

## 4.0 RECOMMENDATIONS

There were noteworthy examples of buildings properly designed and constructed in compliance with current Codes that suffered little to no damage. However, there was also overwhelming field evidence to suggest the existence of certain deficiencies in past design and construction practices in Kauai County permitted under older versions of the Code. Much was learned from these deficiencies and associated building failures. Likewise, much was learned from some fine examples of properly designed and constructed buildings that suffered little to no damage. In the wake of Hurricane Iniki, during repair/ retrofit activities and new construction in Kauai County, it is important that lessons learned be applied in a positive, forward-looking manner.

Therefore, the following recommendations are offered by the Building Performance Assessment Team. Consideration of these recommendations should be viewed as a shared responsibility, with leadership provided by Kauai County and assistance provided by Federal and State Governments and the private sector. Adoption of these recommendations, whether in part or in full, will require certain changes in administrative practices by the Kauai County government; others will require changes in the way that structures are designed and constructed by people in the building industry. Many of the recommendations can be accomplished through basic training and education with minimal increase in construction costs.

### 4.1 FLOODPLAIN MANAGEMENT AND FLOOD DAMAGE

- The single most important mitigating action to reduce future flood damages would be to properly administer NFIP requirements for new construction and the repair of buildings substantially damaged by Hurricane Iniki. These requirements are presently contained in the Floodplain Management provisions of the Kauai County Zoning Ordinance.

- In accordance with NFIP requirements and the Kauai County Zoning Ordinance, all new construction and repair of substantially damaged buildings in Coastal High Hazard Areas along Poipu Beach, Hanalei, and other areas (in addition to all riverine flood hazard areas designated on the FIRM) must be elevated above anticipated flood heights (FIGURE 60) and constructed with proper foundations (FIGURES 61-76).
- For future construction in coastal flood hazard areas, special consideration should be given to the depth of structure foundations relative to the maximum potential depth of erosion that will be caused by flood waters. Piers, posts, and columns should be embedded deep into unconsolidated sediment or, preferably, socketed into the natural lava rock deposits so that the foundation will not be undermined. (FIGURES 60, 62-65, 68-73, 75, and 76).

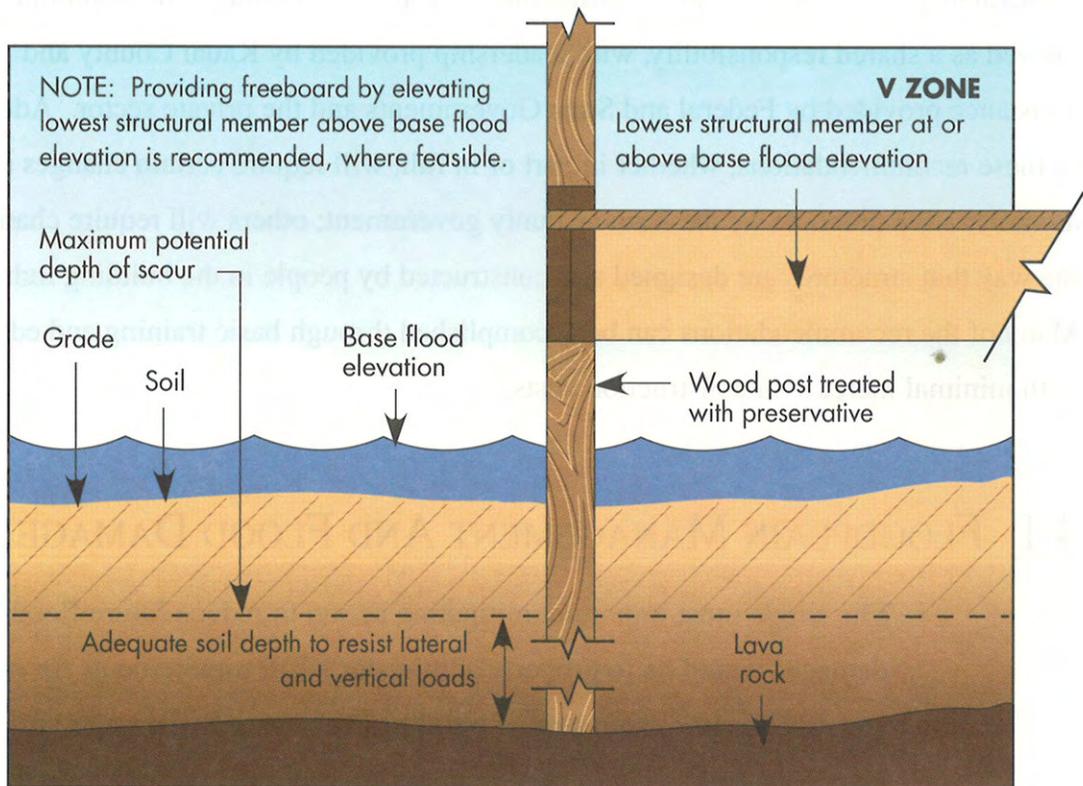


FIGURE 60. NFIP requirements for elevated foundations in V zones.

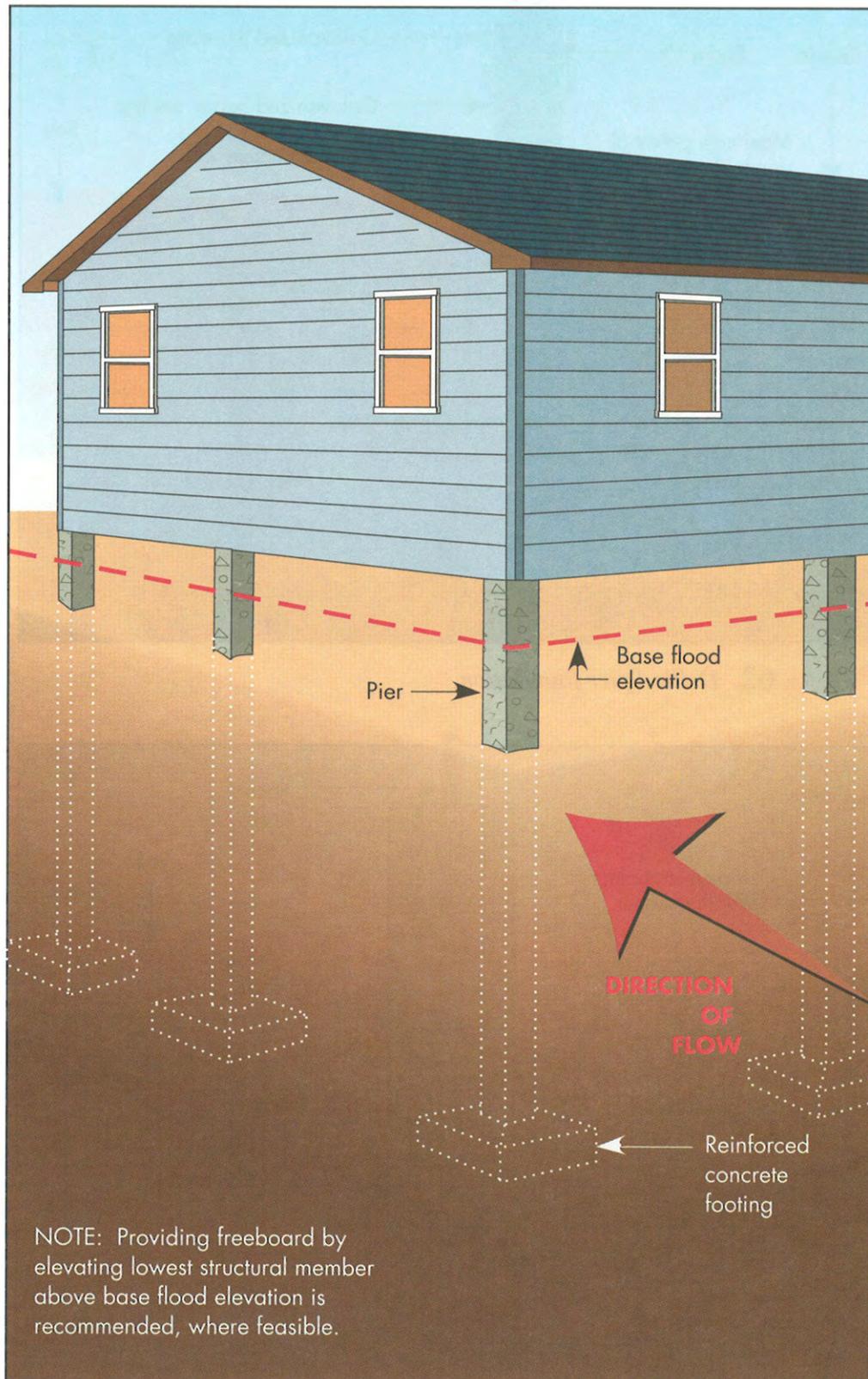


FIGURE 61. One method of support for piers is a reinforced concrete footing.

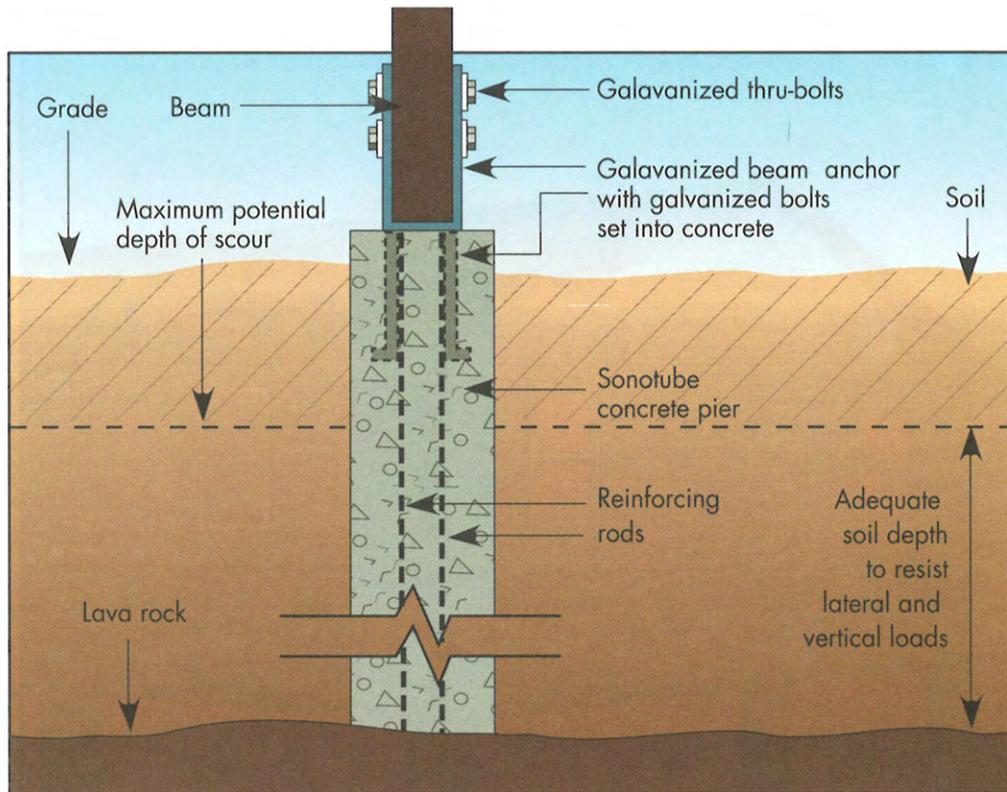


FIGURE 62. Drilled pier foundation.

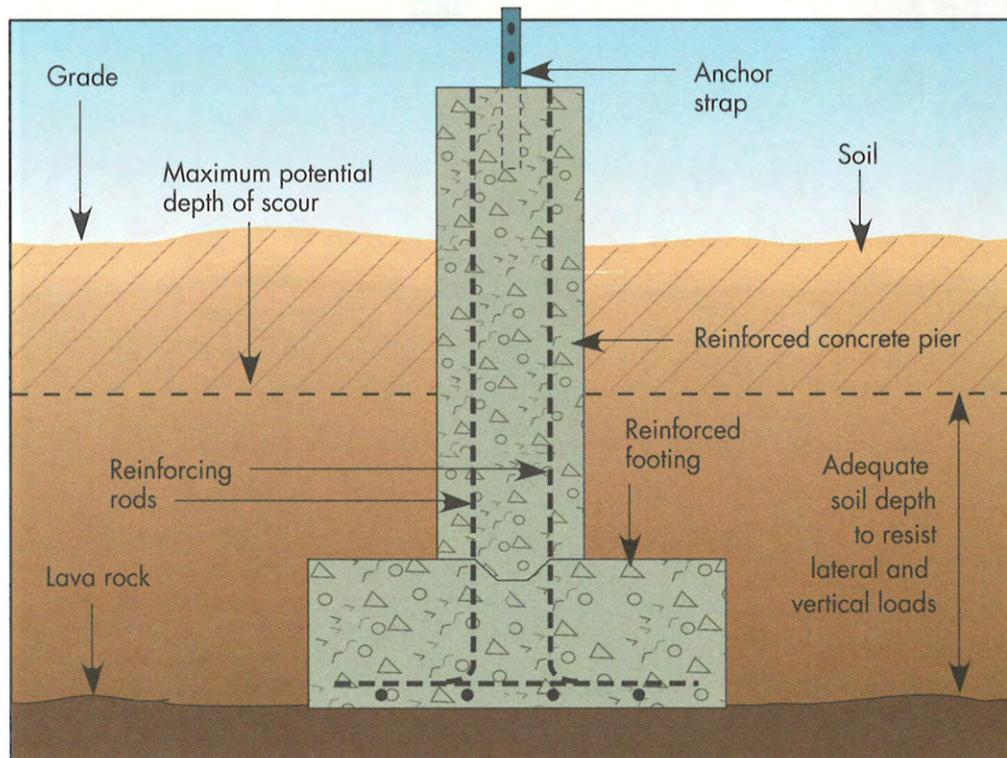


FIGURE 63. Reinforced concrete pier.

