Crawl Space Construction in Special Flood Hazard Areas

By:

D. Allen Hughes, PE

PDHLibrary Course No 000102
2 PDH HOURS

Technical Bulletin

Crawlspace Construction

for Buildings Located in Special Flood Hazard Areas National Flood Insurance Program Interim Guidance

FEMA TB-11 / November 2001

FEMA

Key Word/Subject Index

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

Any comments on the Technical Bulletins should be directed to:

Federal Emergency Management Agency
Federal Insurance and Mitigation Administration
500 C Street, SW.
Washington, DC 20472

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

TECHNICAL BULLETIN 11-01

Crawlspace Construction for Buildings Located in Special Flood Hazard Areas National Flood Insurance Program Interim Guidance

Introduction

Crawlspace foundations are commonly used to elevate the lowest floors of residential buildings located in Special Flood Hazard Areas (SFHAs) above the Base Flood Elevation (BFE). This Technical Bulletin provides guidance on crawlspace construction and supports a recent policy decision to allow construction of crawlspaces with interior grades up to 2 feet below the lowest adjacent exterior grade (LAG), referred to as below-grade crawlspaces, provided that other requirements are met. Prior to that decision, below-grade crawlspaces were considered basements under the National Flood Insurance Program (NFIP) Floodplain Management Regulation definitions at 44 CFR 59.1 and were not permitted below the BFE. This requirement had been established because below-grade crawlspace foundation walls are exposed to increased forces during flood conditions, such as hydrostatic and saturated soil forces.

In many parts of the country, a common practice is to construct crawlspaces with the interior floor 1 or 2 feet below-grade by either (1) backfilling against the exterior of the foundation wall or (2) excavating the crawlspace area to construct footings that result in a below-grade crawlspace floor. Because FEMA wishes to recognize common construction practices that do not increase flood damage, FEMA recently completed a review of the policy for residential crawlspace construction. In this review, the construction practices for below-grade crawlspaces were examined to determine whether a crawlspace that was 1 or 2 feet below grade would increase the flood damage potential to the foundation walls or result in additional damages to the building.

The review included (1) an engineering analysis that assessed the damage potential of floodwaters acting upon below-grade crawlspace foundation walls, (2) a review of available NFIP claims history for crawlspaces, and (3) input from FEMA Regional staff and NFIP General Adjusters of any firsthand knowledge of crawlspace damage during flood events. A review of NFIP claims history and staff input did not reveal evidence of structural damage or failure of crawlspace foundation walls during flood events. The engineering analysis indicates that below-grade foundation walls, when constructed according to common practice, have sufficient capacity to resist flood-related forces from standing and low-velocity floodwaters, subject to the requirements outlined in this bulletin.

This Technical Bulletin presents NFIP minimum requirements for crawlspace construction in the SFHA, including (1) requirements for all crawlspace construction and (2) requirements for below-grade crawlspace construction that may extend 1 or 2 feet below grade in the SFHA. This Technical Bulletin also provides a best practices approach for preferred and below-grade crawlspace construction, illustrated in Figures 1 and 2, including design limitations, water accumulation and drainage considerations, and use of flood-resistant materials. While communities may now allow below-grade crawlspace construction in the SFHA, this type of construction is not the recommended construction method, because of the increased likelihood of problems with water accumulation,

moisture damage, and drainage. The use of crawlspace construction with the interior grade at or above the LAG minimizes the occurrence of these problems. This interim guidance on residential crawlspace construction is based on conclusions from the recently completed review and analyses.

