Buildings in flood hazard areas may be subjected to a variety of flood-induced forces. During inundation by standing or low-velocity floodwaters, a building must primarily resist hydrostatic pressures from saturated soils and floodwaters. This situation is typical of broad, flat floodplains and floodways along lower-gradient rivers and streams. During inundation by high-velocity floodwaters, a building must also resist hydrodynamic forces and impact loads. High-velocity floodwaters are found in floodways along steeper-gradient rivers, sheet flow down slopes, or coastal areas with storm surge and waves.

The community Flood Insurance Study contains a Floodway Data Table that includes data on mean velocities (in feet per second) within the floodway at each cross section along the river or stream. The mean averages the higher channel velocities with lower velocities in overbank areas that are within the floodway. Generally, velocities at sites outside of the floodway are lower than the mean floodway velocities listed in the Floodway Data Table. For example, if the mean floodway velocity at a cross section is 4 feet per second, the velocities outside the floodway are likely less than that value. If in doubt about the floodway velocity or in areas where the mean floodway velocity may exceed 5 feet per second, contact an engineer knowledgeable in hydraulics and hydrology to determine flood velocities at the building site.

Buildings located in areas subject to ponding or low-velocity flows must primarily address issues related to hydrostatic loads on the crawlspace foundation, removal of floodwater and sediment from the crawlspace area, and other NFIP floodproofing requirements, such as protecting or elevating utilities and using flood-resistant materials.

Crawlspace construction is not recommended in A zones with high-velocity floodwaters (greater than 5 feet per second). Other types of foundations, such as open pile or column foundations, that allow floodwaters to flow freely beneath the building are recommended for these areas.

Flood Insurance Implications

In May 1999, the Federal Insurance Administration (now the Federal Insurance and Mitigation Administration – FIMA) revised the rates being charged for residential buildings with below-grade crawlspaces. These rates were considerably lower than the full basement rates previously charged for these buildings. In May 2001, these rates were further reduced based on engineering analyses performed by FEMA. However, rates for buildings with below-grade crawlspaces will be higher than rates for buildings that have the interior grade of the crawlspace at or above the adjacent exterior grade, since the risk of flood damage is greater for the former type of construction. As more experience is gained on crawlspace losses, FEMA will continue to reassess those rates, factoring in the cost of pumping out and cleaning these areas, as well as physical damage to the foundation. Buildings with below-grade crawlspaces currently cannot be rated by an insurance agent using the NFIP *Flood Insurance Manual*. They must be submitted for a special rating under the Submit-to-Rate process by underwriters knowledgeable in this type of construction. FIMA will determine whether the rating for this type of construction should be standardized and included in the Flood Insurance Application and the *Flood Insurance Manual*.

Caution

Buildings that have below-grade crawlspaces will have higher flood insurance premiums than buildings that have the preferred crawlspace construction, with the interior elevation at or above the lowest adjacent exterior grade (LAG).

Best Practices for Crawlspace Foundations in SFHA

The NFIP preferred construction practice for excavated crawlspace construction is to backfill the interior area so that it is level with or higher than the LAG. If trench construction is used to place footings, the trenches should be backfilled to the level of the adjacent exterior grade, to avoid ponding of water. A reinforced masonry or concrete foundation wall that is anchored to the footing and lowest floor with connectors will provide the best performance in flood events. This type of construction will better resist hydrostatic pressures against the foundation and limit the amount of water that will pond under the building after a flood.

The 2000 *International Residential Code* (IRC 2000), Section 327, addresses flood-resistant design and construction of foundation walls in flood hazard areas and is consistent with NFIP requirements. The IRC requires that all structural systems in floodplains be designed, connected, and anchored to resist flotation, collapse, or permanent lateral movement due to structural loads from flooding equal to the design flood elevation. The IRC limits the unsupported height of plain (unreinforced) 8-inch hollow masonry walls to 4 feet for flood-resistant construction, where the unsupported height is the distance from the finished grade of the enclosed crawlspace area to the top of the foundation wall.

