3 Recommendations

The BPAT's recommendations are presented below. Engineering design drawings are also presented that illustrate the recommendations and provide details that can be used to enhance building performance under hurricane and coastal flood conditions.

3.1 Application of V-Zone and A-Zone Design and Construction Requirements

NFIP V-Zone construction requirements specify that new construction be elevated on piles, posts, columns, or piers and that the bottom of the lowest horizontal structural member (e.g., floor beam, joist) be at or above the BFE. Depending on the dimensions of those structural members, the resulting lowest floor elevations can be as much as 1.5 feet above the BFE. By comparison, NFIP A-Zone standards for new construction require that the lowest floor of the structure be at or above the BFE.

FIRMs accounting for wave effects were adopted by the communities in the study area between 1985 and 1987, prior to changes in V-Zone mapping procedures that extended coastal V-Zones to the landward toe of the primary frontal dune. The BPAT believes that this factor, coupled with a decade of long-term erosion, resulted in narrow V-Zones and an underestimation of actual risk along or near the shoreline, which increased the exposure of some post-FIRM A-Zone construction to V-Zone flood forces.

3.1.1 FEMA To Issue Revised FIRMs

FEMA will address the V-Zone issue discussed above by completing restudies and revisions to the FIRMs as necessary for the communities in the study area. Preliminary revised maps for the affected communities will not be completed until 1997; thus, the majority of post-Opal reconstruction will be governed by the FIRMs in effect at the time of the storm and by State CCCL requirements. Until the revised FIRMs are completed, the affected communities should consider studying local coastal flooding conditions that occurred during Hurricane Opal to determine whether areas in coastal A-Zones, as well as areas within several hundred feet of the Gulf of Mexico shoreline, are actually subject to V-Zone flood forces. If such areas are identified, the affected communities should strongly encourage the owners of new construction and substantial improvements to existing structures within those areas to conform with V-Zone construction standards and to provide several feet of freeboard above the BFEs shown on the current FIRMs.

3.1.2 Communities Using Higher Standards in Coastal A-Zones

The benefit of applying more stringent requirements to new construction in coastal A-Zones in the study area was illustrated by the performance of recent post-FIRM A-Zone construction in the City of Pensacola Beach during Hurricane Opal. Under the jurisdiction of the Santa Rosa Island Authority (SRIA), the city enforces V-Zone construction standards in all of the barrier island areas shown as A-Zones on its current FIRM. Within the same A-Zones, the SRIA also requires that the lowest horizontal structural member of all new construction be at or above an elevation of 10 feet NGVD. Therefore, the lowest floor elevation would be approximately 11.5 feet NGVD or higher. The A-Zone BFE ranges from a minimum of 6 feet NGVD to a maximum of 10 feet NGVD. Therefore, the SRIA's requirement results in lowest floor elevations up to 5.5 feet higher than what would otherwise be obtained. During Hurricane Opal, flooding occurred in V-Zone and A-Zone areas shown on the city's FIRM. Recent post-FIRM A-Zone construction generally performed well, as evidenced by the survival of elevated structures in A-Zones and the destruction of nearby pre-FIRM, at-grade structures. The BPAT believes that the higher elevations of lowest floors, coupled with the requirement for construction on piles, helped to significantly reduce the extent of damage in the city's barrier island A-Zones.

Communities that are considering adopting more restrictive requirements in their coastal A-Zones, such as V-Zone construction requirements or freeboard requirements, may want to contact the FEMA Region IV Office or the State of Florida Department of Community Affairs for technical assistance. Communities should also consider that by adopting these more restrictive requirements, they can earn community-wide reductions in flood insurance premiums under the NFIP's Community Rating System. In addition, lower flood insurance premiums can be obtained for individual structures when the structures are built to provide freeboard above the BFE. Such structures, if designed and constructed in accordance with the NFIP requirements, will receive lower premiums in 1-foot increments for up to 4 feet of freeboard above the BFE.

Communities are encouraged to reexamine foundation design requirements for structures in areas near the Gulf of Mexico shoreline in light of damage caused by Hurricane Opal. Structures in these areas should be designed to withstand all anticipated flood, erosion, debris, and wind forces. Foundation designs for structures in A-Zones, B-Zones, C-Zones, and X-Zones should be considered carefully to ensure that the designs reflect actual risks. Therefore, the BPAT recommends that communities and individuals consider the following:

- For all areas subject to high-velocity wave action, strong currents, erosion, or combinations thereof — regardless of flood zone designation — the embedment depths specified for pile foundations should be sufficient to ensure that the foundation will withstand anticipated erosion, conical scour, and storm forces.

- Foundations for masonry columns should be designed to withstand all anticipated flood, erosion, conical scour, debris, and wind forces. Shallow footings should not be used to support masonry columns where the risk of undermining exists.

- In areas known to be subject to storm-induced scour and erosion, any slabs serving as floors for habitable spaces should be designed and constructed to withstand all anticipated erosion, scour, and storm forces. Therefore, if the potential for undermining exists, slabs should be designed and constructed as structural slabs and attached to sufficient foundation systems that do not rely on underlying soil for support.

- In areas known to be subject to storm-induced scour and erosion, slabs used solely for parking should not be attached to structural members and should be designed and constructed to break into small pieces in the event of undermining, thereby minimizing potential transfer of flood loads to the structure.

3.2 Permitting, Plan Review, and Inspection

From the nature and extent of damage observed during its inspections, the BPAT has concluded that the quality of new construction can and should be improved. The specific recommendations of the Hurricane Opal BPAT regarding this issue, listed below, are similar to recommendations made by the BPAT that assessed damage resulting from Hurricane Andrew (FEMA 1992).

- Designer's, building officials, and contractors must ensure that all anticipated storm forces are taken into consideration and must avoid practices that have led to common building failures. Most building failures are predictable from the actual performance of similar structures during previous storms. Communities may want to consider requiring designers and contractors, through certification, registration, or continuing education, to demonstrate knowledge of all anticipated storm loads (e.g., wind, flood, debris, erosion) and proper design and construction methods that enable structures to withstand those forces.

- Quality of construction workmanship should be improved. Contractors and subcontractors should construct strictly according to design plans, and they should not attempt to compensate for changed site conditions or construction flaws and errors with non-engineered adjustments and repairs. Attempts to devise and implement rapid fixes to construction problems may render a structure vulnerable to storm forces and may lead to structural damage or destruction. Field representatives of building departments should require that plans be resubmitted when such concerns are identified in the field.

- Permitting, plan review, and construction inspection procedures should be improved. The knowledge and training of reviewers and inspectors should be enhanced through certification or continuing education. Building departments would need sufficient financial and human resources to ensure that frequent and comprehensive inspections occur during construction. Plan review and construction inspection tasks should make greater use of licensed design professionals. This could be accomplished through various combinations of public and private sector responsibilities. For example, a community with adequate resources could employ design professionals to support both plan review and construction inspection. Alternatively, a community could require that engineers and architects of record assume greater responsibility for monitoring and inspecting construction. The latter approach was taken in Dade County, Florida, after the Hurricane Andrew disaster.

3.3 Construction Materials

All materials should meet or exceed the minimum requirements for building materials in the Standard Building Code. All materials subject to flooding should resist damage, deterioration, corrosion, and decay due to inundation, precipitation, wind-driven water, salt spray, or other corrosive agents. Guidance concerning flood- and corrosion-resistant materials can be found in FEMA's Technical Bulletin 2-93, *Flood-Resistant Materials Requirements* for Buildings Located in Special Flood Hazard Areas (FEMA 1993b) and Technical Bulletin 8-96, *Corrosion Protection for Metal Connectors in Coastal Areas* (FEMA 1996). For example:

- Special consideration should be given to structural connectors such as hurricane straps and hangers to ensure they are specified properly and that precautions are taken with metal structural components to ensure that structural integrity is not compromised by corrosion (FEMA 1996).

