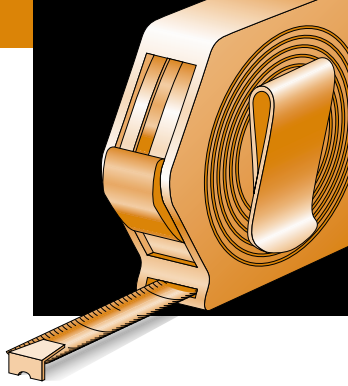


Retrofitting a Roof for High Wind Uplift

Number A410

October 2000

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 technical note 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, height, and location of the roof, these forces can act to hold the roof sheathing on or to pull it off of the roof framing. Of course, the speed of the wind acts in conjunction with shape, 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 insure the performance of a given roof system, it is essential to insure that those forces trying to pull the roof sheathing off are resisted by sufficient fasteners holding the roof down to the framing.

Prior to Hurricane Andrew, there were no broadly accepted roof sheathing attachment schedules available for hurricane/high wind areas. Determination of the attachment schedule for roof sheathing was left up to the designer/builder. Damage surveys conducted after Hurricane Andrew prompted a review of the existing code minimum attachment schedule in the South Florida Building Code. *APA – The Engineered Wood Association* conducted laboratory tests and computer simulations, and early in 1994 published new minimum fastening schedules for high wind areas, as shown in Table 1. These schedules have been accepted by all of the major model building codes in the United States.

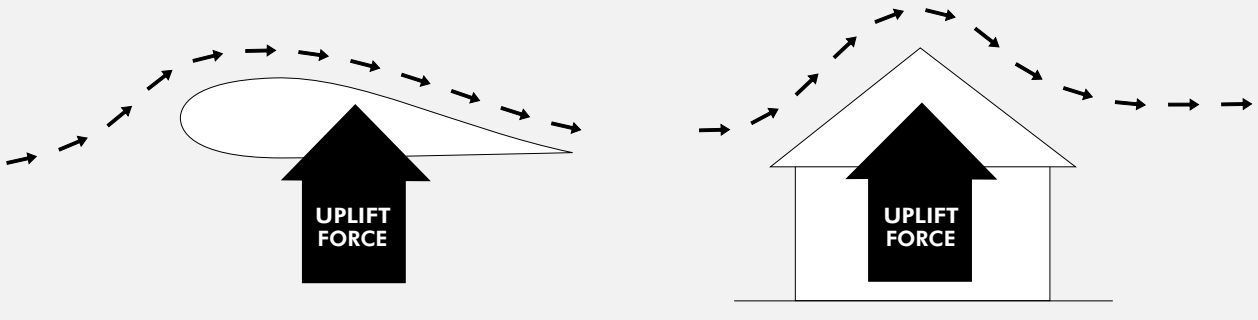
Retrofitting A Roof During Re-Roofing

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 it can be reattached 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.

FIGURE 1

WIND FORCES



a. On the wing of an airplane

b. On the roof of a house

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.

Recommended Fastening Schedules

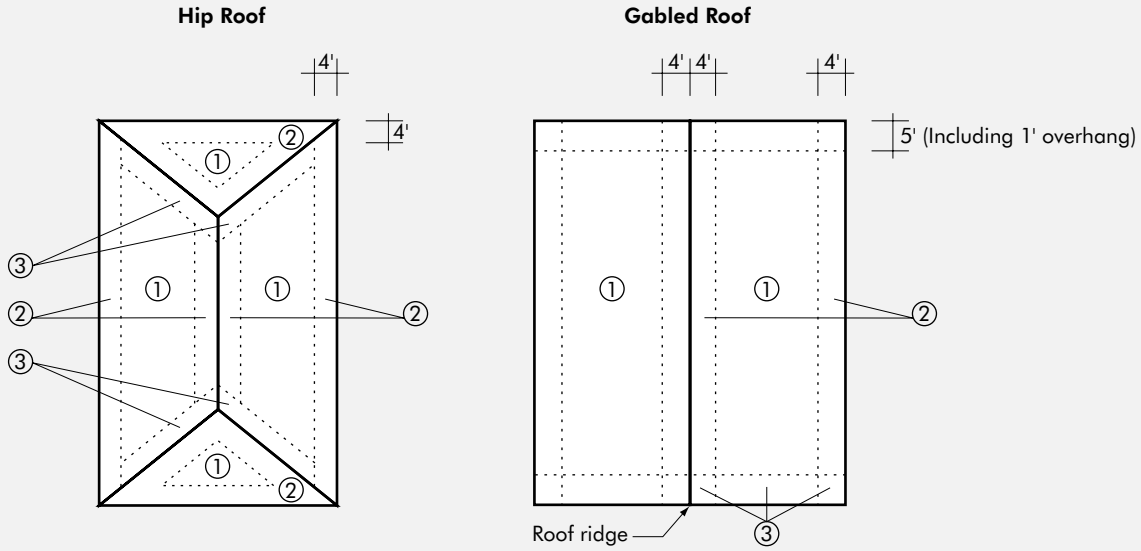
Higher pressures at eaves, corners, ridges and gable-ends require more restrictive schedules than at interior portions of the roof system. For this reason, fastening schedules may be different for each of the three roof fastening zones as illustrated in Figure 2. The fastening schedule presented in Table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