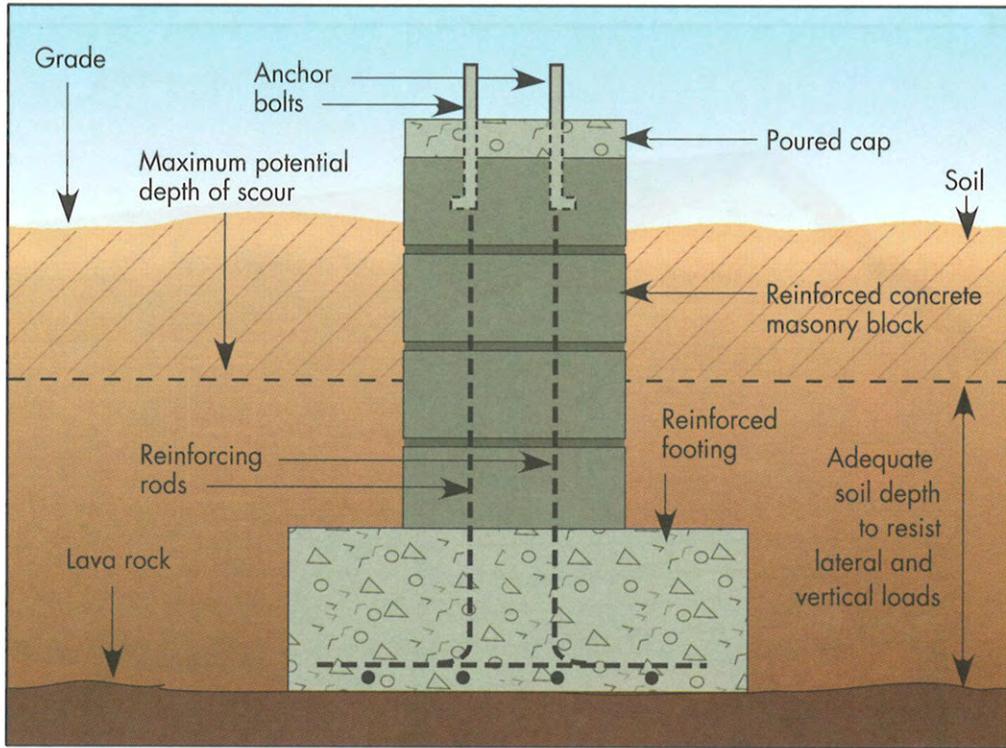


FIGURE 64. Reinforced concrete masonry pier.

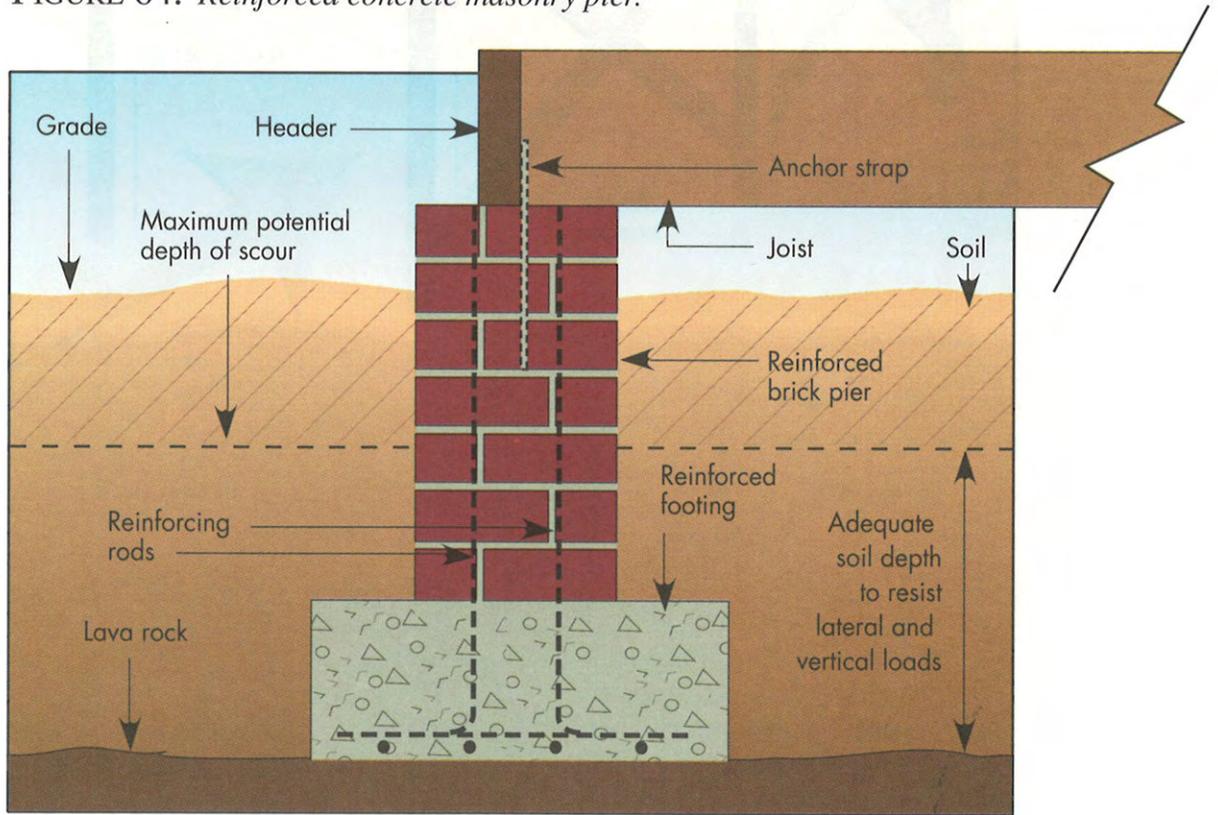


FIGURE 65. Reinforced brick pier.

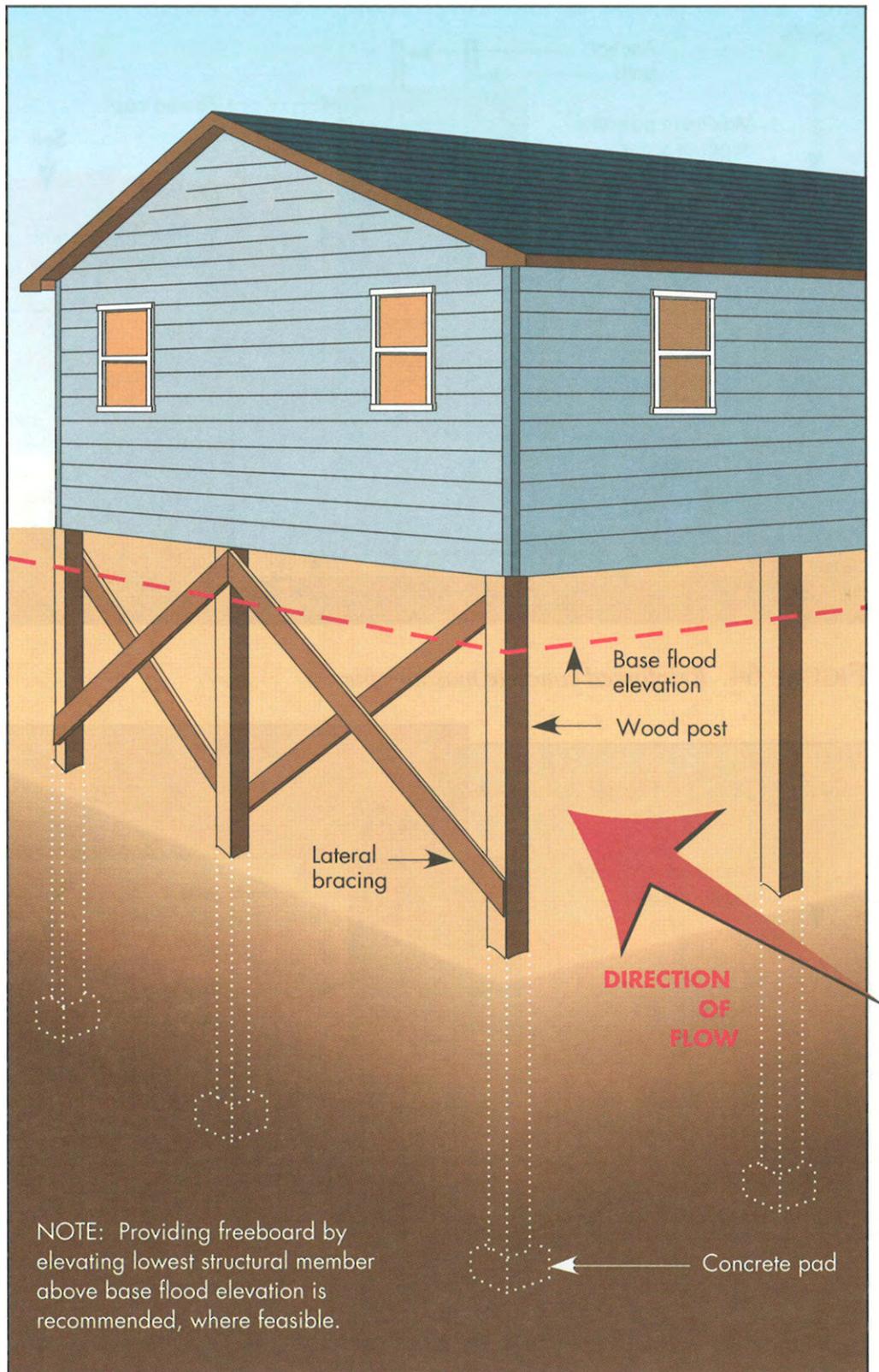


FIGURE 66. Posts are placed into pre-dug holes and may be anchored in a concrete pad at the bottom of the hole. Lateral bracing should be oriented parallel to anticipated flow path.

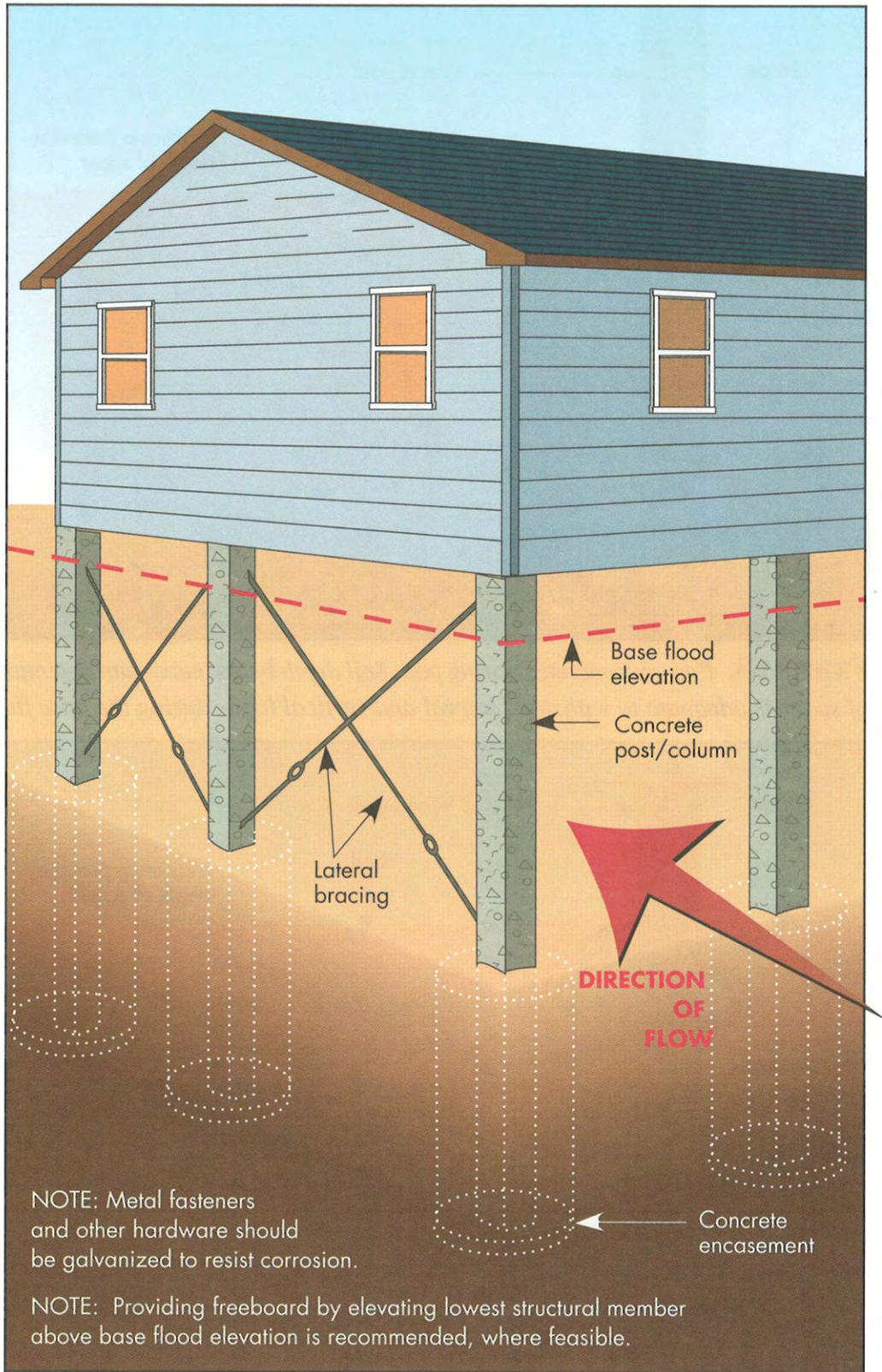


FIGURE 67. Posts can also be anchored in concrete encasements.