- Where used to provide structural support for elevated structures, laminated or structural composite beams and joists should be properly specified, manufactured, treated, and installed for exterior use to avoid deterioration, delamination, or other problems that may result from use of members intended for interior use. Furthermore, designers and contractors should employ connections and connectors recommended by the American Institute of Timber Construction and allowed by the local building code, since standard connections and connectors used with sawn lumber may not be appropriate for laminated or composite lumber.
- Asphalt roofing shingles should be of sufficient size and weight to meet wind resistance requirements in the applicable building code. Roofing tiles should be properly nailed, screwed, or fastened in accordance with the manufacturer's recommendations.
- Metal roofing should be properly fastened to reduce damage, which tends to be progressive — a small defect can result in loss of the entire metal roof.

3.4 Repair and Retrofit of Damaged Structures

Repairs of damaged structures should be completed in accordance with applicable codes and regulations and should be inspected to ensure conformance to the applicable building code and floodplain management requirements. Designers and contractors should be reminded that if a structure is damaged to the point that the cost of repairing it to its pre-damage condition equals or exceeds 50 percent of its pre-damage market value, repair will be governed by local, State, or NFIP substantial damage regulations, as adopted by community floodplain ordinance.

Opportunities to retrofit damaged structures should also be aggressively pursued. Elevation, relocation, floodproofing, and installation of protective structures should be considered as effective means of reducing future damages (Florida Department of Community Affairs 1995). Where possible, retrofitting measures should be passive measures that do not require human intervention.

3.5 New Construction and Substantial Improvements

In V-Zones, construction plans for all new and substantially improved structures must be signed and sealed by a registered design professional. The BPAT recommends that in coastal A-Zones, plans for new and substantially improved structures also be signed and sealed by a registered design professional. Consideration should be given to having building setbacks from the shoreline and first floor elevations exceed minimum requirements where current FIRMs and construction setbacks do not reflect the actual flood levels, erosion, scour, and storm effects experienced during Hurricane Opal.

3.5.1 Pile, Post, Column, and Pier Foundations

Pile, post, column, and pier foundations should be designed to accommodate all design flood, wind, and other loads acting simultaneously in accordance with the requirements of ASCE 7-95, *Minimum Design Loads for Buildings and Other Structures* (ASCE 1995). Documented amounts of erosion and conical scour from Hurricane Opal and earlier storms should be considered in the determination of foundation embedment. When cast-in-place concrete piers are poured, measures should be used to prevent sand or earth from collapsing into the excavation and reducing the pier cross-section. Figure 3-1 shows the survival of a structure built on a well-constructed concrete pile foundation that sustained severe erosion. Figures 3-2 through 3-9 show recommended pile, post, column, and pier foundation designs. While there were no failures observed of spliced wood piles (see Figure 2-8), the recommended practice is to install foundation elements in a continuous length (i.e., in one piece).

3.5.2 Slabs and Grade Beams

With the exception of at-grade parking slabs, slabs-on-grade in areas known to be subject to storm-induced erosion and scour should be designed as freestanding structural elements and reinforced to withstand the loss of underlying soil. Freestanding structural slabs should be designed and constructed to withstand all flood, wind, and debris forces acting simultaneously (in accordance with applicable standards and codes) and to minimize debris trapping.

Grade beams should be designed as freestanding structural elements that are reinforced to withstand the loss of underlying soil, to withstand all flood, wind, and debris forces acting simultaneously, and to minimize debris trapping. The design of other structural components must consider the hydrodynamic and other forces that will act on grade beams and structural slabs once they are exposed to flood forces by storm-induced erosion and scour.

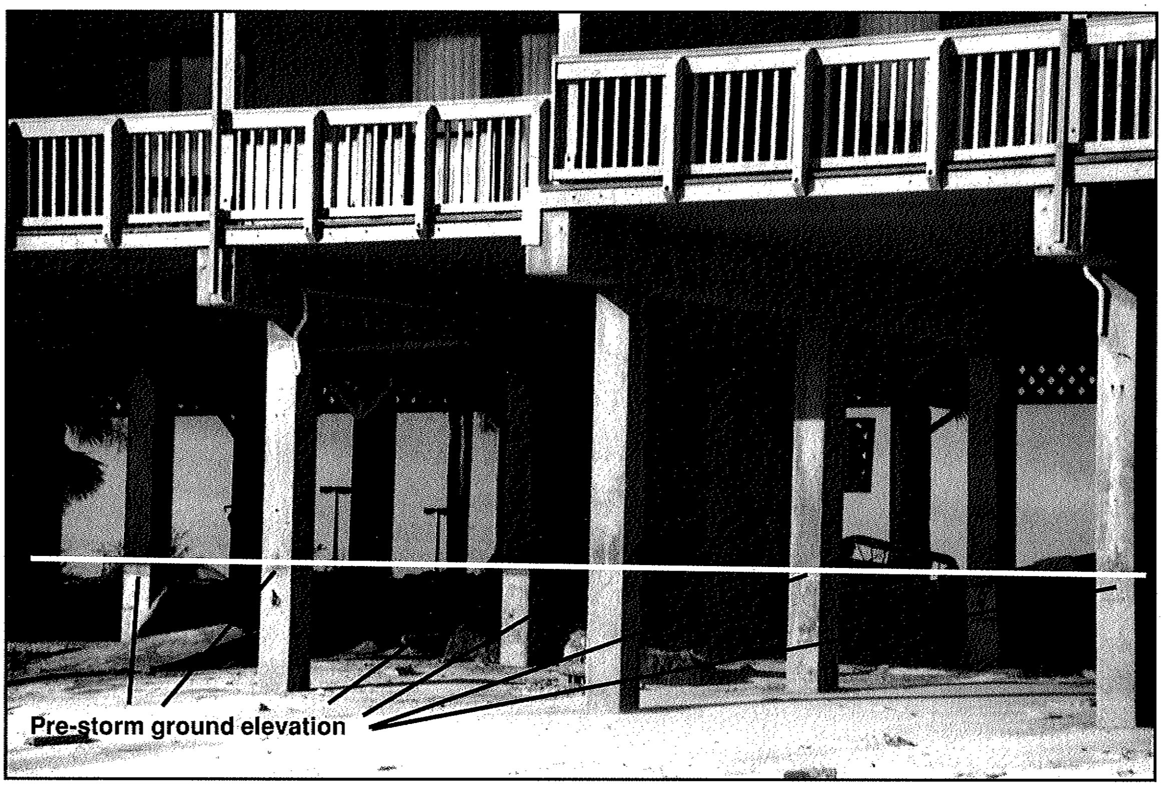

Figure 3-1 *This well-constructed concrete structure survived the storm with little or no damage, even with 5 feet of erosion.*