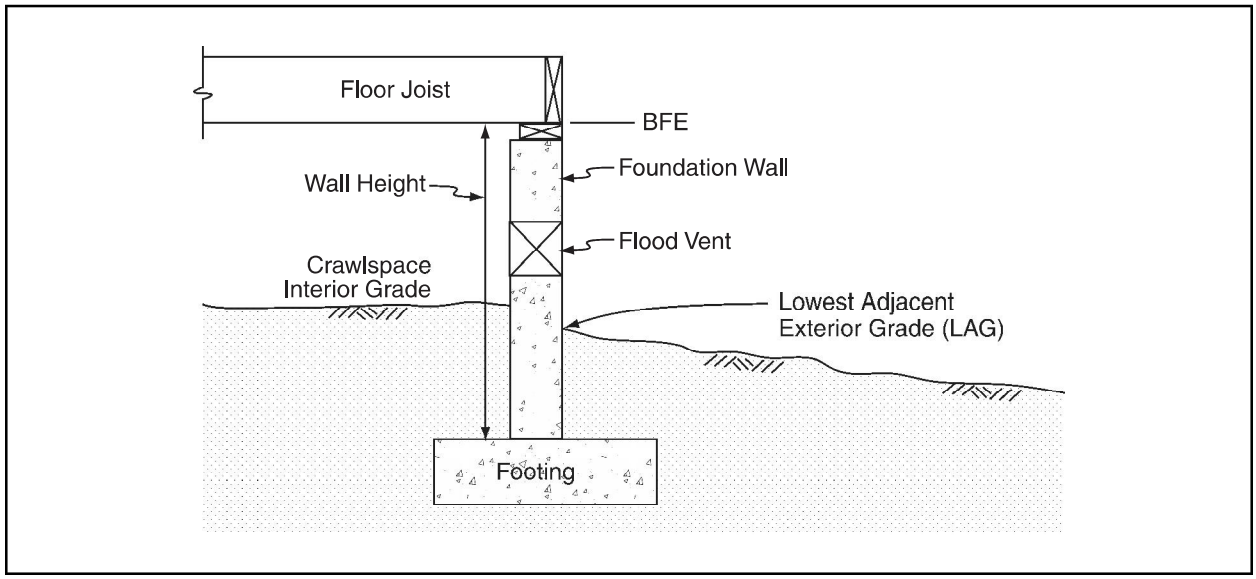

Figure 1 Preferred crawlspace construction.

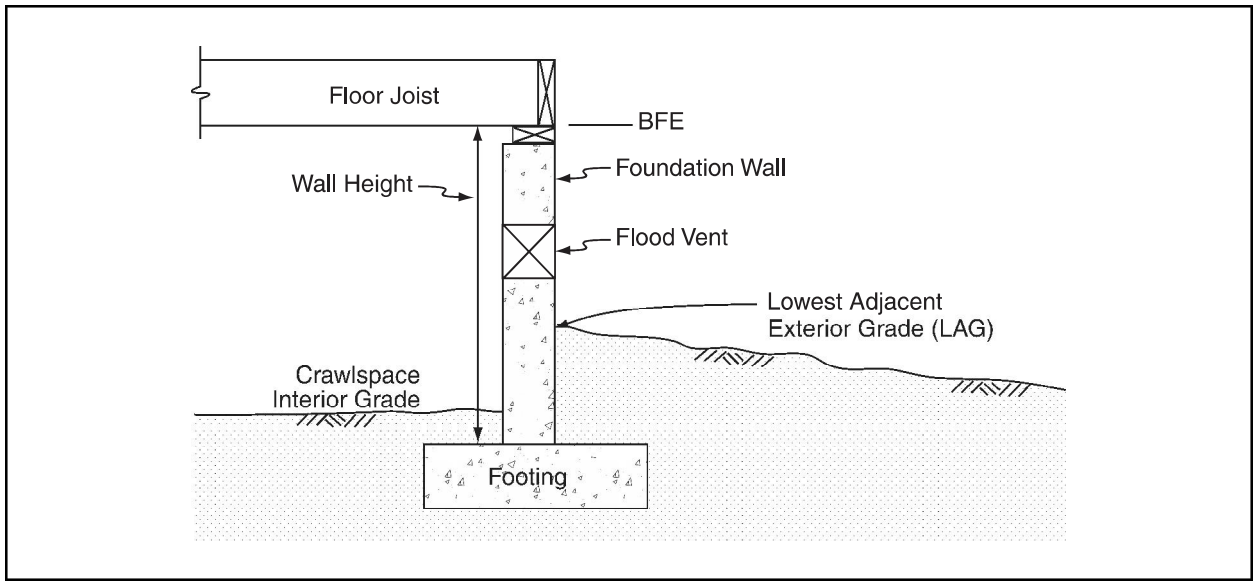

Figure 2 Below-grade crawlspace construction.

This Technical Bulletin provides **interim** guidance. The decision whether or not to allow below-grade crawlspace construction will be left to each community. Communities should review applicable state laws, regulations, and building codes, and consult with their State NFIP Coordinator to determine whether below-grade crawlspace construction is permitted in their state. Communities that choose to allow below-grade crawlspace construction will be required to amend their floodplain management ordinance to include the provisions outlined in the following sections on below-grade crawlspace construction. Please note that communities that choose to amend their ordinance to allow for below-grade crawlspaces in response to this interim guidance may also be required at some later date to amend their ordinance if FEMA adopts revised regulations that differ from the interim guidance.