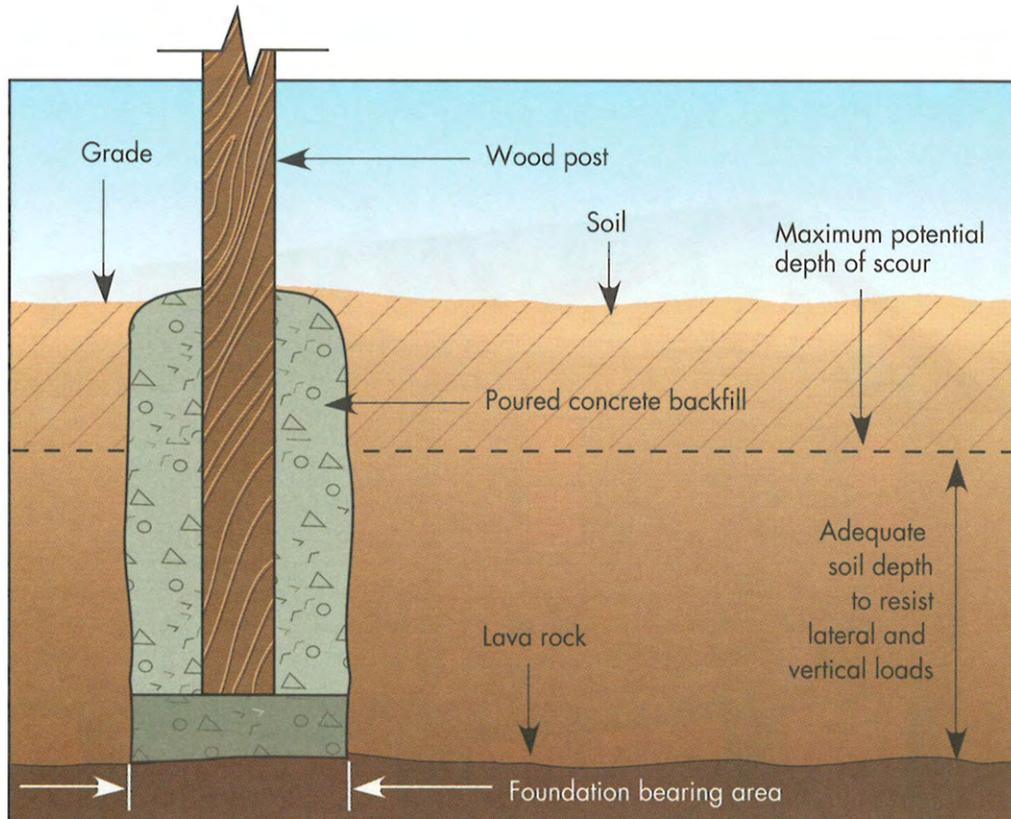


FIGURE 68. Post on concrete bearing pad. Soil depth below maximum potential depth of scour is adequate to withstand lateral and vertical loads during the base flood.

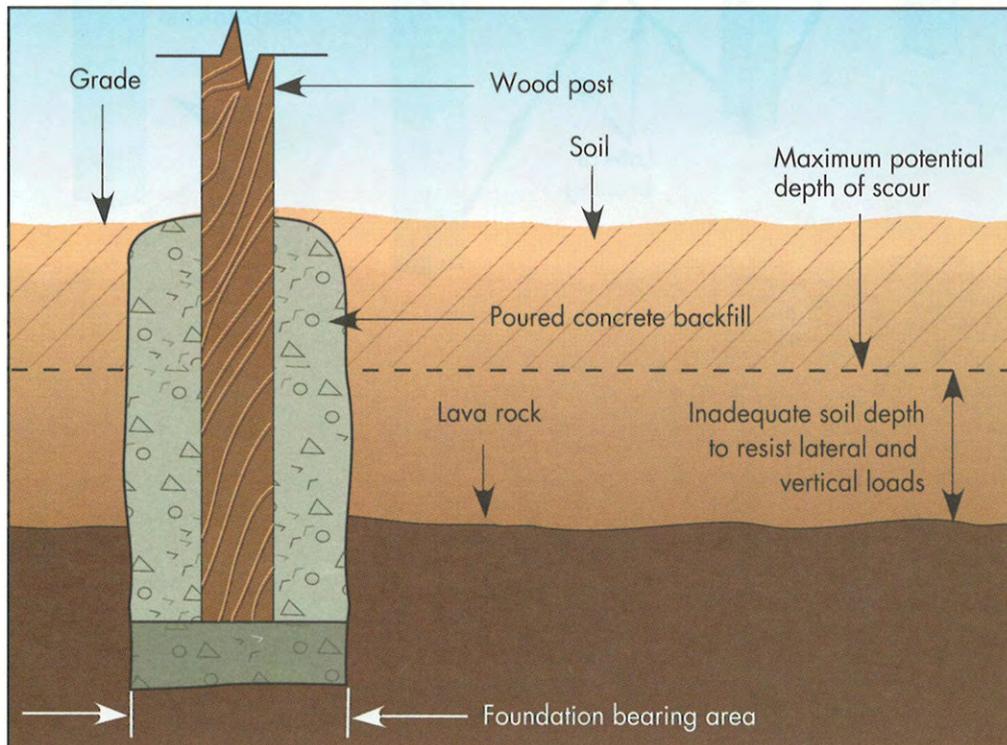


FIGURE 69. Post on concrete bearing pad. Where soil depth below maximum potential depth of scour is inadequate to withstand lateral and vertical loads during the base flood, bottom of concrete should be socketed into lava rock for increased load resistance.

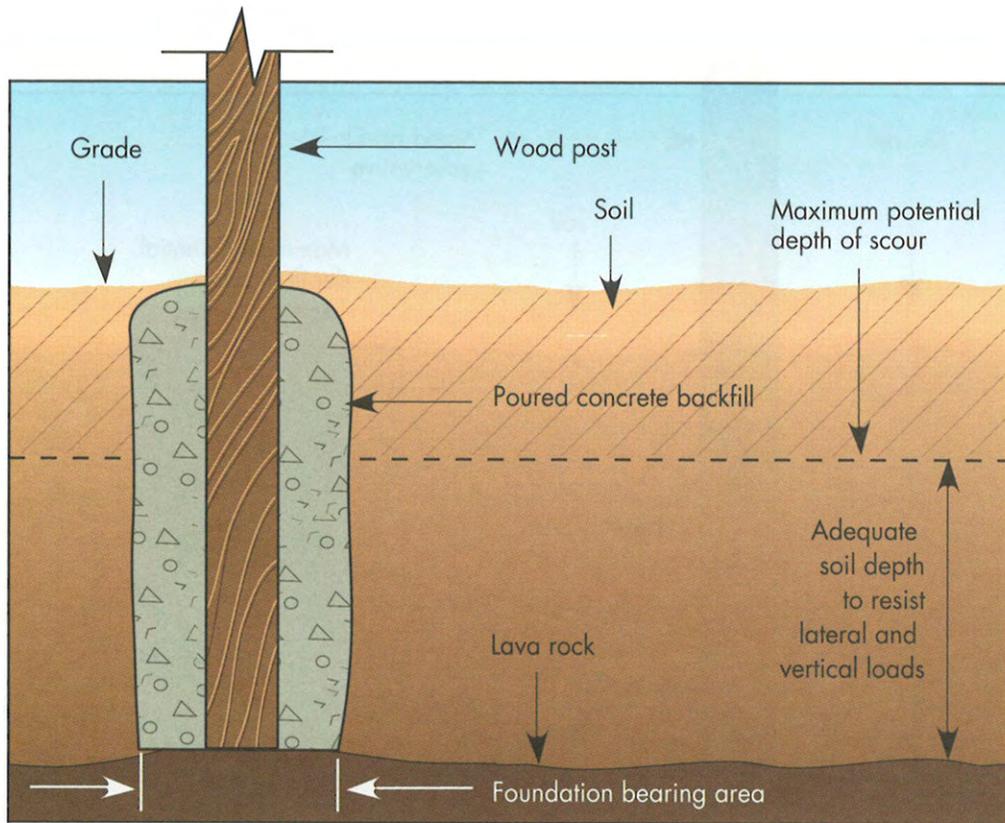


FIGURE 70. *Post in concrete backfill.*

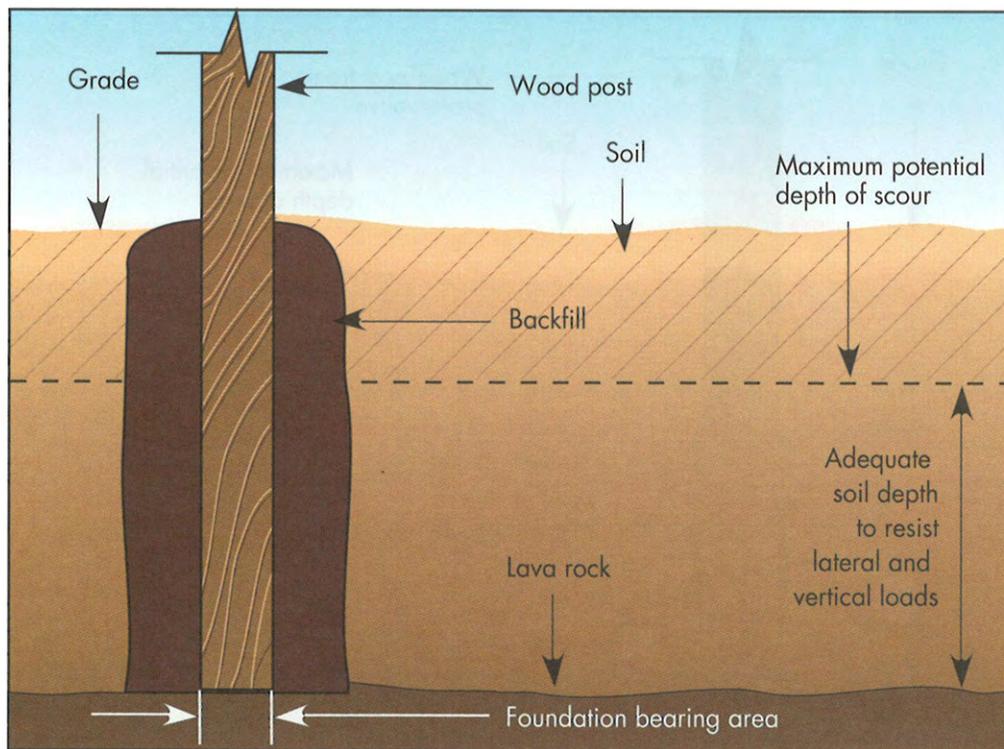


FIGURE 71. *Post on earth bearing.*

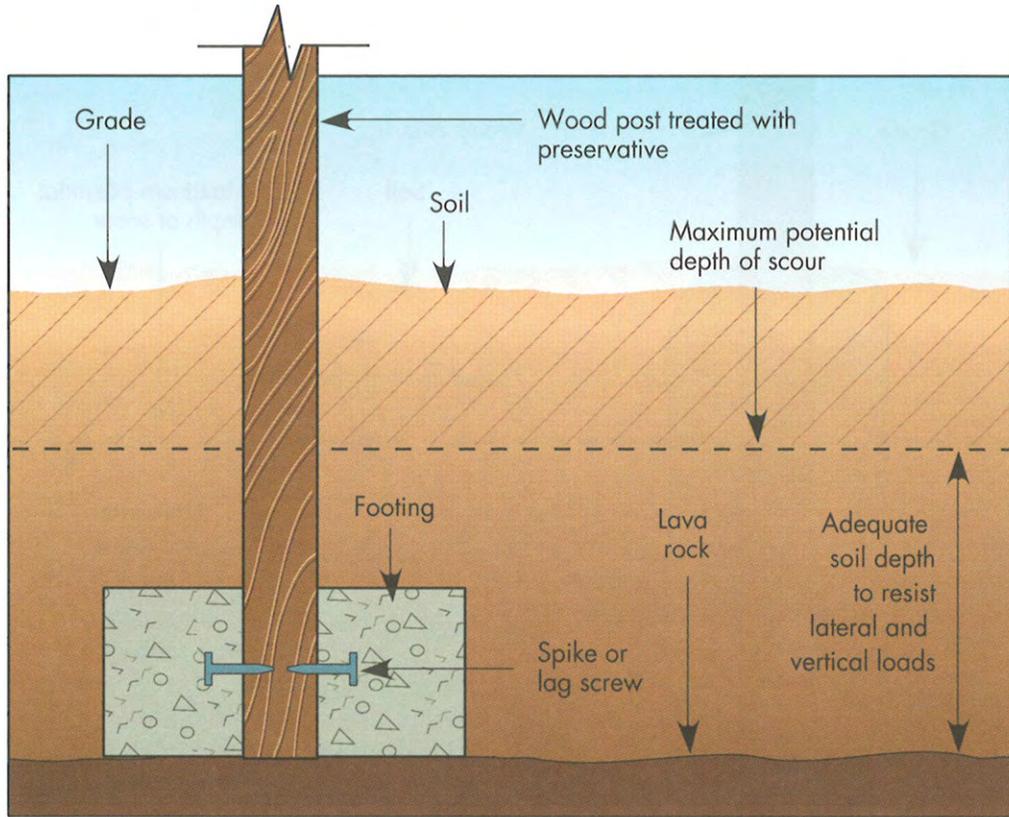


FIGURE 72. Spike anchorage of post.

