

## HIGHLIGHTS OF ASCE 24-14 *Flood Resistant Design and Construction*

Published by the American Society of Civil Engineers (ASCE), *Flood Resistant Design and Construction*, ASCE 24, is a referenced standard in the *International Codes*<sup>®</sup> (I-Codes<sup>®</sup>). ASCE 24 states the minimum requirements and expected performance for the siting and design and construction of buildings and structures in flood hazard areas that are subject to building code requirements. Types of buildings and structures are described in ASCE 24-14, Table 1-1 (see page 5 of these Highlights), and include commercial, residential, industrial, educational, healthcare, critical facilities, and other occupancy types. Buildings and structures designed according to ASCE 24 are better able to resist flood loads and flood damage.



FEMA deems ASCE 24 to meet or exceed the minimum National Flood Insurance Program (NFIP) requirements for buildings and structures. ASCE 24 includes additional specificity, some additional requirements, and some limitations that are not in NFIP regulations.

Buildings and structures within the scope of the IBC and proposed to be located in any flood hazard area must be designed in accordance with ASCE 24. The 2015 I-Codes reference ASCE 24-14, while the 2006 through 2012 I-Codes reference ASCE 24-05. The *International Residential Code*<sup>®</sup> requires dwellings in floodways to be designed in accordance with ASCE 24, and the 2015 edition of the IRC allows use of ASCE 24 for dwellings in any flood hazard area (the 2012 and 2009 editions allow use of ASCE 24 in Coastal High Hazard Areas).

Highlights of ASCE 24-14 that complement the NFIP minimum requirements are described below.

A summary of significant technical revisions from ASCE 24-05 to ASCE 24-14 is reproduced on page 6 of these Highlights.

### Building Performance

- Flood loads and other loads and load combinations are specified in ASCE 7-10, *Minimum Design Loads for Buildings and Other Structures*. Performance of foundations exposed to flooding is specified in ASCE 24. Soil characteristics and underlying strata, including soil consolidation, expansion or movement, erosion and scour, liquefaction and subsidence must be considered, as applicable.
- Flood Design Classes replace Occupancy/Risk Categories for the purpose of establishing elevations of lowest floors, flood-resistant materials, equipment and floodproofing. The 2015 *International Building Code* requires designers to identify the Flood Design Class assigned in accordance with ASCE 24-14.
- Elevation and Freeboard (additional height above the NFIP's base flood elevation) are specified as a function of the Flood Design Class and the nature of the flood hazard areas (see table on page 4 of these Highlights). Essential facilities (Flood Design Class 4) must be elevated or protected to the BFE + 2 ft or 500-year flood elevation, whichever is higher.
- Elevation requirements in Zone V and Coastal A Zones are independent of orientation of the lowest horizontal structural member (relative to direction of wave approach) as a factor in determining the required freeboard (ASCE 24-05 made elevation a function of orientation of the lowest horizontal structural member relative to the direction of wave approach).

ASCE 24 uses 'design flood' and 'design flood elevation' to acknowledge that some communities adopt flood hazard maps that depict flood hazard areas in addition to Special Flood Hazard Areas shown on FEMA's Flood Insurance Rate Maps (FIRM).

The design flood elevation (DFE) equals the base flood elevation (BFE) in communities that regulate based on FIRMs. The DFE is always equal to or higher than the BFE.

