Photo by APA - The Engineered Wood Association

The Portal Frame Option

This site-built assembly supplies proven bracing for openings

BY MARY UHER

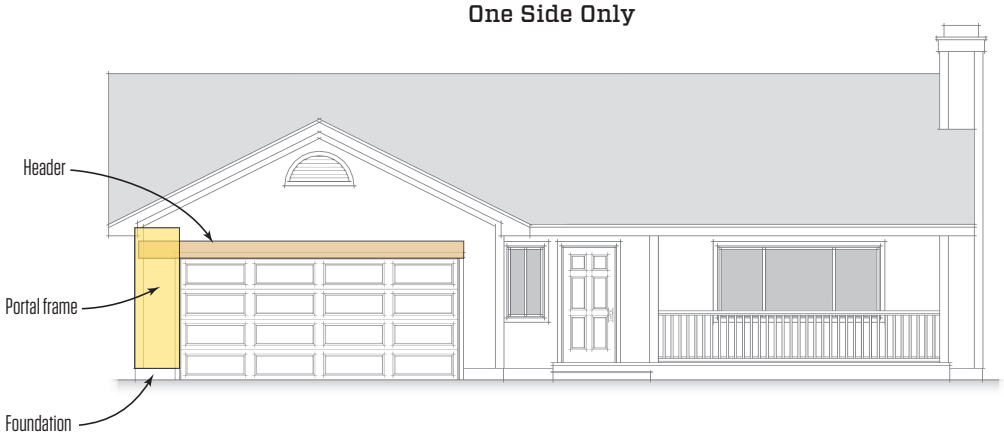
As an engineer with APA - The Engineered Wood Association, one of my jobs is to help study the damage from extreme weather events such as tornadoes. Often, APA teams see buildings that were damaged or destroyed by winds of less than the design wind speed specified in the building code (see "A Texas Tornado: Lessons Learned," May/17). Occasionally we even see a house that has been severely damaged by straight-line winds from a thunderstorm—the kind of wind pressure that a modern wood-frame house should be able to handle. Often we conclude that a damaged home most likely would have stood up to the storm if the builder had applied code-required structural details such as wall bracing and anchor bolts.

If a wall has only a few small openings, bracing it is easy. But large openings such as garage doors can complicate the problem. That's why APA developed a code-recognized wall bracing method called the "portal frame," which is commonly used to frame garage doors, but which you can also use as bracing at other door or window openings. In a portal frame, the header extends past the opening and is tied to its wall with overlapping plywood or OSB to stiffen the joint. The panels are attached to the wall studs and to the header with closely spaced nails, and the sill is bolted to the foundation.

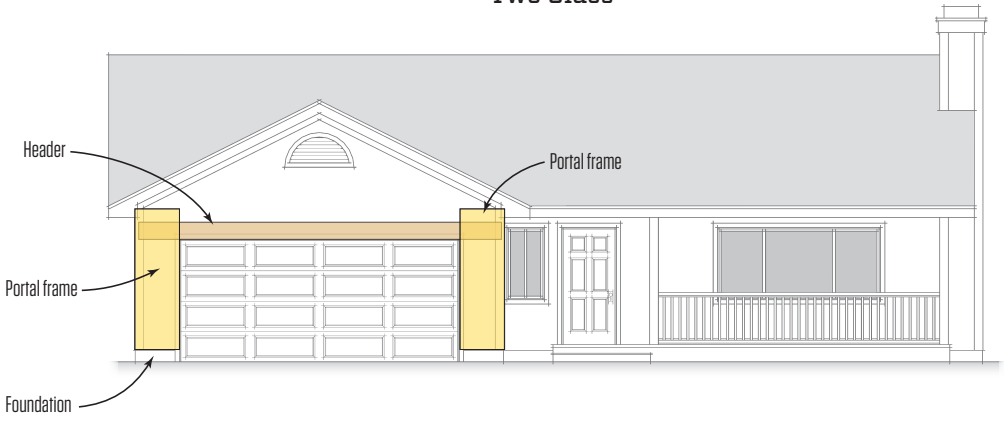
Portal frames are easy to build on site, using common, familiar materials. They are easy to inspect for quality control, and they resist loads that may otherwise be neglected.