Note

Any building utility systems within the crawlspace must be elevated above the BFE or designed so that floodwaters cannot enter or accumulate within system components during flood conditions. Ductwork, in particular, must either be placed above the BFE or sealed to prevent the entry of floodwaters. FEMA 348, *Protecting Building Utilities from Flood Damage*, provides detailed guidance on designing and constructing flood-resistant utility systems.

NFIP Requirements

NFIP requirements that apply to crawlspace construction are found in sections 44 CFR 60.3(a)(3) and 60.3(c)(2) and (c)(5) of the NFIP regulations. NFIP requirements that apply to all crawlspaces are discussed in the first section below. The second section lists additional requirements that must be applied to crawlspaces that have interior grades below the LAG. The additional requirements are intended to ensure that these crawlspaces are not subject to flood-related loads that would exceed the strength of the crawlspace wall and lead to failure and significant damage to the building or to other damage related to poor drainage in the below-grade crawlspace.

NFIP Requirements for All Crawlspace Construction

Crawlspaces are commonly used as a method of elevating buildings in SFHAs to or above the BFE. General NFIP requirements that apply to all crawlspaces that have enclosed areas or floors below the BFE include the following:

- The building must be designed and adequately anchored to resist flotation, collapse, and lateral movement of the structure resulting from hydrodynamic and hydrostatic loads, including the effects of buoyancy. Hydrostatic loads and the effects of buoyancy can usually be addressed though the required openings discussed in the next bullet. Because of hydrodynamic loads, crawlspace construction is not recommended in areas with flood velocities greater than 5 feet per second unless the design is reviewed by a qualified design professional, such as a registered architect or professional engineer. Other types of foundations are recommended for these areas.
- The crawlspace is an enclosed area below the BFE and, as such, must have openings that equalize hydrostatic pressures by allowing for the automatic entry and exit of floodwaters. The bottom of each flood vent opening can be no more than 1 foot above the lowest adjacent exterior grade. For guidance on flood openings, see Technical Bulletin 1-93, *Openings in Foundation Walls*.

- Crawlspace construction is not permitted in V zones. Open pile or column foundations that withstand storm surge and wave forces are required in V zones.
- Portions of the building below the BFE must be constructed with materials resistant to flood damage. This includes not only the foundation walls of the crawlspace used to elevate the building, but also any joists, insulation, or other materials that extend below the BFE. The recommended construction practice is to elevate the bottom of joists and all insulation above BFE. Insulation is not a flood-resistant material. When insulation becomes saturated with floodwater, the additional weight often pulls it away from the joists and flooring. Ductwork or other utility systems located below the insulation may also pull away from their supports. See the section Flood-Resistant Materials, on page 8 this bulletin. For more detailed guidance on flood-resistant materials see Technical Bulletin 2-93, *Flood-Resistant Materials Requirements*.
- Any building utility systems within the crawlspace must be elevated above BFE or designed so that floodwaters cannot enter or accumulate within the system components during flood conditions. Ductwork, in particular, must either be placed above the BFE or sealed from floodwaters. For further guidance on the placement of building utility systems in crawlspaces, see FEMA 348, *Protecting Building Utilities From Flood Damage.*

Flood-resistant materials and utilities, access, and ventilation openings in crawlspaces are further addressed in this bulletin.

Additional Requirements for Below-Grade Crawlspaces

If a community chooses to amend its floodplain management ordinance to allow for the construction of below-grade crawlspaces, the ordinance must include the following provisions in addition to the above requirements:

- The interior grade of a crawlspace below the BFE must not be more than 2 feet below the lowest adjacent exterior grade (LAG), shown as D in Figure 3.
- The height of the below-grade crawlspace, measured from the interior grade of the crawlspace to the top of the crawlspace foundation wall must not exceed 4 feet (shown as L in Figure 3) at any point. The height limitation is the maximum allowable unsupported wall height according to the engineering analyses and building code requirements for flood hazard areas (see the section Guidance for Pre-Engineered Crawlspaces, on page 7 of this bulletin). This limitation will also prevent these crawlspaces from being converted into habitable spaces.
- There must be an adequate drainage system that removes floodwaters from the interior area of the crawlspace. The enclosed area should be drained within a reasonable time after a flood event. The type of drainage system will vary because of the site gradient and other drainage characteristics, such as soil types. Possible options include natural drainage through porous, well-drained soils and drainage systems such as perforated pipes, drainage tiles, or gravel or crushed stone drainage by gravity or mechanical means.
- The velocity of floodwaters at the site should not exceed 5 feet per second for any crawlspace. For velocities in excess of 5 feet per second, other foundation types should be used.

