

PROCEDURE FOR ASSESSING WIND DAMAGE TO WOOD-FRAMED RESIDENCES

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1. INTRODUCTION

The authors have developed a procedure for assessing wind damage to wood-framed residences. This procedure has been utilized by the authors for the past twenty years when determining the extent of damage to buildings from tornadoes, hurricanes, and straight-lined winds. In order to develop the procedure, the authors have compiled information on various building construction techniques as well as analyzed how wind forces interact with buildings and their environments. There are a number of helpful references on the subject including papers by Minor et al. (1977) and Bunting and Smith (1990). Many myths associated with wind effects on buildings have been discussed by Minor (1976, 1982) and Marshall (1992).

This paper presents an overview of how wood-framed residences are constructed as well as how they fail. We will discuss how to recognize flaws or "weak links" in buildings that cause them to fail at relatively low wind speeds. It is hoped that this procedure will help inspectors better determine F-scale ratings (see Fujita, 1971). Although this paper is limited to wood-framed residences, the general principles can be applied to other types of buildings.

2. LOGISTICS

It is important to begin assessing the damage as soon as possible after the storm as cleanup operations begin immediately. Important weather information can be gathered and interviews with local National Weather Service Officials are helpful. Local officials can be contacted to obtain permission to enter the disaster area just after the event. Business cards and magnetic signs provide identification. Sometimes hard hats are required when entering damaged buildings. With major disasters, other storm damage teams from the Federal Emergency Management Agency (FEMA), National Association of Home Builders (NAHB), National Weather Service (NWS), National Roofing Contractors Association (NRCA), as well as various university-sponsored teams might

be in the area. These teams eventually will publish storm damage summaries that may be helpful. An aerial survey can help provide an overall extent of the damage path quickly and interesting areas can be identified for later study on the ground.

It is important to have proper equipment for inspecting damaged buildings. Detailed road maps are essential. Still and video cameras can be utilized to document the damage. A wide-angle lens helps capture the overall damage scene whereas a zoom lens captures specific details. A second camera is a good idea to serve as a backup in case the first camera malfunctions. Faster film speeds help freeze images when moving. Wearing dark clothes also limits camera reflections. A notepad with writing pens and a tape recorder are beneficial to record photograph locations and observations. A tape measure is helpful to determine the distances between objects and fasteners as well as obtain dimensions of building components and projectiles. A hand-held GPS (global positioning system) receiver can help pinpoint ground locations especially if road signs are destroyed.

3. GENERAL INFORMATION

There are many characteristics about a home and its surroundings that should be documented. An easy-to-use "questionnaire" summarizing essential information is included in Appendix A. The name and address of the homeowner are important to locate the house on a map. Also, the year the house was built can determine what building code(s) were in effect. First, walk around the house to determine how susceptible it was to the wind. Homes in urban, suburban, and forested areas may be shielded somewhat from the wind. In contrast, homes situated in open, unobstructed terrain, on hills, besides lakes or oceans, on street corners or at the end of city blocks may be more exposed to the wind. Document any debris (i.e. trees or other building components) that impacted the home.

Items susceptible to wind around the house include air conditioners, storage sheds, fences, trees, and backyard items like lawn furniture, portable spas, and trampolines. Items susceptible to wind on the house

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include awnings, gutters, shutters, patio covers, television antennas, chimneys, siding, windows, fascia and soffit trim.

Certain building configurations are more likely to sustain wind damage. In general, the higher the building, the more it is exposed to the wind and greater its potential for damage. Also, homes not anchored properly can slide off their foundations at relatively low wind speeds. Homes with attached garages sustain greater wind damage when the garage doors fail inward allowing wind pressure to lift the garage roof or push the garage walls outward. High profile gable roofs are more prone to wind damage than low profile hip roofs.

Wind interacting with a house is deflected over and around it. Inward pressure is applied to the windward walls and outward pressure is applied to side and leeward walls. Uplift pressure is applied to the roof especially along windward eaves, roof corners, and leeward ridges. The roof is particularly susceptible to wind damage since it is the highest building component above the ground. If the building is breached, wind enters creating internal pressures that can lift off the roof. Thus, damage to a home from wind typically begins at roof level and progresses downward and inward. The last place wind damage occurs is to the interior of the home. Catastrophic damage to a home usually occurs with failure of wall/foundation connections or roof/wall connections. Therefore it is important to examine these critical areas on a building.

