3.0 RECOMMENDATIONS

The basis for performing this survey is the premise that better performance of building systems can be expected when causes of observed failures are corrected using recognized standards of design and construction. Attention should be paid to the correct design and construction of horizontal and vertical load transfer systems to resist future building failure. The recommendations presented in this report may have application to other communities in Florida.

The field observations indicate the existence of systematic deficiencies in the construction practices that were employed in the observed areas. This was true irrespective of the obvious severe wind conditions brought about by Hurricane Andrew.

3.1 GENERAL RECOMMENDATIONS

The following recommendations are based on the findings of the team and are made for the purpose of promoting general improvements to the Dade County construction process.

1. Quality of construction workmanship should be improved.

— An increased knowledge of proper construction techniques and the consequences of high-wind and flood loads should be provided through the development of an adequate program of training and continuous education for construction tradespeople, supervisors, and inspectors. This could be accomplished through a State or local government certification, registration, and licensing requirement which includes specific continuing education requirements.

— A multifaceted certification program for inspectors and supervisors that focuses on specific areas of design and construction should be developed.

For example, inspectors performing framing inspections should be trained and certified in that particular area and method of construction.

2. The South Florida Building Code, Dade County version, should be expanded to include prescriptive design elements for lateral load transfer and should include illustrations and details as needed.

3. Proper guidance concerning the correct method of transferring loads must be provided to building contractors.

— Permit drawings for construction should include a narrative that explains a building system's transfer of lateral loads. An explicit depiction in the form of construction details may be necessary.

— Permit drawings should be submitted with a completed load transfer path plan-checklist that is specific to the building type being designed.

4. A licensed design professional should have increased participation in the inspection of construction.

5. Inspector supervision should be increased or improved, especially in developments where large tracts of homes of repetitive design occur.

6. Enhancement and maintenance of the Dade County GIS should be encouraged. The information contained within the databases the Department of Building and Zoning contributes to this system can be of value in improving the implementation of the Code. Employment of this technology will strengthen disaster mitigation efforts applied to the Dade County land development process. One example would be the substantial damage provisions contained in the NFIP regulations.

3.2 Specific Recommendations

The following recommendations apply to individual types of buildings and building components. Engineering drawings and photographs are provided where appropriate to support or illustrate the recommendations.

Roof Cladding and Roof Framing Systems

1. In addition to the existing program of systematic framing inspections, a specific roof bracing and sheathing inspection should be required prior to installation of roof underlayment (see Figures 26-29). Note the extra bracing recommended for gable ends in particular.

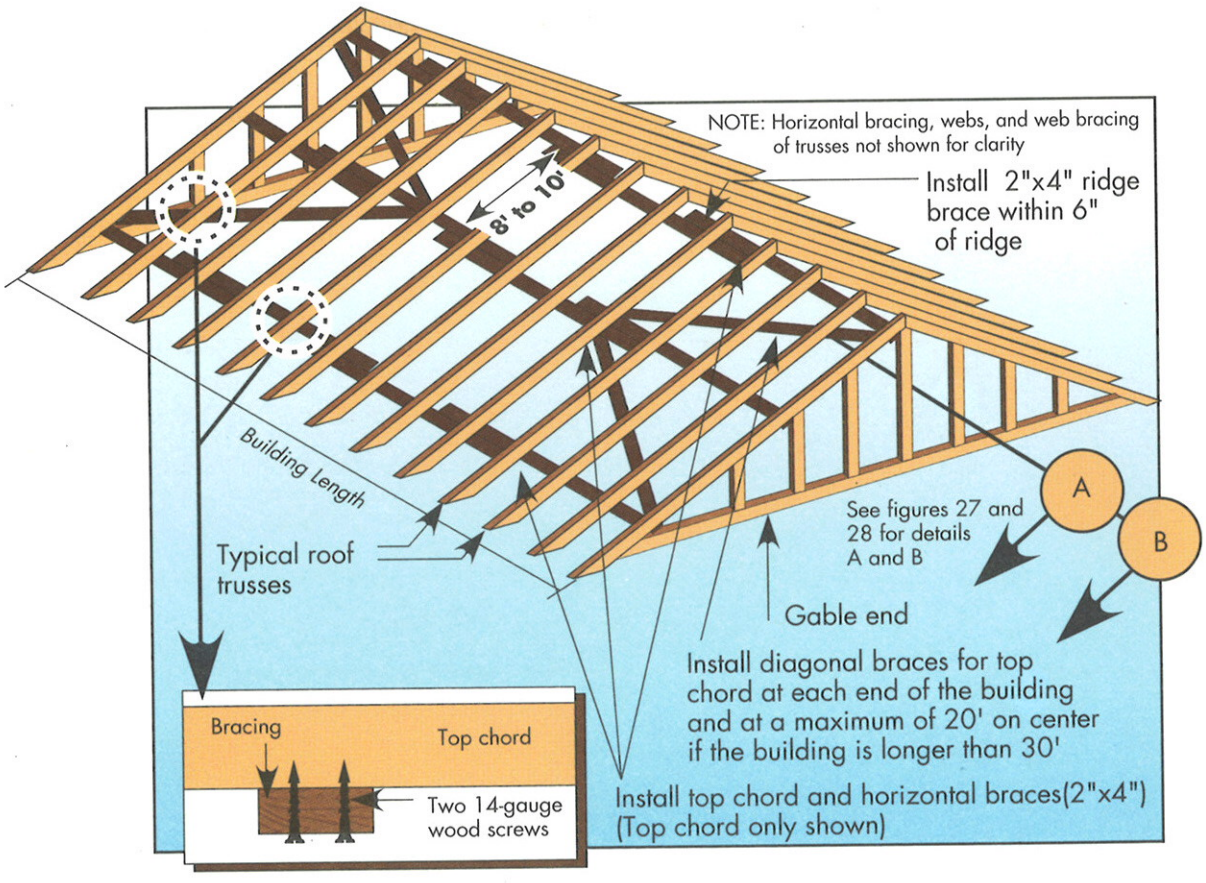

Figure 26. *Typical roof truss top chord bracing.*

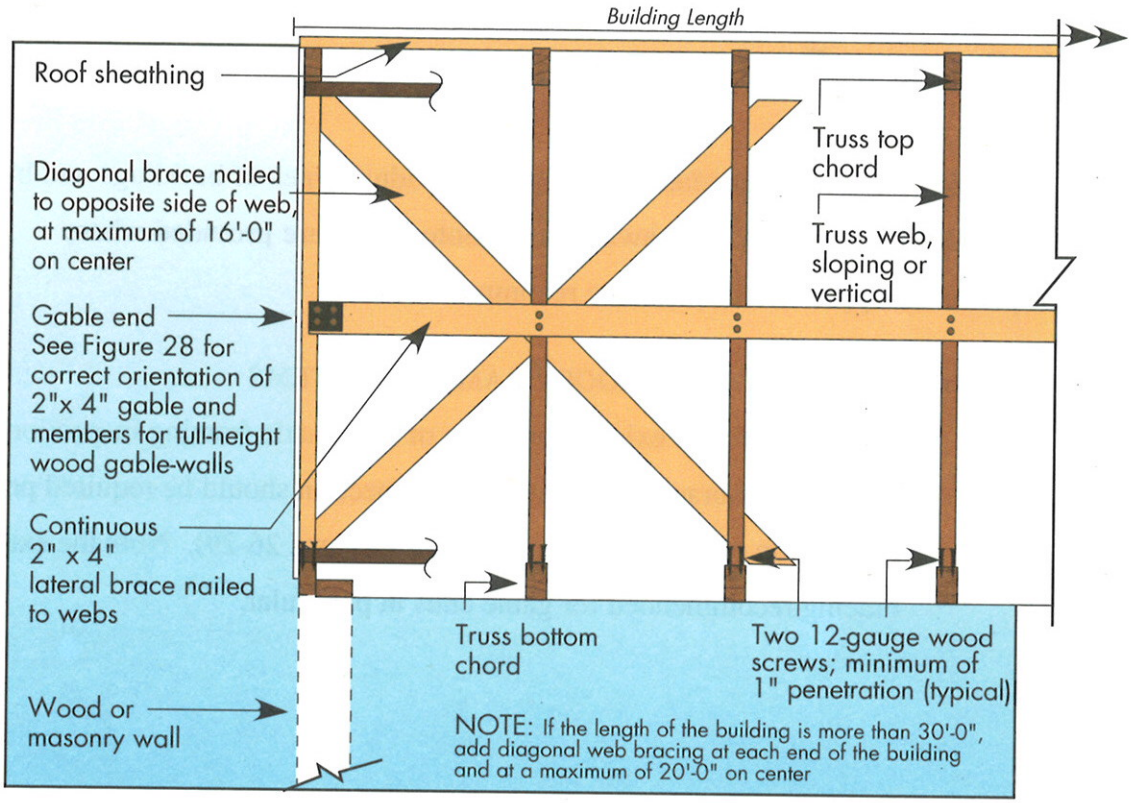

FIGURE 27. *Detail A — Typical truss web bracing. Diagonal web bracing as shown, at each gable end of building.*

