Requirements for Dry Floodproofed Below-Grade Parking Areas Under Non-Residential and Mixed-Use Buildings

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

NFIP Technical Bulletin 6 / January 2021

FEMA

Comments on the Technical Bulletins should be directed to:

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Acronyms

ASCE	American Society of Civil Engineers
BFE	base flood elevation
CFR	Code of Federal Regulations
DFE	design flood elevation
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
IBC®	International Building Code®
ICC®	International Code Council®
I-Codes®	International Codes®
IRC®	International Residential Code®
LiMWA	Limit of Moderate Wave Action
NFIP	National Flood Insurance Program
SFHA	Special Flood Hazard Area

1 Introduction

This Technical Bulletin provides guidance on the National Flood Insurance Program (NFIP) floodplain management requirements for the design and certification of dry floodproofed below-grade parking areas. This guidance applies to new and substantially improved non-residential buildings and mixed-use buildings in Special Flood Hazard Areas (SFHAs) identified as Zone A (A, AE, A1-30, AH, and AO) on Flood Insurance Rate Maps (FIRMs).

Below-grade areas, including areas used for parking, are not permitted under residential buildings in SFHAs identified as Zone A. In addition, below-grade areas are not permitted under any building in SFHAs identified as Zone V (V, VE, V1-30, and VO), and dry floodproofing is not permitted for any buildings in coastal high hazard areas identified on FIRMs as Zone V.

NFIP TECHNICAL BULLETIN 0

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

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

Many large, fully engineered, non-residential and mixed-use buildings are designed with below-grade parking areas. These areas are used for parking of vehicles, access to the above-grade floors, and equipment and machinery servicing the buildings. Buildings in SFHAs designed with dry floodproofed below-grade parking areas may sustain significant structural damage if floodwater rises higher than anticipated in the designs. Such flooding may also damage parked vehicles, stored contents, and service equipment and machinery.

This Technical Bulletin highlights issues specific to dry floodproofing below-grade parking areas. It does not provide detailed guidance on the planning and design of dry floodproofing systems. Extensive guidance is available in FEMA P-936, *Floodproofing Non-Residential Buildings* (2013), and NFIP Technical Bulletin 3, *Requirements for the Design and Certification of Dry Floodproofed Non-Residential and Mixed-Use Buildings*.

ASCE 24: STANDARD OF PRACTICE FOR DRY FLOODPROOFING DESIGN

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

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

When a building owner proposes dry floodproofing measures for a non-residential building that is in an NFIP-participating community, the owner must provide certification that the structural designs, specifications, and plans for the construction of the dry floodproofing measures were developed and/or reviewed by registered professional engineers

or architects (design professionals). The certification must state that the proposed dry floodproofing design and proposed methods of construction are in accordance with accepted standards of practice for achieving the required performance. Design professionals who sign and seal certifications must be licensed to practice in the state where projects are located.

Technical Bulletin 3 describes FEMA Form 086-0-34, NFIP Floodproofing Certificate for Non-Residential Structures, and includes instructions on completing the certificate. FEMA developed the Floodproofing Certificate to provide the information that insurance underwriters require to rate dry floodproofed buildings. The certificate identifies ASCE 24-14 and ASCE 24-05 (or equivalent) as the accepted standard of practice.

Parking areas that are at grade or above grade (i.e., not below grade on all sides) are permitted under elevated buildings provided all other NFIP requirements are met. At-grade and above-grade parking areas are not addressed in this Technical Bulletin.

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

TERMS USED IN THIS TECHNICAL BULLETIN

- **Ancillary area:** Common area such as a lobby, foyer, office used by building management, exercise space, meeting room, and mail room (FEMA P-2037, *Flood Mitigation Measures for Multi-Family Buildings* [2019]).
- **Basement:** "Any area of the building having its floor subgrade (below ground level) on all sides" (Title 44 Code of Federal Regulations [CFR] § 59.1). The NFIP regulations do not allow basements to extend below the base flood elevation (BFE) except in dry floodproofed non-residential buildings.
- **Dry floodproofing:** Combination of measures that makes a building and attendant utilities and equipment watertight and substantially impermeable to floodwater, with structural components having the capacity to resist flood loads.
- **Flood protection level:** Elevation to which flood protection measures are designed. The flood protection level is the most restrictive of (1) the BFE plus the prescribed amount of freeboard specified in ASCE 24, (2) the design flood elevation (DFE) if a different flood is used for regulatory purposes, and (3) the elevation relative to the BFE specified in local floodplain management regulations.
- **Floodproofing:** "Any combination of structural and non-structural additions, changes, or adjustments to structures which reduce or eliminate flood damage to real estate or improved real property, water and sanitary facilities, structures and their contents" (44 CFR § 59.1).
- **Mixed-use building:** Building that has both residential and commercial or other non-residential uses. The term does not include multi-family residential buildings that have ancillary areas but no non-residential uses.

