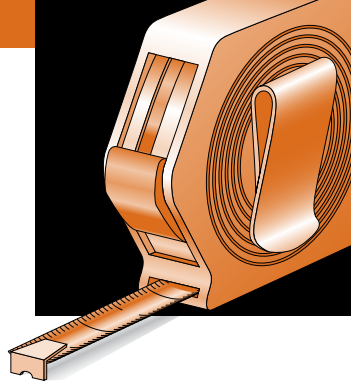


Retrofitting a Roof for High Wind Uplift

Number A410A

July 2007

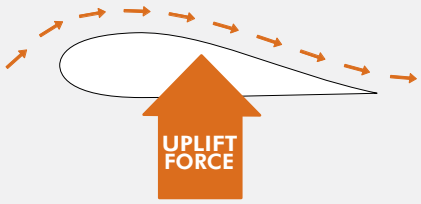
In hurricane country and other high wind areas, it is critical that the homeowner understands the impact high wind forces can have on a roof system, and the preventative fastening techniques essential to maintaining a safe and long-lasting roof system. This data file illustrates the effects of high winds on a roof, and provides three solutions the homeowner can use to increase the roof's resistance to wind damage.

As the wind flows over a roof, the sheathing on the roof is subjected to aerodynamic forces similar to those subjected to the wings of an airplane. See Figure 1. Depending on the shape, slope, height and location of the roof, these forces can act to hold the roof sheathing on or to pull it off of the framing. Of course, the speed of the wind acts in conjunction with shape, slope, height and location of the roof to determine the magnitude of these forces and their direction – either into the roof (holding the roof on) or away from the roof (pulling the roof off).

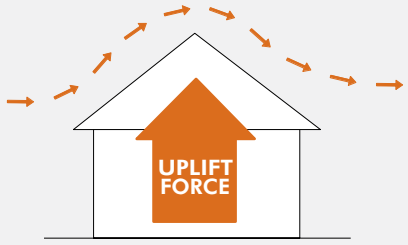
To ensure the performance of a given roof system, it is essential that those forces trying to pull the roof sheathing off are resisted by sufficient fasteners holding the roof down to the framing.

FIGURE 1

WIND FORCES



a. On the wing of an airplane



b. On the roof of a house

RETROFITTING A ROOF DURING RE-ROOFING

Roof Re-Nailing

The easiest, surest and most inexpensive method of retrofitting the roof sheathing attachment is re-nailing the sheathing during re-roofing. When the roof sheathing is exposed, its attachment schedule can be upgraded at little added expense. The existing roof sheathing nailing can be evaluated and additional nails can be added to meet the high wind attachment schedule required for a given area and roof shape.

Note: A second roof covering should never be placed over an existing one if the structure is located in an area subject to high winds or hurricanes.

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Recommended Fastening Schedules