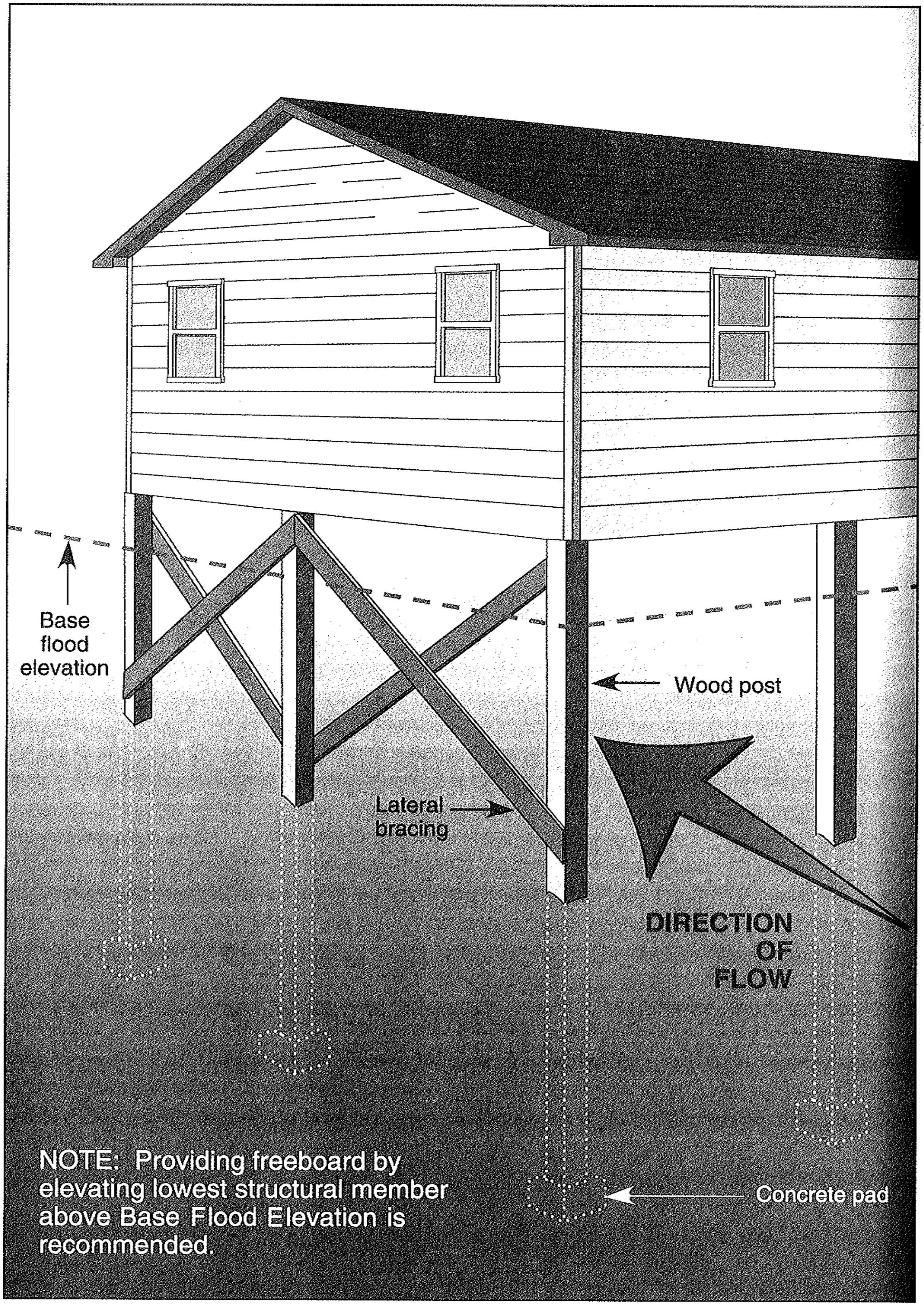

Figure 3-2 *Posts are placed in excavated holes and may be anchored in a concrete pad at the bottom of the hole. Where possible, lateral bracing should be oriented parallel to the anticipated flow path (FEMA 1993a).*

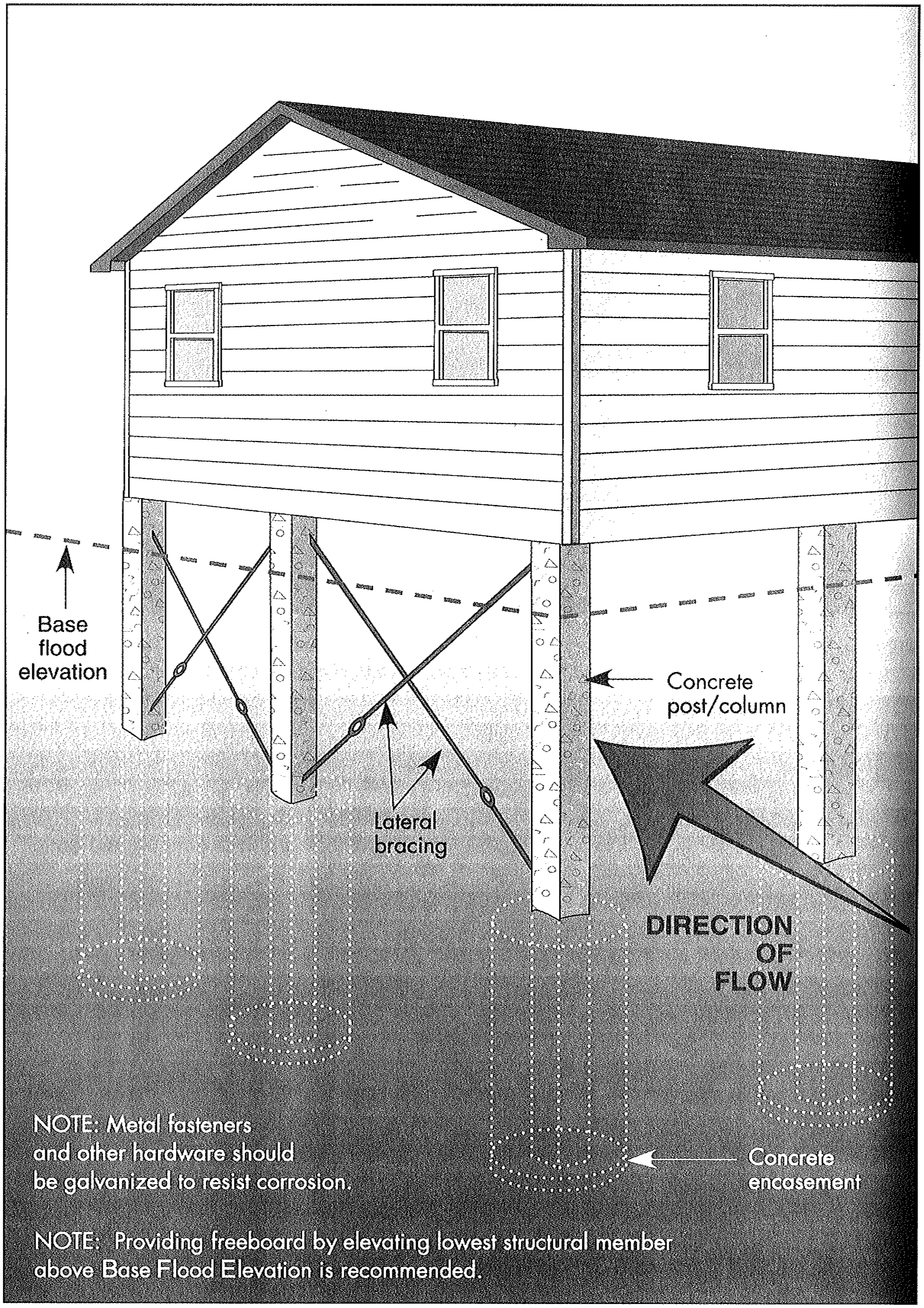

Figure 3-3 *Posts can also be anchored in concrete encasements. Where possible, lateral bracing should be oriented parallel to the anticipated flow path (FEMA 1993a).*