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TERMS USED IN THIS TECHNICAL BULLETIN (continued)

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

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

2 National Flood Insurance Program Regulations

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

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

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

The NFIP regulations for non-residential buildings in SFHAs, including requirements when those buildings are elevated or dry floodproofed, are codified in Title 44 Code of Federal Regulations (CFR) Part 60, Criteria for Land Management and Use. The subsections below provide excerpts of the regulations that are applicable to dry floodproofed below-grade parking areas under non-residential and mixed-use buildings in SFHAs identified as Zone A.

For floodplain management purposes, a basement is "any area of the building having its floor subgrade (below ground level) on all sides" (44 CFR § 59.1). Therefore, parking areas that are below grade on all sides are subject to the requirements for basements that are cited in the excerpts.

NFIP REQUIREMENTS AND HIGHER REGULATORY STANDARDS

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

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

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

2.1 Dry Floodproofed Below-Grade Parking Areas: Permitted Under Non-Residential Buildings in Zone A

Parking areas that are below grade on all sides are permitted under non-residential buildings and mixed-use buildings in any Zone A provided that the buildings (including parking areas) are dry floodproofed to or above the BFE in accordance with the design requirements in 44 CFR Section 60.3(c)(3)(ii) and the structural designs, specifications, and plans are certified.

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

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

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

> Require within any AO zone on the community's FIRM that all new construction and substantial improvements of nonresidential structures (i) have the lowest floor (including

basement) elevated above the highest adjacent grade at least as high as the depth number specified in feet on the community's FIRM (at least two feet if no depth number is specified), or (ii) together with attendant utility and sanitary facilities be completely floodproofed to that level to meet the floodproofing standard specified in [44 CFR] § 60.3(c)(3)(ii).

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

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

2.2 Dry Floodproofed Below-Grade Parking Areas: Permitted Under Mixed-Use Buildings in Zone A

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

FEMA considers buildings with both non-residential and residential uses to be mixed-use buildings. Fully engineered mixed-use buildings may be designed with below-grade parking areas. The non-residential portions of mixed-use buildings are allowed to be dry floodproofed provided that all residential units, the building systems and service equipment that serve residential units, and the ancillary areas for use by residents are elevated above the required elevation. See FEMA P-2037 for more information.

In keeping with the requirements for enclosures below elevated residential buildings, lobbies that provide access to both residential and non-residential portions of mixed-use buildings are allowed to be dry floodproofed, provided there also is separate access to the residential spaces that, if enclosed by walls, complies with the requirements for enclosures below elevated buildings (sometimes called wet floodproofing).

2.3 Dry Floodproofed Below-Grade Parking Areas: Not Permitted Under Residential Buildings in Zone A

A defining characteristic of the NFIP regulations applicable in any Zone A is the requirement for the lowest floor of residential buildings to be elevated to or above the BFE. Any area that is below grade on all sides is a basement, and basements are not permitted under residential buildings. The regulations do not include provisions to allow residential buildings to be dry floodproofed. Areas under elevated

residential buildings may be enclosed and used solely for parking of vehicles, building access, or storage, provided the enclosures comply with the relevant requirements.

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

> Require that all new construction and substantial improvements of residential structures within Zones A1-30, AE and AH zones on the community's FIRM have the lowest floor (including basement) elevated to or above the base flood level …

Section 60.3(c)(7) of the NFIP regulations states that a community shall:

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

3 Building Codes and Standards

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

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

HOTELS AND MOTELS

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

3.1 International Residential Code

The International Residential Code (IRC) applies to one- and two-family dwellings and townhomes not more than three stories above grade plane. The IRC does not allow basements or enclosed areas under elevated dwellings to be below grade on all sides. The IRC does not allow dry floodproofing of buildings within its scope.

3.2 International Building Code and ASCE 24

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

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

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

INTERNATIONAL BUILDING CODE AND ASCE 24 COMMENTARIES

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

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

Topic	Summary of Selected 2018 IBC / ASCE 24-14 Requirements and Changes from 2015 and 2012 IBC / ASCE 24-05	Comparison with NFIP Requirements
Definition of dry floodproofing	**2018 IBC Section 202 Definitions.** Defines dry floodproofing as a combination of design modifications resulting in a building, including the attendant utilities and equipment and sanitary facilities, being watertight with walls that are substantially impermeable and able to resist the loads required by ASCE 7, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*. Change from 2015 to 2018 IBC: No change. Change from 2012 to 2015 IBC: Added "and equipment." **ASCE 24-14 Section 1.2 Definitions.** Defines dry floodproofing as a combination of measures that result in making a structure and its utilities and equipment watertight with all elements substantially impermeable and with structural components having the capacity to resist flood loads. Change from ASCE 24-05: Expands the definition to require building and utilities and equipment serving the building to be watertight with walls substantially impermeable and able to resist flood loads rather than only requiring the building envelope to be substantially impermeable.	The definition of "dry floodproofing" (IBC and ASCE 24) is equivalent to the NFIP definition of "floodproofing" in NFIP 44 CFR § 59.1.
General flood hazard area requirements	**2018 IBC Section 1612.2 Design and construction.** Requires buildings and structures located in flood hazard areas to be designed and constructed in accordance with Chapter 5 of ASCE 7 and ASCE 24. Change from 2015 to 2018 IBC: Section renumbered from 1612.4 to 1612.2. Change from 2012 to 2015 IBC: Applies coastal high hazard area requirements in Coastal A Zones, if delineated.	Exceeds NFIP 44 CFR § 60.3(a)(3) with more specificity.