- Fill is required to be stable under conditions of flooding, including rapid rise and rapid drawdown, prolonged inundation, and erosion and scour. Compaction of structural fill is specified unless otherwise required by the building code or in a geotechnical or engineering report. Fill side slopes must be no steeper than 1:1.5.
- Two methods are specified to meet the requirements for flood openings in walls of enclosures below elevated buildings, to allow for the automatic entry and exit of floodwater: nonengineered openings that do not require certification (1 sq in per sq ft of enclosed area) and engineered openings that must be certified by a registered design professional. The performance of engineered openings must account for the presence of louvers, blades, screens, grilles, faceplates, or other covers and devices and must ensure that the difference between the exterior and interior floodwater levels does not exceed 1 foot. Installation of all flood openings must be in at least two walls and must be no more than 1 foot above the higher of the interior grade or floor and the finished exterior grade immediately under each opening.
- All breakaway walls in all flood hazard areas must have flood openings (ASCE 24-05 did not require flood openings in Zone V breakaway walls).
- Provisions are included for attached and detached decks and porches, and for garages, carports, and accessory storage structures.
- Provisions are listed for concrete slabs-on-grade, depending on the purpose and location of the slabs.
- Stairways and ramps must be designed and constructed to resist flood loads and to minimize transfer of flood loads to foundations, or to break away without causing damage to the main structure, or to be retractable/able to be raised.
- Where stairways are located inside areas enclosed with breakaway walls, exterior doors are required at the main building entry at the top of the stairs, to minimize entry of wind-driven rain and wave splash after breakaway walls have failed.
- In Coastal High Hazard Areas (Zone V) and Coastal A Zones:
  - Coastal A Zones are treated like Coastal High Hazard Areas if FEMA has delineated a Limit of Moderate Wave Action, or if the community has designated a Coastal A Zone.
  - Buildings must be supported on piles, drilled shafts, caissons, or other deep foundations (including columns, and shear walls) and foundation depth must take into account erosion and local scour.
  - Stem walls supporting floors and backfilled with soil or gravel are allowed in Coastal A Zones if designs provide for the effects of local scour and erosion.
  - Requirements are included for shallow foundations in circumstances where soil conditions prevent deep foundations.
  - Provisions are provided for pile foundations, attachment to piles, and different types of piles (wood, steel H, concrete-filled steel pipe, prestressed concrete, precast concrete, cast-in-place concrete).
  - Provisions are provided for pile design (capacity, capacity of supporting soils, minimum penetration, spacing, connections, splicing, and mixed and multiple types of piles).
  - Provisions are provided for footings, mats, rafts, slabs-on-grade, pile caps, grade beams, bracing, and shear walls.
  - Walls designed to break away must not produce debris that is capable of damaging structures.
  - Erosion control structures (bulkheads, seawalls, revetments) must not be attached to buildings or direct floodwater into or increase flood forces or erosion impacts on structures.
  - Pools must be elevated, or designed to breakaway without producing damaging debris, or designed to remain in the ground without obstructing flow that causes damage. Pools must be structurally independent of buildings and structures unless pools are located in or on elevated floors or roofs that are above the design flood elevation.

- Dry floodproofed nonresidential buildings and non-residential portions of mixed-use buildings:
  - The terms “mixed use” and “residential portions of mixed use” now are defined in Commentary.
  - Dry floodproofing measures are not permitted in Coastal High Hazard Areas, Coastal A Zones, High Risk Flood Hazard Areas, where flood velocities exceed 5 ft/sec, and where conformance with certain human intervention limits cannot be achieved.
  - At least one exit door or emergency escape/rescue opening must be provided above the elevation specified for dry floodproofing.
  - If dry floodproofing measures specified require human intervention to activate or implement, there must be a minimum warning time of 12 hours unless a community warning system provides a warning time sufficient to accomplish certain activities. If removable shields are approved as part of design, flood emergency plans must address specified elements and actions and must be posted in at least two conspicuous locations.

### **Flood Damage-Resistant Materials**

- Flood damage-resistant materials must be used below specified elevations (see table on page 4).
- Metal connectors and fasteners exposed to salt water, salt spray or other corrosive agents must be stainless steel or equivalent corrosion resistant material, or hot-dipped galvanized after fabrication.
- Where preservative treated wood is required, treatment must be in accordance with AWPA requirements.

### **Attendant Utilities and Equipment**

- Attendant utilities and equipment must be at or above specified elevations (see table on page 4), or must be specifically designed, constructed, and installed to prevent floodwaters from entering or accumulating within components.
- Fuel supply lines must be equipped with float operated automatic shut-off valves.
- Where required to meet life safety provisions of the code, certain exterior electrical components may be installed below the design flood elevation, provided they are installed on a non-breakaway structural element on the landward or downstream side of structures.
- Tanks that are below the design flood elevation and that are attached to or beneath buildings must be installed and anchored to resist at least 1.5 times the potential buoyant and other flood forces assumed to act on empty tanks.
- Elevator cabs that descend below the design flood elevation must be equipped with controls that prevent the cab from descending into floodwaters. Elevator shafts must be designed to resist flood loads, but are not required to have flood openings or breakaway walls.

### **Siting Considerations**

- New buildings must not be built (1) seaward of the reach of mean high tide, or (2) in areas subject to flash flooding (floodwaters rise to 3 feet or more above banks in less than 2 hours). Unless protected, new buildings must not be built (1) in erosion-prone areas (determined by analysis); or (2) in mudslide areas (determined by analysis); or (3) in certain portions of alluvial fan areas; or (4) in high velocity flow areas (faster than 10 ft/sec); or (5) in ice jam and debris areas.
- Buildings in proximity to flood protective works (dams, levees, floodwalls, diversions, channels, flood control structures) must not have adverse effects on, or conflict with, maintenance and repairs of those protective works.

