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:

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Federal Insurance and Mitigation Administration (FIMA) Risk Management Directorate
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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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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).

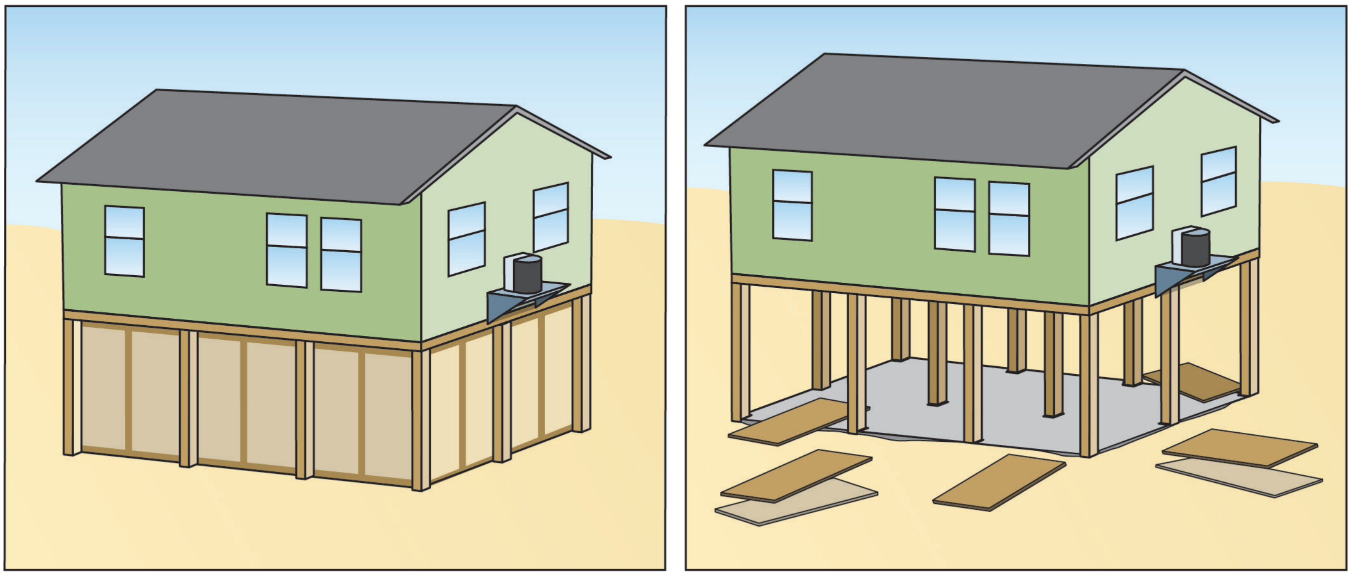

Figure 1: Breakaway walls enclosing an area below an elevated building in Zone V (left); breakaway wall enclosures that have broken away as a result of lateral flood loads (right)

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.

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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.*

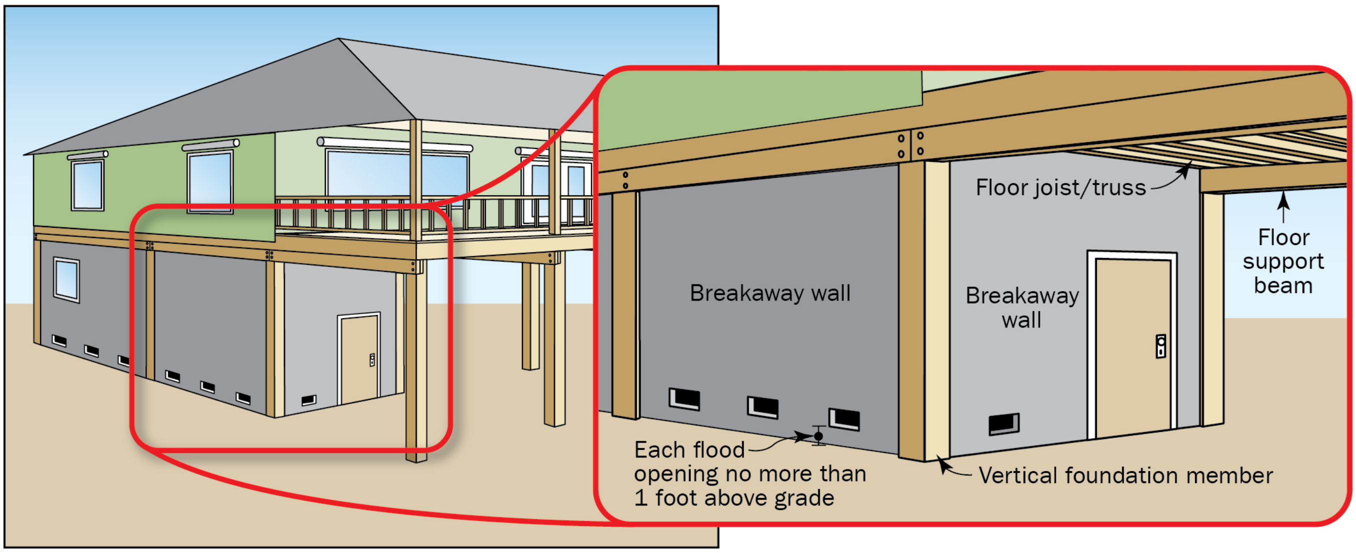


Figure 2: Flood openings in breakaway walls

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.