A community that chooses to allow the construction of below-grade crawlspaces should develop a multi-hazard approach that also resists other loads from hazards such as wind and earthquake. Crawlspace foundation walls must bear or resist all loads that may be experienced during their useful service life.

Guidance for Pre-Engineered Below-Grade Crawlspace Foundations

FEMA performed an engineering analysis to determine the effect of flood-related forces on crawlspace foundation walls (see Figure 4), particularly for unreinforced concrete and concrete masonry construction. The analysis followed design criteria prescribed in the American Concrete Institute (ACI) *Building Code Requirements and Commentary for Reinforced Concrete* (ACI 318-92) and the 1999 Masonry Standards Joint Committee (MSJC) *Building Code Requirements and Specifications*. Flood analysis procedures from FEMA 259, *Engineering Principles and Practices of Retrofitting Flood-Prone Residential Structures,* were used for calculating hydrostatic and hydrodynamic forces. A comprehensive analysis of two flood scenarios was conducted:

- Fully saturated soil and 1-foot-deep floodwaters, that just reach the bottom of the flood opening, but have not flooded the enclosed crawlspace area.
- A fully flooded crawlspace area with velocity floodwaters acting on the above-grade portion of the crawlspace walls.

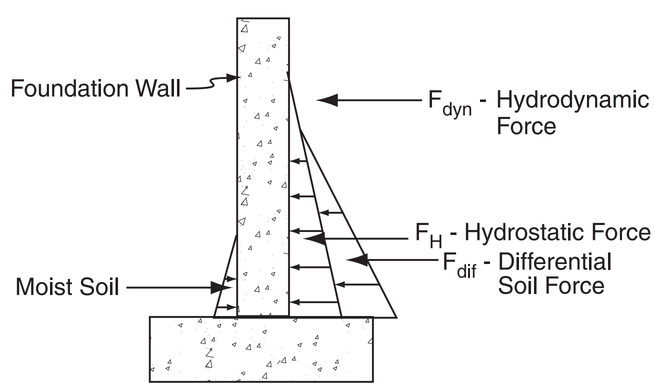

Figure 4 Flood-related forces on a crawlspace wall.

The first analysis evaluated four parameters: (1) wall construction of unreinforced 8-inch and 12-inch masonry block with standard M or S mortar type and 6-inch plain concrete foundation walls, (2) depth of interior crawlspace grade relative to the LAG, (3) flood velocity, and (4) soil types suitable for construction. The hydrostatic pressures from the saturated soil and 1-foot-deep floodwaters cause the maximum loads to occur in the lower section of the wall below the exterior grade. This analysis assumed that the 1-foot-deep floodwaters have a low velocity and are unlikely to cause significant hydrodynamic or impact loads on the foundation wall.

The second analysis evaluated hydrodynamic forces for varied flood depths and flood velocities on a foundation wall. The analysis assumed that the crawlspace was provided with proper openings to equalize hydrostatic pressure. Impact forces were not included in the analysis, as the shallow flood depths and low-velocity flows are not expected to produce significant debris impact damage. This decision was further supported by the lack of field evidence concerning wall failures from impact by debris. However, debris impact should be considered as part of the foundation wall design and analysis for riverine or other locations with high-velocity flows.

These analyses found that a crawlspace can resist flood-related forces for flood velocities up to 5 feet per second, if the wall height is limited to 4 feet and the top of the footing is no more than 2 feet below-grade.

As a result of these analyses, FEMA has determined that communities may allow below-grade residential crawlspace construction provided that the interior grade of the crawlspace does not exceed 2 feet below the LAG, and the height of the crawlspace measured from the interior grade of the crawlspace at any point to the bottom of the lowest horizontal structural member of the lowest floor does not exceed 4 feet for the specified wall construction.