Table 1: Comparison of Select 2018 IBC and ASCE 24-14 Requirements with NFIP Requirements (continued)

Topic	Summary of Selected 2018 IBC / ASCE 24-14 Requirements and Changes from 2015 and 2012 IBC / ASCE 24-05	Comparison with NFIP Requirements
Flood hazard documentation	**2018 IBC Section 1612.4(1.3) Flood hazard documentation.** Requires submission of a certification statement prepared and sealed by a registered design professional that dry floodproofing is designed in accordance with ASCE 24. Change from 2015 to 2018 IBC: Section renumbered from 1612.5 to 1612.4. Change from 2012 to 2015 IBC: Applies coastal high hazard area requirements in Coastal A Zones, if delineated.	Equivalent to NFIP 44 CFR § 60.3(c)(4).
Elevation	**ASCE 24-14 Section 1.5.2 Elevation Requirements.** Allows for dry floodproofing of non-residential and the non-residential portions of mixed-use buildings below the BFE plus specified freeboard or the design flood elevation (DFE), whichever is higher, provided the dry floodproofing measures meet the requirements in Chapter 6. **ASCE 24-14 Section 2.3 Elevation Requirements.** Allows for dry floodproofing of non-residential and the non-residential portions of mixed-use buildings below the BFE plus specified freeboard or DFE, whichever is higher, provided the dry floodproofing measures meet the requirements in Chapter 6. Change from ASCE 24-05: Requires Flood Design Class 4 buildings to be elevated to or protect to BFE plus 2 feet, or DFE, or 500-year flood elevation, whichever is highest.	Exceeds NFIP 44 CFR § 60.3(c)(3) and (8) by requiring freeboard.
Dry floodproofing	**ASCE 24-14 Section 6.2 Dry Floodproofing.** • Permits dry floodproofing of non-residential buildings and non-residential portions of mixed-use buildings when the buildings are located outside High Risk Flood Hazard Areas, Coastal High Hazard Areas, and Coastal A Zones • Requires techniques that make structures substantially impermeable and requires the use of flood damage-resistant materials, except on the interior of structures • Requires sump pumps to remove water that accumulates from the passage of vapor and seepage during flooding • Limits dry floodproofing to flood hazard areas with flood velocities that are less than or equal to 5 feet per second during the design flood • Requires walls below the minimum elevations of dry floodproofing specified in Table 6-1 to be substantially impermeable to passage of water • Requires walls, floors, and flood shields to resist hydrostatic, hydrodynamic, and other flood loads, including the effects of buoyancy • Specifies that soil or fill adjacent to a structure must be compacted and protected from erosion and scour • Requires that at least one door, window, or other opening for emergency escape and rescue be above the elevation specified in Table 6-1 • Specifies several limitations when human intervention is necessary to activate or implement dry floodproofing measures	Exceeds NFIP 44 CFR § 60.3(c)(3) and (8) with more specificity, except (1) the NFIP requires the use of flood damage-resistant materials in areas where seepage will accumulate and (2) FEMA deems that temporarily installed means of flood protection that cover walls are inconsistent with the requirement that walls be substantially impermeable (see Section 3.2 of Technical Bulletin 3).

Table 1: Comparison of Select 2018 IBC and ASCE 24-14 Requirements with NFIP Requirements (continued)

Topic	Summary of Selected 2018 IBC / ASCE 24-14 Requirements and Changes from 2015 and 2012 IBC / ASCE 24-05	Comparison with NFIP Requirements
Dry floodproofing (continued)	Change from ASCE 24-05: Does not require flood damage-resistant materials on the interior of dry floodproofed portions of buildings.	
Garages	**ASCE 24-14 Section 9.4 Garages, Carports, and Accessory Storage Structures.** Specifies that floodproofed, below-grade parking, where allowed, shall meet the requirements of Section 6. Change from ASCE 24-05: Section renumbered from 9.3 to 9.4 and expanded to include accessory storage structures.	Exceeds NFIP 44 CFR § 60.3(c)(3) and (8) with more specificity.

4 NFIP Flood Insurance Implications

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

NFIP FLOOD INSURANCE FOR DRY FLOODPROOFED BUILDINGS

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

An insurance agent with NFIP experience should be consulted during the design phase of buildings with dry floodproofing to estimate the cost of NFIP flood insurance, especially if the design includes dry floodproofed below-grade levels. This consultation is particularly important when considering whether to include dry floodproofing of non-residential portions of mixed-use buildings or dry floodproofing of below-grade parking areas under non-residential and mixed-use buildings.