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See next page for description of Flood Design Classes →

		Flood Design Class 1	Flood Design Class 2	Flood Design Class 3	Flood Design Class 4
<b>Minimum Elevation* of Lowest Floor (Zone A: ASCE 24-14 Table 2-1)</b>	Zone A not identified as Coastal A Zone	DFE	BFE +1 ft or DFE, whichever is higher	BFE +1 ft or DFE, whichever is higher	BFE +2 ft or DFE, or 500-year flood elevation, whichever is higher
<b>Minimum Elevation of Bottom of Lowest Horizontal Structural Member (Zone V: ASCE 24-14 Table 4-1)</b>	Coastal High Hazard Areas (Zone V) and Coastal A Zone	DFE	BFE +1 ft or DFE, whichever is higher	BFE +2 ft or DFE, whichever is higher	BFE +2 ft or DFE, or 500-year flood elevation, whichever is higher
<b>Minimum Elevation Below Which Flood-Damage-Resistant Materials Shall be Used (Table ASCE 24-14 5-1)</b>	Zone A not identified as Coastal A Zone	DFE	BFE +1 ft or DFE, whichever is higher	BFE +1 ft or DFE, whichever is higher	BFE +2 ft or DFE, or 500-year flood elevation, whichever is higher
	Coastal High Hazard Areas (Zone V) and Coastal A Zone	DFE	BFE +1 ft or DFE, whichever is higher	BFE +2 ft or DFE, whichever is higher	BFE +2 ft or DFE, or 500-year flood elevation, whichever is higher
<b>Minimum Elevation** of Utilities and Equipment (ASCE 24-14 Table 7-1)</b>	Zone A not identified as Coastal A Zone	DFE	BFE +1 ft or DFE, whichever is higher	BFE +1 ft or DFE, whichever is higher	BFE +2 ft or DFE, or 500-year flood elevation, whichever is higher
	Coastal High Hazard Areas (Zone V) and Coastal A Zone	DFE	BFE +1 ft or DFE, whichever is higher	BFE +2 ft or DFE, whichever is higher	BFE +2 ft or DFE, or 500-year flood elevation, whichever is higher
<b>Minimum Elevation of Dry Floodproofing of non-residential structures and non-residential portions of mixed-use buildings (ASCE 24-14 Table 6-1)</b>	Zone A not identified as Coastal A Zone	BFE +1 ft or DFE, whichever is higher	BFE +1 ft or DFE, whichever is higher	BFE +1 ft or DFE, whichever is higher	BFE +2 ft or DFE, or 500-year flood elevation, whichever is higher
	Coastal High Hazard Areas (Zone V) and Coastal A Zone	Not permitted	Not permitted	Not permitted	Not permitted
<b>Minimum Elevation of Wet Floodproofing*** (ASCE 24-14 Table 6-1)</b>	Zone A not identified as Coastal A Zone; Coastal A Zone; Coastal High Hazard Areas (Zone V)	BFE +1 ft or DFE, whichever is higher	BFE +1 ft or DFE, whichever is higher	BFE +1 ft or DFE, whichever is higher	BFE +2 ft or DFE, or 500-year flood elevation, whichever is higher
<p>* Flood Design Class 1 structures shall be allowed below the minimum elevation if the structure meets the wet floodproofing requirements of ASCE 24-14 Section 6.3.  ** Unless otherwise permitted by ASCE 24-14 Chapter 7  *** Only if permitted by ASCE 24-14 Section 6.3.1</p>					

