

Appendix H

FEMA NFIP Technical Bulletins

This appendix contains copies of nine National Flood Insurance Program (NFIP) Technical Bulletins (TBs) that provide guidance on topics related to flood hazard mitigation in V zones and coastal A zones. The bulletins summarize pertinent NFIP regulations and explain mitigation techniques compliant with the requirements of the regulations. Copies of all NFIP TBs, including a User's Guide that lists the bulletins prepared to date, are available on the FEMA website at <http://www.fema.gov/mit/techbul.htm>.

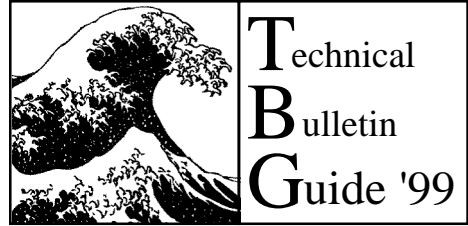
The following bulletins are included in this appendix:

- TB 0 *User's Guide to Technical Bulletins*
- TB 1 *Openings in Foundation Walls*
- TB 2 *Flood-Resistant Materials Requirements*
- TB 3 *Non-Residential Floodproofing – Requirements and Certification*
- TB 4 *Elevator Installation*
- TB 5 *Free-of-Obstruction Requirements*
- TB 6 *Below-Grade Parking Requirements*
- TB 7 *Wet Floodproofing Requirements*
- TB 8 *Corrosion Protection for Metal Connectors in Coastal Areas*
- TB 9 *Design and Construction Guidance for Breakaway Walls Below Elevated Coastal Buildings*



NOTE

FEMA periodically prepares new Technical Bulletins and updates its existing bulletins as necessary. Check the FEMA website, at the address shown at the left, for new and updated bulletins.



User's Guide to Technical Bulletins

Including Key Word/Subject Index



FEDERAL EMERGENCY MANAGEMENT AGENCY
MITIGATION DIRECTORATE

FIA-TB-0
(9/99)

TECHNICAL BULLETIN GUIDE-99

User's Guide to Technical Bulletins Including Key Word/Subject Index

The User's Guide

This User's Guide is intended to assist those using the Technical Bulletins issued by the Federal Emergency Management Agency (FEMA), Mitigation Directorate. This guide contains a Key Word/Subject Index that identifies topics contained in the Technical Bulletins regarding the National Flood Insurance Program (NFIP). Reference sources and information about ordering additional NFIP publications are also provided.

The Technical Bulletins

The Technical Bulletins provide guidance concerning the building performance standards of the NFIP, which are contained in Title 44 of the U.S. Code of Federal Regulations at Section 60.3. The bulletins are intended for use primarily by State and local officials responsible for interpreting and enforcing NFIP regulations and by members of the development community, such as design professionals and builders. New bulletins, as well as updates of existing bulletins, are issued periodically, as necessary. The bulletins do not create regulation; rather, they provide specific guidance for complying with the minimum requirements of existing NFIP regulations. Users of the Technical Bulletins who need additional guidance concerning NFIP regulatory requirements should contact the appropriate FEMA regional office (see page 6).

Comments on the Technical Bulletin Series should be addressed to:

FEMA/Mitigation Directorate
Program Policy and Assessment Branch
500 C Street, SW.
Washington, DC 20472

Copies of the Technical Bulletins can be obtained from the FEMA regional office that serves your area (see page 6). In addition, Technical Bulletins and other FEMA publications can be ordered from the FEMA Publications Service Center at 1-800-480-2520. The Technical Bulletins are also available at the FEMA web site at www.fema.gov.

It should be noted that Technical Bulletins provide guidance on the minimum requirements of the NFIP regulations. Community or State requirements that exceed those of the NFIP take precedence. Design professionals should contact the community to determine whether more restrictive local or State regulations apply to the building or site in question. All applicable standards of the State or local building code must also be met for any building in a flood hazard area.

Available Technical Bulletins

As of September 1999, the following Technical Bulletins are available:

Guide-99 User's Guide to Technical Bulletins

Provides a list of available technical bulletins, a key word/subject reference index for all the bulletins, and information about how to obtain copies of the bulletins.

1-93 Openings in Foundation Walls

Provides guidance on the NFIP regulations concerning the requirement for openings in below-Base Flood Elevation foundation walls for buildings located in Zones A, AE, A1 A30, AR, AO, and AH.

2-93 Flood-Resistant Materials Requirements

Provides guidance on the NFIP regulations concerning the required use of flood-damage resistant construction materials for building components located below the Base Flood Elevation in Special Flood Hazard Areas (both A and V zones).

3-93 Non-Residential Floodproofing – Requirements and Certification

Provides guidance on the NFIP regulations concerning watertight construction and the required certification for floodproofed non-residential buildings in Zones A, AE, A1-A30, AR, AO, and AH whose lowest floors are below the Base Flood Elevation.

4-93 Elevator Installation

Provides guidance on the NFIP regulations concerning the installation of elevators below the Base Flood Elevation in Special Flood Hazard Areas (both A and V zones).

5-93 Free-of-Obstruction Requirements

Provides guidance on the NFIP regulations concerning obstructions to flood waters below elevated buildings and on building sites in Coastal High Hazard Areas (Zones V, VE, and V1-V30).

6-93 Below-Grade Parking Requirements

Provides guidance on the NFIP regulations concerning the design of below-grade parking garages beneath buildings located in Zones A, AE, A1-A30, AR, AO, and AH.

7-93 Wet Floodproofing Requirements

Provides guidance on the NFIP regulations concerning wet floodproofing of certain types of structures located in Zones A, AE, A1-A30, AR, AO, and AH.

8-96 Corrosion Protection for Metal Connectors in Coastal Areas

Provides guidance on the need for, selection of, and use of corrosion-resistant metal connectors for the construction of buildings in coastal areas.

9-99 Design and Construction Guidance for Breakaway Walls Below Elevated Buildings in Coastal Areas

Provides prescriptive criteria for the design and construction of wood-frame and masonry breakaway walls compliant with NFIP regulatory requirements.

Key Word/Subject Index

This index is designed to allow the user to quickly locate key words that pertain to the subject in question. The index also cross-references issues that are addressed by more than one Technical Bulletin. For example, users of Technical Bulletin 6 (Below-Grade Parking Requirements) should also refer to Technical Bulletin 3 (Non-Residential Floodproofing — Requirements and Certification) concerning insurance rating issues.

Technical Bulletin	Key Words and Subjects
3	A-zone floodproofing
5	accessory buildings, as possible obstructions in V zones
5	accessory buildings, low value and small, defined
7	accessory structures
7	agricultural structures
1	basement, definition of
6	below-grade parking garage, considered a basement
6	below-grade parking garage, defined
6	below-grade parking in A and V zones, when allowed, requirements for
9	breakaway wall, failure modes
9	breakaway wall, insurance considerations
2,9	breakaway wall materials in V zones, made of flood-resistant materials
9	breakaway wall, NFIP regulatory requirements
9	breakaway wall, specifications for NFIP-compliant construction
9	breaking wave, impact on vertical surface
5	bulkheads, as possible obstructions in V zones
8	corrosion, classes of building exposure to
8	corrosion, causes of
8	corrosion, planning for
8	corrosion, identifying high-risk buildings
8	corrosion-resistant materials for sheetmetal connectors
5	decks and patios, as possible obstructions in V zones
5	detached garages, elevation requirement for in V zones
4	elevators, types of
4	elevator components, location of in relation to Base Flood Elevation
4	elevator electrical equipment, location of in relation to Base Flood Elevation
5	fill, as obstruction beneath buildings in V zones

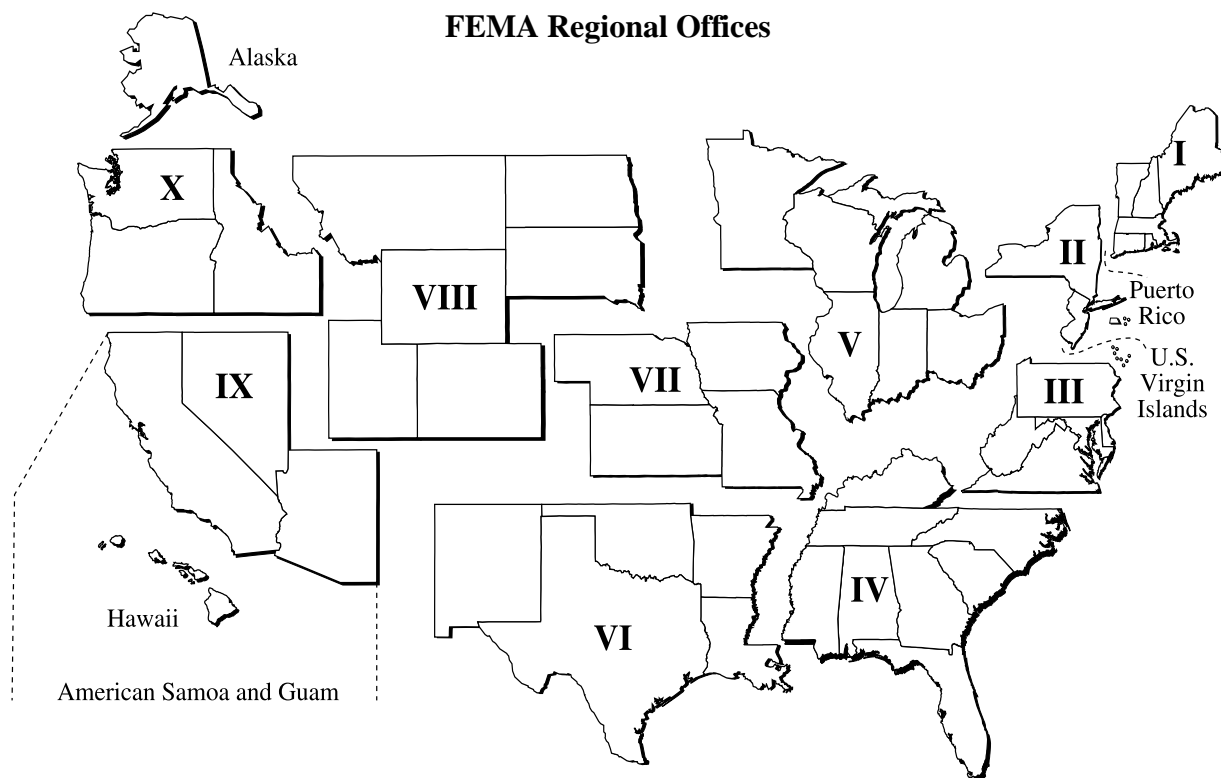
Technical Bulletin

Key Words and Subjects

4	float switch, use of in flood areas (for elevator cab)
4	flood-resistant elevator components, use of
2	flood-resistant flooring materials
2	flood-resistant material, definition of
2	flood-resistant materials, classifications, use of
2	flood-resistant wall and ceiling materials
3	floodproofing certificate, non-residential
6	floodproofing, below-grade parking beneath non-residential buildings, design requirements for
3	floodproofing, Emergency Operations Plan, minimum acceptable
3	floodproofing, Inspection and Maintenance Plan
3,6	floodproofing, recognition of for insurance rating purposes
5	foundation bracing, as possible obstructions in V zones
1	foundations in A zones
1	foundation openings in A zones, size, how to calculate
1	foundation vents in A zones
5	free of obstruction, definition of
5	free of obstruction, designing a foundation system in V zones
5	free of obstruction requirements in V zones
7	functionally dependent use
8	galvanizing
1	garage doors, to meet the openings requirement
7	garages, attached to non-residential structure
1,7	garages, attached to residential buildings
7	garages, detached from structure
5	grade beams, as possible obstructions in V zones
3	high hazard area, safety and access in
7	historic buildings
3	hydrodynamic forces on floodproofed building
3	hydrostatic forces on floodproofed building
1	hydrostatic pressure, automatically equalized
1	hydrostatic pressure, how to calculate
9	insect screening, for below building enclosures
2	insect screening in V zones, made of flood-resistant materials
9	latticework, for below-building enclosures
2	latticework in V zones, made of flood-resistant materials
3	lowest floor, definition of
3	non-residential floodproofing certificate, how to fill out
1	openings for foundations in A zones
1	safety factor for foundation openings
8	salt spray from breaking waves
5	swimming pools, beneath buildings in V zones

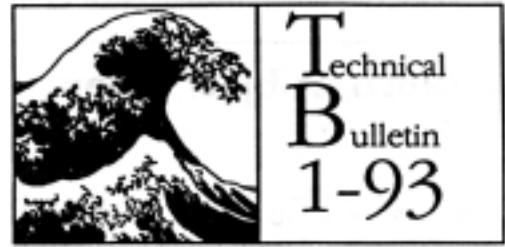
1	substantial damage, foundation wall openings requirement
1	substantial improvement, foundation wall openings requirement
2	U.S. Army Corps of Engineers, <i>Flood Proofing Regulations</i>
7	variances from NFIP requirements
7	variances, issuance in designated floodways
7	wet floodproofing, definition of
7	wet floodproofing, engineering considerations
7	wet floodproofing, flood insurance implications
7	wet floodproofing, planning considerations

FEMA Regional Offices

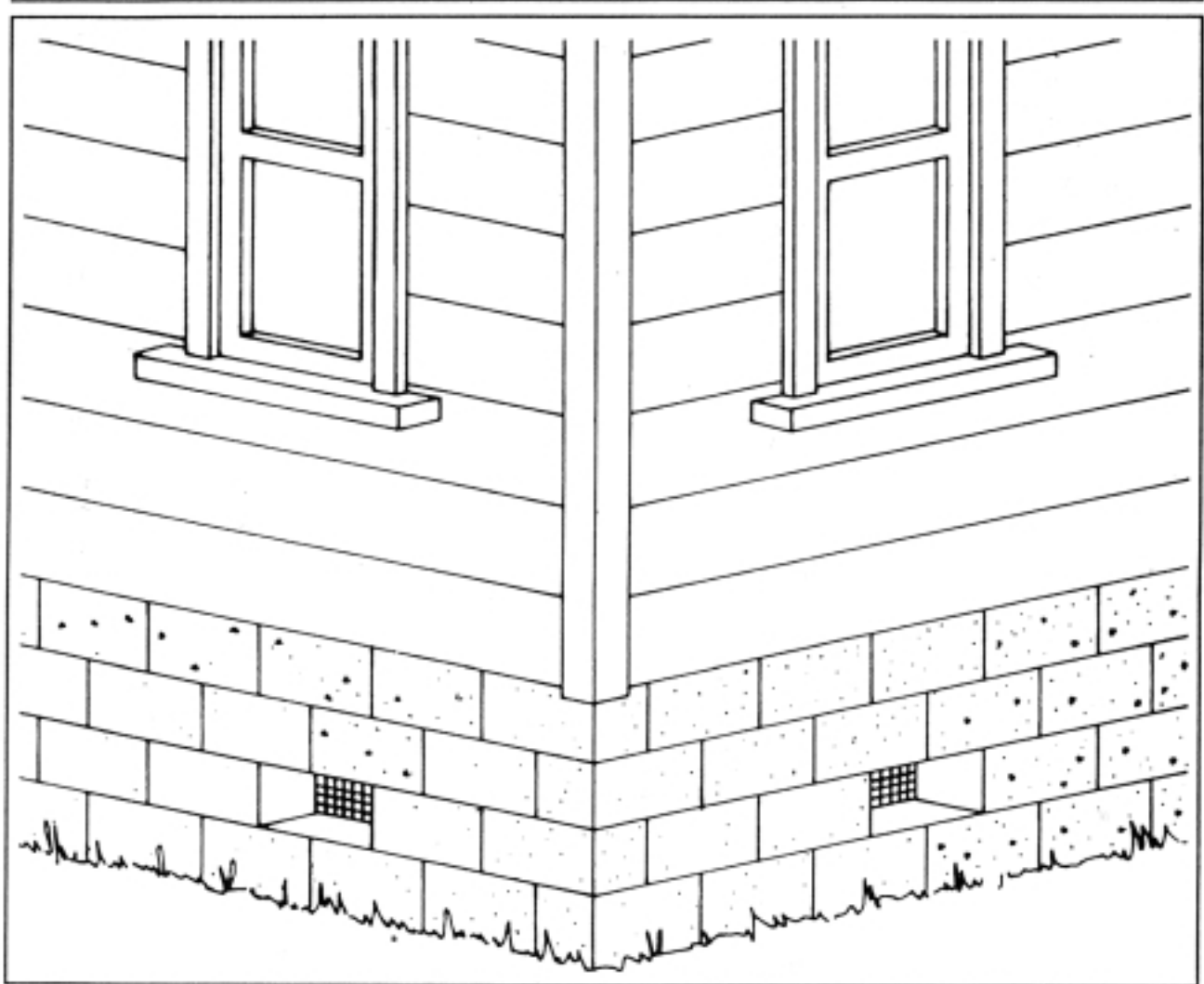


Region I	Mitigation Division 442 J. W. McCormick POCH Boston, MA 02109-4595 (617) 223-9559	Region VI	Mitigation Division Federal Regional Center 800 North Loop 288 Denton, TX 76201-3698 (940) 898-5165
Region II	Mitigation Division 26 Federal Plaza, Room 1337 New York, NY 10278-0002 (212) 225-7200	Region VII	Mitigation Division 2323 Grand Avenue, Suite 900 Kansas City, MO 64108 (816) 283-7002
Region III	Mitigation Division 615 Chestnut Street, Sixth Floor Philadelphia, PA 19106 (215) 931-5502	Region VIII	Mitigation Division Denver Federal Center Building 710, Box 25267 Denver, CO 80225-0267 (303) 235-4830
Region IV	Mitigation Division 3003 Chamblee Tucker Road Atlanta, GA 30341 (770) 220-5406	Region IX	Mitigation Division Building 105 Presidio of San Francisco San Francisco, CA 94129-1250 (415) 923-7175
Region V	Mitigation Division 175 West Jackson, 4th Floor Chicago, IL 60604-2698 (312) 408-5532	Region X	Mitigation Division Federal Regional Center 130 228th Street, SW. Bothell, WA 98021-9796 (425) 487-4678

Other Federal agencies that provide floodplain management assistance include the U.S. Army Corps of Engineers and the U.S. Natural Resources Conservation Service. For their nearest locations, please refer to your local telephone directory under “United States Government.”



Openings in Foundation Walls
for Buildings Located in Special Flood Hazard Areas
in accordance with the
National Flood Insurance Program



FEDERAL EMERGENCY MANAGEMENT AGENCY
FEDERAL INSURANCE ADMINISTRATION

FIA-TB-1
(4/93)

Key Word/Subject Index:

This index allows the user to quickly locate key words and subjects in this Technical Bulletin. The Technical Bulletin User's Guide (printed separately) provides references to key words and subjects throughout the Technical Bulletins. For definitions of selected terms, refer to the Glossary at the end of this bulletin

Key Word/Subject	Page
Basement, definition of	3
Foundations in A zones	1
Foundation openings in A zones, size, how to calculate	9
Garages, attached to residential buildings	4
Garage doors, to meet the openings requirement	4
Hydrostatic pressure, automatically equalized	2
Hydrostatic pressure, how to calculate	7
Openings for foundations in A zones	1
Safety factor for foundation openings	9
Substantial damage, foundation wall openings requirement	2
Substantial improvement, foundation wall openings requirement	2

Any comments on the Technical Bulletins should be directed to:

FEMA/FIA
Office of Loss Reduction
Technical Standards Division
500 C St., SW, Room 417
Washington, D.C. 20472

Technical Bulletin 1-93 replaces Technical Bulletin 85-2 (draft) "Foundation Wall Openings."

Graphic design based on the Japanese print *The Great Wave Off Kanagawa*, by Katsushika Hokusai (1760-1849), Asiatic collection, Museum of Fine Arts, Boston.

TECHNICAL BULLETIN 1-93

Openings in Foundation Walls Required for Buildings Located in Special Flood Hazard Areas in accordance with the National Flood Insurance Program

Introduction

An important objective of the National Flood Insurance Program (NFIP) is to protect buildings constructed in floodplains from structural damage caused by flood forces. In support of this objective, the NFIP regulations include building design criteria that apply to new construction and substantial improvements of existing buildings in Special Flood Hazard Areas (SFHAs). According to these criteria, residential buildings constructed in A zones (Zones A, AE, A1-A30, AR, A0, and AH) must have their lowest floors at or above the base flood elevation (BFE). Non-residential buildings constructed in A zones must either have their lowest floors at or above the BFE or be dry floodproofed (made watertight) to or above the BFE. Residential and non-residential buildings whose lowest floors have been constructed at or above the BFE usually are elevated on piers, columns, piles, extended foundation walls, or fill. While the main portion of such a building is protected from the 100-year and lesser-magnitude floods, the foundation and any enclosures below the BFE used for parking, building access, or limited storage will be exposed to flood forces.

For buildings constructed on extended foundation walls or that have other enclosures below the BFE, these flood forces include the hydrostatic pressure of floodwaters against the foundation or enclosure walls. If the walls are not designed to withstand hydrostatic pressure, they can be weakened or can fail and the building damaged. Therefore, the NFIP regulations require that foundation and enclosure walls that are subject to the 100-year flood contain openings that will permit the automatic entry and exit of floodwaters. These openings allow floodwaters to reach equal levels on both sides of the walls and thereby lessen the potential for damage from hydrostatic pressure. The requirement for openings applies to all new and substantially improved buildings in A zones. This Technical Bulletin explains the requirement for openings and provides guidance for designing and constructing foundation and enclosure walls that include the required openings.

Extended foundation and enclosure walls below the BFE may also be threatened by hydrodynamic forces resulting from velocity flows and debris impact. The requirement for openings is intended to reduce flood damage associated with hydrostatic not hydrodynamic forces. These forces are described within this bulletin, and additional design guidance is given for buildings in areas subject to velocity flood flows, which may include debris.

For buildings in V zones (Zones V, VE, and V1-V30), more stringent design and construction requirements have been established for the portions of the buildings below the BFE. For information on V-zone design and construction requirements, refer to the NFIP regulations, the Technical Bulletin series, and FEMA's "Coastal Construction Manual."

NFIP Regulations

The NFIP regulations require that all enclosures below the BFE in A zones be designed to allow for the automatic equalization of hydrostatic forces during a flood event. Section 60.3(c)(5) of the NFIP regulations states that a community shall:

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

As stated in the regulations, buildings in A zones that are substantially damaged and/or substantially improved must meet all the NFIP requirements for new construction, including the openings requirement. All design plans for substantial improvements to buildings in A zones must be thoroughly reviewed by the community to ensure compliance with the openings requirement. Further information on substantial damage and substantial improvement may be found in the FEMA publication “Answers to Questions About Substantially Damaged Buildings.”

It should be noted that Technical Bulletins provide guidance on the minimum requirements of the NFIP regulations. Community or State requirements that exceed those of the NFIP take precedence. Design professionals should contact the community to determine whether more restrictive local or State regulations apply to the building or site in question. All applicable standards of the State or local building code must also be met for any building in a flood hazard area.

Guidance for Non-Engineered Foundation Openings

Each of the following four design criteria must be met for new and substantially improved A-zone buildings that have enclosed areas below the BFE with openings not designed and certified by a design professional:

1. There must be a minimum of two openings on different sides of each enclosed area. If a building has more than one enclosed area, each area must have openings on exterior walls to allow floodwater to directly enter.
2. The total area of all openings must be at least 1 square inch for each 1 square foot of enclosed area.

3. The bottom of each opening can be no more than 1 foot above the adjacent grade.
4. Any louvers, screens, or other opening covers must not block or impede the automatic flow of floodwaters into and out of the enclosed area.

Types of Buildings Affected

In all cases, any enclosed area below the BFE is subject to flood forces and must be equipped with exterior wall openings in accordance with the NFIP regulations, either at the time of initial construction or, if the building is being substantially improved, at the time of improvement. The only exception to this requirement is floodproofed non-residential buildings that are engineered and meet stringent watertight construction requirements. For further information on this topic, refer to Technical Bulletin 3, "Non-Residential Floodproofing — Requirements and Certification."

Buildings Elevated on Solid Foundation Walls

When a building is elevated on solid foundation walls, an enclosed area is often created below the lowest floor. All foundation enclosures below the BFE must have openings that meet NFIP criteria. Figure 1 shows an example of a properly placed foundation opening. As discussed previously, screens, louvers, or other covers that allow floodwaters to flow freely into the enclosed area may be placed over the openings to keep out vermin and weather.

Care must be taken when placing fill dirt around the outside of the foundation. The resulting enclosed area may be considered a basement under the NFIP. A basement is defined as any area of a building having a floor (finished or unfinished) that is subgrade (below grade) on all sides. The NFIP regulations do not permit a residential building in an SFHA to have a

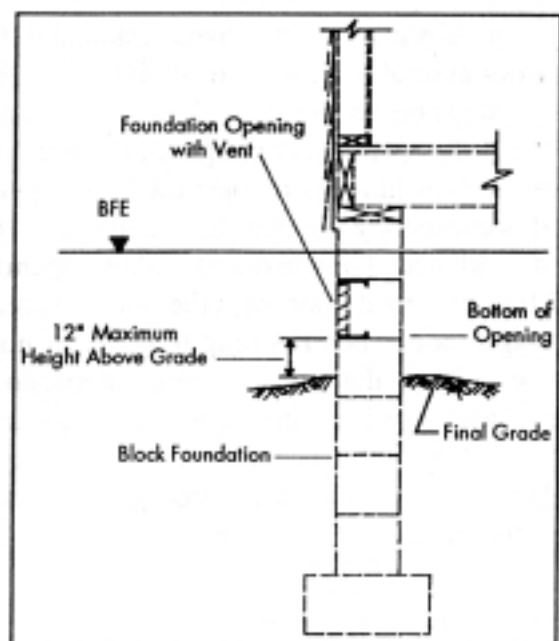


Figure 1. Opening for Solid Foundation Wall

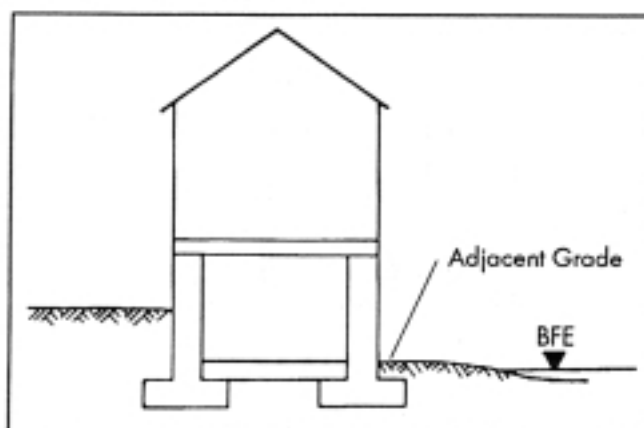


Figure 2. Compliant Grading for a Walkout Basement

basement whose lowest floor (including basement) is below the BFE.

To meet the NFIP requirements, fill placed around foundation walls must be graded so that the grade inside the enclosed area is equal to or higher than the adjacent grade outside the building on at least one side of the building (as illustrated in Figure 2). If the grade inside the foundation walls is above the BFE, openings are not required.

Buildings in Hazardous Velocity Areas

In coastal A zones, or in riverine A zones where flood velocities exceed 5 feet per second, fast-flowing floodwaters can exert considerable pressure on solid foundation walls. This hydrodynamic pressure, as described in the following section, may destroy a building's foundation. In such areas, foundations that allow floodwaters to flow freely beneath the building should be considered. Foundations such as piles, piers, or columns will provide the appropriate level of safety to a building located in a hazardous velocity area, if properly embedded and anchored. See the discussion of hydrodynamic pressure for design guidance.

Buildings in A-zone floodplains with velocity floodwaters may have breakaway walls constructed in areas below the BFE. Compliant foundation openings are required in breakaway walls in A zones.

Buildings with Attached Garages

Any new or substantially improved residential building constructed in an A zone must have its lowest floor at or above the BFE. Many of these buildings have structurally attached garages with floor slabs below the BFE. Because such a below-BFE attached garage is an enclosed area below the BFE, openings are required either in the exterior walls of the garage or in the garage doors themselves in order to meet the NFIP openings criteria (see Figure 3). Openings are required because they prevent flood damage to the garage and subsequently to the structurally attached residence. Garage doors without openings specifically designed to allow for the free flow of floodwaters do not meet the openings requirement. The human intervention necessary to open garage doors when flooding threatens is not an acceptable means of meeting the openings requirement. Gaps that may be present between the door segments and between the garage door and the garage door jamb do not guarantee the automatic entry and exit of floodwaters. Therefore, openings are required either in the exterior walls of the enclosed area or in the garage doors themselves. Openings in garage doors must either meet the non-engineered openings requirements or be certified by a design professional.

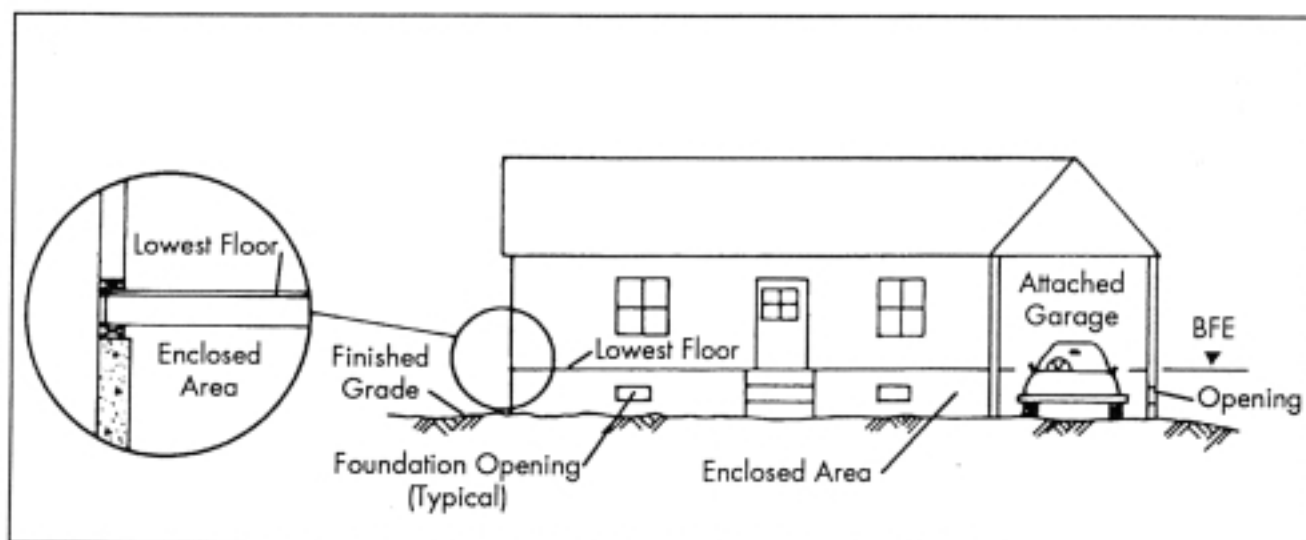


Figure 3. Compliant Residential Building Built on Solid Foundation Walls With Attached Garage

Hydrostatic pressure on an enclosed area above grade can be calculated by multiplying the specific weight of water (62.4 pounds per cubic foot) by the height of the water on the surface being analyzed. The application of the force generated by hydrostatic pressure is always perpendicular (normal) to the surface in question. In the case of a submerged object, this means that hydrostatic forces act in two ways. First, the force will act laterally (see Figure 5), which can result in collapse of walls or movement of the entire building off its foundation. Second, the force will act vertically (the vertical force is also known as buoyancy, see Figure 6), which can result in the building being lifted from its foundation or floor system.

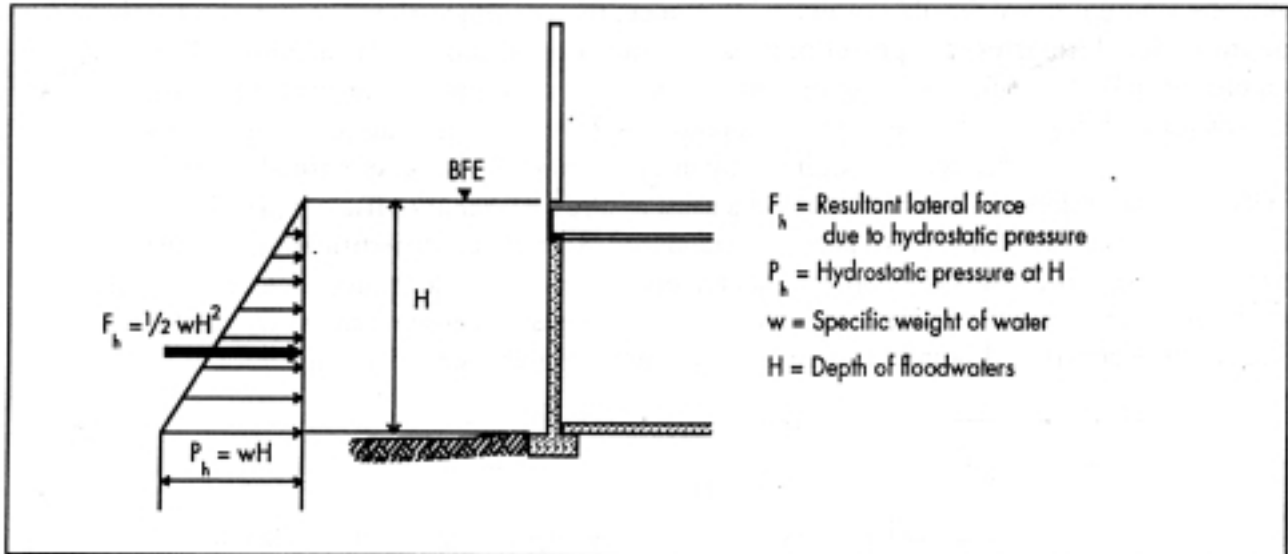


Figure 5. Lateral Hydrostatic Force and Pressure

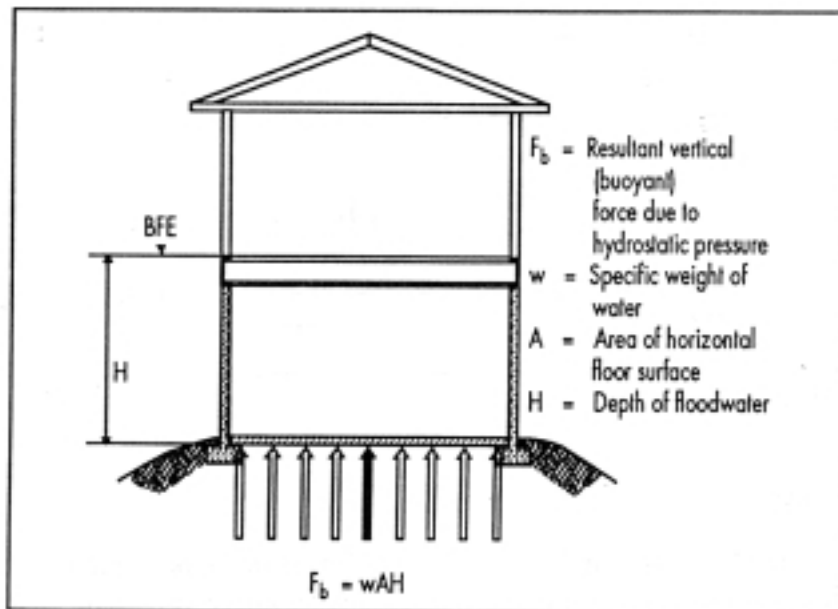


Figure 6. Buoyancy Force

Hydrostatic pressure on an enclosed area above grade can be calculated by multiplying the specific weight of water (62.4 pounds per cubic foot) by the height of the water on the surface being analyzed. The application of the force generated by hydrostatic pressure is always perpendicular (normal) to the surface in question. In the case of a submerged object, this means that hydrostatic forces act in two ways. First, the force will act laterally (see Figure 5), which can result in collapse of walls or movement of the entire building off its foundation. Second, the force will act vertically (the vertical force is also known as buoyancy, see Figure 6), which can result in the building being lifted from its foundation or floor system.