- Below-grade crawlspace construction in accordance with the requirements listed above will not be considered basements.

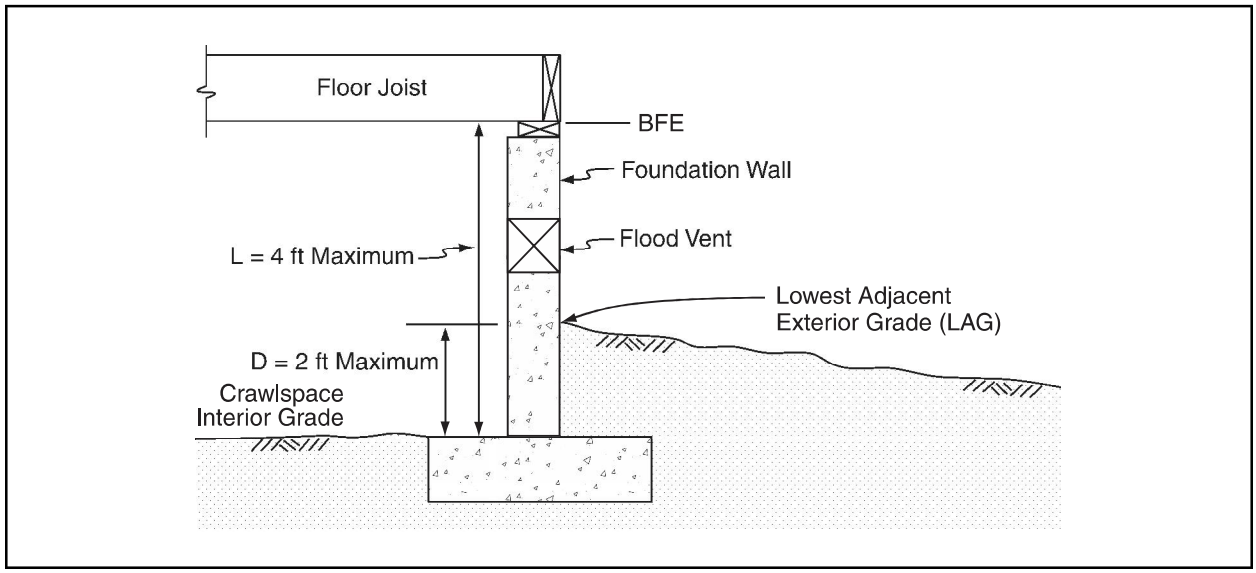

Figure 3 Requirements regarding below-grade crawlspace construction.

Drainage considerations for below-grade crawlspaces are further addressed in this bulletin. For additional information regarding this interim guidance, please contact the FEMA Regional Office or State NFIP Coordinator. Local FEMA regional offices are listed in the separately printed *User's Guide to Technical Bulletins* and may be found at the www.fema.gov website.

Flood Forces on Buildings

Buildings in flood hazard areas may be subjected to a variety of flood-induced forces. During inundation by standing or low-velocity floodwaters, a building must primarily resist hydrostatic pressures from saturated soils and floodwaters. This situation is typical of broad, flat floodplains and floodways along lower-gradient rivers and streams. During inundation by high-velocity floodwaters, a building must also resist hydrodynamic forces and impact loads. High-velocity floodwaters are found in floodways along steeper-gradient rivers, sheet flow down slopes, or coastal areas with storm surge and waves.

The community Flood Insurance Study contains a Floodway Data Table that includes data on mean velocities (in feet per second) within the floodway at each cross section along the river or stream. The mean averages the higher channel velocities with lower velocities in overbank areas that are within the floodway. Generally, velocities at sites outside of the floodway are lower than the mean floodway velocities listed in the Floodway Data Table. For example, if the mean floodway velocity at a cross section is 4 feet per second, the velocities outside the floodway are likely less than that value. If in doubt about the floodway velocity or in areas where the mean floodway velocity may exceed 5 feet per second, contact an engineer knowledgeable in hydraulics and hydrology to determine flood velocities at the building site.