Designers should pay particular attention to the flood protection level (level to which buildings will be dry floodproofed). The NFIP regulations for non-residential structures in Zone A require the lowest floor (including basement) to be elevated to or above the BFE, or the structures may be dry floodproofed below the BFE. However, the NFIP flood insurance rating procedures provide credit for dry floodproofing only if the dry floodproofing measures are certified to be at least 1 foot above the BFE, even if that level of protection is not required by local floodplain management regulations. The NFIP also requires applications for insurance coverage for dry floodproofed buildings to include the NFIP Floodproofing Certificate described in Technical Bulletin 3.

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

before starting design work to understand how design decisions can impact NFIP flood insurance premiums.

5 Planning Considerations

Technical Bulletin 3 describes several planning considerations that building owners and design professionals should examine before determining which floodproofing measures or combination of measures are feasible for specific locations and before undertaking structural designs. Section 5 of Technical Bulletin 3 includes guidance on the following planning considerations:

- Site-specific flood hazards and site conditions (flood velocities, depths, duration of flooding, how quickly floodwater rises, and debris impacts)
- Flood warning time (length of time between recognition that flooding may occur and when floodwater begins to affect a site)
- Functional use requirements (access and interruption while dry floodproofing is deployed)
- Safety and access; also see Section 5.1 of this Technical Bulletin
- Required plans (emergency operations plans and inspection and maintenance plans); also see Section 5.1 of this Technical Bulletin

5.1 Occupant Safety and Required Plans

Dry floodproofed below-grade parking areas present potential safety risks to people who use these areas. For example, there is a high probability that some people may not move vehicles out of the parking areas when flood conditions threaten. When considering below-grade parking areas, building owners and designers should evaluate the following safety factors:

- Dry floodproofed buildings should not be occupied during flooding. Therefore, safety and access considerations are especially important when evaluating mixed-use buildings and whether it is appropriate to design dry floodproofing measures for the non-residential portions of these buildings and below-grade parking areas. Flooding may rise higher than the flood protection level, or dry floodproofing system components may fail, resulting in failure that could endanger occupants who do not evacuate.
- Flood emergency operations plans are necessary. The plans should be developed during the planning

RELIANCE ON HUMAN INTERVENTION

The potential for loss of life and property damage is high if the people who are responsible for buildings fail to maintain, inspect, and deploy measures that rely on human intervention such as flood shields and gates.

Measures that require human intervention should be specified only for buildings that have facility maintenance and operations personnel who are responsible for conducting routine maintenance and inspection and responsible for and capable of deploying flood protection measures well in advance of the onset of flooding.

phase when designers identify site-specific characteristics of flooding. The plans should take into account how quickly floodwater may affect a site and the level of effort and the time necessary to activate or deploy dry floodproofing measures that may require human intervention.

- Time available to implement measures may be insufficient. Designers should investigate alternatives if a proposed dry floodproofing system cannot be implemented and personnel safely evacuated from the area in the available time before the onset of flooding or high winds, taking into account whether roads or bridges may be closed by state or local officials. Alternatives may include eliminating below-grade parking or selecting alternative dry floodproofing system components that require less effort. The plans must specify the location of flood shields and other measures that require installation or deployment and the required tools and hardware, along with step-by-step deployment instructions. The plans should be tested and ready to implement when flooding threatens.
- Inspection and maintenance plans are also necessary. These plans should specify a schedule and instructions for regular inspections and maintenance of all materials and measures that are necessary for the successful functioning of the dry floodproofing systems. Building owners and managers should conduct periodic exercises to ensure that facility operations and maintenance personnel are familiar with installation requirements.

OBSERVATIONS OF DRY FLOODPROOFING FAILURES

Numerous observations by FEMA Mitigation Assessment Teams after significant flood events indicate that many dry floodproofing systems did not provide the intended level of protection in part because deployments were not adequately exercised or system components were not properly maintained.

Communities are encouraged to require the submission of flood emergency operations plans and inspection and maintenance plans along with the construction documents and design certifications that are required as part of applications for building permits. Some communities specify this requirement in local floodplain management regulations or building codes.

5.2 Limitations on the Use of Dry Floodproofing

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

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

ASCE 24, Chapter 6, limits the use of dry floodproofing to areas where flood velocities at building sites are less than or equal to 5 feet per second, although commentary suggests that local officials may accept certified designs that demonstrate resistance to higher velocities. In addition, ASCE 24 does not permit the use of dry floodproofing in coastal areas where breaking wave heights during base flood conditions are expected to be between 1.5 and 3 feet, called Coastal A Zones.