4. FOUNDATION EXAMINATION

There are six common types of house foundations: 1) concrete slab, 2) pier and beam, 3) poured concrete wall, 4) concrete masonry wall, 5) stacked brick or block, and 6) timber piles or masonry and concrete columns. The inspector may encounter one or more of these foundation types in their damage survey. In general, homes on concrete slab foundations are usually found in the south and southwest U.S. Homes with basements or crawl spaces usually have poured concrete or masonry walls and are found in the upper Midwest and southeast. Houses on stacked brick or blocks typically are found in rural areas, especially in the southern United States. Timber piles and masonry or concrete columns are utilized to support homes in coastal and flood-prone areas.

4.1 CONCRETE SLAB FOUNDATIONS

Homes on concrete slab foundations usually are bolted or strapped to their foundations. However, some municipalities have adopted variances in the building codes that allow shot pins or cut nails. Figure 1 shows common types of foundation anchors.

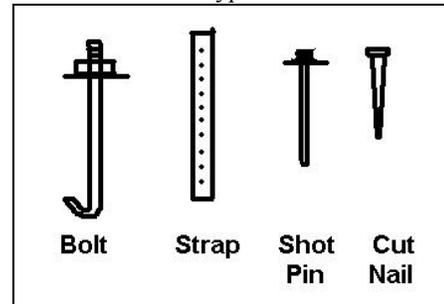


Figure 1. Common types of foundation fasteners.

Anchor bolts are at least 1.3 cm (1/2 inch) in diameter and 30 cm (12 inches) long and have a J-shaped profile that provides significant pull-out resistance. The anchor bolt is inserted into the concrete slab while it is poured with a depth of at least seven inches and must have sufficient height above the slab to pass through the plate and accept a steel nut and washer. Anchor bolts are spaced 1 to 2 meters (3 to 6 feet) apart and located within 30 cm (12 inches) of the end of the plate and wall corners (Figure 2).



Figure 2. Properly bolted bottom plate. However, note the weak straight-nailed connection between the wall studs and bottom plates.

Anchor bolts must be inserted properly into the concrete slab foundation. We have found anchor bolts placed too deep in the concrete to engage the nuts. We also have found bolts placed outside or inside of the wooden sills or bottom plates. Thus, these homes were not anchored to their foundations. Also, nuts and washers must be fitted on the anchor bolts and tightened snug to secure the plates. This might seem obvious, however, we have found numerous bolted plates and sills without nuts or

washers. A properly anchored sill or bottom plate is a strong connection and rarely fails. Instead, failure of the home is more likely where the wall stud is nailed to the bottom plate (Figure 3). Therefore, homes that are bolted down to their foundations are not necessarily well-built or wind resistant.

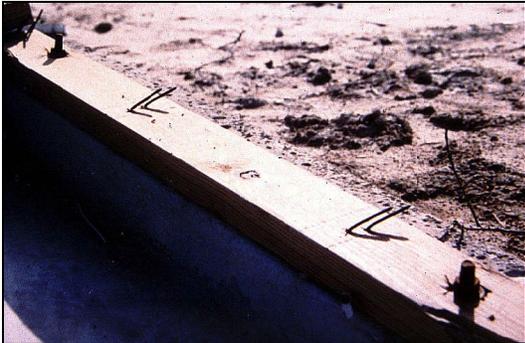


Figure 3. Failure of this home occurred where the wall stud was nailed to the bottom plate.

The bottom plate is either straight-nailed into the wall stud and/or the wall stud is toenailed into the bottom plate (Figure 4). A pair of 16d (8.9 cm or 3.5 in) common nails often are used for this connection. Although such a connection will meet the minimum requirements in most building codes, it is inherently weak when uplifted (Figure 4).

