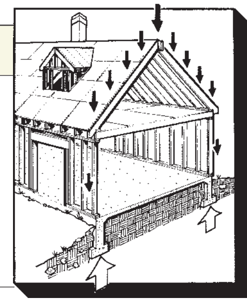
The Strength of Plywood Sheathing

by Philip Westover, P.E.



Occasionally a builder will ask whether let-in bracing is as good as plywood sheathing for resisting lateral loads on buildings. The answer is simple: Let-in bracing does not come close to plywood. In structural design calculations, engineers usually ignore any contribution that let-in braces may make.

Code-Minimum Bracing

Building codes generally prescribe that exterior stud walls be braced, at each end, with let-in 1x4s, metal strap devices, diagonal wood sheathing, or plywood or OSB sheathing. Figure 1 shows two common ways of complying.

Let-in bracing. Building codes require you to nail let-in bracing with two 8d nails (or 1 3/4-inch staples) at every stud and each plate. Yet despite all these nails, the design lateral load capacity is limited by the capacity of the two nails in each plate, where the brace force is concentrated. The nails in the plates will always fail first, and once they fail, the brace is no longer very effective.

Plywood at corners. Some builders use vertical plywood sheets at wall corners, often in conjunction with non-structural insulative sheathing on the rest of the wall. When the plywood is nailed according to code (6 inches on-center on supported panel edges and 12 inches on-center on intermediate supports), the total design shear load capacity is more than five times greater than for let in 1x4s.

Structural Sheathing

Figure 2 shows the two most common ways to sheathe walls with plywood or OSB. Often, the carpenters run the plywood horizontally. For residential construction, builders often use 7/16-inch plywood nailed with 6d common nails. If the plywood is nailed according to minimum code requirements, a 20-foot wall with horizontally applied plywood has a total design shear capacity of 2,460 pounds. That means the wall can resist over a ton of force applied laterally at the top plate.

When the same plywood is installed vertically, the shear capacity goes up to 3,280 pounds. The strength of the vertically sheathed wall is greater because all the plywood panel edges are fastened to solid framing and there are no plywood joints parallel to the shear force. The weak spot in the horizontally sheathed wall is the continuous plywood joint at the 4-foot height where the panel edges are least supported. (When plywood shear walls fail under load, the failure begins at the panel edges, with the plywood pulling away from the framing and pulling out the nails or tearing through the nail heads.) If you add horizontal 2-by blocking and nail the plywood at the horizontal plywood joints, the wall with horizontal panels would have the same shear strength as the wall with panels applied vertically.

Lateral Wind Loads

So what are the forces that create lateral loads on buildings? The two most common are wind and earthquake forces. Since seismic forces rarely control design in the area where I work, I'll concentrate this discussion on wind loading.

A typical building in a suburban neighborhood within 25 miles of the Massachusetts coast must be designed to resist a lateral wind load of 21 psf. Figure 3 shows a typical small garage or shop building in a coastal zone with wind blowing against the eaves side. The lateral wind load on the bottom half of the first story is transferred by the walls directly to the foundation (this assumes the walls are properly anchored to the foundation). The rest of the lateral wind load, from the top half of the first story up to the peak of the roof, must be collected by the walls and roof and transfered through the

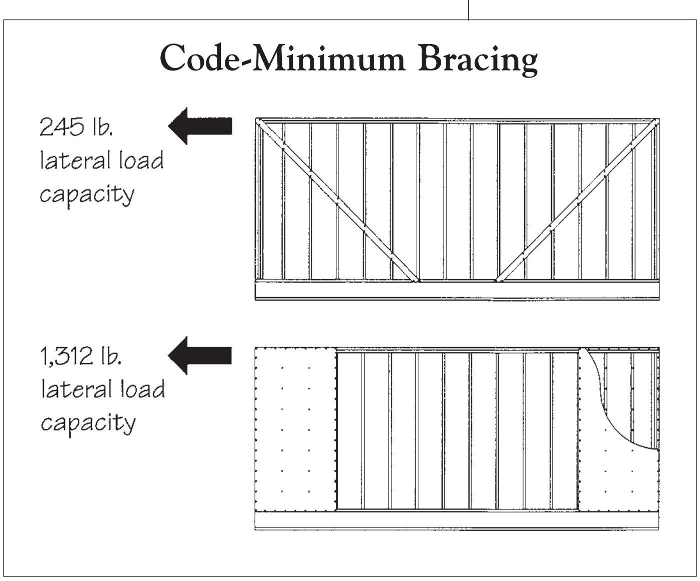


Figure 1. *When nailed with 6d common nails 6 inches on-center on the edges and 12 inches in the field, a pair of 7/16-plywood braces has more than five times the strength of let-in 1x4s (assumes S-P-F faming lumber).*

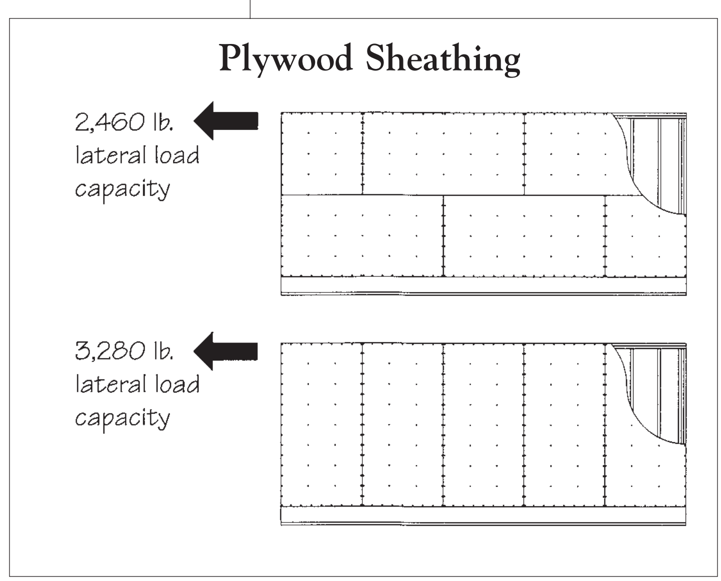
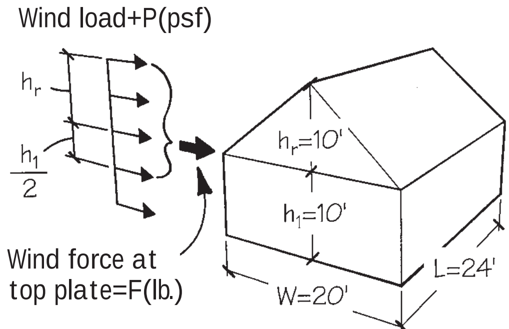


