Wind-Resistant Framing Techniques

Cost-effective details to help houses weather the storm

BY BRYAN READLING

You've seen photos and videos of massive tornadoes ripping through towns and wiping neighborhoods off the map. Given the destruction, you might guess that any house close to an advancing tornado is doomed. The reality, though, is that weaker twisters—those rated EF-0, EF-1, and EF-2 by the National Weather Service—make up 95% of all tornadoes. A carefully constructed house often can survive a hit from one of these smaller, more common storms.

As an engineer for APA-The Engineered Wood Association, I spend a lot of my time studying wind damage to houses and figuring out ways to boost a house's resistance to hurricanes, tornadoes, and windstorms. My work includes plenty of travel, because tornadoes and hurricanes affect most of the country and high-wind events happen everywhere.

My latest field-research project was in April 2011, when two storms two weeks apart spawned tornadoes in seven Southern states. The second storm caused the single largest tornado outbreak in recorded history. In our subsequent investigation of wind-damaged houses 10 years old and newer, my colleagues and I discovered that most of the structural failures were caused by a lack of continuity in the load path that

Seeing storm damage firsthand. *Following an outbreak of deadly tornadoes in the spring of 2011, the author surveyed hundreds of storm-damaged homes in a multistate investigation. His research revealed that many of the most-badly damaged homes could have fared much better had their builders adopted a few simple and inexpensive wind-resistant framing methods.*

INVESTIGATING REAL-WORLD STORM DAMAGE

Missing anchor bolts

Far from the foundation. *This house, which was attached to its masonry foundation with cut nails, was pushed 6 ft. off its foundation by tornado-driven wind. Similar failures occurred with houses that were nailed to slab foundations.*

Unbacked foam sheathing

The weak little triangle. *Foam sheathing performs better when the interior is covered with drywall. Gable ends without drywall, like the gables on these neighboring homes, should be sheathed with structural panels.*

connects a house's structural elements from the foundation to the roof.

Roof failures

The most common and often most devastating load-path failures occurred when rafters and trusses were pulled from exterior walls. Many of the most severely damaged houses had roof framing attached to the walls with toenails, an inherently weak connection because it relies on the nails' withdrawal capacity. Modern building codes allow toenailed rafters in most nonhurricane areas, but many engineers don't believe toenails have the strength to meet some International Residential Code requirements.

Roof failures were not limited to houses with toenailed trusses and rafters. Failures also occurred when metal hurricane ties were nailed on the interior of the top plate instead of the exterior. Exterior-mounted metal connectors hold better because they line up with the wall sheathing's load path.

Wall failures

Another common observation, especially in the hardest-hit areas, was houses blown

The author’s recommendations for improving a house’s resistance to high winds are based on the structural failures he saw after surveying storm damage for APA-The Engineered Wood Association in the wake of two devastating Southern storms in 2011.

Missing connectors

Blown-away roof. *Unless it’s adequately secured, roof framing can be pulled from the walls that it’s attached to during high winds. Toenailed roof framing ripped from walls was the most commonly observed serious building failure in the author’s poststorm research.*

Connectors on the wrong side

Fastened, but not well enough. *This house’s roof framing was attached to the walls’ top plate with metal hurricane ties. Unfortunately, the ties were fastened on the inside of the top plate, where they aren’t as strong as connectors aligned with the wall sheathing on the exterior.*

off their foundations. Most had their walls attached to the foundation with hand-driven, cut masonry nails and, in a few locations, pneumatic framing nails. Obviously, anchor bolts are a better choice, especially when the bolts have large square washers to prevent them from pulling through the plate.

A gable end is often poorly connected to the rest of the building. We saw many houses where the triangle-shaped gable end had blown in, often leading to greater damage from wind and water. The gable end is especially vulnerable to failure because its walls are often not backed with drywall. Walls backed with drywall in living space generally hold up better because the drywall provides additional resistance to wind and debris. Failures like this were even more common when the gables were covered with foam sheathing and vinyl siding because both materials are vulnerable to wind pressure and flying debris.

Poorly fastened sheathing

When the houses we studied were at least partially intact, the loss of wood wall and roof sheathing often could be attributed to

BEYOND CODE FOR HIGH-WIND RESISTANCE

The framing details shown here are not complicated or expensive to execute when they are incorporated into the plans for a new house. In addition to these measures, there are other ways to protect houses in hurricane- and tornado-prone areas.

First, protect large openings. Picture windows, sliding-glass doors, garage doors, and other large openings are vulnerable to damage in high-wind events. Breaches can lead to pressurization of the building interior and increased loads on the structure. Consider installing windows, doors, and garage doors rated for high winds and impact damage.

While a stronger, more wind-resistant structure is certainly safer for occupants, think about adding a safe room in a basement or central space.

Finally, consider using hip roofs, which are more aerodynamic and provide better support to the tops of exterior walls than gable roofs.

Tie down rafters

Secure rafters and trusses with metal connectors. The roof-to-wall connection is subject to both uplift and shear. Inexpensive framing connectors make this important connection simple. Place connectors on the outside of the wall, where they'll do the most good.