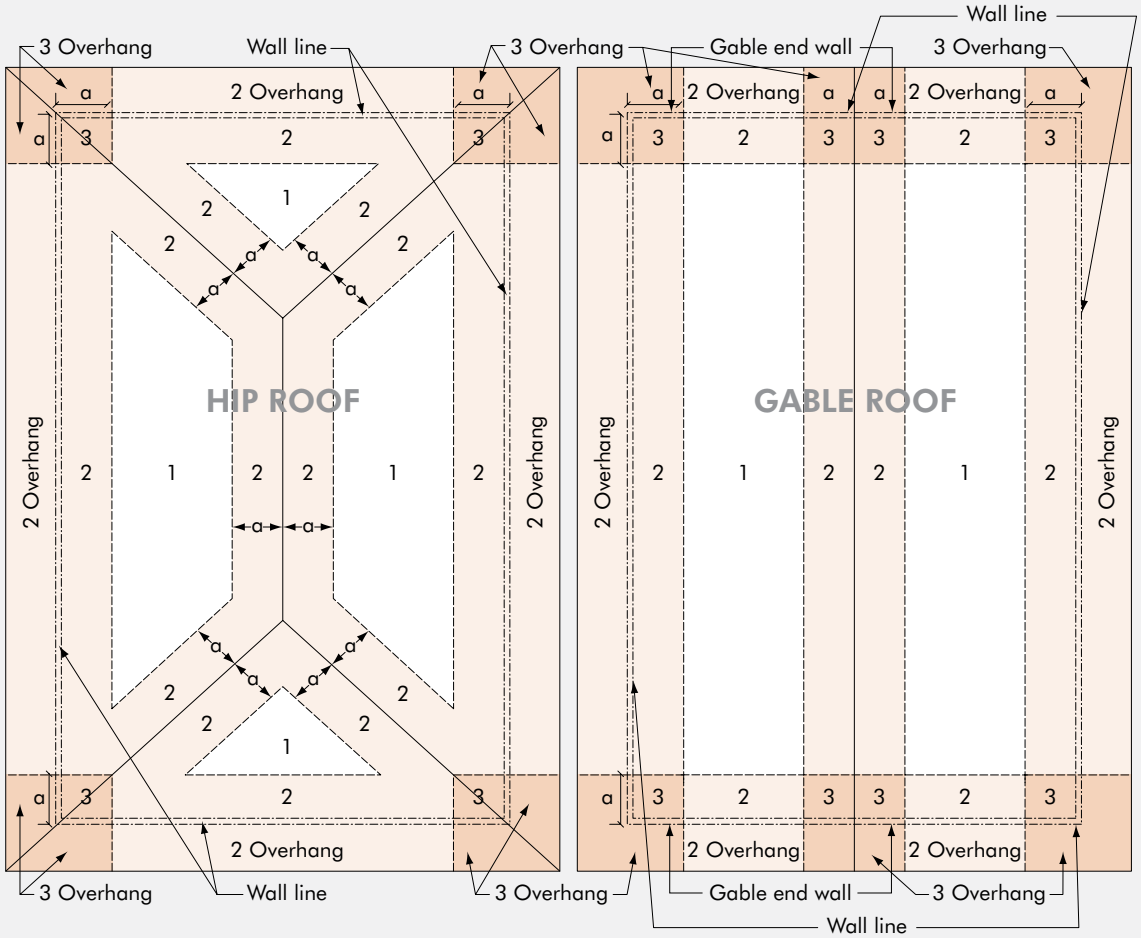
Higher pressures at eaves, corners, ridges and gable-ends require more restrictive schedules than at interior portions of the roof system. For this reason, minimum fastening schedules may be different for each of the three roof fastening zones, as illustrated in Figure 2. The minimum fastening schedule presented in Table 1 reflects the differences in wind uplift pressures that may be anticipated over various portions of roof systems shown in Figure 2.

The minimum fastening schedule provided in Table 1 is for roof applications with framing spaced at 24 inches on center or less. These schedules assume the use of wood structural panels 5/8-inch thick or less and are appropriate for buildings with a mean roof height of up to 35 feet. All fasteners listed in the tables are minimum 8d common nails (0.131 x 2-1/2 inches) with smooth or deformed shanks, depending on the fastener location. Some jurisdictions may require deformed-shank nails. Check your local building department for requirements. All recommendations are based on the use of full-length nails meeting the requirements of FF-N-105B (ASTM F1667).

High wind uplift – The schedule for high wind uplift is appropriate for *all hurricane-prone regions* (Atlantic and Gulf of Mexico coastal areas). In addition, this schedule should be considered for the *transition zones between hurricane-prone and inland regions.* Contact the local building department for the basic wind speed used for design in a given area.

FIGURE 2

ROOF FASTENING ZONES FOR WIND UPLIFT
Zones 1, 2 and 3 shown below indicate areas of the roof that may have different minimum fastening requirements.



Distance a = 4 ft in most cases (10% of least building width or 0.4 times building height, whichever is smaller, but not less than either 4% of least building width or 3 ft).

For conditions outside of those given in Table 1 (Exposure C or D, structures taller than 35 feet, partially enclosed buildings, frame spacings wider than 24 inches on center, etc.) engineered design is recommended.

Caution: More nails are not always better! – When adding nails to the roof sheathing, avoid spacings less than 3 inches on center to minimize the potential for splitting of the framing below. Add only the nails needed to arrive at the required nail spacing. Unless they are seriously overdriven, missed the framing below or have corroded, the existing nails – providing they are 8d or larger – may be counted toward the nail schedule shown in Table 1. For high wind uplift regions, existing 6d nails (permitted under obsolete codes) should be ignored during re-nailing of the roof sheathing.