Figure 2. *These lateral capacities assume 7/16 sheathing, S-P-F framing, and 6d nails 6 inches o.c. on the edges and 12 inches in the field. The vertically installed plywood is stronger because all panel edges fall on framing.*

Calculating Wind Loads



$$F = P\left(\frac{h_1}{2} + h_r\right) x \frac{L}{2}$$

Figure 3. *In this example, the wind exerts a load in pounds per square feet against the side and roof of the building. Assuming the walls are securely bolted to the foundation, the load from the bottom half of the wall is transferred directly into the foundation. The load from the top half of the wall all the way to the roof peak is applied as a force at the top plates of the gable end walls.*

Recommended Shear (pounds per linear foot) for APA-Rated Sheathing Nailed to S-P-F Framing

Nominal Panel Thickness	Nail Size (Common or Galv. Box)	Nail Spacing at Panel Edges[1] 6″	4″
Fully Blocked Shear Walls			
3/8″	6d	164	246
3/8″	8d	188.6	295.2
7/16″	8d	209.1	323.9
15/32″	8d	229.6	352.6
Unblocked Shear Walls			
3/8″	6d	123[2]	
3/8″	8d	147.6[2]	
7/16″	8d	162[2]	
15/32″	8d	176.3[2]	

[1]*Assumes 12-inch spacing on intermediate supports* [2]*16-in. max stud spacing*
Adapted from page 42 of APA's Residential & Commercial Design Guide *(available from APA-The Engineered Wood Association, 206/565-6600), and page 7 of APA Research Report 154,* Structural Panel Shear Walls.

gable end walls to the foundation. Since there are two gable ends, each gable end carries half of the wind load.

The ability of the gable end walls to resist the resulting wind force, applied at the top plate, is largely dependent on the lateral shear strength provided by the plywood sheathing. The lateral force to be resisted at the top plate of each gable end is:

$$F = 21 \text{ psf } x \left(\frac{10 \text{ ft.}}{2} + 10 \text{ ft.}\right) x \frac{24 \text{ ft.}}{2}$$
$$= 3{,}780 \text{ lb.}$$

Notice that neither of the walls shown in Figure 2 would have a design shear capacity large enough to resist this force, so a stronger wall is required. The table in Figure 4 is drawn from APA research on shear walls and diaphragms and shows how increasing the number or size of nails, or the plywood thickness, can increase the lateral design strength of the wall. (Note that the table is simplified and applies only to 2-by S-P-F lumber and other lumber of similar density).

Using the table, you can see how the design strength of the plywood sheathed walls is calculated. For horizontally applied plywood, without blocking at the horizontal plywood joints ("unblocked" shear walls), the shear strength is calculated by multiplying the length of the wall by the shear value for 6d nails:.

20 ft. x 123 lb./ft. = 2,460 lb. capacity

When using the chart, note that the shear values are limited by nail size, not by plywood thickness. With 6d nails, 3/8-inch plywood values apply even if you use 7/16-inch plywood. But if you use 8d nails with 7/16-inch plywood, the lateral capacity goes up to 3,240 pounds (20 ft. x 162 lb./ft.). This still isn't strong enough. The easiest solutions are to apply the plywood vertically (for a 10-foot-high wall, you'll need special-order 10-foot-long plywood) or to provide horizontal blocking at the joints and increase the nail size to 8d, which results in a 4,182-pound shear capacity (20 ft. x 209.1 lb./ft.). Or you can add blocking and use 6d nails spaced 4 inches on-center on the edges to get a 4,920-pound capacity (20 ft. x 246 lb./ft.).

This is a simplified example, meant only to give an idea of how plywood sheathed walls can be used to resist lateral loads. Most real world designs are more complicated and can involve varied building shapes and wall openings along with uplifting and/or overturning forces. Imagine putting a 16-foot-wide garage door in the gable end of the example above; there would only be 2-foot long plywood shear walls left to resist the lateral loads, and they would be subject to large overturning forces. Or suppose the building had a second floor with another 10 feet of height; that would add another 2,520 pounds to the lateral force at the first-story top plate, for a total of 6,300 pounds. These and other common situations might call for a more sophisticated structural design.

Don't underestimate the strength of plywood sheathing for resisting lateral loads. But remember, the strength is dependent on good nailing, especially at the panel edges. If you are trusting your lowest-paid carpenter to install sheathing, make sure you inspect the nailing before roofing and housewraps are applied. Otherwise, you may be sacrificing building strength without knowing it. And even if the plywood is properly nailed, the entire wall (or diaphragm) must be adequately anchored to the supporting structures. Often the code-minimum anchors will be adequate, but more complicated geometries and loadings may require specially designed components and connections, particularly when shear-wall or diaphragm action is being relied upon. ■

Philip Westover is a structural engineer in Winchester, Mass.