ASCE 24 permits the use of dry floodproofing measures that require human intervention to activate or implement only when certain conditions are satisfied, including (1) there is a minimum of 12 hours warning time (unless a community has a warning system that can ensure sufficient warning to implement measures), (2) flood shields and covers for openings are designed to resist flood loads, and (3) flood emergency plans, approved by community officials, specify certain information that is critical for installation, maintenance, and inspection. For safety, all buildings that rely on dry floodproofing should have emergency plans, including those with only passive measures, which do not rely on human intervention. Technical Bulletin 3 includes guidance on warning time and required plans.

COASTAL A ZONE

FEMA delineates a Limit of Moderate Wave Action (LiMWA) on FIRMs when analyses indicate the inland extent of 1.5-foot waves. The Coastal A Zone is the area between the LiMWA and Zone V boundary or between the LiMWA and shoreline if Zone V is not designated. FIRMs do not label these areas as Coastal A Zone.

6 Designing Dry Floodproofed Below-Grade Parking Areas

When designing non-residential structures and mixed-use buildings with dry floodproofed below-grade parking areas, design professionals must determine the flood protection level. Designers must also evaluate other flood conditions to determine site-specific flood loads. Structural designs must account for flood loads, described briefly in Section 6.2 of this Technical Bulletin and in more detail in Technical Bulletin 3. Designers also must determine the requirements for the design and installation of building utility systems and equipment, identify where seepage may occur, and identify other points where water may enter and the paths that seepage flow will take to accumulate at collection points.

6.1 Flood Protection Level

The flood protection level is the elevation to which flood protection measures will be designed. The NFIP regulations specify that when non-residential buildings are dry floodproofed, the structures must be watertight and substantially impermeable below the BFE.

ASCE 24 requires the minimum flood protection level to be the elevations listed in ASCE 24, Table 6-1, but state or local floodplain management regulations may require higher levels. ASCE 24 specifies flood protection levels based on the assignment of one of four Flood Design Classes (similar to risk categories). The minimum flood protection level for

"DESIGN FLOOD ELEVATION" IN ASCE 24

ASCE 24 defines and uses the terms "design flood" and "design flood elevation" (DFE) to account for communities that elect to adopt flood hazard maps based on floods that are higher than the base flood (the 1-percent-annual-chance flood) or to include additional areas not shown on FIRMs.

When communities adopt FEMA Flood Insurance Studies and FIRMs and use the base flood and BFE for regulatory purposes, the DFE is the same as the BFE.

Flood Design Class 2 and Class 3 buildings is the BFE plus 1 foot or the design flood elevation (DFE), whichever is higher. The minimum flood protection level for Flood Design Class 4, considered critical and essential facilities, is the highest of BFE plus 2 feet, the DFE, or the 500-year flood elevation. Flood Design Class 1 includes temporary structures, accessory storage structures, small parking structures, and certain agricultural structures. Local floodplain management officials should be consulted to determine whether local regulations require the flood protection level to be set higher than the minimum elevations in ASCE 24.

For NFIP flood insurance purposes, the flood protection level must be at least 1 foot above the BFE for the building to receive premium credits for dry floodproofing (see Section 4 of this Technical Bulletin). Thus, design professionals should design dry floodproofing measures to extend to at least BFE plus 1 foot unless a higher level of flood protection is required by the community or building owner.

6.2 Flood Loads

Flood loads are the result of floodwater rising to the flood protection level and moving past an object such as a building or component of a building foundation. The four types of flood loads are hydrostatic (including buoyancy), hydrodynamic, wave, and debris impact. Flood loads and the methods of calculating them are discussed in FEMA P-936 and Technical Bulletin 3.

While designers must evaluate all types of flood loads, particular attention must be given to hydrostatic loads when below-grade spaces will be dry floodproofed. Hydrostatic loads (pressures) are imposed on an object or building by standing water. The pressures are oriented horizontally on wall elements and increase linearly with the depth of water (see Figure 1). During conditions of flooding, hydrostatic loads are exerted above the ground and below the ground surface as soils become saturated. Vertical hydrostatic force (buoyancy) is a function of the volume of displaced floodwater. In most designs, loads on the above-grade portions of a building are transferred to below-grade structural elements, including the structural elements of below-grade parking areas. Consequently, any structural failure in below-grade areas could result in partial or complete failure of a building.

Determining the hydrostatic loads on a specific building requires identifying the BFE, the elevation of adjacent grades, the duration of flooding, the nature of soils and saturation potential, and the flood protection level. Flood protection level is discussed in Section 6.1 of this Technical Bulletin.

ASCE 7 AND FLOOD LOADS

For the calculation of flood loads, ASCE 24 refers to ASCE 7, *Minimum Design Loads and Associated Criteria* (2010). ASCE 7 addresses hydrostatic loads, hydrodynamic loads, wave loads, and impact loads from floodborne debris and ice.

CONSEQUENCES OF NOT MOVING CARS

After Hurricane Sandy inundated several buildings with below-grade parking areas, damage investigations noted minor structural damage caused by floating cars impinging on decks and structural columns. Trapped cars can exert uplift loads on submerged parking decks.

