Building for High Wind Resistance in Light-Frame Wood Construction
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Introduction

Designing a structure to withstand the devastating forces of tornados and hurricanes is one of the greatest challenges a builder can face. There's a common myth that all tornados are so strong that structural failure is imminent, no matter how well a building is constructed. The fact is, weaker tornados rated as EF-0, EF-1 and EF-2 by the National Weather Service statistically comprise 95 percent of all tornados. A home that is carefully constructed, in accordance with current building codes, can withstand these smaller, less violent storms.

Stronger tornados rating EF-3, EF-4 and EF-5 are much less common. While it's more difficult for homes to survive these storms, good design details can make a difference, particularly when the structure is located along the outer reaches of the area influenced by the vortex of the storm.

The design and construction recommendations in this guide from APA contribute to improved overall performance in the structural shell and focus on good connection details to tie together exterior walls, roofs, and floors. Some of these design recommendations exceed the minimum code requirements and typical APA recommendations. Whether caused by a tornado or hurricane, high wind forces travel through the load path of a structure. Good connections that tie the floor, walls, and roof together provide continuity in the load path and more reliable building performance.
**A** Nail roof sheathing with 8d ring shank (or deformed shank) (0.131" x 2-1/2") nails at 4 inches on center along the ends of the sheathing and 6 inches on center along intermediate framing.

**B** Tie gable end walls back to the structure. One of the weakest links in residential structures during high wind events is the connection between the gable-end and the wall below.

**C** Sheath gable end walls with wood structural panels, such as plywood or oriented strand board (OSB). In the 2011 tornados, gable end wall failures were frequently observed when non-structural sheathing was used.

**D** For the roof framing to wall connection, use an H1 or equivalent connector, attached on the exterior (sheathing side) of the exterior walls. The roof-to-wall connection under high wind loads is subject to both uplift and shear due to positive or negative wind pressure on the walls below.

**E** Nail upper story sheathing and lower story sheathing into common wood structural panel Rim Board®. The most effective way to provide lateral and uplift load continuity is to attach adjacent wall sheathing panels to one another over common framing.

**F** Nail wall sheathing with 8d common (0.131" x 2-1/2") nails at 4 inches on center at end and edges of wood structural panels and 6 inches on center in the intermediate framing. This enhanced nailing will improve the resistance of the wall sheathing panels to negative wind pressure. Staples offer less resistance to blow-off than nails and so a greater number of them are required to achieve the same level of resistance.

**G** Continuously sheath all walls with wood structural panels including areas around openings for windows and doors.

**H** Extend wood structural panel sheathing to lap the sill plate. The connection of the wall sheathing panel to the sill plate is important because this is where uplift forces are transferred into the sill plate and into the foundation through the anchor bolts.

**I** Space 1/2" anchor bolts 32 inches to 48 inches on center with 0.229" x 3" x 3" square plate washers with slotted holes.
A

NAIL ROOF SHEATHING WITH 8D RING SHANK (0.131" X 2-1/2") OR DEFORMED SHANK NAILS AT 4" ON CENTER AT PANEL ENDS AND EDGES AND 6" ON CENTER IN THE INTERMEDIATE FRAMING

8d Common nails - 6" on center along intermediate framing
8d Common nails - 4" on center at panel ends

Roof sheathing
Roof framing

This installation will greatly increase the wind resistance of the roof sheathing panels.

B

TIE GABLE END WALLS BACK TO THE STRUCTURE

One of the weakest links in residential structures during high wind events is the connection between the gable end and the wall below. The prescriptive codes provide no guidance on how to properly attach these two important elements and failures at this joint are, unfortunately, quite common. Construction details that have been developed to properly secure and tie back a gable end may be used. Also common in high wind areas is to eliminate the gable through the use of hip roofs or, if the gable is an architectural necessity, use balloon framing. (Detail courtesy of Standard for Hurricane Resistant Residential Construction, SSTD 10-93 Section 306.4.2.)
C

SHEATH GABLE END WALLS WITH WOOD STRUCTURAL PANELS, SUCH AS PLYWOOD OR ORIENTED STRAND BOARD (OSB)

Gable end wall failures are frequently observed when non-structural sheathing is used. Most non-structural foam sheathing materials are required to be used in conjunction with gypsum wall board inside of the house, which is frequently neglected in the construction of gable end walls. The easiest way to avoid the need of installing interior gypsum at the gable end walls is to use wood structural panel sheathing on the exterior.