TABLE 1

ROOF SHEATHING FASTENING SCHEDULE[a,b,c,d,e]
8d Common (0.131 x 2-1/2 inches) or Deformed Shank (0.135 x 2-1/2 inches) (Except Where Noted) for Exposure B, Enclosed Buildings, Roof Framing Spaced 24 inches o.c. or Less

Wind Velocity (3-Second Gust)	Panel Location[i]	Roof Fastening Zone						
		Main Roof			Sheathing-to-Gable-End-Wall Framing[g]		Overhang (eaves)	
		1	2	3	2	3	2	3
		Fastening Schedule (inches on center)						
150 mph[f,g]	Supported panel end and edges	6	6	6	3[h]		6	6
	Panel field	6	4	3			4	3
120 mph[f,g]	Supported panel end and edges	6	6	6	3		6	6
	Panel field	12	6	4			6	4
90 mph	Supported panel end and edges	6	6	6	6		6	6
	Panel field	12	12	6			6	6

a. Specific gravity (G) of lumber and panels shall be 0.42 or greater.
b. For Exposure B and a 2-ft overhang.
c. For median roof height 35 ft or less.
d. Gable wall height of 8 ft or less from top floor ceiling to roof peak.
e. Provide adequate uplift hardware at truss-to-wall connections. Such connections are beyond the scope of this publication.
f. When wind speed is 110 mph or greater and when median roof height is between 25 and 35 ft, use 8d deformed shank nails (0.135 x 2-1/2 inches) within 48 inches of gable end walls. (IRC Table R602.3(1), footnote f).
g. When wind speed is 100 mph or greater, block panel edges perpendicular to gable-end-wall framing members in the first two bays of framing. Blocking shall be spaced a maximum of 4 feet o.c. (*Wood Frame Construction Manual,* Section 3.5.5). Some jurisdictions may require deformed-shank nails for high wind areas. Check your local building department for requirements.
h. 10d deformed shank nails (0.148 x 3 inches).
i. Blocking not required.

ROOF RETROFIT WHEN RE-ROOFING IS NOT REQUIRED

Adhesive Systems

While not as easy as re-nailing, there are several methods that have been tested for enhancing the attachment of the roof sheathing to the roof framing from the bottom side. Not limited by access to the topside of the roof sheathing, such as during reroofing, this can be done at any time that the under side of the roof can be accessed. Both methods rely on the use of adhesives to attach the roof sheathing to the roof framing. The first method uses construction adhesives that are commonly used in the APA Glued Floor System. This method is suitable for the do-it-yourselfer. The second method uses a proprietary two-part urethane-based foaming adhesive applied by a trained professional with special equipment.

The following information is based on an investigation sponsored by the Institute for Business and Home Safety (IBHS) and sponsored in part by *A Program to Mitigate Hazards to Low-Rise Buildings and Other Structures* sponsored by the Federal Emergency Management Agency (FEMA), the state of South Carolina, and Clemson University. The investigation focused on the use of commercially available adhesive systems to securely fasten roof sheathing to rafters or truss top chords.

HOW CAN I TELL WHAT MY ROOF SHEATHING ATTACHMENT NAIL SPACING IS?

Detecting the nails: With the roof covering in place, it is difficult to tell what nail spacing or nail size was used to attach the sheathing to the roof framing. From the bottom side, if the fasteners properly hit the framing, there should be no visual indication of their frequency, size or location. Those fasteners that miss the framing are clearly visible and are often referred to as "shiners" by carpenters.

APA has determined that one of the electronic stud finders with a metal detection mode can be helpful in locating nails in a 2 x member. With the back of the finder held up against the framing member and the side placed in contact with the roof sheathing, the stud finder was able to locate the nail positions as it was moved along the roof framing member.

Tip: Put transparent tape over the fuzzy strips on the back of the stud finder and it will slide more smoothly over the rough surface of the roof sheathing.

Determining nail spacing: Remember that there are two separate nail spacings: one at a framing member where two panels meet; and one in the "field" of the panel where the middle of the panel passes over a framing member. The nail spacing in the "field" of a panel is traditionally 12 inches on center, while the edge spacing is from 3 to 6 inches on center. With plywood roof sheathing, by looking at the grain pattern of the panels, it is relatively easy to determine which framing members conceal a joint between two panels. With OSB sheathing panels, it can be considerably more difficult as their surfaces tend to be more alike. To detect a joint, look for staining or dirt patterns that dramatically change at a framing member. It may be necessary to run the stud finder along a number of adjacent framing members until a clear picture of the two nailing patterns emerges.