Some communities reported that efforts to remove disabled cars took weeks or months because low ceiling heights hindered access by tow trucks. When there is a chance that some cars may not be moved before the onset of flooding, designers should consider factoring into the design the potential for floating cars in below-grade parking decks and increasing ceiling heights to facilitate tow truck access.

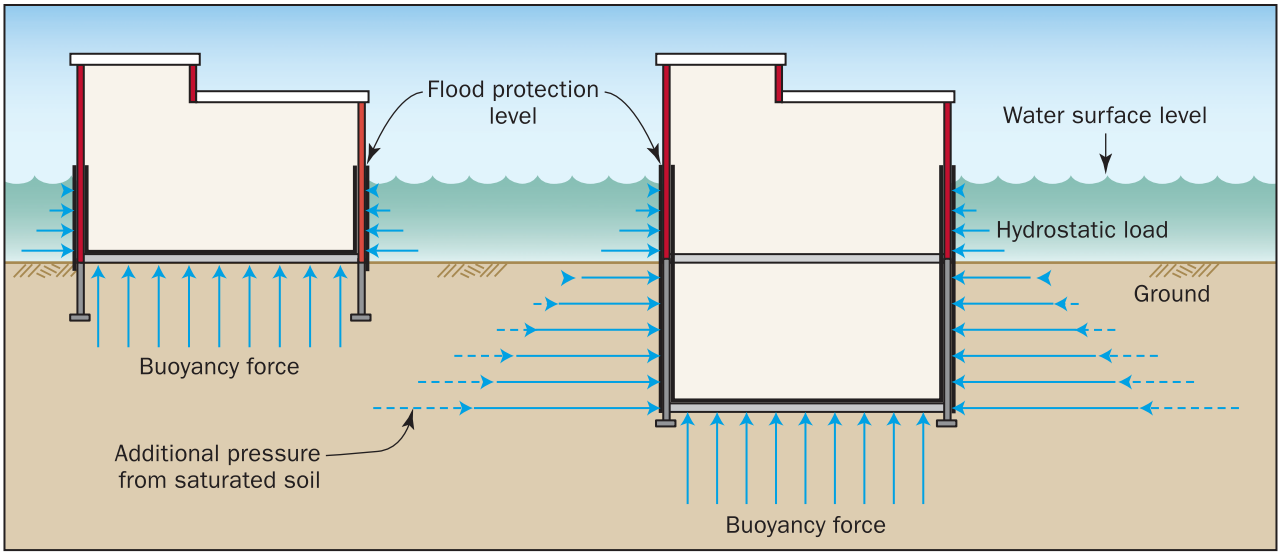

Figure 1: Hydrostatic loads

When water is kept out of a building, the water levels on opposite sides of walls (inside and outside) can be substantially different, which means hydrostatic pressures are unbalanced. Unbalanced hydrostatic loads can cause severe deflection, displacement, or collapse. The sum of the hydrostatic pressures over a surface represents the load acting on that surface.

In structural analysis, hydrostatic forces act vertically upward on the underside of all submerged members such as floor slabs, walls, and footings, and they act laterally on perimeter and foundation walls (see Figure 1). The vertical hydrostatic force (buoyancy) must be resisted by various building elements through the weight of the building elements themselves or by anchoring through the load path. The design of anchoring to resist buoyancy should account for changes in soil capacity caused by saturation. Floor slabs may crack or fail due to shear or bending caused by the buildup of hydrostatic loads underneath slabs, allowing water to enter.

6.3 Building Utility Systems and Equipment

Floodplain management requirements apply to building utility systems (mechanical, electrical and plumbing) and equipment (including fire controls and emergency power or generators). The preferred solution is to locate building utility systems and equipment above the flood protection level. Building utility systems and equipment that serve non-residential buildings and non-residential portions of mixed-use buildings are allowed in dry floodproofed areas, including below-grade parking areas. If dry floodproofing systems fail or are overtopped by floodwater rising above the flood protection level, utility systems and equipment may be damaged and not repairable, which could contribute to loss of building functionality.

The NFIP regulations and ASCE 24 permit equipment and service facilities to be below the flood protection level when "designed … to prevent water from entering or accumulating within the components during conditions of flooding" (44 CFR § 60.3(a)(3)(iv)). The expectation is that equipment and facilities installed below the flood protection level, after being submerged, will be able to be restored to functioning with minimal cleaning and repair. Additional guidance is available in Technical Bulletin 3 and FEMA P-348, *Protecting Building Utility Systems from Flood Damage* (2017).

When non-residential portions of mixed-use buildings are designed with dry floodproofing systems, the building utility systems and equipment that serve the residential uses are required to be elevated above the flood protection level and not located in areas that are protected with dry floodproofing.