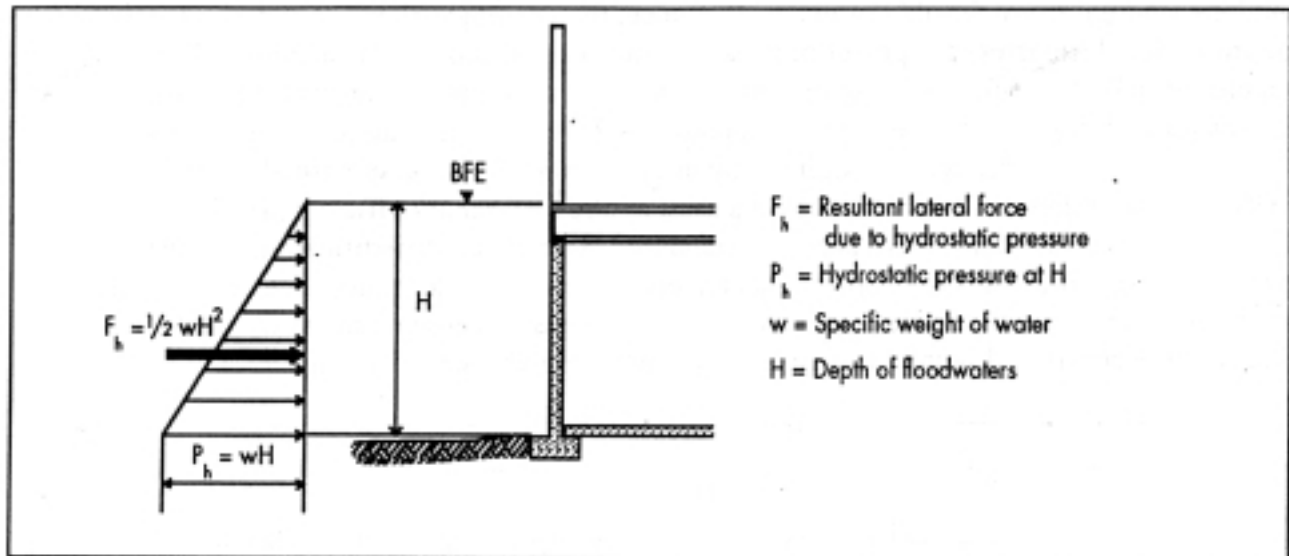


Figure 5. Lateral Hydrostatic Force and Pressure

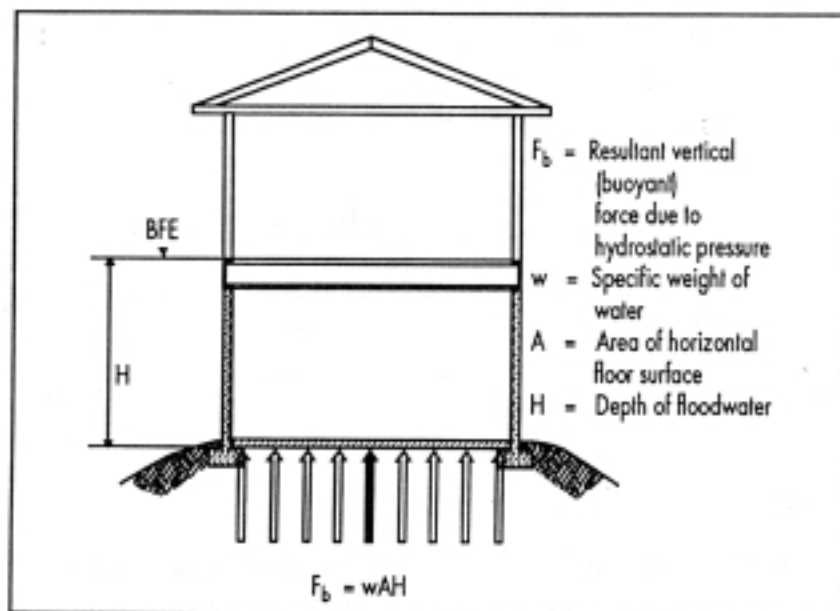


Figure 6. Buoyancy Force

To describe hydrostatic pressure in more technical terms:

The hydrostatic pressure, P_h , at a specific location on a structure is:

$$P_h = wH$$

where: P_h is the pressure in pounds per square foot
 w is the specific weight of water, 62.4 pounds per cubic foot
 H is the depth from the surface of the water to the location in question (generally from BFE to bottom of foundation wall)

The lateral force resulting from hydrostatic pressure is:

The resultant lateral (horizontal) force against the surface is:

$$F_h = \frac{1}{2}P_h H = \frac{1}{2}wH^2$$

where: F_h is the lateral force in pounds per linear foot of surface

Describing the hydrostatic vertical force (buoyancy) in more technical terms:

The buoyant (vertical) hydrostatic force acting against a horizontal surface such as a floor slab is:

$$F_b = wAH$$

where: F_b is the total buoyant force in pounds
 w is the specific weight of water, 62.4 pounds per cubic foot
 A is the area of the horizontal surface in square feet
 H is the depth of the building below the flood level

As shown in the following table, hydrostatic pressure, whether it affects a building laterally or vertically, increases rapidly as floodwater depths increase:

Height, H (in feet)	1	2	3	4	5	6	7	8
Pressure, P_h (in pounds per square foot)	62	125	187	250	312	374	437	499

Hydrodynamic pressure is exerted on all vertical surfaces of obstructions, such as building foundations, by the impact of velocity water and debris. Depending upon site-specific flood characteristics and the strength of the foundation, hydrodynamic pressure can overload and destroy a building's foundation. The openings criteria are intended to equalize hydrostatic pressure and are not intended to minimize hydrodynamic pressure on the foundation. Hydrodynamic pressure must be considered in the design of any foundation system where velocity waters or the potential for debris flow exists. If flood velocities are excessive (greater than 5 feet per second), foundation systems other than solid foundation walls should be considered, so that obstructions to damaging flood flows are minimized. Safe foundations in such locations include pile, post, column, and pier foundations. These types of foundation systems are appropriate for A zones in coastal environs subject to waves and velocity floodwaters, as well as in riverine floodplains subject to velocity floodwaters (velocities greater than 5 feet per second) and areas subject to debris flows and ice floes. In areas with high-velocity floodwaters, it is advisable to construct any enclosures below the BFE using the breakaway wall specifications described in FEMA's "Coastal Construction Manual." As stated previously, breakaway walls in A zones must have openings compliant with NFIP regulatory requirements so that hydrostatic pressures are equalized during low-level flood events.

Design Criteria for Engineered Openings

Engineered openings that allow floodwaters into an enclosure for the purpose of equalizing hydrostatic pressures shall be designed using the following criteria:

- The difference between the exterior and interior floodwater levels should not exceed 1 foot at any time during the flood event. Greater differences can result in excessive hydrostatic pressures and structural damage to the enclosure walls.
- The arrangement of the openings must be capable of equalizing the hydrostatic pressures associated with the "worst-case" rate of rise of floodwaters. Historical flooding information should be used to determine rate of rise. A rate of rise of 5 feet per hour was assumed in the development of the NFIP non-engineered openings design criteria.
- Because of the large amount of debris associated with flooding and because openings will often be equipped with some form of vermin screen to meet applicable building codes, there is a high probability that openings may be obstructed during a flood. For this reason, a substantial safety factor is needed. Standard engineering practice is to use a safety factor of 5 in similar life/safety situations involving potential structural failure; therefore, a safety factor

of 5 was incorporated into the calculations that follow. Openings on the sides of the building facing the primary direction of velocity flow will add an additional safety factor; however, such openings will tend to be blocked with debris sooner than other openings.

- At least two openings must be included to provide for a safety factor against debris blockage. This safety factor is enhanced when openings are located on at least two different sides of the enclosed area. This will allow for more even filling and emptying of the enclosed area and will also reduce the risk of debris being forced against an opening and blocking it.

The first step in determining the total net area required for openings is to calculate the flow rate per square foot of enclosed area, which is based on the rate of rise of the floodwaters. The assumed worst-case rate of rise is 5 feet per hour per square foot of area, or about 0.1 foot per minute. To convert this to gallons per minute per square foot of enclosed area, multiply by a conversion factor of 7.5 gallons per cubic foot. The needed flow rate into the enclosure per square foot of area is then (0.1 foot per minute) times (7.5 gallons per cubic foot), or 0.8 gallon per minute per square foot of enclosed area. The second step is outlined below.

To determine the total net area of the openings, A, needed to permit the above flow rate, the formula is:

$$Q = 38.0cA(p)^5$$

Solving for area A and multiplying by a factor of safety:

$$A = \frac{Q}{38.0cp^5} (FS)$$

where:

A	is the net area of openings required, in square inches
Q	is the flow rate per square foot, which is 0.8 gallon per minute
c	is the coefficient of discharge, which is assumed to be 0.2
p	is the pressure, which for one square foot of differential is 62.4 pounds per square foot, or 0.4 pound per square inch
FS	is the factor of safety, which is 5

Therefore:

$$A = \frac{0.8}{38.0 \times 0.2 \times 0.6} (5)$$

= about 1.0 square inch of opening per square foot of enclosed area.

The NFIP

The NFIP was created by Congress in 1968 to provide federally backed flood insurance coverage, because it was generally unavailable from private insurance companies. The NFIP is also intended to reduce future flood losses by identifying floodprone areas and ensuring that new

development in these areas is adequately protected from flood damage. The NFIP is based on a mutual agreement between the federal government and communities that have been identified as floodprone. FEMA, through the Federal Insurance Administration (FIA), makes flood insurance available to community residents provided that the participating community adopts and enforces adequate floodplain management regulations that meet the minimum NFIP requirements. The NFIP encourages communities to adopt floodplain management ordinances that exceed the minimum NFIP criteria. Included in the NFIP requirements, found under Title 44 of the U.S. Code of Federal Regulations, are minimum building design and construction standards for buildings located in SFHAs. Through their floodplain management ordinances, communities adopt the NFIP design performance standards for new and substantially improved buildings located in floodprone areas identified on FIA's Flood Insurance Rate Maps.

Technical Bulletins

This is one of a series of Technical Bulletins FEMA has produced to provide guidance concerning the building performance standards of the NFIP. These standards are contained in Title 44 of the U.S. Code of Federal Regulations at Section 60.3. The bulletins are intended for use primarily by State and local officials responsible for interpreting and enforcing NFIP regulations and by members of the development community, such as design professionals and builders. New bulletins, as well as updates of existing bulletins, are issued periodically, as necessary. The bulletins do not create regulations; rather they provide specific guidance for complying with the minimum requirements of existing NFIP regulations. Users of the Technical Bulletins who need additional guidance concerning NFIP regulatory requirements should contact the Natural Hazards Branch of the appropriate FEMA regional office. The "User's Guide to Technical Bulletins" lists the bulletins issued to date and provides a key word/subject index for the entire series.

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Further Information

The following publications provide further information concerning openings in foundation walls:

1. "Answers to Questions About Substantially Damaged Buildings," FEMA, May 1991, FEMA-213.
2. "Coastal Construction Manual," FEMA, February 1986, FEMA-55.
3. "Colorado Floodproofing Manual," Colorado Department of Natural Resources, Water Conservation Board, October 1983.
4. "Design Manual for Retrofitting Flood-Prone Residential Structures," FEMA, September 1986, FEMA-114.

5. "Elevated Residential Structures," FEMA, May 1986, FEMA-54.
6. "Elevating Flood-Prone Buildings: A Contractor's Guide," Illinois Department of Transportation, Division of Water Resources, 1985.
7. "Flood Proofing Regulations," U.S. Army Corps of Engineers, March 1992, EP 1165-2-314.
8. "Flood Proofing Systems and Techniques," U.S. Army Corps of Engineers, December 1984.
9. "Foundation Analysis and Design," Second Edition, Joseph E. Bowles, McGraw-Hill Book Co., New York.

Glossary

Base flood — The flood that has a 1-percent probability of being equaled or exceeded in any given year (also referred to as the 100-year flood).

Base Flood Elevation (BFE) — The height of the base flood, usually in feet, in relation to the National Geodetic Vertical Datum of 1929 or other datum as specified.

Basement — Any area of a building having its floor subgrade (below ground level) on all sides.

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.

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Flood Insurance Rate Map (FIRM) — The insurance and floodplain management map issued by FEMA that identifies, on the basis of detailed or approximate analyses, areas of 100-year flood hazard in a community.

Floodprone area — Any land area susceptible to being inundated by floodwater from any source.

Lowest floor — The lowest floor of the lowest enclosed area of a building, including a basement. Any NFIP-compliant unfinished or flood-resistant enclosure useable solely for parking of vehicles, building access, or storage (in an area other than a basement) is not considered a building's lowest floor.

Special Flood Hazard Area (SFHA) — Area delineated on a Flood Insurance Rate Map as being subject to inundation by the base flood and designated as Zone A, AE, A1-A30, AR, A0, AH, V, VE, or V1-V30.

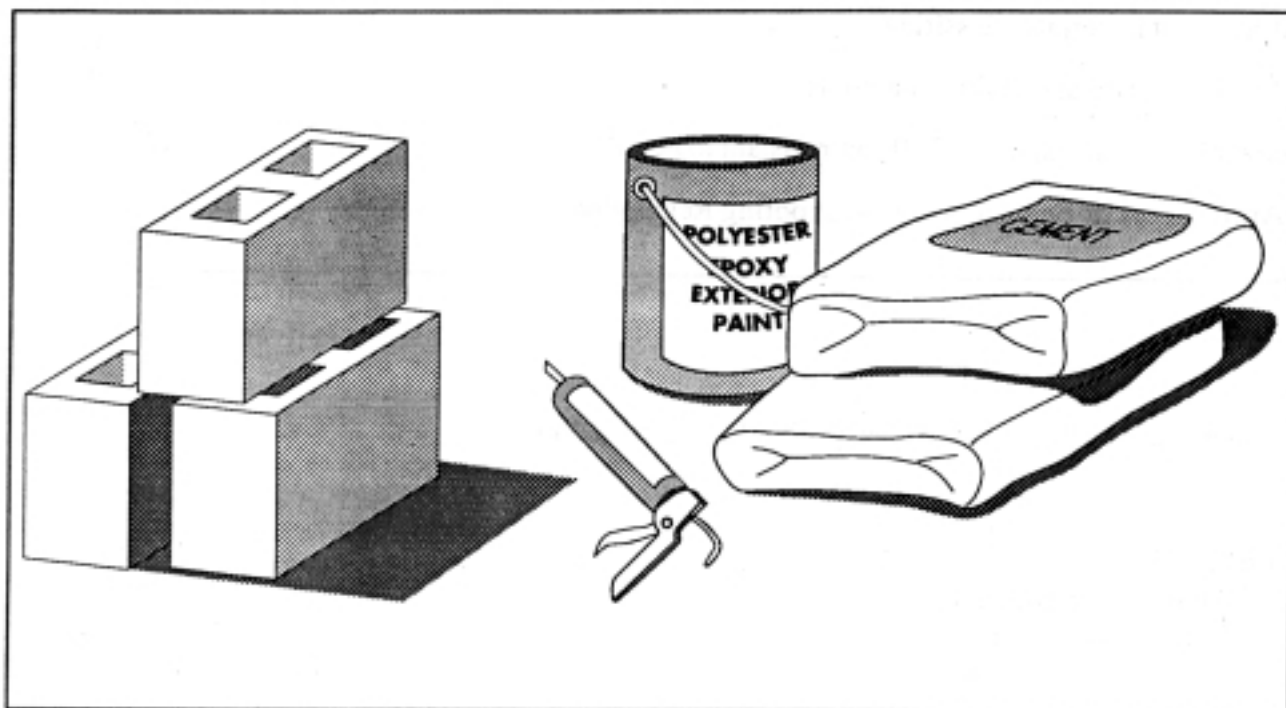
Substantial damage — Damage of any origin sustained by a structure whereby the cost of restoring the structure to its before-damaged condition would equal or exceed 50 percent of the market value of the structure before the damage occurred.

Substantial improvement — Any reconstruction, rehabilitation, addition, or other improvement of a structure, the cost of which equals or exceeds 50 percent of the market value of the structure before the “start of construction” of the improvement. This term includes structures that have incurred “substantial damage,” regardless of the actual repair work performed.



Technical
Bulletin
2-93

Flood-Resistant Materials Requirements
for Buildings Located in Special Flood Hazard Areas
in accordance with the
National Flood Insurance Program



FEDERAL EMERGENCY MANAGEMENT AGENCY
FEDERAL INSURANCE ADMINISTRATION

FIA-TB-2
4/93

Key Word/Subject Index:

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Key Word/Subject	Page
Breakaway wall materials in V zones, made of flood-resistant materials	12
Flood-resistant flooring materials	4
Flood-resistant material, definition of	1
Flood-resistant materials, classifications, use of	2
Flood-resistant wall and ceiling materials	7
Latticework in V zones, made of flood-resistant materials	12
U.S. Army Corps of Engineers "Flood Proofing Regulations"	2

Any comments on the Technical Bulletins should be directed to:

FEMA/FIA
Office of Loss Reduction
Technical Standards Division
500 C St., SW, Room 417
Washington, D.C. 20472

Technical Bulletin 2-93 replaces Technical Bulletin 88-2 (draft) "Flood-Resistant Materials."

Graphic design based on the Japanese print *The Great Wave Off Kanagawa*, by Katsushika Hokusai (1760-1849), Asiatic collection, Museum of Fine Arts, Boston.

TECHNICAL BULLETIN 2-93

Flood-Resistant Materials Requirements for Buildings Located In Special Flood Hazard Areas in accordance with the National Flood Insurance Program

Introduction

The requirement to use construction and finishing materials that are resistant to flood damage in all new and substantially improved buildings in identified Special Flood Hazard Areas (SFHAs) is an important part of the National Flood Insurance Program's (NFIP's) flood-damage-resistant design and construction standards. A residential building's lowest floor is required to be elevated to or above the base flood elevation (BFE). All construction below the lowest floor is susceptible to flooding and must consist of flood-resistant materials. Uses of enclosed areas below the lowest floor in a residential building are limited to parking, building access, and limited storage—areas that can withstand inundation by floodwater without sustaining significant structural damage.

The purpose of this Technical Bulletin is to provide data and guidance on what constitute "materials resistant to flood damage" and how and when these materials must be used to improve a building's ability to withstand flooding.

NFIP Regulations

Section 60.3(a)(3) of the NFIP regulations requires that the community:

"Review all permit applications to determine whether proposed building sites will be reasonably safe from flooding. If a proposed building site is in a floodprone area, all new construction and substantial improvements shall...(ii) be constructed with materials resistant to flood damage..."

It should be noted that Technical Bulletins provide guidance on the minimum requirements of the NFIP regulations. Community or State requirements that exceed those of the NFIP take precedence. Design professionals should contact the community to determine whether more restrictive local or State regulations apply to the building or site in question. All applicable standards of the State or local building code must also be met for any building in a flood hazard area.

Required Use of Flood-Resistant Materials

Flood-Resistant Material

"Flood-resistant material" is defined as any building material capable of withstanding direct and prolonged contact with floodwaters without sustaining significant damage. The term "prolonged contact" means at least 72 hours, and the term "significant damage" means any damage requiring more than low-cost cosmetic repair (such as painting).

As stated previously, **all structural and non-structural building materials at or below the BFE must be flood resistant.** This requirement applies regardless of the expected or historic flood duration. For example, buildings in coastal areas that experience relatively short-duration flooding (generally, flooding with a duration of less than 24 hours) must be constructed with flood-resistant materials below the BFE. As noted in the tables within this bulletin, **only Class 4 and Class 5 materials are acceptable for areas below the BFE in floodprone buildings.**

In some instances, Class 1, 2, and 3 materials may be permitted below the BFE, when specifically required to meet local building code provisions concerning life-safety issues. In below-BFE applications, materials that meet life-safety code requirements and have maximum resistance to damage from flood inundation should be used. This applies to the flood-resistant requirements only. In Zones V, VE, and V1-V30, the installation of such materials may create an obstruction. Because obstructions in V zones could result in structural failure of the building, they represent a life-safety issue and shall therefore take precedence over local building codes. Refer to Technical Bulletin 5, "Free of Obstruction Requirements," for further information.

Lowest Floor

Under the NFIP, the term "lowest floor" is used to define the lowest level of a building that must be located at or above the BFE as required under Sections 60.3(c)(2) and (3) of the NFIP regulations. The floodplain management regulations, under Section 60.3(c)(5), limit the use of all areas below the lowest floor to parking of vehicles, storage, and building access. These reasonable uses below the BFE are permitted because the amount of damage caused by flooding to these areas can easily be kept to a minimum if design and construction requirements contained in the NFIP regulations are met. Failure to meet the requirements can increase the building's damage potential and result in the application of higher flood insurance premiums. The requirement to use flood-resistant materials means that all interior wall, floor, and ceiling materials located below the BFE be unfinished and resistant to flood damage. This is meant to exclude the use of materials and finishes normally associated with living areas constructed above the BFE.

Flood Insurance Implication

An NFIP flood insurance requirement regarding the use of materials in areas below the BFE must also be considered. Flood insurance will not pay a claim for finishing materials (such as clay floor tiles) located in basements or in enclosed areas below the lowest floor of an elevated building, even if such materials are considered to be flood resistant. The NFIP defines finishing materials as anything beyond basic wall construction.

Flood-Resistant Classification of Materials

The information in this Technical Bulletin is based primarily on the U.S. Army Corps of Engineers (COE) 1992 "Flood Proofing Regulations." The following table (Table 1) classifies building materials according to their ability to resist flood damage.

Table 1 Flood-Resistant Classification of Materials		
N F I P	Class	Class Description
A C C E P T A B L E	5	Highly resistant to floodwater damage. Materials within this class are permitted for partially enclosed or outside uses with essentially unmitigated flood exposure.
	4	Resistant to floodwater damage. Materials within this class may be exposed to and/or submerged in floodwaters in interior spaces and do not require special waterproofing protection.
U N A C C E P T A B L E	3	Resistant to clean water damage. Materials within this class may be submerged in clean water during periods of intentional flooding.
	2	Not resistant to water damage. Materials within this class require essentially dry spaces that may be subject to water vapor and slight seepage.
	1	Not resistant to water damage. Materials within this class require conditions of dryness.

Source: COE 1992 "Floodproofing Regulations"

Flooring Materials

Table 2 lists flooring materials commonly used in construction that fall within the five classes described in Table 1. Not all available construction and finishing materials are listed. For products not listed herein, manufacturers' literature should be reviewed for recommended uses. Such recommendations must be complied with fully. All masonry and wood products used in floodprone buildings must comply with the applicable materials standards of the nationally recognized standards organizations, such as the American Society for Testing and Materials (ASTM), the American Concrete Institute (ACI), and the American Wood Products Association (AWPA).

Basis for Classification of Flooring Materials

The classification of flooring materials is based on their vulnerability to damage from inundation by floodwaters. Class 1, 2, and 3 flooring materials are not acceptable for below-BFE applications for one or more of the following reasons:

- Normal suspended-floor adhesives specified for above-grade use are water soluble or are not resistant to alkali or acid in water, including ground seepage and vapor.
- Flooring materials contain wood and wood products.
- Flooring materials are not resistant to alkali or acid in water.
- Sheet-type floor coverings (linoleum, rubber, and vinyl) restrict evaporation from below.
- Flooring materials are impervious but dimensionally unstable.

Table 2 Flooring Materials Classifications for Flood Resistance

Types of Flooring Materials	Classes of Flooring				
	Acceptable		Unacceptable		
	5	4	3	2	1
Asphalt Tile ¹					•
With asphaltic adhesives			•		
Carpeting (glued down type)					•
Cement/bituminous, formed-in-place		•			
Cement/latex, formed-in-place		•			
Ceramic tile ¹					•
With acid-and alkali-resistant grout			•		
Chipboard					•
Clay tile	•				
Concrete, precast or in-situ	•				
Concrete tile	•				
Cork					•
Enamel felt-base floor coverings					•
Epoxy, formed-in-place	•				
Linoleum					•
Magnesite (magnesium oxychloride)					•
Mastic felt-base floor covering					•
Mastic flooring, formed-in-place	•				
Polyurethane, formed-in-place	•				
PVA emulsion cement					•
Rubber sheets ¹					•
With chemical-set adhesives ^{2,3}	•				
Rubber tile ¹					•
With chemical-set adhesives ³		•			
Silicone floor, formed-in-place	•				

Table 2 Flooring Materials Classifications for Flood Resistance

Types of Flooring Materials	Classes of Flooring				
	Acceptable		Unacceptable		
	5	4	3	2	1
Terrazo		●			
Vinyl sheets (homogeneous) ¹					●
With chemical-set adhesives ^{2,3}	●				
Vinyl tile (homogeneous) ¹					●
With chemical-set adhesives ³		●			
Vinyl tile or sheets (coated on cork or wood product backings)					●
Vinyl-asbestos tile (semi-flexible vinyl) ¹					●
With asphaltic adhesives		●			
Wood flooring or underlayments					●
Wood composition blocks, laid in cement mortar				●	
Wood composition blocks, dipped and laid in hot pitch or bitumen				●	
Pressure-treated lumber, .40 CCA ⁴	●				
Naturally decay-resistant lumber ^{4,5}	●				

Notes: 1 Using normally specified suspended flooring (i.e., above-grade) adhesives, including sulfite liquor (lignin or "linoleum paste"), rubber/asphaltic dispersions, or "alcohol" type resinous adhesives (culmar, oleoresin)
 2 Not permitted as Class 2 flooring
 3 E.g., epoxy-polyamide adhesives or latex-hydraulic cement
 4 Not in the COE list; added by FEMA
 5 Refer to local building code for guidance

Wall and Ceiling Materials

Table 3 lists wall and ceiling materials commonly used in construction that fall within the five classes described in Table 1. Not all available construction and finishing materials are listed. For products not listed herein, manufacturers' literature should be reviewed for recommended uses. Such recommendations must be complied with fully. All masonry and wood products used in floodprone buildings must comply with the applicable materials standards of the nationally recognized standards organizations, such as the American Society for Testing and Materials (ASTM), the American Concrete Institute (ACI), and the American Wood Products Association (AWPA).

Basis for Classification of Wall and Ceiling Materials

The classification of wall and ceiling materials is based on their vulnerability to damage from inundation by floodwaters. Class 1, 2, and 3 wall and ceiling materials are not acceptable for below-BFE applications for one or more of the following reasons:

- Normal adhesives specified for above-grade use are water soluble or are not resistant to alkali or acid in water, including ground seepage and vapor.
- Wall and ceiling material contains wood, wood products, gypsum products, or other material that dissolves or deteriorates, loses structural integrity, or is adversely affected by water.
- Wall or ceiling material is not resistant to alkali or acid in water.
- Wall or ceiling material is impervious but is dimensionally unstable.
- Wall or ceiling materials absorb or retain water excessively after submergence.

Table 3 Walls and Ceiling Materials Classifications for Flood Resistance

Types of Wall and Ceiling Materials	Classes of Walls and Ceilings				
	Acceptable		Unacceptable		
	5	4	3	2	1
Asbestos-cement board (and cement board ¹)	•				
Brick, face or glazed	•				
Common				•	
Cabinets, built-in					
Wood				•	
Metal	•				
Cast stone (in waterproof mortar)	•				
Chalkboards					
Slate, porcelain glass, nucite glass	•				
Cement-asbestos				•	
Composition, painted				•	
Chipboard					•
Exterior sheathing grade				•	
Clay tile					
Structural glazed	•				
Ceramic veneer, ceramic wall tile-mortar set		•			
Ceramic veneer, organic adhesives				•	
Concrete	•				
Concrete block	•				
Corkboard				•	
Doors					
Wood hollow				•	
Wood, lightweight panel construction				•	
Wood, solid				•	
Metal, hollow	•				
Metal, Kalamein				•	

Table 3 Walls and Ceiling Materials Classifications for Flood Resistance

Types of Wall and Ceiling Materials	Classes of Walls and Ceilings				
	Acceptable		Unacceptable;		
	5	4	3	2	1
Fiberboard panels, vegetable types					
Sheathing grade (asphalt coated or impregnated)				•	
Otherwise					•
Gypsum products					
Gypsum board (including greenboard ¹)				•	
Keene's cement or plaster				•	
Plaster, otherwise, including acoustical				•	
Sheathing panels, exterior grade				•	
Glass (sheets, colored tiles, panels)		•			
Glass blocks	•				
Hardboard					
Tempered, enamel or plastic coated				•	
All other types				•	
Insulation					
Foam or closed-cell types		•			
Batt or blanket types					•
All other types				•	
Metals, non-ferrous (aluminum, copper, or zinc tiles)			•		
Metals, Ferrous	•				
Mineral fiberboard					•
Plastic wall tile (polystyrene, urea formaldehyde, etc.)					
Set in waterproof adhesives, pointed with waterproof grout			•		
Set in water-soluble adhesives				•	

Table 3 Walls and Ceiling Materials Classifications for Flood Resistance

Types of Wall and Ceiling Materials	Classes of Walls and Ceilings				
	Acceptable		Unacceptable		
	5	4	3	2	1
Paint					
Polyester-epoxy and other waterproof types		●			
All other types					●
Paperboard					●
Partitions, folding					
Wood, pressure treated, .40 CCA minimum 1 (if not treated, then material is Class 2)	●				
Metal		●			
Fabric-covered					●
Partitions, stationary					
Wood, pressure treated, .40 CCA minimum 1 (if not treated, then material is Class 2)	●				
Metal	●				
Glass, unreinforced		●			
Glass, reinforced		●			
Gypsum, solid or block					●
Rubber, moldings and trim with epoxy polyamide adhesive or latex-hydraulic cement		●			
All other applications					●
Steel, (panels, trim, tile) with waterproof applications	●				
With non-waterproof adhesive				●	
Stone, natural solid or veneer, waterproof grout	●				
Stone, artificial non-absorbent solid or veneer, waterproof grout	●				
All other applications				●	

Table 3 Walls and Ceiling Materials Classifications for Flood Resistance

Types of Wall and Ceiling Materials	Classes of Walls and Ceilings				
	Acceptable		unacceptable		
	5	4	3	2	1
Strawboard					
Exterior grade (asphalt-impregnated kraft paper)				●	
All other types				●	
Wall covering					
Paper, burlap, cloth types					●
Wood					
Solid, standard				●	
Solid, naturally decay-resistant ^{1,2}	●				
Solid pressure treated, .40 CCA minimum ¹	●				
Plywood					
Marine Grade ¹	●				
Pressure treated, .40 CCA minimum ¹	●				
Exterior grade				●	
Otherwise					●

Note: 1 Not on the COE list; added by FEMA
 2 Refer to local building code for guidance

Construction Examples

Flood-Resistant Materials in Buildings in Zones A, AE, A1-A30, AR, AO, and AH

Figure 1 illustrates a building elevated on solid foundation walls, over a crawlspace. The NFIP regulations require that the lowest floor be at or above the BFE. The construction method illustrated in Figure 1 meets this requirement. Note, however, that the flooring materials and supporting wood members are at or below the BFE. Therefore, in Figure 1, all materials supporting the lowest floor, including the flooring itself, must be made of flood-resistant materials.

To maximize the use of the area below the lowest floor, it is a common floodplain construction technique to elevate a building a full story (approximately 8 feet), even though the BFE may only be 4 or 5 feet above grade. In such cases, while the NFIP regulations require that Class 4 or 5 building materials be used below the BFE, FEMA strongly recommends that Class 4 or Class 5 materials also be used for the construction of the remainder of the building below the lowest floor. Flood damage from a greater-than-design flood event will thereby be reduced in the lower area.

Flood-Resistant Materials in Buildings in Zones V, VE, and V1-V30

All structural and non-structural materials installed below the BFE must be flood resistant. The NFIP regulations require that the bottom of the lowest horizontal structural member of the lowest floor (usually the floor beam or girder) of a building in Zone V, VE, or V1-V30 be at or above the BFE. Therefore, all materials below the floor beam(s) must be flood resistant. This includes but is not limited to breakaway wall materials and open latticework. Breakaway walls will remain in place during low-level floods and must be flood resistant, so that they will not deteriorate over time after being soaked by floodwaters. Figure 2, on the next page, illustrates this requirement.