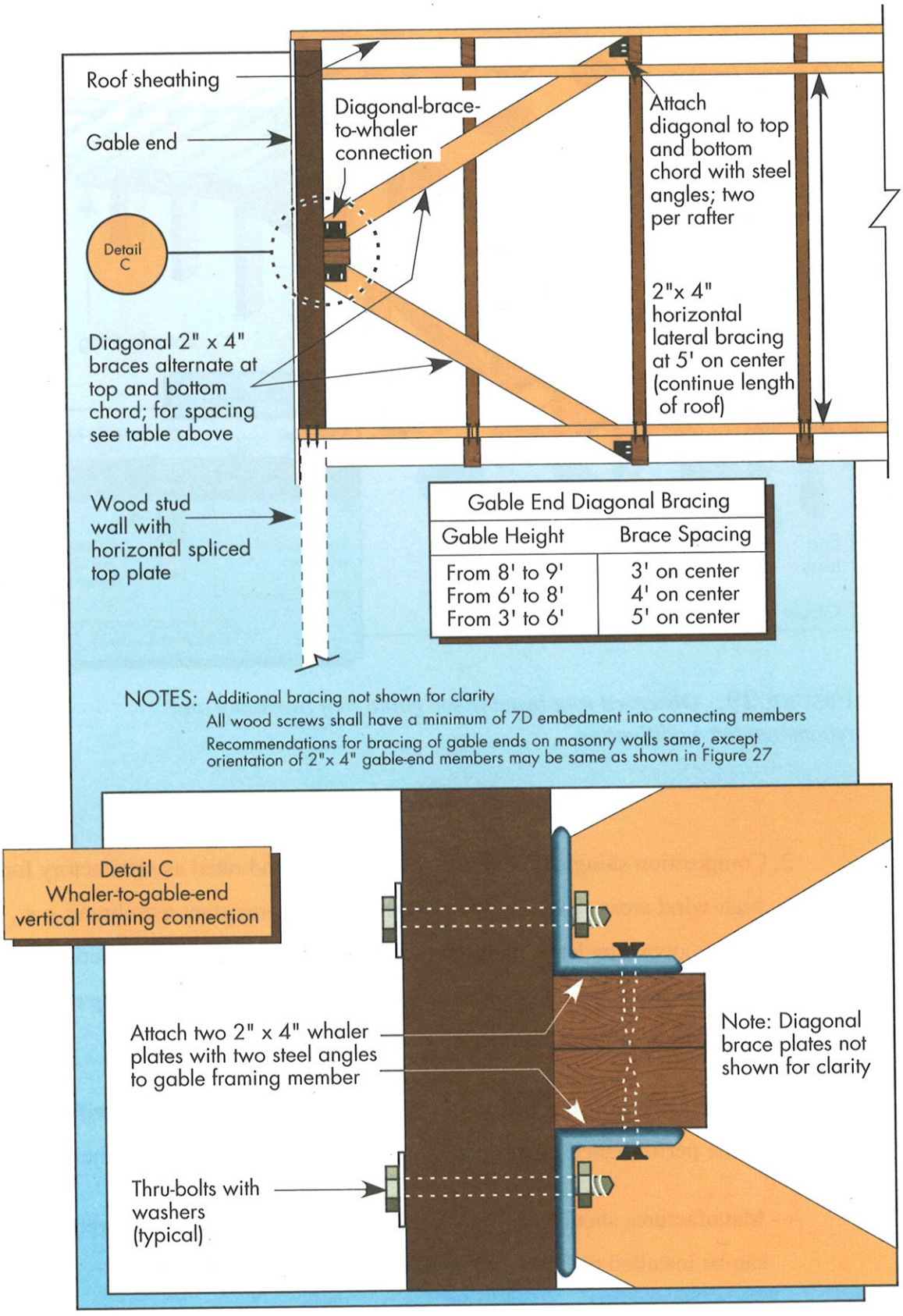

FIGURE 28. *Detail B — Typical wood gable-wall bracing.*

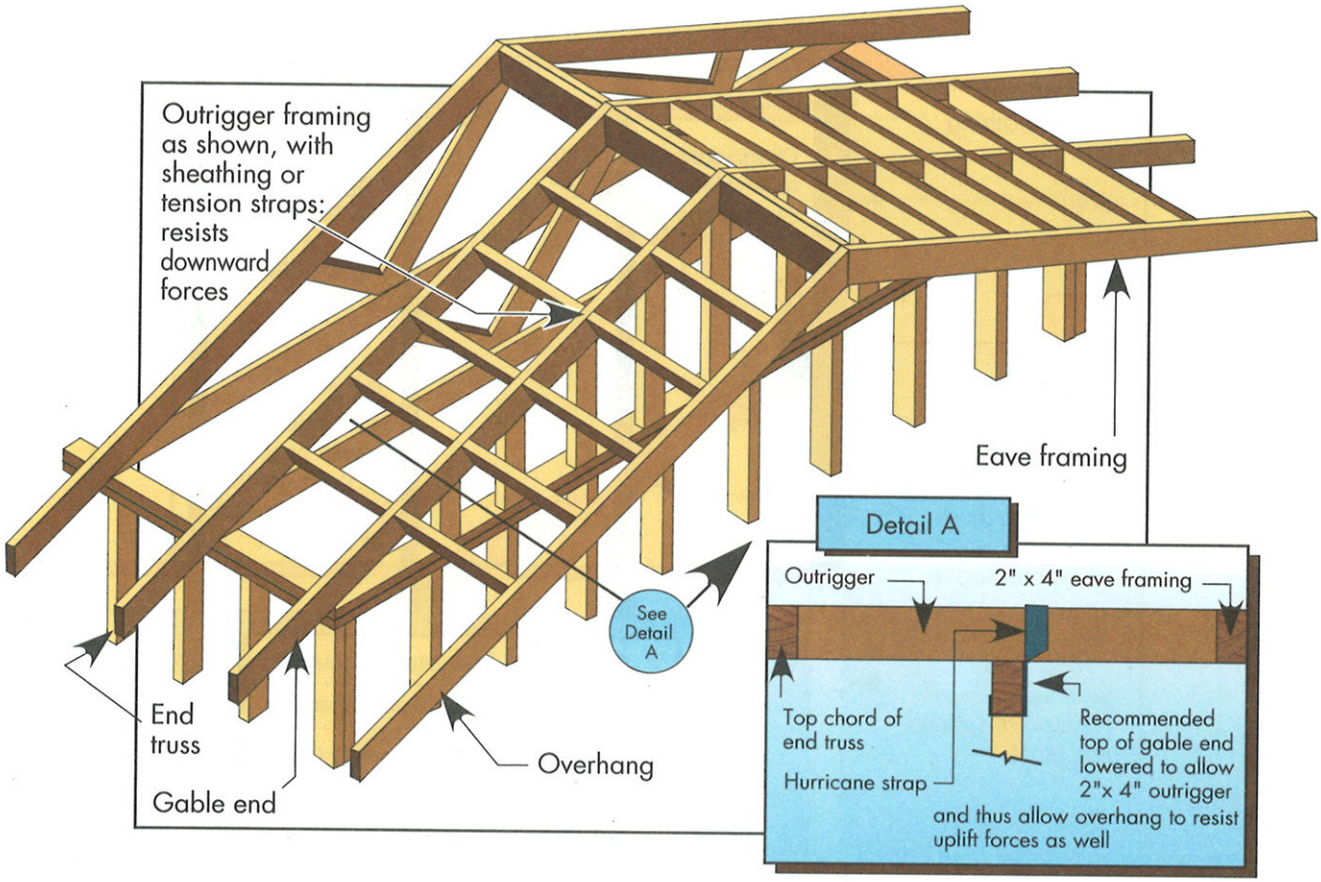

FIGURE 29. *Observed roof bracing for gable roof overhang and recommended modification.*

2. Composition shingles should be manufactured and rated as satisfactory for high-wind areas. In the absence of this, a water-resistant membrane, e.g., a hot-mopped underlayment, should be installed to provide protection from the water infiltration that may result from the loss of roofing material during high-wind storms (SEE FIGURES 30 AND 31).

3. Manufacturers of roof tile products should provide testing and verification of tile performances under realistic conditions (as addressed by the Code).

— Manufactures should verify that mortar used with extruded concrete tiles can be installed to Code requirements.

FIGURE 30. *Composition shingle and underlayment failure.*

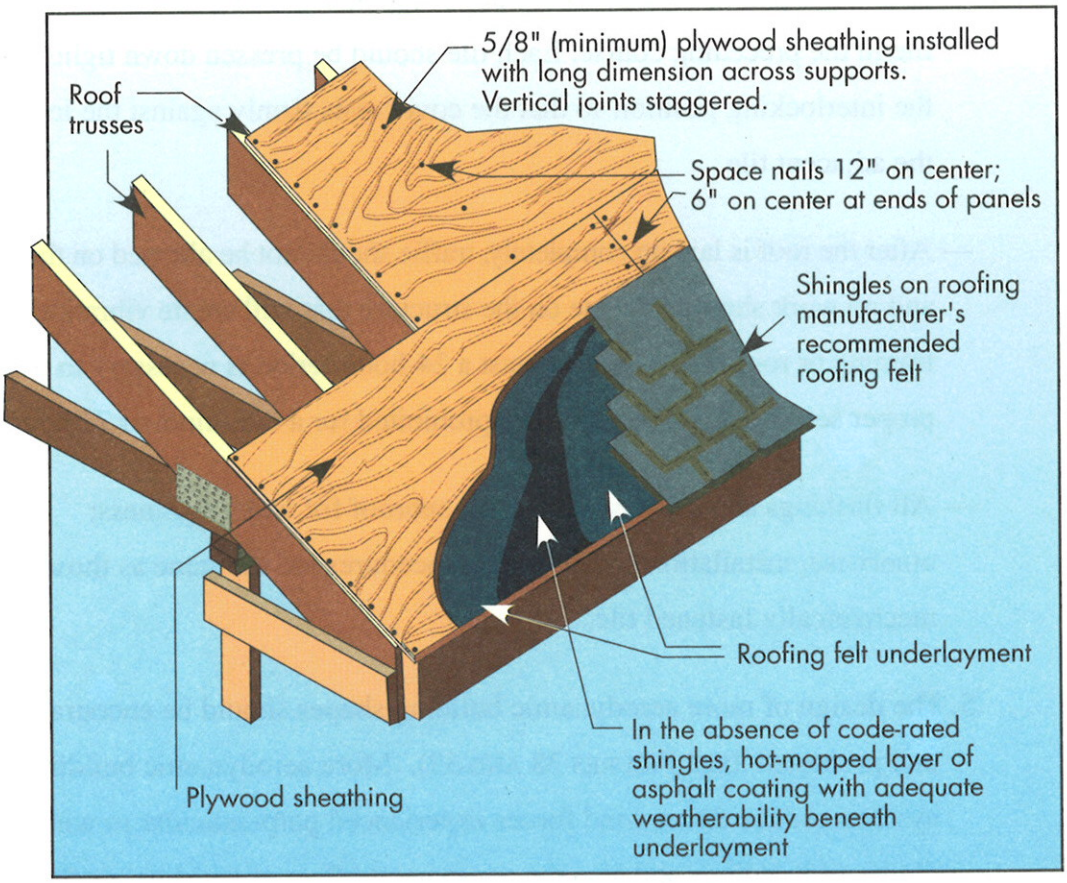

FIGURE 31. *Composition shingle roofing system showing sheathing and hot-mopped underlayment.*

4. Quality control of roof tile installation should be improved by ensuring both consistent mortar pad placements and installation in accordance with manufacturers' requirements, as specified by the Code. (SEE FIGURES 32-37). Though this would improve the survivability of roof tile systems, continued debris impact will result in damage occurring from future wind storms.

— The roof should be marked off vertically and horizontally. Interlocking lugged or unlugged tile should be laid with minimum headlaps in accordance with manufacturers' recommendations (2 1/2 – 3 1/2 inches minimum).

— Prefabricated eave closure strips should be used to elevate the butt end of the first, or eave, tile to attain the proper slope.

— A full 10-inch mason's trowel of mortar should be placed under each tile (under the pan section of "S" or barrel tiles), beginning at the head of the tile in the preceding course. Each tile should be pressed down tightly in the interlocking position so that the cover rests firmly against the lock of the adjacent tile.

— After the roof is laid up completely, traffic should not be allowed on the roof, and no work should be done on the structure that will create vibration in the framing or roof sheathing. At least a 24-hour period is necessary to ensure proper set. Roof traffic should be prohibited for a minimum of 72 hours.

— All flashings should be sealed to the subroof for water tightness; otherwise, installation and flashing procedures are the same as those for mechanically fastened tile.

5. The design of more aerodynamic building shapes should be encouraged and promoted (SEE FIGURES 38 AND 39). More aerodynamic building systems reduce direct wind forces experienced perpendicular to windward planes of buildings and also the consequent effect of whirling air flows, called vortices, that accumulate at the corners and edges of the planes. The

FIGURE 32. *Failure of extruded concrete flat tile roofing. Bond failure between tile and mortar and between mortar and underlayment was observed.*

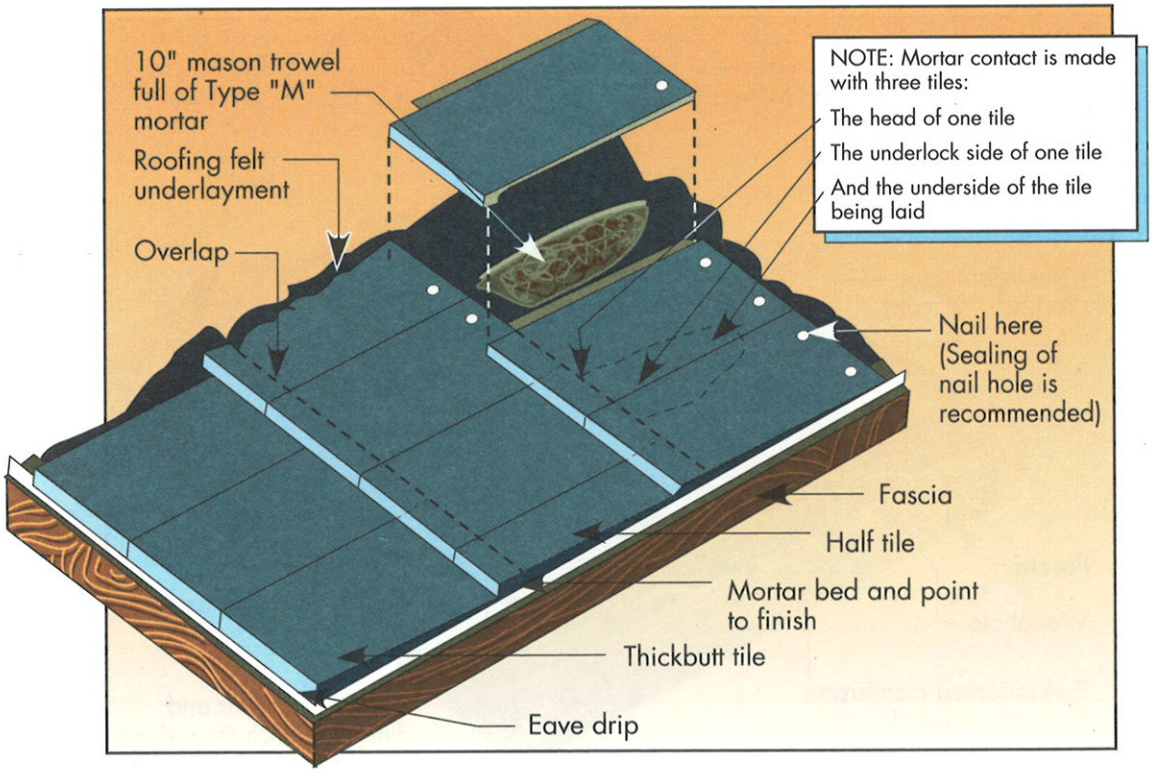

FIGURE 33. *Recommended tile and mortar placement for extruded concrete flat tile roofing system.*

FIGURE 34. *Failure of "S" tile roofing. Bond failure between mortar and tile was observed.*

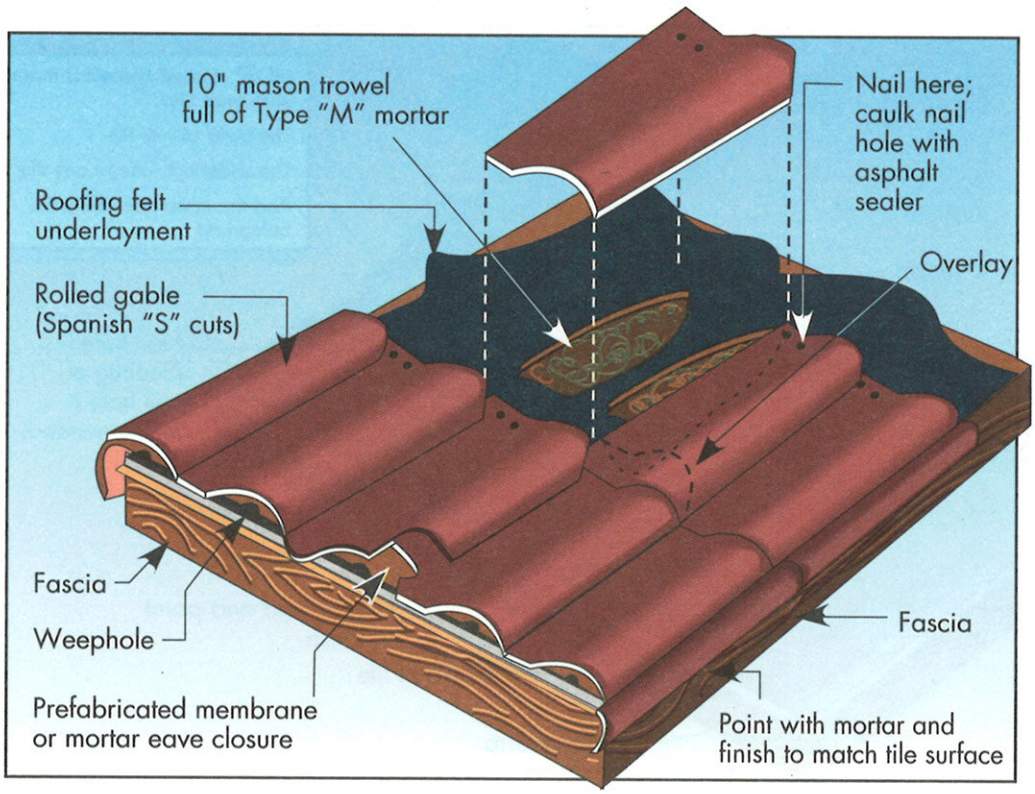

FIGURE 35. *Recommended tile and mortar placement for "S" tile roofing system.*

FIGURE 36. *Failure of barrel tile roofing. Bond failure between underlayment and mortar and between mortar and tile was observed.*