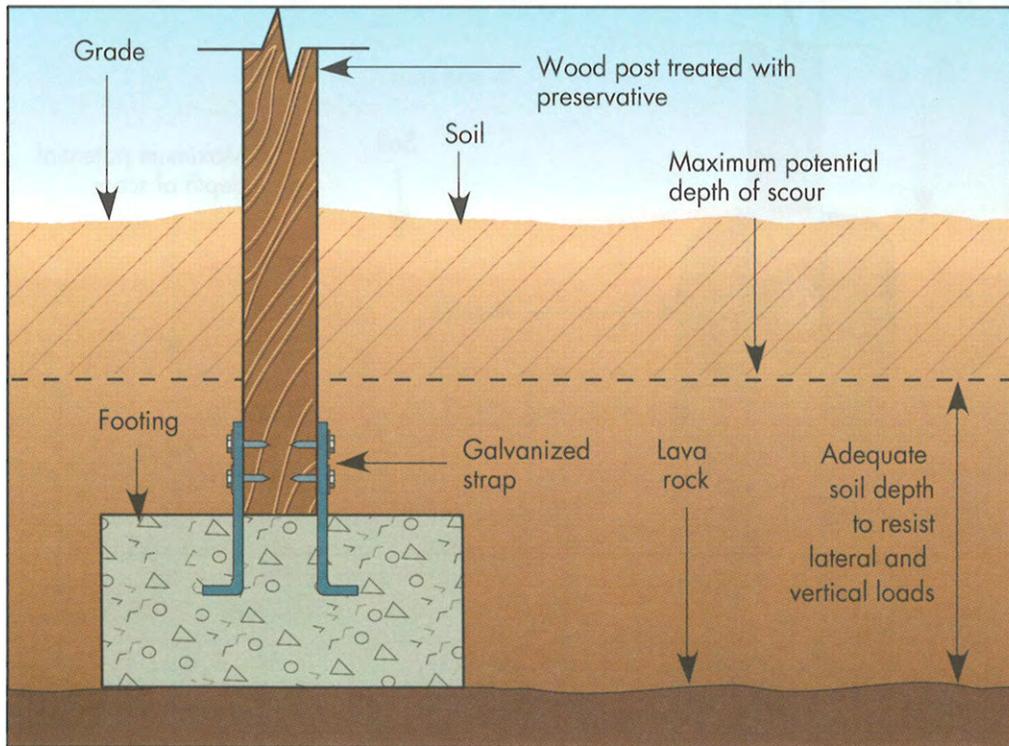


FIGURE 73. Galvanized strap anchorage of post.

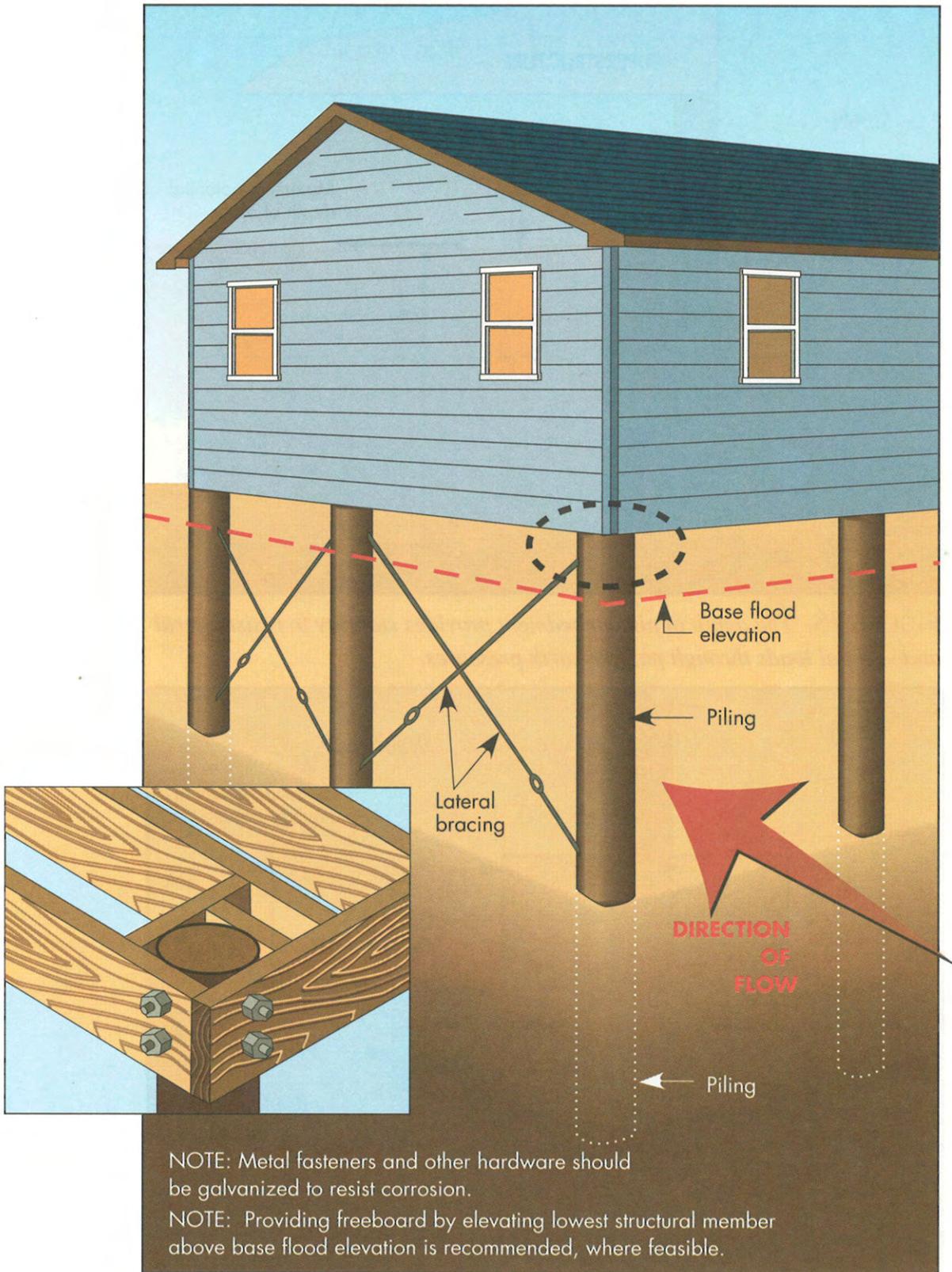


FIGURE 74. Pilings are mechanically driven into the ground, making them less susceptible to velocity flooding, scour, and pullout.

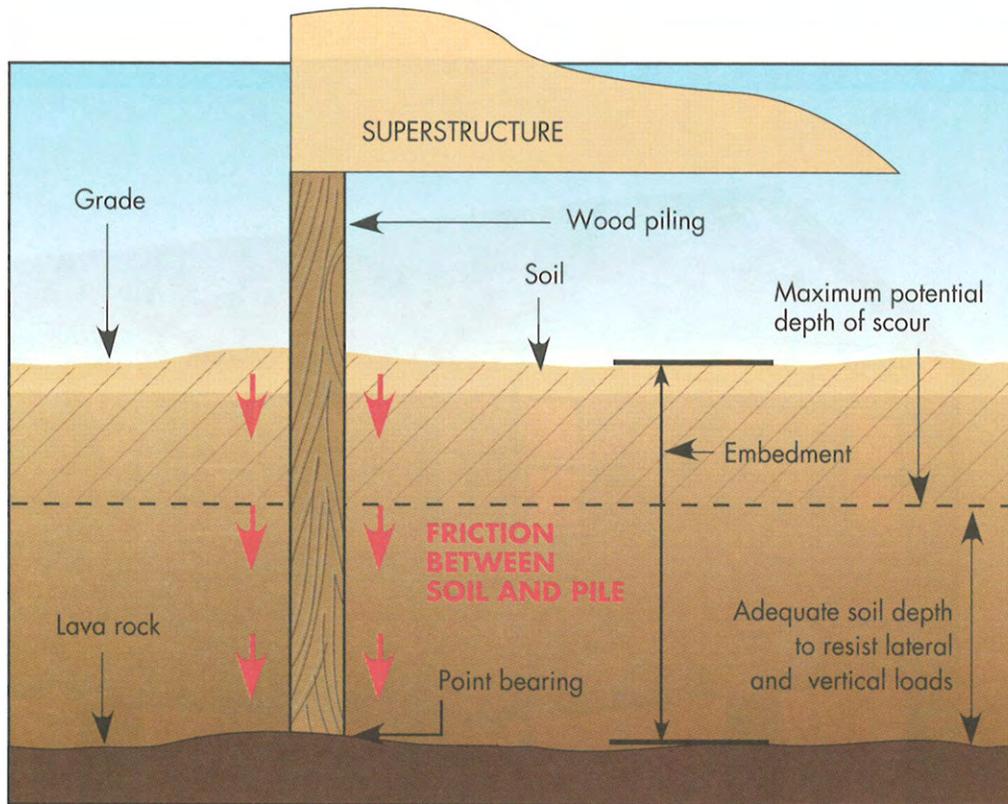


FIGURE 75. The depth of pile embedment provides stability to resist lateral and vertical loads through passive earth pressures.

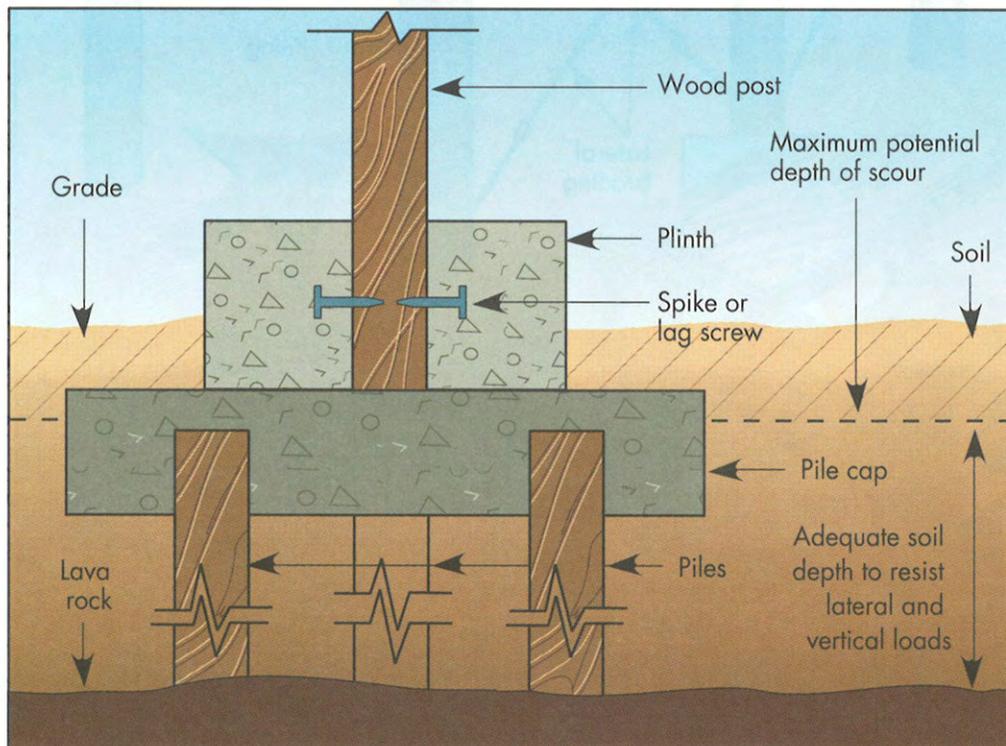


FIGURE 76. Post/pile foundation.

- In conjunction with NFIP requirements, future construction in areas subject to coastal flooding should be located as far back from the shoreline as is feasible or acceptable. This is based on the observed relationship between the distance a building was located from the shoreline and flood damage. The greater the distance, the less the damage due to dissipation of wave energy over the intervening area.
- FEMA and the State of Hawaii should provide technical assistance to Kauai County staff for administration of these NFIP requirements.
- FEMA, in cooperation with the State of Hawaii, Kauai County, and the local building industry, should sponsor a series of workshops in Kauai on floodplain requirements and prudent construction techniques in these hazardous areas. Such training and education will increase the knowledge base and awareness of business and homeowners, construction tradespeople, Engineers/Architects, supervisors, plan reviewers, and inspectors.
- The FIRM for Kauai County predicts flooding in coastal areas based on the threat of tsunamis. Along the south shore of Kauai, a hybrid system which also considers wave runup recorded from Hurricane Iwa (1982) is used to predict flood levels on the FIRM. However, in many areas along Poipu Beach, the flood elevations and penetration produced by Hurricane Iniki surpassed those designated on the FIRM. Therefore, in the short-term (1-3 years), Kauai County should consider adoption of a dual management approach for the design of floodplain construction in the Poipu Beach area. This pertains to new construction and the repair of substantially damaged buildings. The lowest floors of such buildings should be elevated to or above the flood elevations shown on the FIRM or those experienced during Hurricane Iniki, whichever are greater.

## 4.2 WIND DAMAGE AND WOOD-FRAME CONSTRUCTION

- The design and construction of properly engineered buildings, in compliance with the most current Code, which consider the continuous load transfer path from roof to foundation should be integrated at all levels and into all stages of the building process in Kauai County (FIGURES 77-80).
- Hurricane clips and straps, as key elements, must be used to help ensure the integrity of a structure's load path. Emphasis should be placed on the proper sizing, design, installation, and protective coating of these and other metal fasteners (FIGURES 74 and 81). (As noted previously, use of hurricane clips does not, in and of itself, ensure successful building performance).
- Emphasis should be placed on adhering to Code for nailing requirements in general, with special attention to roof and wall sheathing, top and bottom wall plates, and hurricane clips and metal fasteners.
- Additional structural ties at the ceiling line should be provided between large exterior walls and interior walls for large residential units to maintain integrity in the event of the loss of roofing.