Locating the nail spacing in the field of the roof is relatively easy. Calibrate the stud finder in accordance with the manufacturer's recommendations. Run the stud finder down a framing member that supports the center of the panel for about 4 feet or so, marking the "hits" with a felt tip pen. Compute the average as follows:

1. Measure in inches the distance between the first and last hit.
2. Starting with the second hit, count the number of hits. (Do not count the first hit.)
3. Divide the distance by the number counted in step 2. This is the average nail spacing.

Calculating the edge nail spacing is a little more difficult because there are more nails and they are in two rows: one for each panel edge resting on the framing member. The less expensive stud finder is of little help for this application. The more expensive stud finder, set in the metal mode, can read the nails in both rows from one side. If the nails in the two rows are staggered, the stud finder will see individual nails in each row. For example, two rows of nails staggered at 6 inches on center will look the same as a single row at 3 inches on center. If the nails are not staggered, the finder will detect each pair of nails and the pattern will look like a single row at 6 inches on center.

How can you tell the difference? The signal for the double nails is much stronger than that for a single nail. The finder picks them up sooner and holds on to them longer. This means that as you are sliding the finder along the framing member, the buzzer stays on longer for a double nail. You will quickly develop an "ear" for it. APA recommends starting on a field-framing member with single nails. Once you become familiar with the "sound" of a single nail, a double nail will be easy to detect.

Tip: Be careful to move the stud finder at a slow, consistent pace. Find what works best for you and ***stick to it!***

Do I have to do the whole roof? Probably not. Within a few minutes, the nail pattern at a given location can be determined. Spot checking a few locations will give a pretty good indication as to how the roof sheathing was attached, and whether additional nailing is needed. If the pattern from location to location is erratic, then checking the whole roof is recommended.

How can I tell what kind of nails were used to attach my roof? If all of the nails are hidden, you can't. Fortunately, there are always a few "shiners." These are nails that missed the framing members. Be sure to differentiate shiners from roofing nails. They look different. Shiners (the structural fasteners) are longer, smoother, and often, shiny. That is where they get their name. Roofing nails are short, squat and are usually covered with a rough zinc coating.

Measure the diameter of the nail and its length – remember to add back the thickness of the roof sheathing and shingles to obtain the nail length. Compare these dimensions with the table given below to determine the kind of nails used to attach the roof sheathing.

What happens if the "shiners" I find turn out to be staples? Staples can be used to secure roof sheathing for even the strongest wind loads. The trick, as with nails, is getting the correct size and number in the correct location to effectively hold down the roof sheathing.

For more information on the attachment of roof sheathing in high wind areas with staples, please contact:

The International Staple, Nail and Tool Association (ISANTA)
512 West Burlington Avenue, Suite 203
La Grange, IL 60525-2245
(708) 482-8138
www.isanta.org

Nail Type	Penny Weight	Length	Diameter
Common	6d	2	0.113
	8d	2-1/2	0.131
Box	6d	2	0.099
	8d	2-1/2	0.113

Construction Adhesive Systems

The first adhesive system utilizes common construction adhesives. These are the adhesives commonly used to attach floor sheathing to joists to prevent floor squeaks. These adhesives should reference AFG-01 or ASTM D3498 conformance on the tube. These adhesives come in cardboard tubes like caulk and are applied with a manual or pneumatic caulking gun.

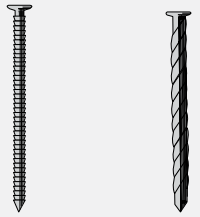
A 1/4-inch bead of adhesive is applied in the corner between the roof sheathing and the roof framing. This bead is applied in the corner in such a way as to form a fillet between the sheathing and framing. See Figure 3. The fillet is applied on both sides of the framing. According to tests conducted at Clemson University, an AFG-01 or ASTM D3498 adhesive applied in such a manner to each side of the lumber-to-sheathing joint provides an ultimate resistance to uplift of at least 225 psf. The use of a 3/4-inch quarter-round at the adhesive joint will increase the average ultimate uplift capacity to over 300 psf. Where the fillet cannot be applied to both sides of the roof framing, as in the case of a gable end, the 3/4-inch quarter-round or some other similar lumber blocking is required. See Figure 3.

