Foundations in Coastal Areas

HOME BUILDER’S GUIDE TO COASTAL CONSTRUCTION

Technical Fact Sheet No. 3.1

Purpose: To describe foundation types suitable for coastal environments.

Key Issues

- Foundations in coastal areas should elevate buildings above the Design Flood Elevation (DFE) in accordance with ASCE 24-05, while withstanding flood forces, high winds, scour and erosion, and floating debris in ASCE 7-10.

- Foundations used for inland construction are generally not suitable for coastal construction. Some examples of foundation systems that have a history of poor performance in erosion prone areas are slab-on-ground, spread footings, and mat (or raft) foundations.

- Deeply embedded pile or column foundations are required for V Zone construction. In A Zones they are recommended instead of solid wall, crawl space, slab, or other shallow foundations, which are more susceptible to scour. (For the reference of this document, the term deeply embedded means “sufficient penetration into the ground to accommodate storm-induced scour and erosion and to resist all design vertical and lateral loads without structural damage.”)

- Areas below elevated buildings in V Zones must be “free of obstructions” that can transfer flood loads to the foundation and building (see Fact Sheet No. 8.1, Enclosures and Breakaway Walls). Areas below elevated buildings in A Zones should follow the same recommended principles as those areas for buildings located in V Zones.

Foundation Design Criteria

All foundations for buildings in flood hazard areas must be constructed with flood-damage-resistant materials (see Fact Sheet No. 1.7, Coastal Building Materials). In addition to meeting the requirements for conventional construction, these foundations must: (1) elevate the building above the Base Flood Elevation (BFE), and (2) prevent flotation, collapse, and lateral movement of the building, resulting from loads and conditions during the design flood event (in coastal areas, these loads and conditions include inundation by fast-moving water, breaking waves, floating debris, erosion, and high winds).

Because the most hazardous coastal areas are subject to erosion, scour, and extreme flood loads, the only practical way to perform these two functions is to elevate a building on a deeply embedded and “open” (i.e., pile or column) foundation. This approach resists storm-induced erosion and scour, and it minimizes the foundation surface area subject to lateral flood loads.

ASCE 24-05 is recommended as a best practice for flood resistance design and construction, especially in V Zones and Coastal A Zones. This standard has specific information on foundation requirements for Coastal High Hazard Areas and Coastal A Zones and it has stricter requirements than the NFIP. Elevation on open foundations is required by the National Flood Insurance Program (NFIP) in V Zones (even when the ground elevation lies above the BFE) and is strongly recommended for Coastal A Zones. Some states and communities have formally adopted open foundation requirements for Coastal A Zone construction.

While using the approach of elevation of structures on pile foundations improves performance and
minimizes some effects, even a deeply embedded open pile foundation will not prevent eventual undermining and loss due to long-term erosion (see Fact Sheet No. 2.2, Selecting a Lot and Siting the Building).

Performance of Various Foundation Types in Coastal Areas

There are many ways to elevate buildings above the BFE: fill, slab-on-grade, crawl space, stem wall, solid wall, pier (column), and pile. Not all of these are suitable for coastal areas. In fact, several of them are prohibited in V Zones and are not recommended for A Zone construction in coastal areas (see Fact Sheet 1.2, Summary of Coastal Construction Requirements and Recommendations for Flood Effects).

Pile: Pile foundations are recommended for V Zones and Coastal A Zones. These open foundations are constructed with square or round, wood, concrete, or steel piles, driven or jetted into the ground, or set into augered holes. Critical aspects of a pile foundation include the pile size, installation method and embedment depth, bracing, and the connections to the elevated structure (see Fact Sheets Nos. 3.2, Pile Installation and 3.3, Wood-Pile-to-Beam Connections). Pile foundations with inadequate embedment will lead to building collapse. Inadequately sized piles are vulnerable to breakage by waves and debris.

Fill: Using fill as a means of providing structural support to buildings in V Zones is prohibited because it is susceptible to erosion. Also, fill must not be used as a means of elevating buildings in any other coastal area subject to erosion, waves, or fast-moving water. However, minor quantities of fill are permitted for landscaping, site grading (not related to structural support of the building), drainage around and under buildings, and for the support of parking slabs, pool decks, patios and walkways (2009 IRC Section R322.3.2). These guidelines are consistent with NFIP Technical Bulletin 5, Free-of-Obstruction Requirements for Buildings Located in Coastal High Hazard Areas (08/08), which states: “Fill must not prevent the free passage of floodwaters and waves beneath elevated buildings. Fill must not divert floodwaters or deflect waves such that increased damage is sustained by adjacent or nearby buildings.”

Slab-on-Grade: Slab-on-grade foundations are also susceptible to erosion and are prohibited in V Zones and are not recommended for A Zones in coastal areas. (Note that parking slabs are often permitted below elevated buildings, but are susceptible to undermining and collapse.) It is recommended that parking slabs be designed to be frangible (breakaway) or designed and constructed to be self-supporting structural slabs capable of remaining intact and functional under base flood conditions, including expected erosion. For more information, see NFIP Technical Bulletin 5, Free-of-Obstruction Requirements for Buildings Located in Coastal High Hazard Areas (08/08).