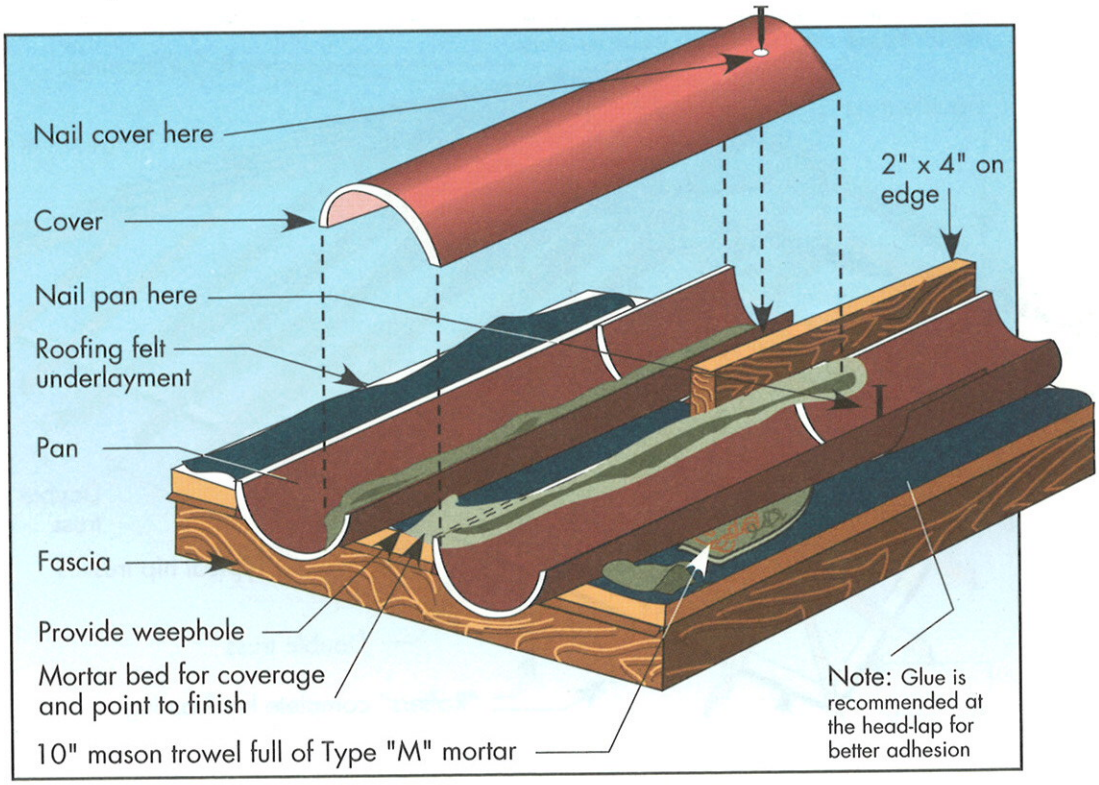

FIGURE 37. *Recommended tile and mortar placement for barrel tile roofing system.*

FIGURE 38. *Hip roof.*

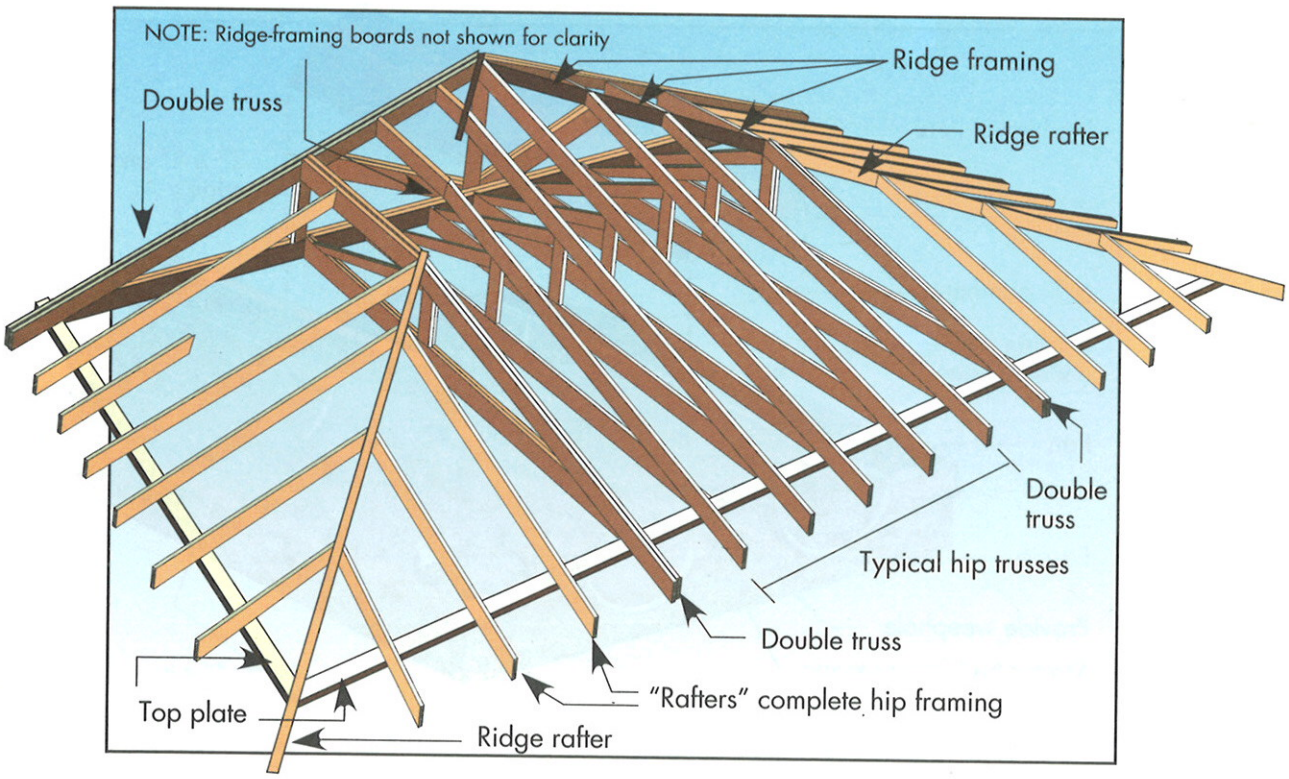

FIGURE 39. *Recommended hip roof framing.*

accumulation of both the direct and negative pressures resulting from these wind flows is particularly prevalent in the more abrupt or orthogonal planes of gabled roof systems.

6. The use of braced truss roof systems that will sufficiently resist lateral forces independent of roof sheathing should be required. Roofing systems could be considerably improved if simple secondary bracing or blocking were to be applied within the truss network (thus relieving the roof's reliance on diaphragm sheathing action alone) (SEE FIGURES 26-29).

7. Substituting hip roofs for gable ends is a particularly advantageous solution and should be encouraged. The construction of a hip roof results in an inherently braced roof system (SEE FIGURE 39).

8. Venting with adequate openings to relieve induced internal pressures on roof structures is recommended (SEE FIGURE 40). However, venting must be installed in such a manner that the entry of uncontrolled air flow is not allowed. Such uncontrolled air flow could result in a buildup of induced internal air pressure.

FIGURE 40. *Roof gable louvered venting and convertible awning/storm shutters.*

EXTERIOR WALL OPENINGS

A breach of a building's envelope (i.e., the system by which the building resists wind penetration) is particularly hazardous during wind storms. Not only does penetration of wind and rain cause damage to the interior contents of buildings, but additional direct internal wind pressures combine with suction pressures on exterior faces, causing partial or complete blowouts of major structural systems such as walls and roofs (SEE FIGURE 41). Double-car garage doors and entry doors especially should be held secure during wind storms.

1. The specifications for garage doors should be increased to meet a factor of safety of at least 2.5.

— Manufacturers' certificates should be required on all garage doors.

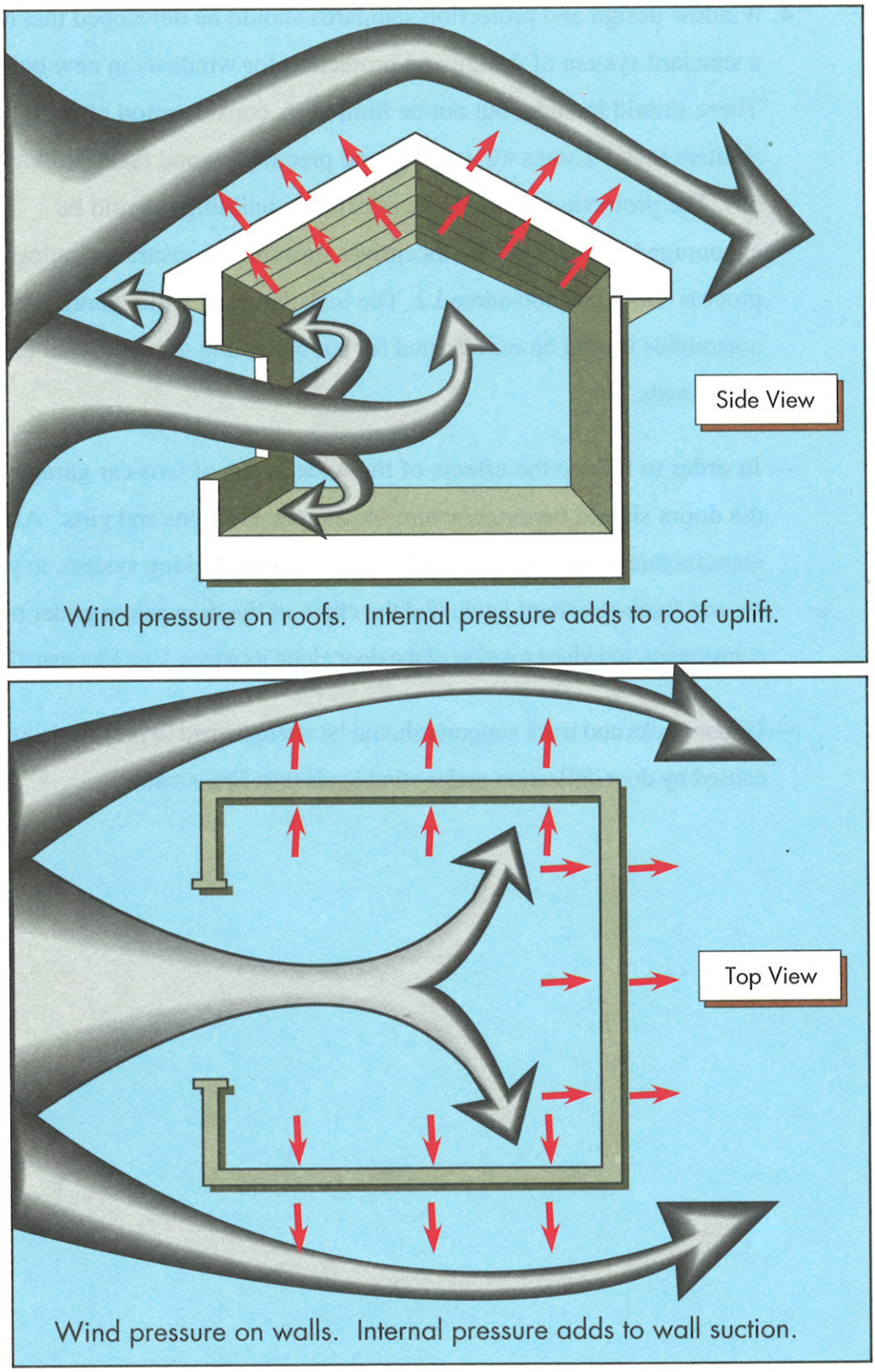

FIGURE 41. *Results of building envelope breach due to failure of external doors and windows.*

4. Window design and protection standards should be developed that require a standard system of design and protection for windows in new buildings. These should include, but not be limited to, consideration of using shutters (SEE FIGURES 40 AND 49) and precut plywood (SEE FIGURES 50-53). The protection of windows in existing buildings should be encouraged. Providing cost incentives through the insurance rating process should be considered.2. The installation of entire garage door assemblies should be reevaluated for strengthening to resist wind and flood loads.

