The Code Corner

RLGA Technical Services

No. 12 — July 2005 (Revised August 2009)

Flood-Resistant Design

By Ronald L. Geren, AIA, CSI, CCS, CCCA, SCIP

For some people who don't live in the Arizona desert (and for some that do!), it is difficult to comprehend that the desert can experience flooding…even flooding that causes serious damage. But, according to a statistic provided by the Flood Control District of Maricopa County (located in central Arizona), almost all states have experienced flooding in some form, and that within a typical 30-year mortgage, there is a 26% chance that flooding will occur if located in a 100-year flood plain; compare that to a 4% chance of fire. Further, the Federal Emergency Management Agency (FEMA) states flooding has caused the deaths of more than 10,000 people since 1990, with an annual property damage cost sitting at an unbelievable $1 billion!

In the past, attempts to control flooding consisted of constructing flood-control projects such as dams, levees, sea-walls, and similar structures, and providing disaster relief to flood victims. However, this approach did not reduce flood-related losses, nor did it discourage development in flood-prone areas. As a result, the U.S. Congress established the National Flood Insurance Program (NFIP) through the *National Flood Insurance Act of 1968*. The Act's purpose was to "reduce future flood damage through community floodplain management ordinances, and provide protection for property owners against potential losses through an insurance mechanism that requires a premium to be paid for the protection." The NFIP was further modified and broadened by the *Flood Disaster Protection Act of 1973* and the *National Flood Insurance Reform Act of 1994*.

To be eligible for this flood insurance, communities must have an agreement with the Federal Government that states if they adopt and enforce a floodplain management ordinance to reduce future flood risks to new construction in flood hazard areas, the Federal Government will make flood insurance available within the community as financial protection against flood losses (To see if your community participates in the NFIP, go to http://www.fema.gov/fema/csb.shtm). Historically, complying with the requirements for NFIP eligibility included multiple regulatory functions (zoning ordinances, building codes, comprehensive plans, etc.) managed by separate agencies, whereas others issued a single ordinance to address the minimum requirements. Recently, another method of qualifying for NFIP protection has come in the form of adopting the International Codes published by the International Code Council (ICC).

Essentially, there are four significant locations where flood resistant design is addressed in the *International Building Code* (IBC): Chapters 8 and 14 for flood-resistant materials, Chapter 14 for protection of utilities from wave action, Chapter 16 for flood loads, and Appendix G for flood-resistant construction. In the *International Residential Code* (IRC), most of the requirements for flood-resistant construction are located in Section R323, however, flood-resistant requirements are also located throughout the code in each of the other Parts regarding such areas as electrical, mechanical, and fuel gas.

Not all structures need to comply with the flood resistance requirements of the codes; only those located within a flood hazard area. But what constitutes a flood hazard area? A flood hazard area, or more appropriately a Special Flood Hazard Area (SFHA), is the area considered within the 100-year floodplain subject to the Base Flood. The Base Flood Elevation (BFE) is the water surface elevation associated with the 100-year flood.

Before going any further, it should be explained that a 100-year flood is not a flood that occurs every 100 years. In fact, it indicates the probability of a flood reaching or exceeding a certain elevation within any year. For the 100-year flood, there is a 1% chance that the BFE will be equaled or exceeded in any year (it's easy to calculate: take 100 and divide by the flood year, and that will give you the percentage of probability - e.g. 100/100-yr = 1%, 100/50-yr = 2%, 100/10-yr = 10%, etc.).

The next question is: how does one determine whether or not their property is within a SFHA? The answer is not as difficult to find as it might seem. SFHA's are annotated in a series of maps referred to as Flood Insurance Rate Maps, or FIRMs. They're prepared by FEMA and are available for viewing on their website just by entering a street address. If the property is located in a shaded area that is annotated with either an "A" or "V" designation, then the property is within the 100-year flood plain. Both of these designations have variations (i.e. AE, AO, VE, VO), which are explained in the map's legend. "A" zones apply to either inland or coastal regions, while "V" zones apply only to coastal regions subject to high velocity wave actions.

Depending on the zone, FIRMs may indicate the BFE for a flood hazard area. However, the IBC uses the term Design Flood Elevation, or DFE. The DFE may or may not equal the BFE, but it will never be lower than the BFE. A DFE set at a higher elevation may be established by a jurisdiction based on actual flood elevations experienced by the jurisdiction which are not reflected in the most current FIRMs available.

Assuming that the property is within a SFHA, what next? For the structural engineer, it means compliance with ASCE (American Society of Civil Engineers) 24-98, *Flood Resistant Design and Construction*, in accordance with Section 1612 of the 2003 IBC, for any structure that will be built on the property. For the architect, it's the selection of flood-resistant materials for interior and exterior walls in accordance with Sections 801.1.3 and 1403.6, respectively. And, for mechanical and electrical engineers, it means coordinating installation of mechanical, electrical, and plumbing systems so that they aren't mounted on, or penetrating through, exterior walls designed to break away under flood loads as required by Section 1403.7.