Buildings located in areas subject to ponding or low-velocity flows must primarily address issues related to hydrostatic loads on the crawlspace foundation, removal of floodwater and sediment from the crawlspace area, and other NFIP floodproofing requirements, such as protecting or elevating utilities and using flood-resistant materials.

Crawlspace construction is not recommended in A zones with high-velocity floodwaters (greater than 5 feet per second). Other types of foundations, such as open pile or column foundations, that allow floodwaters to flow freely beneath the building are recommended for these areas.

Flood Insurance Implications

In May 1999, the Federal Insurance Administration (now the Federal Insurance and Mitigation Administration – FIMA) revised the rates being charged for residential buildings with below-grade crawlspaces. These rates were considerably lower than the full basement rates previously charged for these buildings. In May 2001, these rates were further reduced based on engineering analyses performed by FEMA. However, rates for buildings with below-grade crawlspaces will be higher than rates for buildings that have the interior grade of the crawlspace at or above the adjacent exterior grade, since the risk of flood damage is greater for the former type of construction. As more experience is gained on crawlspace losses, FEMA will continue to reassess those rates, factoring in the cost of pumping out and cleaning these areas, as well as physical damage to the foundation. Buildings with below-grade crawlspaces currently cannot be rated by an insurance agent using the NFIP *Flood Insurance Manual*. They must be submitted for a special rating under the Submit-to-Rate process by underwriters knowledgeable in this type of construction. FIMA will determine whether the rating for this type of construction should be standardized and included in the Flood Insurance Application and the *Flood Insurance Manual*.

Caution

Buildings that have below-grade crawlspaces will have higher flood insurance premiums than buildings that have the preferred crawlspace construction, with the interior elevation at or above the lowest adjacent exterior grade (LAG).

Best Practices for Crawlspace Foundations in SFHA

The NFIP preferred construction practice for excavated crawlspace construction is to backfill the interior area so that it is level with or higher than the LAG. If trench construction is used to place footings, the trenches should be backfilled to the level of the adjacent exterior grade, to avoid ponding of water. A reinforced masonry or concrete foundation wall that is anchored to the footing and lowest floor with connectors will provide the best performance in flood events. This type of construction will better resist hydrostatic pressures against the foundation and limit the amount of water that will pond under the building after a flood.

The 2000 *International Residential Code* (IRC 2000), Section 327, addresses flood-resistant design and construction of foundation walls in flood hazard areas and is consistent with NFIP requirements. The IRC requires that all structural systems in floodplains be designed, connected, and anchored to resist flotation, collapse, or permanent lateral movement due to structural loads from flooding equal to the design flood elevation. The IRC limits the unsupported height of plain (unreinforced) 8-inch hollow masonry walls to 4 feet for flood-resistant construction, where the unsupported height is the distance from the finished grade of the enclosed crawlspace area to the top of the foundation wall.

A community that chooses to allow the construction of below-grade crawlspaces should develop a multi-hazard approach that also resists other loads from hazards such as wind and earthquake. Crawlspace foundation walls must bear or resist all loads that may be experienced during their useful service life.

Guidance for Pre-Engineered Below-Grade Crawlspace Foundations

FEMA performed an engineering analysis to determine the effect of flood-related forces on crawlspace foundation walls (see Figure 4), particularly for unreinforced concrete and concrete masonry construction. The analysis followed design criteria prescribed in the American Concrete Institute (ACI) *Building Code Requirements and Commentary for Reinforced Concrete* (ACI 318-92) and the 1999 Masonry Standards Joint Committee (MSJC) *Building Code Requirements and Specifications*. Flood analysis procedures from FEMA 259, *Engineering Principles and Practices of Retrofitting Flood-Prone Residential Structures,* were used for calculating hydrostatic and hydrodynamic forces. A comprehensive analysis of two flood scenarios was conducted:

- Fully saturated soil and 1-foot-deep floodwaters, that just reach the bottom of the flood opening, but have not flooded the enclosed crawlspace area.
- A fully flooded crawlspace area with velocity floodwaters acting on the above-grade portion of the crawlspace walls.