— In order to reduce the effects of the wide spans of two-car garage doors, the doors should be manufactured to include mullions and girts. Also, manufacturers should reinforce both the security locking system, to provide a wind-force-resisitant latch, and the chain of the door pin to glider track connections, to reduce rotation of the door along its edges. (SEE FIGURES 42-45).

— Glider tracks and track supports should be strengthened to prevent failure caused by door deflection under wind loads (SEE FIGURE 46).

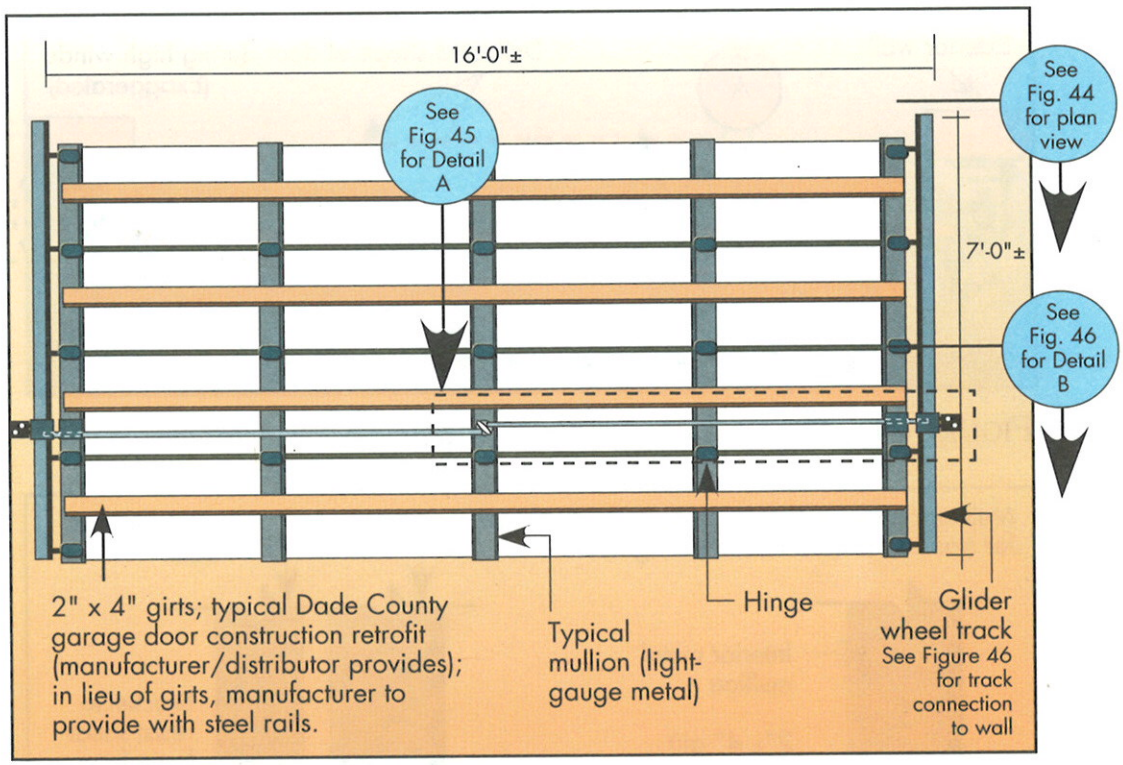

FIGURE 42. *Typical garage door elevation.*

FIGURE 43. *Example of garage door with 2"x 4" girts and metal mullions.*

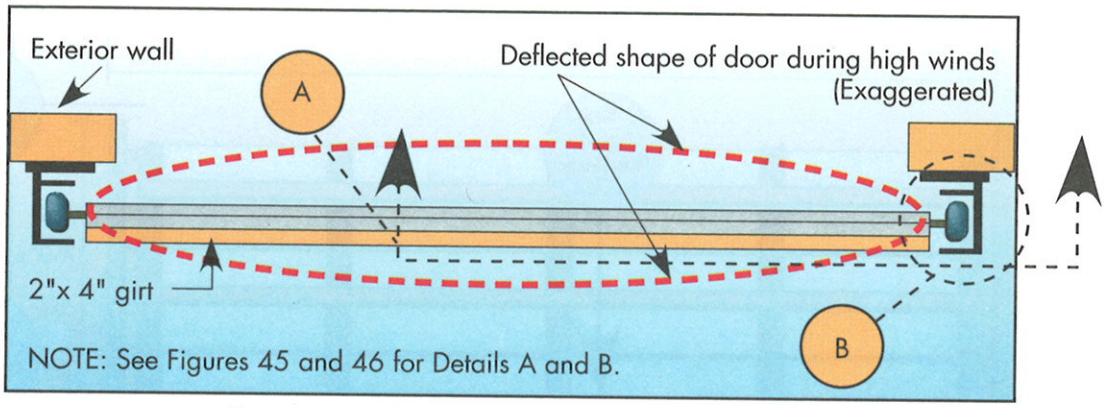

FIGURE 44. *Plan view of typical garage door.*

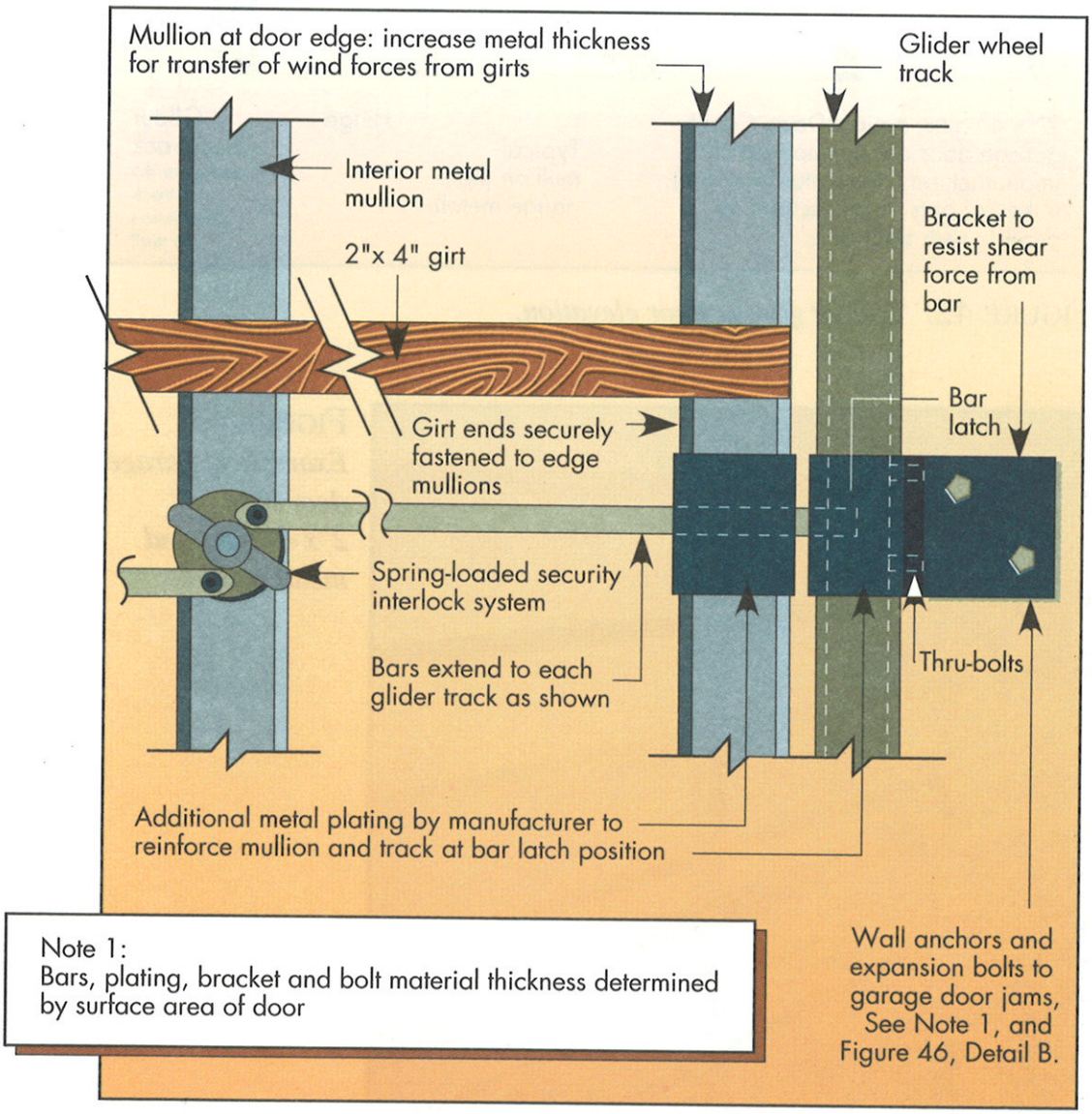

FIGURE 45. *Detail A — Recommended reinforced horizontal latch system for garage door.*

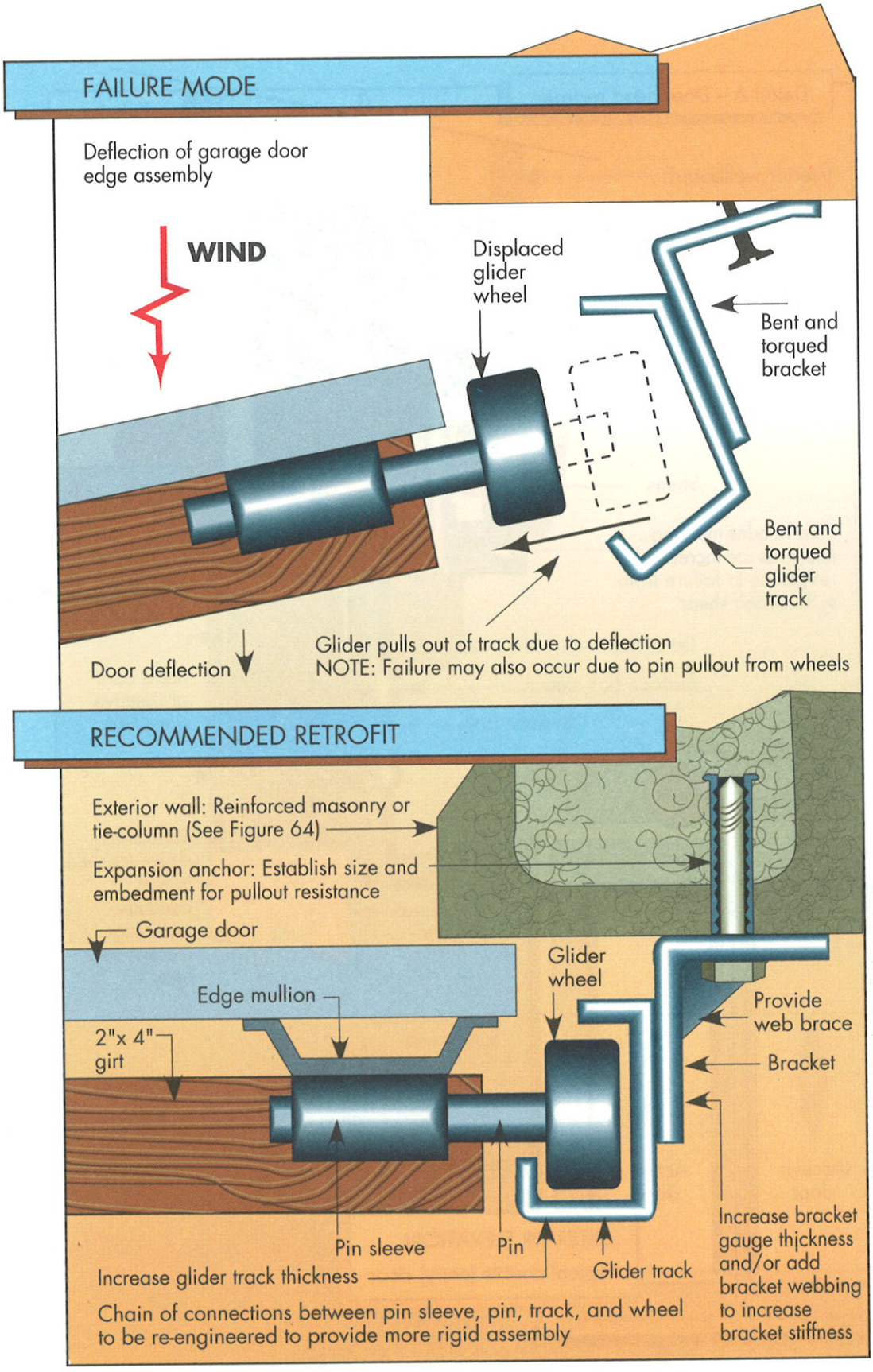

FIGURE 46. *Detail B — Garage door failure at edge and recommended assembly improvements.*