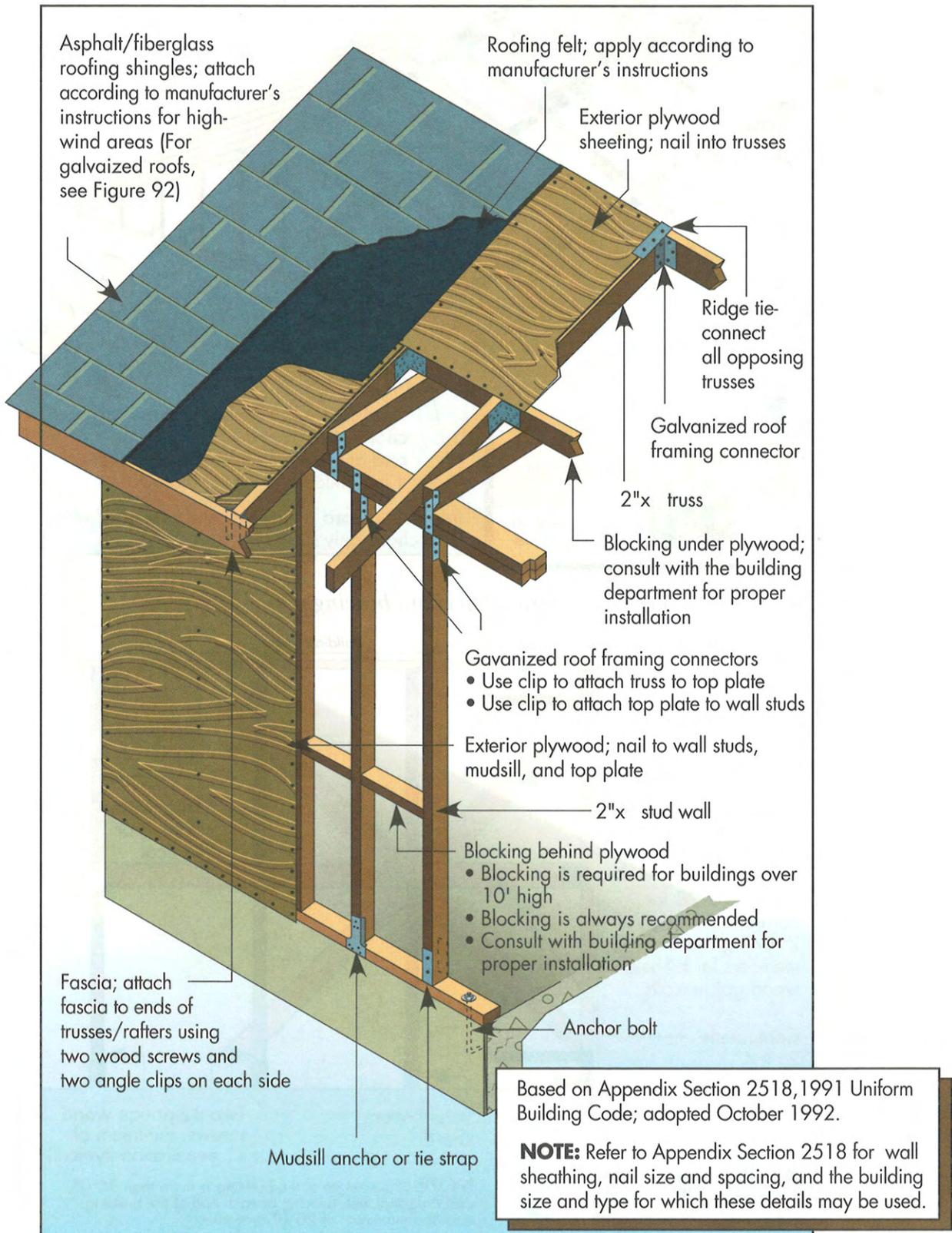


FIGURE 77. Recommended wood-frame construction.

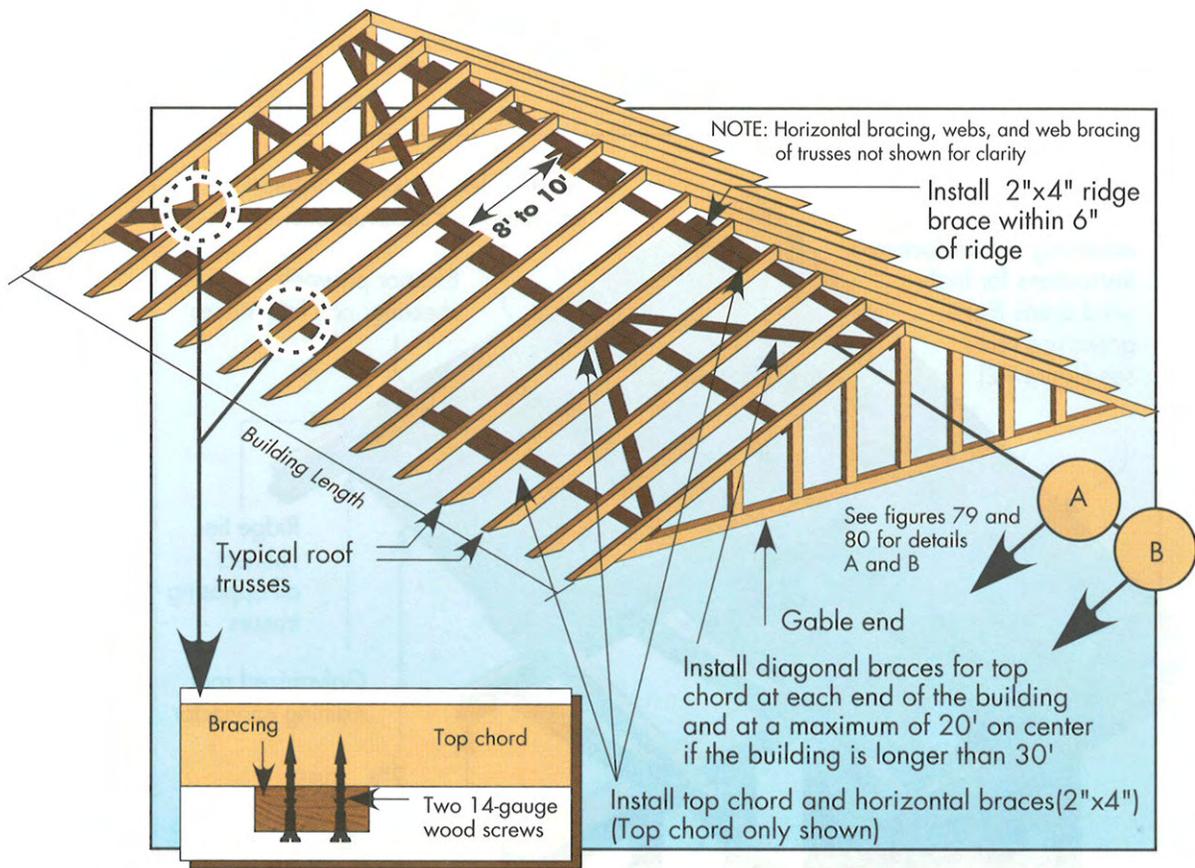


FIGURE 78. Typical roof truss top chord bracing.

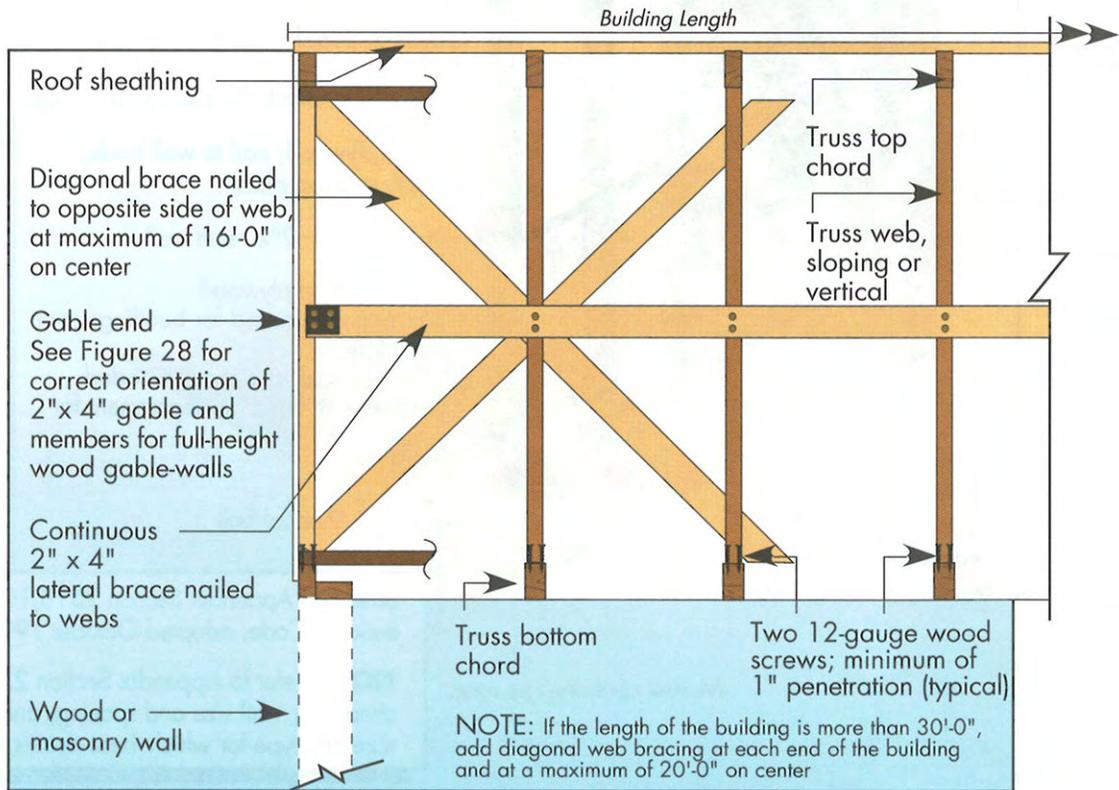


FIGURE 79. Detail A—Typical web bracing.

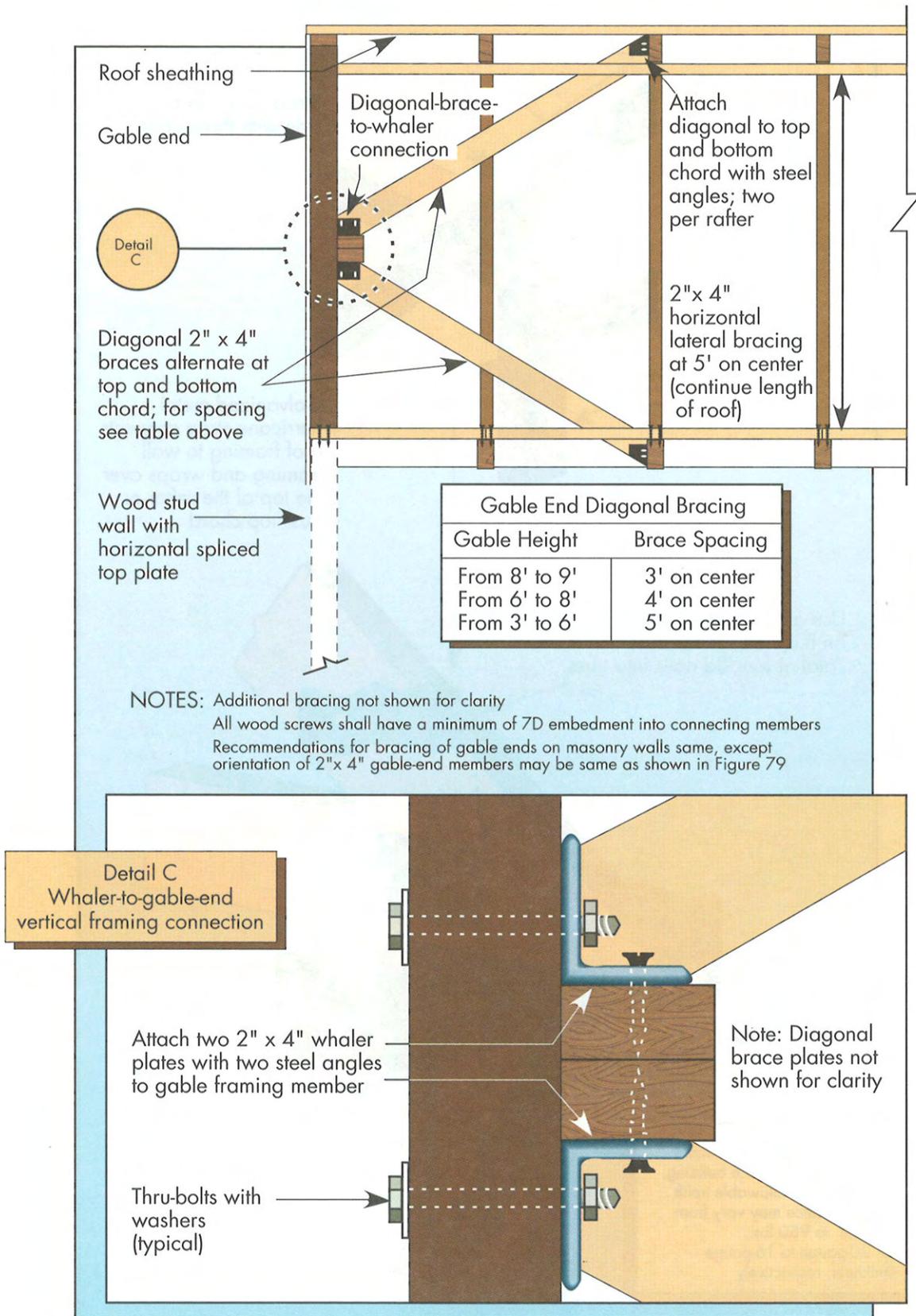


FIGURE 80. Detail B—Typical wood gable-wall bracing with nailed connections.