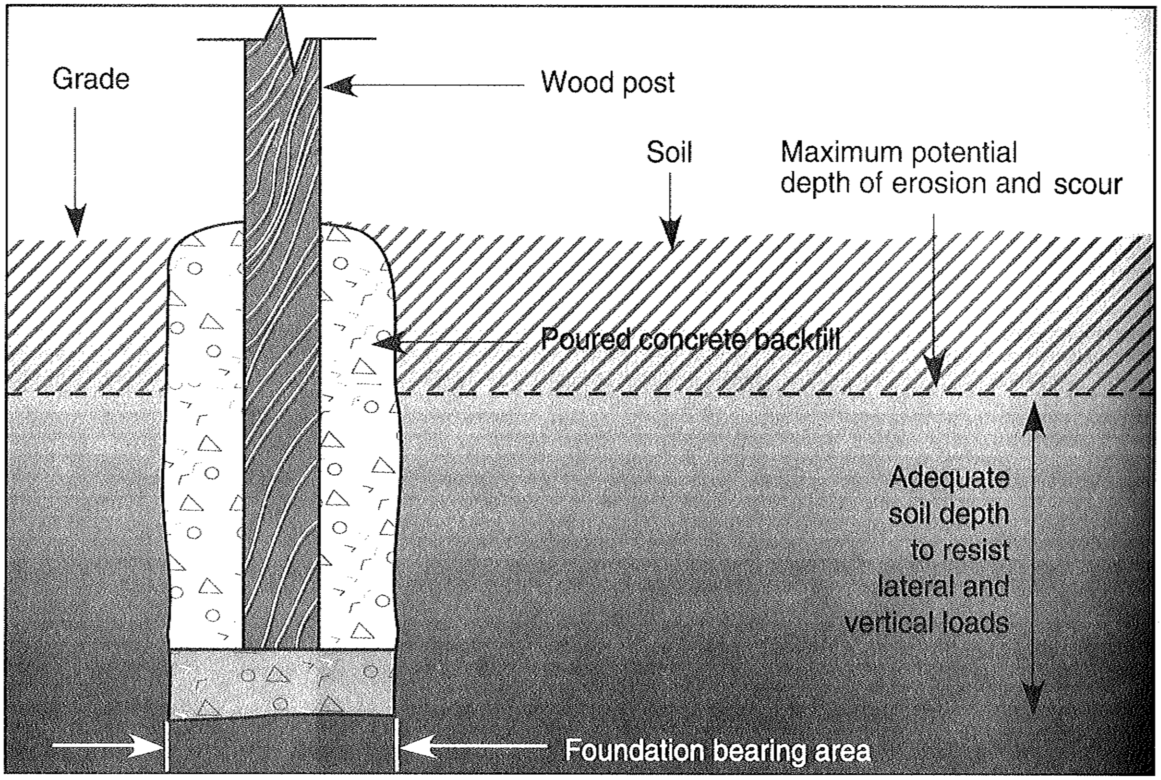

Figure 3-4 *Post on concrete bearing pad. Soil depth below maximum potential depth of scour is adequate to withstand lateral and vertical loads during the base flood (after FEMA 1993a).*

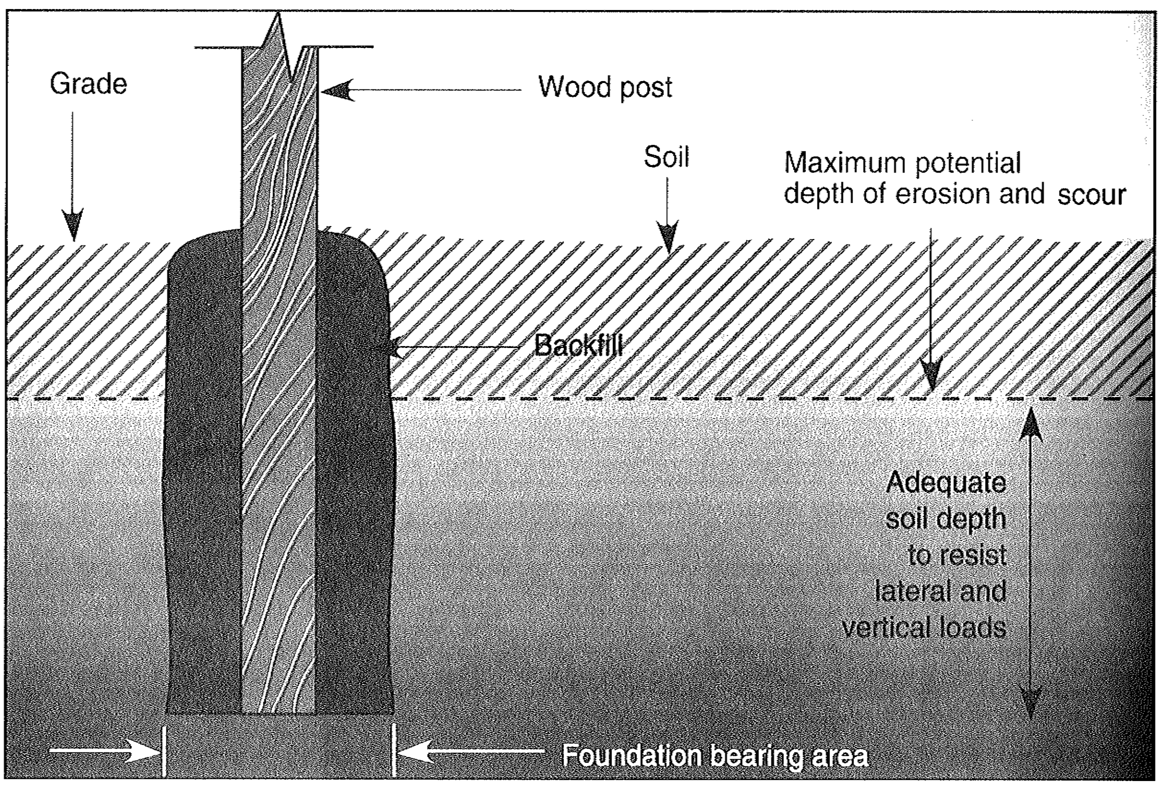

Figure 3-5 *Post on earth bearing. Soil depth below maximum potential depth of scour is adequate to withstand lateral and vertical loads during the base flood (after FEMA 1993a).*