Flood-Resistant Materials

All structural and non-structural building materials at or below the BFE must be flood resistant. A flood-resistant material is defined as any building material capable of withstanding direct and prolonged contact with floodwaters without sustaining significant damage. Flood-resistant materials must be used for all building elements subject to exposure to floodwaters, including floor joists, insulation, and ductwork. If flood-resistant materials are not used for building elements, those elements must be elevated above the BFE. The term "prolonged contact" means at least 72 hours, and the term "significant damage" means any damage requiring more than low-cost cosmetic repair (such as painting). This requirement applies regardless of the expected or historical flood duration. Technical Bulletin 2-93, *Flood Resistant Materials Requirements*, further defines NFIP criteria for flood-resistant materials and material categories.

Drainage Considerations

A significant issue associated with below-grade crawlspaces is drainage of the interior crawlspace area after normal precipitation and flood events. Moisture damage to a building can be severe when water remains standing in the crawlspace area after precipitation or a flood event. Standing water also creates significant health hazards, such as mosquito breeding grounds and growth of bacteria, mold, and fungus. If crawlspace access doors do not remain secured, standing water also presents a drowning hazard.

The interim guidance for below-grade crawlspace construction requires an adequate drainage system that allows floodwaters to drain from the interior area of the crawlspace within a reasonable time. A maximum time of 72 hours is recommended to minimize floodwater contact with crawlspace materials and related moisture damage. The interim guidance is not prescriptive as to a type of drainage system; however, it is the community's responsibility to ensure that all buildings with below-grade crawlspaces have adequate drainage systems to ensure that accumulated waters drain from the crawlspace area. Communities must include in their ordinances a provision that addresses drainage requirements.

Drainage systems for below-grade crawlspace areas will vary because of site characteristics and soil types. Possible drainage system options include perforated pipes, drainage tiles, or gravel or crushed stone drainage by gravity or mechanical means. Fill dirt placed around the outside of the foundation wall should be adequately graded to slope away from the foundation and aid natural site drainage. If lots are too small to provide adequate site drainage through grading, other methods, such as swales, may be used to provide drainage away from the structure. Foundation drainage practices required by local codes must be met in addition to drainage of the enclosed below-grade crawlspace area.

Any enclosed area below the BFE is subject to flood forces and must have exterior wall openings whose bottom edges are no more than 1-foot above the LAG, in accordance with NFIP regulations. The wall openings allow the automatic entry and exit of floodwaters and for the floodwaters to reach equal levels on both sides of the foundation wall. The only exception to this requirement is dry floodproofed non-residential buildings. Further information on NFIP requirements for flood openings in foundation walls is found in Technical Bulletin 1-93, *Openings in Foundation Walls*.

Utilities, Access, and Ventilation Openings

NFIP regulations at 44 CFR, Section 60.3(a)(3)(iv) require that "utility systems shall be constructed with electrical, heating, ventilation, plumbing, and air conditioning equipment and other service facilities that are designed and/or located to prevent water from entering or accumulating within the components during conditions of flooding." The utility systems can be either elevated above the BFE or floodproofed in a manner that prevents floodwaters from infiltrating or accumulating within any component of the system. Elevation is the recommended method of mitigation for utility systems in A Zones. FEMA 348, *Protecting Building Utilities from Flood Damage*, provides detailed guidance on designing and constructing flood-resistant utility systems.

Access and ventilation openings shall be provided to the crawlspace area according to the local building codes and regulations. Access and ventilation requirements under the IRC 2000 include the following:

- An access opening 18 inches by 24 inches shall be provided to the enclosed crawlspace area to allow access to mechanical equipment or building utilities located in this space.
- The minimum net area of required ventilation openings shall not be less than 1 square foot for each 150 square feet of enclosed crawlspace area. One such ventilation opening shall be within 3 feet of each corner of the building. Ventilation openings shall be covered with an appropriate material.