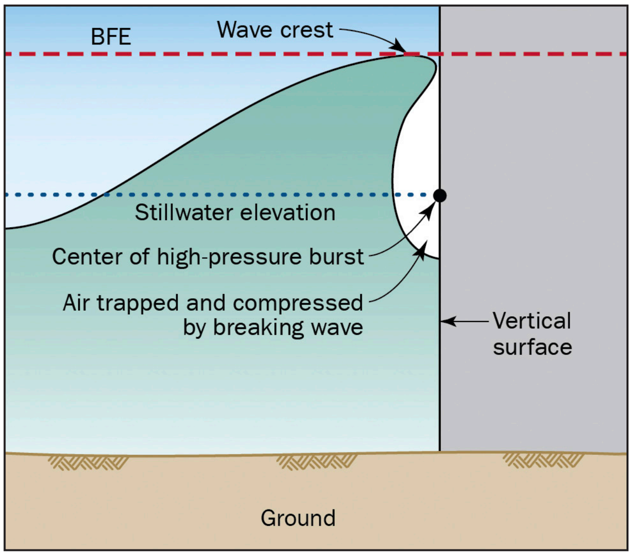


Figure 3: Impact of a breaking wave on a vertical surface

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

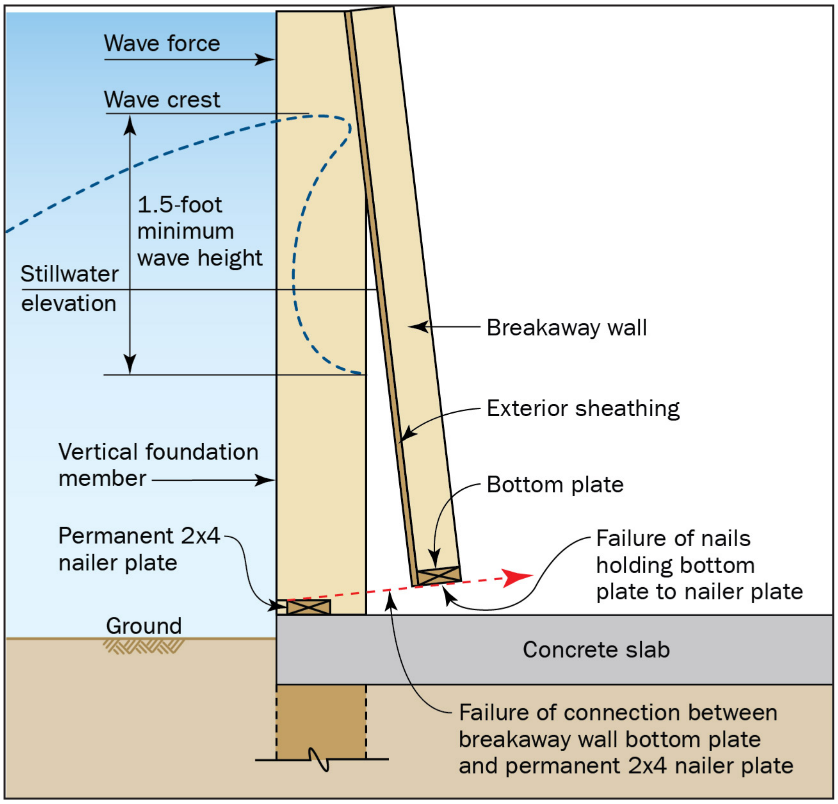
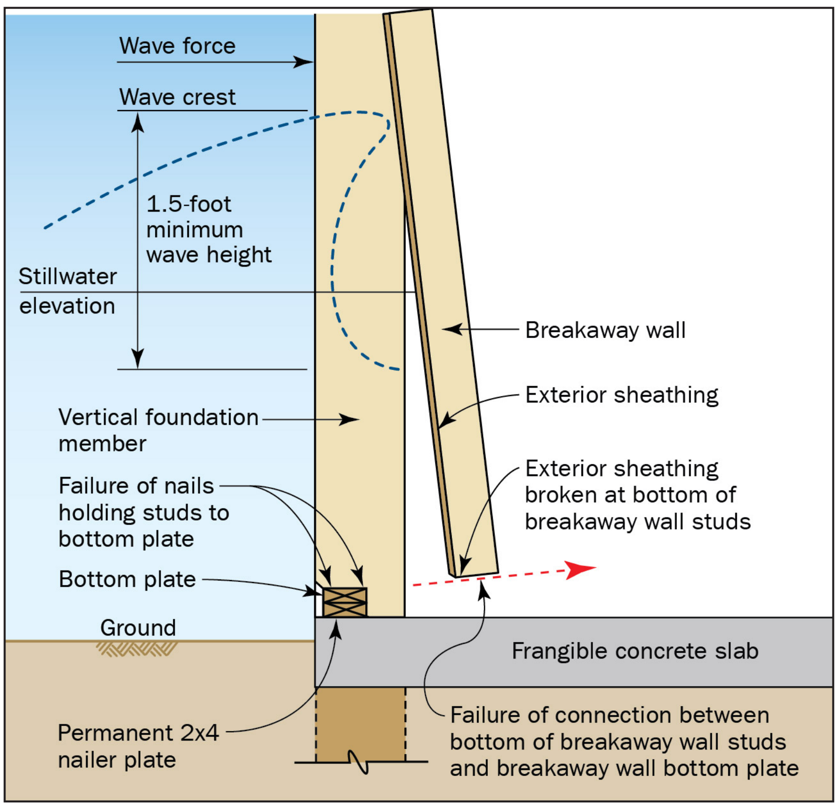


Figure 12: Secondary failure mode of wood-framed breakaway wall as determined from full-scale testing



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).