Use enough nails

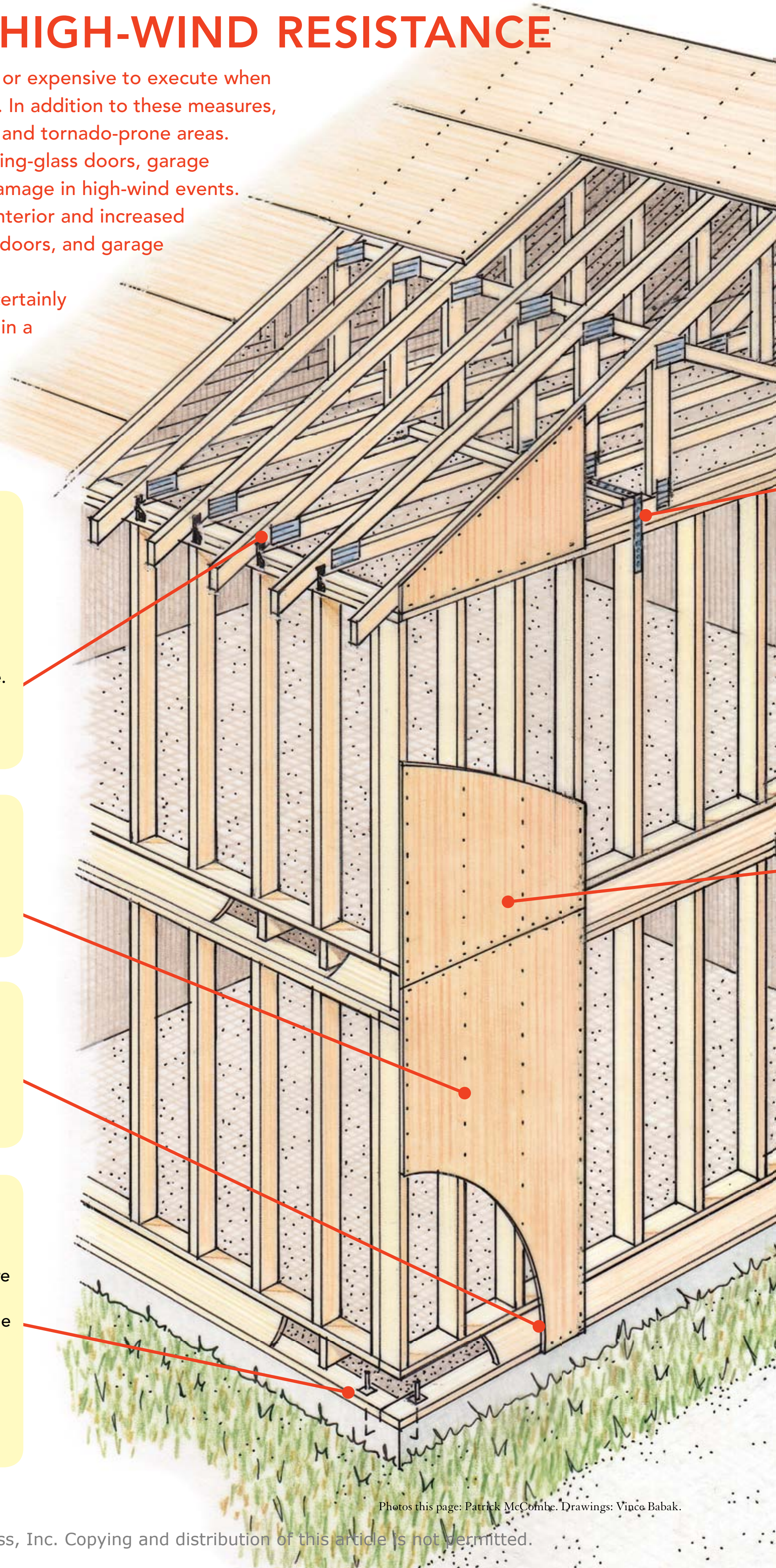
Nail wall sheathing with 8d common (0.131 in. by 2½ in.) nails 4 in. on center at ends and edges and 6 in. on center in the intermediate framing. This installation will greatly increase wind and racking resistance compared to code-minimum requirements.

Lap the sill

Extend wood structural-panel sheathing to the sill plate. The connection of the wall sheathing to a properly anchored sill plate is an important part of the load path. Available at many pro-oriented lumberyards, 9-ft.-long and 10-ft.-long OSB simplifies this connection.

Bolt sill plates

Anchor sill plates with ½-in. anchor bolts equipped with 0.229-in.-thick, 3-in. by 3-in. square plate washers. Space the bolts from 32 in. to 48 in. on center. The IRC requires a minimum spacing of 6 ft. for houses subjected to wind speeds up to 110 mph, but tighter spacing greatly improves wall performance.



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improper attachment. Nails used as prescribed in the building codes provided good performance, while staples performed poorly because they offer less pullout resistance than nails and must be used in greater quantity. Poorly attached roof sheathing at the last rafter or gable-end truss was identified as a weak link in roof construction.