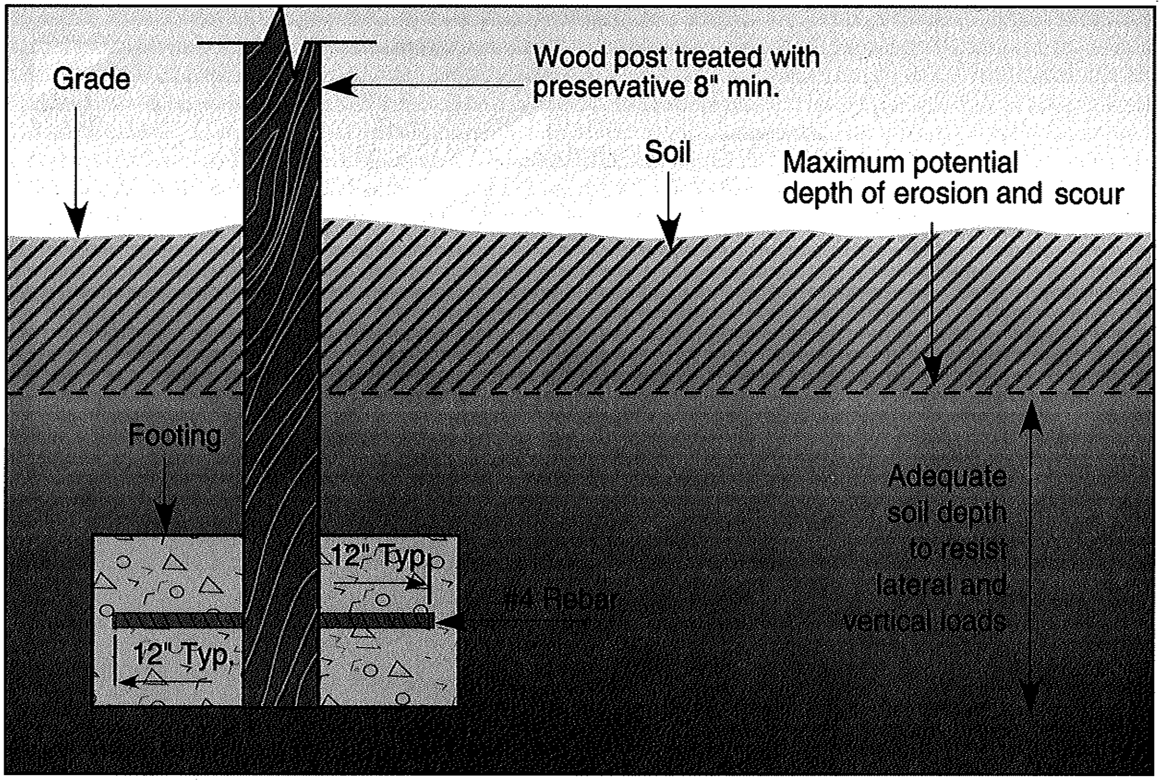

Figure 3-6 *Anchorage of post. Soil depth below maximum potential depth of scour is adequate to withstand lateral and vertical loads during the base flood (after FEMA 1993a).*

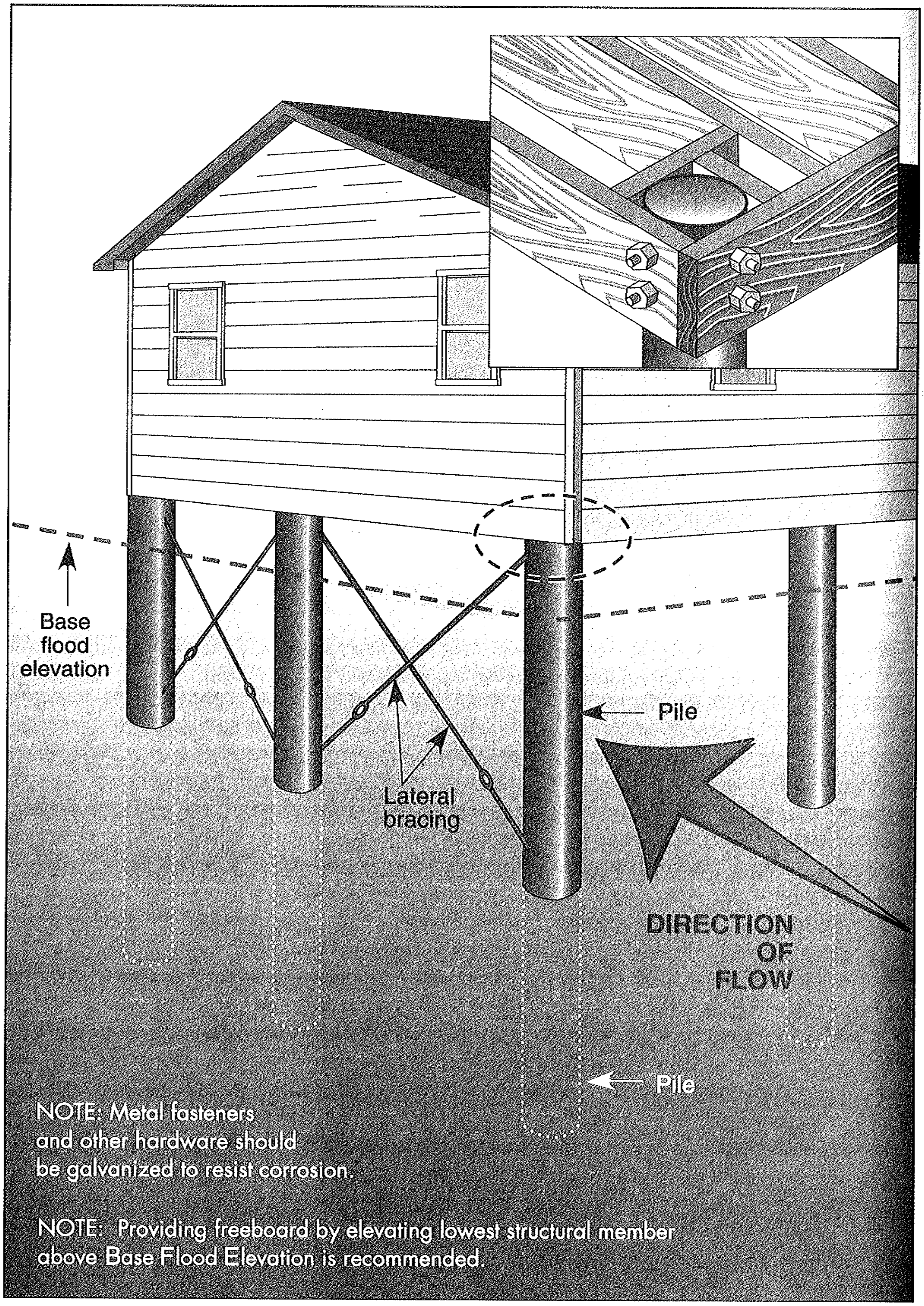

Figure 3-7 *Piles are mechanically driven into the ground and are therefore less susceptible to high-velocity flooding, erosion, conical scour, and pullout. Where possible, lateral bracing should be oriented parallel to the anticipated flow path (FEMA 1993a).*