The NFIP

The NFIP was created by Congress in 1968 to provide federally backed flood insurance coverage, because flood coverage was generally unavailable from private insurance companies. The NFIP is also intended to reduce future flood losses by identifying floodprone areas and ensuring that new development in these areas is adequately protected from flood damage. The NFIP is based on an agreement between the Federal government and participating communities that have been identified as floodprone. FEMA, through the Federal Insurance and Mitigation Administration, makes flood insurance available to the residents of a participating community, provided the community adopts and enforces adequate floodplain management regulations that meet the minimum NFIP requirements. The NFIP encourages communities to adopt floodplain management ordinances that exceed the minimum NFIP criteria set forth in Part 60 of the NFIP Floodplain Management Regulations (44 CFR 60). Included in the NFIP requirements, found under Title 44 of the U.S. Code of Federal Regulations, are minimum building design and construction standards for buildings located in SFHAs. Through their floodplain management ordinances or laws, communities adopt the NFIP performance standards for new, substantially improved, and substantially damaged buildings in floodprone areas identified on FEMA's Flood Insurance Rate Maps (FIRMs).

Technical Bulletins

This publication is one of a series of Technical Bulletins that FEMA has produced to provide guidance concerning the building performance standards of the NFIP. These standards are contained in 44 CFR 60.3. The bulletins are intended for use primarily by state and local officials responsible for interpreting and enforcing NFIP regulations and by members of the development community, such as design professionals and builders. New bulletins, as well as updates of existing bulletins, are issued periodically, as necessary. The bulletins do not create regulations; rather they provide specific guidance for conforming with the minimum requirements of existing NFIP regulations. Users of the Technical Bulletins who need additional guidance concerning NFIP regulatory requirements should contact the Mitigation Division of the appropriate FEMA Regional Office or the local floodplain administrator. NFIP Technical Bulletin 0, *User's Guide to Technical Bulletins,* lists the bulletins issued to date, provides a key word/subject index for the entire series, and lists addresses and telephone numbers for FEMA's 10 Regional Offices.

Ordering Information

Copies of FEMA Technical Bulletins can be obtained from the FEMA Regional Office that serves your area. In addition, Technical Bulletins and other FEMA publications can be ordered from the FEMA Publications Distribution Facility at 1-800-480-2520. The Technical Bulletins are also available at the FEMA web site at www.fema.gov.

Further Information

The following publications contain information related to the guidance presented in this bulletin:

American Concrete Institute. 1992. ACI318-92. *Building Code Requirements and Commentary for Reinforced Concrete*. Detroit, MI.

American Society of Civil Engineers. 1998. SEI/ASCE 7-98. *Minimum Design Loads for Buildings and Other Structures*. Reston, VA.

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Federal Emergency Management Agency. 1986. *Floodproofing Non-Residential Structures*. FEMA 102. Washington, DC.

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National Association of Home Builders Research Foundation, Inc. 1977. *Manual for the Construction of Residential Basements in Non-Coastal Flood Environs*. Upper Marlboro, MD. March.

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Glossary

Base Flood – The flood that has a 1-percent probability of being equaled or exceeded in any given year (also referred to as the 100-year flood).

Basement – Any area of a building having its floor subgrade (below ground level) on all sides.

Community – Any state or area or political subdivision thereof, or any Indian tribe or authorized tribal organization, or Alaska Native village or authorized native organization, which has the authority to adopt and enforce floodplain management regulations for the areas within its jurisdiction.

Federal Emergency Management Agency (FEMA) – The independent Federal agency that, in addition to carrying out other activities, administers the NFIP.

Federal Insurance and Mitigation Administration (FIMA) – The component of FEMA directly responsible for administering the flood hazard identification, floodplain management, and flood insurance activities of the NFIP.

Flood Insurance Rate Map (FIRM) – The insurance and floodplain management map issued by FEMA that identifies, on the basis of detailed or approximate analysis, areas of 100-year flood hazard in a community.

Floodprone area – Any land area susceptible to being inundated by flood water from any source.

New construction/structure – For floodplain management purposes, new construction means structures for which the start of construction commences on or after the effective date of a floodplain management regulation adopted by a community and includes subsequent improvements to the structure. For flood insurance purposes, these structures are often referred to as "post-FIRM" structures.

Special Flood Hazard Area (SFHA) – Area subject to inundation by the base flood, designated Zone A, A1-30, AE, AH, AO, V, V1-V30, or VE.