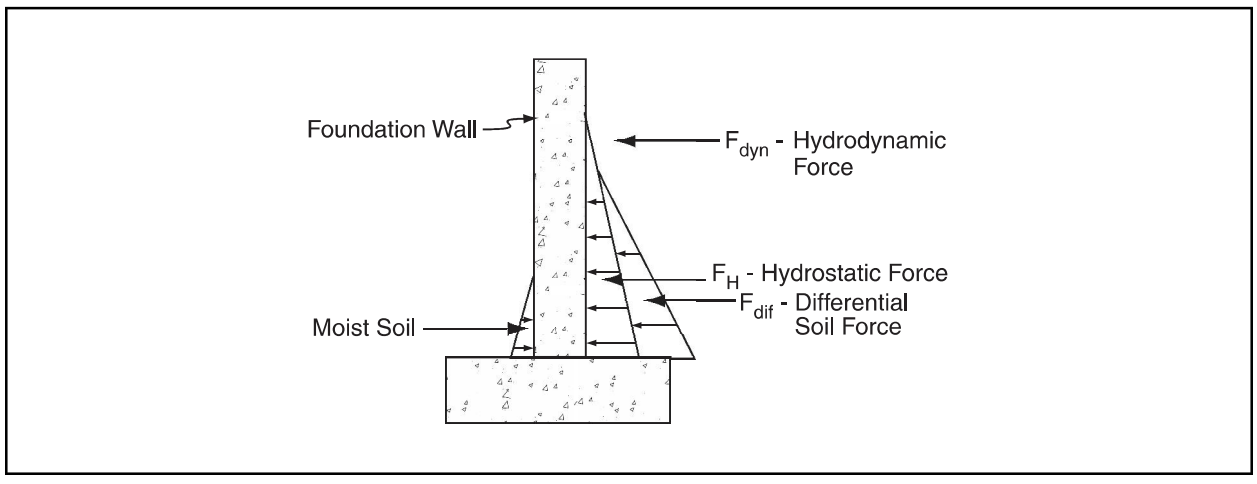

Figure 4 Flood-related forces on a crawlspace wall.

The first analysis evaluated four parameters: (1) wall construction of unreinforced 8-inch and 12-inch masonry block with standard M or S mortar type and 6-inch plain concrete foundation walls, (2) depth of interior crawlspace grade relative to the LAG, (3) flood velocity, and (4) soil types suitable for construction. The hydrostatic pressures from the saturated soil and 1-foot-deep floodwaters cause the maximum loads to occur in the lower section of the wall below the exterior grade. This analysis assumed that the 1-foot-deep floodwaters have a low velocity and are unlikely to cause significant hydrodynamic or impact loads on the foundation wall.

The second analysis evaluated hydrodynamic forces for varied flood depths and flood velocities on a foundation wall. The analysis assumed that the crawlspace was provided with proper openings to equalize hydrostatic pressure. Impact forces were not included in the analysis, as the shallow flood depths and low-velocity flows are not expected to produce significant debris impact damage. This decision was further supported by the lack of field evidence concerning wall failures from impact by debris. However, debris impact should be considered as part of the foundation wall design and analysis for riverine or other locations with high-velocity flows.

These analyses found that a crawlspace can resist flood-related forces for flood velocities up to 5 feet per second, if the wall height is limited to 4 feet and the top of the footing is no more than 2 feet below-grade.

As a result of these analyses, FEMA has determined that communities may allow below-grade residential crawlspace construction provided that the interior grade of the crawlspace does not exceed 2 feet below the LAG, and the height of the crawlspace measured from the interior grade of the crawlspace at any point to the bottom of the lowest horizontal structural member of the lowest floor does not exceed 4 feet for the specified wall construction.

Flood-Resistant Materials

All structural and non-structural building materials at or below the BFE must be flood resistant. A flood-resistant material is defined as any building material capable of withstanding direct and prolonged contact with floodwaters without sustaining significant damage. Flood-resistant materials must be used for all building elements subject to exposure to floodwaters, including floor joists, insulation, and ductwork. If flood-resistant materials are not used for building elements, those elements must be elevated above the BFE. The term "prolonged contact" means at least 72 hours, and the term "significant damage" means any damage requiring more than low-cost cosmetic repair (such as painting). This requirement applies regardless of the expected or historical flood duration. Technical Bulletin 2-93, *Flood Resistant Materials Requirements*, further defines NFIP criteria for flood-resistant materials and material categories.

Drainage Considerations

A significant issue associated with below-grade crawlspaces is drainage of the interior crawlspace area after normal precipitation and flood events. Moisture damage to a building can be severe when water remains standing in the crawlspace area after precipitation or a flood event. Standing water also creates significant health hazards, such as mosquito breeding grounds and growth of bacteria, mold, and fungus. If crawlspace access doors do not remain secured, standing water also presents a drowning hazard.