The use of a construction adhesive can be best used in accessible, unfinished, uninsulated attic areas with a roof pitch of 5 in 12 or greater. For shallow roof slopes, the difficulty in applying the adhesive to those areas near the exterior may require the use of a special extension tool developed by Clemson University and the IBHS. This extension can be fabricated from common plumbing fittings by the do-it-yourselfer. Plans are available through the IBHS. Ask for *Holding on to Your Roof* at:

Institute for Business and Home Safety
4775 East Fowler Avenue • Tampa, FL 33617
Phone: (813) 286-3400 • Fax: (813) 286-9960 • info@ibhs.org

As an alternative to the caulking gun extension in areas with limited access, pieces of quarter-round about 3 to 4 feet long can be used. The adhesive is applied to the two adjacent edges of the quarter-round. The quarter-round is lifted in place and pressed into the corner between the roof sheathing and the roof framing such that the adjacent edges contact the sheathing and the framing. The quarter-round is clamped or nailed in place until the adhesive sets up. Like the glue fillets, this is done on both sides of the roof framing.

THE CASE FOR DEFORMED SHANK NAILS



Ring-Shank Nail **Spiral-Shank Nail**

Deformed shank nails – typically ring-shank or spiral-shank nails – are nails that have a series of annular grooves along the shank of the nail. The purpose of these grooves is to increase the friction between the shank of the nail and the wood fiber in contact with it. The result of this increased friction is a nail with increased withdrawal resistance.

As one of the purposes of the fasteners attaching the roof sheathing is to resist the wind uplift pressures, increasing the capacity of the fastener correspondingly increases the uplift resistance of the sheathing panel. (Studies conducted at Clemson University have indicated that the withdrawal resistance of deformed shank nails can be as much as two times as great as smooth shank nails.) Deformed shank nails can be applied with the same nail guns as smooth shank nails, are available from the same suppliers and increase cost by less than $50 per house.

While APA recommendations call for deformed shank nails for some applications, such as for the highest wind speeds at the gable ends of buildings over 25 feet high, using such nails for **all** roof sheathing applications in high wind areas may be easier to specify and be well worth considering.

Recommendations for the do-it-yourselfer:

1. The best time to work in the attic is in the winter in the morning. This keeps the temperature down and allows you to wear long sleeve clothing and a dust mask in relative comfort. It also makes the adhesive a little thicker and less likely to run. A temperature range between 65 and 70 degrees in the attic is ideal.

2. Be sure to use an AFG-01 or ASTM D3498 adhesive, which is marked on the tube if the adhesive meets either specification.

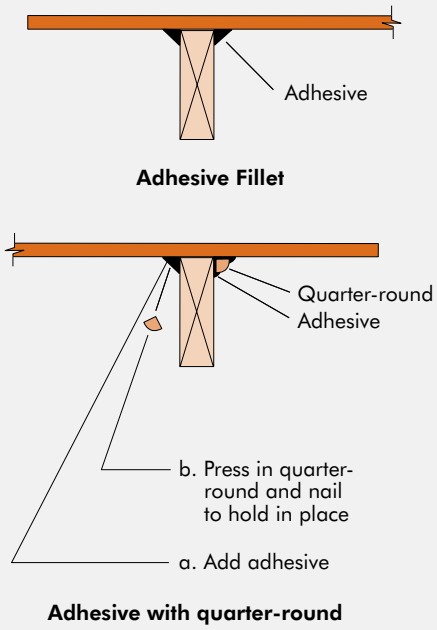
3. Read the cautionary notes on the back of the adhesive container. Many rely on the loss of solvents in the drying process and require ventilation to prevent asphyxiation. Use a portable fan if sufficient ventilation is not present in the attic, or use a chemical mask. *A paper dust mask will NOT filter out solvent fumes.*

4. If fiberglass insulation is present in the attic space, wear long pants and a long-sleeved shirt, with a baseball cap or a painters hood and gloves. Use masking tape at the ankles and wrists, and wear a chemical mask available from an automobile paint supply store. It will keep out the fiberglass dust particles and the solvents released from the drying adhesive.

5. The use of a pneumatic caulking gun is highly recommended. While not absolutely necessary where a regular tube may be used, it is a necessity when the long applicator wand is used to access areas that are hard to reach.

FIGURE 3

ATTACHMENT OF ROOF SHEATHING TO LUMBER FRAMING WITH CONSTRUCTION ADHESIVE



6. Place boards over the lower chords of the trusses or ceiling framing to form a stable working platform and to prevent you from putting a foot through the ceiling. Make sure the boards are centered over the supports and be careful of standing on unsupported ends of boards.

7. Beware of exposed nails on the bottom of the roof sheathing. The IBHS recommends considering the use of a bicycle helmet or hard hat to protect your head and scalp if such conditions exist.