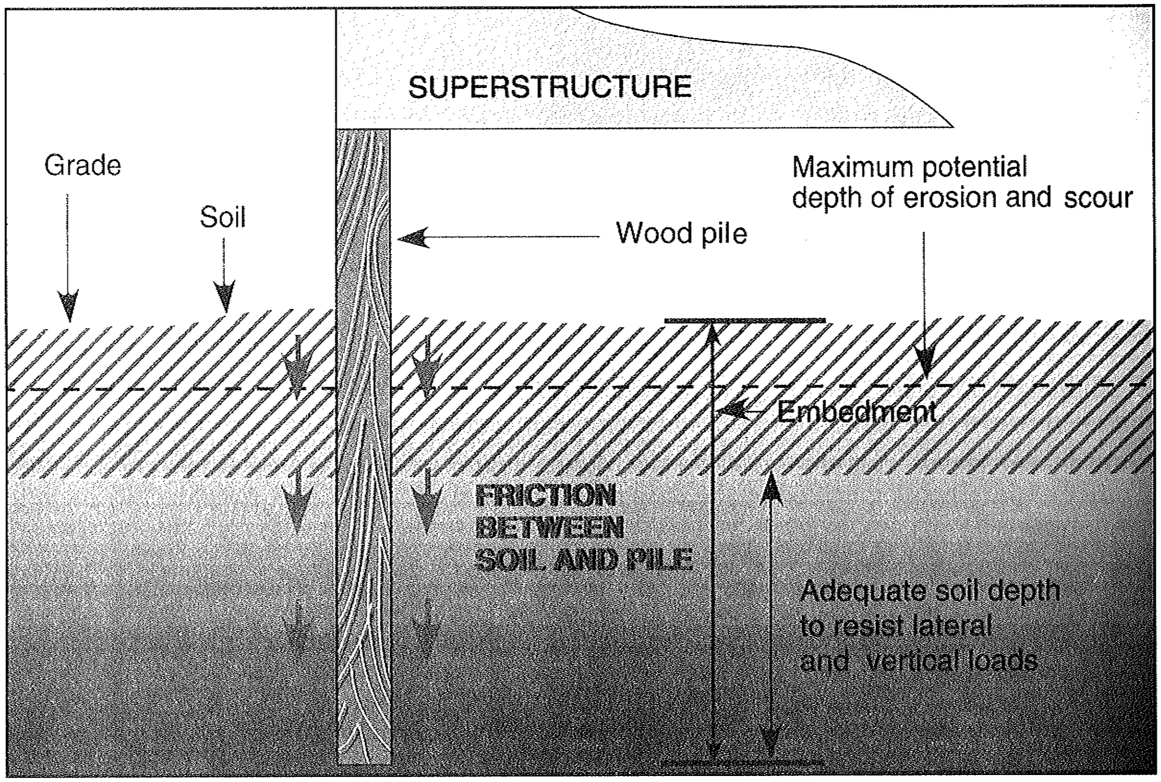

Figure 3-8 *The depth of pile embedment provides stability by enabling the pile to resist lateral and vertical loads through passive earth pressure . Soil depth below maximum potential depth of scour is adequate to withstand lateral and vertical loads during the base flood (after FEMA 1993a).*

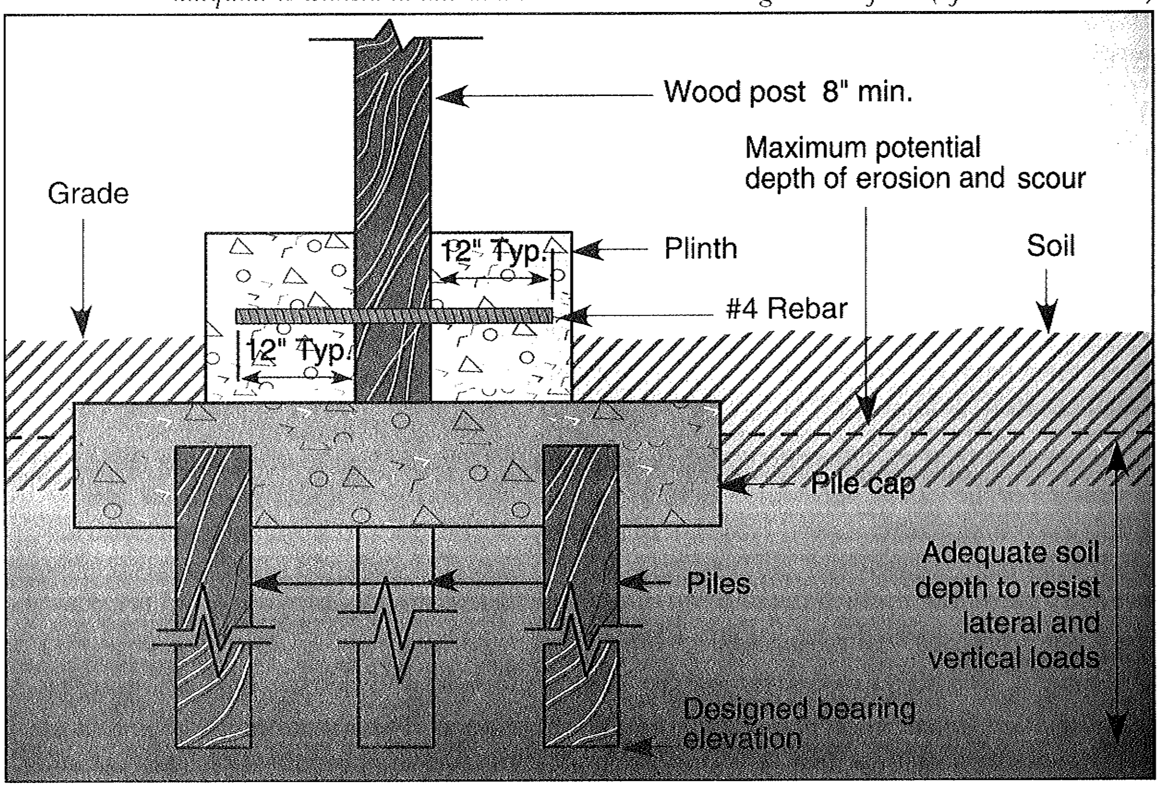

Figure 3-9 *Post/pile foundation. Soil depth below maximum potential depth of scour is adequate to withstand lateral and vertical loads during the base flood (after FEMA 1993a).*

3.5.3 Framing Systems

Framing systems should be designed to support all anticipated loads, and any cutting of holes for electrical lines, ductwork, or plumbing piping must be in accordance with code requirements. Framing systems should not be compromised by the excessive or improper drilling or cutting of holes. If such drilling or cutting is necessary, additional support may be required to return the structure to its design strength. It is also important that proper bracing and fire stops be included.

3.5.4 Connections

All metal connectors should, at a minimum, be constructed of hot-dip galvanized steel and should conform to the Standard Building Code specifications; the guidance provided in FEMA's Technical Bulletin 8-96, *Corrosion Protection for Metal Connectors in Coastal Areas* (FEMA 1996); and any other requirements specified by the design professional of record. Metal connectors include the following:

- wood-to-wood anchors and angles, caps and bases, hangers, and structural connectors
- wood-to-masonry foundation straps, masonry hangers, purlin anchors, plates, tension ties, truss anchors, and brick anchors
- wood-to-concrete anchors and holddowns; bases for beam seats, post bases, and truss seats; hangers; and wedge shims.

Wood should not be used as a shim material since it is subject to compression and may lead to connection failure; instead, metal, brick, or mortar can be used.

3.5.5 Bracing

It is preferable that structures be designed with deep foundations to withstand all anticipated loads without reliance on bracing. However, where used to provide additional stiffening, bracing should consist of hot-dip galvanized steel rods threaded on both ends and joined in the center with a turnbuckle (see Figure 2-10). Alternatively, wood bracing can be used if it is properly designed and attached to piles with bolts. All bracing should be designed as part of the structure by the designer to survive hydrodynamic and debris impact forces generated by the base flood.

3.5.6 Breakaway Construction, Free-of-Obstruction, and Enclosure Requirements Under the NFIP

In general, recently constructed breakaway walls in Coastal High Hazard Areas (V-Zones) and seaward of the CCCL performed well. However, State and local building officials and floodplain administrators should be aware of and should prevent two problems noted during post-Opal damage assessments: (1) breakaway walls attached to walls and other structure elements above the lowest floor and (2) attachment of utility lines and similar components to breakaway walls. In accordance with V-Zone requirements:

- Breakaway walls and panels below an elevated structure must be separate and distinct from walls and construction above the lowest floor elevation. These sections are intended to break free and must be able to do so without damaging upper walls, sheathing, cladding, and other components.

- No wiring, conduits, plumbing, or utility components may be placed behind or fastened to breakaway walls or panels.
- Areas below an elevated building should be designed and constructed in accordance with FEMA's Technical Bulletin 5-93, *Free-Of-Obstruction Requirements for Buildings Located in Coastal High Hazard Areas* (FEMA 1993c).

Figures 3-10 and 3-11 show recommended designs for breakaway wall systems.

3.5.7 Stairs, Decks, and Porches

These structures are frequently damaged by floods and storms. Much of this damage can be prevented by the application of a few simple techniques:

- Support elevated decks on piles rather than posts or piers. If a pile foundation is not used for the deck, use knee bracing connected to the foundation piles that support the main structure; however, do not notch the foundation piles to seat the knee bracing.
- Design and construct stairs to hinge at the top, so they can be raised prior to a storm.
- Design and construct fixed steps and walkovers with piles and sturdy structural members. Consider steps and horizontal decks to be sacrificial, and construct them so that they will break loose in small sections when acted on by flood forces.