The interim guidance for below-grade crawlspace construction requires an adequate drainage system that allows floodwaters to drain from the interior area of the crawlspace within a reasonable time. A maximum time of 72 hours is recommended to minimize floodwater contact with crawlspace materials and related moisture damage. The interim guidance is not prescriptive as to a type of drainage system; however, it is the community's responsibility to ensure that all buildings with below-grade crawlspaces have adequate drainage systems to ensure that accumulated waters drain from the crawlspace area. Communities must include in their ordinances a provision that addresses drainage requirements.

Drainage systems for below-grade crawlspace areas will vary because of site characteristics and soil types. Possible drainage system options include perforated pipes, drainage tiles, or gravel or crushed stone drainage by gravity or mechanical means. Fill dirt placed around the outside of the foundation wall should be adequately graded to slope away from the foundation and aid natural site drainage. If lots are too small to provide adequate site drainage through grading, other methods, such as swales, may be used to provide drainage away from the structure. Foundation drainage practices required by local codes must be met in addition to drainage of the enclosed below-grade crawlspace area.

Any enclosed area below the BFE is subject to flood forces and must have exterior wall openings whose bottom edges are no more than 1-foot above the LAG, in accordance with NFIP regulations. The wall openings allow the automatic entry and exit of floodwaters and for the floodwaters to reach equal levels on both sides of the foundation wall. The only exception to this requirement is dry floodproofed non-residential buildings. Further information on NFIP requirements for flood openings in foundation walls is found in Technical Bulletin 1-93, *Openings in Foundation Walls*.

Utilities, Access, and Ventilation Openings

NFIP regulations at 44 CFR, Section 60.3(a)(3)(iv) require that "utility systems shall be constructed with electrical, heating, ventilation, plumbing, and air conditioning equipment and other service facilities that are designed and/or located to prevent water from entering or accumulating within the components during conditions of flooding." The utility systems can be either elevated above the BFE or floodproofed in a manner that prevents floodwaters from infiltrating or accumulating within any component of the system. Elevation is the recommended method of mitigation for utility systems in A Zones. FEMA 348, *Protecting Building Utilities from Flood Damage*, provides detailed guidance on designing and constructing flood-resistant utility systems.

Access and ventilation openings shall be provided to the crawlspace area according to the local building codes and regulations. Access and ventilation requirements under the IRC 2000 include the following:

- An access opening 18 inches by 24 inches shall be provided to the enclosed crawlspace area to allow access to mechanical equipment or building utilities located in this space.
- The minimum net area of required ventilation openings shall not be less than 1 square foot for each 150 square feet of enclosed crawlspace area. One such ventilation opening shall be within 3 feet of each corner of the building. Ventilation openings shall be covered with an appropriate material.

The NFIP

The NFIP was created by Congress in 1968 to provide federally backed flood insurance coverage, because flood coverage was generally unavailable from private insurance companies. The NFIP is also intended to reduce future flood losses by identifying floodprone areas and ensuring that new development in these areas is adequately protected from flood damage. The NFIP is based on an agreement between the Federal government and participating communities that have been identified as floodprone. FEMA, through the Federal Insurance and Mitigation Administration, makes flood insurance available to the residents of a participating community, provided the community adopts and enforces adequate floodplain management regulations that meet the minimum NFIP requirements. The NFIP encourages communities to adopt floodplain management ordinances that exceed the minimum NFIP criteria set forth in Part 60 of the NFIP Floodplain Management Regulations (44 CFR 60). Included in the NFIP requirements, found under Title 44 of the U.S. Code of Federal Regulations, are minimum building design and construction standards for buildings located in SFHAs. Through their floodplain management ordinances or laws, communities adopt the NFIP performance standards for new, substantially improved, and substantially damaged buildings in floodprone areas identified on FEMA's Flood Insurance Rate Maps (FIRMs).

Technical Bulletins

This publication is one of a series of Technical Bulletins that FEMA has produced to provide guidance concerning the building performance standards of the NFIP. These standards are contained in 44 CFR 60.3. The bulletins are intended for use primarily by state and local officials responsible for interpreting and enforcing NFIP regulations and by members of the development community, such as design professionals and builders. New bulletins, as well as updates of existing bulletins, are issued periodically, as necessary. The bulletins do not create regulations; rather they provide specific guidance for conforming with the minimum requirements of existing NFIP regulations. Users of the Technical Bulletins who need additional guidance concerning NFIP regulatory requirements should contact the Mitigation Division of the appropriate FEMA Regional Office or the local floodplain administrator. NFIP Technical Bulletin 0, *User's Guide to Technical Bulletins,* lists the bulletins issued to date, provides a key word/subject index for the entire series, and lists addresses and telephone numbers for FEMA's 10 Regional Offices.