Portal Frame Scenarios

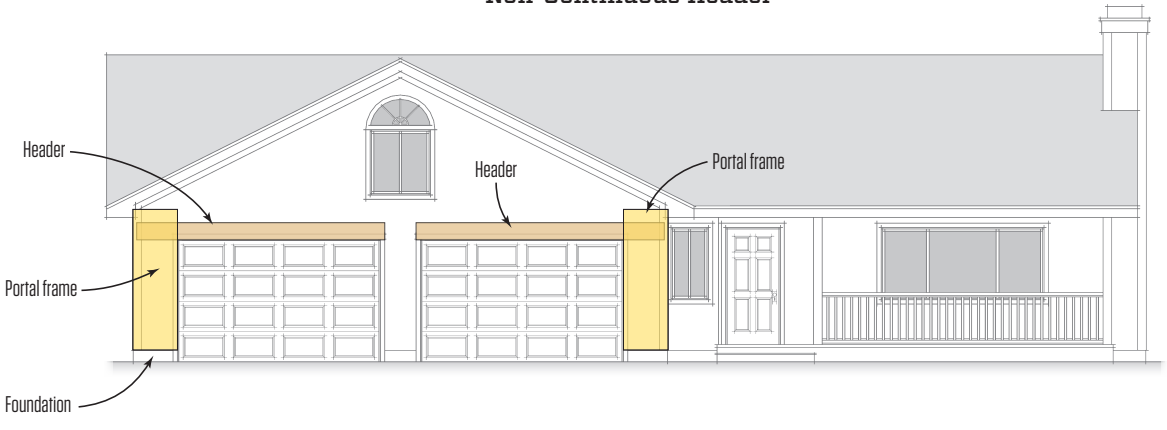
One Side Only



Two Sides



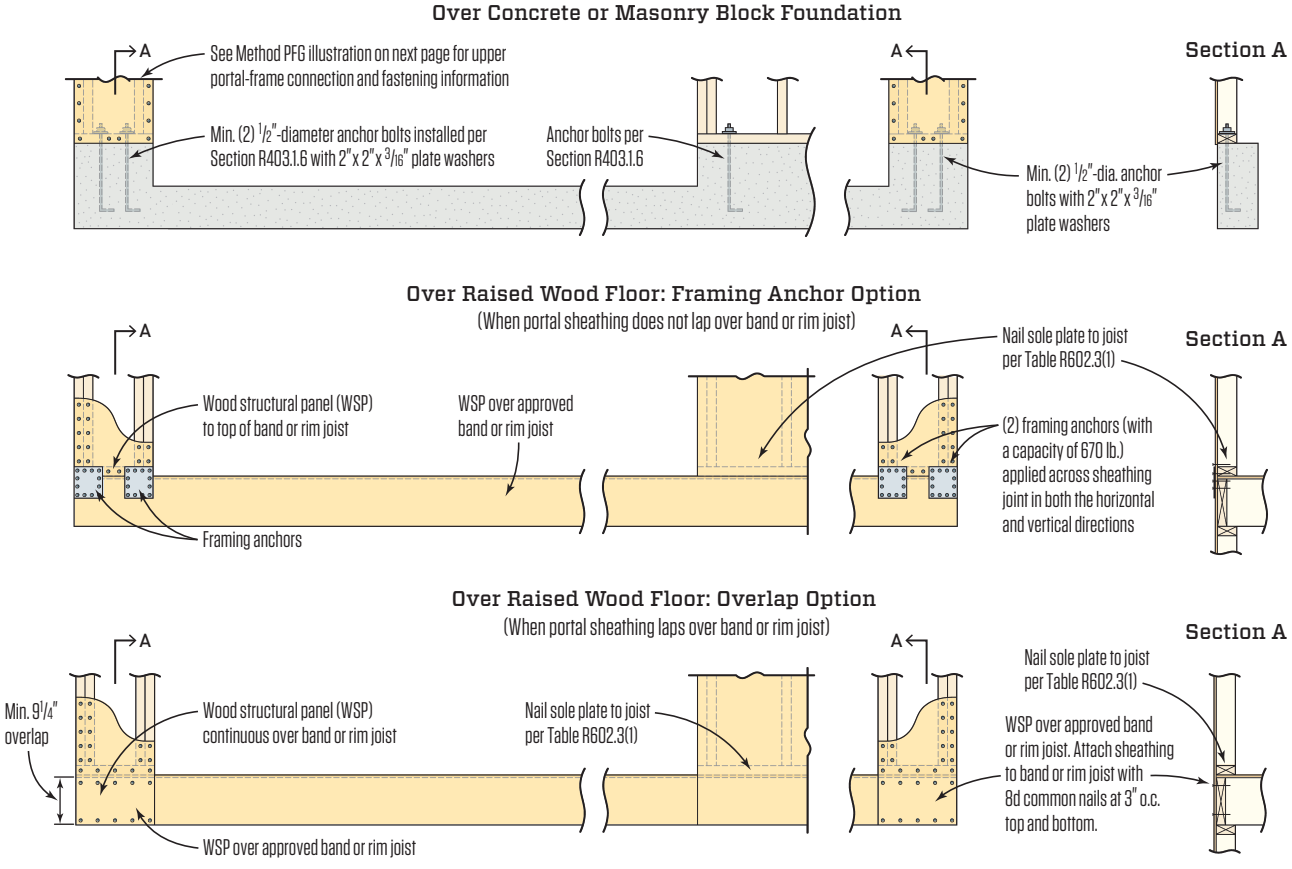
Non-Continuous Header



In a house design where some main walls may have many openings, portal frames can be the key to providing code-compliant wall bracing. The examples above illustrate a portal-frame solution with just one reinforced corner (top), two reinforced corners on a single garage door (middle), and two reinforced corners flanking a double garage door. The two-garage-door assembly could also have a portal frame in the center, but either way, the header should not be continuous.

Illustrations by Tim Healey

Method CS-PF (Continuously Sheathed Portal Frame Panel)



The Continuously Sheathed Portal Frame is allowed only if the builder has sheathed the entire braced wall line with plywood or OSB. But this method can be anchored to a wood floor frame using either overlapping sheathing or a properly detailed steel connector, allowing portal frames over basements and crawlspaces, or even on upper stories of multistory buildings. Wall-to-header attachment details are the same as for the PFH, as drawn on page 45.