<b>ASCE 24-14 Table 1-1 Flood Design Class of Buildings and Structures</b>	
<b>Use or Occupancy of Buildings and Structures</b>	<b>Flood Design Class</b>
Buildings and structures that normally are unoccupied and pose minimal risk to the public or minimal disruption to the community should they be damaged or fail due to flooding. Flood Design Class 1 includes (1) temporary structures that are in place for less than 180 days, (2) accessory storage buildings and minor storage facilities (does not include commercial storage facilities), (3) small structures used for parking of vehicles, and (4) certain agricultural structures. [Note (a)]	<b>1</b>
Buildings and structures that pose a moderate risk to the public or moderate disruption to the community should they be damaged or fail due to flooding, except those listed as Flood Design Classes 1, 3, and 4. Flood Design Class 2 includes the vast majority of buildings and structures that are not specifically assigned another Flood Design Class, including most residential, commercial, and industrial buildings.	<b>2</b>
Buildings and structures that pose a high risk to the public or significant disruption to the community should they be damaged, be unable to perform their intended functions after flooding, or fail due to flooding. Flood Design Class 3 includes (1) buildings and structures in which a large number of persons may assemble in one place, such as theaters, lecture halls, concert halls, and religious institutions with large areas used for worship; (2) museums; (3) community centers and other recreational facilities; (4) athletic facilities with seating for spectators; (5) elementary schools, secondary schools, and buildings with college or adult education classrooms; (6) jails, correctional facilities, and detention facilities; (7) healthcare facilities not having surgery or emergency treatment capabilities; (8) care facilities where residents have limited mobility or ability, including nursing homes but not including care facilities for five or fewer persons; (9) preschool and child care facilities not located in one- and two-family dwellings; (10) buildings and structures associated with power generating stations, water and sewage treatment plants, telecommunication facilities, and other utilities which, if their operations were interrupted by a flood, would cause significant disruption in day-to-day life or significant economic losses in a community; and (11) buildings and other structures not included in Flood Design Class 4 (including but not limited to facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, hazardous waste, or explosives) containing toxic or explosive substances where the quantity of the material exceeds a threshold quantity established by the authority having jurisdiction and is sufficient to pose a threat to the public if released. [Note (b)]	<b>3</b>
Buildings and structures that contain essential facilities and services necessary for emergency response and recovery, or that pose a substantial risk to the community at large in the event of failure, disruption of function, or damage by flooding. Flood Design Class 4 includes (1) hospitals and health care facilities having surgery or emergency treatment facilities; (2) fire, rescue, ambulance, and police stations and emergency vehicle garages; (3) designated emergency shelters; (4) designated emergency preparedness, communication, and operation centers and other facilities required for emergency response; (5) power generating stations and other public utility facilities required in emergencies; (6) critical aviation facilities such as control towers, air traffic control centers, and hangars for aircraft used in emergency response; (7) ancillary structures such as communication towers, electrical substations, fuel or water storage tanks, or other structures necessary to allow continued functioning of a Flood Design Class 4 facility during and after an emergency; and (8) buildings and other structures (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, or hazardous waste) containing sufficient quantities of highly toxic substances where the quantity of the material exceeds a threshold quantity established by the authority having jurisdiction and is sufficient to pose a threat to the public if released. [Note (b)]	<b>4</b>
<p>[Note (a)] Certain agricultural structures may be exempt from some of the provisions of this standard; see ASCE 24-14 Section C1.4.3.</p> <p>[Note (b)] Buildings and other structures containing toxic, highly toxic, or explosive substances shall be eligible for assignment to a lower Flood Design Class if it can be demonstrated to the satisfaction of the authority having jurisdiction by a hazard assessment as described in ASCE 7-10 Section 1.5.3 of <i>Minimum Design Loads for Buildings and Other Structures</i> that a release of the substances is commensurate with the risk associated with that Flood Design Class.</p>	

## Significant Technical Revisions

ASCE 24-14 lists a number of significant technical revisions from the 2005 edition:

1. Defines *Flood Design Class* rather than use Risk/Occupancy Classification assigned under ASCE 7 and requires each building or structure governed by the standard to be assigned to Flood Design Class 1, 2, 3, or 4. Uses the assigned Flood Design Class to apply elevation requirements specified in Chapters 2, 4, 5, 6 and 7. Flood Design Class 4 buildings and facilities are equivalent to Occupancy Category/Risk Category IV buildings, which ASCE 7-10 identifies as essential facilities.
2. Adds definitions for *Mixed Use* and *Residential Portions of Mixed Use* in commentary to clarify limitations on use of dry floodproofing measures.
3. Changes the Coastal A Zone determination requirement from the designer's responsibility to one depending on either: 1) delineation of a Limit of Moderate Wave Action (LiMWA) on a Flood Insurance Rate Map, or 2) designation by the Authority Having Jurisdiction.
4. Separates specifications for flood openings from the installation requirements. Requires the presence of louvers, blades, screens, faceplates, or other covers and devices to be accounted for in determining net open area for non-engineered openings and in determining the performance of engineered openings. Revises coefficient of discharge table for engineered flood openings. Adds commentary regarding selection of coefficient of discharge and for grouping or stacking of flood openings.
5. For Flood Design Class 4 buildings, requires the minimum lowest floor elevation (or floodproofing level of protection) to be the higher of: the Base Flood Elevation plus freeboard specified in Chapters 2, 4 and 6, the Design Flood Elevation, or the 500-year flood elevation. The 500-year flood elevation requirement is new.
6. Clarifies text pertaining to alluvial fan high risk flood hazard areas.
7. In coastal high hazard areas (V Zone) and Coastal A Zones (if delineated):
  - a. Makes explicit that designs must account for local scour and erosion
  - b. Provides for shallow foundations in Coastal A Zones under certain circumstances
  - c. Requires flood openings in breakaway walls
  - d. Eliminates orientation of the lowest horizontal structural member as a factor to determine elevation for lowest floors, equipment, and flood damage-resistant materials
  - e. Requires exterior doors at the top of stairways that are located inside enclosed areas with breakaway walls
  - f. Consolidates requirements for all nonstructural concrete slabs
  - g. Allows substantial improvement of existing buildings seaward of the reach of mean high tide in V zones (makes ASCE 24 consistent with NFIP) and Coastal A Zones.
8. Updates flood damage-resistant material requirements.
9. Clarifies emergency escape and rescue opening requirements for dry floodproofed buildings.
10. Clarifies requirements for garages, carports, and accessory storage structures. Adds new section for multistory parking structures.
11. Consolidates requirements for tanks and more clearly distinguishes between requirements based on flood hazard area.