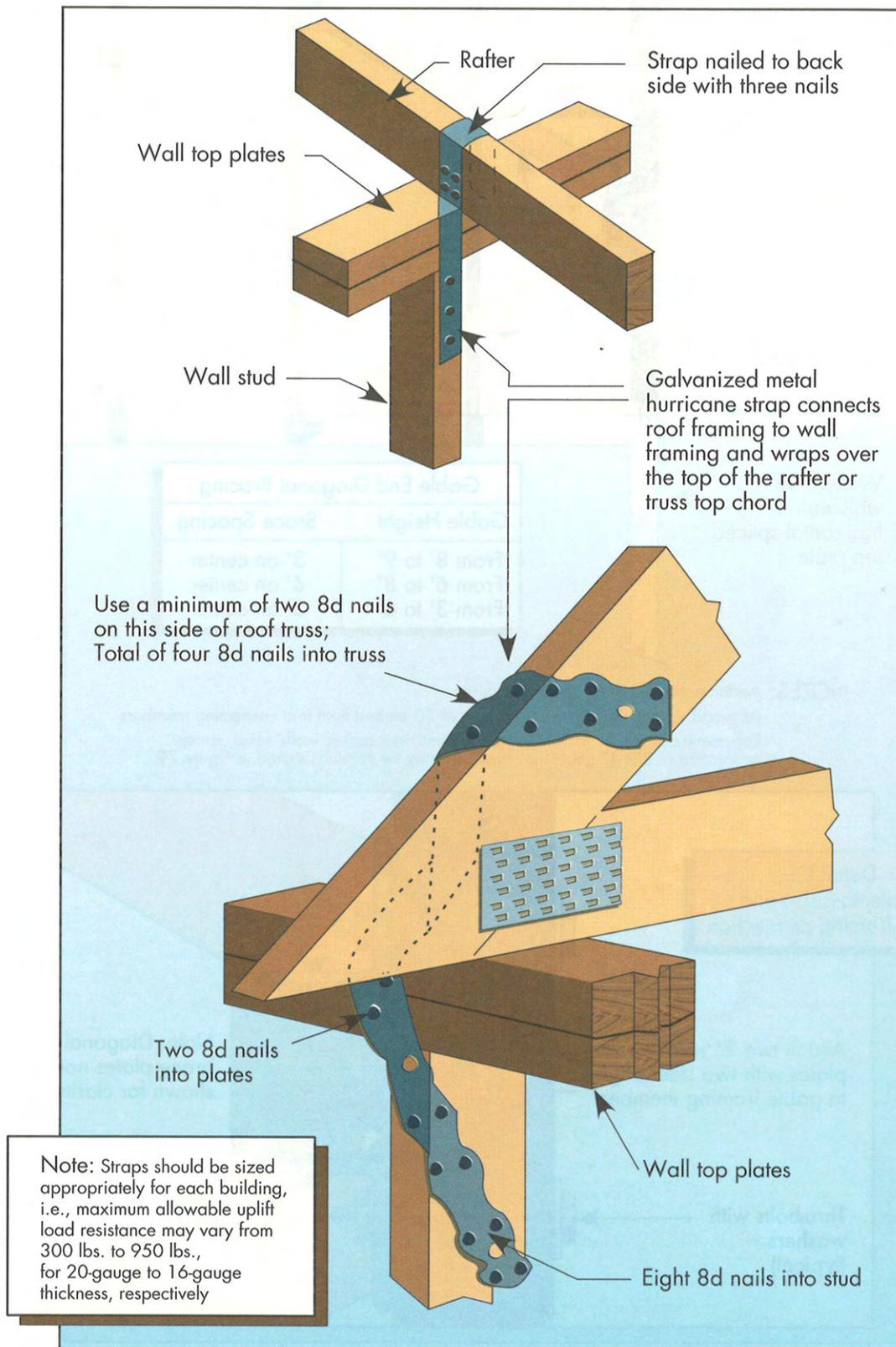


FIGURE 81. Typical hurricane strap to roof framing detail. Rafter or prefabricated roof truss.

- The design of more aerodynamic building shapes should be encouraged, where feasible. Substituting low-angled hip roofs for steep angled, gabled-end, and clearstory roofs, and other such designs would be particularly advantageous (FIGURES 82 and 83).

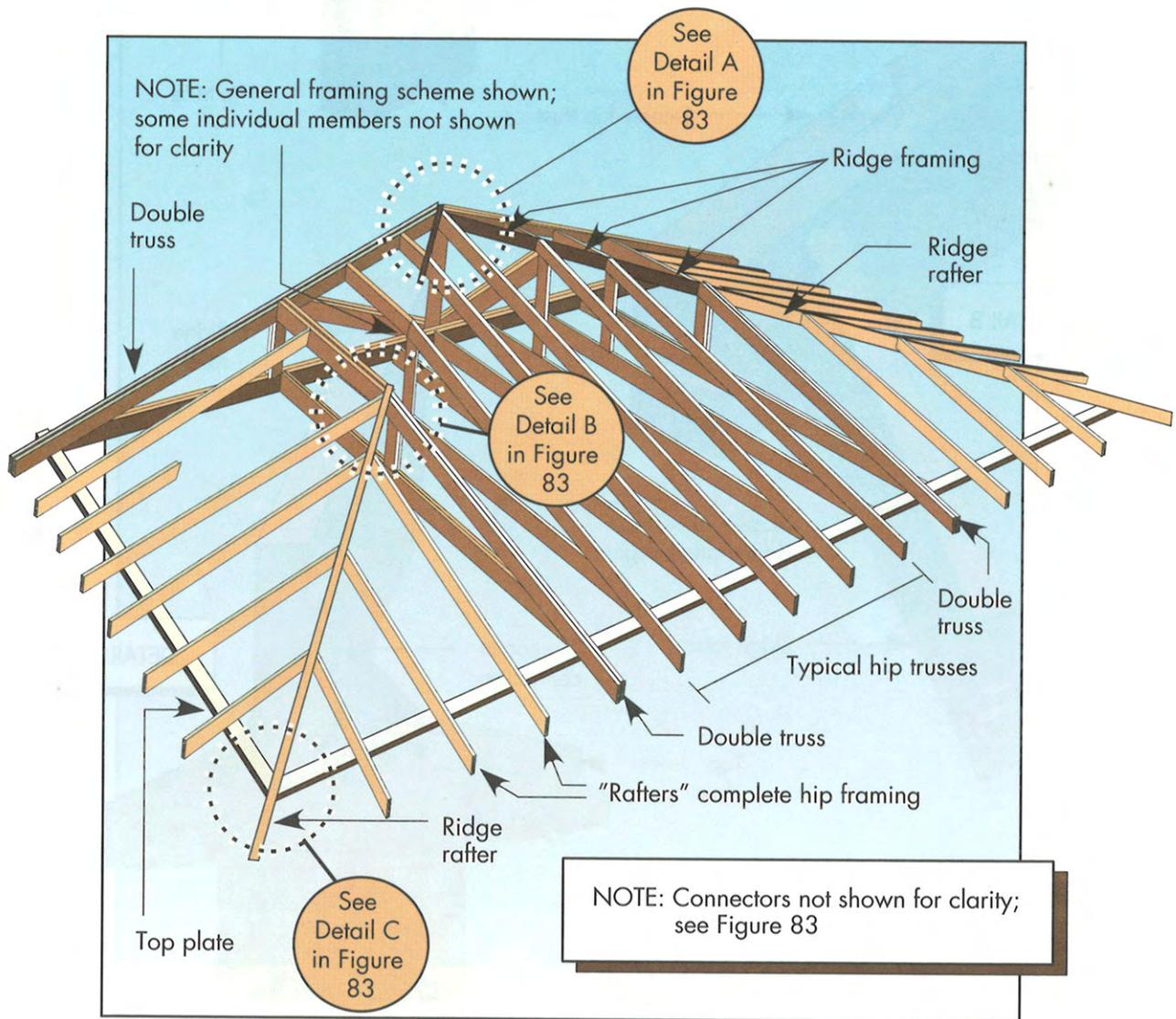


FIGURE 82. Recommended hip roof framing.

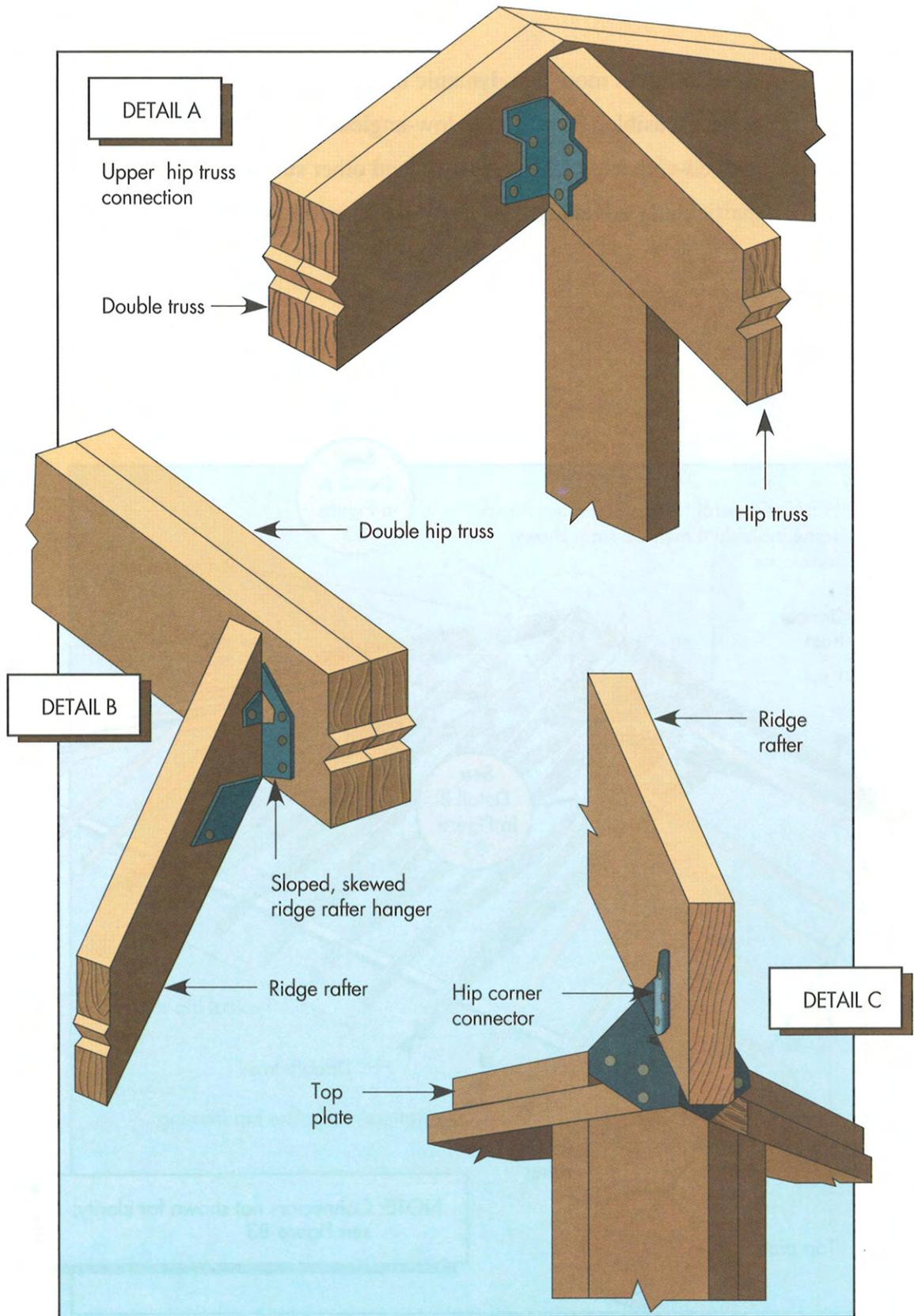


FIGURE 83. *Hip roof framing connectors.*

- Large roof overhangs should be reviewed closely. Uplift-resistant connections for large overhangs should be engineered.
- Requirements for tiedown straps for widely spaced roof framing members and corresponding wall-to-foundation connections should be defined.
- Conventional construction Code requirements appear to take into consideration lateral forces such as wind and seismic loading; however, special consideration must be given to construction in areas where wind speed is amplified or areas of great exposure due to extreme topography (FIGURES 84-87).
- Adoption of the 1991 UBC Appendix Section 2518 should be permanent. Appendix Section 2518 addresses previous Code deficiencies which relied on implicit provisions in the 1985 UBC. Appendix Section 2518 is very explicit in its requirements and contains graphical representations not previously contained in older versions of the Code.