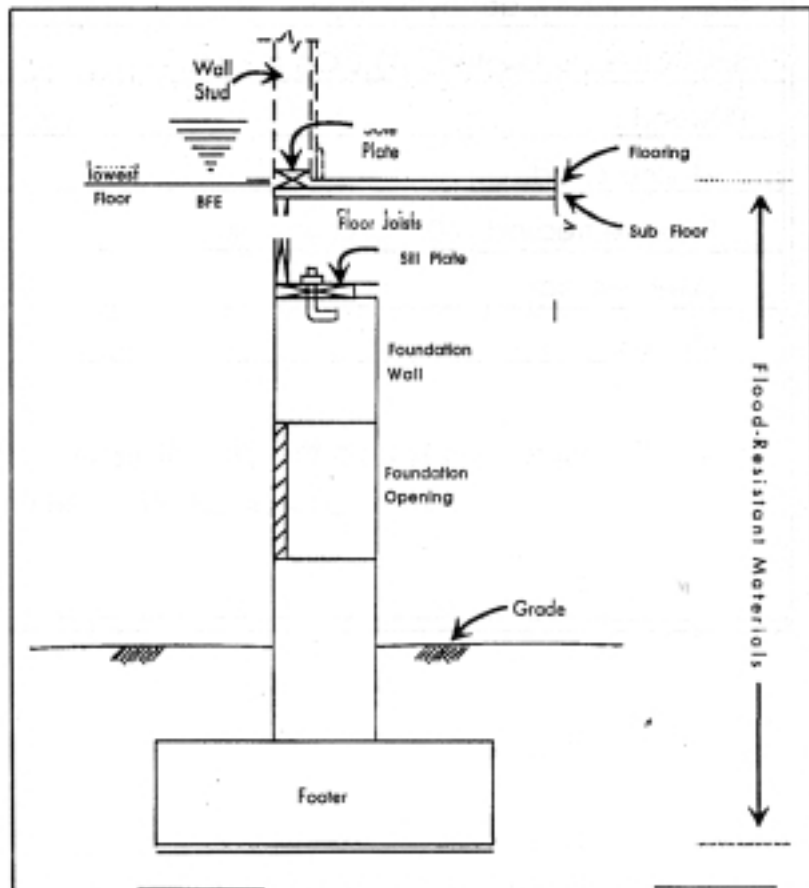


Figure 1. Building Elevated on Solid Foundation Walls Meeting the Minimum NFIP Requirements for Zones A, AE, A1-A30, AR, AO, and AH

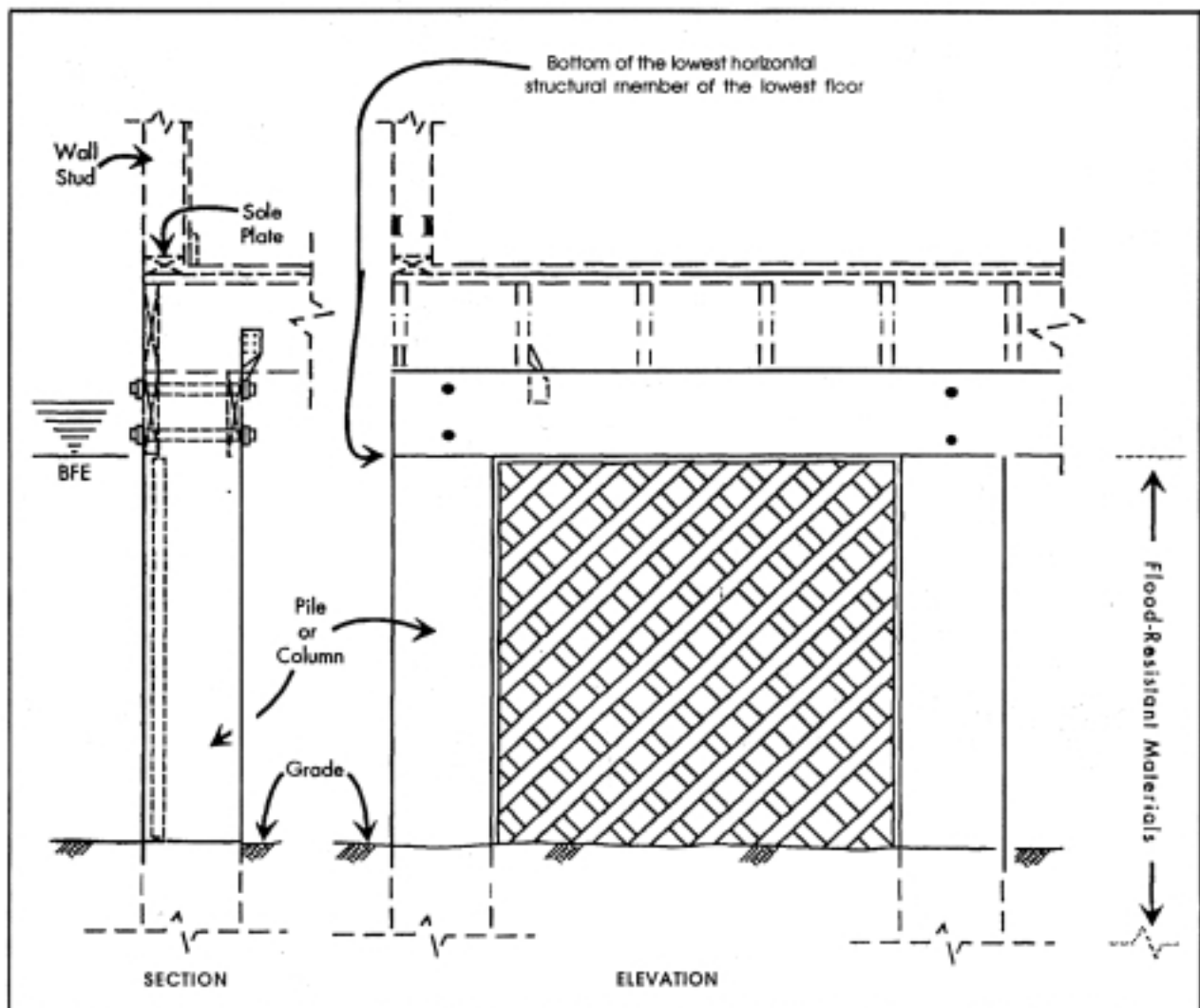


Figure 2. Flood-Resistant Material Requirements for Buildings Elevated in Accordance with NFIP Requirements for Zones V, VE, and V1-V30

Accessory Buildings

Some communities permit the construction of low-cost, small detached accessory buildings (e.g., garages, storage sheds) with a lowest floor elevation below the BFE (Technical Bulletin 5, "Free-of-Obstruction Requirements," provides definitions of "low-cost" and "small"). The below-BFE portions of such buildings must be constructed of flood-resistant materials so that flood damage will be minimized. Additional construction requirements for these buildings, such as the need to anchor the building to resist flotation, collapse, and lateral movement, also must be met before the building is permitted and built. For additional information about these requirements, contact the community that has permitting jurisdiction.

Wet Floodproofing

Wet floodproofing is designing a building to allow floodwaters to enter in order to equalize hydrostatic forces. The NFIP does not allow wet floodproofing in lieu of meeting the lowest

floor elevation requirements. However, in situations where the NFIP regulations do not apply, such as voluntary floodproofing of an existing (Pre-FIRM) building not in association with substantial improvements, the use of flood-resistant materials is advisable. Using flood-resistant materials will make cleanup and repair following a flood much easier and less costly than if the floodprone areas are constructed of non-flood-resistant materials.

The NFIP

The NFIP was created by Congress in 1968 to provide federally backed flood insurance coverage, because flood insurance was generally unavailable from private insurance companies. The NFIP is also intended to reduce future flood losses by identifying floodprone areas and ensuring that new development in these areas is adequately protected from flood damage. The NFIP is based on an agreement between the federal government and participating communities that have been identified as floodprone. FEMA, through the Federal Insurance Administration (FIA), makes flood insurance available to the residents of a participating community provided that the community adopts and enforces adequate floodplain management regulations that meet the minimum NFIP requirements. The NFIP encourages communities to adopt floodplain management ordinances that exceed the minimum NFIP criteria. Included in the NFIP requirements, found under Title 44 of the U.S. Code of the Federal Regulations, are minimum building design and construction standards for buildings located in SFHAs. Through their floodplain management ordinances, communities adopt the NFIP design performance standards for new and substantially improved buildings located in floodprone areas identified on FIA's FIRMs.

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Further Information

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2. "Floodproofing Non-Residential Structures," FEMA, May 1986, FEMA-102.
3. "Flood Proofing Regulations", Chapters 9 and 10, U.S. Army Corps of Engineers, March 1992, EP 1165-2-314.
4. "Flood Proofing Systems and Techniques," U.S. Army Corps of Engineers, December, 1984.
5. "Repairing Your Flooded Home," FEMA and the American Red Cross, August 1992, FEMA-234, ARC 4477.
6. "Technical Notes for Brick Construction," Brick Institute of America, McLean, Virginia, n.d.

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Substantial damage — Damage of any origin sustained by a structure whereby the cost of restoring the structure to its before-damaged condition would equal or exceed 50 percent of the market value of the structure before the damage occurred.

Substantial improvement — Any reconstruction, rehabilitation, addition, or other improvement of a structure, the cost of which equals or exceeds 50 percent of the market value of the structure before the "start of construction" of the improvement. This term includes structures that have incurred "substantial damage," regardless of the actual repair work performed.



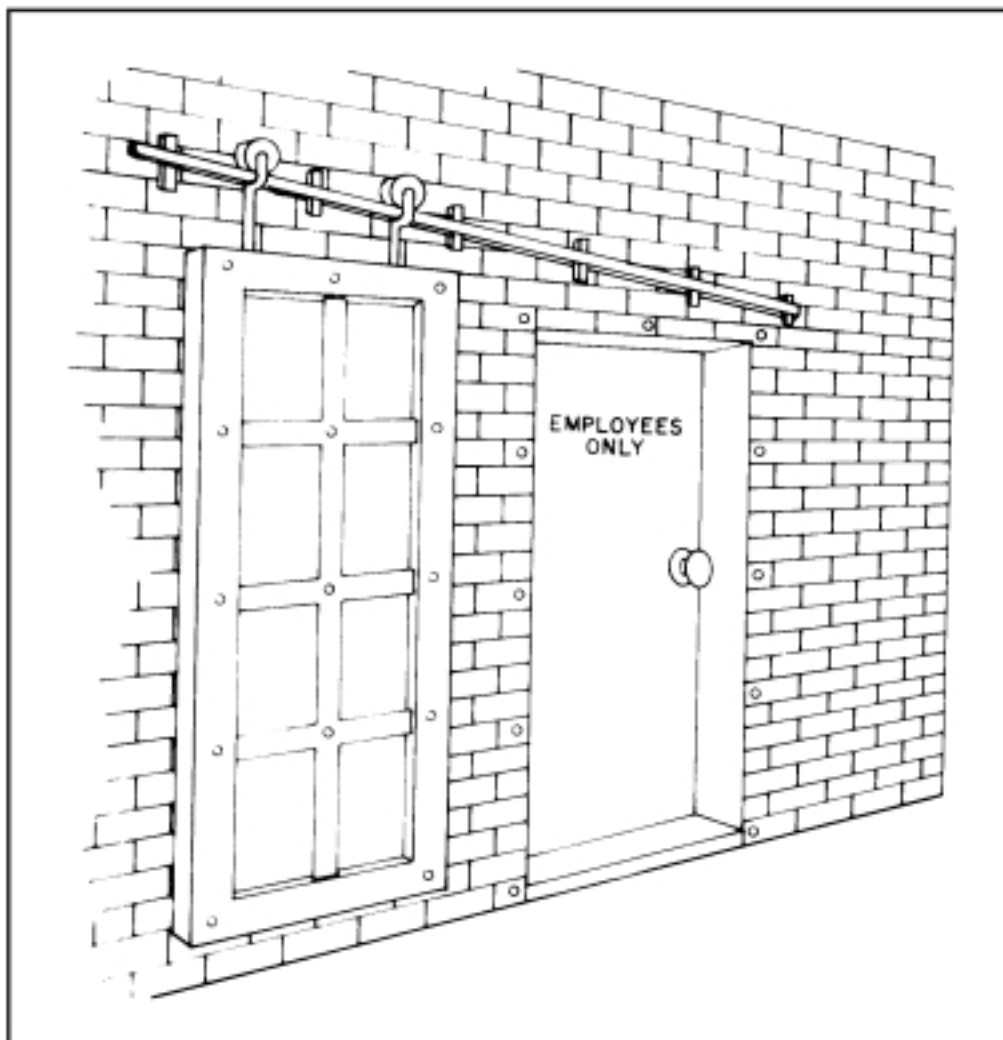
Technical
Bulletin
3-93

Non-Residential Floodproofing — Requirements and Certification

for Buildings Located in Special Flood Hazard Areas

in accordance with the

National Flood Insurance Program



FEDERAL EMERGENCY MANAGEMENT AGENCY
FEDERAL INSURANCE ADMINISTRATION

FIA-TB-3
4/93

Key Word/Subject index:

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Key Word/Subject	Page
A-zone floodproofing	2
Floodproofing, Emergency Operations Plan, minimum acceptable	5
Floodproofing, Inspection and Maintenance Plan, minimum acceptable	5
Floodproofing, recognition of for insurance rating purposes	4
High hazard area, safety and access in	3
Hydrodynamic forces on floodproofed building	8
Hydrostatic forces on floodproofed building	6
Non-residential floodproofing certificate, how to fill out	10

Any comments on the Technical Bulletins should be directed to:

FEMA/FIA
Office of Loss Reduction
Technical Standards Division
500 C St., SW, Room 417
Washington, D.C. 20472

Technical Bulletin 3-93 replaces Technical Bulletin 90-3 (draft) "Non-Residential Floodproofing Certification Requirements."

Graphic design based on the Japanese print *The Great Wave Off Kanagawa*, by Katsushika Hokusai (1760-1849), Asiatic collection, Museum of Fine Arts, Boston.

TECHNICAL BULLETIN 3-93

Non-Residential Floodproofing — Requirements and Certification for Buildings Located in Special Flood Hazard Areas in accordance with the National Flood Insurance Program

Introduction

This bulletin describes design, construction, and planning requirements for the floodproofing of non-residential buildings under the 'National Flood Insurance Program (NFIP) regulations and how to correctly complete the NFIP's Floodproofing Certificate for Non-Residential Structures form. For the purposes of this bulletin, floodproofing means making a building watertight, substantially impermeable to floodwaters.

Before a floodproofed building is designed, numerous planning considerations, including flood warning time, uses of the building, mode of entry to and exit from the building and the site in general, floodwater velocities, flood depths, debris impact potential, and flood frequency, must be addressed to ensure that dry floodproofing will be a viable floodplain management tool. These critical considerations are discussed within this bulletin.

In the FEMA publication "Floodproofing of Non-Residential Structures," floodproofing is described as a combination of adjustments and/or additions of features to buildings that eliminate or reduce the potential for flood damage. Examples of such adjustments and additions include anchoring of the building to resist flotation, collapse, and lateral movement; installation of watertight closures for doors and windows; reinforcement of walls to withstand floodwater pressures and impact forces generated by floating debris; use of membranes and other sealants to reduce seepage of floodwater through walls and wall penetrations; installation of pumps to control interior water levels; installation of check valves to prevent the entrance of floodwater or sewage flows through utilities; and the location of electrical, mechanical, utility, and other valuable damageable equipment and contents above the expected flood level.

Floodproofing components for an individual building may also include floodwalls, small localized levees, or berms around buildings. However, such components, because they are not part of the building itself, are generally not credited for the flood insurance rating of a building under the NFIP and are therefore not detailed within this bulletin.

The NFIP allows a new or substantially improved non-residential building in an A zone (Zone A, AE, A 1-A30, AR, AO, or AH) to have a lowest floor below the base flood elevation (BFE), provided that the building has been designed, constructed, and certified to be floodproofed and to meet established criteria. Floodproofing of areas below the BFE in residential buildings is not permitted under the NFIP. In a Coastal High Hazard Area (Zone V, VE, or V 1 -V30), construction or substantial improvement of a building with a lowest floor elevation below the BFE is not allowed, regardless of any floodproofing techniques employed.

A Floodproofing Certificate for Non-Residential Structures (FEMA Form 81 -65) has been developed by FEMA for use in the certification of non-residential floodproofing designs. Because of the increased potential for significant building damage due to the failure of the floodproofing system, the NFIP requires a design certification for all floodproofed buildings. In

accordance with Section 60.3(c)(4), communities shall require a correctly completed certificate (or its equivalent) for every floodproofed building within a Special Flood Hazard Area (SFHA) and shall maintain the completed certificates on file.

A Floodproofing Certificate for Non-Residential Structures is required for the following types of buildings (in A zones only):

- Floodproofed non-residential buildings (no residential uses).
- Floodproofed mixed-use buildings that are professionally designed with all residential uses located above the floodproofing design elevation.

NFIP Regulations

The NFIP regulations that specifically apply to the design of floodproofing for non-residential buildings are within Section 60.3(c)(3), which states that the community shall:

“Require that all new construction and substantial improvements of non-residential structures within Zones A1 -A30, AE, and AH on the community’s FIRM (i) have the lowest floor (including basement) elevated to or above the base flood level, or (ii) together with attendant utility and sanitary facilities, be designed so that below the base flood level the structure is watertight with walls substantially impermeable to the passage of water and with structural components having the capability of resisting hydrostatic and hydrodynamic loads and effects of buoyancy. ”

Section 60.3(c)(8) further states that the community shall:

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

Additionally, Section 60.3(c)(4) requires that any floodproofing design be certified in the following manner:

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

It should be noted that Technical Bulletins provide guidance on the minimum requirements of the NFIP regulations. Community or State requirements that exceed those of the NFIP take precedence. Design professionals should contact the community to determine whether more restrictive local or State regulations apply to the building or site in question. All applicable standards of the State or local building code must also be met for any building in a flood hazard area.

Planning Considerations

A review of the following factors for the site in question will assist the design professional in determining whether floodproofing is appropriate. For example, if a site will be surrounded by rapidly rising, high-velocity floodwaters during a flood, and the available warning time is short, then the site is unsuitable for a floodproofed building.

Warning Time

The rate-of-rise of floodwaters for the site in question, the established flood warning system (if any), the flood warning time available, and the reliability of the flood warning must be reviewed to determine appropriate floodproof design elements. The rate-of-rise or the flood warning time available through an existing reliable (community-based or regionally based) flood warning system must be adequate to provide sufficient lead time to evacuate a floodprone building when flooding threatens. In addition, sufficient warning time must exist to successfully place floodproofing components, such as removable flood shields or gates, if such components are to be included in the floodproofing design. Other examples of floodproofing techniques that can require human intervention are operating sump pumps and closing valves. The amount of time necessary to put human intervention floodproofing components in place will depend upon the number of components, their complexity, and the availability of personnel to place them. Floodproofed buildings are not appropriate for any site in a flash flood area, because of the potentially short warning time.

Safety and Access

Safe access to a floodproofed building is a critical factor in the determination of whether floodproofing is an appropriate design alternative. In 1987, Colorado State University conducted a study of human stability in flood flow conditions based on the product number of depth of flow multiplied by the floodwater velocity. Results of this study indicated that any floodplain location with a product number of 4 or greater represents a significant hazard to individuals. Floodplain sites with a base flood product number number of 4 or greater (depth in feet multiplied by velocity in feet per second) will create a hazard for anyone attempting to escape from or gain access to the site. Such sites are not generally acceptable for floodproofed buildings, unless modifications are made to the site to reduce the flood hazard.

For any floodproofed building, all roads to be used as evacuation routes must remain passable as the floodwaters rise. In addition, all roads that provide access to buildings whose dry-floodproofing components require human intervention must remain passable long enough for the

floodproofing components to be installed and for all personnel to safely evacuate the site. For sites with an acceptably low hazard (product number less than 4) that are contiguous to land above the BFE, evacuation and access during times of flooding are generally not critical considerations.

Flood Velocities, Flood Depths, and Debris

For sites with flood velocities in excess of 5 feet per second or base flood depths in excess of 3 feet, the cost of dry-floodproofed construction may be prohibitive. Part 3 of the section of this bulletin titled "Minimum Engineering Considerations" describes the flood forces that a floodproofed building must be able to resist. Flood-borne debris can generate impact forces that may make a dry-floodproofed design technically infeasible and therefore inappropriate. A level of safety above the BFE, referred to as freeboard, is recommended, as discussed under "Minimum Engineering Considerations."

Note: While buildings need only be protected to the BFE for floodplain management purposes, freeboard is considered for flood insurance rating purposes. Because of the additional risk associated with any floodproofed building, 1 foot is subtracted from the elevation to which a building has been floodproofed, for insurance rating (if the building is floodproofed at least to the BFE). Therefore, to receive an insurance rating based on 100-year flood protection, the building must be floodproofed to an elevation at least 1 foot above the BFE. Insurance premiums will be lower if floodproofing exceeds this requirement.

Flood Frequency

A site that has been flooded frequently may not be appropriate for a dry-floodproofed building. The cumulative wear-and-tear on a building's external components as a result of recurring inundation may render a dry floodproofing strategy infeasible. The cost of repeated business interruption and of frequent cleanup activities, as well as the effects of having to repeatedly implement a flood emergency plan, must be assessed.

If the evaluation of each of the aforementioned factors indicates that dry floodproofing is a viable floodplain management alternative, then a floodproofing design is developed. For all floodproofed buildings, the design professional must then produce both a Flood Emergency Operation Plan and an Inspection and Maintenance Plan for the building.

Flood Emergency Operation Plan

A Flood Emergency Operation Plan is an integral part of any building's floodproofing design and is critical when the floodproofing requires human intervention such as the installation of flood gates or flood shields. A Flood Emergency Operation Plan is necessary for any floodproofed building to ensure that the floodproofing components will operate properly under all conditions, including power failures. A continuous source of electricity to operate any necessary floodproofing components, such as pumps, will be needed for any floodproofing design that

includes such components. The design professional must produce the plan. An adequate plan must include the following:

1. An established chain of command and responsibility with leadership responsibilities clearly defined for all aspects of the plan.
2. A procedure for notification of necessary parties when flooding threatens and flood warnings are issued. Personnel required to be at the building should have a planned and safe means of ingress and should have no other emergency response duties during a flood event. Alternates should be assigned in the event that the primary persons responsible are unable to complete their assigned duties under the plan.
3. A list of specific duties assigned to ensure that all responsibilities are addressed expeditiously. The locations of materials necessary to properly install all floodproofing components must be included in the list.
4. An evacuation plan for all personnel—those without duties for the flood emergency as well as those with duties for implementing the plan. All possible ingress and egress routes must be identified.
5. A periodic training and exercise program to keep personnel aware of their duties and responsibilities. Training drills should be held at least once a year and should be coordinated with community officials. Flood safety precautions should be repeated during each training drill.

Inspection and Maintenance Plan

Every floodproofing design requires some degree of periodic maintenance and inspection to ensure that all components will operate properly under flood conditions. The necessary inspection and maintenance activities, including inspection intervals and repair requirements, must be described in the Inspection and Maintenance Plan. Components that should be inspected as part of an annual (as a minimum) maintenance and inspection program include the following:

1. Mechanical equipment such as sump pumps and generators.
2. Flood shields and closures, to ensure that they fit properly and that the gaskets and seals are in good working order, properly labeled, and stored as indicated in the Flood Emergency Operation Plan.
3. Walls and wall penetrations, for cracks and potential leaks.
4. Levees and berms, for excessive vegetative growth, cracks, or leaks.

Both the Flood Emergency Operation Plan and the Inspection and Maintenance Plan are necessary at the time that the Non-Residential Floodproofing Certificate is submitted to the community. Before issuing a building permit, the community should require that the property owner sign an agreement stating that the plan will be adhered to. The community should also be assured that the inspection and maintenance activities required by the plan will continue regardless of changes in the ownership of the floodproofed building. This assurance should be accomplished by appropriate deed restrictions. Any lease agreement should also contain clear language stating the leaseholder's responsibilities for the floodproofed building.

Minimum Engineering Considerations

The design professional, a registered professional engineer or architect, must certify that the following requirements have been met by the building's design, specifications, and plans:

1. The building must be watertight (i.e., floodwaters must not enter the building envelope):
 - a. The building must be watertight to the floodproof design elevation, which is further defined as being at least the BFE. As previously noted, floodproofing to any elevation less than 1 foot above the BFE will have a serious negative impact on the flood insurance rating for the building. Generally a minimum of 1 foot of freeboard is recommended. Additional freeboard is warranted for sites where predicted flood depths may be inaccurate, such as sites within large drainage areas and rapidly urbanizing areas.
 - b. The building's walls must be "substantially impermeable to the passage of water." FEMA has adopted the U.S. Army Corps of Engineers (COE) definition of substantially impermeable from the COE publication "Flood Proofing Regulations." This document states that a substantially impermeable wall "shall not permit the accumulation of more than 4 inches of water depth during a 24-hour period if there were no devices provided for its removal. However, sump pumps shall be required to control this seepage." Flood-resistant materials, described in Technical Bulletin 2, "Flood-Resistant Materials Requirements," must be used in all areas where such seepage is likely to occur.
2. The building's utilities and sanitary facilities, including heating, air conditioning, electrical, water supply, and sanitary sewage services, must be located above the BFE, completely enclosed within the building's watertight walls, or made watertight and capable of resisting damage during flood conditions.
3. All of the building's structural components must be capable of resisting specific flood-related forces. These are the forces that would be exerted upon the building as a result of floodwaters reaching the BFE (at a minimum) or floodproofing design level, and include the following:
 - a. Hydrostatic Flood Force—This is the force that water at rest exerts on any submerged object. For a floodproofed building design, the calculations of hydrostatic flood forces must include saturated soil pressure on any portion of the building that is below grade (see Figure 1). Guidelines for determining hydrostatic pressure are provided on the following page.

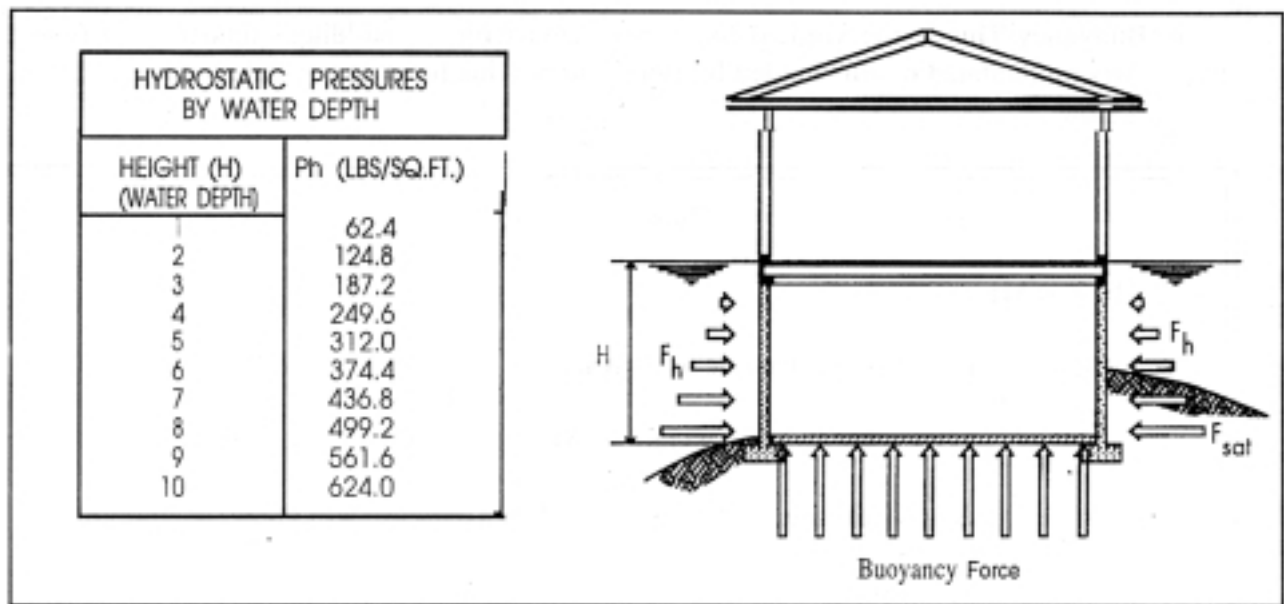


Figure 1. Hydrostatic Pressure Diagram

Resultant Lateral Force Due to Hydrostatic Pressure from Freestanding Water:

$$F_h = \frac{1}{2}wH^2$$

where: F_h is the lateral force from freestanding water (in pounds per linear foot of surface)

w is the specific weight of water (62.4 pounds per cubic foot)

H is the height of the standing water (to the floodproof design level)

If any portion of the building is below grade, then calculate the Resultant Cumulative Lateral Force Due to Hydrostatic Pressure from Saturated Soil:

$$F_{sat} = \frac{1}{2}SD^2 + F_h$$

where: F_{sat} is the lateral force from saturated soil

S is the equivalent fluid weight of saturated soil (in pounds, per cubic foot)

D is the depth of saturated soil (in feet)

F_h is the lateral force from freestanding water

Note: See Appendix C of the FEMA "Design Manual for Retrofitting Flood-Prone Residential Structures" for further information.

- b. Buoyancy—This is the vertical force associated with the building's tendency to float when inundated or surrounded by floodwaters. This force can be calculated as shown below.

Buoyancy Force:

$$F_b = wAH$$

- where:
- F_b is the force due to buoyancy
 - w is the specific weight of water (62.4 pounds per cubic foot)
 - A is the area of horizontal surface (floor or slab) being acted upon (in square feet)
 - H is the depth of building below the floodproofing design level (in feet)

Note: See Appendix C of the FEMA "Design Manual for Retrofitting Flood-Prone Residential Structures" for further information.

- c. Hydrodynamic Force—This is the force exerted on vertical surfaces exposed to moving floodwaters. The determination of hydrodynamic force is based on the expected velocity of the floodwaters with depths to the floodproofing design level (BFE or higher). The projected average base flood velocity within the floodway may be obtained using FEMA Flood Insurance Studies (FIS) where a floodway has been identified. It should be noted that velocities in the flood fringe will generally be less than the floodway velocities presented in the FIS. Where no FIS velocity data exist, velocities should be determined using Manning's equation, as found in most hydraulic reference and text books.

Hydrodynamic Force:

$$F_d = C_d m^{1/2} (V)^2 A$$

- where:
- F_d is the lateral force due to hydrodynamic pressure
 - C_d is the drag coefficient
 - m is the mass density of water (1.94 slugs per cubic foot)
 - V is the velocity of the water (in feet per second)
 - A is the area of the wall affected (in square feet)

Note: See Appendix C of the FEMA "Design Manual for Retrofitting Flood-Prone Residential Structures" for further information.

- d. **Debris Impact Force**—This is the force associated with flood-borne debris striking the side of a building. This force presents the greatest unknown to the designer, but a value must be estimated to develop an effective floodproofing design. Unless more detailed information is available, such as historical debris flow data, the formula shown below should be used. This formula assumes a 1-second duration of impact. The weight of the object is generally estimated at 1,000 pounds but can be reduced to 500 pounds for areas subject to minor debris flow potential. Any areas subject to severe debris (such as mountainous regions or areas subject to ice floes) are not appropriate sites for floodproofed buildings unless the designer takes these forces into account in designing and armouring the building. Armouring often results in designs that are not cost-effective.

Debris Impact Force:

$$F_i = \frac{WV}{gt}$$

- where: F_i is the Impact Force
 w is the weight of the object (in pounds)
 v is the velocity of the object (in feet per second)
 g is the acceleration due to gravity (32.2 feet per second²)
 t is the duration of impact (in seconds)

Note: See Appendix C of the FEMA "Design Manual for Retrofitting Flood-Prone Residential Structures" for further information.

4. Like all construction that falls under the NFIP regulations, the building must meet the requirements of all applicable portions of local and State building codes, including the provisions of the Americans with Disabilities Act; life-safety codes for ingress, egress, and clearing; and venting and combustion air requirements.

Preparation of the Floodproofing Certificate for Non-Residential Buildings

The Floodproofing Certificate is required for all non-residential buildings to be floodproofed and is to be completed by the design professional. The first part of the Certificate contains information concerning the location and ownership of the building.

FEDERAL EMERGENCY MANAGEMENT AGENCY NATIONAL FLOOD INSURANCE PROGRAM		O.M.B. No. 3067-007
<h3 style="margin: 0;">FLOODPROOFING CERTIFICATE</h3> <p style="margin: 0;">FOR NON-RESIDENTIAL STRUCTURES</p>		
<p><i>The floodproofing of non-residential buildings maybe permitted as an alternative to elevating to or above the Base Flood Elevation; however, a floodproofing design certification is required. This form is to be used for that certification. Floodproofing of a residential building does not alter a community's floodplain management elevation requirements or affect the insurance rating unless the community has been issued an exception by FEMA to allow floodproofed residential basements. The permitting of a floodproofed residential basement requires a separate certification specifying that the design complies with the local floodplain management ordinance.</i></p>		
		FOR INSURANCE COMPANY USE
BUILDING OWNER'S NAME		POLICY NUMBER
STREET ADDRESS (including Apt., Unit, Suite and/or Bldg. Number) OR P.O. ROUTE AND BOX NUMBER		COMPANY NAIC NUMBER
OTHER DESCRIPTION (Lot and Block Numbers, etc.)		
CITY	STATE	ZIP CODE

Building location and Ownership information

Section I of the Certificate is the Flood Insurance Rate Map (FIRM) information, including the BFE used in designing the floodproofing system. Copies of the FIRM should be available through the community's floodplain administrator.

SECTION I FLOOD INSURANCE RATE MAP (FIRM) INFORMATION					
Provide the following from the proper FIRM:					
COMMUNITY NUMBER	PANEL NUMBER	SUFFIX	DATE OF FIRM INDEX	FIRM ZONE	BASE FLOOD ELEVATION (in AO Zones use depth)

Section I

Section II requests information regarding the floodproofing design. The first item is the elevation, referenced to the datum of the FIRM (generally the National Geodetic Vertical Datum of 1929), to which the building is floodproofed. This elevation must be equal to or greater than the BFE. It is important to note that for insurance rating purposes, the floodproofing design must provide protection to 1 foot above the BFE to receive rating credit. If the building is floodproofed only to the BFE, then the building's insurance rating will result in a higher premium. Before a decision is made to floodproof to less than 1 foot above the BFE, insurance implications should be carefully considered.

The second item is the height of the floodproofing above the lowest adjacent grade. This information is intended to be used by community building officials, FEMA, and NFIP insurance underwriters to analyze the level of safety that the floodproofing design will provide. Since floodwaters exert greater pressure on the floodproofed building as the height of the flooding increases (see Figure 1), floodproofing that exceeds 3 feet in height represents a greater risk and may result in insurance rates that reflect this increased risk.

SECTION II FLOODPROOFING INFORMATION (By a Registered Professional Engineer or Architect)
Floodproofing Design Elevation Information: Building is floodproofed to an elevation of ____ feet NGVD. (Elevation datum used must be the same as that on the FIRM.) Height of floodproofing on the building above the lowest adjacent grade is ____ feet. <i>(NOTE: for insurance rating purposes, the building's floodproofed design elevation must be at least one foot above the Base Flood Elevation to receive rating credit. If the building is floodproofed only to the Base Flood Elevation, then the building's insurance rating will result in a higher premium.)</i>

Section II

Section III is the actual certification of the floodproofing design as required in Section 60.3(c)(4) of the NFIP regulations. It is important to note that design professionals signing this form are certifying that they have developed and/or reviewed the design plans and specifications and find them in compliance with accepted standards of practice for dry floodproofing. This certification is based on the floodproofing design, not the as-built condition of the building. The person signing this form must be a registered professional engineer or architect within the state or territory where the building will be constructed or substantially improved.

SECTION III CERTIFICATION (By a Registered Professional Engineer or Architect)

Non-Residential Floodproofed Construction Certification:

I certify that based upon development and/or review of structural design, specifications, and plans for construction that the design and methods of construction are in accordance with accepted standards of practice for meeting the following provisions:

The structure, together with attendant utilities and sanitary facilities, is watertight to the floodproofed design elevation indicated above, with walls that are substantially impermeable to the passage of water.

All structural components are capable of resisting hydrostatic and hydrodynamic flood forces, including the effects of buoyancy, and anticipated debris impact forces.

I certify that the information on this certificate represents my best effort to interpret the data available. I understand that any false statement may be punishable by fine or imprisonment under 18 U.S. Code, Section 1001.

CERTIFIER'S NAME	LICENSE NUMBER (or Affix Seal)		
TITLE	COMPANY NAME		
ADDRESS	CITY	STATE	ZIP
SIGNATURE	DATE	PHONE	

Copies should be made of this certificate for: 1) community official, 2) insurance agent/company, 3) building owner.

FEMA Form 81-65

Section III

The NFIP

The NFIP was created by Congress in 1968 to provide federally backed flood insurance coverage, because flood insurance was generally unavailable from private insurance companies. The NFIP is also intended to reduce future flood losses by identifying floodprone areas and ensuring that new development in these areas is adequately protected from flood damage. The NFIP is based on an agreement between the federal government and participating communities that have been identified as being floodprone. FEMA, through the Federal Insurance Administration (FIA), makes flood insurance available to the residents of a participating community provided that the community adopts and enforces adequate floodplain management regulations that meet the minimum NFIP requirements. The NFIP encourages communities to adopt floodplain management ordinances that exceed the minimum NFIP criteria. Included in the NFIP requirements, found under Title 44 of the U.S. Code of Federal Regulations, are minimum building design and

construction standards for buildings located in SFHAs. Through their floodplain management ordinances, communities adopt the NFIP design performance standards for new and substantially improved buildings located in floodprone areas identified on FIA's FIRMs.

Technical Bulletins

This is one of a series of Technical Bulletins FEMA has produced to provide guidance concerning the building performance standards of the NFIP. These standards are contained in Title 44 of the U.S. Code of Federal Regulations at Section 60.3. The bulletins are intended for use primarily by State and local officials responsible for interpreting and enforcing NFIP regulations and by members of the development community, such as design professionals and builders. New bulletins, as well as updates of existing bulletins, are issued periodically, as necessary. The bulletins do not create regulations; rather they provide specific guidance for complying with the minimum requirements of existing NFIP regulations. Users of the Technical Bulletins who need additional guidance concerning NFIP regulatory requirements should contact the Natural Hazards Branch of the appropriate FEMA regional office. The "User's Guide to Technical Bulletins" lists the bulletins issued to date and provides a key word/subject index for the entire series.

