Insurance Institute for Business and Home Safety

Wind-Resilient Buildings
A guide to building against hurricane winds and tornadoes

BY JLC STAFF

As storms, hurricanes and tornadoes are different beasts, but they share enough similarities that the construction methods to make homes more resilient to destruction from both types of storms are similar. Both hurricanes and tornadoes are "cyclonic" storms with very strong winds swirling in a spiral around a center. The horizontal "tangential" winds at the outside of the storm are moving at higher speeds, predominately upward, while the winds closer to the center push predominately downward. Homes near the track of a cyclonic storm see strong winds from all directions. If the eye passes over a home, it will be subjected to winds approximately half the time from one direction and half the time from the opposite direction. At any given time, the windward face of a structure will experience positive pressures while the leeward face will experience negative pressures. The negative pressures are about 20% higher, owing to the aerodynamics of wind rising over and moving around the building.

Hurricanes tend to be more destructive because of their sheer size, which ranges from about 60 miles in diameter up to 1,000 miles. They generate all their force over the ocean, but that force can carry them inland for 100 to 200 miles, and they can persist for several days. Tornadoes are relatively small—on average mowing a path of destruction 300 to 500 yards wide—and relatively short-lived, sometimes lasting only a few minutes. On average, tornadoes move a distance of about 26 miles, usually at speeds from 30 mph to 60 mph, though the largest travel up to 50 miles at speeds up to 300 mph.