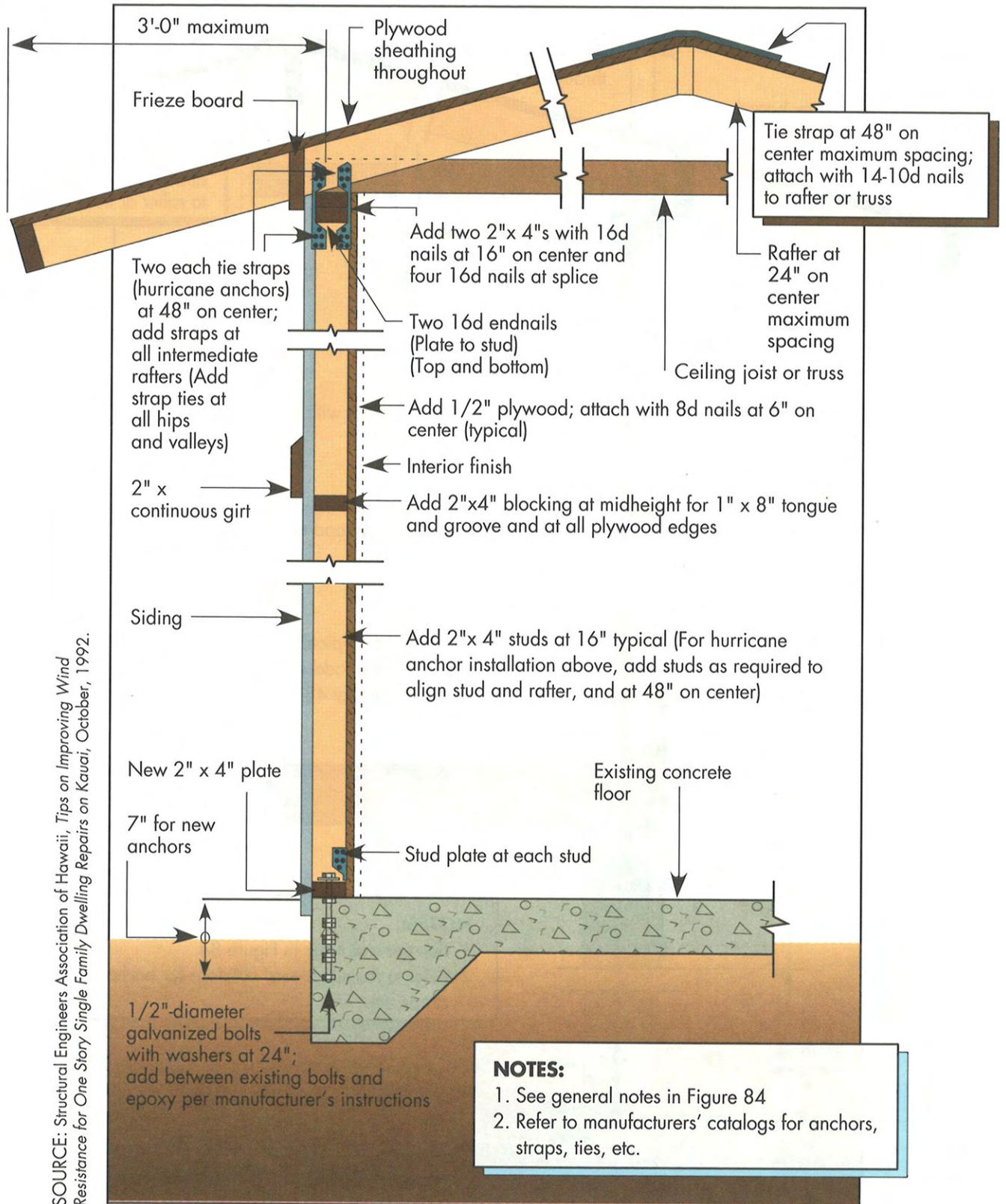
### GENERAL:

1. All work shall conform to the building code of the County of Kauai.
2. There are many different types of construction and details for existing single-family dwellings. The information and drawings presented are for general informational purposes only to illustrate the concept of the complete load path to resist high winds. The drawings are not complete design details or drawings and shall not be used as such. The information and details provided shall not be used or relied upon for any specific application without independent professional examination and verification of their accuracy, suitability, and applicability.
3. The details are based on the following types of construction:
  - A. Repair work only (not new construction)
  - B. Single-story, single-family dwelling, with floor-to-ceiling height of approximately 8 feet
  - C. Regular-shaped buildings with floor area of approximately 1,200 square feet, constructed on stable ground

### MATERIALS:

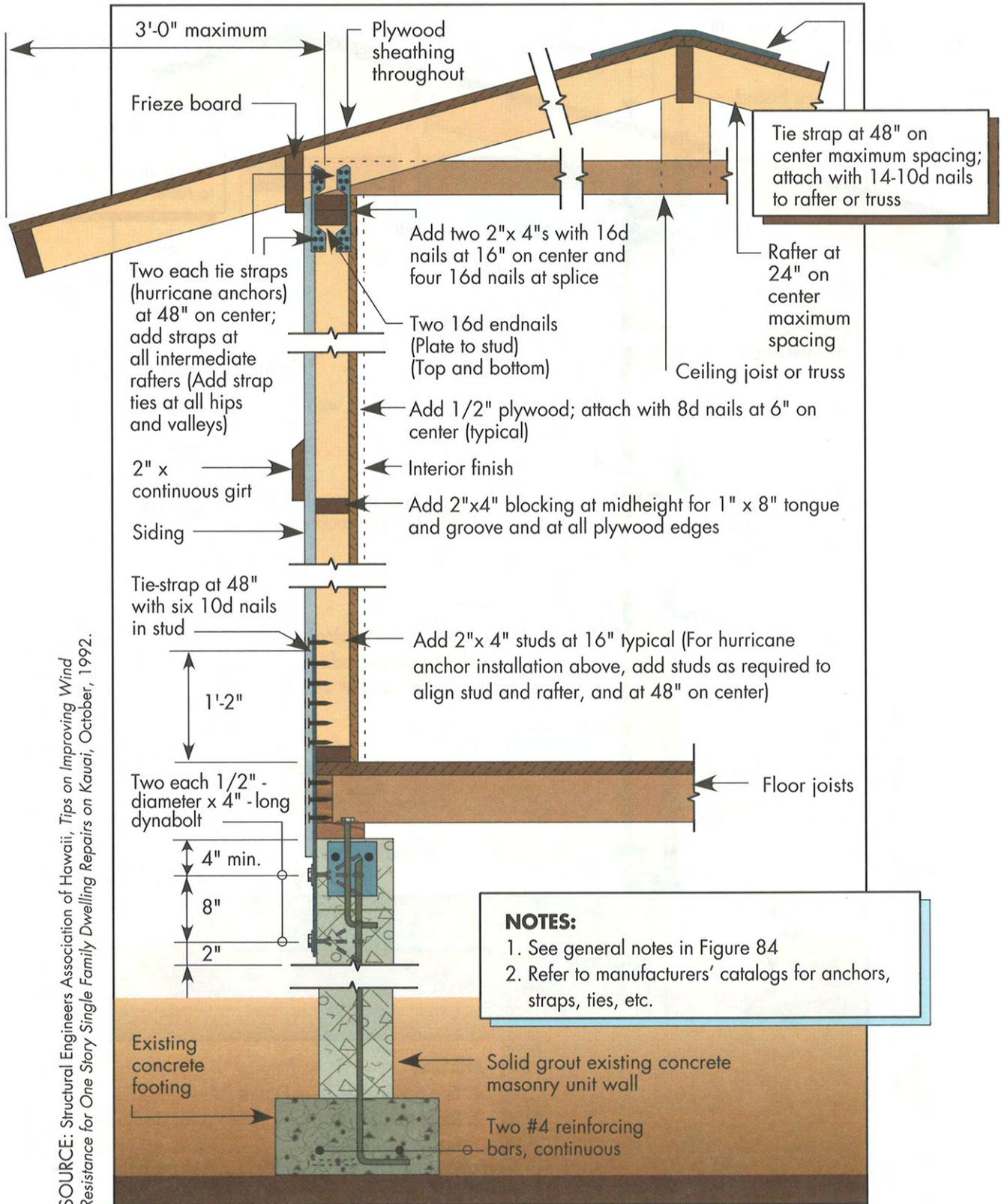
1. Lumber: Douglas Fir/Larch, preservative treated, S4S, No. 2 Grade or better.
2. Unless noted otherwise, all nailing shall be galvanized common nails and shall conform to Table 25-Q of the 1985 Uniform Building Code.
3. Framing hardware: Galvanized and of adequate strength.
4. Framing, finish, and trim shall be notched for hardware as required to provide snug fit at all joints.
5. Trim and finish details are not shown on framing details and sections.

FIGURE 84. *General notes for Figures 85-87.*



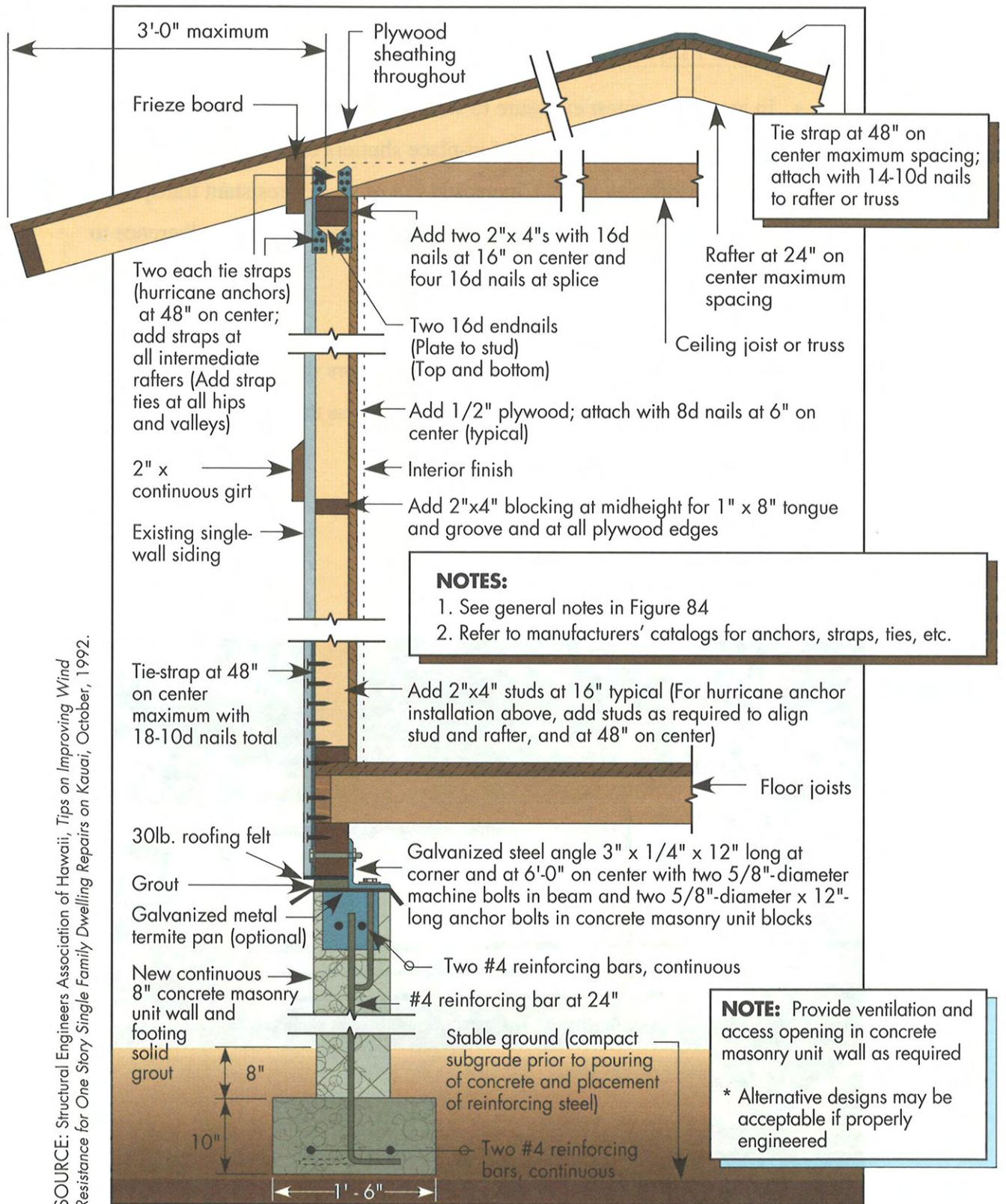
SOURCE: Structural Engineers Association of Hawaii, *Tips on Improving Wind Resistance for One Story Single Family Dwelling Repairs on Kauai*, October, 1992.

FIGURE 85. Existing "single wall" on slab-on-grade.



SOURCE: Structural Engineers Association of Hawaii, *Tips on Improving Wind Resistance for One Story Single Family Dwelling Repairs on Kauai*, October, 1992.

FIGURE 86. Existing "single wall" on existing concrete masonry unit wall.



SOURCE: Structural Engineers Association of Hawaii, *Tips on Improving Wind Resistance for One Story Single Family Dwelling Repairs on Kauai*, October, 1992.

FIGURE 87. Existing "single wall" on new concrete masonry unit wall and footing.

### 4.3 GLAZING AND TRANSPARENT STRUCTURAL OPENINGS

- In areas of greatest exposure to windborne projectiles, consideration should be given to the use of in-place shutters or emergency protection devices (FIGURES 88-91), increased use of shatter-resistant transparent material, a reduction in the use of glazing, and improved adherence to adequate attachment procedures.
- The specifications for windows and glass doors should be stated such that the design criteria for wind loading are the same as those for the structure itself.