PORTAL FRAME POSSIBILITIES

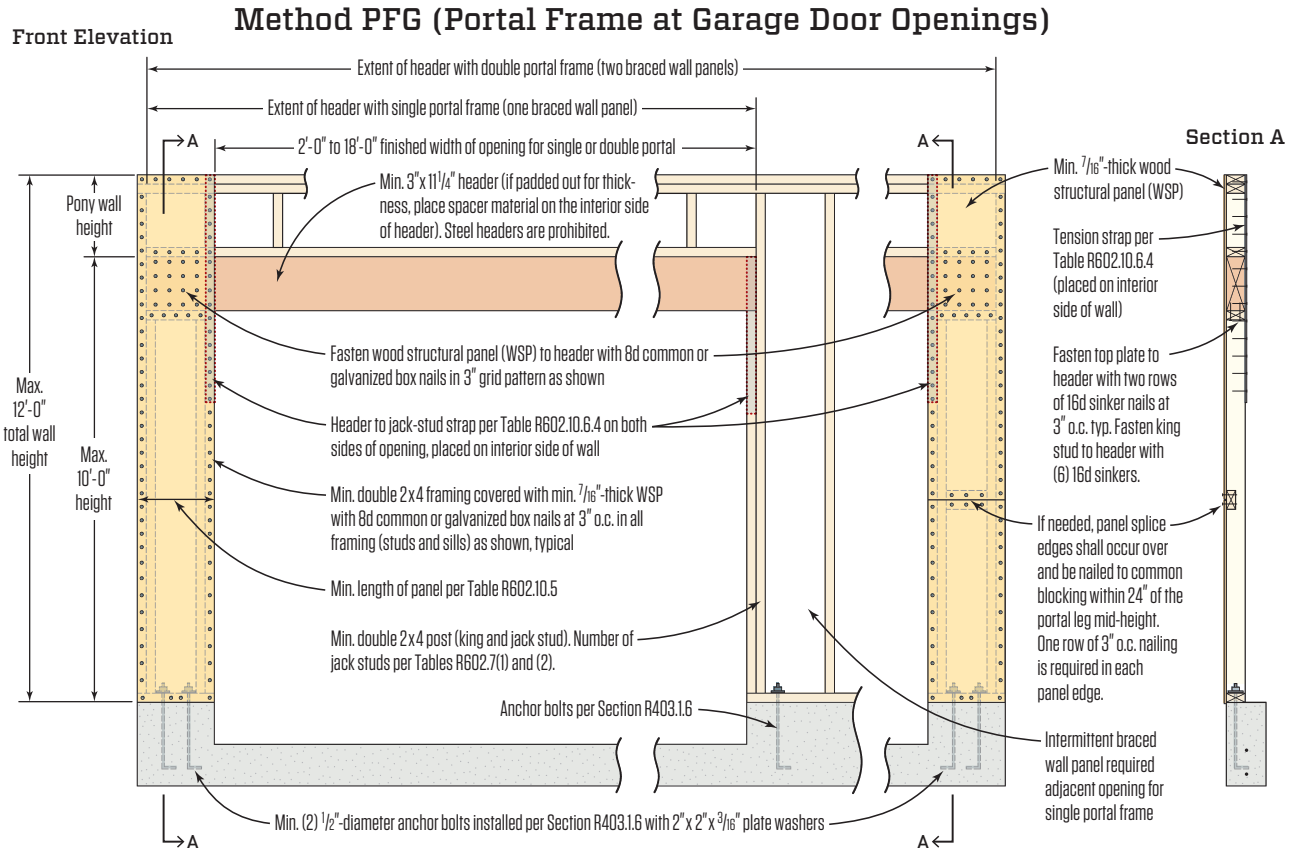
The drawing on the facing page illustrates portal frames incorporated into several different wall configurations. In each example, using a portal frame provides bracing capability, where otherwise you would need a wider wall or a proprietary system.

In case A, just one side of the opening receives the reinforced portal frame corner. In case B, both sides of the opening are detailed as portal frames, which increases the wall's capacity. In case C (a garage wall with two door openings), the two outer corners are shown here as portal frames. The center support between openings could also be constructed as a portal, or not; but either way, each of the openings should have its own header (the header should not be a single continuous member across the two rough openings).

To make the best use of portal frames, you need to consult the building code. In the 2015 International Residential Code (IRC), portal frames are included as one of many prescriptive bracing methods for braced wall construction (Sections R602.10 and R602.12). The different methods use different materials and have different requirements, and so the length of braced wall required for any situation varies, depending on the method employed.

Wood structural panels (WSP)—that is, plywood or oriented strand board (OSB)—are one of the higher-capacity bracing materials when combined with continuous sheathing. Compared to other assemblies, walls continuously sheathed with WSP resist lateral loads with a lesser amount of wall, and so they simplify the design problem by offering more flexibility in terms of the size and location of wall openings.

A code-compliant portal frame gives you even more design flexibility, because portal frames provide bracing in areas where the walls are too narrow for other methods.