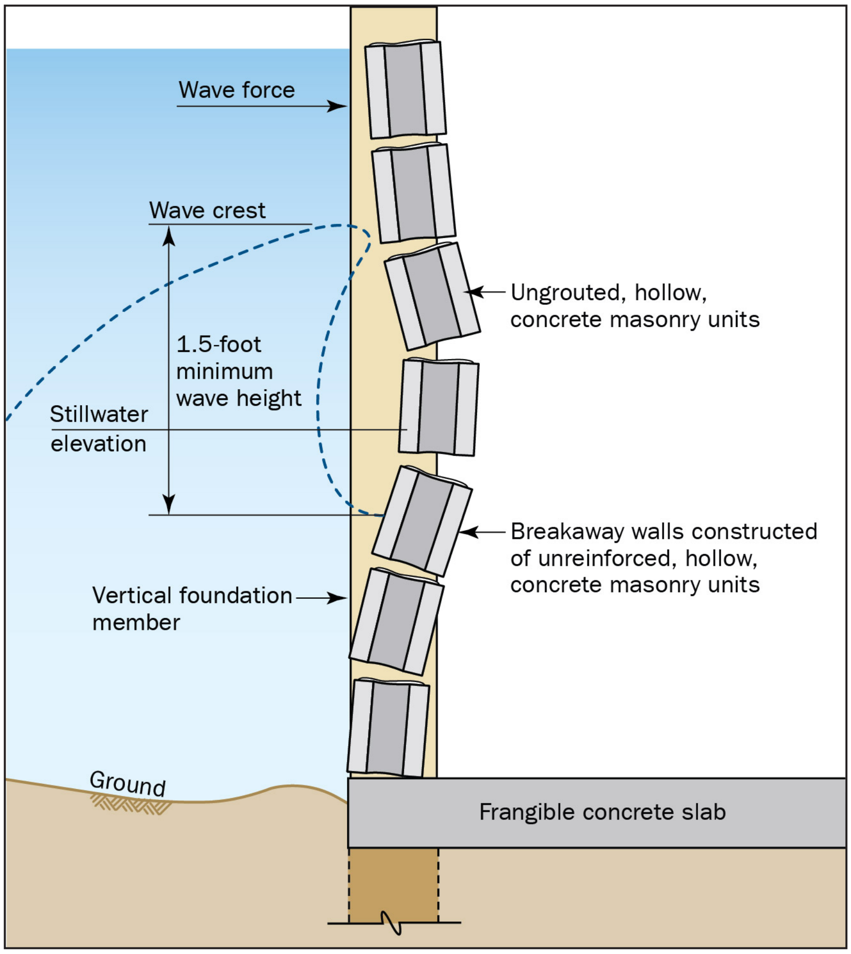


Figure 13: Expected failure mode of unreinforced masonry breakaway wall

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)

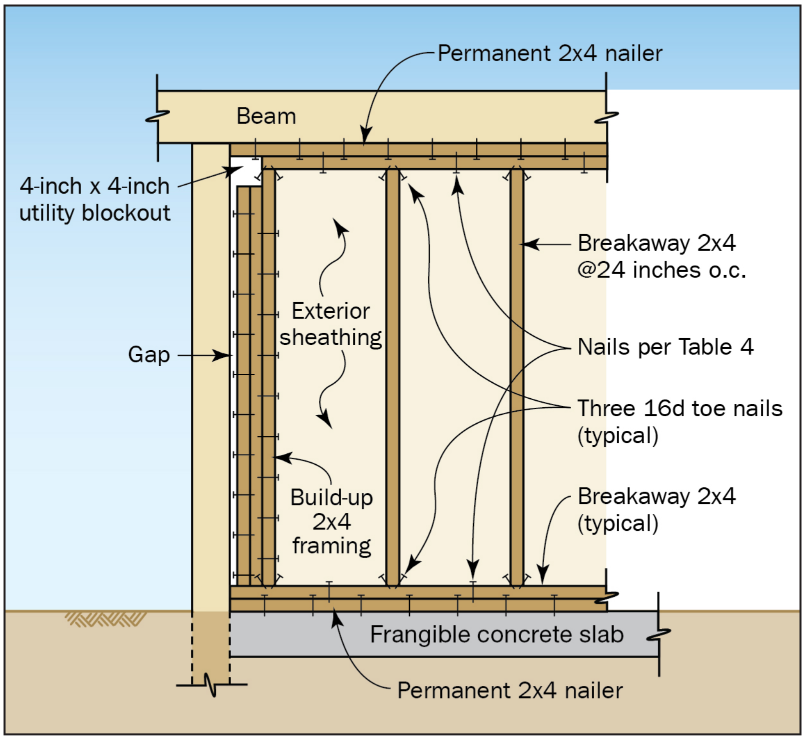


Table 4: Required Size and Number of Galvanized Common Nails for Wood-Framed Breakaway Walls with Different Heights and Pile Spacings

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

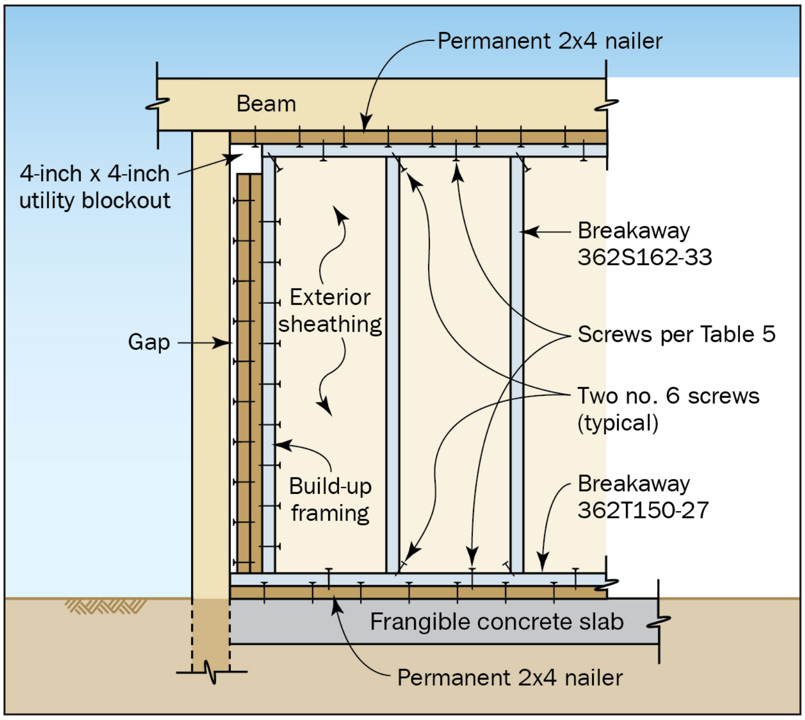


Figure 15: Typical steel stud-framed breakaway wall construction with designated section type, gauge, and size (prescriptive design method); see Table 5 for screw requirements. Note that two no. 6 screws are shown as a diagonal connection for clarity; the typical connection location is between the flanges 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.