Flood loads on structural elements below the DFE are determined according to ASCE 7-02, and include calculations for such conditions as hydrostatic loads, hydrodynamic loads (moving water), wave impact loads, and debris impact loads. Once these loads are determined, then building elements are designed according to ASCE 24 to withstand the applied loads. But, in addition to withstanding loads, ASCE 24 also establishes criteria for floodproofing buildings. Floodproofing consists of a variety of methods that make a building resistant to flood damage including passive measures such as reducing the building's contact with floodwaters (dry-floodproofing), or reducing the extent of damage from contact with floodwaters (wet-floodproofing).

Of the two methods, only wet-floodproofing is permitted for all types of flood hazards; the use of dry-floodproofing is limited to non-residential structures in "A" zones, and is not permitted in any structure in "V" zones. Additionally, wet-floodproofing is limited to where it may be used. Generally, the floor elevation of the lowest floor must be at or above the DFE, thereby making it unnecessary to wet-floodproof a structure. However, enclosed areas used solely for parking, building access, and limited storage, plus attached garages, may be wet-floodproofed. Other structures may be allowed to be wet-floodproofed, but only through a variance. For additional guidance on wet-floodproofing, refer to FEMA Technical Bulletin 7-93, which is available for download on the FEMA website.

For structures using the wet-floodproofing method, materials below the DFE, both interior and exterior, must be of flood damage-resistant materials. The IBC defines flood damage-resistant materials as "capable of withstanding direct and prolonged contact with floodwaters without sustaining any damage that requires more than cosmetic repair." Only the IRC provides specific guidance by referencing FEMA Technical Bulletin 2-93 (also available for download), which establishes flood resistance classifications for common materials. For projects regulated by the IBC, there is no specific guidance prescribed, but Technical Bulletin 2-93 is listed in the *IBC Commentary* as a resource. For materials not listed in Technical Bulleting 2-93, the National Evaluation Service (now a part of ICC Evaluation Services) prepared an evaluation protocol to determine the flood-resistance of materials; however, this document is no longer available for download on the internet.

Dry-floodproofing involves the use of special sealants, coatings, and specialized equipment and components (i.e. flood shields, panels, gates, and backflow valves) to virtually eliminate the entrance of water into the structure. Unlike wet-floodproofing, dry-floodproofing requires the structure to resist hydrostatic pressure since floodwaters aren't equalized on both sides of a wall. Vertical buoyant forces must be addressed, too, especially for small, lightweight structures, which could literally float out of the ground. In accordance with the IBC, if dry-floodproofing is used, the construction documents must clearly indicate that the dry-floodproofing complies with ASCE 24.

As previously stated, the International Codes provide one approach to complying with the NFIP, but this requires adoption of both the IRC and IBC (including Appendix G). Elimination of any flood-related requirement from either of these documents must be replaced with provisions that either equal or exceed the original requirements in order to obtain, or retain, NFIP eligibility. It is important to note that if a community participates in the NFIP and a property in that community is located in a special flood hazard area, the purchase of flood insurance by the property owner is mandatory. If an insured structure is deemed to be in noncompliance with the flood-resistance regulations, the policy could be rerated, effectively increasing the cost of premiums, or it could be denied coverage, period. However, come heck or high water, designing for flood resistance will definitely prepare you for the latter. As for the former, you're on your own.

Resources:

Federal Emergency Management Agency (FEMA) (http://www.fema.gov)
- NFIP Program Description (http://www.fema.gov/library/viewRecord.do?id=1480)
- Technical Bulletins (http://www.fema.gov/plan/prevent/floodplain/techbul.shtm)
- "Reducing Flood Losses through the International Codes Series" (http://www.fema.gov/library/viewRecord.do?id=2094)

National Institute of Building Sciences (NIST), Whole Building Design Guide (http://www.wbdg.org)
- "Flood Resistance of the Building Envelope" (http://www.wbdg.org/resources/env_flood.php)

To comment on this article, suggest other topics, or submit a question regarding codes, contact the author at ron@specsandcodes.com.

About the Author: Ronald L. Geren, AIA, CSI, CCS, CCCA, SCIP, is an ICC Certified Building Plans Examiner, and is the principal of RLGA Technical Services located in Scottsdale, Arizona, which provides specifications and code consulting services to architects, engineers, owners, and product manufacturers. A 1984 graduate of the University of Arizona, Ron has over 23 years of experience with military, public, and private agencies.