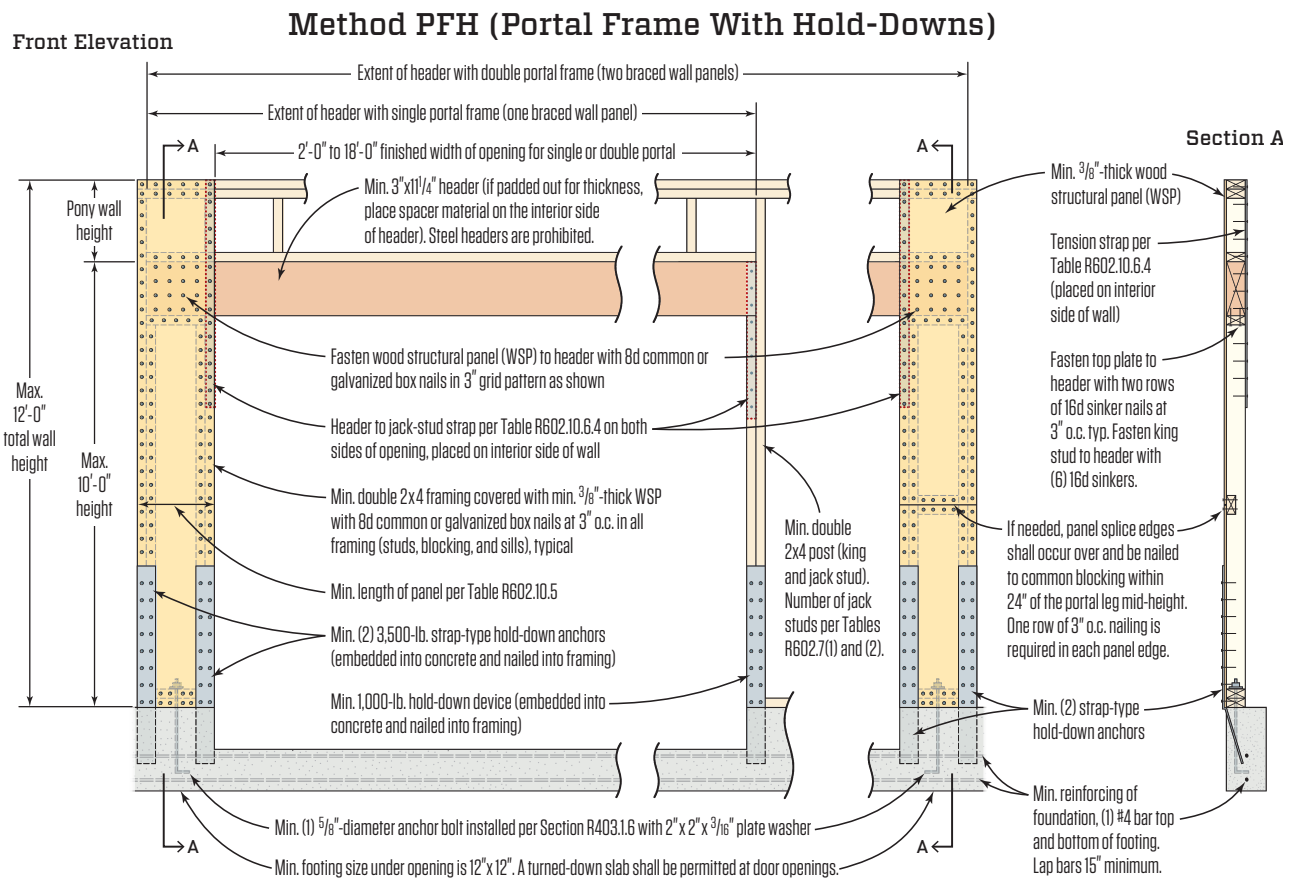
Method PFG is commonly used to supply wall bracing at garage door openings. Supporting walls may be as narrow as 2 feet in length, depending on door-opening height, and each portal frame earns credit for braced panel length of 1.5 times its actual length. Any sheathing joint must be placed within 24 inches of the portal leg height, nailed to a common piece of blocking.

DESIGNING TO CODE

The building code allows three different types of portal frame: the CS-PF, or "continuously sheathed portal frame" (see illustration, page 43), the PFG, or "portal frame garage" (see illustration, above), and the PFH, or "portal frame with hold-downs" (see illustration, facing page). The anchoring methods at the base differ, but most other requirements are similar with only minor differences in fastening and WSP sheathing thickness.