Ordering Information

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

Further Information

The following publications contain information related to the guidance presented in this bulletin:

American Concrete Institute. 1992. ACI318-92. *Building Code Requirements and Commentary for Reinforced Concrete*. Detroit, MI.

American Society of Civil Engineers. 1998. SEI/ASCE 7-98. *Minimum Design Loads for Buildings and Other Structures*. Reston, VA.

American Society of Civil Engineers. 1998. SEI/ASCE 24-98. *Flood Resistant Design and Construction*. Reston, VA.

Federal Emergency Management Agency. 1986. *Floodproofing Non-Residential Structures*. FEMA 102. Washington, DC.

Federal Emergency Management Agency. 1999. *Protecting Building Utility Systems From Flood Damage*. FEMA 348. Washington, DC.

Federal Emergency Management Agency. 2001. *Engineering Principles and Practices for Retrofitting Flood-Prone Residential Structures*. FEMA 259. Washington, DC.

International Code Council. 2000. *International Building Code*. Birmingham, AL.

International Code Council. 2000. *International Residential Code*. Birmingham, AL.

Masonry Standards Joint Committee. 1999. ACI 530-99/ASCE 5-99/TMS 402-99. *Building Code Requirements for Masonry Structures*.

National Association of Home Builders Research Foundation, Inc. 1977. *Manual for the Construction of Residential Basements in Non-Coastal Flood Environs*. Upper Marlboro, MD. March.

National Association of Home Builders Research Center, Inc. 2000. *Residential Structural Design Guide: 2000 Edition*. Upper Marlboro, MD.

National Concrete Masonry Association. 2000. TR121. *Concrete Masonry Design Tables*. Herndon, VA.

Glossary

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

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

Community – Any state or area or political subdivision thereof, or any Indian tribe or authorized tribal organization, or Alaska Native village or authorized native organization, which has the authority to adopt and enforce floodplain management regulations for the areas within its jurisdiction.

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

Federal Insurance and Mitigation Administration (FIMA) – The component of FEMA directly responsible for administering the flood hazard identification, floodplain management, and flood insurance activities of the NFIP.

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

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

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

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

A Guide to Crawl Space Construction in Special Flood Hazard Areas

1. _____ foundations are commonly used to elevate the lowest floors of residential buildings located in Special Flood Hazard Areas (SFHA's) above the Base Flood Elevation (BFE).

a. Passage
b. Underpass
c. Crawlspace
d. Shaft

2. While communities may now allow below-grade crawlspace construction in the SFHA, this is not the recommended construction method, because of the increased likelihood of problems.

a. True
b. False

3. The building must be designed and adequately anchored to resist which of the following resulting from hydrodynamic and hydrostatic loads.

a. Flotation
b. Collapse
c. Lateral movement of the structure
d. All of the above

4. The maximum design velocity of floodwaters at the site should not exceed __ feet per second for any crawlspace.

a. 3
b. 4
c. 5
d. 6

5. Crawlspace construction is not recommended in __ zones with high-velocity floodwaters (greater than 5 feet per second).

a. V
b. Z
c. A
d. L

6. Which of the following will provide the best performance in flood events?

a. A reinforced masonry or concrete foundation wall that is anchored to the footing and lowest floor with connectors
b. An open crawlspace
c. An underground house
d. None of the above

7. Rates for buildings with below-grade crawlspaces will be lower than rates for buildings that have the interior grade of the crawlspace at or above the adjacent exterior grade, since the risk of flood damage is greater for the former type of construction.

a. True
b. False

8. A _____ material is defined as any building material capable of withstanding direct and prolonged contact with floodwaters without sustaining significant damage.

a. Flood-retardant
b. Flood-resistant
c. Flood-proof
d. Flood-free

9. An access opening __ inches by __ inches shall be provided to the enclosed crawlspace area to allow access to mechanical equipment or building utilities located in this space.

a. 18, 24
b. 12, 18
c. 24, 30
d. 24, 24

10. The minimum net area of required ventilation openings shall not be less than 1 square foot for each 175 square feet of enclosed crawlspace area.

a. True
b. False