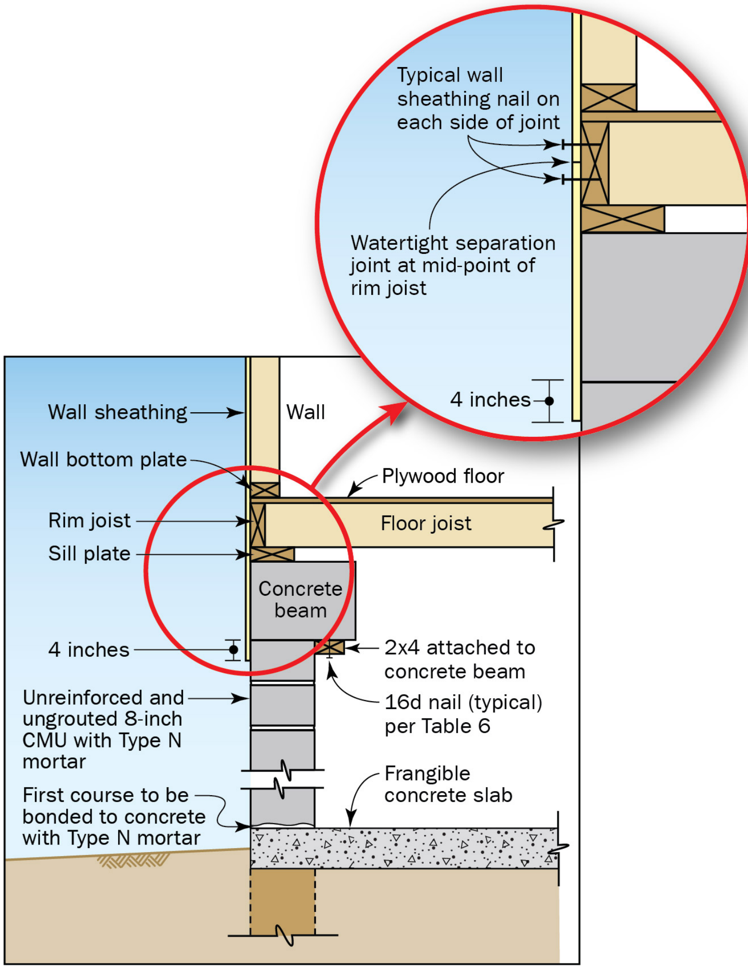


Figure 16: Typical breakaway masonry wall where the lowest horizontal structural member is a concrete beam (prescriptive design method); see Table 6 for nailing requirements

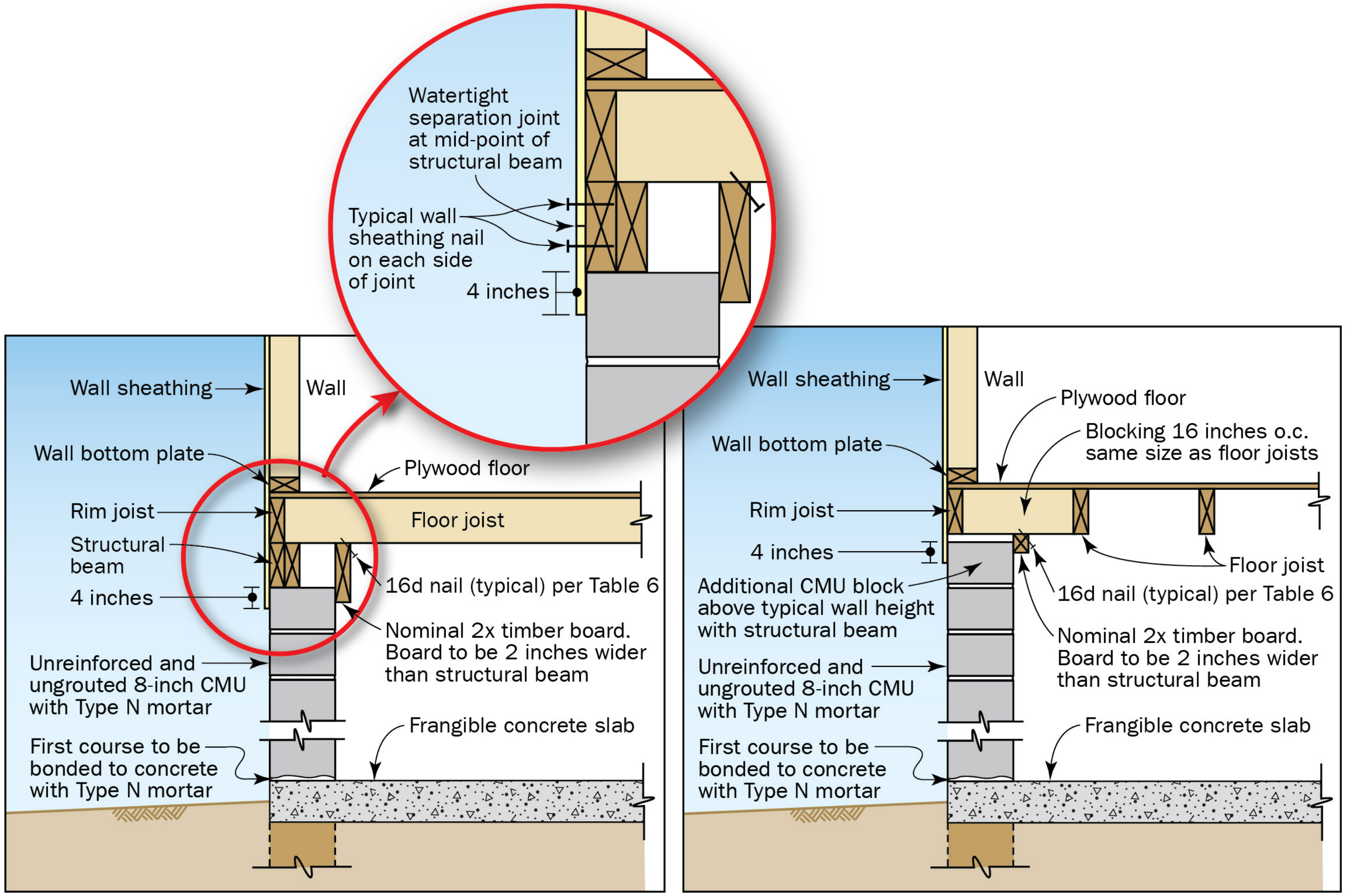


Figure 17: Typical breakaway masonry wall where the lowest horizontal structural member is a timber structural beam with floor joists bearing on the structural beam (prescriptive design method). Left image is perpendicular to the floor joists, and the right image is normal to the floor joists; see Table 6 for nailing requirements.