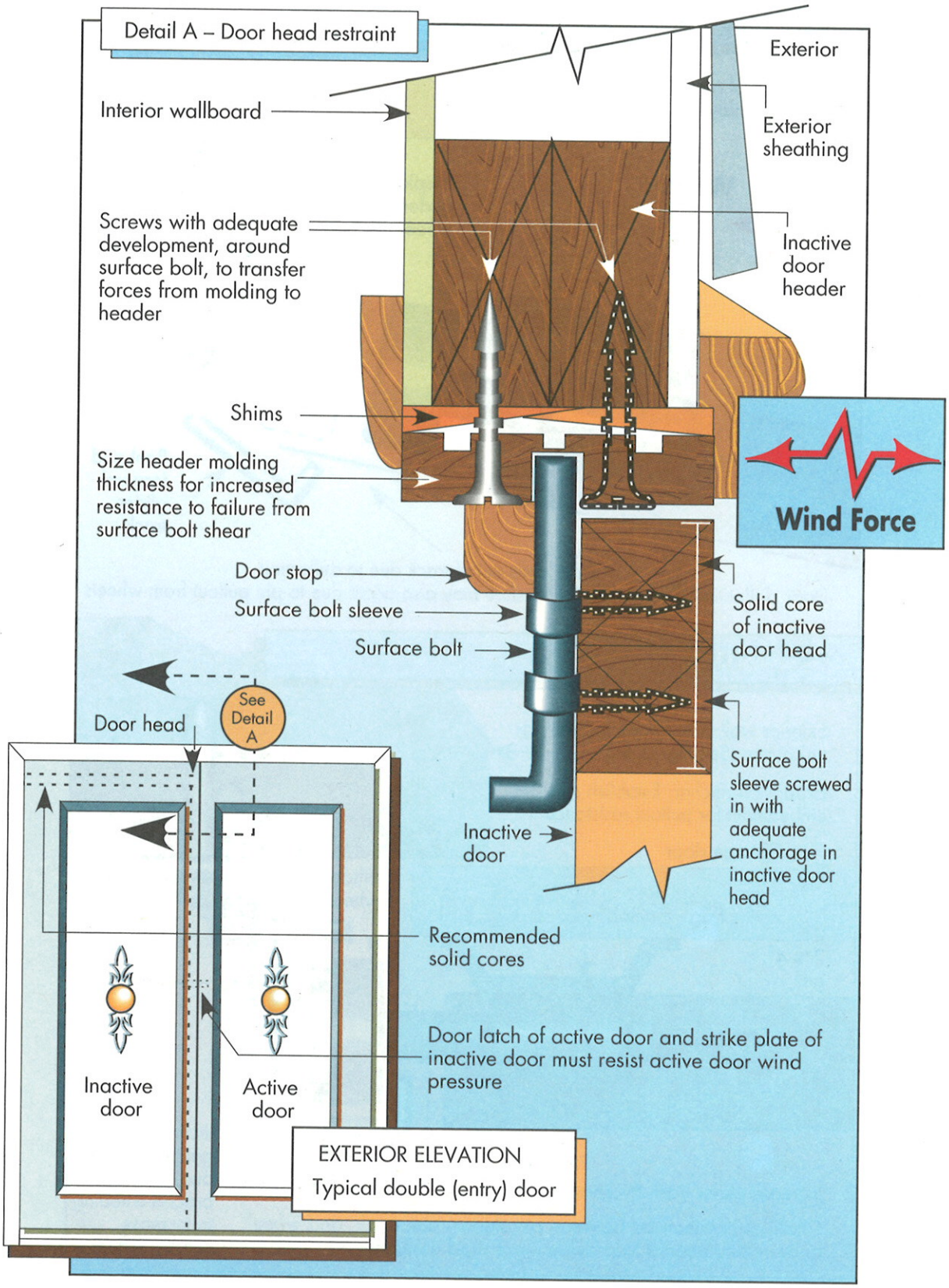

FIGURE 47. *Double entry door header recommendations.*

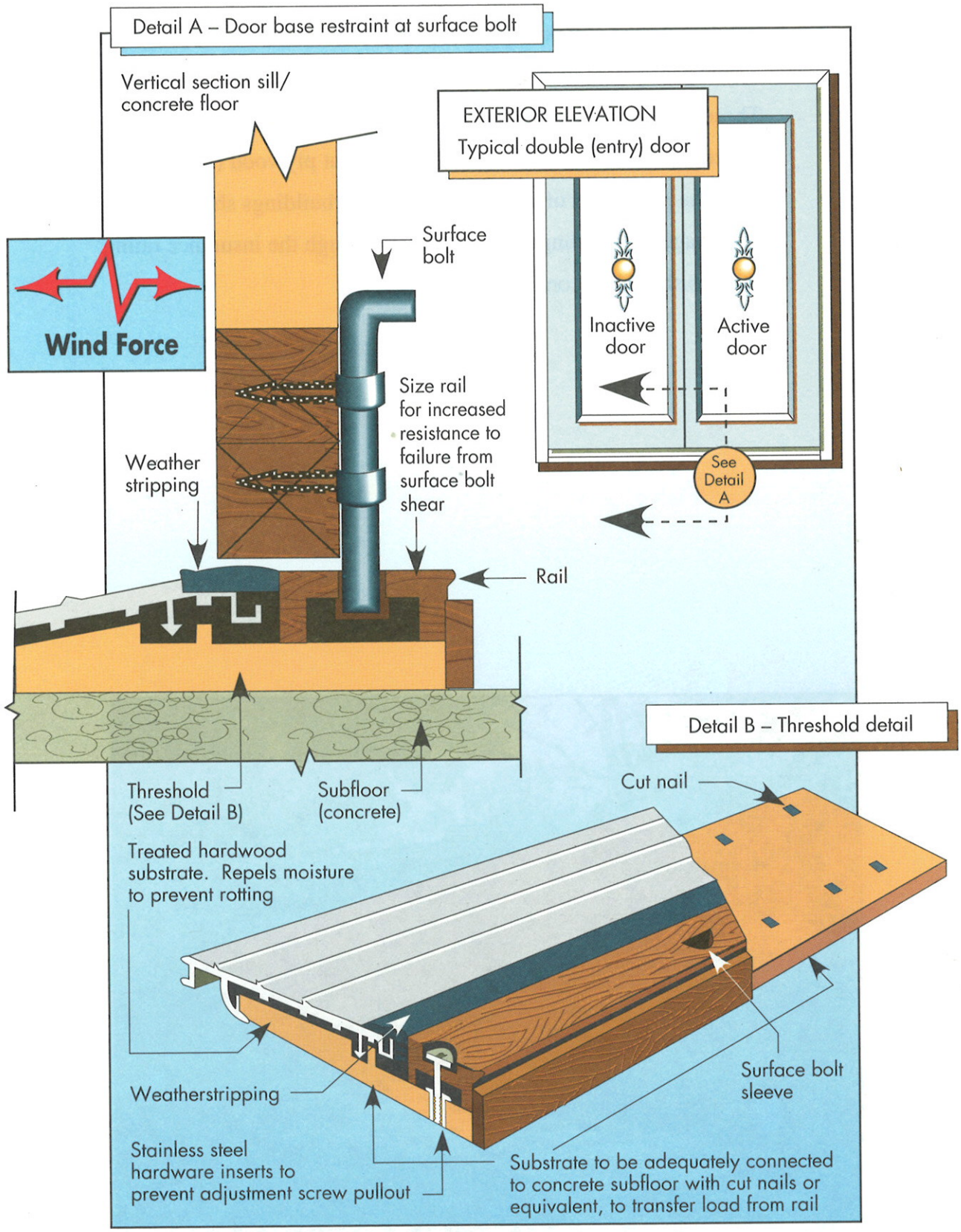

FIGURE 48. *Double entry door threshold recommendations.*

4. Window design and protection standards should be developed that require a standard system of design and protection for windows in new buildings. These should include, but not be limited to, consideration of using shutters (SEE FIGURES 40 AND 49) and precut plywood (SEE FIGURES 50-53). The protection of windows in existing buildings should be encouraged. Providing cost incentives through the insurance rating process should be considered.

FIGURE 49. *Prefabricated storm shutters.*

FIGURE 50. *Previously purchased plywood stored for use as openings protection during storm conditions.*

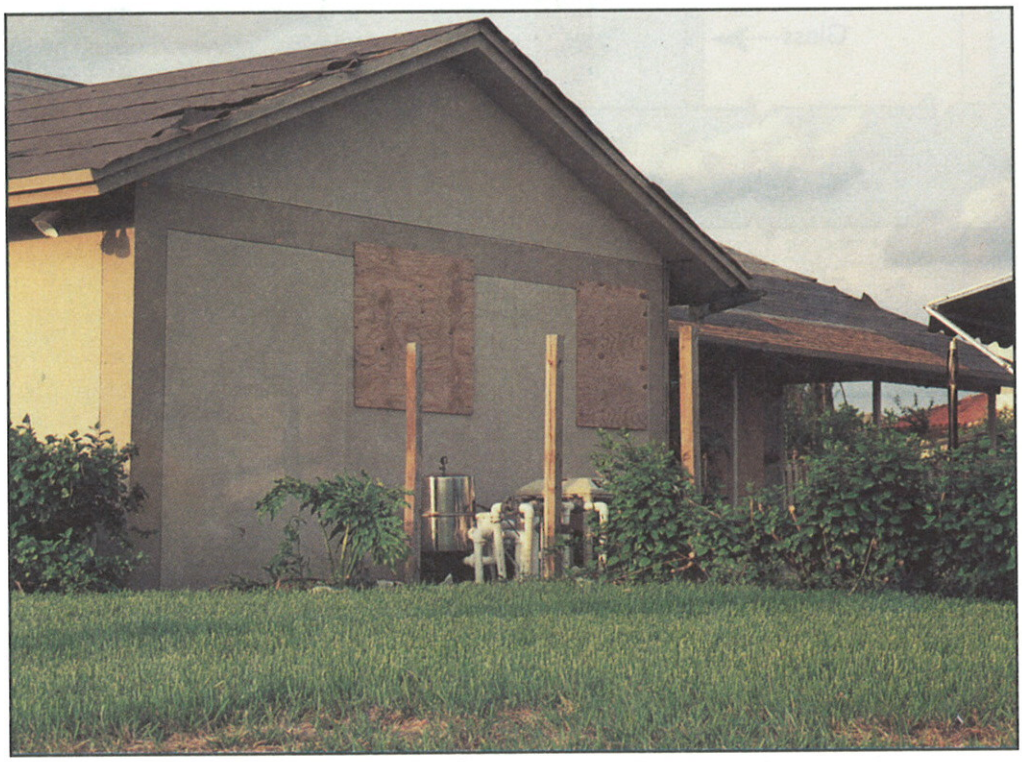

FIGURE 51. *Plywood used as openings protection installed. See Figures 52 and 53 for details.*

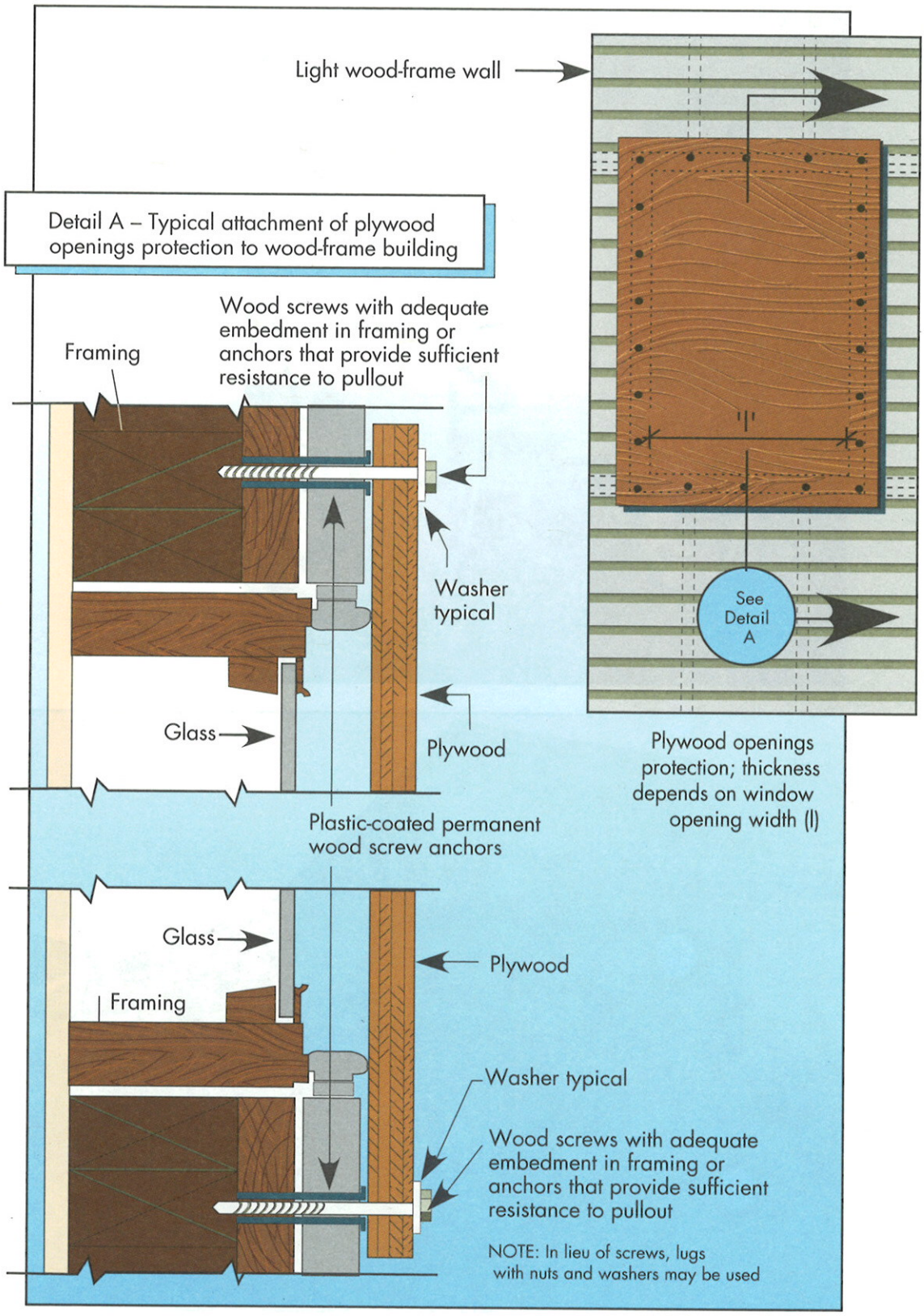

FIGURE 52. *Typical installation of plywood openings protection for wood-frame building.*