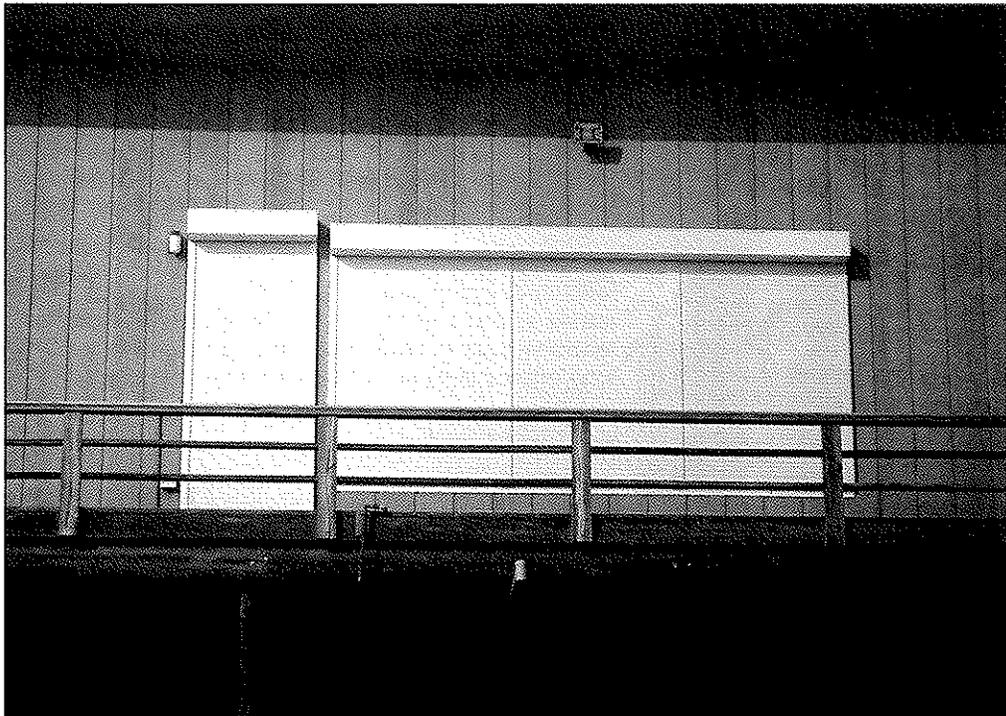


FIGURE 88. *Prefabricated storm shutters.*



FIGURE 89.  
*Previously purchased plywood stored for use as openings protection during storm conditions.*

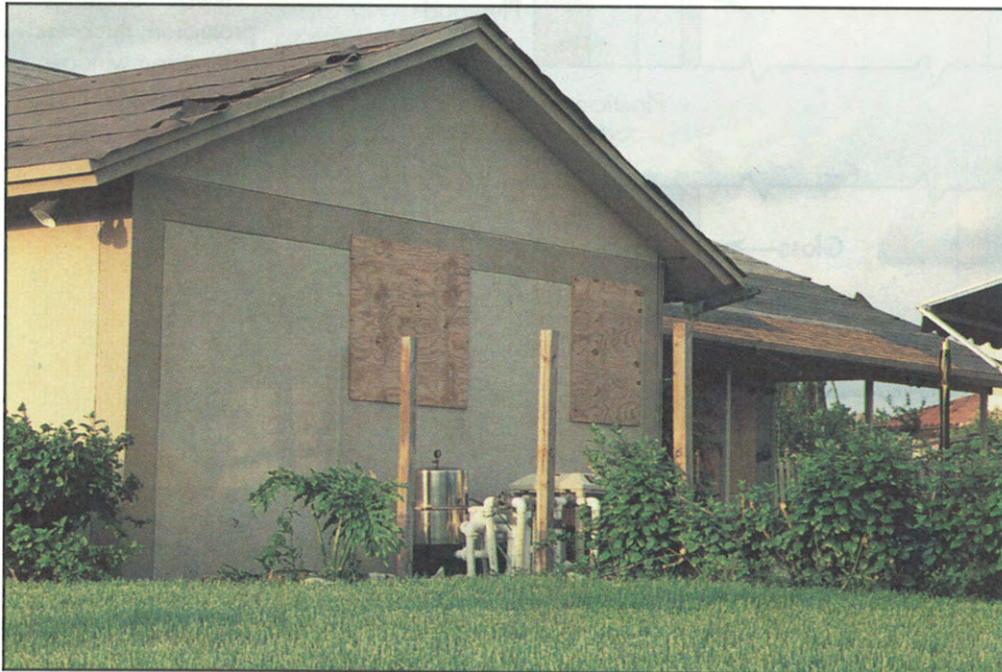


FIGURE 90. *Plywood used as openings protection installed. See Figure 91 for details.*

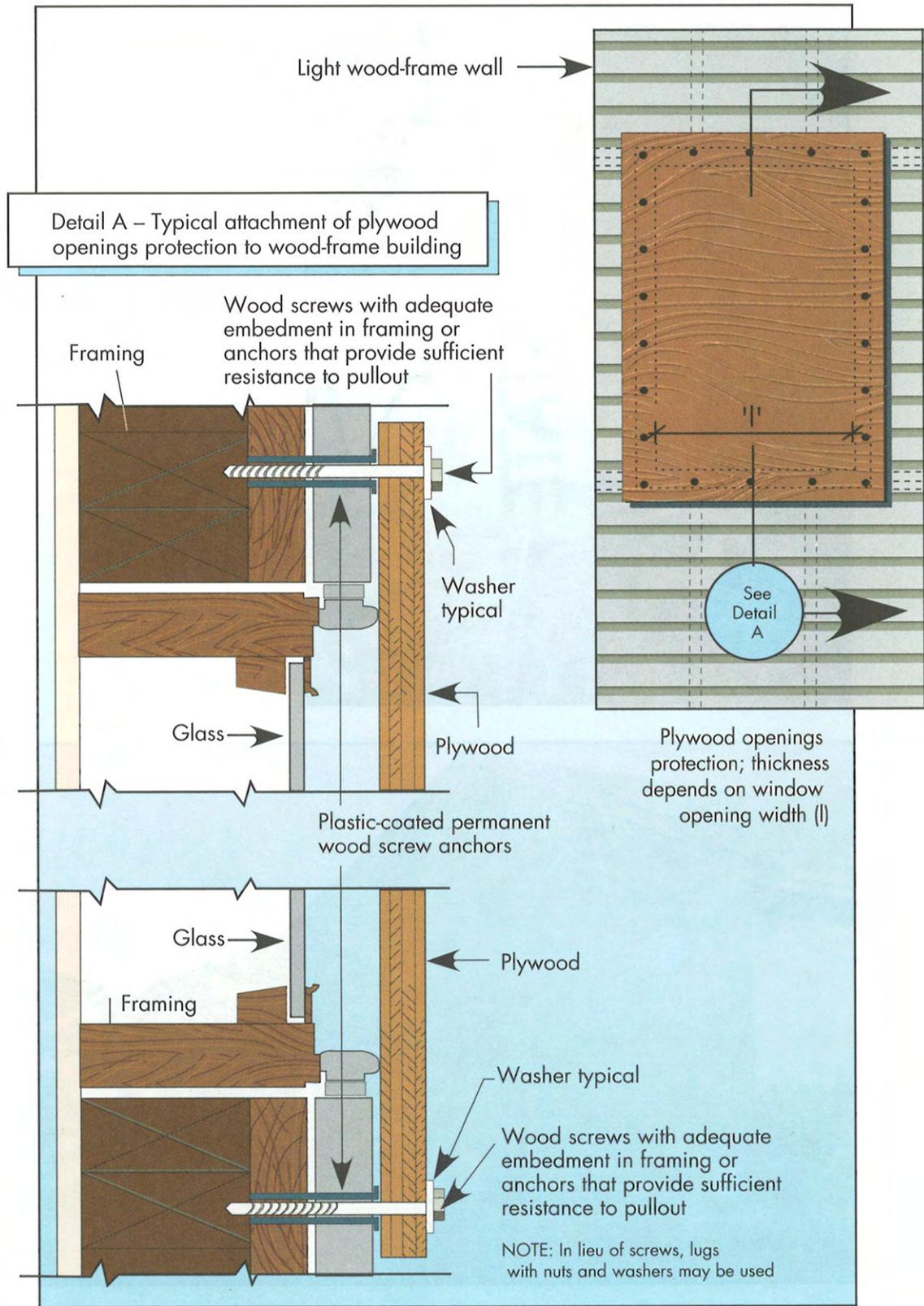


FIGURE 91. Typical installation of plywood openings protection for wood-frame building.

- The adequacy of the engineering design and method of attachment of windows and sliding transparent doors of all types should be reviewed by manufacturers for applications in areas subject to wind exposure. Wind loads should be adequately transferred to the supporting structure.

## 4.4 ROOFING

- Recognized procedures for testing roofing for resistance to wind (across the surface of the roofing) need to be developed.
- Roofing materials should be installed according to the latest manufacturer's recommendations (FIGURE 92).
- Roofing suppliers, manufacturers and associations should educate specifiers and installers concerning the proper installation requirements and techniques.
- A program of periodic roof cladding inspection during installation should be adopted where such a program would not be cost-prohibitive.

## 4.5 BUILDING PERMITTING, PLAN REVIEW AND INSPECTION

- Consistency of quality construction workmanship should be encouraged. Properly engineered construction drawings that are more prescriptive and detailed should be provided, and the depth of construction inspection should be increased, especially for tracts of homes of repetitive design.

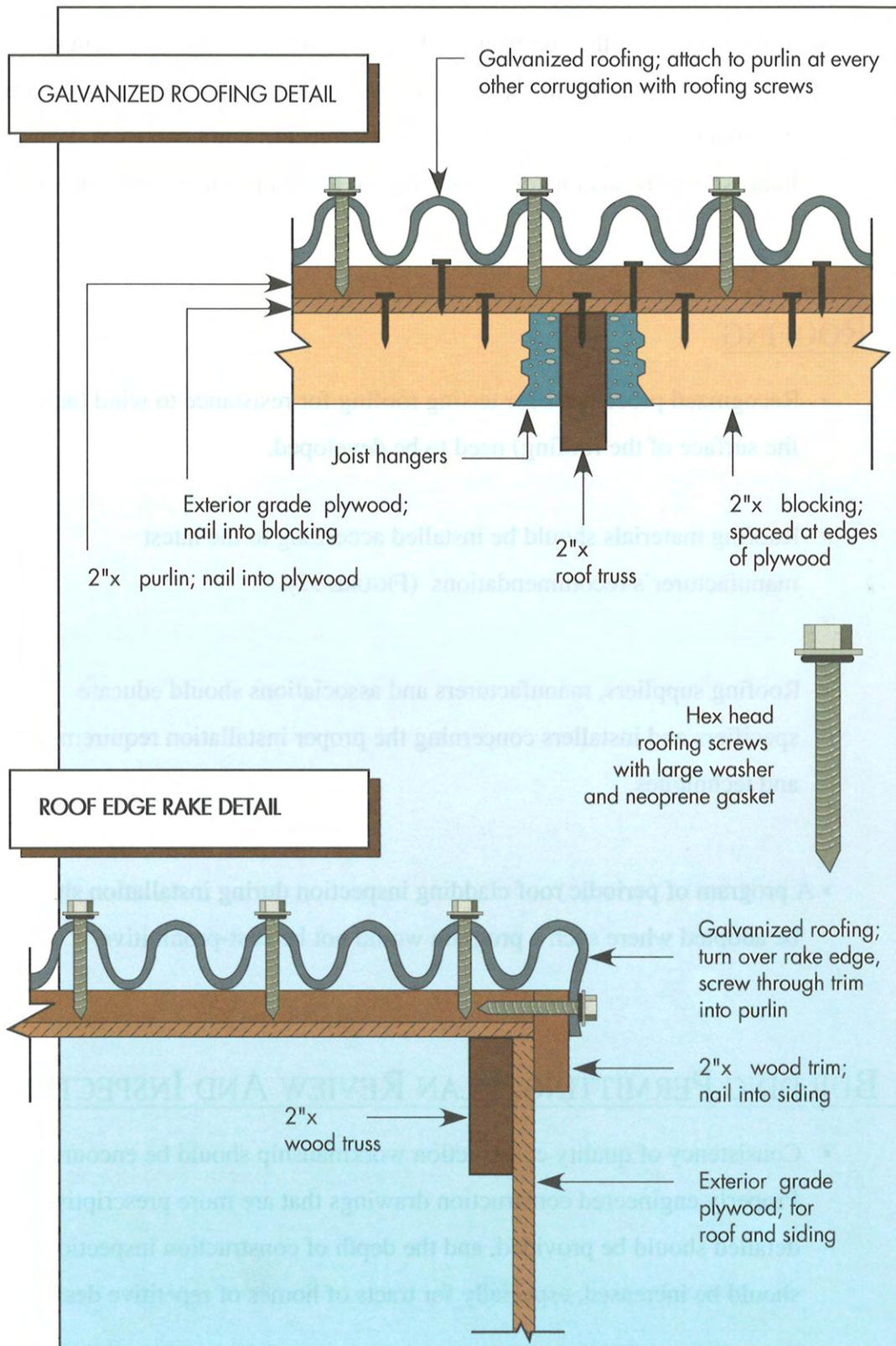


FIGURE 92. *Tips for galvanized roofing.*

- Kauai County should retain a person qualified in structures on staff to assist in examining the adequacy of construction plans. This in-house expertise will allow for greater indepth County review of design and construction inspection. Responsibilities should include a program of systematic wall and roof framing and roof sheathing inspections.
- Permit drawings for construction should include details and a narrative statement that explains the building system's transfer of forces, especially between the roof and wall systems, and the wall system and foundation. These permit drawings should include a checklist which verifies that the necessary continuous load transfer path has been provided.
- Implementation of UBC Section 306, Special Inspection, requirements for large multi-family, commercial, and resort projects should be considered.

## 4.6 TRAINING AND EDUCATION

- The State and Kauai County governments and the local building industry, in cooperation with FEMA, should sponsor a program of training and continuous education in Kauai on Code requirements and construction techniques. In addition to structural design, these programs should cover roof sheathing, proper attachment of roof cladding, prevention of wood and metal deterioration, and the design and prudent use of glazing and transparent structural openings. Such training and education will increase the knowledge and awareness of business and homeowners, construction tradespeople, Architects/Engineers, supervisors, plan reviewers, and inspectors.

- Considerable effort should be given to teaching building contractors, and especially home owners, the proper attachment of corrugated metal roofs to the underlying rafters and purlins.
- A program should be established to gain the fullest participation of the citizens of Kauai County in the building development process and to ensure their awareness of the need to maintain critical building components.
- A program should be established to educate sub-professionals who prepare plans to comply with current Code provisions. Review of these plans by qualified professionals should be encouraged.

#### 4.7 REPAIR/RETROFIT OF PARTIALLY DAMAGED AND UNDAMAGED BUILDINGS

- During the Hurricane Iniki rebuilding period, Kauai County should explore all available resources for expanding the pool of qualified building inspectors.
- Although some buildings suffered irreparable damage, most buildings are repairable, and repairs should be carried out with attention to the recommendations made in this report.
- Retrofitting of undamaged buildings should be strongly encouraged so that wind damages to buildings constructed under the previous Code are minimized.