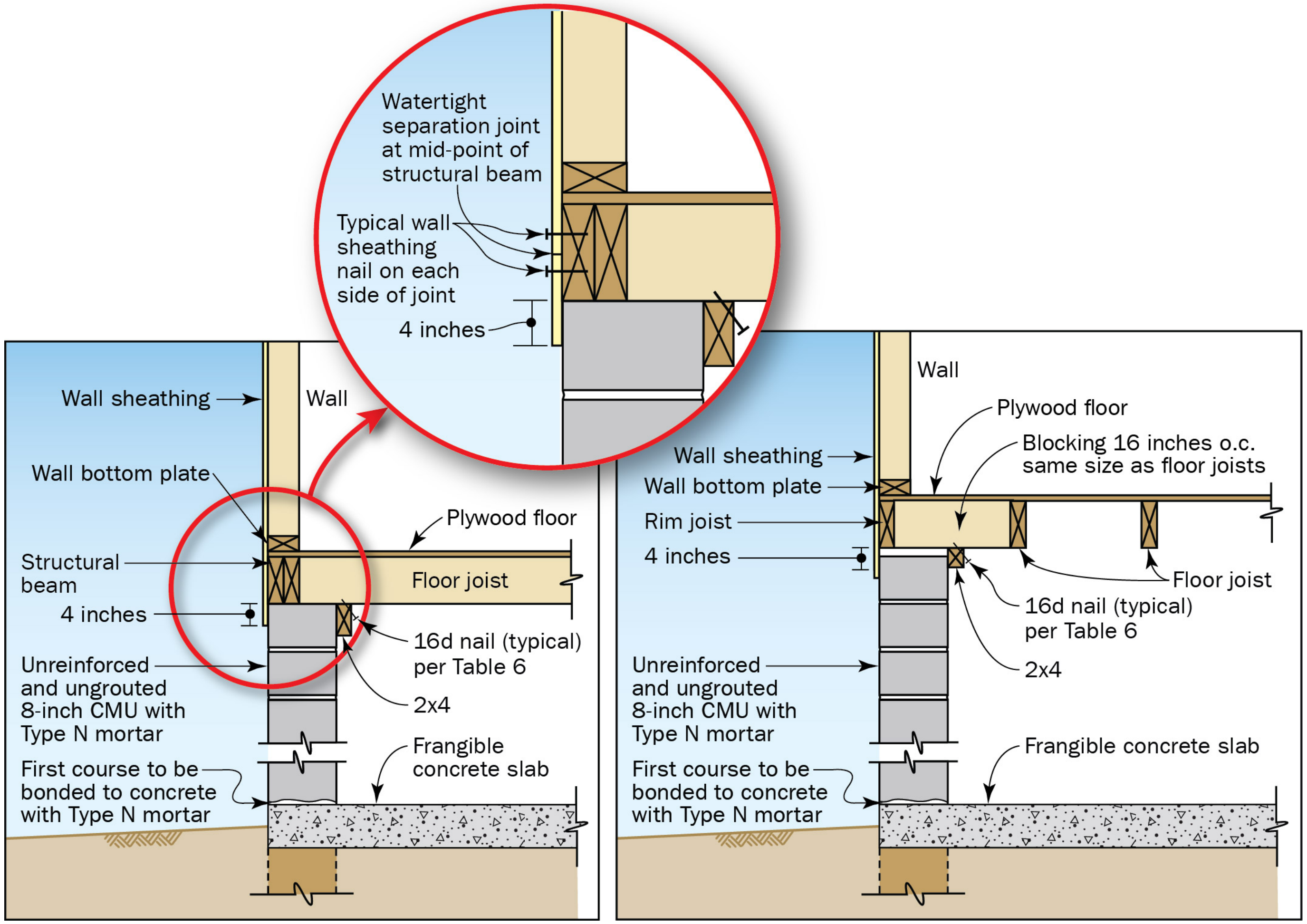


Figure 18: Typical breakaway masonry wall where the lowest horizontal structural member is a timber structural beam with floor joists hanging from the face of the structural beam (prescriptive design method). Left image is perpendicular to the floor joists, and the right image is normal to the floor 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.