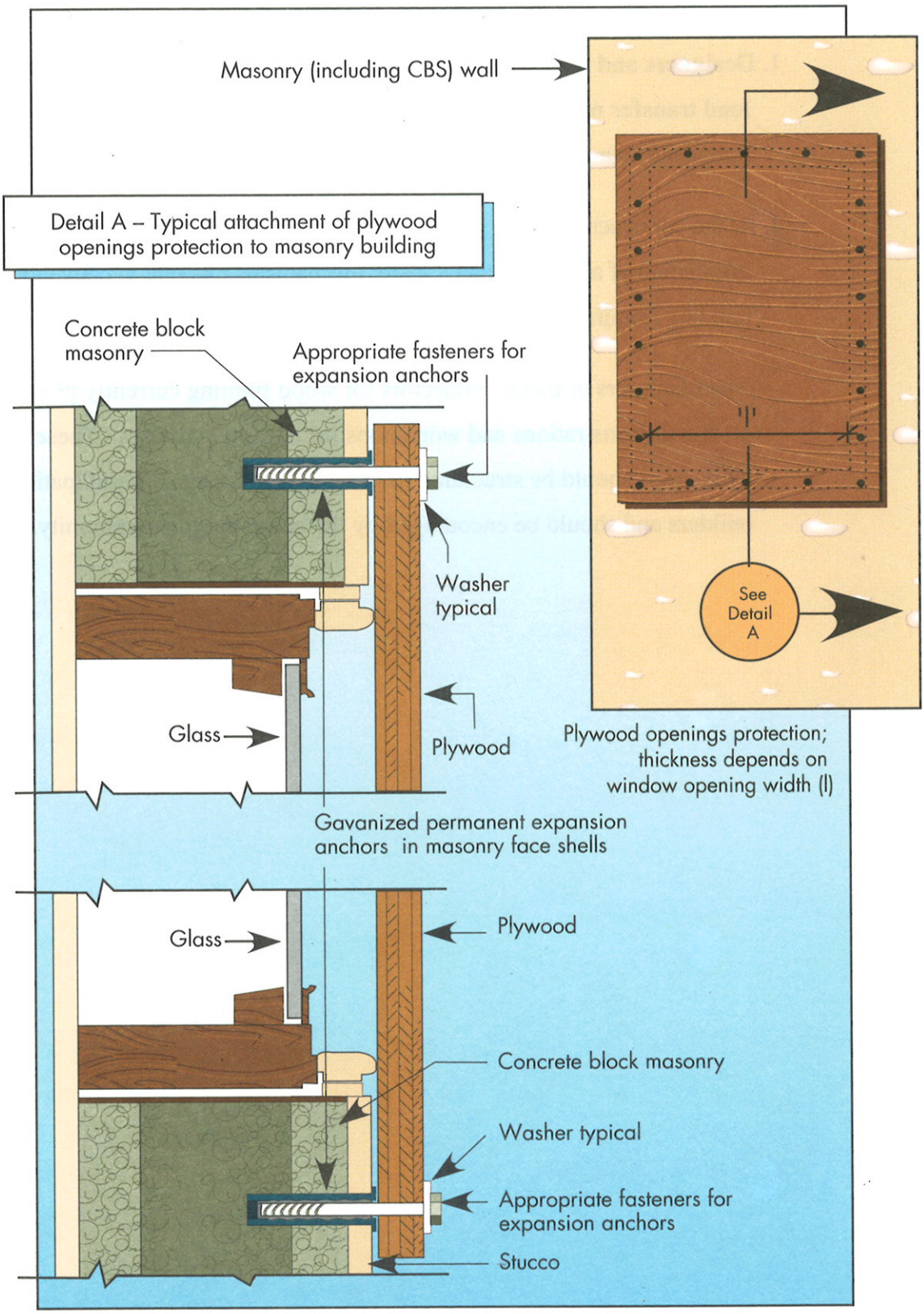

FIGURE 53. *Typical installation of plywood openings protection for masonry (including CBS) building.*

Light Wood-Frame Buildings

1. Designers and plan reviewers should pay greater attention to lateral load transfer mechanisms because of high lateral loads generated by hurricane winds (see Figures 9, 10, and 54-58).

2. At the construction stage, greater attention must be paid to the proper installation of all lateral load transfer mechanisms inherent in conventional building framing, especially hurricane straps and clips (see Figures 59-62).

— Manufacturers of metal connectors for wood framing currently provide on-site demonstrations and workshops for training purposes. These workshops should be structured to provide certificates of participation to builders and should be encouraged by the home-buying community.

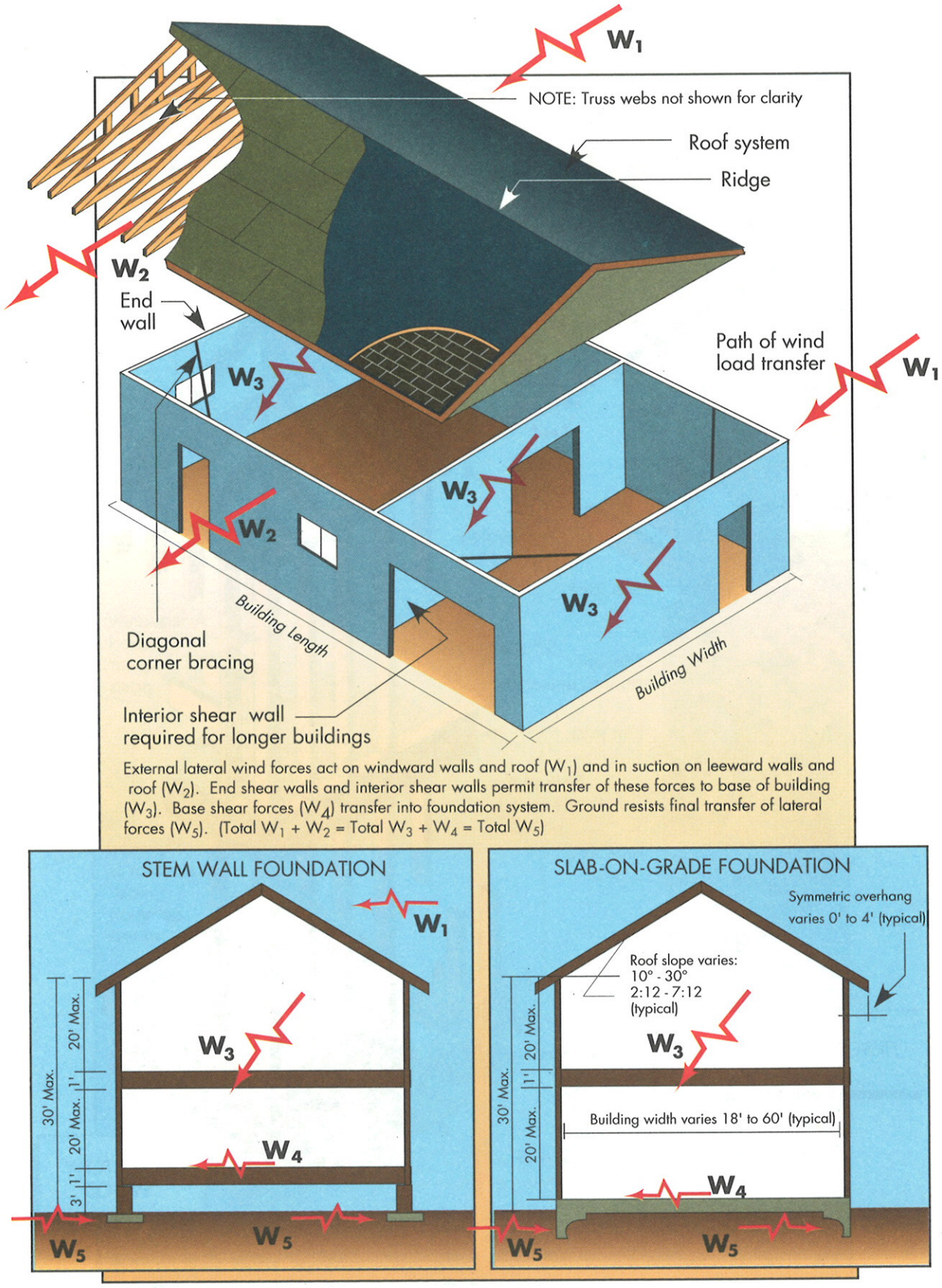

FIGURE 54. *Typical lateral load transfer for one- and two- story buildings.*

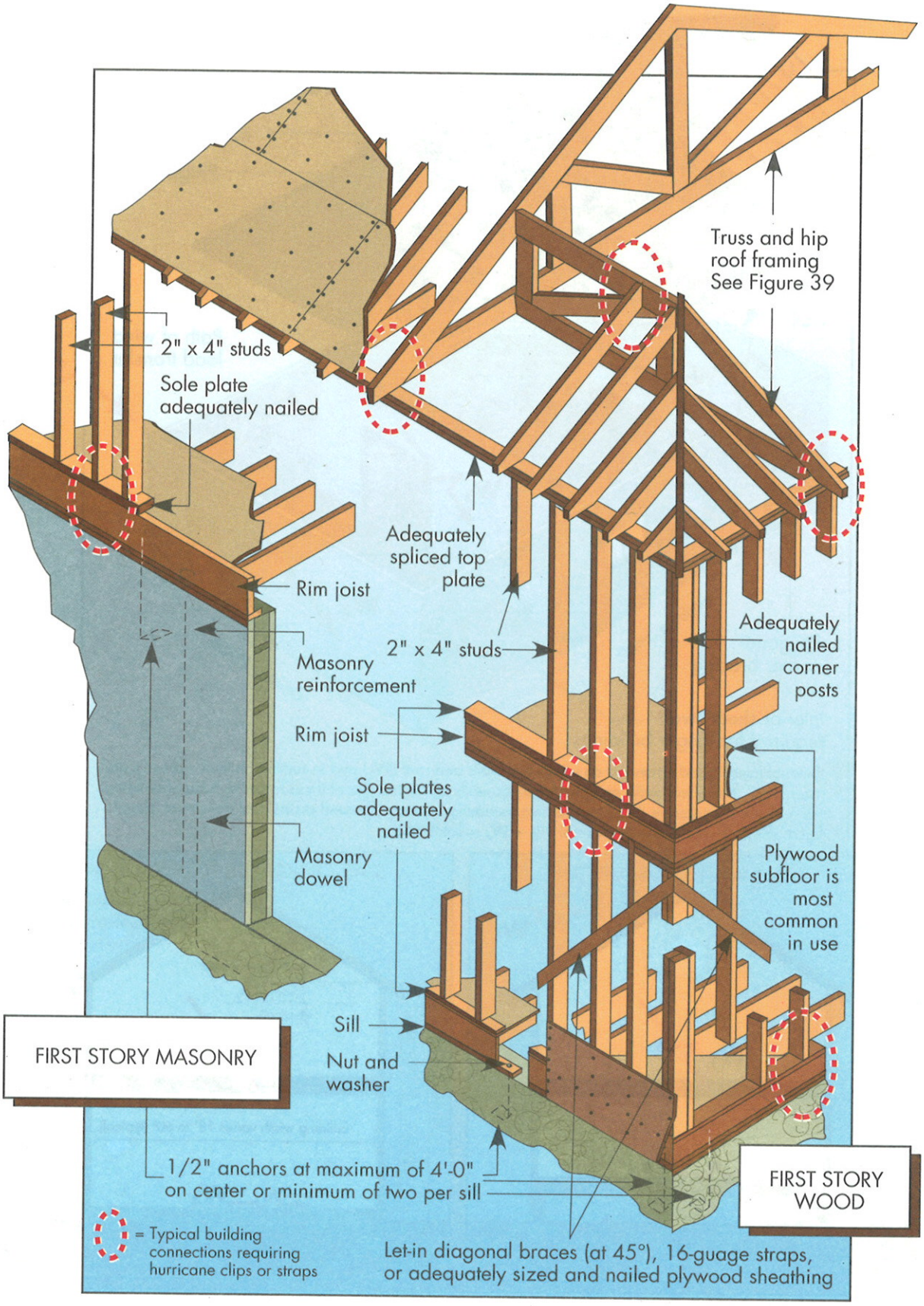

FIGURE 55. *Primary wood framing systems: walls, roof diaphragm, and floor diaphragm.*

FIGURE 56. *Properly placed hurricane straps from masonry tie-beams to roof trusses.*