Ordering Information

Copies of the Technical Bulletins can be obtained from the appropriate FEMA regional office. Technical Bulletins can also be ordered from the FEMA publications warehouse. Use of FEMA Form 60-8 will result in a more timely delivery from the warehouse — the form can be obtained from FEMA regional offices and your state's Office of Emergency Management. Send publication requests to FEMA Publications, P.O. Box 70274, Washington, D.C. 20024.

Further Information

The following publications provide further information concerning non-residential floodproofing:

1. "Answers to Questions About Substantially Damaged Buildings," FEMA, May 1991, FEMA-213.
2. "Block and Brick Wall Integrity Against Water Heights and Systems and Materials to Prevent Flood Waters From Entering Buildings," Carl E. Pace, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi, 1984.
3. "Commercial-Industrial Flood Audit," New England District, U.S. Army Corps of Engineers, n.d.
4. "Cooperative Flood Loss Reduction, A Technical Manual for Communities and Industries," Flood Loss Reduction Associates, 1981.
5. "Design Manual for Retrofitting Flood-Prone Residential Structures," FEMA, September 1986, FEMA-1 14.
6. "Floodproofing Non-Residential Structures," FEMA, May 1986, FEMA- 102.

7. "Flood Proofing Regulations," U.S. Army Corps of Engineers, March 1992, EP 1165-2-314.
8. "Human Stability in a High Flood Hazard Zone," S.R. Abt, R.J. Whittlen, A. Taylor, and D.J. Love, Water Resource Bulletin, August 1989.
9. "Sealants, Part 1," John P. Cook, Progressive Architecture, December 1974.
10. "Sealants, Part 2," John P. Cook, Progressive Architecture, February 1975.
11. "Systems and Materials to Prevent Flood Waters from Entering Buildings," U.S. Army Corps of Engineers, 1984.
12. "Tests of Brick-Veneer Walls and Enclosures for Resistance to Flood Waters," Carl E. Pace, U.S. Army Corps of Engineers, Lower Mississippi Division, Vicksburg, Mississippi, 1978.

Glossary

Base flood — The flood that has a 1-percent probability of being equaled or exceeded in any given year (also referred to as the 100-year flood).

Base Flood Elevation (BFE) — The height of the base flood, usually in feet, in relation to the National Geodetic Vertical Datum of 1929 or other datum as specified.

Basement — Any area of a building having its floor subgrade (below ground level) on all sides.

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.

Federal Emergency Management Agency (FEMA) — The independent federal agency that, in addition to carrying out other activities, oversees the administration of the National Flood Insurance Program.

Federal Insurance Administration (FIA) — The component of FEMA directly responsible for administering the National Flood Insurance Program.

Flood Insurance Rate Map (FIRM) — The insurance and floodplain management map issued by FEMA that identifies, on the basis of detailed or approximate analyses, areas of 100-year flood hazard in a community.

Floodprone area — Any land area susceptible to being inundated by floodwater from any source.

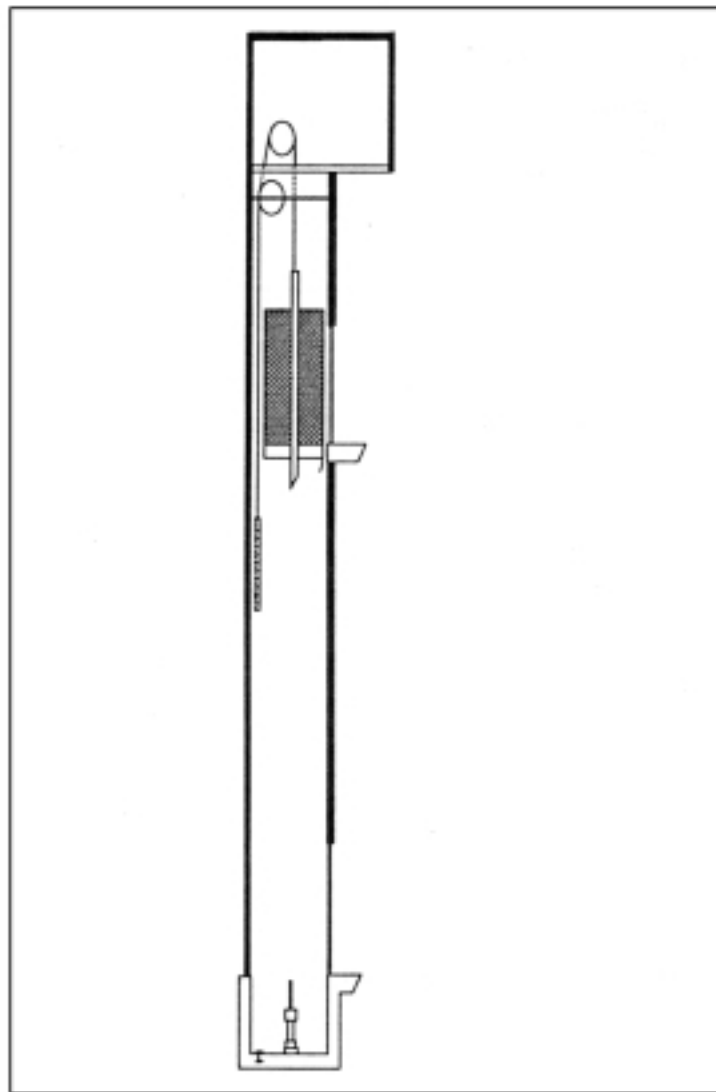
Lowest floor — The lowest floor of the lowest enclosed area of a building, including a basement. Any NFIP-compliant unfinished or flood-resistant enclosure useable solely for parking of vehicles, building access, or storage (in an area other than a basement) is @ considered a building's lowest floor.

Special Flood Hazard Area (SFHA) — Area delineated on a Flood Insurance Rate Map as being subject to inundation by the base flood and designated as Zone A, AE, A1-A30, AR, AO, AH, V, VE, or V1-V30.

Substantial damage — Damage of any origin sustained by a structure whereby the cost of restoring the structure to its before-damaged condition would equal or exceed 50 percent of the market value of the structure before the damage occurred.

Substantial improvement — Any reconstruction, rehabilitation, addition, or other improvement of a structure, the cost of which equals or exceeds 50 percent of the market value of the structure before the “start of construction” of the improvement. This term includes structures that have incurred “substantial damage,” regardless of the actual repair work performed.

Elevator Installation
for Buildings Located in Special Flood Hazard Areas
in accordance with the
National Flood Insurance Program



Key Word/Subject Index:

This index allows the user to quickly locate key words and subjects in this Technical Bulletin. The Technical Bulletin User's Guide (printed separately) provides references to key words and subjects throughout the Technical Bulletins. For definitions of selected terms, refer to the Glossary at the end of this bulletin.

Key Word/Subject	Page
Elevators, types of	2
Elevator components, location of in relation to BFE	3
Elevator electrical equipment, location of in relation to BFE	4
Float switch, use of in flood areas	3
Flood-resistant elevator components, use of	3

Any comments on the Technical Bulletins should be directed to:

FEMA/FIA
Office of Loss Reduction
Technical Standards Division
500 C St., SW, Room 417
Washington, D.C. 20472

Technical Bulletin 4-93 replaces Technical Bulletin 88-4 (draft) "Protection of Elevator Equipment."

Graphic design based on the Japanese print *The Great Wave Off Kanagawa*, by Katsushika Hokusai (1760-1849), Asiatic collection, Museum of Fine Arts, Boston.

TECHNICAL BULLETIN 4-93

Elevator Installation for Buildings Located In Special Flood Hazard Areas in accordance with the National Flood Insurance Program

Introduction

Under the National Flood Insurance Program (NFIP), flood insurance coverage is limited for elevator equipment. New or replacement equipment relevant to an elevator, installed on or after October 1, 1987, and located below the lowest floor of an elevated building or in a basement is not covered for flood damage.

This Technical Bulletin provides information on proper installation of elevators in flood hazard areas to reduce flood damage. Elevator types and their associated equipment are described, and practical methods of protecting them from flood damage are provided.

The guidelines within this bulletin meet existing NFIP regulations that pertain to elevators, as well as serve to encourage the use of loss prevention measures that would reduce both the level of damage that can occur and the amount of time and work needed to make repairs. If these guidelines are followed, restoration of elevator service to the undamaged portion of the building can be accomplished as soon as possible after floodwaters recede and power is restored.

NFIP Regulations

The NFIP regulations require that elevators and their associated equipment be protected from flood damage. Section 60.3(a)(3) states that the community shall:

“Review all permit applications to determine whether proposed building sites will be reasonably safe from flooding. If a proposed building site is in a floodprone area, all new construction and substantial improvements shall...(ii) be constructed with materials resistant to flood damage, (iii) be constructed by methods and practices that minimize flood damages, and (iv) be constructed with electrical...equipment and other service facilities that are designed and/or located so as to prevent water from entering or accumulating within the components during conditions of flooding.”

As these regulations indicate, all appropriate measures must be taken to mitigate flood damage to elevators and associated equipment to the maximum extent possible. While some components, to function properly, must be located below the lowest floor of a building, i.e., below the base flood elevation (BFE), most elevator components that can be damaged by floodwater can be located above the BFE or be designed to minimize flood damage. Components that can be damaged by floodwaters may be located below the BFE only if it is not technically feasible to elevate them above the BFE.

It should be noted that Technical Bulletins provide guidance on the minimum requirements of the NFIP regulations. Community or State requirements that exceed those of the NFIP take precedence. Design professionals should contact the community to determine whether more restrictive local or State regulations apply to the building or site in question. All applicable standards of the State or local building code must also be met for any building in a flood hazard area.

Types of Elevators

There are two types of elevators, hydraulic and traction. The hydraulic elevator consists of a cab attached to the top of a hydraulic jack similar to a jack used for a car lift in a service station. The hydraulic jack assembly normally extends below the lowest floor and is operated by a hydraulic pump and reservoir, both of which are usually located in a separate room adjacent to the elevator shaft, as shown in Figure 1. Hydraulic elevators are the type generally used in single-family residences.

The second type is the traction elevator. This is the system that is most commonly associated with elevators. The traction system consists of a cable that is connected to the top of the cab and is operated by an electric motor located in a penthouse above the elevator shaft, as shown in Figure 2.

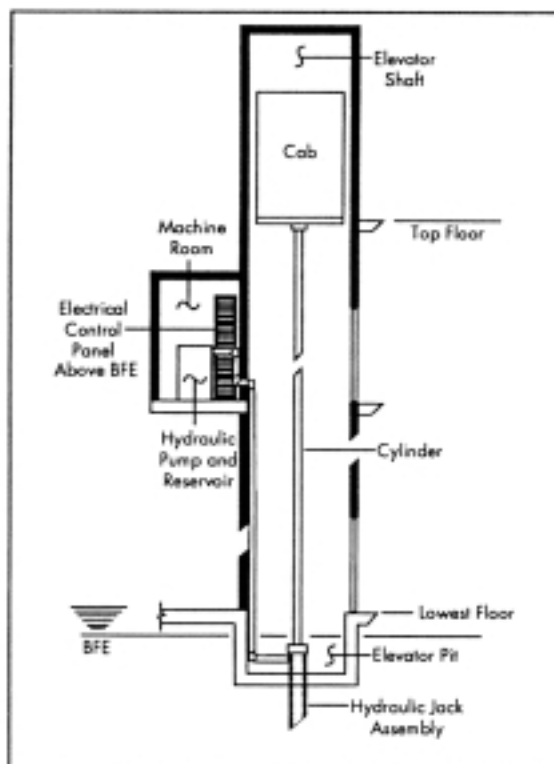


Figure 1. Hydraulic Elevator

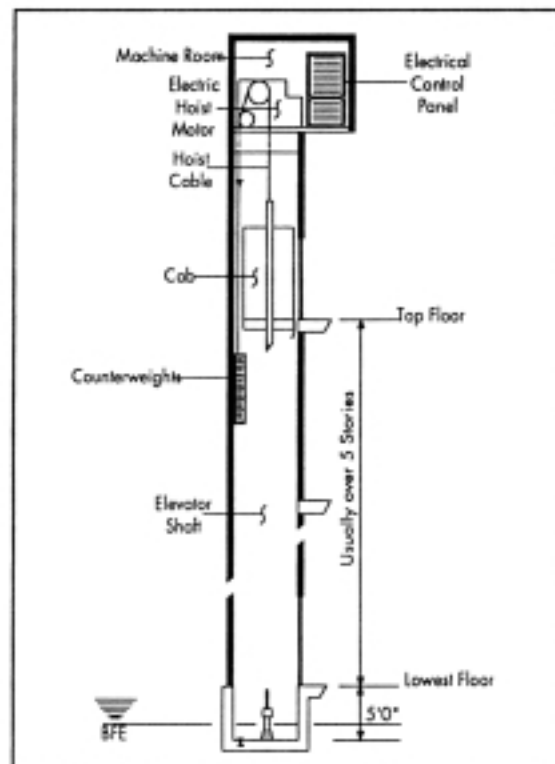


Figure 2. Traction Elevator

Flood Damage Protection

For compliance with NFIP regulations, the design and construction of an elevator installation must include all possible steps for protecting the elevator equipment from flood damage.

Hydraulic Elevators

The jack assembly for a hydraulic elevator (see Figure 1) will, by necessity, be located below the lowest floor and therefore generally below the BFE. The jack is located in a casing, and while it will resist damage from small amounts of water seepage, total inundation by floodwaters will usually result in contamination of the hydraulic oil and possible damage to the cylinders and seals of the jack. Salt water, because it is corrosive, can be particularly damaging. The hydraulic pump and reservoirs of the hydraulic elevator are also susceptible to water damage, but they can easily be located up to two floors above the jack and above the BFE as shown in Figure 1.

Traction Elevators

For traction elevators (see Figure 2), the electric motor and most other equipment are normally located above the elevator shaft and would not be susceptible to flood damage. Some equipment, however, such as the counterweight roller guides, compensation cable and pulleys, and oil buffers, usually must be located at the bottom of the shaft. When such equipment cannot be located above the BFE, it must be constructed using flood-resistant materials where possible.

Elevator Equipment

Some equipment common to all elevators will be damaged by floodwaters unless protected. The most obvious example is the elevator cab. Depending upon the size of the cab and the types of interior materials used, a cab may cost between \$5,000 and \$50,000. Flood damage, which can range from superficial to nearly a complete loss, can easily be avoided by keeping the cab above floodwaters. However, in most elevator control systems, the cab automatically descends to the lowest floor upon loss of electrical power. Installing a system of interlocking controls with one or more float switches in the elevator shaft to always keep the elevator cab from descending into floodwaters (see Figure 3) will result in a much safer system. **A float switch system or an-**

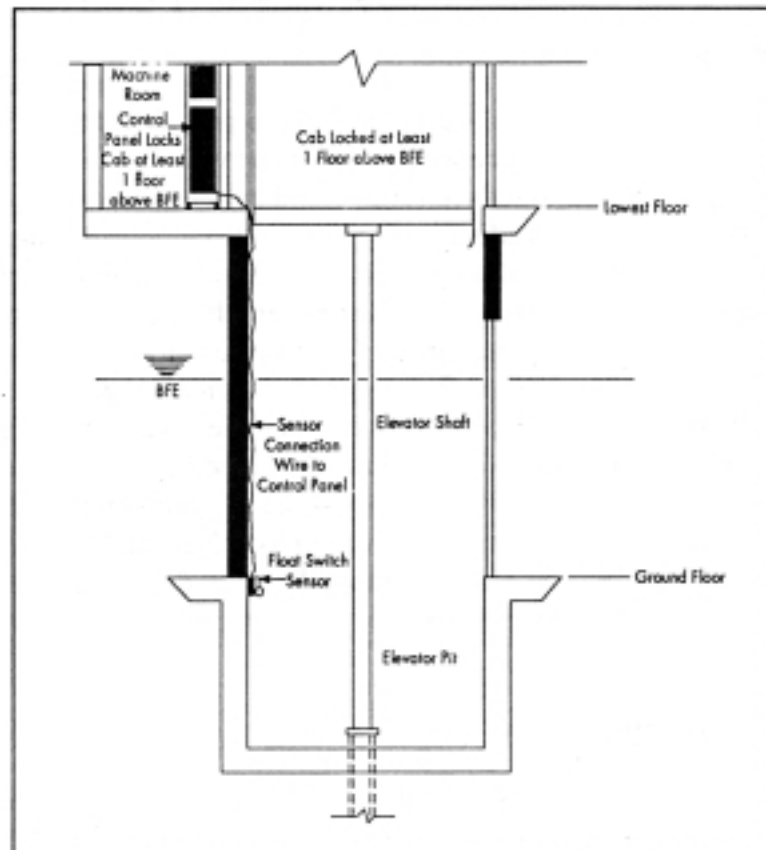


Figure 3. Float and Control Mechanism to Control Cab Descent

other system that provides the same level of safety is necessary for all elevators where there is a potential for the elevator cab to descend below the BFE during a flood.

Electrical equipment is often located below the BFE for both types of elevator systems. Some electrical equipment, such as electrical junction boxes and circuit and control panels, can be located above the BFE as shown in Figure 1. Other elevator components, such as doors and pit switches, must be located at or below the lowest floor. Where this becomes necessary, components may sometimes be replaced with more floodwater-resistant models. Some elevator equipment manufacturers offer water-resistant components; design professionals should contact suppliers to determine the availability of these components.

The NFIP

The NFIP was created by Congress in 1968 to provide federally backed flood insurance coverage, because flood insurance was generally unavailable from private insurance companies. The NFIP is also intended to reduce future flood losses by identifying floodprone areas, and ensuring that new development is adequately protected from flood damage. The NFIP is based on an agreement between the federal government and participating communities that have been identified as floodprone. FEMA, through the Federal Insurance Administration (FIA), makes flood insurance available to the residents of a participating community provided that the community adopts and enforces adequate floodplain management regulations that meet the minimum NFIP requirements. The NFIP encourages communities to adopt floodplain management ordinances that exceed the minimum NFIP criteria. Included in the NFIP requirements, found under Title 44 of the U.S. Code of Federal Regulations, are minimum building design and construction standards for buildings located in Special Flood Hazard Areas. Through their floodplain management ordinances, communities adopt the NFIP design performance standards for new and substantially improved buildings located in floodprone areas identified on FIA's Flood Insurance Rate Maps.

Technical Bulletins

This is one of a series of Technical Bulletins FEMA has produced to provide guidance concerning the building performance standards of the NFIP. These standards are contained in Title 44 of the U.S. Code of Federal Regulations at Section 60.3. The bulletins are intended for use primarily by State and local officials responsible for interpreting and enforcing NFIP regulations and by members of the development community, such as design professionals and builders. New bulletins, as well as updates of existing bulletins, are issued periodically, as necessary. The bulletins do not create regulations; rather they provide specific guidance for complying with the minimum requirements of existing NFIP regulations. Users of the Technical Bulletins who need additional guidance concerning NFIP regulatory requirements should contact the Natural Hazards Branch of the appropriate FEMA regional office. The "User's Guide to Technical Bulletins" lists the bulletins issued to date and provides a key word/subject index for the entire series.

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from FEMA regional offices and your state's Office of Emergency Management. Send publication requests to FEMA Publications, P.O. Box 70274, Washington, D.C. 20024.

Further Information

The following publications provide further information concerning elevator installation in buildings located in Special Flood Hazard Areas:

1. "Answers to Questions About Substantially Damaged Buildings," FEMA, May 1991, FEMA-213.
2. "Floodproofing Non-Residential Structures," FEMA, May 1986, FEMA-102.
3. "Flood Proofing Regulations," U.S. Army Corps of Engineers, March 1992, EP 1165-2-314.
4. "Floodproofing Test: Tests of Materials and Systems for Floodproofing Structures," U.S. Army Corps of Engineers, August 1988.

Glossary

Base flood — The flood that has a 1-percent probability of being equaled or exceeded in any given year (also referred to as the 100-year flood).

Base Flood Elevation (BFE) — The height of the base flood, usually in feet, in relation to the National Geodetic Vertical Datum of 1929 or other datum as specified.

Basement — Any area of a building having its floor subgrade (below ground level) on all sides.

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.

Federal Emergency Management Agency (FEMA) — The independent federal agency that, in addition to carrying out other activities, oversees the administration of the National Flood Insurance Program.

Federal Insurance Administration (FIA) — The component of FEMA directly responsible for administering the National Flood Insurance Program.

Flood Insurance Rate Map (FIRM) — The insurance and floodplain management map issued by FEMA that identifies, on the basis of detailed or approximate analyses, areas of 100-year flood hazard in a community.

Floodprone area — Any land area susceptible to being inundated by floodwater from any source.

Lowest floor — The lowest floor of the lowest enclosed area of a building, including a basement. Any NFIP-compliant unfinished or flood-resistant enclosure useable solely for parking of vehicles, building access, or storage (in an area other than a basement) is not considered a building's lowest floor.

Special Flood Hazard Area (SFHA) — Area delineated on a Flood Insurance Rate Map as being subject to inundation by the base flood and designated as Zone A, AE, A1-A30, AR, A0, AH, V, VE, or V1-V30.

Substantial damage — Damage of any origin sustained by a structure whereby the cost of restoring the structure to its before-damaged condition would equal or exceed 50 percent of the market value of the structure before the damage occurred.

Substantial improvement — Any reconstruction, rehabilitation, addition, or other improvement of a structure, the cost of which equals or exceeds 50 percent of the market value of the structure before the "start of construction" of the improvement. This term includes structures that have incurred "substantial damage," regardless of the actual repair work performed.



Technical
Bulletin
5-93

Free-Of-Obstruction Requirements
for Buildings Located in Coastal High Hazard Areas
in accordance with the
National Flood Insurance Program



FEDERAL EMERGENCY MANAGEMENT AGENCY
FEDERAL INSURANCE ADMINISTRATION

FIA-TB-5
(4/93)

Key Word/Subject Index:

This index allows the user to quickly locate key words and subjects in this Technical Bulletin. The Technical Bulletin User's Guide (printed separately) provides references to key words and subjects throughout the Technical Bulletins. For definitions of selected terms, refer to the Glossary at the end of this bulletin.

Key Word/Subject	Page
Accessory buildings, as possible obstructions in V zones	4
Accessory buildings, low value and small, defined	4
Bulkheads, as possible obstructions in V zones	4
Decks and patios, as possible obstructions in V zones	5
Detached garages, elevation requirement for in V zones	4
Fill, as obstruction beneath buildings in V zones	6
Foundation bracing, as possible obstructions in V zones	6
Free of Obstruction, definition of	1
Free of Obstruction, designing a foundation system in V zones	3
Free of Obstruction requirement in V zones	1
Grade beams, as possible obstructions in V zones	6
Swimming pools, as obstructions in V zones	6

Any comments on the Technical Bulletins should be directed to:

FEMA/FIA
Office of Loss Reduction
Technical Standards Division
500 C St., SW, Room 417
Washington, D.C. 20472

Technical Bulletin 5-93 replaces Technical Bulletin 88-3 (draft) "Free of Obstruction Requirement in Coastal Areas."

Graphic design based on the Japanese print *The Great Wave Off Kanagawa*, by Katsushika Hokusai (1760-1849), Asiatic collection, Museum of Fine Arts, Boston.

TECHNICAL BULLETIN 5-93

Free-Of-Obstruction Requirements for Buildings Located In Coastal High Hazard Areas in accordance with the National Flood Insurance Program

Introduction

In coastal high hazard areas (Zones V, VE, and V1-V30), the National Flood Insurance Program (NFIP) requires that all new and substantially improved buildings be elevated to or above the base flood elevation (BFE). Foundations must be designed to allow water moving at high velocities (velocity water) and waves to flow beneath the elevated superstructure of the building. The result is that floodwaters transfer only minimal forces to the foundation system, and flood damage to the elevated superstructure is thereby minimized. The NFIP further requires that the area beneath an elevated building remain free of any obstructions that would reduce or eliminate the free flow of coastal floodwaters during a design coastal storm. This free-of-obstruction requirement is critical to the protection of buildings constructed in V zones.

The velocity water and wave action associated with coastal flooding can exert strong hydrodynamic forces on any obstruction to the flow of water. Standard foundations such as solid masonry walls or wood-frame walls will obstruct flow and be at risk to damage from high-velocity flood forces. In addition, solid foundations can direct coastal floodwaters into the elevated portion of the building or into adjacent buildings. The result is generally structural failure of the building. Therefore, foundations that offer minimal resistance to floodwaters passing beneath an elevated building are required in V zones. The use of pile or column foundations meets the elevation requirement in V zones. It should be noted that the use of structural fill as a means to elevate buildings is expressly prohibited in V zones.

Under the free-of-obstruction requirement, open lattice panels, insect screening, and non-bearing solid breakaway walls are allowed below the elevated lowest floor because they will easily break away under the combined effects of storm wind and water loads without transferring damaging flood loads to the foundation. Breakaway solid enclosure walls will not significantly increase the damage potential to the foundation and/or superstructure provided they meet the applicable NFIP criteria. Under the free-of-obstruction requirement, any type of lower area enclosure or other construction element (as described later in this bulletin) that will obstruct the flow of velocity water and wave action beneath an elevated building during a base flood event is not allowed. For NFIP purposes, an enclosure is defined as an area partially or totally enclosed by rigid walls.

Under the NFIP general requirement that buildings be constructed by methods that will minimize flood damage, the placing of any construction element (such as bulkheads, swimming pools, and septic systems, as described later in this bulletin) on a building site in a V zone must include consideration of the potential effects on the building and adjacent buildings. V-zone obstructions placed outside the perimeter (footprint) of a building located in a V zone must not result in

damage to nearby buildings during coastal storms. Floodwaters can be redirected by such obstructions through ramping and deflection. This will increase the potential for damage to nearby buildings, either on the site or on adjacent sites. In addition to causing ramping and deflection, obstructions can become debris that may result in unanticipated impact forces on the foundation systems of nearby buildings.

To evaluate the effects of construction elements as potential obstructions in V zones, FEMA recommends referring to the U.S. Army Corps of Engineers' (COE's) "Shore Protection Manual" for detailed engineering information and guidance related to wave ramping and deflection as well as localized scour and erosion.

This bulletin provides specific guidance concerning how to meet the NFIP free-of-obstruction requirement in V zones as well as the general requirement for construction that will minimize flood damage potential, as it applies to V-zone construction. Typical construction elements and their relationship to the NFIP V-zone requirements are discussed.

NFIP Regulations

Section 60.3(a)(3) of the NFIP regulations states:

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

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

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

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

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

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

Section 60.3(e)(6) states that a community shall:

“Prohibit the use of fill for structural support of buildings within Zones V1-30, VE, and V on the community’s FIRM.”

It is important to note that any building materials used below the BFE must meet the flood-resistant materials requirement of Section 60.3(a)(3). Further guidance on this requirement can be found in Technical Bulletin 2, “Flood-Resistant Materials Requirements.”

It should be noted that Technical Bulletins provide guidance on the minimum requirements of the NFIP regulations. Community or State requirements that exceed those of the NFIP take precedence. Design professionals should contact the community to determine whether more restrictive local or State regulations apply to the building or site in question. All applicable standards of the State or local building code must also be met for any building in a flood hazard area.

Obstruction Considerations

Any construction element, such as a garage, deck, bulkhead, or accessory building, that is structurally dependent on or attached to a V-zone building is considered to be part of that building and must meet the requirements of Sections 60.3(e)(4),(5), and (6). If any of these elements are attached to the building and located below the lowest horizontal structural member of the building, they constitute an obstruction and are prohibited unless constructed to the breakaway standards of Section 60.3(e)(5). The construction of such a prohibited feature attached to an otherwise compliant building may result in a significantly higher flood insurance premium being assessed against the entire building because of the increased risk of damage to the building.

Construction elements outside the perimeter (footprint) of and not attached to a coastal building (such as bulkheads, swimming pools, and accessory buildings) may alter the physical characteristics of flooding or significantly increase wave or debris impact forces affecting nearby buildings. As part of the certification process for V-zone buildings, as detailed in Section 60.3(e)(4),

the design professional must consider the effects that any of these elements will have on the building in question and any nearby buildings. Construction elements that will increase storm-related loadings on the building (and that are not specifically precluded by the NFIP regulations) may be constructed if the impacted buildings are designed to withstand the additional impact (hydrodynamic) forces. Increased foundation element embedment depth, size, and number should be employed to compensate for any increased impact forces. Such compensatory design considerations must be made by the design professional and reviewed by the community floodplain administrator prior to construction.

Following are common construction elements for coastal buildings and sites. The factors that must be considered prior to construction in order to comply with the NFIP requirements are discussed for each.

Access Stairs and Elevators Access stairs and elevators attached to or beneath an elevated building are excluded from the breakaway requirement but must meet the flood-resistant material requirements of Section 60.3(a)(3). Further requirements regarding elevators can be found in Technical Bulletin 4, "Elevator Installation." Although access stairs and elevators need not be breakaway, the potential loads generated by these obstructions must be taken into account in the design of the building.

Accessory Buildings Unless properly elevated on piles or columns in accordance with Section 60.3(e)(4), accessory buildings in V zones must be limited to low-value or small structures such as small metal or wooden sheds that are "disposable." If a low-cost or small building is placed on a site, consideration must be given to the effects the debris from the building will have on the building or adjacent buildings. If the building is of significant size and strength to create either a debris impact or flow diversion problem, it must be elevated in accordance with Section 60.3(e)(4).

For purposes of defining and administering the floodplain ordinance, if a community wishes to allow unelevated accessory buildings, the community must establish the meaning of low-cost and small accessory buildings. FEMA recommends that low cost be defined as having a value of less than \$500 and small be defined as less than 100 square feet of floor space. Accessory buildings meeting these criteria must be unfinished on the interior, constructed with flood-resistant materials below the BFE, and used only for storage. Unless properly elevated on piles or columns in accordance with Section 60.3(e)(4), detached garages are not allowed in V zones.

Bulkheads Any bulkhead beneath a coastal building, whether or not it is attached to the foundation system, is an obstruction and is therefore prohibited. Bulkheads transfer damaging flood loads to piles and greatly increase the potential for redirecting velocity water and wave action into the elevated portions of coastal buildings.

While the NFIP does not prohibit bulkheads or seawalls that are not beneath or attached to a coastal building, the community and the design professional must carefully consider the potentially significant effects of these structures before construction is initiated. As with all floodplain construction, local and State requirements must be determined and complied with. If a proposed seawall or bulkhead will result in ramping or deflection of velocity waters, or erosion that will damage any nearby buildings or other structures, its construction should be prohibited by the

community. Determining the potential damaging effects of a seawall or bulkhead is an important part of the design professional's responsibility. The COE's "Shore Protection Manual" should be consulted for guidance on bulkheads.

Concrete Pads A concrete pad with minimal or no reinforcement, to be used for parking, as a floor in an enclosed storage area, or as the floor of an enclosed area used for access to the elevated lowest floor of a building, may be poured beneath an elevated coastal building. A concrete pad placed at grade is not considered an obstruction if it is not structurally attached to the building's foundation system. The use of fill beneath an elevated building to elevate a slab above natural grade is considered an obstruction and is therefore prohibited. It is important to note that compliant concrete pads often collapse during coastal storms due to erosion and localized scour of underlying soils.

Decks and Patios Decks or patios constructed at grade may involve considerable alteration of the site in the construction process. The proposed construction must be evaluated to determine whether buildings on the site or on adjacent sites will be adversely affected. Floodwaters should not be diverted into the elevated building or into nearby buildings. Debris from destroyed decks or patios should not damage the foundation of the building or of adjacent buildings. Decks and patios constructed below the BFE must be structurally independent of the building's foundation system.

If a deck is structurally attached to the building, the lowest horizontal member of the deck must be elevated to or above the BFE. Like an at-grade deck, an elevated deck should not worsen flooding conditions or create debris that will damage adjacent buildings. A deck that is properly elevated on embedded piles to withstand flood forces generated by a base flood should not cause additional flood or debris damage to adjacent buildings.

Enclosed Areas The area beneath the elevated superstructure of a V-zone building may be enclosed only with non-loadbearing breakaway walls. Open lattice and insect screening may also be used in lower areas.

Uses of the area beneath an elevated building are restricted to parking, access, and storage; lower areas must not be finished or used for recreational or habitable purposes. No mechanical, electrical, or plumbing equipment is to be installed below the BFE.

There are no NFIP restrictions on the size of the area that may be enclosed. However, V-zone buildings with lower area enclosures (constructed with breakaway walls) that exceed 300 square feet may be subject to higher insurance premiums due to the potential for increased loadings on the foundation system caused by the enclosure. Design professionals may wish to contact an insurance agent for information regarding any additional insurance premium that would be assessed.

Fences Like other construction elements on V-zone building sites, fences must be analyzed for their effects on flood conditions, including ramping effects on adjacent buildings and the effects of debris during flood events.

Fill The NFIP prohibits the use of fill for structural support of buildings in V zones. Fill may be used on coastal building sites for landscaping and site grading as long as the fill does not interfere with the free passage of floodwaters and debris underneath the building or cause changes in flow direction during coastal storms such that floodwaters will cause additional damage to buildings on the site or to any adjacent buildings. Under the building, no fill may be used except for minor landscaping and minor site grading for drainage purposes. An example of unacceptable placement of fill would be the construction of a small berm or retaining wall that is back-filled and used for landscaping purposes when it has been determined that ramping or deflection of floodwaters will adversely affect adjacent buildings and thereby create additional flood damage potential.

Foundation Bracing Bracing is intended to provide lateral wind-resistance support to a pile or column foundation by stiffening the foundation system. While diagonal bracing is allowed under the NFIP, it will obstruct velocity floodwaters and waves to some degree and will often trap debris. Foundation bracing may not be necessary for a V-zone building if the number, size, and embedment of the piles or columns are adequate.

Bracing is to be placed parallel to the primary direction of flow, generally perpendicular to the shoreline. Only the minimum amount of bracing that is necessary to stiffen the foundation may be used. Bracing should be composed of members that will offer the least resistance to floodwaters flowing under the elevated building.

Grade Beams Grade beams, made of wood or reinforced concrete, tie together the perimeter piles or columns to provide additional lateral support. Grade beams that are placed with their upper surfaces flush with the natural grade are allowed under the NFIP. However, storm erosion and localized scour will generally expose grade beams, leaving them elevated above the post-storm beach profile. Therefore, grade beams must be designed to remain in place when erosion and localized scour remove the supporting soil beneath them. It must be noted that grade beams are not to be used as a substitute for adequate number, size, and embedment of piles or columns.

Septic Systems Mounded septic systems generally require a significant volume of fill and therefore constitute an obstruction if placed under an elevated coastal building. Septic systems must not be attached directly to the foundation. Mounded septic systems may be allowed on a V-zone site if they will not worsen flooding conditions for the building in question or any adjacent buildings.

An additional consideration for septic systems in V zones is addressed by Section 60.3(a)(6)(ii), which requires "on-site waste disposal systems to be located to avoid impairment to them or contamination from them during flooding."

Swimming Pools A swimming pool may be placed beneath a coastal building only if the top of the pool and accompanying pool deck or walkway are flush with the existing grade and only if the lower area (below the lowest floor) remains unenclosed. Lower-area enclosures around pools constitute a recreational use and are therefore not allowed, even if constructed to breakaway standards. Lattice and insect screening are allowed as they do not create an enclosed area.

Pools, either at-grade or elevated, are allowed adjacent to coastal buildings only if the pools will not act as obstructions that will result in damage to nearby buildings. Community officials must be assured by the design professional that a pool beneath or near a V-zone building will not be subject to breaking up or floating out of the ground during a coastal flood and will therefore not increase the damage potential to the foundation and elevated portion of any nearby buildings. In addition, the design professional must design and site the pool so that any increased wave or debris impact forces will not affect any nearby buildings.