The 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

FIGURE 2

ROOF FASTENING ZONES FOR WIND UPLIFT

(Zones shown below indicate areas of the roof with different fastening requirements and should not be confused with ASCE 7 pressure coefficient zones.)



The zones indicated above are measurements taken directly on the roof sheathing itself by using a tape measure that is held level. (The actual distance measured up the roof slope will be slightly greater.) The gable end measurement assumes a 1-foot roof overhang. If the overhang at the gable end is greater or less than 1 ft, the end zone (Zone 3) distance should be adjusted accordingly. For example, given a 2-foot overhang at the gable end, the Zone 3 distance used should be 6 feet.

TABLE 1

ROOF SHEATHING FASTENING SCHEDULE FOR HIGH WIND UPLIFT

Region	Nails	Panel Location	Roof Fastening Zone		
			1	2	3
			Fastening Schedule (inches on center)		
High Wind Uplift	8d common	Panel edges[a]	6	6	4[b]
		Panel field	6	6	6[b]

(a) Edge spacing also applies over roof framing at gable-end walls.

(b) Use 8d ring-shank nails in this zone if mean roof height is greater than 25'.

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 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 new 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.

APA tested two types of stud finder: the type that detects a change in density and the type with a metal detecting mode.

The first stud finder APA tested was the Zircon StudSensor with Sound, which cost less than $15 at a retail lumberyard. After a few trial runs, it was found to be effective in finding the hidden nails as long as they were 8d or larger. The effectiveness of the stud finder decreased as the density of the wood increased. This stud finder actually "located" the nail by detecting a change in the density of the framing. It occasionally gave false readings when knots were present in the lumber.

The second stud finder APA tested was the Zircon Videoscanner 5.5, which cost around $40. It found the studs more easily and it had a metal detecting mode that very easily located the nails – both 6d and 8d – and was never fooled by the presence of a knot. It was also insensitive to the density of the lumber, "seeing" nails in Southern Yellow pine as easily as in the softer woods. A disadvantage is that it detects 6d and 8d equally well. You will have to use a different method to determine the type of fasteners used to secure your roof sheathing. (Refer to "How can I tell what kind of nails were used to attach my roof?".)

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" for 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 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

Nail Type	Penny Weight	Length	Diameter
Common	6d	2	.113
	8d	2-1/2	.131
Box	6d	2	.099
	8d	2-1/2	.113

minimum 8d common nails with smooth or ring shanks, depending on the fastener location. 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 oceanline regions* (Atlantic and Gulf of Mexico coastal areas). In addition, this schedule should be considered for the *transition zone between hurricane oceanline and inland regions*. Appendix A is provided to assist in determining at which basic wind speed (for inland regions) the high wind uplift schedule is recommended. Contact the local building department for the basic wind speed used for design in a given area.

For conditions that are not addressed by these general guidelines, such as the "special wind regions" identified in ASCE 7-98, engineered design is recommended.

Caution: More nails is not always better! – When re-nailing the roof, avoid spacings less than 3" on center to minimize 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 should be ignored during re-nailing of the roof sheathing.