8. Start at the ridge and work down. Where access is relatively open, use the standard caulking gun until the roof slope will not permit you to proceed further. Use the extension gun to complete the job where the roof overhead is reduced.

9. Make sure the tip of the caulking tube is centered in the corner between the sheathing and the roof framing so that the bead contacts both the sheathing and lumber framing to form a fillet as shown in Figure 3.

10. Cut the tip of the caulking tube so that a 1/4-inch bead will be laid. Experiment with the air pressure to maintain a controllable flow of caulk. It doesn't take much pressure.

For more information on the use of construction adhesives for hurricane roof retrofit, contact the IBHS (contact information on page 5).

Urethane Foam Adhesive Systems

At least one manufacturer – ITW Devcon Futura Coatings – has developed a proprietary urethane foam system that can be used to provide uplift resistance to an existing roof from the bottom side. This system uses specialized equipment to mix two components together which form urethane foam. This mixture is applied with a sprayer to the joint between the roof sheathing and the roof framing. As it foams up, the mixture fills the small spaces between the sheathing and the roof framing, creating an adhesive bond. The fillet formed at the joint also increases the holding power of the foamed system. Both adding additional foam to these joints and/or adding a fillet to both sides increases the uplift resistance. The use of this product can increase the hold-down capacity of the nailed-only joint by a factor of over three times, based on tests conducted at Clemson University. See Figure 4.

Due to the nature of the foam, application around surface imperfections, shiners, and exposed roofing nails present in the lumber framing/sheathing joint can be easily accommodated. The mixture will simply foam up around these impediments without any additional operator action.

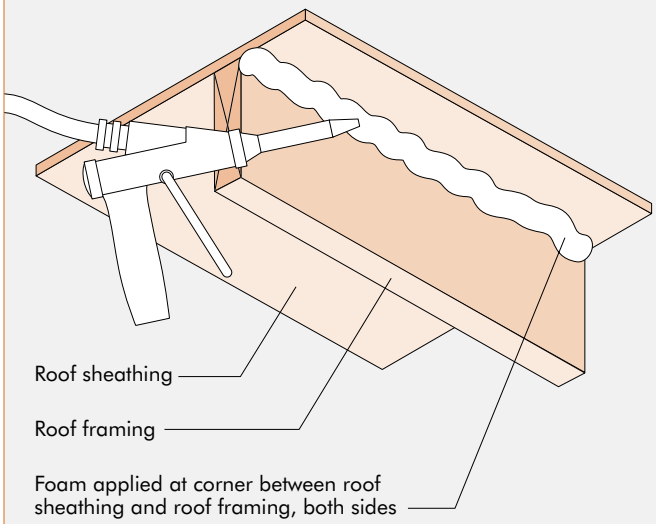
Because of the special equipment and application training necessary, these systems at present are applied by approved applicators and are not for the do-it-yourselfer. For more information, contact IBHS at the contact information on page 5, or contact:

ITW Devcon Futura Coatings
2425 North Lapeer Road • Oxford, MI 48371
(248) 628-2587 • www.futuracoatings.com

Check with your insurance company for possible discounts. For more information, go to www.mysafefloridahome.com.

FIGURE 4

FOAM ADHESIVE APPLIED TO RETROFIT ROOF SHEATHING ATTACHMENT



OTHER CONSIDERATIONS

Whichever method you select for reattaching your roof sheathing, you should also evaluate the type of connection that is used to attach your roof rafters or roof trusses to the perimeter walls of the structure. If toenails are used for the attachment of the roof framing to the exterior walls, your house has a potentially serious weakness at this location. By attaching the roof sheathing to the framing more securely, the hurricane forces may cause a failure at the next weakest link – the attachment of the roof framing to the exterior walls.

Contact your local building department for minimum hold-down requirements for roof framing in your area. Preformed framing anchors are available at your local hardware store and can be retrofitted, which will adequately secure your roof during a high wind event.

We have field representatives in many major U.S. cities and in Canada who can help answer questions involving APA trademarked products. For additional assistance in specifying engineered wood products, contact us:

APA HEADQUARTERS: 7011 So. 19th St. ▪ Tacoma, Washington 98466 ▪ (253) 565-6600 ▪ Fax: (253) 565-7265

APA PRODUCT SUPPORT HELP DESK: (253) 620-7400 ▪ E-mail: help@apawood.org

www.apawood.org

Form Number A410A

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