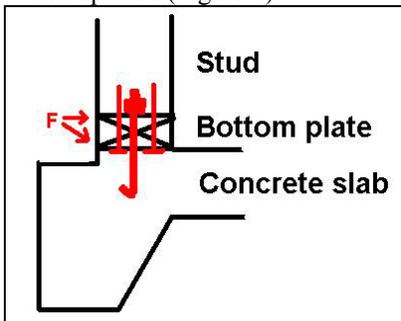


Figure 4. Typical wall cross section on concrete slab foundation showing a bottom plate bolted to the foundation and straight-nailed into the wall stud. Connections and failure points ("F") are in red.

Marshall (1983) conducted pull tests on pairs of 16d nails that connected plates to studs. For straight-nailed connections, the average pull-out strength was 984 N (220 lbs.) with a standard deviation of 375 N (84 lbs). For toenailed connections, the average pull-out strength was 1313 N (295 lbs) with a standard deviation of 304 N (68 lbs). Canfield et al. (1991) conducted similar pull tests with similar results. However, they could increase the average pull-out strength to 1842 N (414 lbs) if the wood did not split when nailed. By comparison, Canfield et al. (1991) also conducted pull tests on metal "hurricane" clips and found an average strength of 5341 N (1200 lbs)

depending on the type of clip used. Thus, a metal clip can be about three times stronger than a 16d (8.9 cm or 3.5 in) toenailed connection (Figure 5).



Figure 5. A metal clip connecting the wall stud to the bottom plate provides considerably more uplift resistance than conventional straight- or toe- nailing.

Besides anchor bolts, bottom plates are attached to the concrete slab with metal straps, shot pins, or cut nails. Metal straps can be just as effective as bolts in anchoring the bottom plate to the foundation if they have proper thickness and are installed correctly (Figure 6). The straps are typically made from 18 gauge metal (1.2 mm or .0478 inches) and are perforated for the fasteners. Steel shot pins look like thick nails and literally are shot into the foundation with a powder actuated hammer. Shot pins are typically 7.6 cm (3 inches) long and have an accompanying washer (Figure 7). Unfortunately, cut nails sometimes are used to secure the bottom plates to the foundations. Cut nails are easily pulled through the bottom plate when the plate is uplifted or rotated. Building codes do not allow the use of cut nails, however, some building officials have allowed cut nails to secure interior (not perimeter) walls. Unfortunately, we have found many homes where cut nails were installed around the perimeter of the foundation (Figure 8).

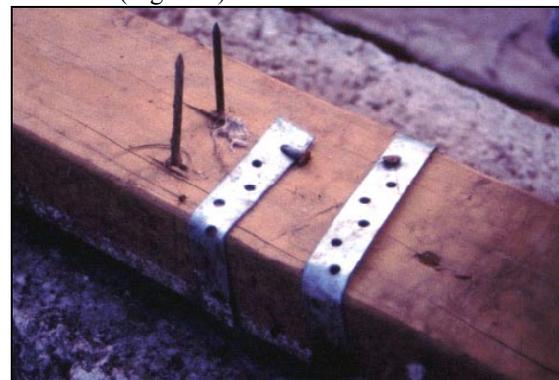


Figure 6. Metal straps held the bottom plate in place, however, failure occurred where the wall stud was straight-nailed through the bottom plate.



Figure 7. Shot pin with attached washer in the bottom plate. Inset photo shows aftermath of tornado where bottom plate broke around the fasteners.

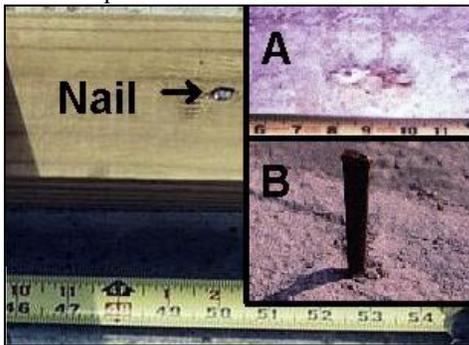


Figure 8. Cut nail in the perimeter bottom plate was a violation of the local building code. Inset photograph A shows scrape mark in the slab after wall slid off foundation. Inset photograph B is a cut nail left in the foundation after home was blown away.