Pools, pool decks, walkways, and associated accessory buildings placed under or adjacent to coastal buildings must be structurally independent of the building and its foundation.

The NFIP

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1. "Answers to Questions About Substantially Damaged Buildings," FEMA, May 1991, FEMA-213.
2. "Coastal Construction Manual," FEMA, February 1986, FEMA-55.
3. "Elevated Residential Structures," FEMA, March 1984, FEMA-54.
4. "Shore Protection Manual," U.S. Army Corps of Engineers, (latest edition).

Glossary

Base flood — The flood that has a 1-percent probability of being equaled or exceeded in any given year (also referred to as the 100-year flood).

Base Flood Elevation (BFE) — The height of the base flood, usually in feet, in relation to the National Geodetic Vertical Datum of 1929 or other datum as specified.

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Federal Insurance Administration (FIA) — The component of FEMA directly responsible for administering the National Flood Insurance Program.

Flood Insurance Rate Map (FIRM) — The insurance and floodplain management map issued by FEMA that identifies, on the basis of detailed or approximate analyses, areas of 100-year flood hazard in a community.

Floodprone area — Any land area susceptible to being inundated by floodwater from any source.

Lowest floor — The lowest floor of the lowest enclosed area of a building, including a basement. Any NFIP-compliant unfinished or flood-resistant enclosure useable solely for parking of vehicles, building access, or storage (in an area other than a basement) is not considered a building's lowest floor.

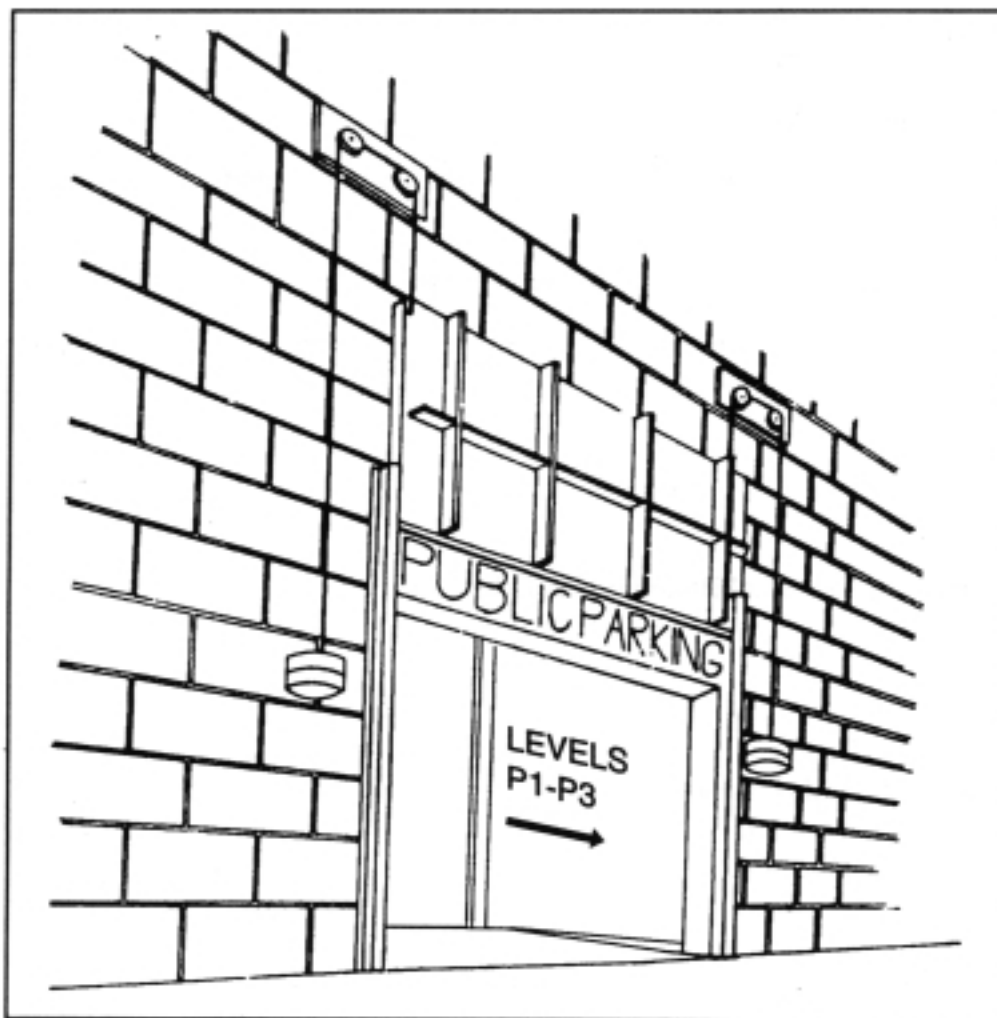
Special Flood Hazard Area (SFHA) — Area delineated on a Flood Insurance Rate Map as being subject to inundation by the base flood and designated as Zone A, AE, A1-A30, AR, A0, AH, V, VE, or V1-V30.

Substantial damage — Damage of any origin sustained by a structure whereby the cost of restoring the structure to its before-damaged condition would equal or exceed 50 percent of the market value of the structure before the damage occurred.

Substantial improvement — Any reconstruction, rehabilitation, addition, or other improvement of a structure, the cost of which equals or exceeds 50 percent of the market value of the structure before the "start of construction" of the improvement. This term includes structures that have incurred "substantial damage," regardless of the actual repair work performed.



Below-Grade Parking Requirements
for Buildings Located in Special Flood Hazard Areas
in accordance with the
National Flood Insurance Program



FEDERAL EMERGENCY MANAGEMENT AGENCY
FEDERAL INSURANCE ADMINISTRATION

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Key Word/Subject Index:

This index allows the user to quickly locate key words and subjects in this Technical Bulletin. The Technical Bulletin User's Guide (printed separately) provides references to key words and subjects throughout the Technical Bulletins. For definitions of selected terms, refer to the Glossary at the end of this bulletin.

Key Word/Subject	Page
Below-grade parking garage, considered a basement	1
Below-grade parking garage, defined	1
Below-grade parking in A and V zones, when allowed, requirements for	2
Floodproofing, below-grade parking beneath non-residential buildings, design requirements for	4
Floodproofing, recognition of for insurance rating purposes	4

Any comments on the Technical Bulletins should be directed to:

FEMA/FIA
Office of Loss Reduction
Technical Standards Division
500 C St., SW, Room 417
Washington, D.C. 20472

Technical Bulletin 6-93 replaces Technical Bulletin 90-2 (draft) "Below Grade Parking Garages."

Graphic design based on the Japanese print *The Great Wave Off Kanagawa*, by Katsushika Hokusai (1760-1849), Asiatic collection, Museum of Fine Arts, Boston.

TECHNICAL BULLETIN 6-93

Below-Grade Parking Requirements for Buildings Located In Special Flood Hazard Areas in accordance with the National Flood Insurance Program

Introduction

The purpose of this bulletin is to provide technical guidance on the National Flood Insurance Program (NFIP) floodplain management requirements for below-grade parking garages for non-residential buildings in Special Flood Hazard Areas (SFHAs) shown on Flood Insurance Rate Maps (FIRMs).

Below-grade parking garages are commonly found in large engineered commercial buildings and are used for parking and access to the above-grade floors of the building. Flooding of these enclosed areas may result in significant damage to the building and any mechanical, electrical, or other utility equipment located there, such as ventilation equipment, lighting, elevator equipment, and drainage pumps. The garage walls, which often are major structural components of the building's foundation, are also susceptible to flood damage. The potential for injury to anyone in the garage, the potential for damage to parked cars, and the safety issue of removing parked cars when flooding threatens are important design considerations.

Note: Users of this bulletin are advised that it provides guidance that must be used in conjunction with Technical Bulletin 3, "Non-Residential Floodproofing — Requirements and Certification." The conditions and requirements set forth in both bulletins must be met for any below-grade parking garage to be in compliance with the minimum requirements of the NFIP regulations. A Floodproofing Certificate for Non-Residential Structures must be completed for any building in an SFHA with below-grade parking.

NFIP Regulations

The NFIP regulations provide direction concerning whether or not below-grade parking is permitted in SFHAs, both coastal and riverine. For the purposes of the NFIP, below-grade parking is considered a basement. A basement is defined as any area of a building having its floor subgrade (below ground level) on all sides. The following subsections provide applicable excerpts from the NFIP regulations.

Below-Grade Parking Garages in Residential Buildings in A Zones

Section 60.3(c)(2) of the NFIP regulations states that a community shall:

"Require that all new construction and substantial improvements of residential structures within Zones A1-A30, AE and AH on the community's FIRM have the lowest floor (including basement) elevated to or above the base flood level..."

Under the NFIP, a below-grade parking garage is considered a basement if it is below grade on all sides. Therefore, the construction of below-grade parking garages is prohibited beneath residential buildings in Zones A1-A30, AE, and AH.

Section 60.3(c)(7) of the NFIP regulations deals with residential buildings in Zone A0 (sheet flow with depths of 1 to 3 feet) requirements. Section 60.3(c)(7) states that a community shall:

“Require within any A0 zone on the community’s FIRM that all new construction and substantial improvements of residential structures have the lowest floor (including basement) elevated above the highest adjacent grade at least as high as the depth number specified in feet on the community’s FIRM (at least two feet if no depth number is specified).”

Therefore, below-grade parking garages beneath residential buildings in Zone A0 are prohibited.

Below-Grade Parking Garages in Non-Residential Buildings in A Zones

Section 60.3(c)(3) of the NFIP regulations states that a community shall:

“Require that all new construction and substantial improvements of non-residential structures within Zones A1-A30, AE, and AH on the community’s FIRM (i) have the lowest floor (including basement) elevated to or above the base flood level, or (ii) together with attendant utility and sanitary facilities, be designed so that below the base flood level the structure is watertight with walls substantially impermeable to the passage of water and with structural components having the capability of resisting hydrostatic and hydrodynamic loads and effects of buoyancy.”

Below-grade parking garages are permitted beneath non-residential buildings in Zones A1-A30, AE, and AH provided the building (including the parking garage) is floodproofed to the base flood level in accordance with the design performance standards provided above in Section 60.3(c)(3)(ii). Only below-grade parking garages (in non-residential buildings) that are dry floodproofed are permitted under the NFIP. Guidance on floodproofing is provided in the FEMA manual “Floodproofing Non-Residential Structures” and in Technical Bulletin 3, “Non-Residential Floodproofing — Requirements and Certification.”

Section 60.3(c)(8) of the NFIP regulations deals with non-residential buildings in Zone A0 (sheet flow with depths of 1 to 3 feet) requirements. Section 60.3(c)(8) states that a community shall:

“Require within any A0 zone on the community’s FIRM that all new construction and substantial improvements of nonresidential structures (i) have the lowest floor (including basement) elevated above the highest adjacent grade at least as high as the depth number specified in feet on the community’s FIRM (at least two feet if no depth number is specified), or (ii) together with attendant utility and sanitary facilities be completely floodproofed to that (base flood) level to meet the floodproofing standard specified in Section 60.3(c)(3)(ii).”

Therefore, below-grade parking garages are permitted beneath non-residential buildings in Zone A0 provided the building (including the parking garage) is floodproofed to the base flood level in accordance with the design performance standards of Section 60.3(c)(3)(ii). Because of the

severe damage that can be caused by velocity waters and debris, below-grade parking garages are not recommended in A0 zones where velocities have been identified.

Section 60.3(c)(4) further states:

“...that where a non-residential structure is intended to be made watertight below the base flood level, i) a registered professional engineer or architect shall develop and/or review structural design, specifications, and plans for the construction, and shall certify that the design and methods of construction are in accordance with accepted standards of practice for meeting the applicable provisions of paragraph (c)(3)(ii) or (c)(8)(ii) of this section.”

The floodproofing of a below-grade parking garage and any other portion of a building below the base flood elevation (BFE) must be certified to meet the standards of Section 60.3(c)(3). Additional guidance on this certification requirement can be found in Technical Bulletin 3, “Non-Residential Floodproofing — Requirements and Certification.”

Below-Grade Parking Garages in V Zones

Section 60.3(e)(4) of the NFIP regulations states that a community shall:

“Provide that all new construction and substantial improvements in Zones VI-V30 and VE, and also in 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.”

The floor of a below-grade parking garage would be considered the “lowest floor” of a V-zone building under the NFIP (since the lowest horizontal structural member would be the footing of the garage) and could not meet the above requirement. Therefore, below-grade parking garages are prohibited beneath all residential and non-residential buildings in V zones.

It should be noted that Technical Bulletins provide guidance on the minimum requirements of the NFIP regulations. Community or State requirements that exceed those of the NFIP take precedence. Design professionals should contact the community to determine whether more restrictive local or State regulations apply to the building or site in question. All applicable standards of the State or local building code must also be met for any building in a flood hazard area.

Designing a Floodproofed Below-Grade Parking Garage

All below-grade parking garages must be dry-floodproofed; therefore, hydrostatic and hydrodynamic forces must be considered in the design. In most designs, the loadings on the above-grade portion of the building are transferred to the structural elements of the below-grade parking garage. Therefore, any structural failure in the parking garage may well result in a failure of the entire

building. FEMA's Technical Bulletin 3, "Non-Residential Floodproofing — Requirements and Certification," must be consulted for necessary guidance on floodproofing designs for below-grade parking garages.

Note: While the NFIP regulations require that non-residential buildings be floodproofed only to the BFE, flood insurance rating procedures include a freeboard, or level of safety criterion. When a floodproofed building is rated for flood insurance, the level of flood protection is assumed at 1 foot below the top elevation of the floodproofing. For rating purposes, the NFIP requires that non-residential buildings be floodproofed to 1 foot above the BFE in order to receive rating credit for the floodproofing design.

A critical element in any floodproofing design for a below-grade parking garage is the point where the garage entrance ramp meets the street grade. The best method of protecting a dry-floodproofed garage from floodwaters is to design the garage entry to be above BFE. The entry can also be brought up and over a ramp of fill dirt placed above the BFE. In some cases, however, the garage entry must meet street grade at an elevation below the BFE. Such a design requires that a high-strength flood shield that can withstand the high hydrostatic pressure be installed so that floodwaters will not enter the dry-floodproofed garage.

Any portions of a floodproofing design that entail human intervention (such as placing a flood shield) greatly increase the potential for loss of life and property damage during a flood. A sufficient number of emergency exits must be available so that anyone in the garage will not be trapped by rising floodwaters, and a warning and evacuation plan must be developed and tested so that it can be readily implemented when a flood threatens. Such a plan is necessary for all below-grade garages as stated in Technical Bulletin 3, which provides guidance on warning and evacuation plans.

Below-Grade Parking for Mixed-Use Buildings

While the NFIP regulations state that dry floodproofing of below-grade parking garages is allowed only for non-residential buildings in A zones, professionally designed buildings that have both commercial (non-residential) and residential uses may be designed with floodproofed below-grade parking garages. All residential-use areas of the building must be above the BFE. An insurance agent experienced in the NFIP should be consulted during the design phase concerning the cost of insurance for a mixed-use building.

The NFIP

The NFIP was created by Congress in 1968 to provide federally backed flood insurance coverage, because flood insurance was generally unavailable from private insurance companies. The NFIP is also intended to reduce future flood losses by identifying floodprone areas and ensuring that new development in these areas is adequately protected from flood damage. The NFIP is based on an agreement between the federal government and participating communities that have been identified as floodprone. FEMA, through the Federal Insurance Administration (FIA), makes flood insurance available to the residents of a participating community provided that the

community adopts and enforces adequate floodplain management regulations that meet the minimum NFIP requirements. The NFIP encourages communities to adopt floodplain management ordinances that exceed the minimum NFIP criteria. Included in the NFIP requirements, found under Title 44 of the Code of Federal Regulations, are minimum building design and construction standards for buildings located in SFHAs. Through their floodplain management ordinances, communities adopt the NFIP design performance standards for new and substantially improved buildings located in floodprone areas identified on FIA's FIRMs.

Technical Bulletins

This is one of a series of Technical Bulletins FEMA has produced to provide guidance concerning the building performance standards of the NFIP. These standards are contained in Title 44 of the U.S. Code of Federal Regulations at Section 60.3. The bulletins are intended for use primarily by State and local officials responsible for interpreting and enforcing NFIP regulations and by members of the development community, such as design professionals and builders. New bulletins, as well as updates of existing bulletins, are issued periodically, as necessary. The bulletins do not create regulations; rather they provide specific guidance for complying with the minimum requirements of existing NFIP regulations. Users of the Technical Bulletins who need additional guidance concerning NFIP regulatory requirements should contact the Natural Hazards Branch of the appropriate FEMA regional office. The Technical Bulletin Guide, "User's Guide to Technical Bulletins," lists the bulletins issued to date and provides a key word/subject index for the entire series.

Ordering Information

Copies of the Technical Bulletins can be obtained from the appropriate FEMA regional office. Technical Bulletins can also be ordered from the FEMA publications warehouse. Use of FEMA Form 60-8 will result in a more timely delivery from the warehouse — the form can be obtained from FEMA regional offices and your state's Office of Emergency Management. Send publication requests to FEMA Publications, P.O. Box 70274, Washington, D.C. 20024.

Further Information

The following publications provide further information concerning below-grade parking garages:

1. "Answers to Questions About Substantially Damaged Buildings," FEMA, May 1991, FEMA-213.
2. "Floodproofing Non-Residential Structures," FEMA, May 1986, FEMA-102

Glossary

Base flood — The flood that has a 1-percent probability of being equaled or exceeded in any given year (also referred to as the 100-year flood).

Base Flood Elevation (BFE) — The height of the base flood, usually in feet, in relation to the National Geodetic Vertical Datum of 1929 or other datum as specified.

Basement — Any area of a building having its floor subgrade (below ground level) on all sides.

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.

Federal Emergency Management Agency (FEMA) — The independent federal agency that, in addition to carrying out other activities, oversees the administration of the National Flood Insurance Program.

Federal Insurance Administration (FIA) — The component of FEMA directly responsible for administering the National Flood Insurance Program.

Flood Insurance Rate Map (FIRM) — The insurance and floodplain management map issued by FEMA that identifies, on the basis of detailed or approximate analyses, areas of 100-year flood hazard in a community.

Floodprone area — Any land area susceptible to being inundated by floodwater from any source.

Lowest floor — The lowest floor of the lowest enclosed area of a building, including a basement. Any NFIP-compliant unfinished or flood-resistant enclosure useable solely for parking of vehicles, building access, or storage (in an area other than a basement) is not considered a building's lowest floor.

Special Flood Hazard Area (SFHA) — Area delineated on a Flood Insurance Rate Map as being subject to inundation by the base flood and designated as Zone A, AE, A1-A30, AR, A0, AH, V, VE, or V1-V30.

Substantial damage — Damage of any origin sustained by a structure whereby the cost of restoring the structure to its before-damaged condition would equal or exceed 50 percent of the market value of the structure before the damage occurred.

Substantial improvement — Any reconstruction, rehabilitation, addition, or other improvement of a structure, the cost of which equals or exceeds 50 percent of the market value of the structure before the "start of construction" of the improvement. This term includes structures that have incurred "substantial damage," regardless of the actual repair work performed.



Technical
Bulletin
7-93

Wet Floodproofing Requirements
for Structures Located in Special Flood Hazard Areas
in accordance with the
National Flood Insurance Program



FEDERAL EMERGENCY MANAGEMENT AGENCY
MITIGATION DIRECTORATE
FEDERAL INSURANCE ADMINISTRATION

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Key Word/Subject Index:

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Key Word/ Subject	Page
Accessory Structures	3
Agricultural Structures	4
Functionally Dependent Use	3
Garages, Attached to Residential Structure	2
Garages, Attached to Non-Residential Structure	2
Garages, Detached From Structure	3
Historic Buildings	3
Variances from NFIP Requirements	3
Variances, Issuance in Designated Floodways	3
Wet Floodproofing, Definition of	1
Wet Floodproofing, Engineering Considerations	11
Wet Floodproofing, Flood Insurance Implications	5
Wet Floodproofing, Planning Considerations	8

Any comments in the Technical Bulletins should be directed to:

FEMA/Mitigation Directorate
Program Development Branch
500 C St., S.W.
Washington, D.C. 20472

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TECHNICAL BULLETIN 7-93

Wet Floodproofing Requirements for Buildings Located in Special Flood Hazard Areas in Accordance with the National Flood Insurance Program

INTRODUCTION

This bulletin describes planning, design, and construction requirements for wet floodproofing certain types of structures and their uses under the National Flood Insurance Program (NFIP). The basic characteristic that distinguishes wet floodproofing from dry floodproofing is the internal flooding of a structure as opposed to providing essentially watertight protection. Specifically, wet floodproofing can be defined as:

Permanent or contingent measures applied to a structure and/or its contents that prevent or provide resistance to damage from flooding by allowing flood waters to enter the structure.

Flooding of a structure's interior is intended to counteract hydrostatic pressure on the walls, surfaces, and supports of the structure by equalizing interior and exterior water levels during a flood. Inundation also reduces the danger of buoyancy from hydrostatic uplift forces. Such measures may require alteration of a structure's design and construction, use of flood-resistant materials, adjustment of building operation and maintenance procedures, relocation and treatment of equipment and contents, and emergency preparedness for actions that require human intervention.

In accordance with the NFIP, Wet Floodproofing is allowed in only limited situations

Application of wet floodproofing as a flood protection technique under the NFIP is limited to specific situations in A Zones (including A, AE, A1-30, AH, AO, AR zones). For certain uses and types of structures described in this bulletin, communities may allow wet floodproofing only through the issuance of a variance from certain floodplain management requirements. The situations and conditions in which a community may allow wet floodproofing are described in detail in the section entitled **Applicability**.

For structures in V zones (includes V, VE, V1-30 zones), more stringent design and construction requirements have been established for the portion of a structure below the Base Flood Elevation (BFE). For information on V-zone design and construction requirements, refer to the NFIP regulations under 44 CFR Section 60.3, the Technical Bulletin series, and FEMA's "Coastal Construction Manual" (FEMA 55).

APPLICABILITY

New Construction and Substantial Improvements of Residential and Non-Residential Structures

An important objective of the NFIP is to protect structures constructed in floodplains from flood-induced damage. In support of this objective, the NFIP regulations include building design and construction criteria that apply to new construction and substantial improvements (including structures which have incurred substantial damage) of existing structures in Special Flood Hazard Areas (SFHA). According to these criteria, residential structures in A zones must be constructed with their lowest floors elevated to or above the BFE. Non-residential structures constructed in A zones must either have their lowest floors elevated to or above the BFE or be dry floodproofed (made watertight) to or above the BFE. Measures to accomplish dry floodproofing of non-residential structures must not only provide watertight protection but also must be designed to withstand hydrostatic, hydrodynamic, and impact forces produced by flooding. The intent is to provide complete protection at least up to the floodproofing design level which must, at a minimum, be at the BFE.

Note: To receive a flood insurance rate based on 100 year flood protection, the structure must be dry floodproofed to an elevation at least 1 foot above the BFE. (i.e. 1 foot of freeboard)

In accordance with the NFIP, there are limited enclosed areas within newly constructed and substantially improved residential and non-residential structures where the community may allow wet floodproofing without a variance as a flood protection technique. These are limited to:

Enclosed areas below the BFE that are used solely for parking, building access, or limited storage. New construction and the substantial improvement of residential and non-residential structures whose lowest floors have been constructed at or above the BFE may be constructed with enclosed areas below the BFE. These areas must; (1) be used solely for parking, building access, or limited storage, (2) be designed to allow for the automatic entry and exit of flood waters through the use of openings, and (3) be constructed of flood resistant materials.

Attached garages. A garage attached to a residential structure, constructed with the garage floor slab below the BFE, must be designed to allow for the automatic entry of flood waters. Openings are required in the exterior walls of the garage or in the garage doors. In addition to allowing the automatic entry of flood waters, the areas of the garage below the BFE must be constructed with flood resistant materials. Garages attached to non-residential structures must meet the aforementioned requirements or be dry floodproofed. For guidance on below-grade parking areas refer to Technical Bulletin 6, "Below-Grade Parking Requirements".

Certain categories of structures where FEMA has advised communities that variances to allow wet floodproofing may be issued.

Communities must determine whether a variance from local floodplain management regulations may be issued to allow wet floodproofing for the categories of structures described in this section. To make such a determination, the community must, at a minimum, apply the NFIP variance criteria set forth in the 44 CFR Section 60.6. Included in these criteria is the requirement that the variance be the minimum necessary to afford relief, considering the flooding conditions at the site. This means that when a community issues a variance from elevation or dry floodproofing requirements, the structure must still be protected to the maximum extent possible using an appropriate alternative flood protection technique, such as wet floodproofing. To properly administer the granting of a variance for wet floodproofing, communities should have variance review procedures in place. These variance procedures must be within the bounds of State enabling law and meet the minimum requirements of the NFIP.

Variances to allow wet floodproofing may be issued for the following categories of structures. **These structures must comply with floodway encroachment provisions of the NFIP Regulations in accordance with section 60.6(a)(1).**

Structures Functionally Dependent On Close Proximity to Water: Certain structures that must be located near water are functionally dependent uses, as defined in section 59.1, and are permitted to be wet floodproofed after the issuance of a variance from NFIP elevation and dry floodproofing requirements. These structures may include certain types of docking, seafood processing, and port facilities associated with marine activities. Specific criteria for issuing a variance for functionally dependent uses are established in section 60.6(a)(7). These include the requirement that the structure or other development be protected by methods that minimize flood damage and create no additional threat to public safety.

Historic Buildings: Under section 60.6, variances may be issued for the repair and rehabilitation of historic structures, as defined in Section 59.1, upon the determination that the proposed repair or rehabilitation will not preclude the structure's continued designation of a historic structure and the variance is the minimum necessary to preserve the historic character and design of the structure.

Accessory structures, used solely for parking (two-car detached garages or smaller) or limited storage (small, low-cost sheds): If a community wishes to allow a non-elevated/non-dry floodproofed accessory structures, the community must establish the meaning of low-cost and small accessory structures. Communities may allow wet floodproofing of these structures provided that they represent a minimal investment and are designed to have a low damage potential with respect to the structure and contents.

The following requirements, at a minimum, must be attached to the variance for an accessory structure:

- 1) it must be anchored to resist flotation, collapse, and lateral movement;
- 2) the portions of these structures located below the BFE must be constructed of flood-resistant materials;
- 3) it must be designed to allow for the automatic entry of flood waters;
- 4) mechanical and utility equipment must be elevated or floodproofed to or above the BFE;
- 5) it must comply with the floodway encroachment provisions of the NFIP Regulations; and
- 6) its use must be limited to parking and/or limited storage.

Some communities have included provisions in their floodplain management ordinance for permitting the construction of these low-cost, small detached accessory structures. Communities wishing to regulate the placement of such structures in this manner should contact their FEMA Regional Office for guidance and assistance.

Certain Agricultural Structures: FEMA recognizes that wet floodproofing may be appropriate for certain types of agricultural structures located in wide, expansive floodplains. A variance may be issued only if the structure is used solely for agricultural purposes in which the use is exclusively in connection with the production, harvesting, storage, drying, or raising of agricultural commodities, including the raising of livestock. Only in circumstances when it can be demonstrated that agricultural structures can be designed in such a manner that results in minimal damage to the structure and its contents and will create no additional threats to public safety, may a variance be issued. Because the wet floodproofing of a new agricultural structure with the lowest floor below the BFE is not in conformance with NFIP requirements, any variance issued must address both the nonconforming flood protection technique and the restriction of use to the above-described agricultural purposes. Types of agricultural structures that may be wet floodproofed following the issuance of a variance are:

- ▶ **Farm Storage Structures** used exclusively for the storage of farm machinery and equipment (e.g., pole and pre-fabricated metal frame structures with open or closed sides).
- ▶ **Grain bins.**
- ▶ **Corn cribs.**

► **General purpose barns** for the temporary feeding of livestock, provided they remain open on at least one side.

In addition to the variance requirements 1-5 under the Accessory Structure category presented above, a variance for an agricultural structure must also be limited to agricultural purposes.

Existing (Pre-FIRM) Structures That Are Not Substantially Improved or Substantially Damaged

For existing structures that are not being substantially improved or that have not been substantially damaged, the NFIP elevation and dry floodproofing regulations do not apply. Owners may voluntarily choose to wet floodproof such a particular structure to reduce potential flood damage. Many existing structures are constructed of materials that are generally permeable to flood waters, difficult to make watertight, or unsuitable for flood protection techniques other than elevation or relocation. Although it may be technically feasible to retrofit some older structures by sealing the perimeter walls and creating a watertight structure, it is often unadvisable to do so because of high probability that the dry floodproofing will fail due to some unforeseen factor in these usually non-engineered, older structures. In these cases, wet floodproofing and flood protection through either relocation or elevation of structures may offer the only technically viable flood-damage reduction alternatives. In some situations, wet floodproofing may be the only realistic economic alternative for existing structures that are not substantially improved or damaged.

INSURANCE IMPLICATION

It must be emphasized that variances are granted with respect to floodplain management requirements and do not affect flood insurance rates. The Federal Insurance Administration, by statute, must charge insurance rates commensurate with the risk to which a building is exposed. Insurance rates for buildings constructed under variances are generally higher than rates for a comparable structure that is fully compliant. In some instances the additional costs of insuring these buildings, if they are not elevated or floodproofed in accordance with the NFIP requirements, would approach or even exceed the costs of meeting NFIP elevation or dry floodproofing requirements, and the structure would still be exposed to flood damages.

In accordance with the NFIP regulations, communities must notify the applicant in writing that the issuance of a variance will result in increased premium rates for flood insurance and that such construction below the BFE increases risks to life and property [44 CFR 60.6(a)(5)].

NFIP Regulations

44 CFR Section 60.3 (a)(3) of the NFIP regulations requires that the community must:

"Review all permit applications to determine whether proposed building sites will be reasonably safe from flooding. If a proposed building site is in a flood-prone area, all new construction and substantial improvements shall (i) be designed (or modified) and adequately anchored to prevent flotation, collapse, or lateral movement of the structure resulting from hydrodynamic and hydrostatic loads, including the effects of buoyancy, (ii) be constructed with materials resistant to flood damage, (iii) be constructed by methods and practices that minimize flood damages, and (iv) be constructed with electrical, heating, ventilation, plumbing, and air conditioning equipment and other service facilities that are designed and/or located so as to prevent water from entering or accumulating within the components during conditions of flooding."

NFIP regulations require that all enclosures below the BFE in A Zones must either be designed to allow for the equalization of hydrostatic forces during a flood event or be floodproofed. When water is allowed to enter, section 60.3(c)(5) of the NFIP regulations states that a community shall:

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

Section 60.3(d)(3) places further restrictions on construction in floodways by stating that a community shall:

"Prohibit encroachments, including fill, new construction, substantial improvements, and other development within the adopted regulatory floodway unless it has been demonstrated through hydrologic and hydraulic analyses performed in accordance with standard engineering practice that the proposed encroachment would not result in any increase in flood levels within the community during the occurrence of the base flood discharge."

Concerning the issuance of variances, section 60.6(a)(3) states:

"Variances shall only be issued by a community upon (i) a showing of good and sufficient cause, (ii) a determination that failure to grant a variance would result in exceptional hardship to the applicant, and (iii) a determination that granting of a variance will not result in increased flood heights, additional threats to public safety, extraordinary public expense, create nuisances, cause fraud on or victimization of the public, or conflict with existing local laws or ordinances;"

And section 60.6(a)(4) states that

"Variances shall only be issued upon a determination that the variance is the minimum necessary, considering the flood hazard, to afford relief;"

Concerning functionally dependent uses under the NFIP variance criteria, "Functionally dependent use" is defined in section 59.1 as:

"Functionally dependent use means a use which cannot perform its intended purpose unless it is located or carried out in close proximity to water. The term includes only docking facilities, port facilities that are necessary for the loading and unloading of cargo and passengers, and ship building and ship repair facilities, but does not include long-term storage or related manufacturing facilities."

Section 60.6(a)(7) states that:

"Variances may be issued by a community for new construction and substantial improvements and for other development necessary for the conduct of a functionally dependent use provided that (i) the criteria of paragraphs (a)(1) through (a)(4) of this section are met, and (ii) the structure or other development is protected by methods that minimize flood damage during the base flood and create no additional threats to public safety."

Concerning granting variances for historic structures under the NFIP variance criteria, section §60.6(a) states that:

"...Variances may be issued for the repair and rehabilitation of historic structures upon the determination that the proposed repair or rehabilitation will not preclude the structure's continued designation as a historic structure and the variance is the minimum necessary to preserve the historic character and design of the structure."

Lastly, concerning granting variances in designated floodways, section 60.6(a)(1) states that:

"Variances shall not be issued by a community within any designated regulatory floodway if any increase in flood levels during the base flood discharge would result;"

Note: Readers are strongly advised to become familiar with all provisions of section 60.6.

It should be noted that Technical Bulletins provide guidance on the minimum requirements of the NFIP regulations. Community or State requirements that exceed those of the NFIP take precedence. Those contemplating wet floodproofing a structure should contact the community to determine whether more restrictive local or State regulations apply to the structure or site in question. All applicable standards of the State or local building code must also be met for any structure in a special flood hazard area.

Planning Considerations

A review of the following factors for the site in question will assist in determining whether wet floodproofing is appropriate. For example, if a site will be subject to rapidly rising, high-velocity flood waters during a flood, and the available warning time is short, then the site is unsuitable for a wet floodproofed structure. In this situation, elevation or relocation of the building outside the floodplain would be the preferred alternatives.

Warning Time

The rate-of-rise of flood waters for the site in question, the established flood warning system (if any), the flood warning time available, and the reliability of the flood warning must be reviewed to determine appropriate wet floodproof design elements. The rate-of-rise or the flood warning time available through an existing reliable (community-based or regionally-based) flood warning system must be adequate to provide sufficient lead time to evacuate a flood prone structure when flooding threatens. In addition, sufficient warning time must exist to successfully implement a plan that requires human intervention which would include such items as the removal of equipment or contents, or the elevation of contents within the structure. Wet or dry floodproofed structures are not appropriate for any site in a flash flood area, because of the potentially short warning time.

Safety and Access

Safe access to a wet floodproofed structure may be a critical factor in the determination of whether wet floodproofing is an appropriate design alternative. It is anticipated that most wet floodproofed structures will not need to be accessed during flooding. In situations where there is a need to access the structure during conditions of flooding, safe access shall be considered. In 1987, Colorado State University conducted a study of human stability in flood flow conditions based on the product number of depth of flow multiplied by the floodwater velocity. Results of this study indicated that any floodplain location with a product number of 4 or greater (depth in feet multiplied by velocity in feet per second) will create a hazard for anyone attempting to escape from or gain access to the site. Such sites are only acceptable for wet floodproofed structures if modifications are made to the site to reduce the flood hazard and sufficient warning time is available to safely evacuate the site.

Other flood characteristics that must be considered include:

Floodway Encroachment: Encroachments, including fill, new construction, substantial improvements, and other development within the adopted regulatory floodway are prohibited under the NFIP unless it has been demonstrated, through hydrologic and hydraulic analysis performed in accordance with standard engineering practice, that the proposed encroachment would not result in any increase in flood levels within the community during the occurrence of the base flood discharge. Floodways are usually the most dangerous portion of the floodplain, containing the highest velocity and debris-laden flood flows. Extreme caution must be used in the placement of any structure in a floodway.

Duration: The amount of time a structure's interior is flooded presents two major concerns. First, damage due to the deterioration of structural components, interior finishes, equipment/machinery, and contents generally increases with prolonged inundation. The other concern is the financial loss due to business interruption, determined by both the length of time inundated and time to clean-up. Financial losses due to disruption can be extreme.