3.5.8 Utilities

All utility components (including electric meters) should be located on the landward side of the structure and, according to NFIP requirements for V-Zones, must be elevated to or above the BFE and anticipated flood level (including wave effects and runup) whenever possible. In A-Zones, utilities may be below the BFE provided that the CCCL requirements are also adhered to. Utility components below the BFE should be contained in floodproof enclosures. Figures 3-12 and 3-13 show recommended designs for mechanical platforms .

3.5.9 Seawalls and Erosion Control Structures

Although permitted in many states and jurisdictions, seawalls, bulkheads, and other erosion control structures should not be relied on to contain soil required for support of a habitable structure. The structure should be supported on a foundation that can withstand or accommodate erosion and loss of support.

Where used, seawalls, bulkheads, and erosion control devices should be designed to resist failure due to wave and flood forces, overtopping, undermining, and debris impact. Wing walls or return walls should extend landward to a point beyond that affected by storm-induced erosion.

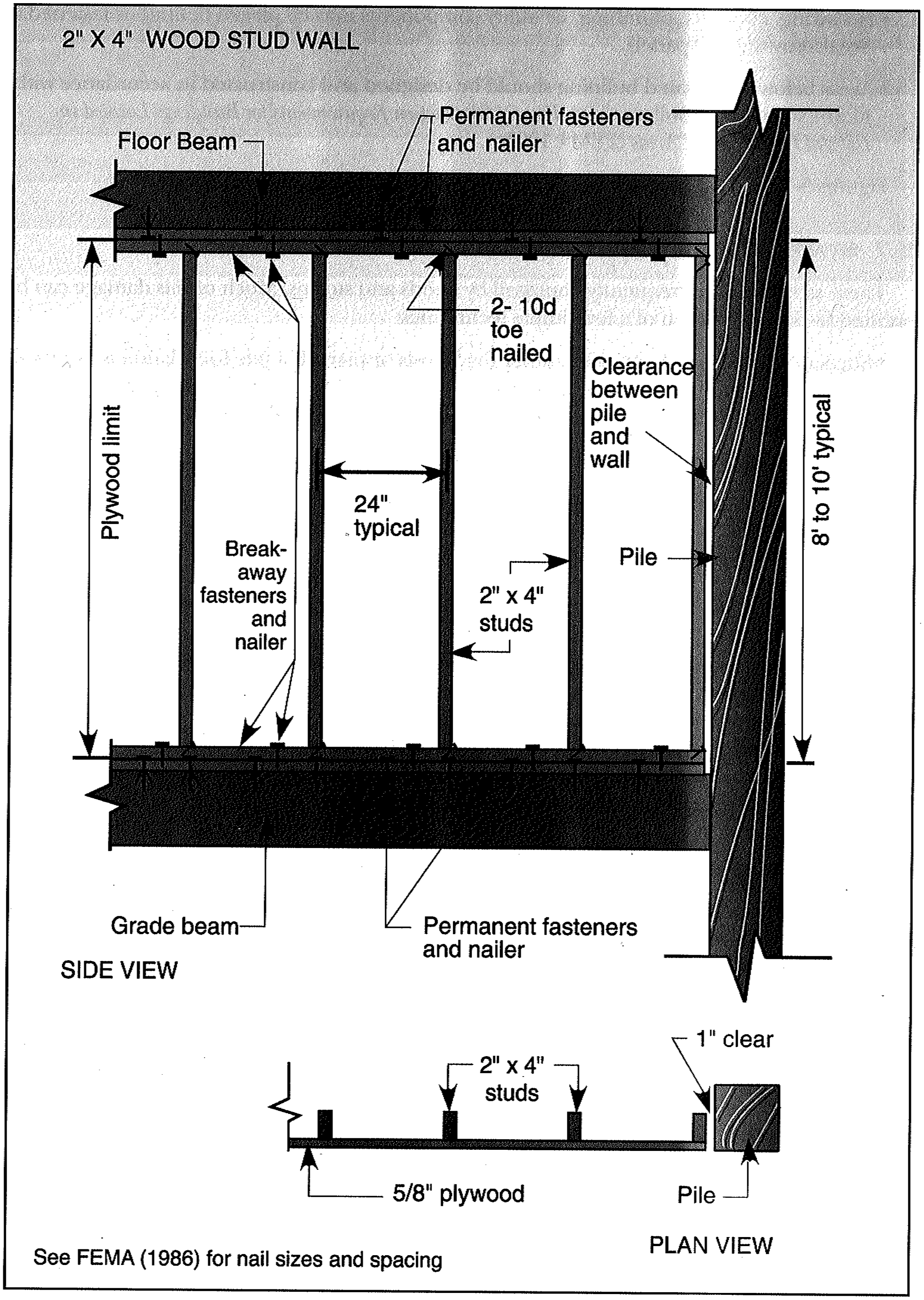

Figure 3-10 *Wood stud breakaway wall (after FEMA 1986).*

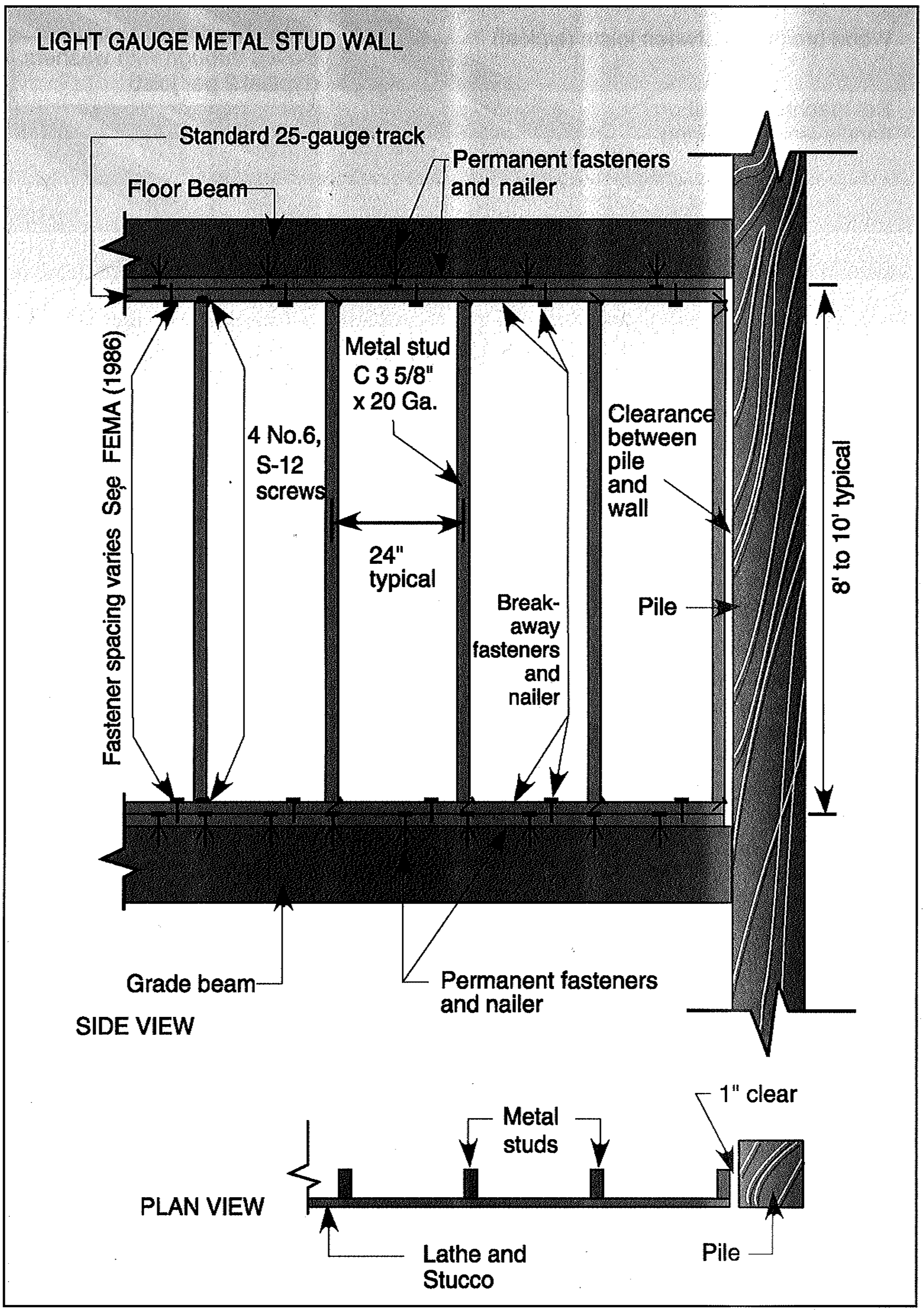

Figure 3-11 Light-gauge metal stud breakaway wall (after FEMA 1986).

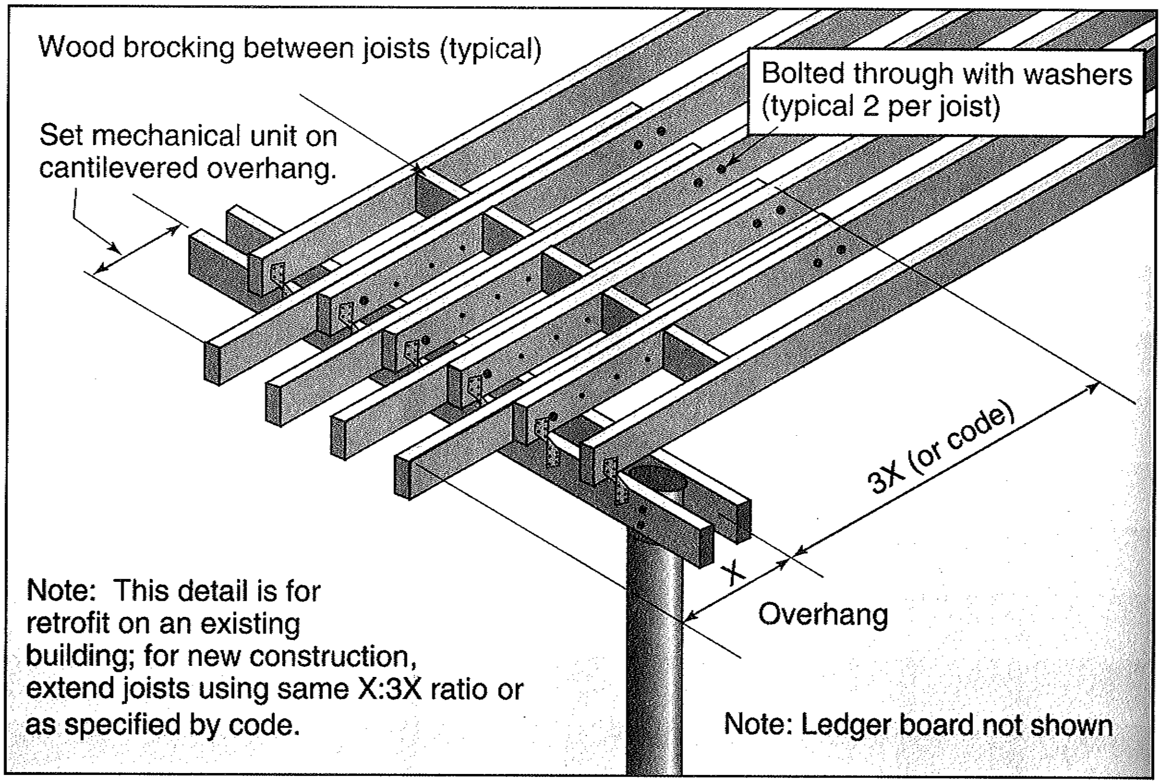

Figure 3-12 Installation of cantilevered floor joists as a retrofit for an elevated home to allow for a mechanical balcony.

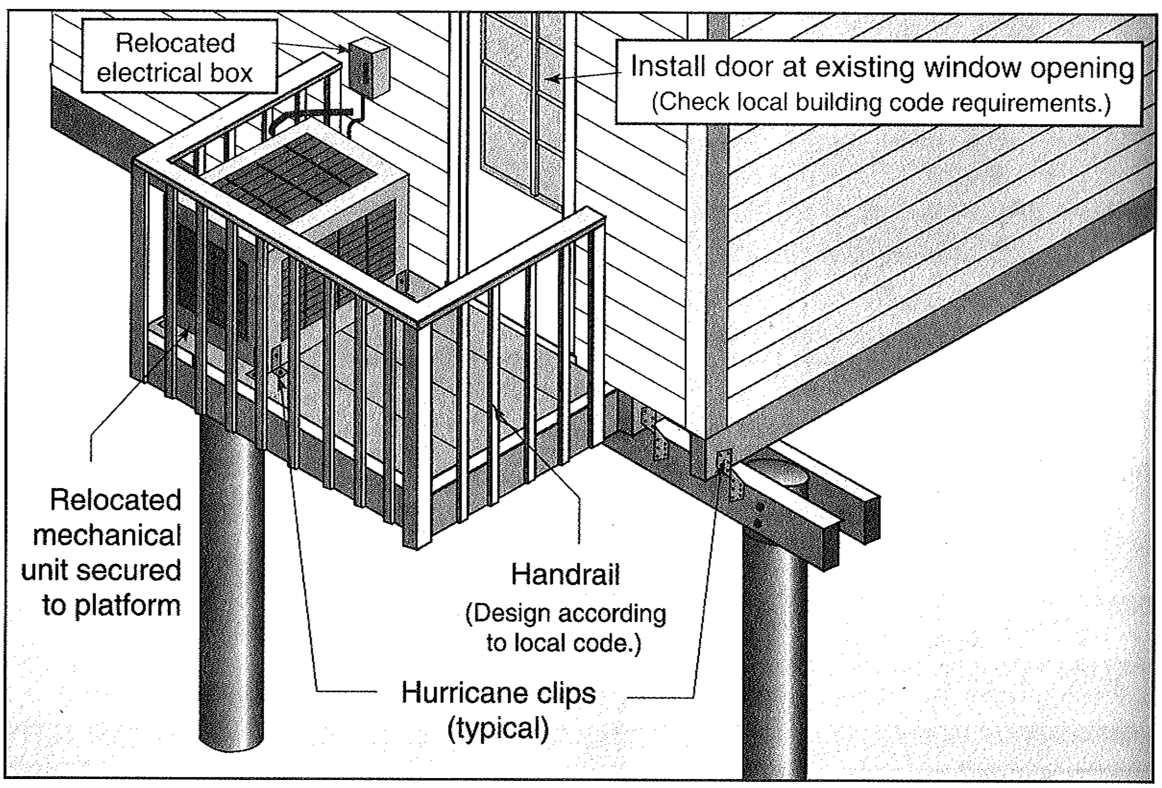

Figure 3-13 Installation of a mechanical balcony as a retrofit for an elevated home.