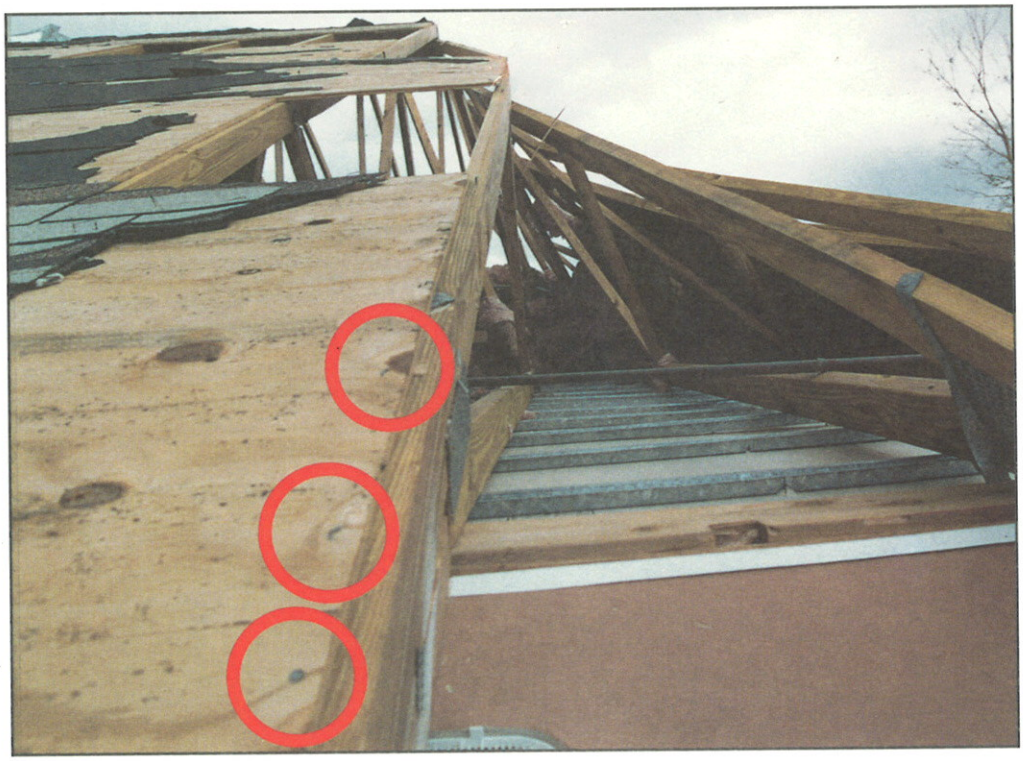

FIGURE 57. *Sheathing only tack-nailed.*

FIGURE 58. *End wall failure. Example of lack of load transfer capacity after separation.*

FIGURE 59.
End column/corner post missing from wall.

FIGURE 60.
Side wall failure. Side wall has no lateral load transfer capacity due to inadequately built-up corner post.

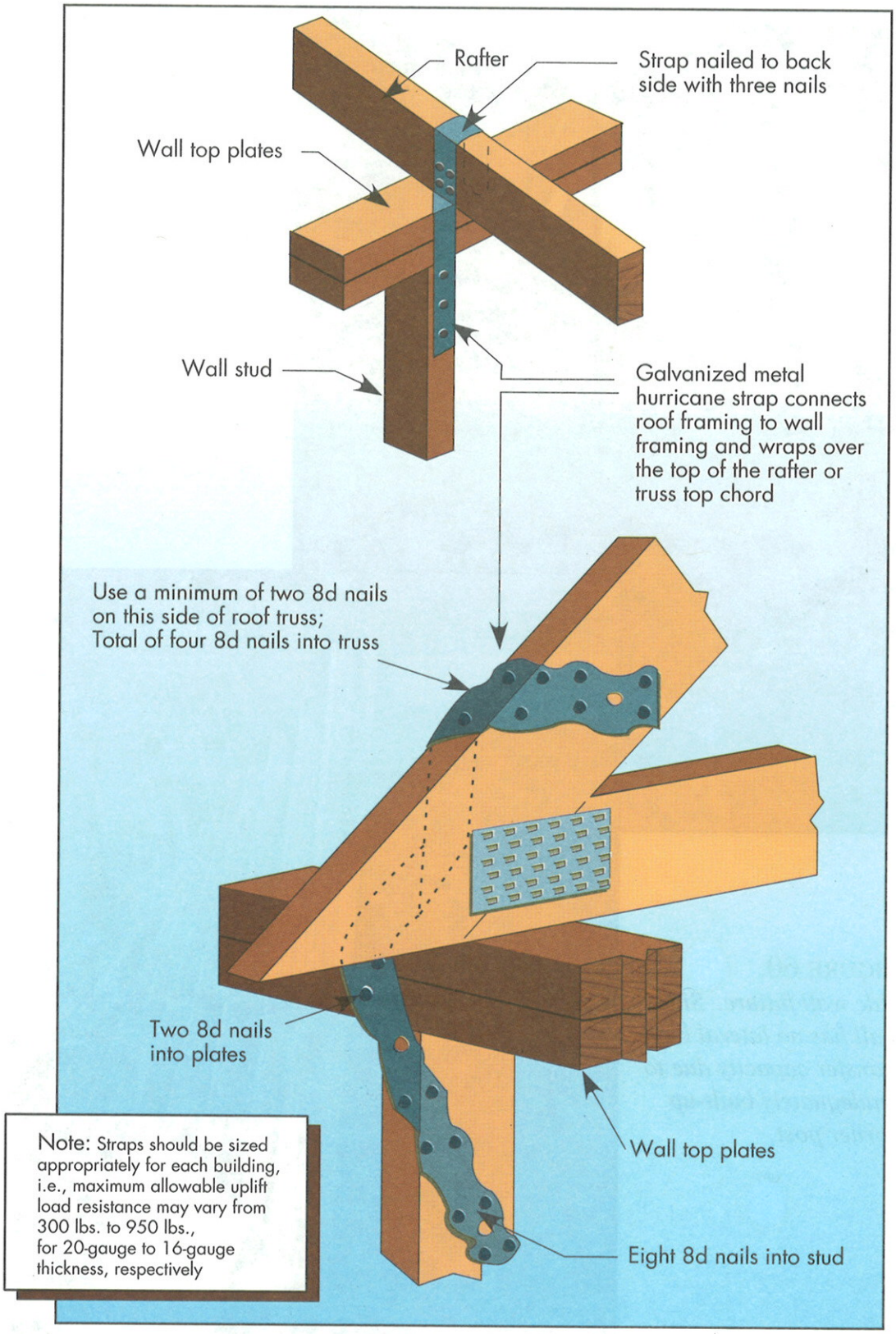

FIGURE 61. *Typical hurricane strap to roof framing detail. Rafter or prefabricated roof truss.*

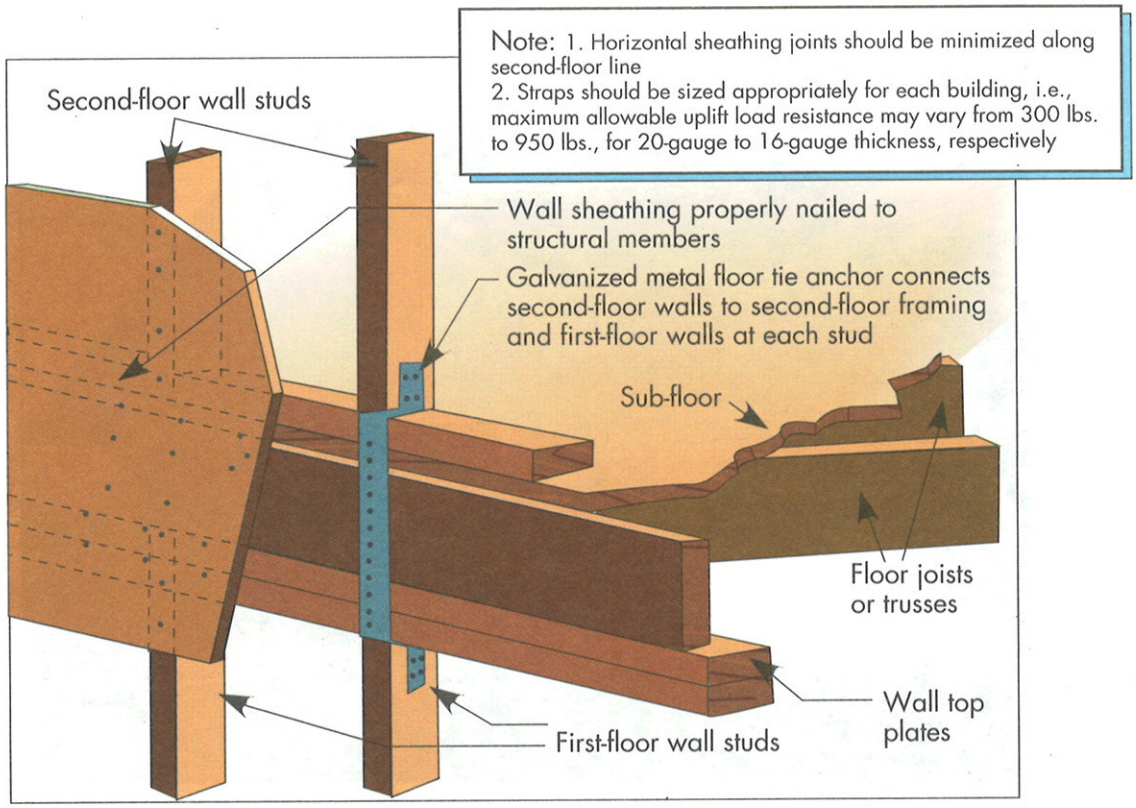

FIGURE 62. *Upper-floor tie to lower floor for two-story building. Floor tie anchor and nailed wall sheathing.*

MASONRY BUILDINGS

1. Adequately designed and constructed masonry walls must be ensured through compliance with the provisions of the Code.

— The Code requirements for tie-beams/tie-columns, or alternative reinforced masonry construction, should be reviewed and enforced (SEE FIGURES 63 AND 64).

FIGURE 63. *Example of masonry construction. Wall separated from building envelope due to inadequate vertical wall reinforcing in connection to horizontal tie-beam.*

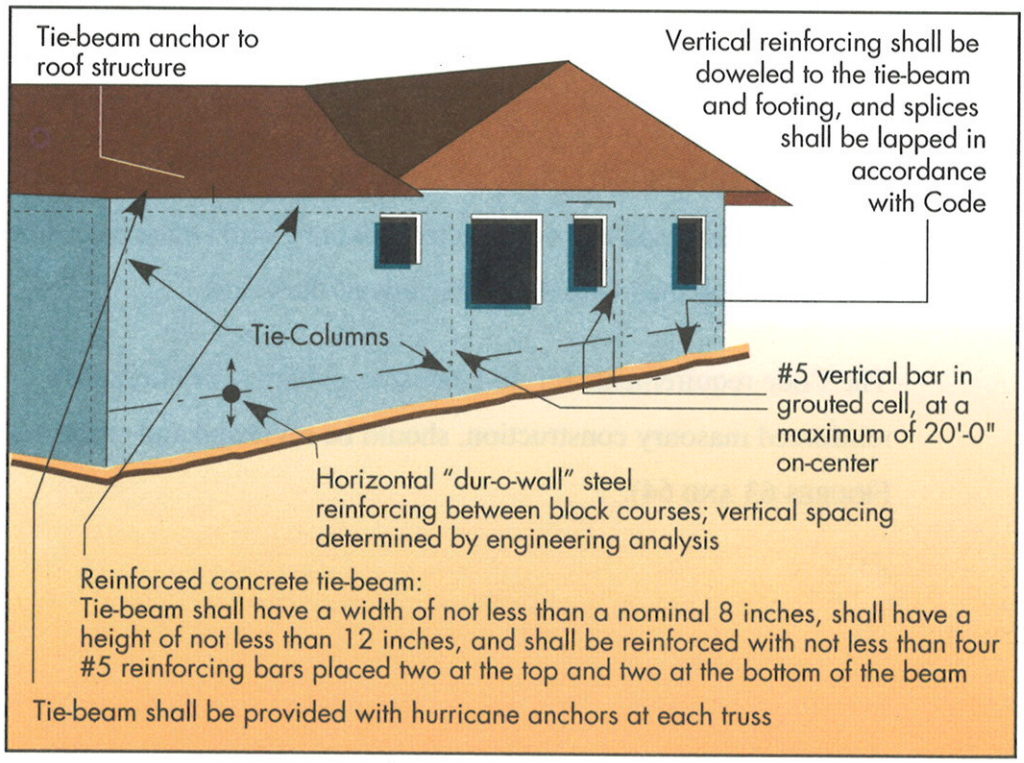

FIGURE 64. *Adequately designed and constructed tie-beam/tie-column masonry wall.*

— A tie-beam of reinforced concrete should be placed in all walls of unit masonry, at each floor or roof level, and at such intermediate levels as may be required to limit the vertical heights of the masonry units to 16 feet.

— The use of concrete tie-columns at all corners, and at intervals not to exceed 20 feet on center of columns, should be reviewed as a Code improvement. The maximum area of wall panels of 8-inch-thick unit masonry as measured between concrete members which frame the panel, such as the tie-beams and tie-columns, should not exceed 256 square feet.

2. Masonry walls with continuous tie-beams should be engineered and constructed to support the specific architecture of the building. This includes consideration of freestanding cantilevered wall systems for elements such as firewalls that have discontinuous tie-beams. (SEE FIGURES 65-68).

— Bracing with struts or pilaster columns in walls perpendicular to the free-standing walls, or adequate reinforcing in the walls sufficiently anchored in the foundation or story below, must be engineered and installed.

3. Greater emphasis should be given to the transfer of loads to concrete slabs and masonry walls from wood framing (SEE FIGURES 8, 69, AND 70). For example, the use of cut nails in lieu of bolted masonry-to-wood connections must be eliminated. Also masonry-to-wood-frame straps must be properly located.