Once you're familiar with the three types of portal frames, you'll be able to take advantage of their capacity when you're getting your plans approved at the building department. The plans should include "braced wall lines," defined as "a straight line through the building plan that represents the location of the lateral resistance provided by the wall bracing," as well as "braced wall panels," defined as "a full-height section of wall constructed to resist in-plane shear loads through interaction of framing members, sheathing material and anchors." A 4-foot length of OSB-sheathed wall with anchor bolts is one example of a braced wall panel. Portal frames also count as braced wall panels; for each portal frame in a wall, you get credit for a specified length of braced wall panel, as spelled out in IRC Table R602.10.5, "Minimum Length of Braced Wall Panels." So if you don't have room for 4 feet of sheathed wall next to your garage door, you can get credit for the equivalent bracing by constructing a portal frame, whose supporting wall might be as narrow as 16 inches, depending on the situation.

The IRC wall-bracing provisions are a common source of misapplication and confusion. It's helpful to study the topic. One excellent resource is *A Guide to the 2015 IRC Wood Wall Bracing Provisions*, published jointly by the International Code Council (ICC) and APA, and available as a $39.95 PDF download (see www.apawood.org/walls).



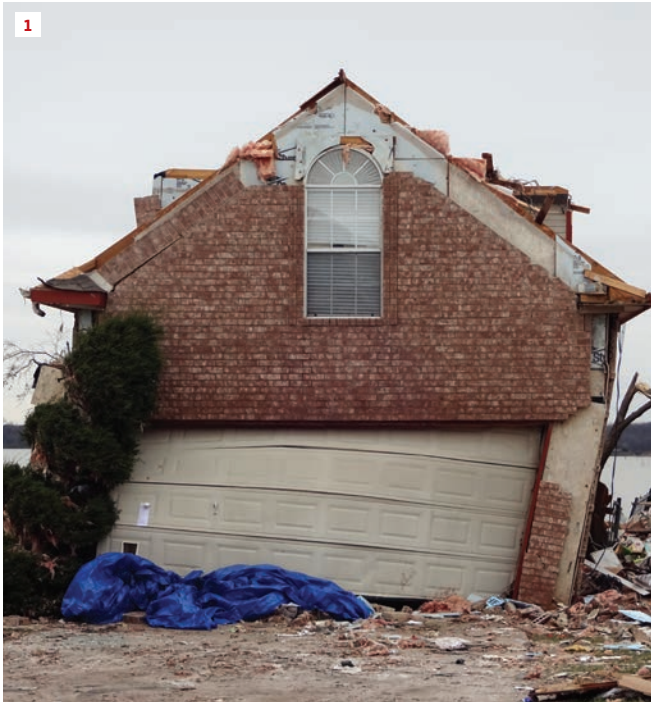
Built using correctly installed hold-downs of the code-specified capacity, the PFH can supply credit for greater bracing than a PFG. Supporting walls may be as narrow as 16 inches in length, and the assembly earns credit equivalent to a 48-inch ordinary braced wall panel. As with all portal frames, nail spacing specifications must be strictly followed.

CHOOSING A SOLUTION

As you consider bracing, one question is whether your building is continuously sheathed with wood structural panels. In the building code, this is bracing method "CS-WSP," and it provides the greatest bracing capacity for either wind or seismic loads. With this method, you may also use the continuously sheathed portal frame (CS-PF), in which case the wall supporting your header could be as narrow as 16 inches, depending on wall height.

Unlike method PFG or method PFH, which have to be anchored to a concrete foundation, method CS-PF can be attached to a wood floor frame at the wall base. You can do that either on the first floor level (over a basement or crawlspace foundation), or even on the uppermost stories of a taller building. You can tie the base of the CS-PF to the wood floor framing either using an approved metal connector, or with properly nailed overlapping plywood. This makes the CS-PF suitable for second-story situations such as the sliding door for a deck, a large bay window, or just a wall with so many window openings that it's hard to find enough sections of sheathed wall of the required minimum length to brace the structure adequately.