4.2 PIER AND BEAM FOUNDATIONS

Pier and beam foundations usually are made of different materials. Piers can be wood, loose block, masonry, or concrete. Perimeter grade beams are usually poured-in-place concrete or masonry. The same types of anchors are used to secure the house to the beams as with concrete slab foundations. However, floors are supported by the piers and rarely anchored (Figure 9). Note the floor platform separates the walls from the foundation, resulting in

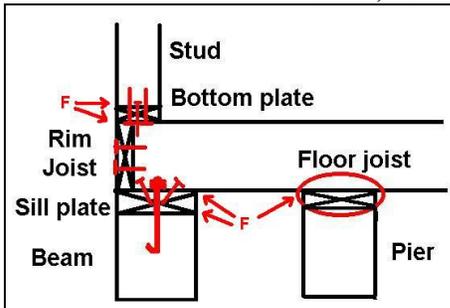


Figure 9. Typical pier and beam foundation showing connections and failure points (in red). However, piers are rarely attached to the flooring (circled).

more nailed connections. In general, the more nailed connections in a foundation, the greater the chances for a poor connection. The authors have identified failures at each of the nailed location points in this type of foundation. Usually, the anchor bolted sill plate remains. Homes on pier and beam foundations tend to shift off their foundations and sustain more catastrophic damage (Figure 10).



Figure 10. This home shifted and disintegrated from its wooden pier and concrete beam foundation. Floor joists were not attached to the piers.

4.3 POURED CONCRETE WALL FOUNDATIONS

Poured concrete wall foundations are found in homes that have basements or crawl spaces. A concrete footing supports the foundation wall. The wooden sill plate is either bolted or strapped around the perimeter of the foundation. Floor joists typically are toenailed to the sill plate. A center beam extends across the middle of the basement or crawl space and is supported by columns and slotted into the perimeter wall. The center beam and columns are either wood or steel (Figure 11).

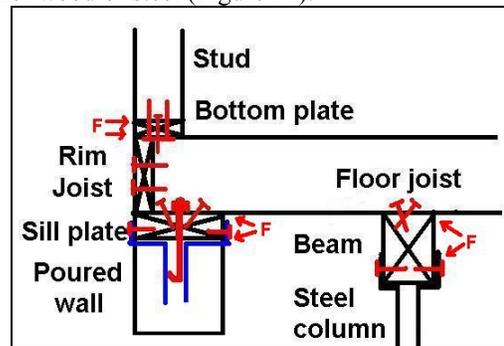


Figure 11. Typical cross section of a poured concrete wall foundation showing nailed and bolted connections with failure points (in red) and strapped connections (in blue). Center beam is wood or steel.

A common failure point is where the bottom plate is secured to the floor. The bottom plate is straight nailed to the floor at certain intervals and the nails usually miss the underlying floor joists. Thus, this

connection has little resistance to lateral wind loads and the connection simply pulls apart as the wall is rotated (Figure 12). In many instances, the authors have found nails driven into the open joint between the rim joist and the floor joist leaving the wall virtually unattached. The floor platform usually remains if properly anchored to the foundation.

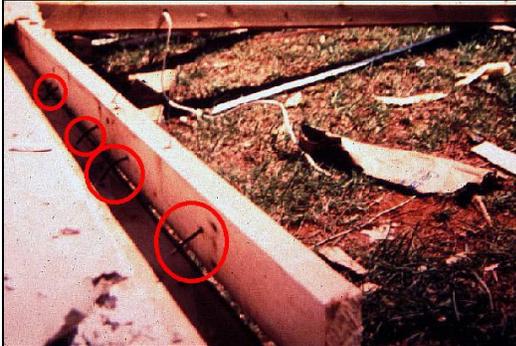


Figure 12. Straight-nailed bottom plate pulled out of the floor as the wall rotated. This was an inherently weak connection (circled).

A more catastrophic failure occurs when the connection between the floor joists and sill plate fails. This results in the entire home sliding off its foundation. The authors also have found no attachment of the center beam to the floor joists especially if the center beam was steel. Also, doors and windows in the foundation wall can weaken its lateral resistance leading to overturning of the foundation wall (Figure 13).