MANUFACTURED HOMES AND MODULAR BUILDINGS

1. Re-examination of State and Federal regulations concerning the wind safety design standards for manufactured homes is recommended.

2. The issue of providing safe, affordable housing in high-wind areas needs to be further examined.

FIGURE 65. *End wall failure. Freestanding concrete masonry wall has discontinuous tie-beam.*

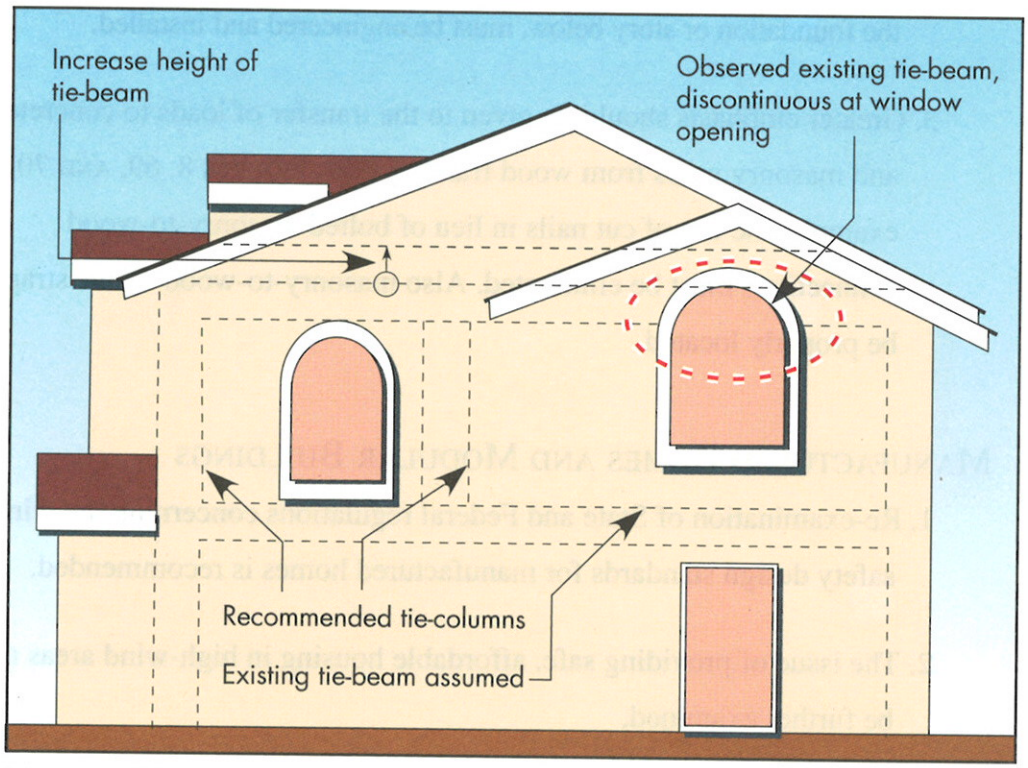

FIGURE 66. *Individualized architectural systems require designs for structural support.*

FIGURE 67. *Firewall separation . Results from building corners being discontinuous with tie-beams. (See Figure 68 for side view)*

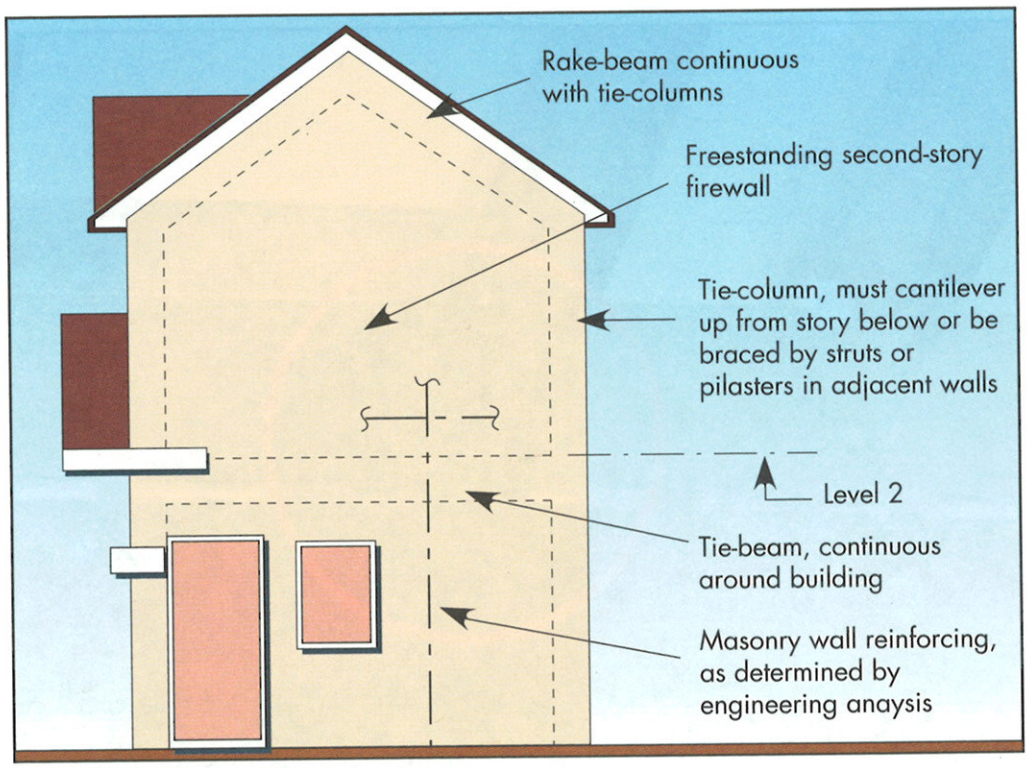

FIGURE 68. *Adequately designed and constructed freestanding cantilevered wall system.*

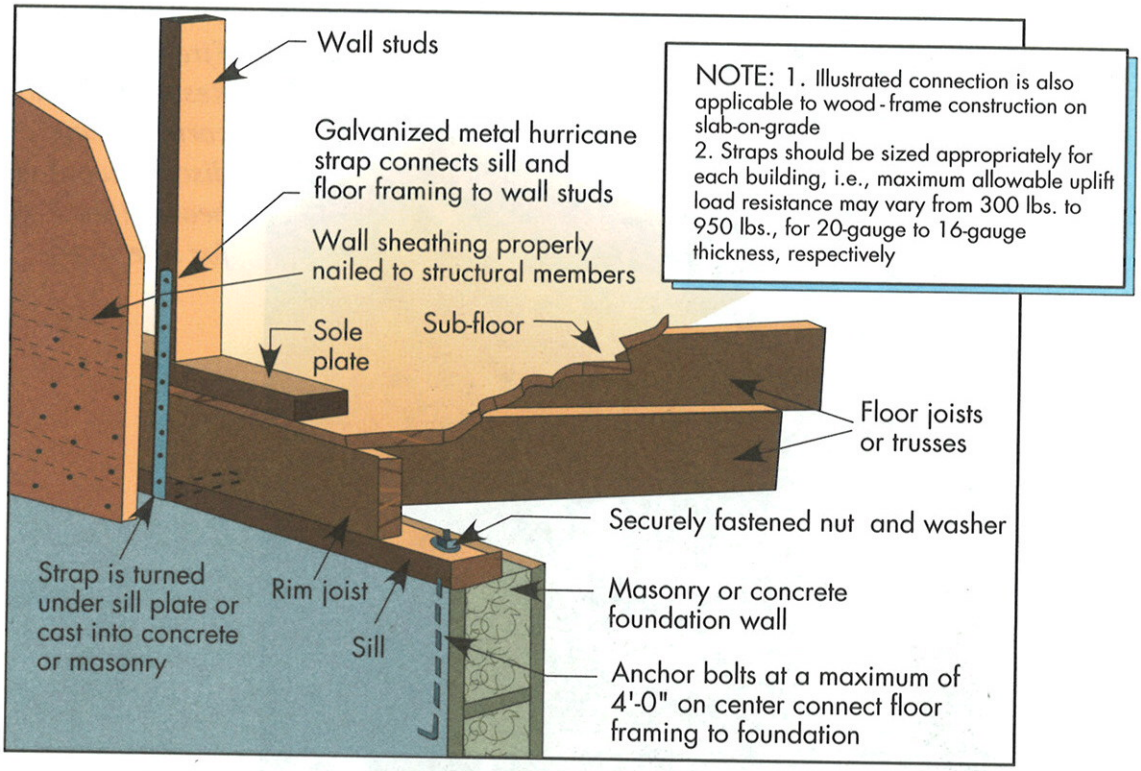

FIGURE 69. *Lower-story wall anchorage to masonry (or concrete) base. Straps properly nailed at wall studs.*

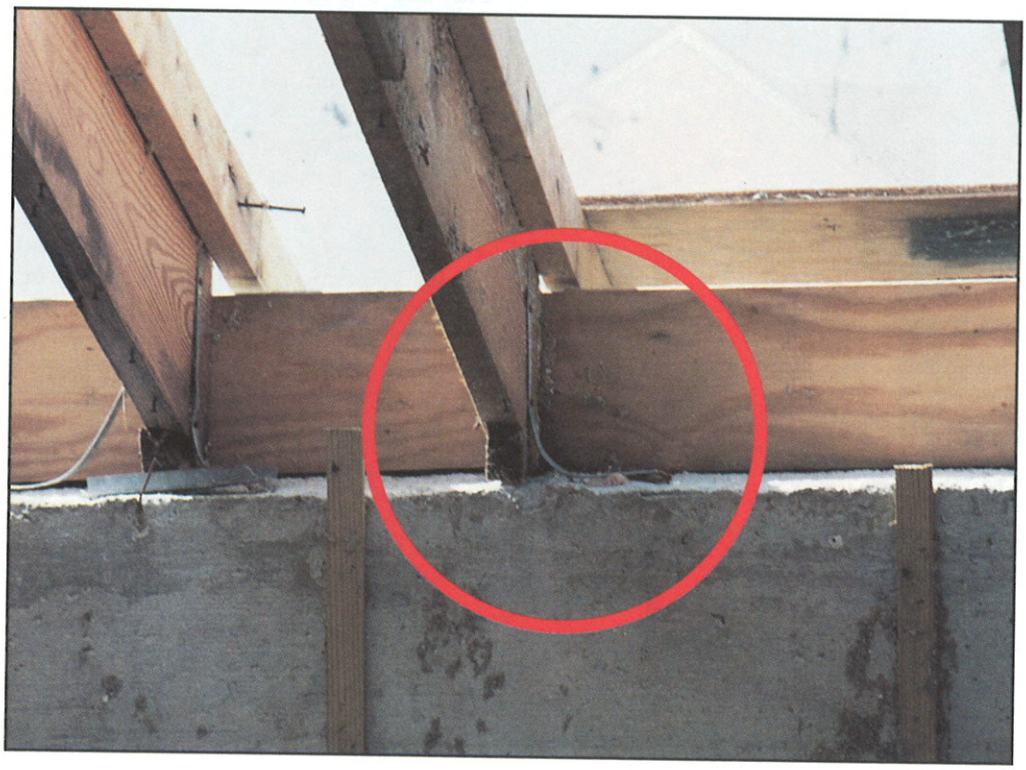

FIGURE 70. *Improperly located masonry-wall-to-wood-frame straps.*

3. Although the modular systems (SEE FIGURE 18) generally performed well, possible alternatives to the detailing and construction of weaker components of the systems should be reviewed. Most notably, the end-panel connections of end units, and roof sheathing should be reevaluated (SEE FIGURE 71).

FIGURE 71. *Modular home. Partial separation of end panel (right) from roof structure (left). Evidence of failure due to nail withdrawal.*

Accessory Structures

1. Accessory structures should be appropriately designed, manufactured, and installed to minimize the creation of airborne debris. To meet this goal, the community may want to further regulate these structures to ensure Code compliance.

Repair/Retrofit of Partially Damaged and Undamaged Buildings

1. The NFIP requirements concerning "substantial damage" provisions contained in the county Code must be enforced. The lowest floors of all substantially damaged buildings must be located at or above the BFE. This form of mitigation will reduce damages from future flood events.

2. During the Hurricane Andrew rebuilding period, building departments within Dade County should explore all available resources for expanding the pool of qualified building inspectors.

3. Although southern Dade County experienced extensive damage, many buildings are repairable. Repairs should be carried out with attention to the recommendations made in this report.

4. Technically feasible methods of retrofitting damaged and undamaged buildings for compliance with current Code requirements should be identified and promoted.

5. An audit program for existing undamaged buildings for retrofit needs should be developed and promoted. Undamaged portions of damaged buildings must be evaluated during the repair process.

6. A program that offsets retrofit burdens should be explored. This may be done through public funding of a building assessment program and/or by financial assistance through such vehicles as loan supports, tax credits, and insurance incentives.

7. A public awareness program that focuses on the maintenance of critical building components should be developed. This program could be undertaken by existing educational institutions such as community colleges.

8. A program to gain the fullest participation of the citizens in the building code process should be established.

9. Community outreach programs promoting hurricane-resistant construction should be developed and institutionalized using available local resources such as State and local colleges, trade organizations, and trade schools. If homebuyers had a greater understanding of hurricane-resistant construction, they could demand better built homes. Because market forces may well dictate future design and construction trends, this may be one of the most effective ways of promoting sound design and construction practices in Dade County.