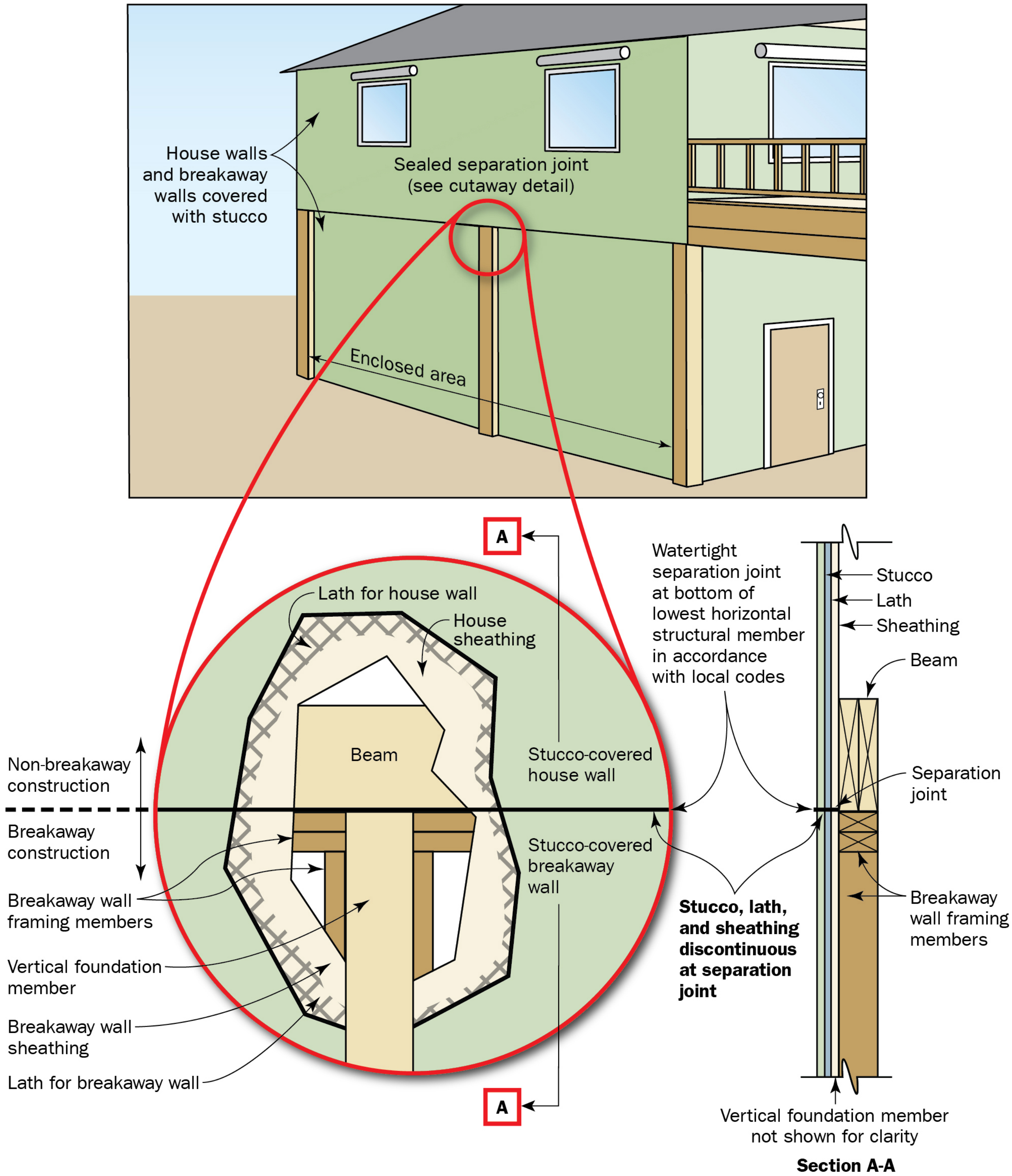


Figure 19: Separation joint between sheathing and wall covering (e.g., stucco, siding) on house walls and breakaway walls

- 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.

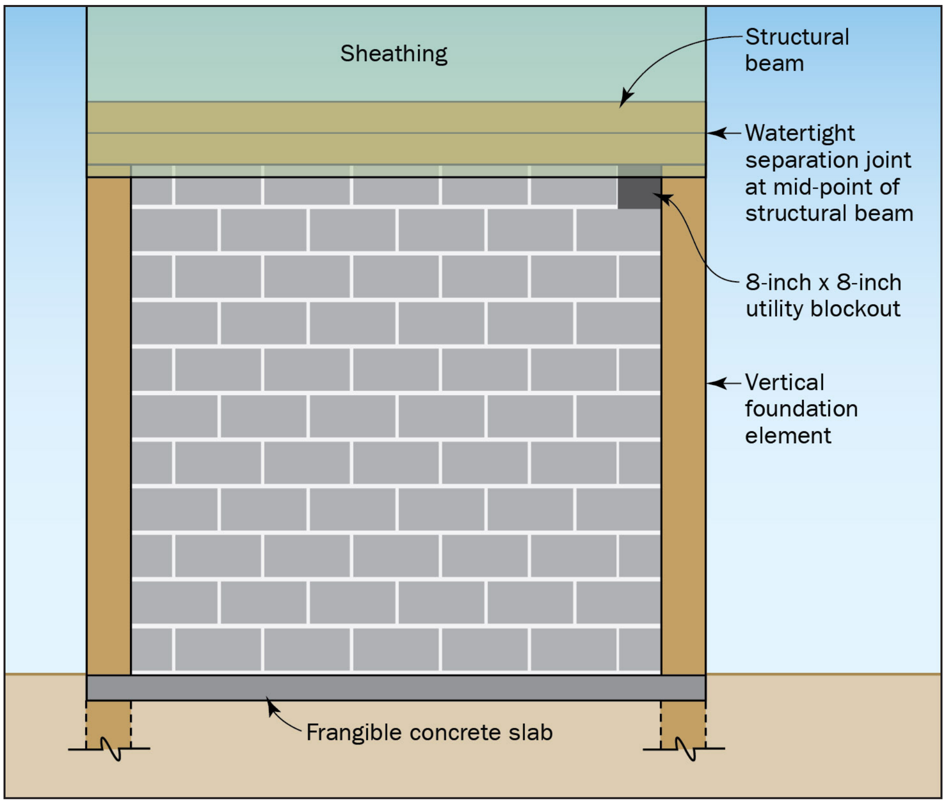


Figure 20: Utility blockout for an unreinforced masonry breakaway wall

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).

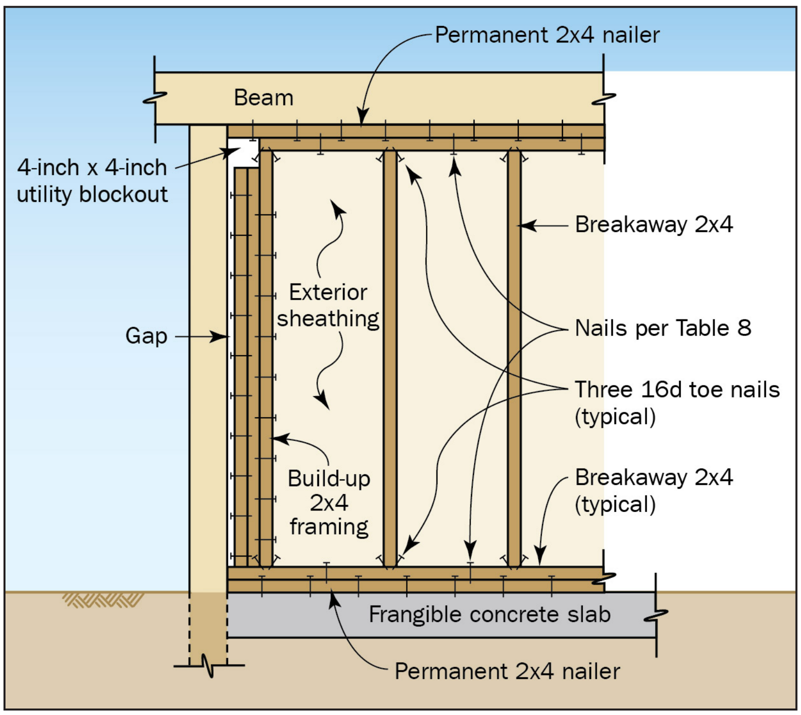


Figure 21: Typical wood-framed breakaway wall construction (simplified design method)

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.