Flood-Borne Contaminants: Flood waters may contain numerous contaminants and are often caustic and toxic. In urbanized and industrialized areas, floodwater can contain higher amounts of salts, alkalis, oils, wastes, chemicals, and debris. In agricultural areas flood water often contains, herbicides, pesticides, and fertilizers. Based on flooding characteristics, some flooding sources will contain higher concentrates of suspended solids than others. Due to the action of "dirty" floodwater, inundated materials can absorb and surfaces can become coated with mud, debris, and grime, exposing contents and building components to corrosive salts and chemicals. This often leads to residual deposits and odors after flood waters recede. These deposits and odors can render a structure unsafe and non-occupiable for an extended period of time after the flood waters recede.

Frequency: Frequent flooding may render a wet floodproofing strategy infeasible. Detriments that must be assessed include cumulative "wear and tear" effects of recurring inundation and the costs associated with repeated business interruption, frequent remove of contents, and frequent clean-up activities.

Depth: It is difficult to establish a safe range of flood depths for the use of wet floodproofing, and perhaps inappropriate to attempt to do so. It is somewhat more applicable to evaluate limiting factors. Many wet floodproofing actions involve some degree of either permanent or contingent elevation of contents, equipment, and machinery. A maximum depth may be established as the depth that would preclude the use of wet floodproofing procedures that can effectively protect the structure and its contents.

Water Temperature: In very cold weather, ice may pose significant problems in implementing wet floodproofing. The impact of large, water-borne, chunks of ice can damage or destroy a structure, and water that freezes inside of a structure can result

in strong expansive forces that can damage both structural and non-structural building components.

Operational Procedures

The operational procedures aspect of applying wet floodproofing techniques involves both the structure's functional requirements for daily use and the allocation of space, with consideration of each function's potential for flood damage. Daily operations and space use can be organized and modified to greatly reduce the structure and contents vulnerability to damage. The goals are to minimize damage caused by floodwater and to minimize economic losses due to business interruption. The following describes the various operations concerns involved in an effective wet floodproofing concept:

Flood Warning System. Because wet floodproofing will, in most cases, require some human intervention when a flood is imminent, it is extremely important that there be adequate time to execute such actions. Specific time required is a function of the type and degree of actions necessary in addition to the resources available for their implementation. In some areas, it may be possible to benefit from the use of an existing flood warning system. In other cases, however, it will be necessary to independently develop a system. Such a system may be as simple as a weather band radio that operates on a tone alarm from the National Weather Service for smaller watersheds and monitoring river forecast levels for larger watersheds.

Inspection and Maintenance Plan Every wet floodproofing design requires some degree of periodic maintenance and inspection to ensure that all components will operate properly under flood conditions. The necessary inspection and maintenance activities, including inspection intervals and repair requirements, must be described in the Inspection and Maintenance Plan. Components that should be inspected as part of an annual (as a minimum) maintenance and inspection program include opening covers and valves intended to equalize hydrostatic pressure.

Flood Emergency Operation Plan. A Flood Emergency Operation Plan is an integral part of any structure's floodproofing design and is critical when the floodproofing requires human intervention such as adjustments to, or relocation of contents and utilities. While such a plan is recommended for existing structures, it is a requirement for all new structures where human intervention is critical to the proper operation of the floodproofing. An adequate plan for the type of structures discussed in this bulletin shall include a list of specific duties to ensure that all wet floodproofing measures requiring human intervention are addressed. The locations of materials necessary to properly install all floodproofing components must be included in the list.

A pre-determination of the flood stages at which floodwater enters each wet floodproofed structure must be made, along with a pre-determination of the amount of warning time available. Based upon these elements, contingency actions should be

prioritized, particularly any evacuation that will be involved. The plan should be completely tested to ascertain its practicality, and also should be reviewed and updated following a flood event.

Other Considerations

Having considered all of the above, a community may choose to:

limit the size and number of structures that may be wet floodproofed,

restrict the location of wet floodproofed structures to areas where the depth of flooding and/or floodwater velocity will not result in damage to structure or its contents, and/or

consider the possibility of combining elevation and dry floodproofing with wet floodproofing where the level of risk warrants such action.

Engineering Considerations

There are three main components to wet floodproofing a structure; design elements, flood resistant materials, and protection of contents. As with the application of dry floodproofing techniques, developing a wet floodproofing strategy requires site-specific evaluations that may necessitate the services of a design professional.

Protection of the Structure

Hydrostatic forces must be counteracted to prevent wall collapse and flood-induced uplift. This is achieved through the use of wall openings that allow water to enter the structure, thereby equalizing the hydrostatic pressure. The NFIP requirements concerning openings are discussed in Technical Bulletin 1, "Openings in Foundation Walls." In addition, provisions must be made to prevent air trapped within the structure during periods of inundation from becoming pressurized and damaging on the exterior walls and roof. Because structures may become buoyant in the presence of flood water, superstructures need to be designed to prevent separation from the foundation. All structural and non-structural components must be constructed of materials that are durable, resistant to flood forces, and resistant to deterioration caused by repeated inundation by floodwater. Components not inundated with flood water must be able to resist damage as a result of excessive humidity associated with flooding and post-flood conditions. Technical Bulletin 2 "Flood Resistant Materials" provides specific guidance on which materials are acceptable under the NFIP.

Foundations: The failure of foundations in structures subjected to inundation is a major cause of structural damage. Foundation design is a site-specific process that must take into account local soils and building load conditions. Included in the site analysis should be the influence of hydrologic and hydraulic conditions (velocity of

flow, rate-of-rise, depth, flood-borne constituents, and duration) on the foundation design. The ability of floodwater to adversely affect the integrity of structure foundations by eroding supporting soil, scouring foundation material, and undermining footings necessitates careful examination of foundation designs.

An extremely important consideration is that the structure be adequately anchored to the foundation. Uplift forces during a flood event are often great enough to separate an improperly anchored structure from its foundation.

Cavity Wall Construction: Wet floodproofing equalizes hydrostatic pressure throughout the structure by allowing floodwater to fill in all spaces and equalize internal and external hydrostatic pressure. Thus, any attempt to seal internal air spaces within the wall system is not only technically difficult, but also contrary to the wet floodproofing approach. Provisions must be made so that the cavity space fills with water and drains at a rate approximately equal to the floodwater rate-of-rise and fall.

If the cavity wall air space is filled with insulation, it should be a type that is not subject to damage from inundation. Batt and blanket types such as spun mineral fiber or fiberglass bat insulation are not acceptable as they retain water and contaminants within their voids. Foam and closed cell type insulation have characteristics that can withstand a certain level of inundation. These include polystyrene, expanded foam, and thermal glass.

The air space within the cavity wall will also be inundated by floodwater and the contaminants it carries. Silt, chemicals, and organic materials, will remain in the cavity space after the floodwater has receded. Such contaminants can be hazardous to the structure and the occupants; caustic chemicals can deteriorate building materials and debris that harbors organic growth can have associated bacterial problems and odors. If a cavity wall is used, the cavity wall should have "clean-out" access panels that allow the internal air space to be flushed with water or other cleaning agents and fresh air to circulate within the cavity. Refer to FEMA 234, "Repairing Your Flooded Home" for further guidance on cleaning wall cavities.

Solid Wall Construction: Wall systems without internal air spaces are considered solid wall construction, which includes cast-in-place concrete, fully grouted cell masonry, pressure treated wood- or metal-frame shell. Solid walls are designed without internal spaces that could retain floodwater. Because these walls can be somewhat porous, they can absorb moisture, and to a limited degree, associated contaminants. Such porous wall systems that permit the intrusion of moisture into the wall could cause internal damage especially in a cold (freeze-thaw) climate. Solid walls made of non-porous materials are preferred over cavity walls. But in those cases where solid wall construction made of porous material is being considered, the use of both exterior and interior cladding with properties as described above for cavity wall systems is more desirable.

Wall Finishes: The exterior cladding of a structure subject to flooding should be nonporous, resistant to chemical corrosion or debris deposits, and conducive to easy cleaning. Relatively impervious cladding such as hard brick, pressure-treated wood, metal, and concrete are some of the acceptable materials.

As with exterior surfaces, interior cladding should be easy to clean and not susceptible to damage from inundation. Materials that are solid and relatively impervious such as concrete, hard brick, plastic, and pressure-treated wood, are most suitable.

Metal-clad structures such as those found in many agricultural operations should be constructed of corrosion-resistant materials. Framing and cladding must meet the same flood-resistant requirements as all other materials. Metal fasteners used with metal panel cladding systems are susceptible to corrosion and should be a corrosion-resistant type, such as hot dipped galvanized or stainless steel.

Where interior wall finishes are present, they shall meet the same flood resistant standards as all other materials located below the BFE.

Floors: Subfloor systems in wet floodproofed structures are normally concrete or gravel. Materials that are attached to the concrete subfloor, such as tile, paint, or wood, and the attachment mechanism (adhesives, nails, screws, etc.) that secures the finish material to the subfloor structure, should be able to withstand inundation associated with a base flood event without damage or alteration.

Ceilings and Roofs. When it is anticipated that flood levels will come in contact with the ceiling, flood resistant material requirements apply for ceiling materials and attachment mechanisms (hangers, adhesives, screws). To protect the ceilings and roofs from the pressure of entrapped air or water, pressure relief vents should be used. Even in those cases where flood waters are expected to be below ceiling levels, ceilings materials including attachment mechanisms should be able to withstand prolonged exposure to moisture and humidity associated with flood and post-flood conditions.

Building Envelope Openings. Openings in a structure's floors, walls, ceilings, and roofs are often enclosed by architectural components such doors, windows, louvers, vents, skylights, etc. These components include fasteners, gaskets, seals, glazing, locks, and finishes. Again, even those items not expected to be inundated must be resistant to humidity and moisture damage. NFIP flood resistant material requirements apply to all architectural components that are to be exposed to flooding or resulting excessive moisture. All materials shall be capable of resisting damage associated with a base flood event. Door systems include frame, hinges, threshold, and panels. Since solid wood, wood laminate, or hollow core wood door panels may warp, swell and/or rot, sealed metals are preferable.

Windows are susceptible to damage from debris carried by floodwater. The use of glass blocks, sealed unbreakable panes, and wire-reinforced glass will resist flood

damage. Protective screens may also be successful in preventing debris impact. The use of tempered glass or impact-resistant plastic (acrylic or polycarbonate) is recommended for large window areas of 20 square feet or more.

Protection of Mechanical and Electrical Systems: While the NFIP regulations do not prohibit the placement of mechanical and electrical components below the BFE, they are required to be designed and/or located so as to prevent flood water from entering or accumulating within them. The preferred method of meeting this requirement is to locate flood-threatened components above the expected flood level. Other options that may meet the NFIP requirements for electrical systems that can not be elevated involve emergency operation and maintenance procedures, including disconnecting and elevating or relocating electrically controlled equipment, installing elevated control panels for cutoff of electricity, or enclosing service equipment in waterproof utility enclosure areas. Mechanical systems that must be located below the design flood level should be provided with waterproofed enclosures to protect bearings, seals, gears clutches, valves, or controls that will not withstand immersion, silt damage, or water pressure.

Electrical System. Electricity is a primary source of energy for many vital building operations. Wet floodproofing an electrical system primarily involves preventing vulnerable components from coming in contact with water. Elevation of all electrical components except the minimum necessary to operate the structure (minimal number of light switches and receptacles) is required. Where switches and receptacles must be located below the BFE, sealed or capped moisture-resistant components are required. Ground Fault Circuit Interrupters shall be utilized for all electrical circuits that serve areas below the BFE. Key system components for which elevation above floodwater is desirable include transformers, switchboards, and branch panels. A possible alternative may be to enclose these elements with a waterproof protective barrier. In circumstances which dictate that it is not practicable to safely maintain power during inundation, complete cutoff must be utilized. This of course presents the need for inspections and actions to ensure complete drying of electrical components prior to power restoration.

Electrical service provided to a structure from poles or other overhead sources should enter the structure at a point above the expected flood level. Underground service cables may be feasible provided that they are waterproofed and not exposed to direct contact with flood water.

Heating and Ventilating In general, heating and ventilating equipment is not designed to withstand inundation and is prone to severe floodwater damage. Thus, elevating is recommended to preclude inundation of system components. In situations where elevation is not practical, quick release/disconnect mechanisms should be incorporated into the design. One example is fan motor components for grain bin aeration systems which are configured to be easily removed and relocated prior to flooding.

Liquid Storage Containers Liquid and gas containers are subject to extreme hydrostatic pressure during inundation. Where possible, such containers should be elevated to or above the BFE or located outside the floodplain. If a newly constructed container will be subject to inundation, it is required under the NFIP to be anchored to withstand a buoyant force acting upon it in its empty state. Containers should have watertight fill caps and vents that extend above the expected flood level, and should be labelled according to contents. Labeling will allow emergency personnel to identify the contents in the event the tanks breaks loose and floats away. It is important to note that underground tanks are also subject to uplift forces. Empty tanks, both above and below ground, should be filled with potable water prior to the arrival of floodwater. The post-flood disposal of this possibly contaminated water must be in accordance with all applicable federal, state and local regulations.

Flood Resistant Materials

In accordance with the NFIP, all materials exposed to floodwater must be durable, resistant to flood forces, and retardant to deterioration caused by repeated exposure to flood water. Generally, these performance requirements result in masonry construction being the most suited to wet floodproofing in terms of damage resistance. In some cases wood or steel structures may be candidates, provided that the wood is pressure treated or naturally decay resistant and steel is galvanized or protected with rust-retardant paint. Detailed guidance is provided in Technical Bulletin #2 "Flood-Resistant Material Requirements."

Protection of Contents and Equipment

- **Isolation from Floodwater.** Consideration should be given to preventing, to the maximum extent possible, the contact of floodwater with damage-susceptible items. This can be accomplished through relocation prior to flooding, elevation, or in-place protection of flood-damageable items.

Relocation: The most effective method of protection for equipment and contents is to relocate threatened items out of harm's way. The interior of the structure must be organized in a way that ensures easy access and facilitates relocation. Aisles, doors, and corridors shall be wide enough and equipment size should be evaluated to allow any planned relocation or removal. Where structures are used to store bulk materials, such as grain, provisions must be made for the orderly removal and relocation of the contents to an area outside the floodplain.

Elevation: Within the flood-prone structure, elevation of key items could be achieved through the use of existing or specially constructed platforms or pedestals. Contingent elevation can be accomplished by the use of hoists or some type of overhead suspension system. Elevation techniques can be applied to a wide range of objects--machinery, utility system components (particularly electrical equipment), fuel and storage containers, and contents.

In-Place Protection: Some items can be protected, in-place, through a variety of options. Protective waterproof enclosures may be feasible for items that are difficult to move or relocate. Anchors and tie-downs, shall be used where appropriate to prevent flotation and movement, especially in the case of storage containers. Depending on flood characteristics, such enclosures may not have to be inconveniently high or completely permanent. Low barriers or flood shields may supply the necessary protection. Also, steps or ramps can be incorporated into the design to further maintain easy access.

Protective coatings can be applied to equipment to reduce inundation damage. Petroleum based greases, hot dip plastics, spray or cold plastics can all be applied to oily surfaces. If they are applied to painted surfaces they must be non-migratory and not applied to threaded surfaces. Coatings can provide protection and enhance cleanup ease.

The use of "quick-disconnect" type plug and receptacle sets on standard electrical motors and other electrical connections provides several advantages. This allows for rapid shutdown, eliminates the need for an electrician, simplifies removal operations, and enables rapid reinstallation and restart. Similarly, motor-pump type units can be equipped with quick disconnect fittings on both suction and discharge lines in addition to electrical power lines. These actions also provide the added benefit of facilitating routine maintenance and relocation of equipment.

Mounting equipment and inventory on skids or pallets contributes greatly to contingent relocation, elevation, and removal actions using a fork lift. Large items that can be lifted from overhead should be permanently fitted with lifting bars or lugs. This eliminates time for rigging and benefits routine procedures. Any accessory items required, such as motor mount shims or necessary tools, should be stored nearby.

Technical Bulletins

This is one of a series of Technical Bulletins FEMA has produced to provide guidance concerning the building performance standards of the NFIP. These standards are contained in Title 44 of the U.S. Code of Federal Regulations at Section 60.3. The bulletins are intended for use primarily by State and local officials responsible for interpreting and enforcing NFIP regulations and by members of the development community, such as design professionals and builders. New bulletins, as well as updates of existing bulletins, are issued periodically, as necessary. The bulletins do not create regulations; rather they provide specific guidance for complying with the minimum requirements of existing NFIP regulations. Users of the Technical Bulletins who need additional guidance concerning NFIP regulatory requirements should contact the Mitigation Division of the appropriate FEMA regional office. The User's Guide to Technical Bulletins lists the bulletins issued to date and provides a key word/subject index for the entire series.

Ordering Information

Copies of the Technical Bulletins can be obtained from the appropriate FEMA regional office. Technical Bulletins can also be ordered from the FEMA publications warehouse. Use of FEMA Form 60-8 will result in a more timely delivery from the warehouse. The form can be obtained from FEMA regional offices and your state's Office of Emergency Management. Send publication requests to FEMA Publications, P.O. Box 70274, Washington, D.C. 20024.

Further Information

The following publications provide further information concerning non-residential floodproofing:

1. "Answers to Questions About Substantially Damaged Buildings," FEMA, May 1991, FEMA-213.
2. "Commercial-Industrial Flood Audit," New England District, U.S. Army Corps of Engineers, n.d.
3. "Cooperative Flood Loss Reduction," A Technical Manual for Communities and Industries, Flood Loss Reduction Associates, 1981.
4. "Design Manual for Retrofitting Flood-Prone Residential Structures," FEMA, September 1986, FEMA-114.
5. "Floodproofing Non-Residential Structures," FEMA, May 1986, FEMA-102.
6. "Flood Proofing Regulations, U.S. Army Corps of Engineers," March 1992, EP 1165-2-314.
7. "Human Stability in a High Flood Hazard Zone," S.R. Abt, R.J. Whittlen, A. Taylor, and D.J. Love, Water Resource Bulletin, August 1989.
8. "Repairing Your Flooded Home," FEMA, August 1992, FEMA-234.
9. "Sealants, Part 1," John P. Cook, Progressive Architecture, December 1974.
10. "Sealants, Part 2," John P. Cook, Progressive Architecture, February 1975.

11. "Tests of Brick-Veneer Walls and Enclosures for Resistance to Flood Waters," Carl E. Pace, U.S. Army Corps of Engineers, Lower Mississippi Division, Vicksburg, Mississippi, 1978.

Glossary

Base flood The flood that has a 1-percent probability of being equaled or exceeded in any given year (also referred to as the 100-year flood).

Base Flood Elevation (BFE) The height of the base flood, usually in feet, in relation to the National Geodetic Vertical Datum of 1929 or other datum as specified.

Basement Any area of a structure having its floor subgrade (below ground level) on all sides.

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. These areas are identified as V zones.

Existing Construction/Structure For floodplain management purposes, existing construction means structures for which the start of construction commences before the effective date of a floodplain management regulation adopted by a community. These structures are often referred to as "Pre-FIRM" structures.

Federal Emergency Management Agency (FEMA) The independent federal agency that, in addition to carrying out other activities, oversees the administration of the NFIP.

Federal Insurance Administration (FIA) The component of FEMA directly responsible for administering the flood insurance aspects of the National Flood Insurance Program.

Flood Insurance Rate Map (FIRM) The insurance and floodplain management map issued by FEMA that identifies, on the basis of detailed or approximate analyses, areas of 100-year flood hazard in a community.

Flood Prone Area Any land area susceptible to being inundated by floodwater from any source.

Lowest Floor The lowest floor of the lowest enclosed area of a structure, including a basement. Any NFIP-compliant unfinished or flood-resistant enclosure useable solely for parking of vehicles, building access, or storage (in an area other than a basement) is not considered a structure's lowest floor.

Mitigation Directorate The component of FEMA directly responsible for administering the floodplain management aspects of the National Flood Insurance Program.

New Construction/Structure For floodplain management purposes, new construction means structures for which the start of construction commences on or after the effective date of a floodplain management regulation adopted by a community and includes all subsequent improvements to the structure. These structures are often referred to as "Post-FIRM" structures.

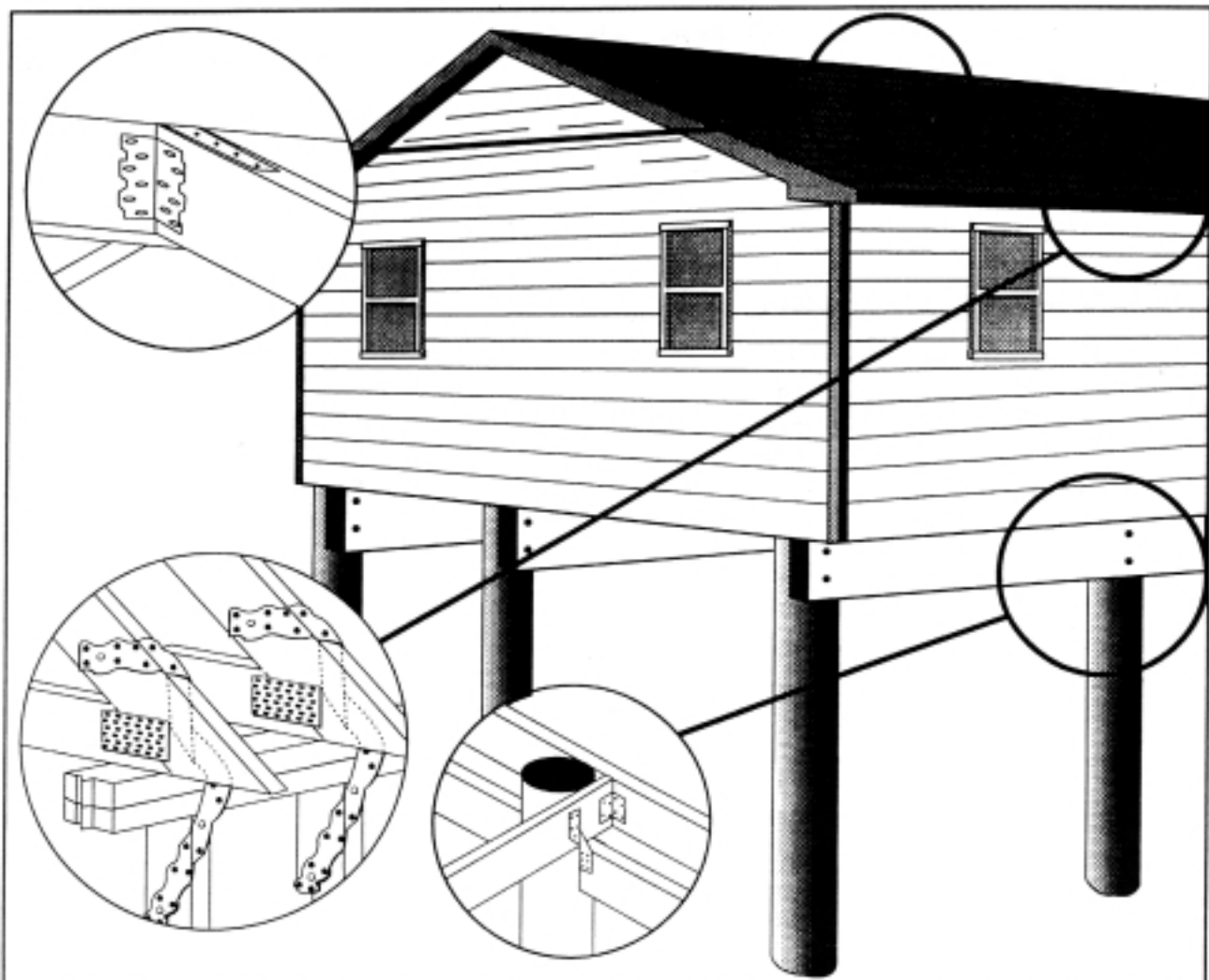
Special Flood Hazard Area (SFHA) Area delineated on a Flood Insurance Rate Map as being subject to inundation by the base flood and designated as Zone A, AE, A1-A30, AR, A0, AH, V, VE, or V1-V30.

Substantial Damage Damage of any origin sustained by a structure whereby the cost of restoring the structure to its before-damaged condition would equal or exceed 50 percent of the market value of the structure before the damage occurred.

Substantial Improvement Any reconstruction, rehabilitation, addition, or other improvement of a structure, the cost of which equals or exceeds 50 percent of the market value of the structure before the "start of construction" of the improvement. This term includes structures that have incurred "substantial damage," regardless of the actual repair work performed.

Wet Floodproofing Permanent or contingent measures applied to a structure and/or its contents that prevent or provide resistance to damage from flooding by allowing water to enter the structure.

**Corrosion Protection for Metal Connectors in Coastal Areas
for Structures Located in Special Flood Hazard Areas
in accordance with the
National Flood Insurance Program**



Key Word/Subject Index:

This index allows the user to locate key words and subjects in this Technical Bulletin. The Technical Bulletin User's Guide (printed separately) provides references to key words and subjects throughout the Technical Bulletins. For definitions of selected terms, refer to the Glossary at the end of this bulletin.

Key Word/Subject	Page
Corrosion, classes of building exposure to	5
Corrosion, causes of	3
Corrosion, planning for	7
Corrosion, identifying high-risk buildings	5
Corrosion-resistant materials for sheetmetal connectors	6, 7, 9
Galvanizing	2
Salt spray from breaking waves	3

Any comments on the Technical Bulletins should be directed to:

FEMA / Mitigation Directorate
Program Development Branch
500 C Street, SW.
Washington, DC 20472

TECHNICAL BULLETIN 8-96

Corrosion Protection for Metal Connectors in Coastal Areas

Introduction

An important objective of the National Flood Insurance Program (NFIP) is to protect buildings from the effects of hurricanes. The NFIP regulations include requirements concerning the resistance of buildings to flood and wind forces (as described in the following section). For a building in a Coastal High Hazard Area to comply with these requirements, many of its components must be adequately anchored. In wood-frame buildings, the necessary anchoring is usually achieved through the use of metal connectors such as joist hangers, truss plates, and hurricane straps. The need for such connectors is especially great in coastal areas, where storm-induced flooding and high winds pose significant threats. However, metal connectors are subject to corrosion when exposed to moisture and salt, both of which are prevalent in coastal areas.

This bulletin describes the causes of accelerated corrosion of metal connectors in buildings located near the ocean and some larger saltwater bays. The variation in the corrosive environments within a typical building is also described. This bulletin outlines available corrosion-resistant materials and methods of maintaining proper anchorage for the life of the building. It recommends connector materials for buildings at various distances from the ocean and for different exposure conditions within an individual building. Few local building codes and no national building codes address accelerated corrosion near the coast. This bulletin describes areas where corrosion is known to be a problem and recommends a variety of solutions.

NFIP Regulations

Section 60.3(a)(3) of the NFIP regulations states that the community shall:

"Review all permit applications to determine whether proposed building sites will be reasonably safe from flooding. If a proposed building site is in a flood-prone area, all new construction and substantial improvements shall (i) be designed (or modified) and adequately anchored to prevent flotation, collapse, or lateral movement of the structure..."

And Section 60.3(e)(4) states that the community shall:

"Provide that new construction and substantial improvements in...(the coastal high hazard area)...are elevated on pilings and columns so that...(ii) the pile or column foundation and structure attached thereto is anchored to resist flotation, collapse and lateral movement due to the effects of wind and water loads acting simultaneously on all building components. Water loading values 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 ... (ii) of this section."

Standard Metal Connectors

Common Uses

When buildings are damaged by natural hazards such as high wind, waves, flooding, and earthquakes, the structural damage usually does not start with a wood board breaking. The weak link is normally the connection between individual wooden members, and it is here that structural failure often begins. In many cases, replacing conventional nailing with a sheetmetal connector produces a connection over 10 times stronger. Hurricanes and earthquakes have demonstrated repeatedly that for most buildings, good connections often make the difference between survival and severe damage.

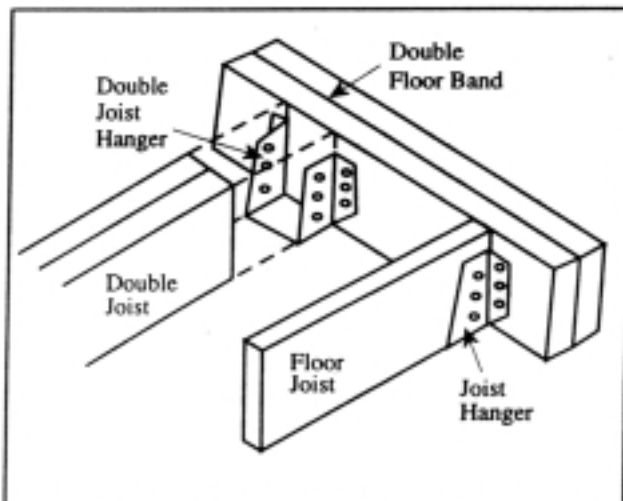


Figure 2. Single and double joist hangers

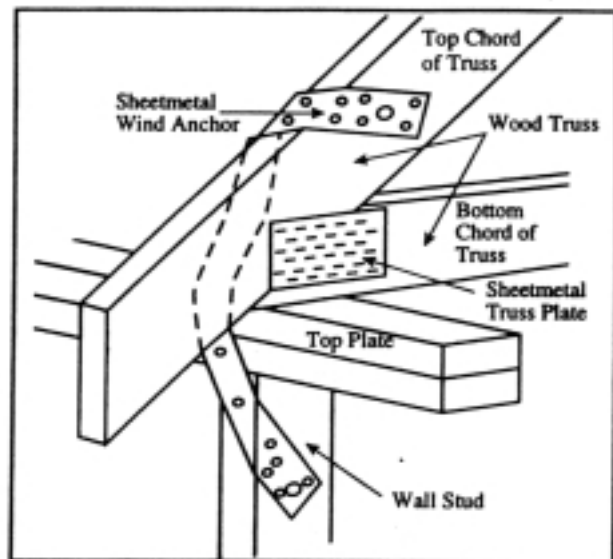


Figure 1. Wind anchor and truss plate

Typical metal connectors that are potentially subject to corrosion include hurricane straps and wind anchors used to connect roofs to walls (see Figure 1); truss plates that connect the separate members of premanufactured roof and floor systems (see Figure 1); joist hangers used on floor joists, beams, and rafters (see Figure 2); and various other metal straps used to connect wood components throughout the building. These include straps that attach the roof to the walls and prevent the aerodynamic lift of high winds from removing the roof or displacement caused by lateral forces during earthquakes.

Standard Materials: Galvanized Steel

Most connectors are fabricated from steel sheetmetal. In thin sheets, steel is sufficiently strong, readily workable, and relatively inexpensive, characteristics that make it well-suited for connectors. However, bare steel is subject to corrosion, or rusting, even in inland areas, and it corrodes rapidly in salt air. Most sheetmetal connectors, therefore, are galvanized for corrosion protection. Galvanizing is the process of coating steel with zinc. After careful cleaning, the steel sheet is dipped into a vat of molten zinc. The high temperature melts the surface of the steel and forms several steel/zinc alloys to tightly bond the zinc coating to the steel base metal. The coating of zinc still corrodes, but generally over 50 times more slowly than steel in the same salt air environment.

Galvanizing is particularly effective for steel because, unlike most other coatings, the zinc sacrificially protects any bare steel edges or scratches. The zinc surface near a scratch will corrode slightly faster than the zinc surrounding it and will fill small scratches with zinc

corrosion products, preventing the steel from rusting until the nearby zinc is consumed. Zinc also differs from other coatings (or paints) and most metals by corroding at a relatively steady rate in most atmospheric exposures. Therefore, doubling the thickness of the zinc coating approximately doubles the protection period.

Most connectors are fabricated after the steel sheetmetal has been galvanized. The American Society for Testing and Materials (ASTM) has established national standards for galvanizing that are accepted by the Standard (Southern Building Code Congress International), National (Building Officials & Code Administrators International), Uniform (International Conference of Building Officials), and most local building codes. Most connector manufacturers specify ASTM A-525 G 60 for the galvanized steel sheetmetal from which connectors are fabricated. ASTM A-525 is a general standard that establishes a variety of galvanizing thicknesses identified by different G numbers. The G 60 designation used for most connectors indicates a zinc coating thickness of 0.5 mil (1 mil = 0.001 inch) on each side of the steel. The numerical G designation increases or decreases proportionally with the coating thickness. For example, the coating of zinc on a G 90 connector is 1.5 times thicker than that on a G 60 connector.

Causes of Corrosion Near the Ocean

The conditions that accelerate corrosion near the coast have been studied in a few corrosion field stations and research laboratories around the world. Several of these conditions occur along most shorelines. Understanding the causes of accelerated corrosion can help identify some of the worst corrosion exposures that affect coastal buildings.

Salt Spray from Breaking Waves and Onshore Winds

Salt spray from breaking waves and onshore winds significantly accelerates the corrosion of metal connectors. The ocean salts, which are primarily sodium chloride but include other compounds, accumulate on the metal surfaces and accelerate the electrochemical reactions that cause rusting and other forms of corrosion. The combination of salt accumulation on the surface and the high humidity common to many coastal areas significantly accelerates the corrosion rate of steel and other metals commonly used for connectors or other building materials. The longer a surface remains damp during normal daily fluctuations in humidity, the higher the corrosion rate. Onshore winds carry both salt and moisture inland. Therefore, corrosion rates along shorelines with predominately onshore winds will be higher than those along shorelines with predominately offshore winds.

Distance from the Ocean

Corrosion rates vary considerably from community to community. But the amount of salt spray in the air is greatest near the breaking waves and can decline rapidly in the first 300 to 3000 feet (roughly 100 to 1000 meters) landward of the shoreline. Farther landward, corrosion is akin to that which occurs in milder, inland conditions. The width of the high-corrosion zone must be determined in each community, but oceanfront buildings will always be more severely affected than buildings farther inland.

One series of tests in North Carolina in the 1940s found that samples of iron corroded 10 times faster at 80 feet (25 meters) landward of the shoreline than samples of the same type at 800 feet (250 meters) landward of the shoreline (LaQue, 1975, see #6 in the section titled "Further

Information"). Similar results have been noted around the world. Where waves break, salt is tossed into the air and the wind tends to distribute the salt spray to inland areas.

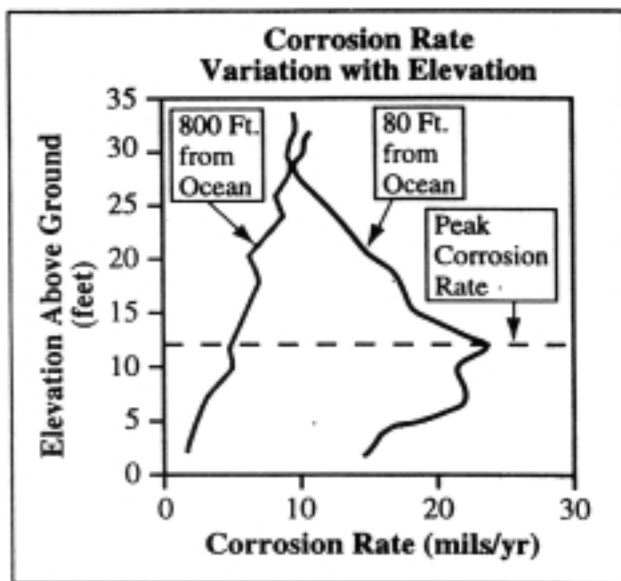


Figure 3. The variation in the corrosion rate of steel with elevation for Kure Beach, NC

can be expected to suffer high corrosion rates. But partially sheltered exposures, such as underneath open, piling-supported buildings or underneath decks and walkways, can sustain even worse corrosion than bold exposures. The results of other exposure tests from near the ocean in Kure Beach are shown in Figure 4 (LaQue, 1975). Steel samples were weighed, then exposed under a wooden roof. After 2 years, rust and other corrosion products were stripped from the samples, and the samples were weighed again to measure the weight loss.