If the braced wall line isn't continuously sheathed with wood structural panels, then you can't use method CS-PF. However, you could still use method PFG. With that method, however, your supporting wall must be at least 24 inches in length for an 8-foot-tall wall (and wider for taller walls), and it must be bolted to concrete. If your design requires narrower walls next to an opening and you're willing to install hold-downs, you could choose method PFH. The hold-downs boost the bracing capacity, and the walls may be as narrow as 16 inches (if supporting just a roof), while still providing a bracing contribution equal to a 48-inch length of WSP-sheathed wall.



In what has become a classic failure mode, the upper corners of this garage **(1)** have rotated, unable to withstand the lateral force of strong winds (note the bad location of the panel joint at the upper right hand corner). Another example **(2)** shows the same pattern, as well as the failure of a garage door. In both cases, properly designed and installed portal frames would have likely improved the performance of the homes.

WHY PORTAL FRAMES MATTER

The photos above come from APA investigations of tornado damage. To an engineer, these failures are not surprising: Conventionally-built stud walls this narrow just can't provide sufficient shear capacity to withstand the force of the expected wind on the side wall of the building. Properly constructed portal frames at these openings likely would have improved their performance.

The materials used in these examples aren't as strong as plywood or OSB either. But on the back walls of these garages, where there are few openings (or no openings), that's less important, because 8 feet of sheathed wall is enough to resist that shear. That's why the rear walls of the garages didn't experience the same failure as the front.

In these examples, even though these structures experienced very high wind speeds, extending the header all the way out over the flanking walls and tying the header to the walls to make a portal frame would have likely minimized the damage to the structure.

CRAFTSMANSHIP AND QUALITY CONTROL

Portal frames are a tested assembly. To verify the capacity of the portal frame, APA engineers designed the walls based on engineering calculations, built full-sized assemblies, tested them to failure according to the applicable ASTM standards, and analyzed the results to obtain a structural capacity. If you build a portal wall on site, as long as you stick to the code-prescribed design, you know the wall will withstand the loads.

But if you don't follow the instructions, you may not get the full capacity. In my work, I spend a fair amount of time on jobsites looking at construction details and advising builders. In some parts of the country, builders and trades are becoming familiar with portal

Photos Courtesy APA - Engineered Wood Association

Typical construction errors shown here would reduce the strength of the portal frame: breaking the structural panel joint below the header **(3)**, which reduces the elbow's resistance to rotation; making a panel joint near to the bottom of the supporting wall **(4)**, which weakens the wall's resistance to shear; and locating anchor bolts away from the ends of the wall **(5)**, which weakens the wall base's resistance to overturning forces.

frames, and I don't see many mistakes or quality concerns. But other times, I see portal frames being built wrong. The photos on the facing page show some common construction errors.

In photo 3 (above), the sheathing joint occurs at the wall-to-header framing joint. This defeats the purpose of the portal frame; the joint between the wall and the header has to be rigid in order for the assembly to work. At the top corner of an opening, it's important to carry the sheathing material all the way up the wall and across the header, to the top of the wall. (This same condition can be observed in the damaged garage in photo 1 on the facing page, where the joint has rotated in response to the lateral pressure of wind.)

If you need to have a joint in the sheathing, that joint should occur within 2 feet of the middle of the wall, as shown in the drawings on pages 44 and 45. The wall in photo 4 has a joint just one foot above the foundation—a mistake that weakens the assembly.

Nailing details are also important. The portal frame requires the wood structural panel to be fastened with 8d common or galvanized nails into all framing members at 3 inches on-center, and a 3-inch on-center grid of nails at the header. Anything less will not provide the wall's rated capacity. Framers often miss this detail because they don't understand that the heavy nailing is a critical factor in keeping the corner joint stiff to prevent racking.

Anchoring details also matter. Each portal frame needs two anchor bolts, and they should be as close to the edges of the wall panel as it's practical to place them (not both on one side, as seen in photo 5, above). The anchor bolts should have 2-inch square plate washers and nuts, not round washers as shown in the photo here.

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Photos Courtesy APA - Engineered Wood Association