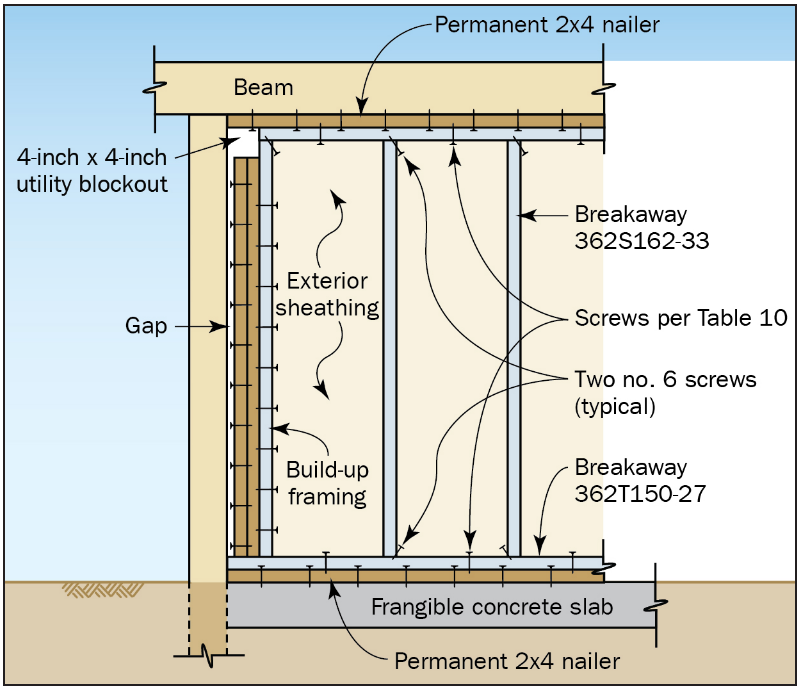


Figure 22: Typical steel stud-framed breakaway wall construction (simplified design method)

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.

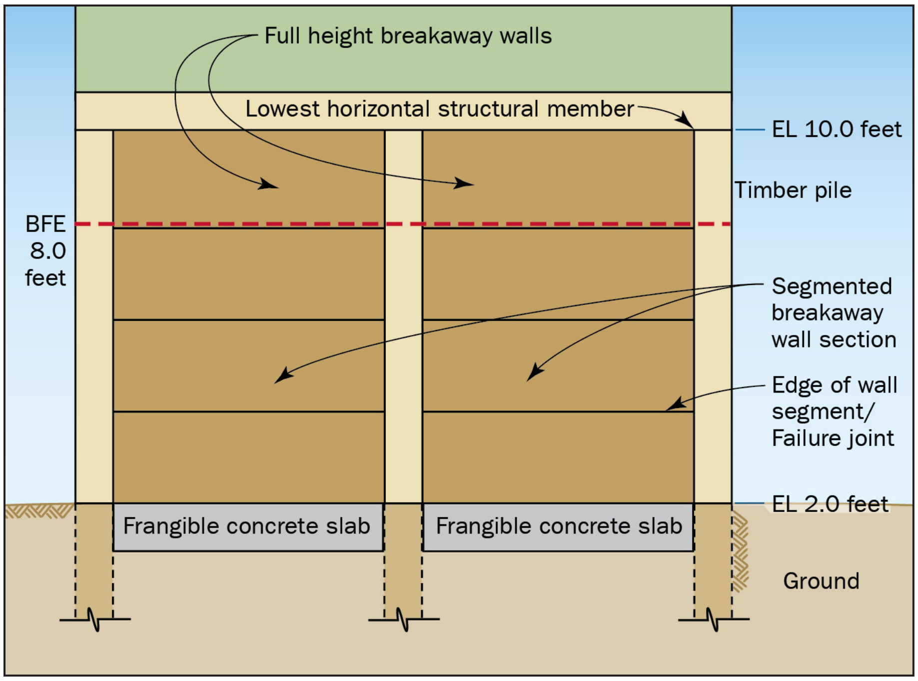


Figure 23: Example of a segmented breakaway wall using horizontal segments. Example elevations are provided for clarity.

10.4 Design Details

All breakaway walls designed using the performance-based design method must be designed and detailed in accordance with the following:

- 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).

> **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.

- 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).

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.

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.

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.

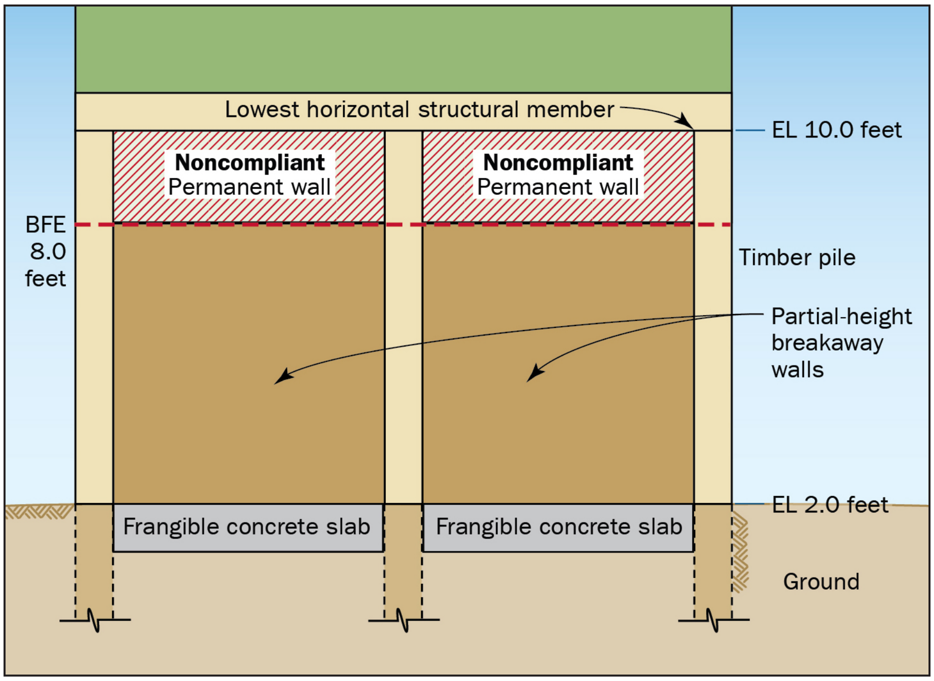
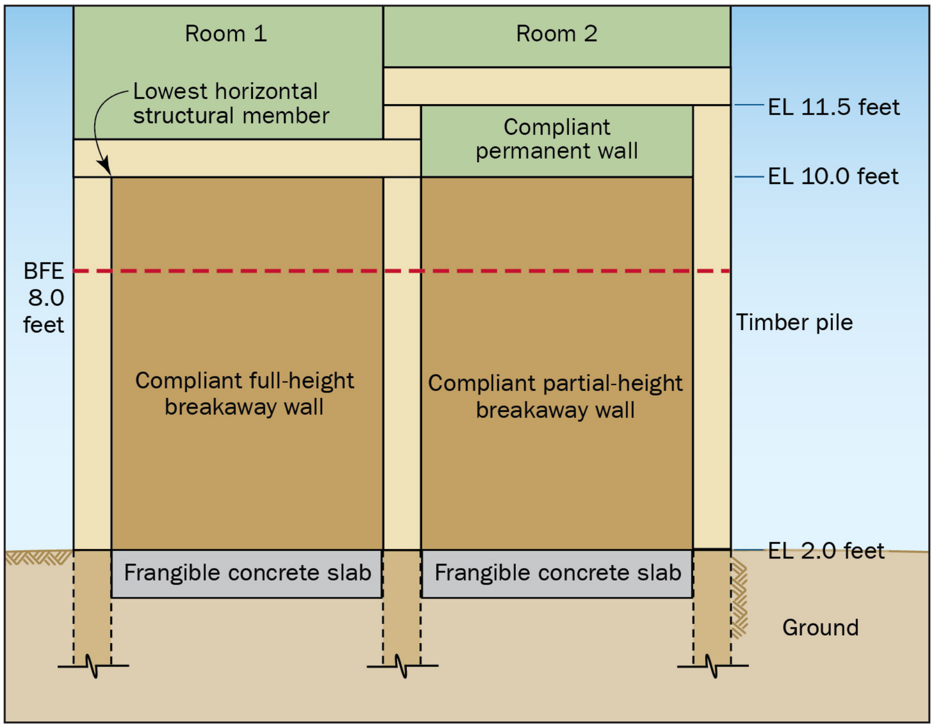