The study reported that salt spray accumulations on bold exposures are rinsed periodically by rainfall (Positions 4 and 5), reducing the surface salt concentrations. Sheltered exposures receive little salt spray (Position 1). Partially sheltered exposures (Positions 2 and 3) receive almost as much incoming spray as bold exposures. However, the surface concentrations remain high,

Elevation

Other tests conducted in North Carolina found that corrosion reached a peak at about 12 feet (3.6 meters) above the ground (see Figure 3), approximately equal to the lowest floor elevation of an elevated building with lower level parking. Several rows of buildings farther inland, the overall corrosion rate is lower, but it is highest at an elevation above the roofs of small buildings. Figure 3 also indicates that the worst corrosion nearest the ocean was more than double the worst farther inland.

Shelter and Orientation

Bold exposures such as building exteriors are coated with large amounts of salt spray and

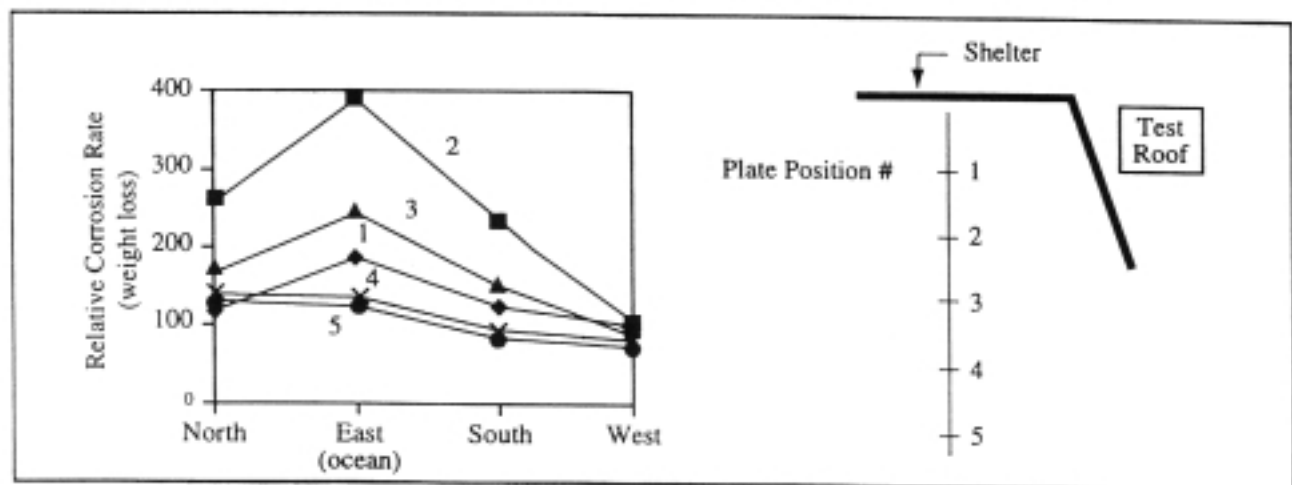


Figure 4. The effect of shelter and orientation under the test roof shown on the right

because of the shelter from cleansing rain. An additional factor is the duration of surface wetness. Accelerated corrosion occurs primarily when a certain level of surface wetness is exceeded, initiating electrochemical reactions among the metal, salts, and air. Bold exposures are more rapidly dried because they are exposed to sunlight. Drying slows the corrosion rate. Partially sheltered exposures stay damp longer and therefore corrode faster. The effect of building orientation on corrosion is also shown in Figure 4. The metals on the side of a building facing the ocean will corrode much faster than those facing away from the ocean.

Weather and Time

Weather affects the rate of corrosion in all exposures, both coastal and inland. Most chemical reactions, including corrosion rates, are affected by temperature, humidity, wind speed, and other factors. Like any weather-driven condition, the corrosion rate can vary considerably from year to year. Average conditions for factors like rainfall seldom occur. The measured rainfall is often either much higher or much lower than the average. Average years seldom occur. Likewise, the annual corrosion rate in any individual year will be significantly higher or lower than the long-term average. Therefore, annual measurements of corrosion can be very misleading unless compared to long-term averages for nearby locations.

Identifying Corrosion-Prone Buildings

In a few communities, corrosion test facilities can predict the distance from the shoreline at which corrosion will be most severe. Unfortunately, in most communities, corrosion data will not be available. Estimates of the width of the zone where corrosion-resistant materials and methods are necessary should be based on local experience. Metal connectors should be observed in older buildings at various distances from the shoreline. If oceanfront buildings are experiencing severe corrosion problems in less than 10 years, then the second or third row buildings will experience severe corrosion over a typical useful lifetime of 50 to 70 years.

Classes of Exposure for Connectors in a Building

Corrosion exposures for metal connectors in most buildings can be grouped into five classes, four of which are shown in Figure 5. The five classes are listed below in order of decreasing corrosion severity.

Partially sheltered exterior exposures.

Examples include open, underhouse storage and parking areas below a piling-, column-, or post-supported building and areas underneath roof overhangs, decks, and walkways. Corrosion can significantly weaken standard sheetmetal connectors after 5 to 10 years in these exposures on oceanfront buildings.

Boldly exposed exterior exposures. Examples include exterior walls with the connector fully exposed. If the exposed connector is fully dried

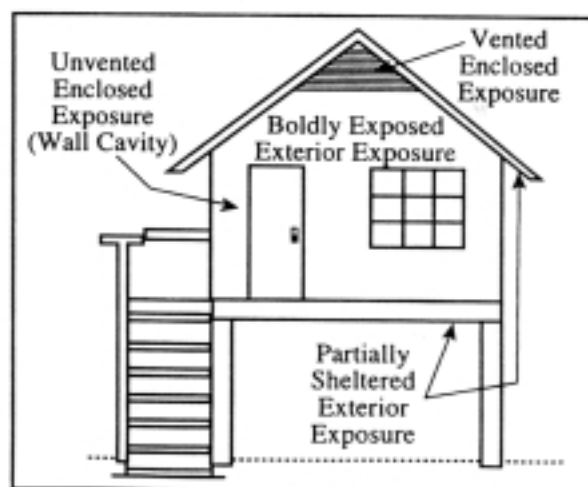


Figure 5. The locations of various classes of corrosion

between wettings by the ocean spray, the corrosion rate will be lower than that in partially sheltered exterior exposures. Otherwise, the corrosion rate can match that in partially sheltered exterior exposures.

Vented enclosed exposures. Attics, which must be vented to release excess heat and moisture, are typical examples of this type of exposure. Corrosion will vary with the location of the connector in the enclosed space. Corrosion rates for connectors near exterior vents, where outside airflow is concentrated, are often similar to those for connectors in partially sheltered exterior exposures. For connectors that are away from the vents or covered by insulation, the corrosion rate is expected to be much lower.

Unvented enclosed exposures. Examples include enclosed floor systems with solid joists or trusses. Because of the limited airflow and incoming salt spray, corrosion rates for connectors in these exposures are expected to be lower than those for connectors in the previous three exposures.

Interior living space exposures. These spaces are sealed from most salt spray, and normal heating and cooling further reduce interior humidity below the threshold needed for rapid corrosion. Connectors in these spaces should have the lowest corrosion rates.

Corrosion-Resistant Materials and Coatings

Improved corrosion resistance can be obtained by fabricating connectors from more resistant sheetmetal or by treating standard connectors after they have been fabricated. The relative improvement in corrosion resistance for different options is estimated in this section. Better materials can sometimes mean higher cost. Typical cost differences for the alternative materials are also estimated in this section.

Thicker Galvanizing

There are two methods of producing thicker galvanizing on connectors: 1) fabricating connectors from steel sheet with thicker initial galvanizing, or 2) regalvanizing standard connectors after fabrication. Galvanized sheet steel is available in a variety of coating thicknesses. Several manufacturers now market standard connectors in various designs fabricated from G 180 or G 200 grades of galvanized steel, which, compared to the standard G 60 connector, have zinc coatings that are 3 or 3.3 times thicker, respectively. Since the corrosion resistance of zinc is proportional to the thickness of the zinc, these connectors should last approximately 3 or 3.3 times longer, respectively, than standard connectors. Advertised costs for connectors with thicker galvanizing have been known to range from 1.3 to 1.7 times the cost of standard connectors.

Thicker galvanizing can also be obtained by hot-dipping standard connectors after fabrication. The manufacturer usually sends the connectors to an outside galvanizing company for dipping. Several variables can affect the thickness of the galvanizing, but the result is typically a coating of zinc four times thicker than that on a standard G 60 connector. A few types of these connectors are regularly available. Other connector designs are available by special order. The cost estimate for sheetmetal connectors hot-dipped after fabrication has been known to be roughly 1.75 times the cost of standard G 60 grade connectors.

Stainless Steel

Several connector manufacturers also produce a variety of the most commonly used connectors in stainless steel. Stainless steel is very resistant to corrosion in salt air and should last longer in a wood-frame building than most other materials, even in the most corrosive oceanfront situation. For extended lifetimes, stainless connectors must be attached with stainless steel nails when separate fasteners are needed. Stainless steel sheetmetal is a more costly raw material than the sheetmetal used to make galvanized connectors. It is also harder; therefore, stainless steel connectors are more difficult to fabricate. The cost of a stainless steel connector, including the cost of the necessary stainless steel nails, can be 6 to 15 times the cost of the same connector in G 60 grade galvanized steel.

Paint Coatings

Painting standard galvanized steel connectors can significantly improve their corrosion resistance. However many paints commonly used for buildings do not adhere well to galvanized surfaces. The Truss Plate Institute (TPI) has considered the use of truss plates in corrosive environments like coastal buildings. The TPI design specifications, which are accepted by the national model codes, recommend that one of three types of industrial paint systems be applied by brush to embedded plates after delivery of the completed truss to the job site or after truss installation (see TPI-85). The paints are specific formulations of (1) epoxy-polyamide, (2) coal-tar epoxy-polyamide, and (3) zinc chromate-vinyl butyral primer with asphaltic mastic.

The increased corrosion resistance provided by the recommended paint coatings in coastal buildings is difficult to estimate. Unlike changes in galvanizing thickness, changes in paint thickness do not proportionally change the corrosion resistance. Paint lifetimes are significantly affected by salt spray, but exposure conditions can affect paints and galvanizing differently. Surface preparation and care in application are critical for improved corrosion resistance with paints. The added cost of these coatings will vary with local labor costs. In general, other types of paints should not be assumed to significantly improve the corrosion resistance of standard connectors or truss plates. For other types of connectors, the alternatives described previously are recommended over any type of painting. However, for maintenance, zinc-rich coatings of paint may be better than nothing.

Guidance for Connector Corrosion Control

All construction materials deteriorate with time. The average useful lifetime of the structural components of a wood-frame building is approximately 70 years in the United States. Continued use of a building requires that (a) the original materials be durable enough to last the expected lifetime, (b) periodic maintenance be conducted to extend the life of original materials, or (c) the material be replaced one or more times during the lifetime of the building.

Avoid the problem

Most connectors are intended for inland uses with mild corrosion and, under normal conditions, appear to last as long as or longer than other materials in the building. Many buildings in communities near the coast are likely to experience only slightly increased corrosion rates, and standard connectors appear appropriate for those buildings. But close to the ocean, drastically higher corrosion rates can be expected. The use of standard connectors in these areas may

necessitate care in controlling the exposure. Otherwise, alternative materials should be used.

For some uses, corrosion can be partially avoided by altering the exposure of the connectors. For example, on exteriors, a connector should be fully covered if possible or otherwise protected from salt spray and moisture. Exterior siding should be designed to completely cover connectors. Applying siding in this way changes the exposure from boldly exposed to unvented enclosed. An easy, but more costly, way to protect joist hangers and truss plates in the floors of piling-supported buildings is to sheath the underside of the floor joists to reduce the exposure to salt air. Adding such sheathing transforms one of the worst

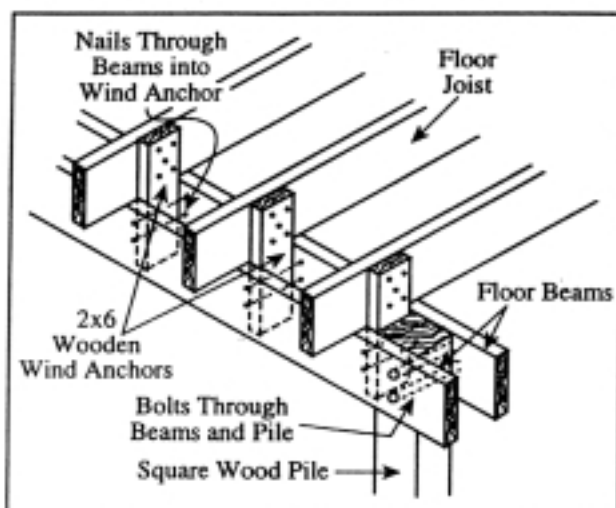


Figure 7. Wooden wind anchors used to connect floor joists to floor beams

where they are accessible and maintainable. In milder exposures, applying a regular coat of exterior house paint may be enough to extend the life of the connector. But in severe exposures, even annual painting is unlikely to prolong the life of a connector to that of the rest of the building. In these exposures, accessible connectors may be inspected for corrosion and, if necessary, replaced. Galvanized sheetmetal connectors should be replaced as soon as partial surface rusting appears. The presence of more than thin rusty edges indicates that the zinc coating has been consumed and the sacrificial effects have been lost. Corrosion of the thin, steel sheet will occur quickly and will rapidly deteriorate the structural integrity of the connector.

When the option of periodic replacement is evaluated, the cost over the lifetime of the building should be considered. Corrosion-resistant connectors, available for a moderately higher price, can have significantly longer lifetimes than standard connectors. The cost of labor for initial installation is the same for both materials. The material and labor cost for even one replacement

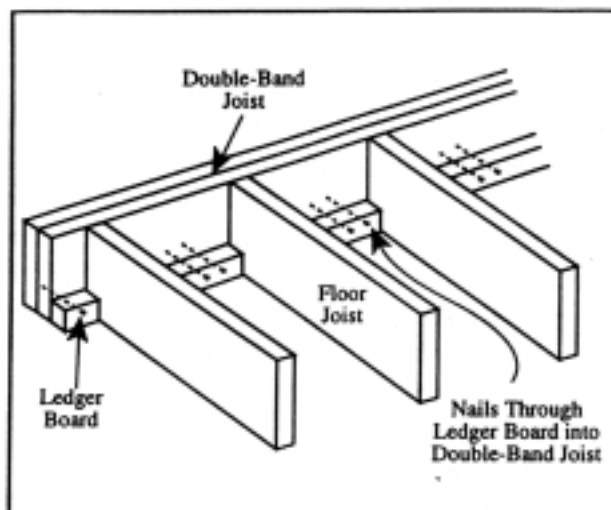


Figure 6. Traditional wooden ledger boards used in place of joist hangers in high-corrosion areas

exposures, partially sheltered exterior, into a less corrosive, unvented enclosed.

For some connections, corrosion may be avoided by not using sheetmetal. Underneath unsheathed floors and decks, the traditional use of ledger boards avoids the need for joist hangers in the worst corrosion exposures (see Figure 6). The wooden wind anchors in Figure 7 attach piling-supported floor beams to floor joists. Commonly used on the Texas coast, these anchors proved effective during Hurricane Alicia's 90- to 100-mph winds in 1983.

Maintenance and Replacement

In some uses, connectors may be placed

is often greater than the added initial cost for corrosion-resistant materials. By using better materials initially, one can avoid the cost of two or three replacements of standard materials. In the worst exposures, where standard connectors may have to be replaced as often as every 5 years, even the use of stainless steel connectors may prove less costly over the long run.

Given the low likelihood of regular inspection by most building owners and the brief expected lifetime of standard connectors in the worst exposures, replacement is usually a poor option. Furthermore, many connectors are hidden structural components that are difficult or impossible to maintain or replace. In such cases, replacement is rarely an option and more corrosion-resistant materials should be selected. Replacement may be the only option in existing buildings where connectors have already been damaged by corrosion or were never installed. In existing buildings, adding roof connectors can significantly improve the wind resistance and is therefore worthwhile, even if some dismantling is needed to gain access.

Summary of Recommendations

For many connector applications in corrosion-prone buildings, the use of corrosion-resistant materials is the best solution for new construction. The choice of alternative connector material or coating specifications should be guided by the location of the building relative to the observed corrosion hazards in each community and by the class of exposure in the building. Recommended materials for a typical community are listed in Table 1.

Location Class of Exposure **	Oceanfront Buildings (300 feet or less from the shoreline)***	Intermediate Rows of Buildings in Corrosion-Prone Areas (300 to 3,000 feet from the shoreline)***	Buildings Farther Landward (Greater than 3,000 feet from the shoreline)***
Partially sheltered exteriors	1. Avoid sheetmetal connectors where possible. 2. Use stainless steel connectors. 3. Use connectors with thicker galvanizing and replace them when necessary.	Use connectors with thicker galvanizing. (Optional: stainless steel)	Use connectors with standard galvanizing. (Optional: thicker galvanizing)
Boldly exposed exteriors	1. Avoid sheetmetal connectors where possible. 2. Use stainless steel connectors. 3. Use connectors with thicker galvanizing and replace them when necessary.	Use connectors with thicker galvanizing. (Optional: stainless steel)	Use connectors with standard galvanizing. (Optional: thicker galvanizing)
Vented enclosures	1. Use connectors with thicker galvanizing. (Optional: stainless steel) 2. Use TPI paints on truss plates. (Optional for truss plates: thicker galvanizing, TPI paints over thicker galvanizing, or stainless steel)	1. Use connectors with thicker galvanizing near vents. 2. Use TPI paints on truss plates near vents. (Optional: thicker galvanizing for all connectors)	Use connectors with standard galvanizing. (Optional: thicker galvanizing)
Unvented enclosures	1. Use connectors with thicker galvanizing. 2. Use TPI paints on truss plates. (Optional for truss plates: thicker galvanizing)	Use connectors with standard galvanizing. (Optional: thicker galvanizing)	Use connectors with standard galvanizing. (Optional: thicker galvanizing)
Interior living space	Use connectors with standard galvanizing. (Optional: thicker galvanizing)	Use connectors with standard galvanizing. (Optional: thicker galvanizing)	Use connectors with standard galvanizing. (Optional: thicker galvanizing)

* Recommendations are based on the available research and are subject to change in future Technical Bulletins.

** See Figure 5 for corrosion classes.

*** Distances may vary considerably depending on local climate. The width of the corrosion hazard area relative to the ocean should be determined in each community from field observations and any existing corrosion studies.

In Table 1, building locations are categorized as oceanfront buildings, intermediate rows of buildings in corrosion-prone areas, and buildings near the coast but far enough away from the ocean that excessive corrosion is not anticipated. In most communities, connectors on oceanfront buildings can be expected to corrode at high rates. Corrosion rates should approach inland levels 300 to 3000 feet (roughly 100 to 1000 meters) landward of the ocean in most communities. The types of connector exposures in a building are listed in Table 1 in order of decreasing severity of location. Truss plate treatments are noted separately, based on TPI recommendations for corrosive environments. Recommendations in the table are in some cases based on limited research. When the severity of the exposure is unknown, selecting more corrosion-resistant materials prudent. Optional materials for superior corrosion resistance are also noted.

Technical Bulletins

This publication is one of a series of Technical Bulletins FEMA has produced to provide guidance concerning the building performance standards of the NFIP. These standards are contained in Title 44 of the U.S. Code of Federal Regulations at Section 60.3. The bulletins are intended for use primarily by State and local officials responsible for interpreting and enforcing NFIP regulations and by members of the development community, such as design professionals and builders. New bulletins, as well as updates of existing bulletins, are issued periodically, as necessary. The bulletins do not create regulations; rather they provide specific guidance for complying with the minimum requirements of existing NFIP regulations. Users of the Technical Bulletins who need additional guidance concerning NFIP regulatory requirements should contact the Mitigation Division of the appropriate FEMA regional office. The User's Guide to Technical Bulletins (FIA-TB-0) lists the bulletins issued to date and provides a key word/subject index for the entire series.

Ordering Information

Copies of the Technical Bulletins can be obtained from the appropriate FEMA regional office. Technical Bulletins can also be ordered from the FEMA publications warehouse. Use of FEMA Form 60-8 will result in a more timely delivery from the warehouse. The form can be obtained from FEMA regional offices and your state's Office of Emergency Management. Send publication requests to FEMA Publications, P.O. Box 2012, Jessup, MD 20794-2012.

Further Information

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2. "Coastal Construction Manual," FEMA, 1986, FEMA-55.
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6. Marine Corrosion: Causes and Prevention, by F. R. LaQue, John Wiley & Sons, 1975.

7. "Selected Specifications for Hot Dip Galvanizing," by the American Society for Testing and Materials (ASTM), 1994, available from the American Galvanizers Association.
8. "Standard Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process," ASTM, 1987, ASTM A 525-90.

Glossary

Base Flood — The flood that has a 1-percent probability of being equaled or exceeded in any given year (also referred to as the 100-year flood).

Base Flood Elevation (BFE) — The height of the base flood, usually in feet, in relation to the National Geodetic Vertical Datum of 1929 or other datum as specified.

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. These areas are identified as V zones.

Federal Emergency Management Agency (FEMA) — The independent Federal agency that, in addition to carrying out other activities, oversees the administration of the National Flood Insurance Program.

Federal Insurance Administration (FIA) — The component of FEMA directly responsible for administering the flood insurance aspects of the National Flood Insurance Program.

Flood Insurance Rate Map (FIRM) — The insurance and floodplain management map issued by FEMA that identifies, on the basis of detailed or approximate analyses, areas of 100-year flood hazard in a community.

Floodprone Area — Any land area susceptible to being inundated by floodwater from any source.

Lowest Floor — The lowest floor of the lowest enclosed area of a structure, including a basement. An unfinished or flood-resistant enclosure useable solely for parking of vehicles, building access, or storage in an area other than a basement area is not considered a building's lowest floor, as long as the enclosure is not built in such a way that it violates the non-elevation design requirements of Section 60.3 of the National Flood Insurance Program regulations.

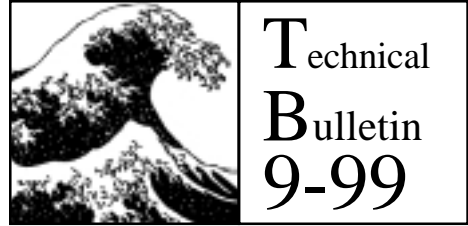
Mitigation Directorate — The component of FEMA directly responsible for administering the floodplain management aspects of the National Flood Insurance Program and for carrying out hazard mitigation activities related to flood and other disasters.

New Construction/Structure — For floodplain management purposes, new construction means structures for which the start of construction commences on or after the effective date of a floodplain management regulation adopted by a community and includes subsequent improvements to the structure. These structures are often referred to as "Post-FIRM" structures.

Special Flood Hazard Area (SFHA) — Area delineated on a Flood Insurance Rate Map as being subject to inundation by the base flood and designated Zone A, AE, A1-A30, AR, AO, AH, V, VE, or V1-V30.

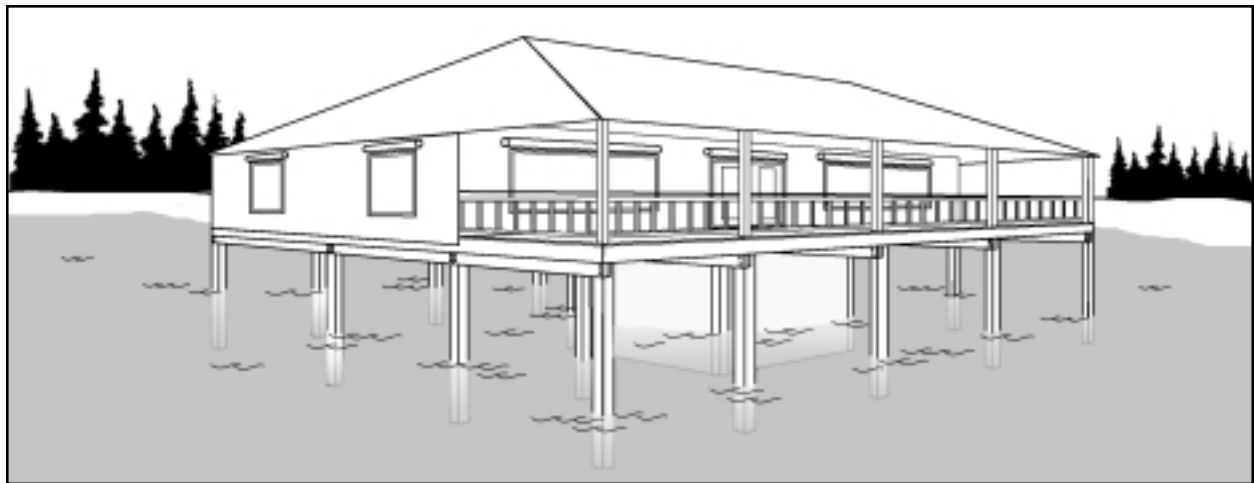
Substantial Damage — Damage of any origin sustained by a structure whereby the cost of restoring the structure to its before-damaged condition would equal or exceed 50 percent of the market value of the structure before the damage occurred.

Substantial Improvement — Any reconstruction, rehabilitation, addition, or other improvement of a structure, the cost of which equals or exceeds 50 percent of the market value of the structure before the “start of construction” of the improvement. This term includes structures that have incurred “substantial damage,” regardless of the actual repair work performed.



Design and Construction Guidance for Breakaway Walls Below Elevated Coastal Buildings

**in accordance with the
National Flood Insurance Program**



**FEDERAL EMERGENCY MANAGEMENT AGENCY
MITIGATION DIRECTORATE**

**FIA-TB-9
(9/99)**

Key Word/Subject Index

This index allows the user to locate key words and subjects in this Technical Bulletin. The Technical Bulletin User's Guide (printed separately) provides references to key words and subjects throughout the Technical Bulletins. For definitions of selected terms, refer to the Glossary at the end of this bulletin.

Key Word/Subject Index	Page
Breakaway wall, failure modes	6, 7
Breakaway wall, insurance considerations	13
Breakaway wall, NFIP regulatory requirements	1, 3
Breakaway wall, requirement for construction with flood-resistant materials	1, 12
Breakaway wall, specifications for NFIP-compliant construction	3, 4
Breaking wave, impact on vertical surface	5
Insect screening, for below-building enclosures	4
Latticework, for below-building enclosures	4

Any comments on the Technical Bulletins should be directed to:

Federal Emergency Management Agency
Mitigation Directorate
Program Policy and Assessment Branch
500 C Street, SW.
Washington, DC 20472

Technical Bulletin 9-99 replaces Technical Bulletin 85-3 (draft), *Breakaway Walls*.

Wave design on cover based on the Japanese print *The Great Wave Off Kanagawa*, by Katsushika Hokusai (1760 – 1849), Asiatic Museum of Fine Arts, Boston.

**Design and Construction Guidance for Breakaway Walls
Below Elevated Coastal Buildings
in accordance with the National Flood Insurance Program**

Introduction

In Coastal High Hazard Areas (Zones V, VE, and V1-30), the National Flood Insurance Program (NFIP) regulations require that communities participating in the program adopt floodplain management ordinances or laws requiring that all new and substantially improved buildings be elevated to or above the base flood elevation (BFE) on foundations consisting of piles, posts, piers, or columns. These open foundations must be designed to allow waves and water moving at high velocity to flow beneath the building. Local ordinances or laws adopted by participating communities must further require that the area below the lowest floor of the elevated building be left free of obstructions. Walls or other obstructions below the elevated building can significantly increase the potential for flood damage to the elevated building by increasing the surface area subject to wave impact and velocity flow during a coastal storm.

Although obstructions are prohibited, the area below the lowest floor of an elevated building in a Coastal High Hazard Area may be enclosed with open wood latticework, insect screening, or non-supporting “breakaway” walls (see Figure 1). However, each of these must be designed and constructed 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. In addition, like all other construction in the Special Flood Hazard Area, any enclosure below the lowest floor of an elevated building must be built with flood-resistant materials and with methods and practices that minimize flood damage. Furthermore, the area below the lowest floor of the elevated building may be used only for parking, building access, or storage.

Specific design requirements are included in the NFIP regulations for breakaway walls. More recent research on breakaway walls performed for the Federal Emergency Management Agency (FEMA) and the National Science Foundation by North Carolina State University and Oregon State University evaluated the failure mechanisms (see *Further Information* on page 14 of this bulletin). The research included full-scale, laboratory wave-tank tests of breakaway wall panels. This bulletin describes prescriptive design details that comply with the requirements of the NFIP regulations and that may be used by design professionals as an alternative to the performance requirements listed in the regulations.

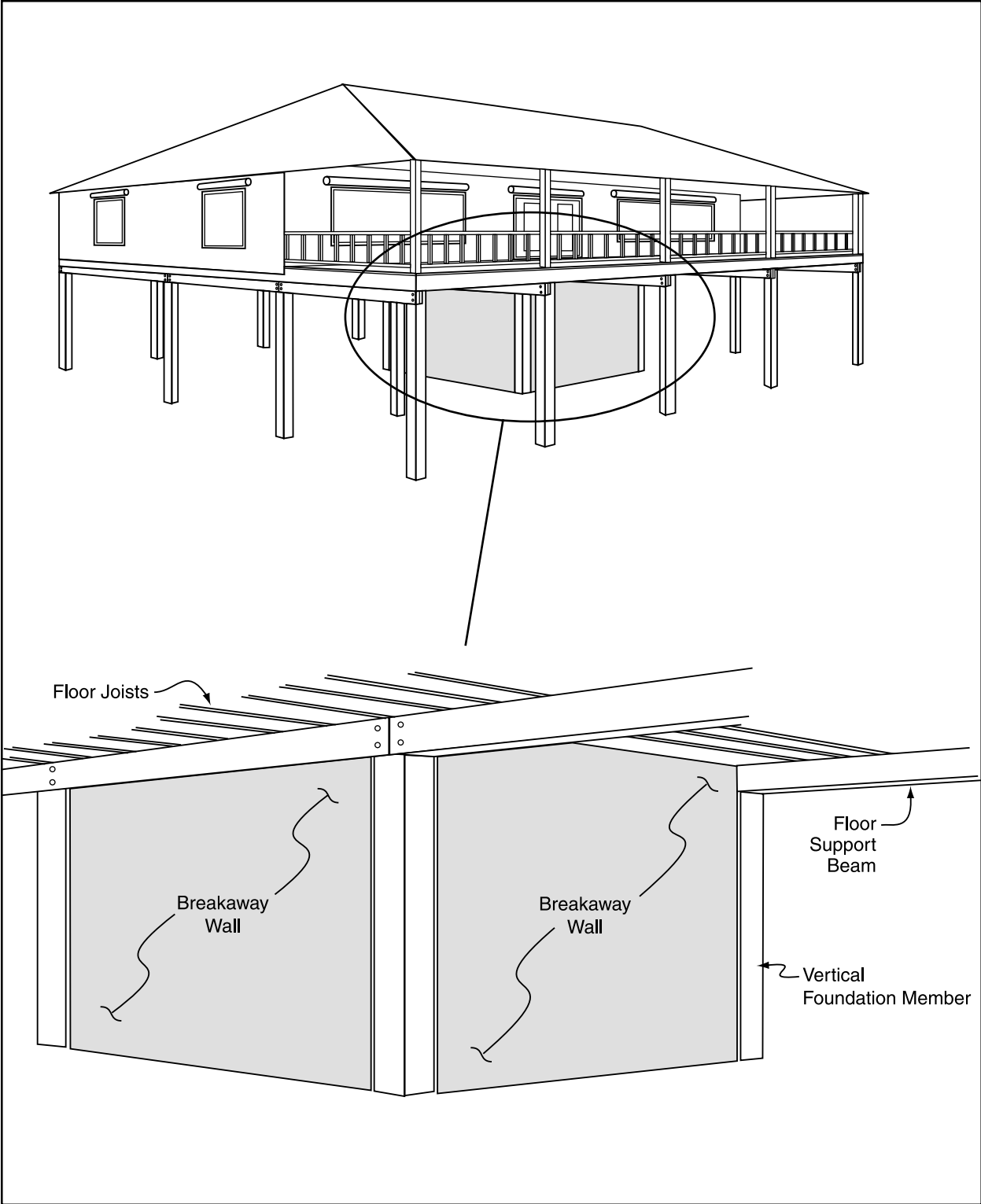


Figure 1 Area enclosed by breakaway walls below an elevated building.

NFIP Regulations

Section 60.3(e)(4) of the NFIP regulations states that the community shall:

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

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

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

Technical Bulletins provide guidance on the **minimum** requirements of the NFIP regulations. State or local requirements that exceed those of the NFIP take precedence. Design professionals should contact community officials to determine whether more restrictive State or local regulations apply to the building or site in question. All applicable standards of the State or local building code must also be met for any building in a flood hazard area.

Below-Building Enclosure Options Compliant With the Regulations

According to Section 60.3(e)(5) of the NFIP regulations, areas below elevated buildings in Coastal High Hazard Areas (Zones V1-V-30, VE, and V) may be enclosed in one of two ways: (1) with insect screening or open latticework or (2) with breakaway walls.

Insect Screening and Open Latticework

Insect screening and open latticework below elevated buildings are not considered obstructions as long as they meet the performance requirements of Section 60.3(e)(5) of the NFIP regulations. To increase the likelihood that the screen or latticework will collapse as intended, without transferring loads to the building or its foundation, this bulletin recommends that the vertical framing members on which the screen or latticework is mounted (such as 2 x 4's) be spaced at least 2 feet apart. Either metal or synthetic insect screening is acceptable. Lattice is available in 4' x 8' sheets in wood or plastic. The material used to fabricate the lattice should be no thicker than 1/2 inch, and the finished sheet should have an opening ratio of at least 40 percent. (Although Section 60.3(e)(5) specifies wood lattice, plastic lattice is acceptable as long as it meets the requirements listed above.)

Breakaway Walls

Section 60.3(e)(5) of the NFIP regulations requires that breakaway walls either (1) be constructed to meet prescriptive criteria for resistance to wind and water loads or (2) be certified by a registered professional engineer or architect.

Walls Meeting the Prescriptive Criteria

According to NFIP performance criteria for breakaway walls, any wall with a designed safe working resistance of not less than 10 and not more than 20 pounds per square foot (psf) is considered a breakaway wall and does not require certification by an engineer or architect. Previous NFIP design guidance, in the 1986 edition of FEMA's *Coastal Construction Manual*, specified standard stud wall panels placed between pilings or other vertical foundation members, but connected to the building only at the top and bottom of the panel with a specific number of fasteners intended to restrict the capacity of the wall to the 10- to 20-psf range. Higher loads will cause a failure at the top or bottom connections. Breakaway walls built according to this previously developed guidance continue to be compliant with the NFIP performance criteria.

Walls Requiring Certification

In many coastal areas, local building codes include wind design requirements that exceed the 20-psf maximum described above. NFIP performance criteria allow for construction of breakaway walls that meet these wind requirements. Breakaway walls with capacities higher than 20 psf are permitted if an 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 on all building components. The remainder of this bulletin presents a prescriptive description of breakaway walls that meet the two certification conditions based on more recent research.

Wave Forces and Rising Storm Surge

The results of previous breakaway wall analyses, which served as the basis of recommendations in the 1985 edition of FEMA's *Coastal Construction Manual*, assumed design flood conditions and oscillating (non-breaking) wave conditions. The more recent research conducted by North Carolina State University and Oregon State University assumed two significant differences to better model coastal storms: breaking waves and rising water levels with time. In addition, full-scale wall panels were tested in a wave tank at Oregon State University to confirm the theoretical results.