D

ROOF FRAMING TO WALL CONNECTION WITH H1 OR EQUIVALENT CONNECTOR ATTACHED ON SHEATHING SIDE OF THE EXTERIOR WALLS

The roof to wall connection under high wind loads is subject to uplift and shear in either suction or pressure loads on the walls below. A large number of inexpensive framing anchoring systems have been developed that can make this complicated connection as simple as putting in a nail at each hole.
NAIL OFF UPPER STORY AND LOWER STORY SHEATHING INTO COMMON WOOD STRUCTURAL PANEL RIM BOARD

The most effective way to provide lateral and in some cases uplift load continuity is to attach adjacent wood structural panel wall sheathing to one another over common framing. The common availability of long length Rim Board can be used as this common framing member to ensure shear and uplift continuity, which eliminates the need for horizontal blocking. Being at least 9-1/2” in depth, the Rim Board makes an excellent “target” for mating adjacent panels. The problems associated with mating two panels over the edge of a 2x member while maintaining a 1/8” spacing between panels, a 3/8” edge distance from the nail to the edge of the panel, and still being able to hit the framing behind the panel with the nail are greatly reduced. For use around windows and doors or as an alternative to this detail, metal strap anchors designed for such applications may be used. For designed applications, additional information is available in APA Data File: Shear Transfer at Engineered Wood Floors, Form Y250.

NAIL WALL SHEATHING WITH 8D COMMON (0.131” X 2-1/2”) NAILS AT 4” ON CENTER IN THE BOUNDARY OF WOOD STRUCTURAL PANEL WALL SHEATHING AND 6” ON CENTER IN THE INTERMEDIATE STUDS

This installation will increase the wind resistance of the wall sheathing panels, as compared to the minimum nailing requirements specified in the code.
Even with the loss of wall covering and building paper, continuous plywood and OSB sheathing offers additional protection.

A solid plywood or OSB box is created when the roof and walls, properly attached, are completely sheathed. All of the wall needs protection from high wind and wind driven debris, not just the bracing panels at corners and at intervals along the length of a wall. The minute the siding is blown off the wall, the remainder of the wall left behind must be able to protect the contents of the structure from the wind and rain by itself. Buildings that are continuously sheathed with wood structural panels have an additional layer of protection if siding is lost or brick veneer collapses during high wind events. In addition, if there is not structural panel sheathing attached to the sill plate in the area of the anchor bolt, its hold down capacity is not transferred to the structure above.

The connection of the wall sheathing panel to sill plate is extremely important because this is the connection by which the hold down capacity of the sill plate anchor bolting is distributed into the structure above. At this location, the panel can overlap the sill plate by the full 1-1/2" of the sill plate depth. It is wise to use all of this depth as it permits the use of nail-to-edge distances of up to 3/4", yielding the maximum possible uplift capacity of the nailed joint. See Detail F for nailing recommendations.
Other Considerations:
While not falling into the category of relatively simple ways to increase the wind performance of a structure, there are a number of topics for consideration by the builder/homeowner during the planning or construction phase of the project. A partial list and brief discussion are as follows:

Protection of large openings - As far as wind damage is concerned, large openings in walls such as picture windows, sliding glass doors, and garage doors, are extremely vulnerable to damage in high wind events. Because their areas are large, the total force on the windows/doors is also extremely large. They also make for big targets for wind-born debris. Breeching of these elements can be especially damaging to the structure because the size of the opening can lead to pressurization of the entire building, which can cause failures of other portions of the structure that would be otherwise secure. For these reasons a builder or homeowner may want to consider windows and doors that are rated for high wind and impact damage.

Basements and Safe Rooms – The provisions covered in this guide are meant to develop a stronger, more wind resistant structure. While a stronger structure is certainly safer for the occupants, the homeowner is wise to consider the use of a full or partial basement or safe room or a combination of both for life-safety protection.

Hip roofs – While they will not appeal to everyone's esthetic sense, hip roofs have a long history of superior performance in high wind events when compared to gable-end styles. The very common problems associated with gable-end-type failures are virtually eliminated by a properly designed hip roof.
Building for High Wind Resistance

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