Roof Retrofit when Re-Roofing Is Not Required

Adhesive Systems

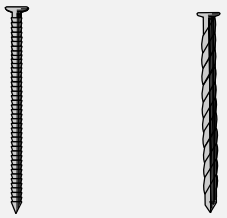
While not as easy as re-nailing, there are several methods that have been tested for attachment of the roof sheathing to the roof framing from the bottom side. Not limited by access to the topside of the roof sheathing such as during reroofing, this can be done at any time that the under side of the 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.

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.

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 ft high, using such nails for **all** roof sheathing applications in high wind areas may be easier to specify and be well worth considering.

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.

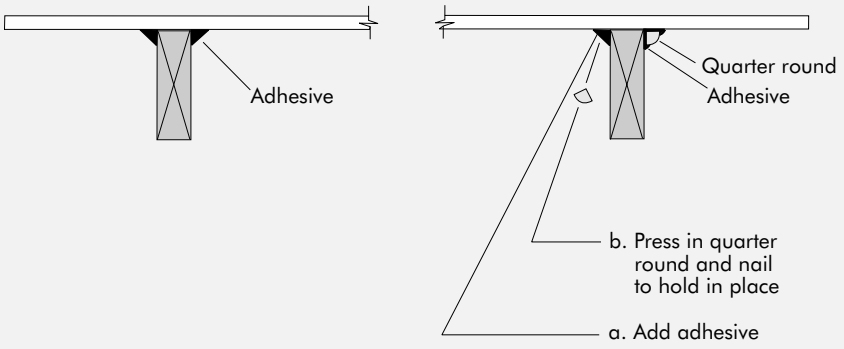
The use of a construction adhesive can be best used in accessible, unfinished, uninsulated attic areas with a roof pitch of 5 in 12 or greater. For shallow roof slopes, the difficulty in applying the adhesive to those areas near the exterior may require the use of a special extension tool developed by 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
175 Federal Street, Suite 500
Boston, MA 02110
(617) 722-0200 - Phone
(617) 722-0302 - Fax

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 nailed or clamped in place until the adhesive sets up. Like the glue fillets, this is done on both sides of the roof framing.

FIGURE 3

ATTACHMENT OF ROOF SHEATHING TO LUMBER FRAMING WITH CONSTRUCTION ADHESIVE



Adhesive Fillet **Adhesive with quarter-round**

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. The tube will be marked as such 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.

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.

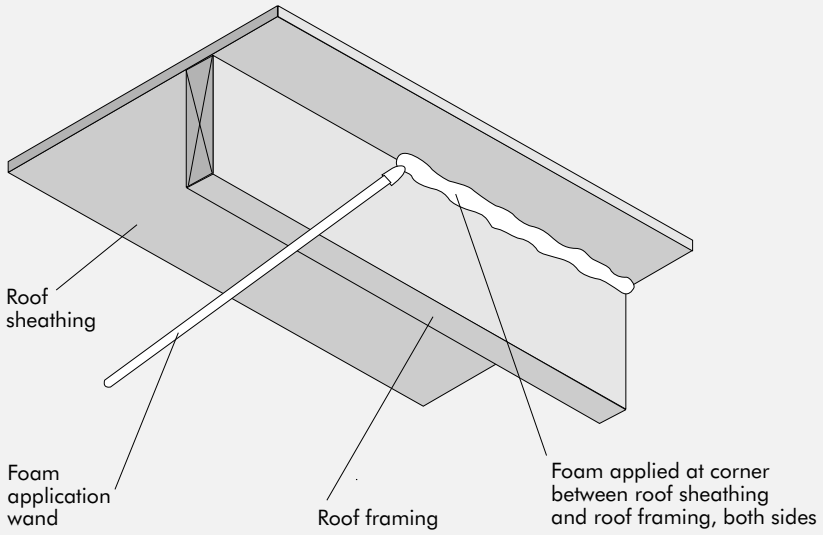
For further information on the use of construction adhesives for hurricane roof retrofit, contact the IBHS.