Crawlspace: Crawlspace foundations are prohibited in V Zones and are not recommended for A Zone construction in coastal areas. They are susceptible to erosion when the footing depth is inadequate to prevent undermining. Crawlspace walls are also vulnerable to wave forces. Where used, crawl space foundations must be equipped with flood openings; grade elevations should be such that water is not trapped in the crawlspace (see Fact Sheets Nos. 3.5, Foundation Walls and 8.1, Enclosures and Breakaway Walls).

Stemwall: Stemwall foundations are similar to crawlspace foundations in construction, but the interior space that would otherwise form the crawlspace is often backfilled with structural fill or sand that supports a floor slab. Stemwall foundations have been observed to perform better during storms than many crawlspace and pier foundations. Although the IRC allows for heights of up to six feet, it is usually more economical and a better design choice to use another foundation system if stemwalls are over a few feet in height. During periods of high water backfill, soils may become flooded and cause damage to the slab. The designer should ensure that this does not cause consolidation of the backfill. In addition, in some soils such as sand, capillary action can cause water and moisture to affect the slab. Flood openings are not required in a backfilled stemwall foundation. Stemwall foundations are

Figure 2. Performance comparison of pier foundations. Piers on discrete footings (foreground) failed by rotating and overturning while piers on more substantial footings (in this case a concrete mat) survived (Pass Christian, Mississippi)
prohibited in V Zones but are recommended in A Zone areas subject to limited wave action, as long as embedment of the wall is sufficient to resist erosion and scour (see FEMA 549, Hurricane Katrina in the Gulf Coast).

**Solid Foundation Walls:** The NFIP prohibits solid foundation walls in V Zones and are not recommended for A Zone areas subject to breaking waves or other large flood forces—the walls act as an obstruction to flood flow. Like crawlspace walls, they are susceptible to erosion when the footing depth is inadequate to prevent undermining. Solid walls have been used in some regions to elevate buildings one story in height. Where used, the walls must allow floodwaters to pass between or through the walls (using flood openings). (See Fact Sheets Nos. 3.5, Foundation Walls and 8.1, Enclosures and Breakaway Walls.)

**Pier (column):** Pier foundations are recommended for A Zone areas where erosion potential and flood forces are small. This open foundation is commonly constructed with reinforced and grouted masonry units atop a concrete footing. Shallow pier foundations are extremely vulnerable to erosion and overturning if the footing depth and size are inadequate. They are also vulnerable to breakage. Fact Sheet No. 3.4, Reinforced Masonry Pier Construction, provides guidance on how to determine whether pier foundations are appropriate, and how to design and construct them.

**Foundations for High-Elevation Coastal Areas**

Foundation design is problematic in bluff areas that are vulnerable to coastal erosion but outside mapped flood hazard areas. Although NFIP requirements may not apply, the threat of undermining is not diminished.

Moreover, both shallow and deep foundations will fail in such situations. Long-term solutions to the problem may involve better siting (see Fact Sheet No. 2.2, Selecting a Lot and Siting the Building), moving the building when it is threatened, or (where permitted and economically feasible) controlling erosion through slope stabilization and structural protection. Additionally FEMA 232, Homebuilders’ Guide to Earthquake Resistant Design and Construction, provides information on foundation anchorage for hillside structures.

**Foundations in V Zones with Ground Elevations Above the BFE**

In some instances, coastal areas will be mapped on an NFIP Digital Flood Insurance Rate Map (DFIRM) as Zone V, but will have dunes or bluffs with ground elevations above the BFE shown on the DFIRM. During a design flood event, erosion of the bluffs and high dunes can be expected at these areas as well as waves and inundation. Therefore, the ground level can be expected to be lowered to a point that wave forces and loss of soil are a critical factor. The foundations for structures in these V Zone areas with high ground elevation are the same as V Zone areas with lower ground elevations. Deeply embedded pile or column foundations are still required in these areas, and solid or shallow foundations are still prohibited. The presence of a V Zone designation in these instances indicates that the dune or bluff is expected to erode during the base flood event and that V Zone wave conditions are expected after the erosion occurs. The presence of ground elevations above the BFE in a V Zone should not be taken to mean that the area is free from base flood and erosion effects.

**Additional Resources**


FEMA 549, Hurricane Katrina in the Gulf Coast (July 2006). (http://www.fema.gov/library/viewRecord.do?id=1857)


American Society of Civil Engineers (ASCE/SEI) Standard 7-10: Minimum Design Loads for Buildings and Other Structures, ASCE 7-10, (http://www.asce.org)

American Society of Civil Engineers (ASCE), Flood Resistant Design and Construction, ASCE/SEI 24-05, (http://www.asce.org)