In this illustrated resource, we focus on framing methods to

Recommended Tornado-Resistant Wood Framing

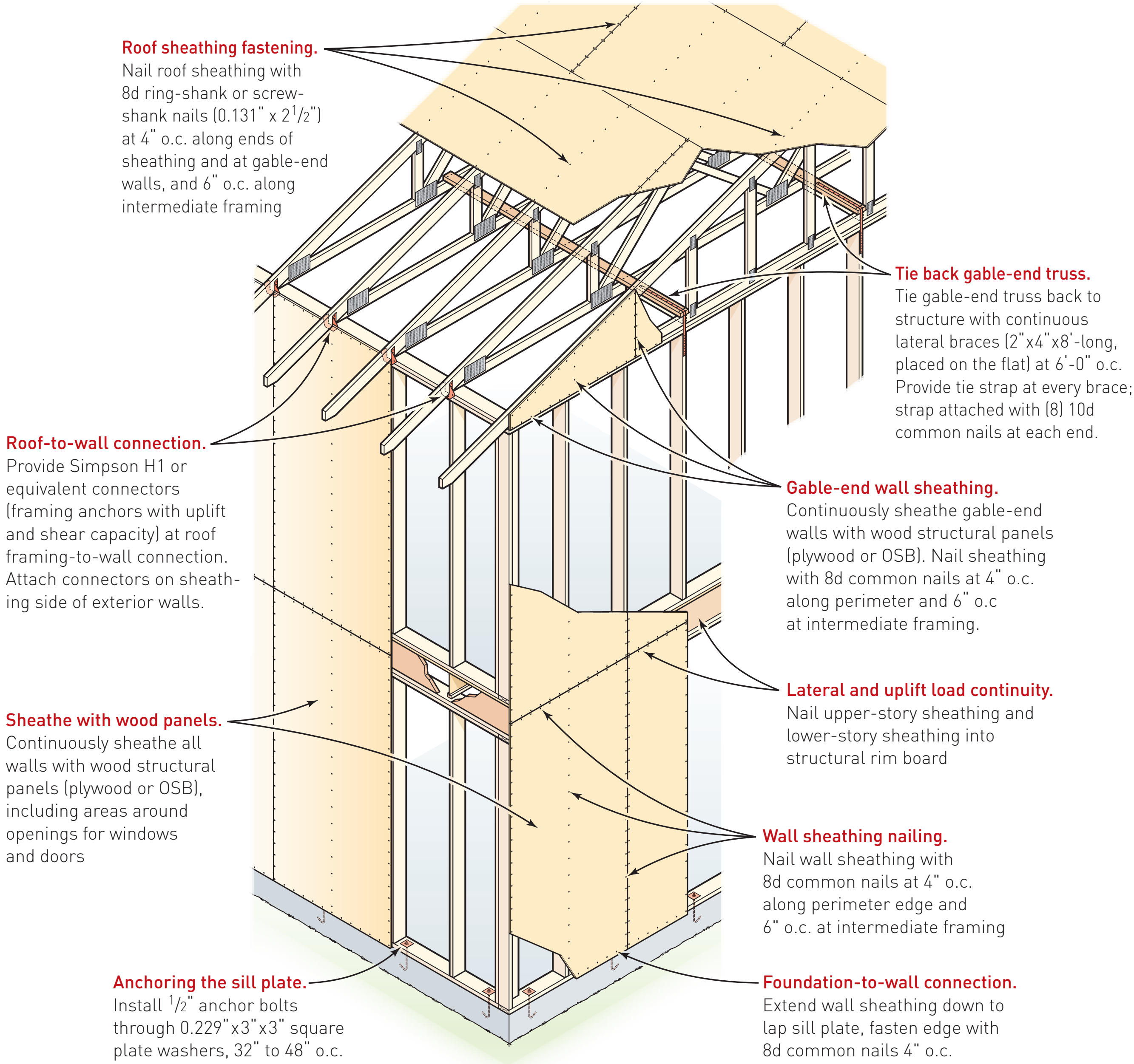
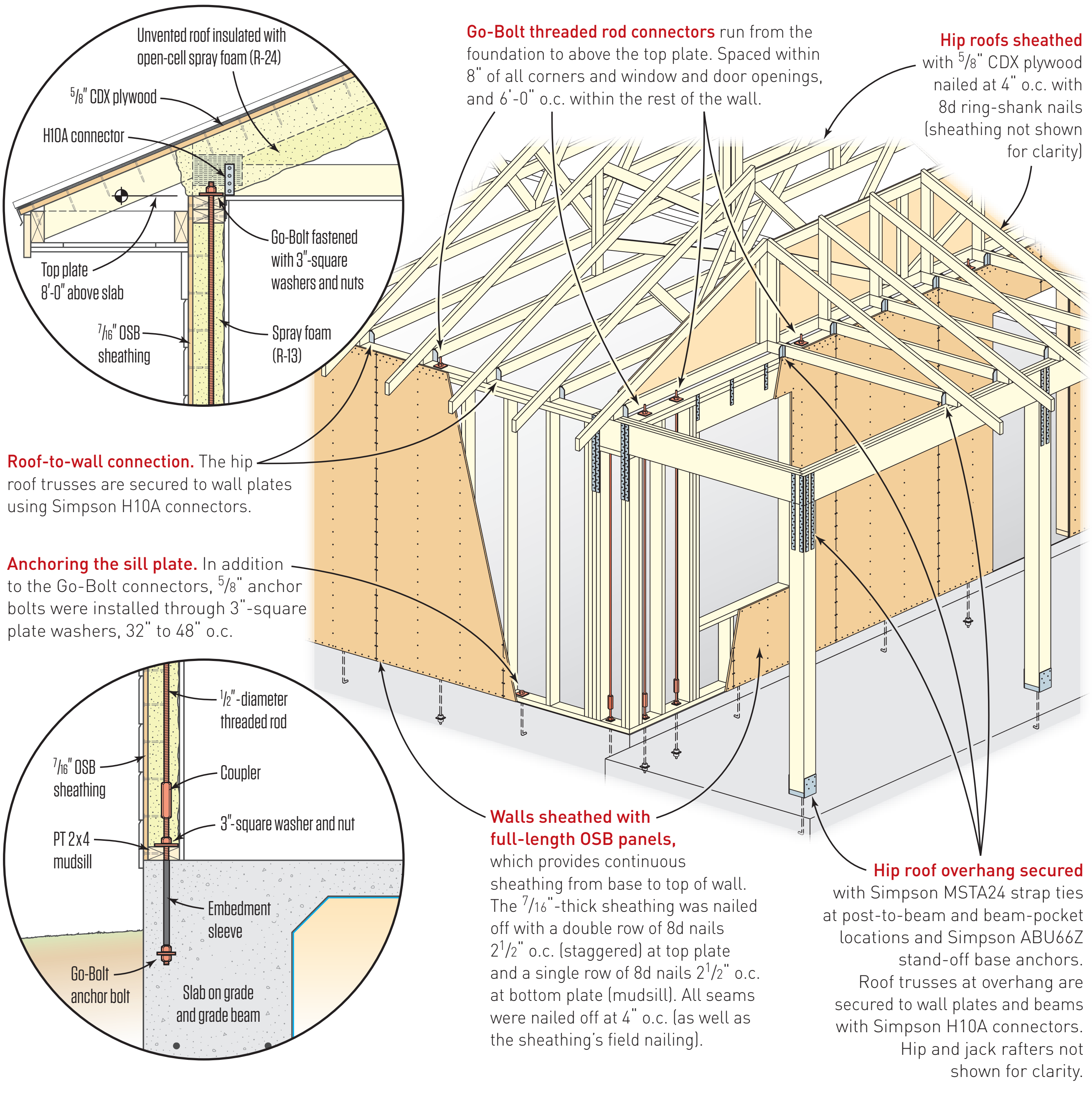