Figure 13. Exit door weakened the concrete wall foundation (circled). The foundation wall rotated and broke apart at the opposite corner. Steel rebar was used only at the wall corners. The house was pushed into the ravine in the background.

4.4 MASONRY FOUNDATION WALLS

Masonry wall foundations are constructed with concrete masonry units (CMU). These units have open cells that are stacked in a common pattern with mortared joints. The connection of the house to the foundation is similar to that of concrete foundation walls. However, the top cell is usually filled with

mortar or concrete where the anchor bolts or straps are placed (Figure 14).

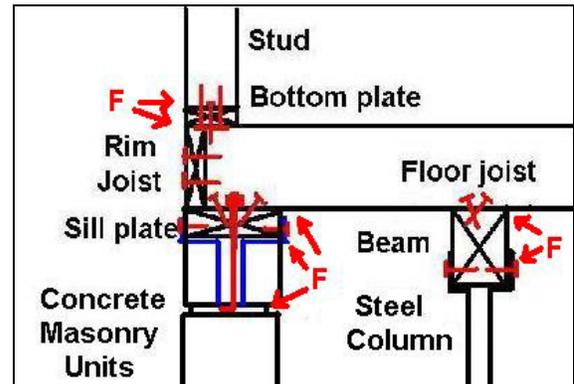


Figure 14. Typical cross section of a masonry wall foundation showing nailed and bolted connections (in red) and strapped connections (in blue). Center beam is wood or steel. Failure of this foundation type frequently occurs at areas denoted by the letter "F".

Unreinforced concrete masonry foundations are inherently weak in resisting lateral and uplift forces and frequently fail causing the house to slide along with the top row of concrete masonry (Refer to Figure 15). Interestingly, building codes in high wind areas require steel reinforcement to extend through the cells all the way down into the footing.



Figure 15. This home shifted off its foundation when the masonry foundation failed. Inset photograph A shows that the top row of masonry was attached with J-bolts as shown in inset photograph B. Note how little damage there was to the roof.

4.5 LOOSE BRICK OR BLOCK FOUNDATIONS

Homes constructed on loosely stacked brick or block foundations are not anchored and can be easily shifted from their foundations (Figure 16). Such homes can be "swept clean" from their foundations resulting in F-5 damage on the Fujita scale with wind speeds less than 45 m/s (100 mph).



Figure 16. Unanchored home on stacked CMU foundation slid 90m (295 ft) off its foundation.

4.6 PILE OR COLUMN FOUNDATIONS

Homes elevated on timber pilings, or concrete or masonry columns usually have substantial anchoring of the floor system. Weak points in this type of construction are where the bottom plates are nailed to the floors or where the wall studs are nailed to the bottom plates. Use of hurricane clips or straps can provide a much stronger connection provided they are installed properly and are protected from corrosion due to salt exposure. Wind damage to these homes usually involves loss of the walls leaving the floor intact (Figures 17 and 18).

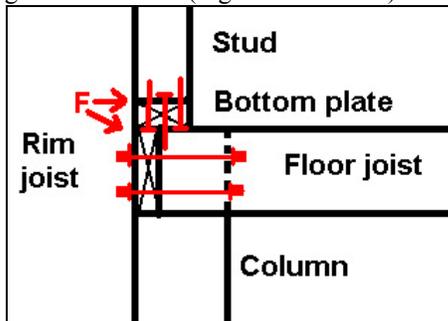


Figure 17. Typical cross section of home elevated on timber piles, concrete or masonry columns. Floors are usually bolted or strapped to the columns (in red). Common failure points are the nailed connections where the wall is attached to the floor.



Figure 18. Wind damage to a home elevated on timber piles. Failure commonly occurs where the walls are attached to the floor.

Although rare, the pilings or columns can fail when they are not adequately braced or extend sufficiently below grade.