Figure 25: Breakaway walls that extend up to the lowest horizontal structural member of the lowest floor, which are considered full-height breakaway walls. The section of the permanent wall above the right section of a breakaway wall is compliant since the lowest horizontal structural member of the lowest 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.

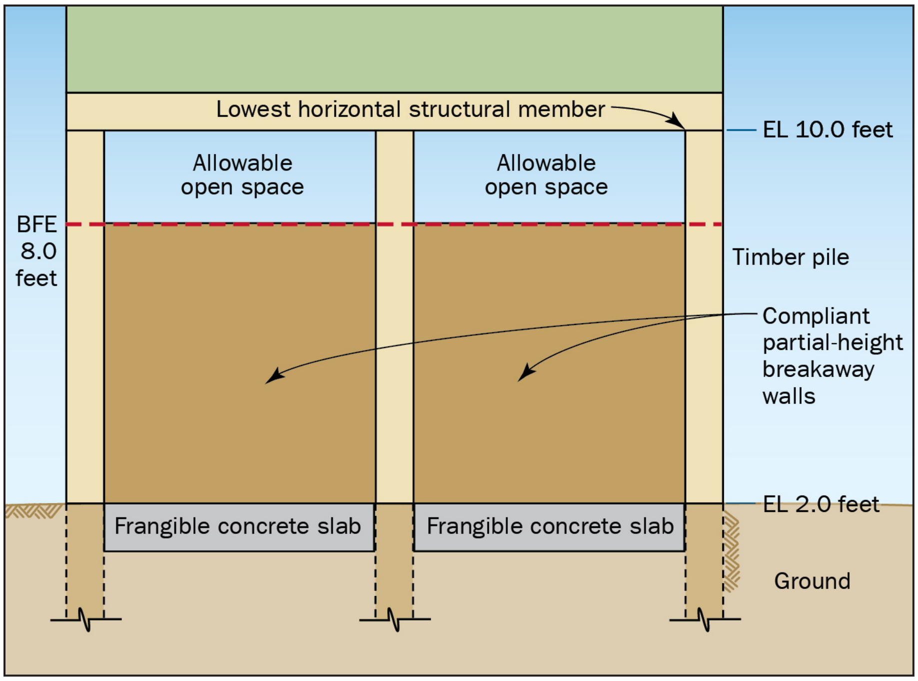
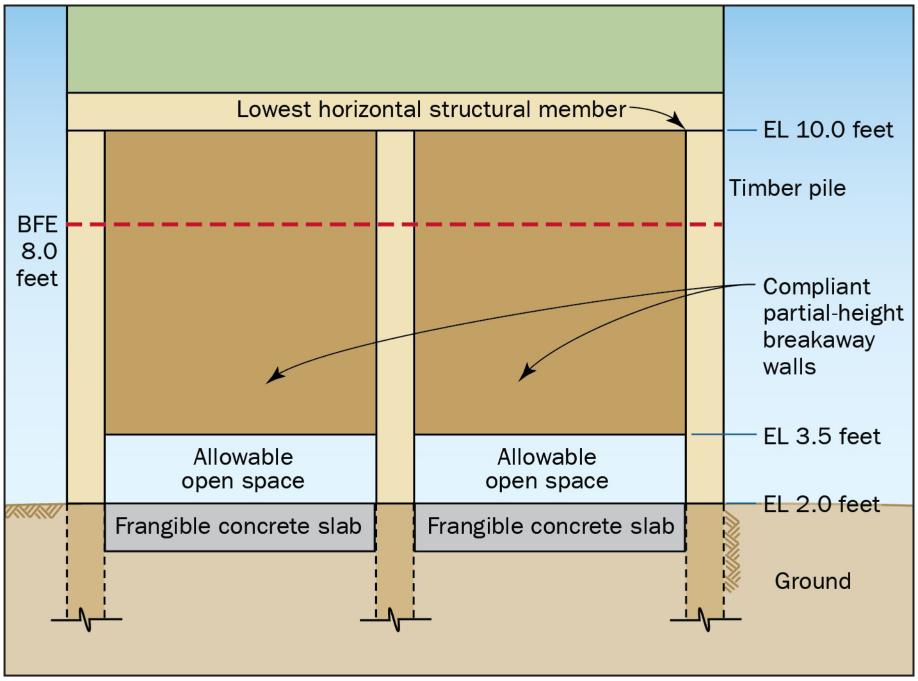


Figure 26: Breakaway walls that do not extend up to the lowest horizontal structural member of the lowest floor, which are allowable if the space between the top of the breakaway wall and the lowest horizontal structural member is open or covered with open lattice-work or insect screening and the performance-based 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.

15 References

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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 5, *Free-of-Obstruction Requirements.*
- Technical Bulletin 8, *Corrosion Protection for Metal Connectors and Fasteners in Coastal Areas.*

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