Illustration adapted by JLC from APA "Building for High Wind Resistance in Light-Frame Wood Construction Manual" (M310, 2015).

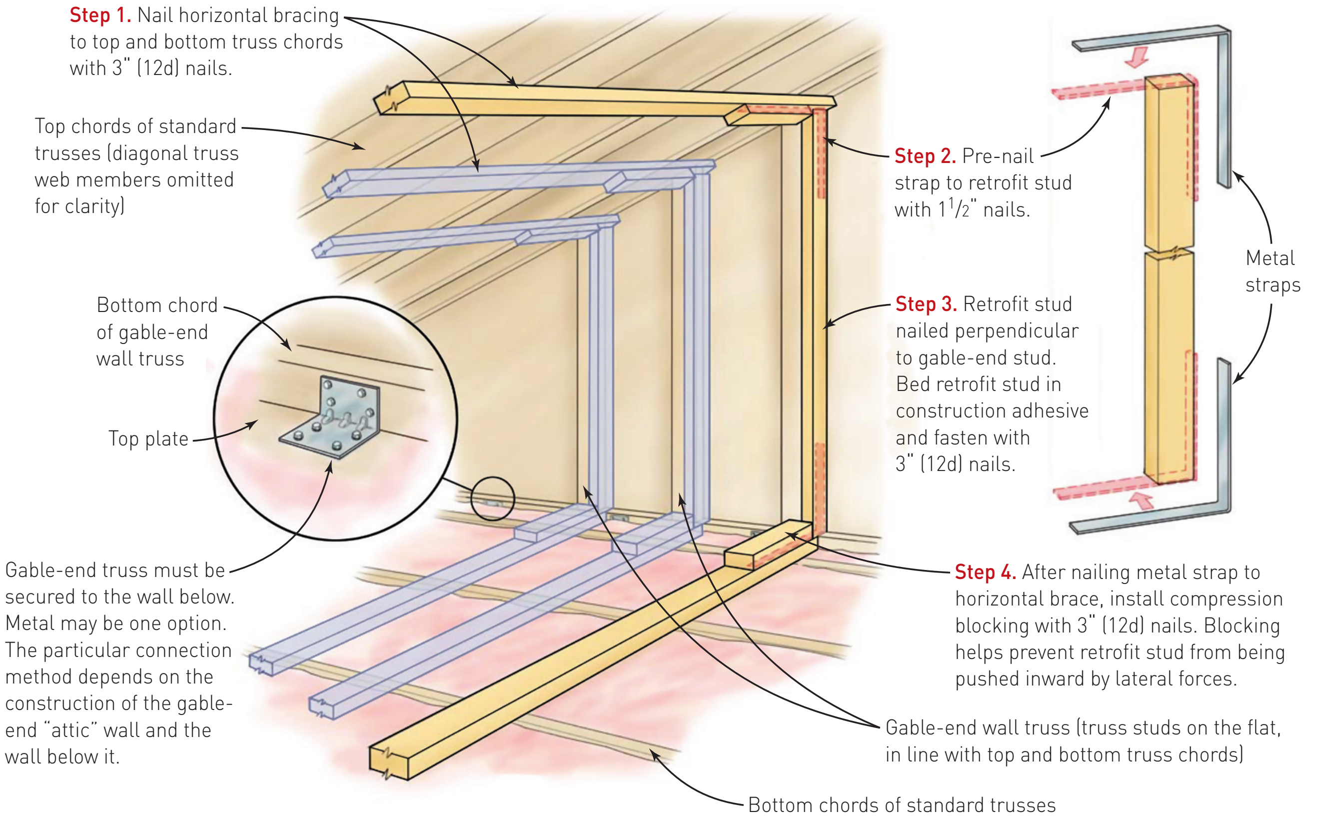
New-construction framing. The framing recommendations shown here reflect hundreds of inspections of tornado-damaged homes by APA engineers. The engineers concluded that many homes in regions at risk of tornadoes could be saved at a reasonable cost if built with these upgrades to framing component and assembly connections.