5. WALL EXAMINATION

Wood-framed walls need to be braced properly to stiffen the frame and resist racking from lateral loads. At a minimum, diagonal bracing or "let-ins" are required at all wall corners. Typically, wall studs are notched to receive a wooden board that extends diagonally from the top plate at the wall corner to the bottom plate and is nailed to the studs. Plywood or oriented strand board (OSB) is some times utilized at the wall corners, especially when diagonal bracing cannot be installed due to an intervening window or door (Figure 19).

Loss of brick veneer is a common problem due to improper attachment of the masonry to the wood-framed wall. Corrugated brick ties or wires must be imbedded at least two inches into the mortar joints and attached properly to the wall. Walls that are not attached properly are free-standing and can be moved even by applying hand pressure. Such walls can topple easily in relatively low winds (Figure 20).



Figure 19. Installation of solid sheathing at wall corners helps stiffen the frame. Top plate clips as shown in inset photograph A and diagonal bracing as shown in inset photograph B also stiffen the frame.

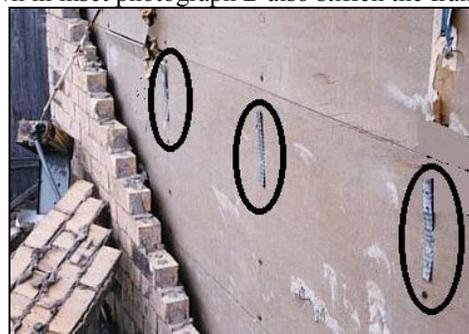


Figure 20. Brick ties (circled) were installed on this home but not engaged into the mortar joints. As a result, wind easily toppled this unanchored wall.

Weak links in wall systems are large windows or doors that interrupt the continuity of the framing. In addition, failure of windows and doors allows wind to enter the building increasing internal pressures that can help lift the roof and push out perimeter walls. Garage doors are inherently weak and often fail in wind speeds as low as 36 m/s (80 mph). The doors buckle or pop off the door tracks allowing the wind to enter the garage (Figure 21).



Figure 21. Inward failure of garage door led to outward failure of sidewall and collapse of the garage. Note little damage to remainder of home.

6. ROOF EXAMINATION

Roof systems typically are held in place by gravity. Thus, minimal attention is given to wind uplift effects. Typically, the rafters or trusses are toenailed to the wall top plates and this type of connection will meet most building codes (Figure 22). However, this connection is inherently weak when uplifted. Rafters or trusses will break away from the top plates. It is less common for the top plates to separate. Metal straps or clips can secure all of these members together.

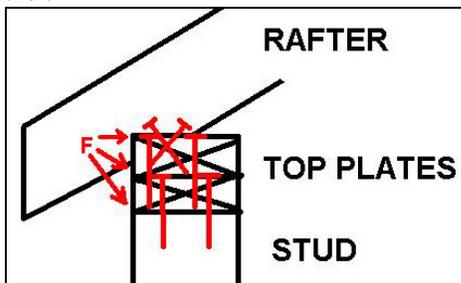


Figure 22. Typical cross section of roof/wall top plate showing nailed connections and common failure points (in red).

The authors have found numerous examples where rafters and trusses were not fastened adequately to the wall top plates. Nails had split the wood or were driven through knots or other defects in the wood (Figure 23). As a result, the entire roof was susceptible to being removed in relatively low wind speeds. Properly installed hurricane clips or metal

straps can strengthen this connection greatly. A house that is missing its roof usually had poor attachments at the tops of the walls.



Figure 23. Nails driven through rafters and ceiling joists protruded through the top plate and split the wood. A better connection would have been to install metal clips as shown in the inset photograph that places the nails in shear (strong) instead of tension (weak).

Rafters and trusses require proper cross bracing to resist lateral wind forces. Installation of ridge blocking and metal brackets can prevent the trusses from falling down like dominoes. Although gable ends are non-structural components, they are susceptible to being blown inward or outward depending on the wind direction (Figure 24).



Figure 24. Toppled roof trusses due to a lack of lateral bracing. A metal bracket (inset photograph) along with proper wooden blocking between the trusses would have prevented rotation of the trusses.

The shape of the roof also will determine its wind resistance. In general, gable and flat roofs are not as strong structurally as hip roofs. Hip roofs are more streamlined and are structurally stronger as each slope is supported by intersecting planes of the roof. This is one reason why many homes in hurricane prone areas have low-pitched, hip style roofs.