6.4 Managing Points of Entry and Seepage

Critical elements in the design of below-grade parking areas are openings and points of entry where floodwater could enter dry floodproofed areas. Designers who prepare structural designs for dry floodproofed buildings should avoid specifying points of entry through exterior walls and slabs below the flood protection level. Possible points of entry are penetrations through walls and slabs for utility conduits, pedestrian entrances, stairwells, elevators, connections with adjacent buildings, and vehicle ramps. When points of entry cannot be avoided, designers should minimize the number of penetrations. All openings and points of entry below the flood protection level must be protected. Technical Bulletin 3 contains guidance for the design and specification of flood shields.

USE OF EQUIPMENT AND PRODUCTS APPROVED ACCORDING TO ANSI/FM 2510

Use of equipment and products that are tested and approved in accordance with ANSI/FM 2510, *American National Standard for Flood Mitigation Equipment* (2020), is not required for compliance with the NFIP or ASCE 24. However, specifying FM Approved equipment and products may provide designers more assurance when developing designs for dry floodproofing systems.

The ANSI/FM 2510 standard, described in Technical Bulletin 3, specifies the flood conditions for testing each type of equipment and product. Designers should verify the applicability of approved equipment and products for site-specific flood conditions.

To be considered "substantially impermeable," the dry floodproofing system below the flood protection level must limit seepage through walls, through joints and utility penetrations, and around flood shields. The system must not allow more than 4 inches of water depth from seepage during a 24-hour period. If the designer determines that the total seepage of a proposed system will exceed the limitation, the design must be modified to satisfy the accumulation limit. Although sump pumps are required to handle seepage, sump pumps cannot be relied on to meet the maximum accumulation limit. Guidance on estimating total seepage through an example dry floodproofing system is provided in Technical Bulletin 3.

Designers must plan the paths along which seepage will flow in order to determine where collection points, drains, and sumps will be installed. For buildings with below-grade parking areas, collection points are usually at the lowest point of the lowest parking level. Flood damage-resistant materials must be used in areas where seepage collects to minimize damage and downtime. When designing buildings with more than one below-grade level, designers should consider the flow path of floodwater between below-grade levels in the event that the floodproofing systems are overtopped or fail. Water should be able to easily flow between levels to prevent a hydrostatic or standing water load from exceeding the capacity of the concrete parking slab or deck as it travels to the lowest point.

FLOW PATH OF FLOODWATER

Failure to address the flow path of floodwater between below-grade levels could result in the accumulation of water and unanticipated loading, which could cause structural damage.

Particular attention must be paid when adjacent buildings share below-grade components such as utility chases and pedestrian corridors that could allow floodwater from an unprotected building to enter a building that is supposed to be dry floodproofed. Dry floodproofed below-grade parking areas should not be shared by two buildings unless both buildings are permitted to have dry floodproofed below-grade parking areas and both buildings are dry floodproofed to the same flood protection level.

Vehicle ramps and methods to prevent floodwater from entering through vehicle ramps must be considered carefully. The best method of protection is to design the ramps to be above the elevation of the dry floodproofing measures. For example, if dry floodproofing extends to the BFE plus 2 feet, the lowest point on the ramp should be at least the same elevation, and the ramp and surrounding site must be configured to prevent water from overtopping that elevation at any point (see Figure 2). If it is not possible to configure vehicle ramps to provide this level of protection, the ramps must be designed to accommodate flood shields, gates, stop logs, or other components that are designed to span the garage entry, withstand the hydrostatic pressure, and keep floodwater out of dry floodproofed below-grade parking areas (examples shown in Figures 3 through 6).