Recommended Hurricane-Resistant Wood Framing



New-construction framing. The details shown here summarize load-path upgrades modeled on the recommendations of the Fortified Home program developed by the Institute for Business and Home Safety (IBHS). These were employed by builder Eric Anderson in Florida for Habitat for Humanity's Habitat Strong program, demonstrating cost-effective solutions for homes at risk of hurricanes with winds speeds of 130 to 156 mph (Category 4).

Strengthening and Bracing a Gable-End Truss



Retrofit framing. To strengthen the gable ends of existing homes in hurricane zones, each stud of a gable-end truss gets this basic retrofit assembly: Horizontal braces (each about 6 feet long) are first attached to the top and bottom chords of the roof, and then a retrofit stud is installed perpendicular to the gable-end truss. The L-straps must be preinstalled at the end of each retrofit stud before the stud is secured to the horizontal braces.

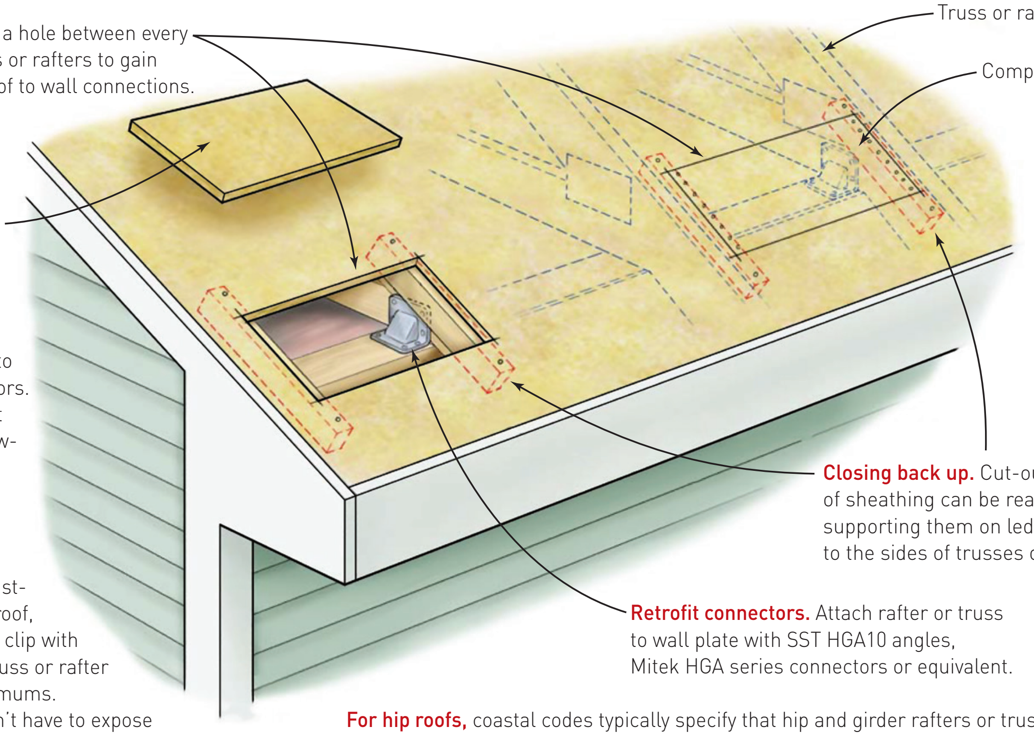
resist wind forces. But both hurricanes and tornadoes are also water events. Along with delivering destructive winds, hurricanes can cause floods from both sustained rainfall and storm surge—the wall of ocean water pushed up by descending winds at the center of the storm. Tornadoes are usually accompanied by heavy thunderstorms, which can cause water damage too. To address these risks, we will cover water-resilient buildings in a later issue.