Roof decking is typically plywood, oriented strand board (OSB), or wooden boards. The decking is fastened at six-inch intervals and fasteners must penetrate into the underlying rafters or trusses.

Commonly, pneumatic guns are used to drive fasteners into the decking and in some instances, the fasteners miss the underlying framing. As a result, the roof deck is not attached and is quite susceptible to being removed in the wind. The authors have found entire sheets of plywood fully clad with roof shingles in the debris around the home. Exposure of the rafters and trusses usually indicates inadequate deck attachment (Figure 25).



Figure 25 House that lost all of its roof decking on the leeward slope. Close inspection revealed that staples missed the underlying rafters (inset photograph).

There are many different types of roofing materials on residences including asphalt shingles, tile, metal, wood shingles, shakes, etc. Each industry has guidelines available for proper installation of the roofing product. Installation instructions usually are printed on labels accompanying the roofing product indicating the proper size, number and spacing of fasteners. Roof coverings also must meet the minimum wind uplift requirements as stated in the building codes. However, the authors have found numerous deficiencies with installations of roof coverings that have led to their removal in relatively low wind speeds (Figure 26). Common roof installation errors include placing fasteners too high on the product, overdriving, under-driving, or orienting the fasteners incorrectly. Tile roofs secured with mortar tend to unbond leading to tile removal.



Figure 26. Poor installation of the roof covering on this home led to its complete removal. Staples were installed crooked and under-driven (inset photograph).

7. DETERMINING THE F-SCALE RATING

Fujita (1971) developed the F-scale to rate the severity of wind damage to buildings. He rated homes from 0 to 5 based on the increasing severity of damage to “well-constructed” or “strong” wood-framed houses. The terms “well-constructed” and “strong” are subjective and debatable. Most homes have nailed connections, and these connections are inherently weak especially when wood members are fastened together in tension. Also, homes are not homogeneously constructed, so rating them without regard to knowing how they are constructed (or failed) will introduce large errors. Fujita (1992) realized this and introduced corrections to the F-scale to account for variations in building strength but did not provide an explanation of how to employ such corrections. Therefore, the authors provide the following descriptors to aid the inspector in assigning F-scale damage ratings.

Homes rated F0 lost a few roof shingles, windows, some siding, a chimney, a garage door or carport. Homes rated F1 lost a small portion of the roof structure and/or suffered collapse of the garage. Homes with F2 damage lost most of their roof but the exterior walls remained. However, if the roof was not fastened properly to the walls, the F-scale rating is reduced one. F3 homes lost their roof and exterior walls. However, if the roof or walls were not fastened properly, the F-scale rating is reduced one. An F4 rating means the house was reduced to a pile of debris on the foundation. However, if the roof or walls were not fastened properly, the house damage rating is reduced by two F-scale numbers or to the damage rating of the adjacent house(s). An F5 rating still means a house was swept away from its foundation. However, if the roof and walls were not fastened properly, the house damage rating is reduced by three F-scale numbers or to the damage rating of the adjacent house(s).

Fujita (1971) also assigned wind speed ranges that would cause F-scale damage. The wind speed ranges were derived empirically and have been determined by Minor et al.(1977) and others to be too high, especially at the higher F-scale numbers. Marshall (2002) showed that most wood-framed buildings suffered significant damage with wind velocities of only 45 m/s (100 m.p.h.), and most wood-framed houses are leveled by winds exceeding 62 m/s (140 m.p.h.). Interestingly, the design wind speed for most of the U.S. is a three-second gust of 41 m/s (90 m.p.h.) at 10 m (33 feet) above the ground in open, unobstructed terrain (Exposure C).

8. SUMMARY

Inspecting a house for wind damage involves careful examination of the building components from the ground, up. This paper presented a procedure for inspecting wood-framed buildings for wind damage. Common weak links associated with nailed connections were discussed and many examples were presented. A questionnaire was developed by the authors to aid inspectors in assessing a house for wind damage and assigning an F-scale rating.