We also saw many cases where breaches in the exterior walls due to wind pressure or flying debris caused pressurization of the building, sometimes resulting in homes that blew apart completely. Field and wind-tunnel research has revealed that wind and flying-debris damage to doors, windows, and nonstructural claddings like brick and vinyl siding often lead to more catastrophic structural failures. Large openings such as garage doors are especially vulnerable to impact and wind-pressure damage.

A small price to pay

Most of these above-code improvements are easy to implement and surprisingly affordable. In researching the 2013 Georgia Disaster Resilient Building Code, the Georgia Department of Community Affairs determined that the added cost of implementing the APA's recommendations is about $595. This estimate, which includes materials and labor, is based on a 2100-sq.-ft. slab-on-grade ranch house with a 10-in-12 roof pitch and three gables. □

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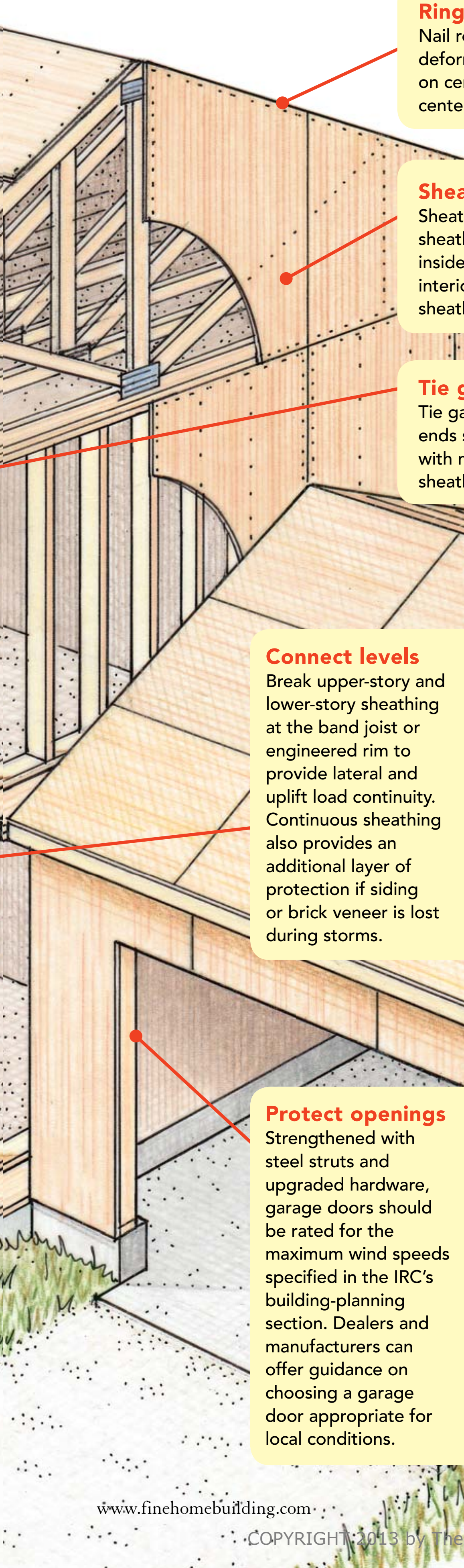
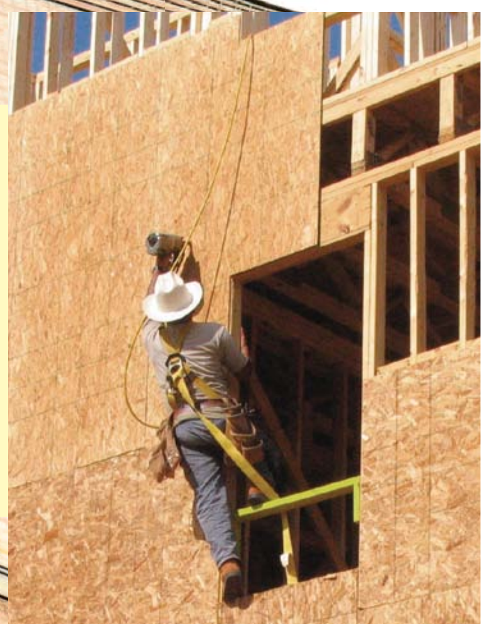


Ring-shank nails on roof
Nail roof sheathing with 8d ring-shank or deformed-shank (0.131 in. by 2½ in.) nails at 4 in. on center along eaves and panel ends and 6 in. on center at intermediate framing.

Sheathe gables
Sheathe gable ends with plywood or OSB. Foam sheathing works better when used with drywall inside the house. The easiest way to avoid interior gypsum at the gable end is to use wood sheathing on the exterior.

Tie gables to walls
Tie gable-end walls back to the structure. Gable ends should be tied to the wall framing below with metal straps and by lapping the gable sheathing onto the wall below.

Connect levels
Break upper-story and lower-story sheathing at the band joist or engineered rim to provide lateral and uplift load continuity. Continuous sheathing also provides an additional layer of protection if siding or brick veneer is lost during storms.



Protect openings
Strengthened with steel struts and upgraded hardware, garage doors should be rated for the maximum wind speeds specified in the IRC's building-planning section. Dealers and manufacturers can offer guidance on choosing a garage door appropriate for local conditions.