OVERCOMING UPLIFT

The key to hurricane and tornado resilience is found in strengthening the load path. Most builders understand that buildings need a continuous load path to support down-bearing gravity forces. To support the roof, the beams and rafters must be supported on columns and load-bearing walls, which in turn must be supported by a solid foundation. The forces here are largely compressive, pushing the parts of the house into each other, so every framing member must be supported by another, and each must be sufficiently large enough to bear the downward force, which is ultimately borne by the earth itself. In addition, this downward force threatens to shear off the fasteners—many driven horizontally—that are holding the frame together. Too few or too small, and the fasteners fail. Shear forces also affect beams that are supported at the ends on columns or on joists that rest on sills: The downward force threatens to shear the wood fibers where they hang out over empty space beyond their end supports.

In a high-wind event, intense uplift pressures are the loads pulling the parts of the house in the other direction—up. To resist these forces, we need to focus on the same load path as for gravity loads, but we need to make sure that tension forces don't pull the connections apart and that extreme shear forces don't sever the horizontal connections as the framing is wrenched upward. Steel hardware as well as shear walls and plywood gussets with tight nailing patterns are the prime defenders along the load path to keep the building from flying apart in high winds.

Strengthening Roof-to-Wall Connections



Retrofit framing. To minimize demolition of the roof edge, rectangular holes are cut into every other rafter or truss bay, and gusset angles are installed on each side of the hole. The cut-out can be saved and used to patch in the opening by securing it to scabs nailed to the side of the trusses.

WEIGHING RISKS

If you put enough steel, which is very strong in tension, into a wood frame, you can resist even very high uplift pressures. But at what cost in material and labor? The recommendations put forward by organizations like the APA – The Engineered Wood Association (APA), American Wood Council (AWS), and the Insurance Institute for Business and Home Safety (IBHS) tend to look at this question through a risk lens, which weighs the likelihood that a house in a given location will experience a high wind event. It wouldn't make sense for every house to be built to hurricane or tornado standards, or even for homes in tornado country to be built to the same standards as those subject to hurricanes, which are larger storms affecting more homes for longer periods.

The illustrations on pages 42 and 43 show two approaches to upgrading the load path. Both will work in hurricane and tornado zones, but the one on page 42 is less expensive to build and probably better suited to homes in tornado country, where the chances of a home being hit by a tornado are lower than the chances of a home in a coastal zone being hit by a hurricane.

The approach on page 43 uses more steel hardware, which is more expensive but requires much less nailing and is easier to inspect.

RETROFIT OPTIONS

When it comes to retrofitting existing homes, access to all the load-path connections is more of a challenge. The focus here is narrower, targeting the highest frequency failures in roof connections. Rafters and trusses that are typically fastened in place with a few 10d or 16d toenails are easily torn apart in a high wind. Also, gable-end trusses that are toenailed into the top plates often blow out when the attic gets pressurized by high winds, leading to catastrophic failure. The framing retrofits shown here offer effective ways to strengthen these critical structural connections.