9. ACKNOWLEDGEMENTS

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WIND DAMAGE TO RESIDENCES ASSESSMENT FORM

GENERAL INFORMATION ABOUT THE HOUSE

- 1) Name of homeowner _____
- 2) What is the house address? _____
- 3) What year was the building constructed? _____ Building Code (if known) _____
- 4) What is the surrounding terrain? Urban (Exp. A), Suburban (Exp. B), Open (Exp. C), On lake/ocean (Exp. D)
- 5) Where is the house located? In a forest, In middle of the block, At a street corner, On a hill, In a valley.
- 6) What is the number of stories? 1, 1-1/2, 2, 3, split level. Describe _____
- 7) What direction does the front of the house face? N NE E SE S SW W NW
- 8) What is the shape of the house plan? Rectangular, L-shape, U-shape, H-shape, Other _____
- 9) What type of cladding is on the house? Brick, Stone, Wood, Vinyl, Metal, Stucco/EIFS, other _____
- 10) Does the house have an attached garage or carport? YES NO If so, is it 1, 1-1/2, 2, 3.
- 11) What are the sizes of the garage doors? 1 car wide 2 car wide _____ feet
- 12) Where is the attached garage located on the house? N NE E SE S SW W NW
- 13) Which direction does the garage face? N NE E SE S SW W NW.
- 14) What appurtenances are on the house? Awnings, Gutters, Shutters, Patio Cover, Antenna _____
- 15) What is the number and location of windows? _____ Sliding glass doors? _____
- 16) Is there a chimney? If so, what is the type and location on house? _____
- 17) What appurtenances are around the house? Storage Shed, Fence, Air conditioner, Type _____
- 18) What is the number and location of windows? _____
- 19) Location from tornado center N NE E SE S SW W NW Estimate distance from tornado center _____ feet.

FOUNDATION COMPONENTS

- 20) What is the foundation type? Slab, Pier & Beam, Concrete, CMU, Stacked brick/block, Timber piles
- 21) How is the bottom plate or sill attached to the foundation? Bolted, Shot Pin, Strapped, Clipped, Nailed, None
- 22) Describe the number, type, interval, and length of fasteners in foundation _____
- 23) Are fasteners installed correctly? YES NO If no, explain _____.
- 24) Did house fail at the foundation? YES NO If yes, explain where it failed. _____

WALL COMPONENTS

- 25) How is the wall cladding fastened to the framing? Nailed, Stapled, Brick, Ties _____
- 26) Did cladding fail? YES NO If yes, explain where it failed _____
- 27) Are the walls standard 2 x 4's at 16 inches on centers? YES NO If no, explain _____
- 28) How is the bottom plate fastened to the stud? Straight-nailed, Toe-nailed, Strapped, or Clipped _____
- 29) Describe number, type, interval, and length of fasteners at base of wall _____
- 30) Are nuts and washers secured properly on the bolts? YES NO If not, describe _____
- 31) Did the walls fail? YES NO. If yes, explain where it failed _____

ROOF COMPONENTS

- 32) What is the shape of the roof? Gable, Hip, Gambrel, Shed, Flat, Mansard, Other explain _____
- 33) What is the type of roof covering? Asphalt shingles, wood shingle/shake, tile, metal, other _____
- 34) How is the roof covering fastened? Nailed, Stapled, Clipped, Loose hung on battens, Mortared _____
- 35) What is the age of the roof covering? _____ years
- 36) What is the type of roof deck? Plywood, Oriented strand board(OSB), Wood plank, other _____
- 37) How is the roof deck attached and at what intervals? Nailed ___ inches apart Stapled at ___ inches apart
- 38) Did roof deck fasteners penetrate into rafters? YES NO. If no, explain _____
- 39) How is the roof framed? Rafters and joists or Pre-manufactured trusses Other _____
- 40) How are the rafters or trusses fastened to the top of the walls? Toenailed, metal straps, Other _____
- 41) Describe number, type, interval, and length of rafter/top plate fasteners _____
- 42) Did the roof structure fail? YES NO. If yes, explain where it failed _____
- 43) Did the roof covering fail? YES NO. If yes, explain where it failed _____