Urethane Foam Adhesive Systems

At least one manufacturer – ITW Foamseal, Inc. – 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 an applicator 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 up to 3 times, based on tests conducted at Clemson University. See Figure 4.

FIGURE 4

FOAM ADHESIVE APPLIED TO RETROFIT ROOF SHEATHING ATTACHMENT



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.

Another advantage of the foam system is that it does not off-gas the solvents that are a part of the drying process of most construction adhesives. This can be a benefit to people sensitive to such chemicals.

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 further information contact the Institute for Business and Home Safety at the address given above or contact:

ITW Foamseal
2425 North Lapeer Road
Oxford, MI 48371
(248) 628-2587
http://www.itwfoamseal.com

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 more securely attaching the roof sheathing to the framing, the hurricane forces can cause a failure at the next weakest link, the attachment of the roof 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 that can be easily retrofitted and that will adequately secure your roof during a high wind event.

Appendix A

High Wind Uplift Fastening Schedule for Inland Regions

The high wind uplift fastening schedule is recommended at hurricane oceanline and transition regions. To determine the basic wind speed at which the high wind uplift fastening schedule is recommended for a specific structure in an **inland region,** consider the following:

1. The ability of a roof sheathing panel to resist high winds is directly related to how well it is secured to the roof framing. The type and number of fasteners required for a specific application is obviously an important consideration. Another important consideration is the wood species of the roof framing members into which the sheathing fasteners are driven. Wood of more dense species such as Douglas-fir and southern pine provides greater nail withdrawal resistance and significantly improves the performance of the sheathing nailing. As shown in Table A1, if less dense species such as hem-fir or spruce-pine-fir are specified and used, the high wind uplift schedule is recommended at lower basic wind speeds than if the denser species are used.

2. Another consideration relates to the condition of the building envelope during the high wind event. If the building envelope remains intact during the storm the destructive forces of the wind are considerably less than experienced if a large window, sliding glass door, or garage door is breached, or if there are large permanent openings. Breaching of the building envelope **can** be prevented by the use of impact resistant glazing or hurricane resistant shutters.

Generally speaking, well designed and installed shutter systems are intended to keep the building envelope intact during high wind conditions. In addition to maintaining the building envelope intact and lowering the wind forces on the structure, shutters also serve to protect the interior of the building from water damage caused by failed doors and glass. As can be seen from Table A1, the high wind uplift schedule is recommended at lower basic wind speeds when there is a possibility that the envelope may be breached by breakage or by large permanent openings.

TABLE A1

BASIC WIND SPEEDS[(a)(b)] FOR WHICH THE HIGH WIND UPLIFT SCHEDULE IS RECOMMENDED FOR INLAND REGIONS

Wood Species of Roof Framing	Building Envelope Intact (Shutters or impact resistant glazing)	Building Envelope Breached
Hemlock, Eastern Spruce, Hem-fir, White Pine, Northern Pine or Spruce-Pine-Fir (Specific gravity between 0.42 and 0.49)	130 MPH or greater	120 MPH or greater
Douglas-fir or Southern Pine (Specific gravity between 0.50 and 0.55)	140 MPH or greater	130 MPH or greater

(a) Three-second gust wind speed.

(b) Contact your local building department for basic wind speed used for design in your area.

We have field representatives in most major U.S. cities and in Canada who can help answer questions involving APA trademarked products. For additional assistance in specifying APA engineered wood products, get in touch with your nearest APA regional office. Call or write:

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Tacoma, Washington 98411-0700
(253) 565-6600 ▪ Fax: (253) 565-7265

EASTERN REGION
2130 Barrett Park Drive, Suite 102
Kennesaw, Georgia 30144-3681
(770) 427-9371 ▪ Fax: (770) 423-1703

U.S. HEADQUARTERS AND INTERNATIONAL MARKETING DIVISION
7011 So. 19th St. ▪ P.O. Box 11700
Tacoma, Washington 98411-0700
(253) 565-6600 ▪ Fax: (253) 565-7265

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

(Offices: Antwerp, Belgium; Bournemouth, United Kingdom; Hamburg, Germany; Mexico City, Mexico; Tokyo, Japan.) For Caribbean/Latin America, contact headquarters in Tacoma.

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A P A

The Engineered Wood Association