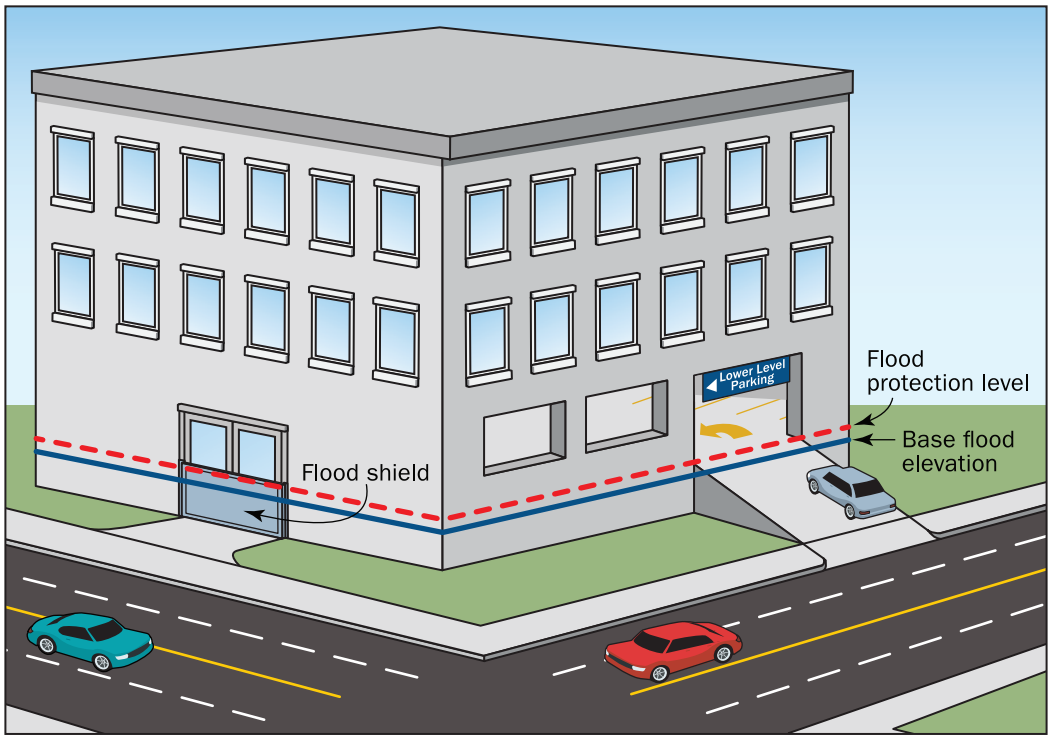

Figure 2: Raised vehicle ramp for dry floodproofed below-grade parking

Figure 3: Stop logs deployed inside the building to trap seepage around the garage door and avoid accumulation of rainfall

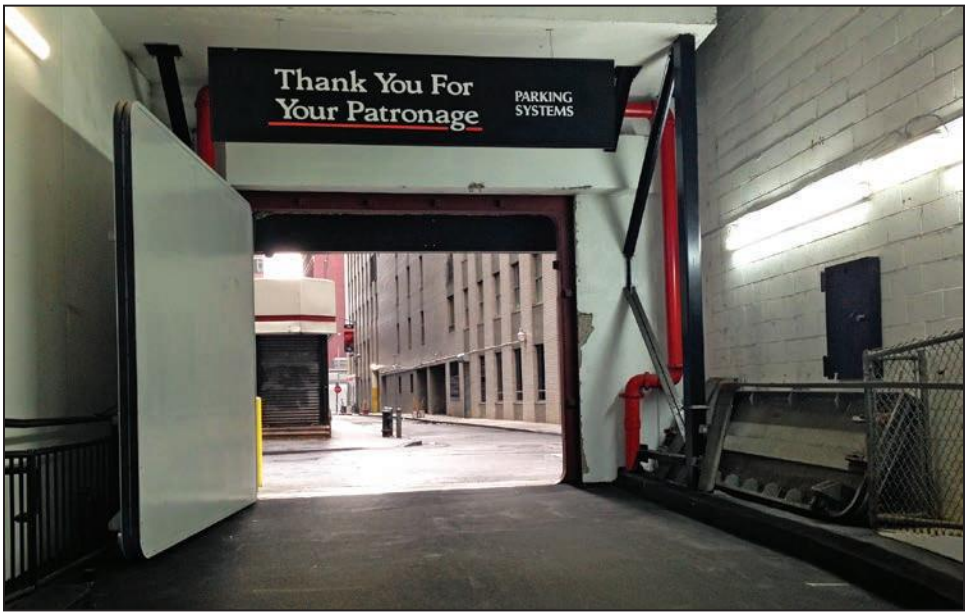

Figure 4: Permanent swing door (deployment requires closing and securing the door)

Figure 5: Manually deployed panel

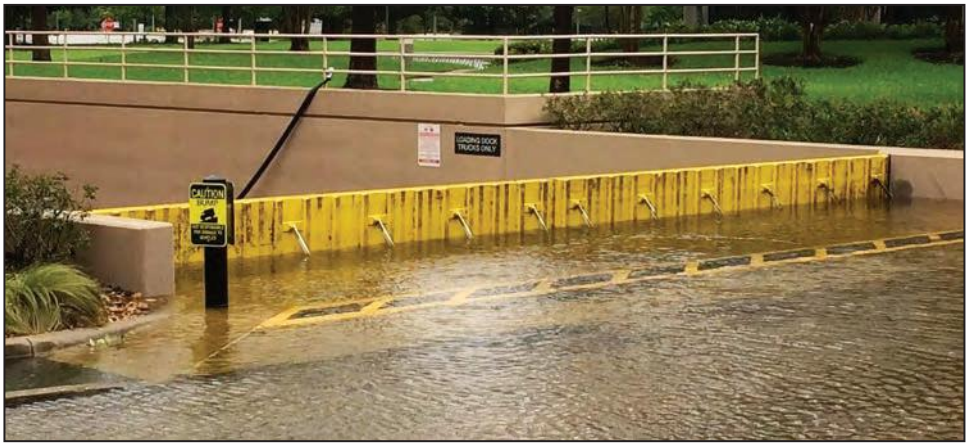

Figure 6: Automatic gate (deploys automatically when triggered by rising floodwater)

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