The severity of the flood hazard in V zones and coastal A zones is greater than that in non-coastal A zones, primarily because of the presence of breaking waves, which generally do not occur in non-coastal A zones. As a breaking wave passes a piling foundation or other open foundation, the structure experiences an oscillating, high-velocity flow that peaks at the wave crest, just as the wave breaks. While there are drag forces on the foundation, most of the flow under the building is undisturbed, making open foundations a manageable design. When a breaking wave hits a vertical surface, the effect is quite different. When the crest of a breaking wave impacts a vertical surface, a pocket of air is trapped and compressed by the wave (see Figure 2). As the air pocket collapses, an exceedingly high-pressure burst is placed on the wall, centered around the stillwater level. For example, peak pressures from a 5-foot breaking wave can be 100 times higher than the 10- to 20-psf range specified in the NFIP regulations.

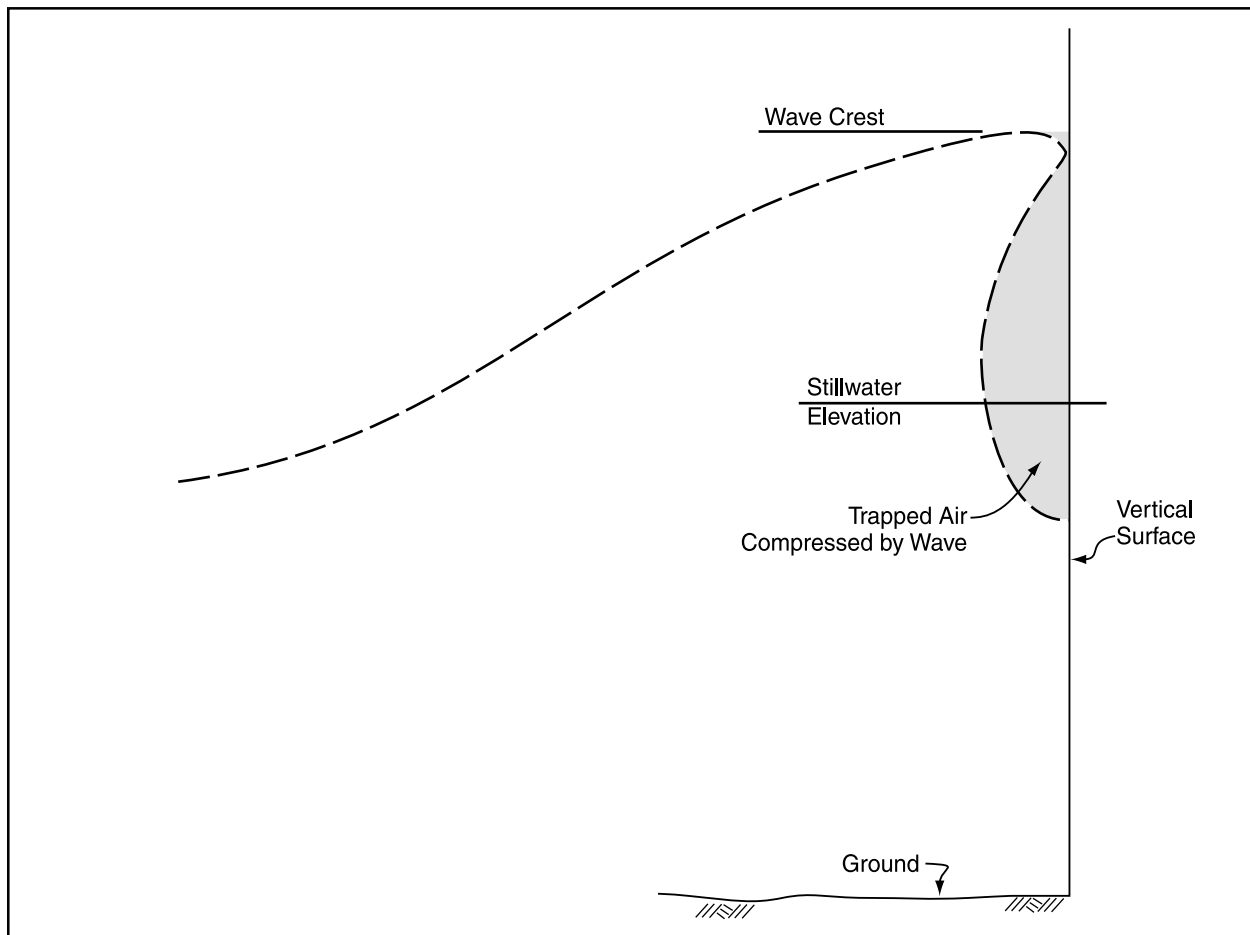


Figure 2 Impact of breaking wave on vertical surface.

The research found that standard wood stud wall construction with structural wood sheathing failed after being hit by several breaking waves averaging 2 feet in height. Those conditions will occur early in the storm when the stillwater depth is approximately 2 feet. Although the forces acting on the wall are high, they can be expected to act close to the ground, where much of the force is transferred into the ground or to the foundation near the ground. Therefore, prior to failure, the forces transferred to the elevated building by the breakaway wall can be minimized.

The full-scale tests conducted as part of the research showed that wood-frame breakaway walls designed to meet high-wind conditions will fail reliably at the connection between the bottom plate of the wall and the floor (see Figure 3a). The tests showed that the failure begins with the bowing and gradual displacement of the bottom plate (see Figure 3b) or a similar secondary failure beginning with the central studs of the breakaway wall. Wood-frame breakaway walls built according to the criteria presented in the following section of this bulletin are expected to fail in this manner. In addition, the tests demonstrated a secondary failure mode that occurs if the bottom plate of the wall fails to break away. In that situation, failure will occur at the connection between the bottom plate of the wall and the bottom of each wall stud, with little increase in capacity (see Figure 4). The conclusion of the research is that wood-frame breakaway walls will fail well before they transfer excessive loads caused by higher wave forces to the elevated building or foundation.

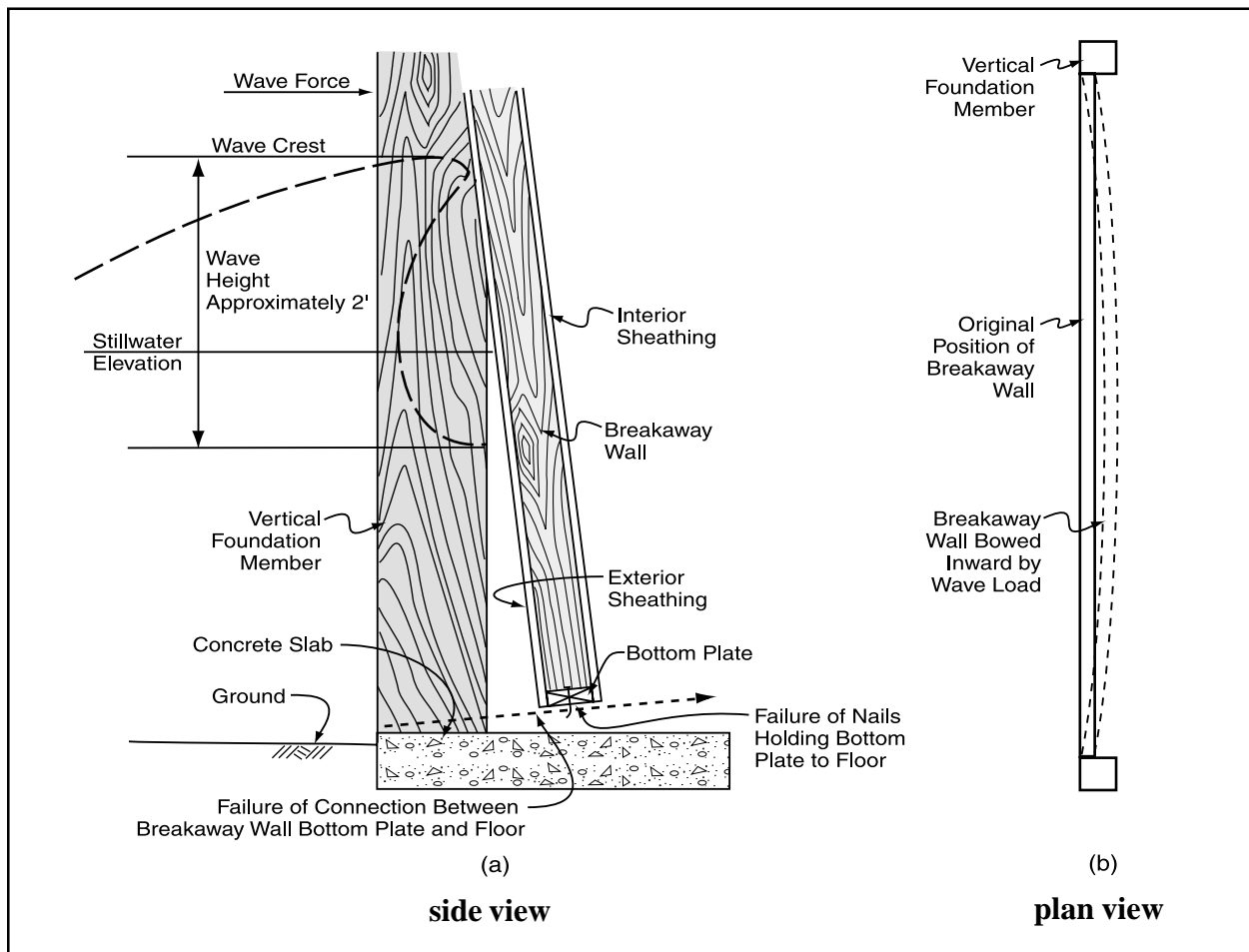


Figure 3 Expected failure mode of wood-frame breakaway wall based on full-scale testing – side view (a) and plan view (b).

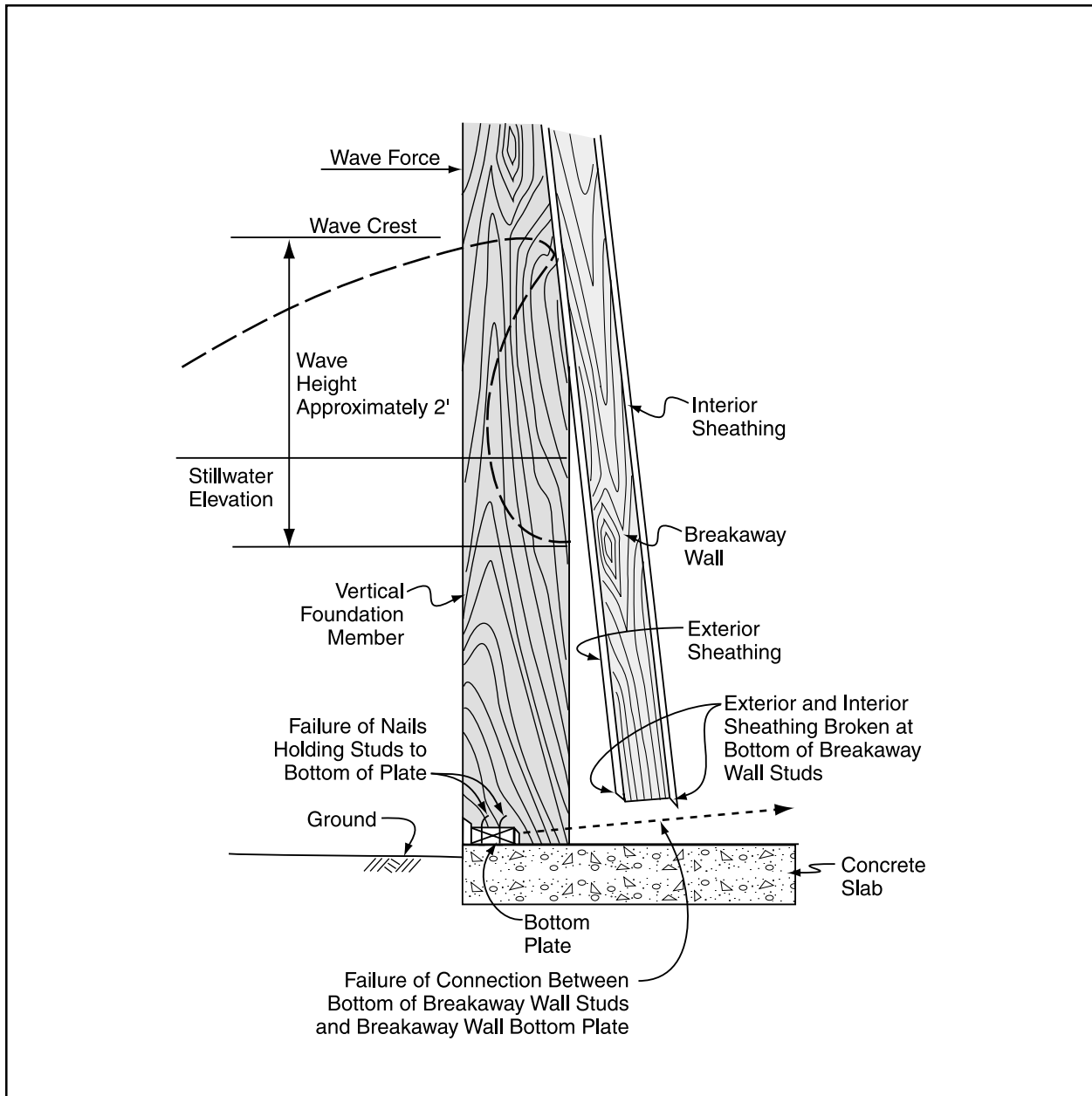


Figure 4 Secondary failure mode of wood-frame breakaway wall as determined from full-scale testing.

Breakaway walls consisting of unreinforced masonry are expected to fail at the mortar joints between the masonry units, beginning near the stillwater level (see Figure 5), where the pressure on the wall is greatest.

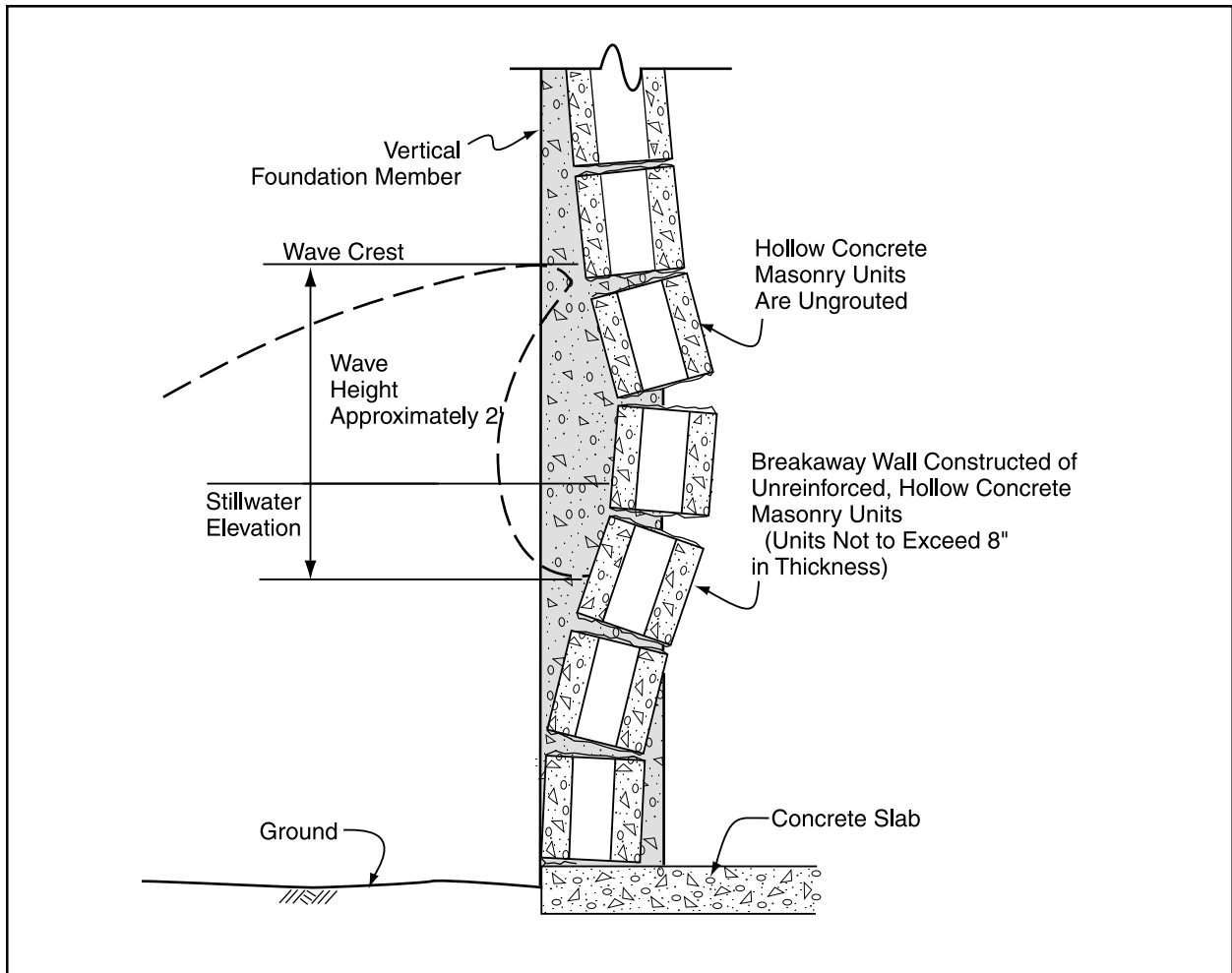


Figure 5 Expected failure mode of unreinforced masonry breakaway wall.

Prescriptive Breakaway Wall Criteria

Design and Construction

A professional designer may specify a breakaway wall with a capacity outside the 10- to 20-psf range using the following specifications.

1. The building must be elevated on a piling or other open foundation designed to withstand wind and water loads acting simultaneously and any other loads prescribed by applicable State or local building codes or other applicable laws, ordinances, or regulations.
2. Breakaway walls shall be designed to meet or exceed all applicable building code requirements for wind, earthquake, and other criteria.

3. The floors of areas enclosed with breakaway walls are assumed to be soil or unreinforced concrete slabs less than 4 inches thick. An unreinforced concrete slab has no wire mesh or steel rods. Floor slabs shall not be structurally attached to the pilings or other vertical foundation members.
4. Breakaway wall panels may be attached to the pilings or other vertical foundation members, elevated floor support beams, or slab floor with nails or other comparable-capacity fasteners (see Figure 6). All four sides of the wall panel may be attached to the foundation and elevated building. High-capacity connectors such as bolts, lag screws, metal straps, or hurricane fasteners (e.g., clips or straps) shall not be used.
5. The exterior sheathing on breakaway wall panels placed between pilings or other vertical foundation members may overlap and be attached to the vertical foundation members.
6. Breakaway walls may be constructed as continuous, non-bearing walls, attached to the floor and elevated floor joists, with or without attachment to the pilings or other vertical foundation members.
7. Breakaway wall sheathing and siding may overlap and attach to elevated floor beams and joists provided a separation joint is present to prevent damage to the sheathing or siding of the elevated building if the breakaway wall collapses (see Figure 7). As shown in Figure 7, separation joints shall be fitted with a watertight seal that prevents wind-driven rain water and sea spray from entering the building envelope.
8. Utilities, including electrical wiring, breaker boxes, power meters, plumbing, conduits, and ventilation ducts, shall not be placed in or on a breakaway wall panel. Building supply lines and other utility line components, such as light switches or electrical outlets, may be attached to pilings or other vertical foundation members as allowed by applicable building codes and floodplain management ordinances and laws (which generally require that utilities be elevated above the BFE). If utility lines must be routed into or out of an area enclosed by breakaway walls, one or more of the walls shall be constructed with a utility blackout (see Figure 6). Utility lines that pass through the blackout will be independent of the walls and therefore will not be damaged if the wall panel breaks away under flood or wind loads.
9. Breakaway wall panels shall be positioned such that on failure, they do not collapse against cross-bracing or threaten other foundation components.
10. Standard residential garage doors may be considered breakaway panels. Although these doors were not tested, published loading capacities for garage doors are comparable to the ultimate capacity for the tested breakaway walls (55 psf).
11. Because enclosures below buildings in V zones must be constructed with breakaway walls that meet the performance requirements of the NFIP regulations, flood vents or openings are not required for such enclosures. Note: Numerous State and local governments require openings in breakaway walls. See your local building official or floodplain administrator for further information.

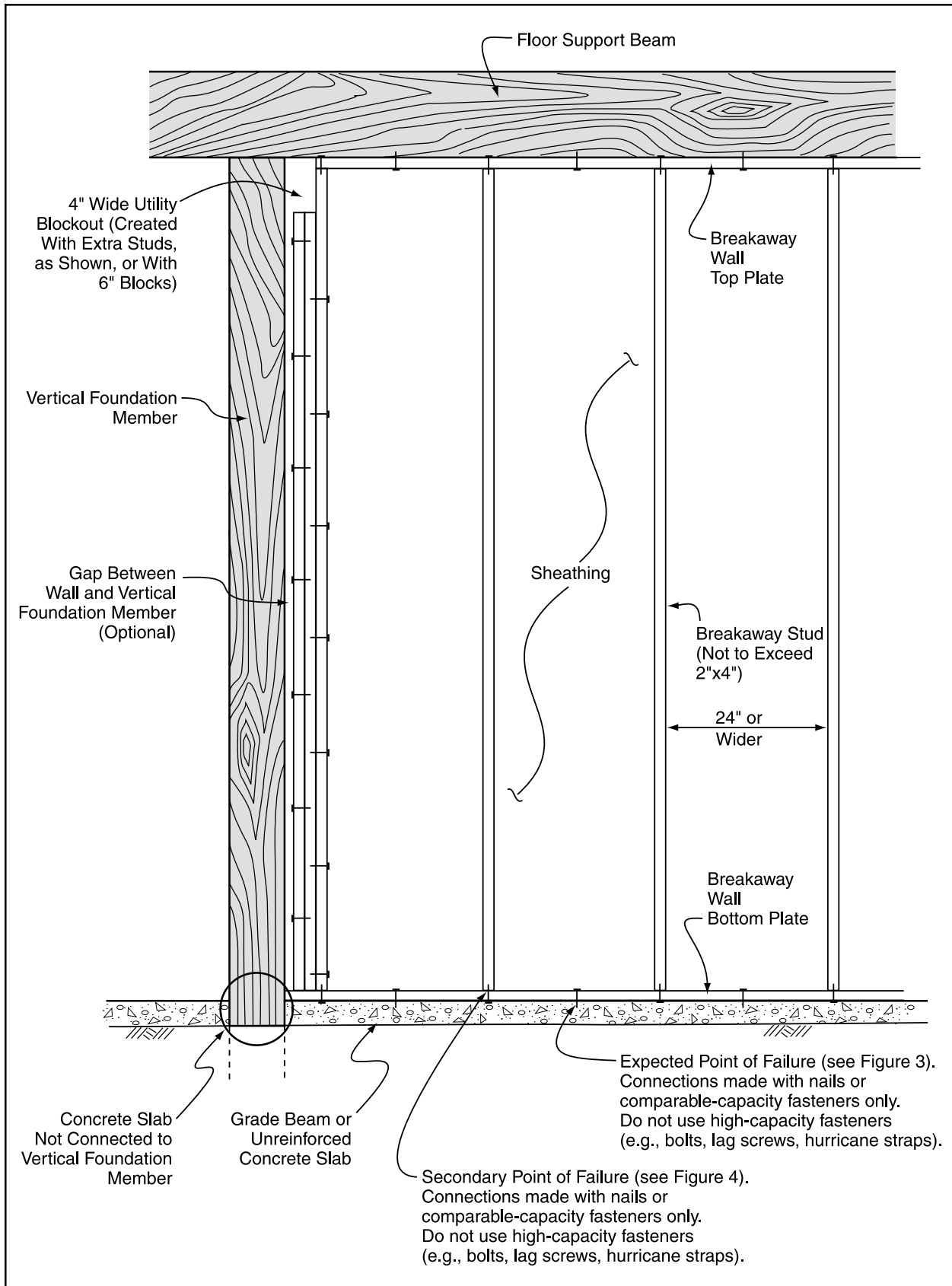


Figure 6 Typical wood-frame breakaway wall construction.

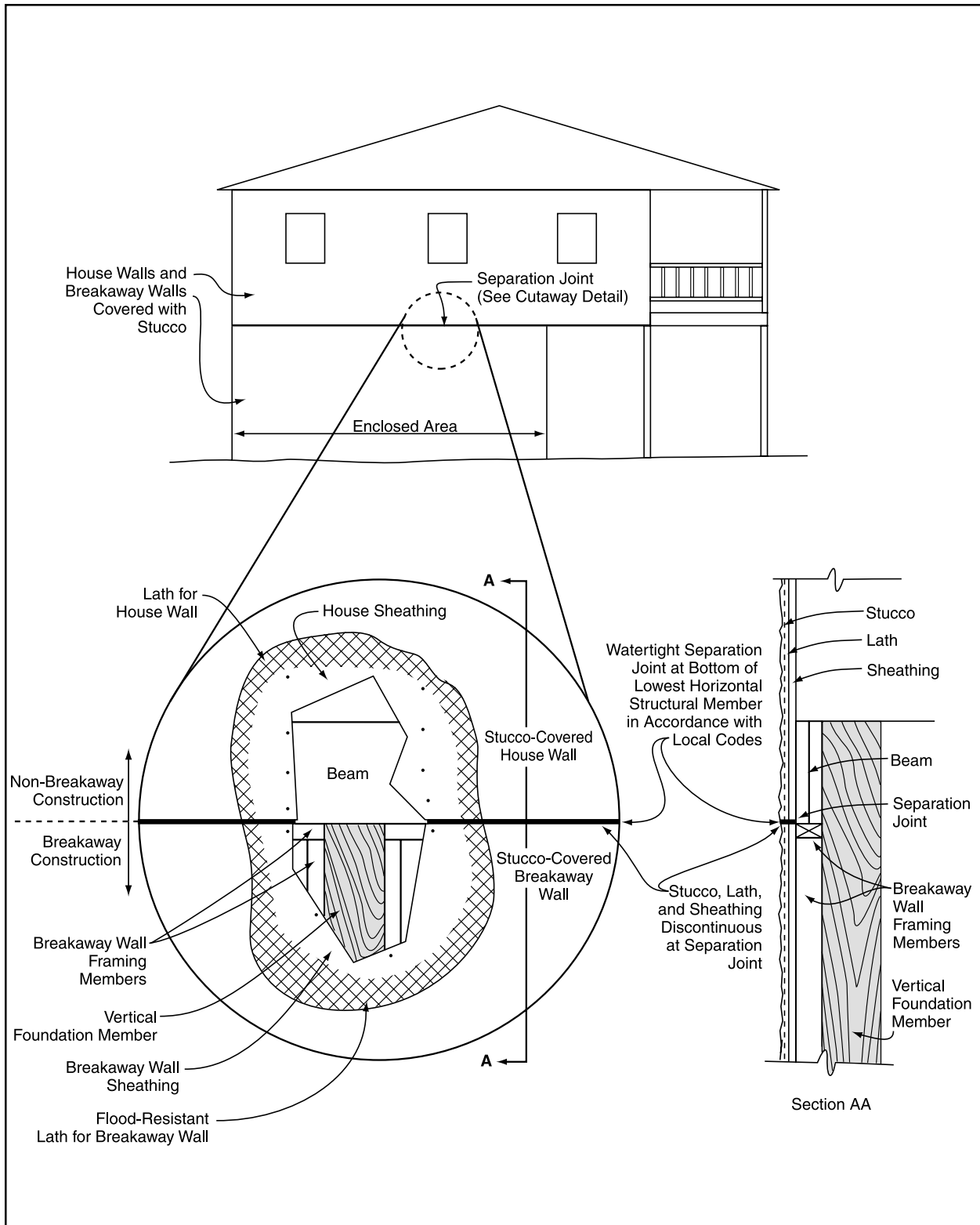


Figure 7 Separation joint between sheathing and wall covering (e.g., stucco, siding) on house walls and breakaway walls.

Construction Materials

As explained in FEMA Technical Bulletin 2-93, *Flood-Resistant Materials Requirements for Buildings Located in Special Flood Hazard Areas*, construction materials used below the BFE must be resistant to flood damage. “Flood-resistant” construction materials are those capable of withstanding direct and prolonged contact (i.e., at least 72 hours) with floodwaters without suffering significant damage (i.e., damage requiring more than cleanup or low-cost cosmetic repair, such as painting). The requirement for flood-resistant construction materials applies to breakaway walls.

In addition, except where heavier materials are required by the local building code, construction materials used for breakaway walls should meet the following specifications:

Wood-Frame Materials

- Exterior siding on breakaway wall panels shall be no thicker than 5/8-inch plywood, APA 32/16 rated sheathing or other equivalent sheathing material.
- Breakaway wall studs shall be no larger than 2 inches x 4 inches (nominal dimensions).
- Breakaway wall stud spacing shall be 24 inches on center or greater.
- Breakaway wall panels attached to concrete slabs shall be constructed with single top and bottom plates. Walls that enclose areas with earth floors may use a double bottom plate.
- Interior wall sheathing on breakaway wall panels shall be a maximum of 5/8-inch plywood or equivalent material.

Other Materials

- Light-gauge steel framing, such as steel studs, is expected to perform in a manner similar to wood studs and may be used with the conditions for wood framing listed above.
- Stucco, Exterior Insulation Finishing System walls, and other lightweight exterior sheathing material may be applied over breakaway walls, provided a separation joint is installed in any sheathing (see Figure 7), insulation, or reinforcing where attached at or near the bottom of the elevated floor beam or joists.
- Unreinforced, ungrouted hollow-cell masonry units with a width of 8 inches or less may be attached to floor beams and to concrete or masonry vertical foundation members with standard mortars. Minimum perimeter connections are acceptable as long as the wall is unreinforced.

Warning: Unreinforced masonry walls shall not be used in earthquake hazard areas. Consult local building officials for seismic safety requirements.

Other Regulatory Requirements

In addition to the NFIP regulatory requirements cited in this bulletin, State and local requirements, and the recommendations listed above, other regulatory requirements may apply, such as those listed in the following FEMA Technical Bulletins:

- *Flood-Resistant Material Requirements*, FIA-TB-2
- *Elevator Installation*, FIA-TB-4
- *Free-Of-Obstructions Requirements*, FIA-TB-5
- *Corrosion Protection for Metal Connectors in Coastal Areas*, FIA-TB-8

Flood Insurance Considerations

The presence of breakaway walls or other obstructions below an elevated building in the Coastal High Hazard Area (Zones V1-V30, VE, or V) significantly increases the cost of flood insurance. Generally, flood insurance rates increase as the size of the enclosure increases. Flood insurance policies place significant limits on the coverage of any enclosure and/or stored contents below the elevated building. Contact an insurance agent before installing breakaway walls or other obstructions.

The NFIP

The NFIP was created by Congress in 1968 to provide federally backed flood insurance coverage, because flood coverage was generally unavailable from private insurance companies. The NFIP is also intended to reduce future flood losses by identifying floodprone areas and ensuring that new development in these areas is adequately protected from flood damage. The NFIP is based on an agreement between the Federal government and participating communities that have been identified as floodprone. FEMA, through the Federal Insurance Administration (FIA), makes flood insurance available to the residents of a participating community, provided the community adopts and enforces adequate floodplain management regulations that meet the minimum NFIP requirements. The NFIP encourages communities to adopt floodplain management ordinances that exceed the minimum NFIP criteria. Included in the NFIP requirements, found under Title 44 of the U.S. Code of Federal Regulations, are minimum building design and construction standards for buildings located in Special Flood Hazard Areas. Through their floodplain management ordinances or laws, communities adopt the NFIP performance standards for new, substantially improved, and substantially damaged buildings in floodprone areas identified on FEMA's Flood Insurance Rate Maps.

Technical Bulletins

This publication is one of a series of Technical Bulletins that FEMA has produced to provide guidance concerning the building performance standards of the NFIP. These standards are contained in Title 44 of the U.S. Code of Federal Regulations at Section 60.3. The bulletins are intended for use primarily by State and local officials responsible for interpreting and enforcing NFIP regulations and by members of the development community, such as design professionals and builders. New bulletins, as well as updates of existing bulletins, are issued periodically, as

necessary. The bulletins do not create regulations; rather they provide specific guidance for conforming with the minimum requirements of existing NFIP regulations. Users of the Technical Bulletins who need additional guidance concerning NFIP regulatory requirements should contact the Mitigation Division of the appropriate FEMA regional office or the local floodplain administrator. The *User's Guide to Technical Bulletins* (FIA-TB-0) lists the bulletins issued to date, provides a key word/subject index for the entire series, and lists addresses and telephone numbers for FEMA's 10 regional offices.

Ordering Information

Copies of FEMA Technical Bulletins can be obtained from the FEMA regional office that serves your area. In addition, Technical Bulletins and other FEMA publications can be ordered from the FEMA Publications Service Center at 1-800-480-2520. The Technical Bulletins are also available at the FEMA web site at www.fema.gov.

Further Information

The following publications contain further information concerning breakaway walls:

Federal Emergency Management Agency. 2000. *Coastal Construction Manual – Principles and Practices of Planning, Siting, Designing, Constructing, and Maintaining Residential Buildings in Coastal Areas*. (Available spring 2000.)

Rogers, Spencer M. 1991. "Foundations and Breakaway Walls of Small Coastal Buildings in Hurricane Hugo." *Proceedings of Coastal Zone '91*. American Society of Civil Engineers. New York, NY.

Tung, C.C.; Bohumil Kasal; Spencer M. Rogers, Jr.; S.C. Yeh. 1999. *Behavior of Breakaway Wall Subjected to Wave Forces: Analytical and Experimental Studies*. North Carolina Sea Grant, North Carolina State University. Raleigh, NC.

Glossary

Base flood – The flood that has a 1-percent probability of being equaled or exceeded in any given year (also referred to as the 100-year flood).

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. These areas are identified as V zones.

Federal Emergency Management Agency (FEMA) – The independent Federal agency that, in addition to carrying out other activities, administers the NFIP.

Federal Insurance Administration (FIA) – The component of FEMA directly responsible for administering the flood insurance aspects of the NFIP.

Flood Insurance Rate Map (FIRM) – The insurance and floodplain management map issued by FEMA that identifies, on the basis of detailed or approximate analysis, areas of 100-year flood hazard in a community.

Floodprone area – Any land area susceptible to being inundated by flood water from any source.

Mitigation Directorate – The component of FEMA directly responsible for administering the flood hazard identification and floodplain management aspects of the NFIP.

New construction/structure – For floodplain management purposes, new construction means structures for which the start of construction commences on or after the effective date of a floodplain management regulation adopted by a community and includes subsequent improvements to the structure. These structures are often referred to as “post-FIRM” structures.

Special Flood Hazard Area (SFHA) – Area subject to inundation by the base flood, designated Zone A, A1-30, AE, AH, AO, V, V1-V30, or VE.

Substantial damage – At minimum, damage of any origin sustained by a structure whereby the cost of restoring the structure to its before-damaged condition would equal or exceed 50 percent of the market value of the structure before the damage occurred. More stringent local requirements may apply.

Substantial improvement – At a minimum, any reconstruction, rehabilitation, addition, or other improvement of a structure, the cost of which equals or exceeds 50 percent of the market value of the structure before the “start of construction” of the improvement. This term includes structures that have incurred “substantial damage,” regardless of the actual repair work performed. More stringent local requirements may apply.