Residential Guide to Earthquake Design and Construction - Part 2

An Online Continuing Education Course for Engineers

Course Number: S-4006

Credit: 4 Hours / 4 PDH / 4 CPD

Residential Guide to Earthquake Design and Construction – Part 2

Chapter 1: Walls

1.1 WOOD LIGHT-FRAME CONSTRUCTION

1.1.1 General Components

In residential construction, the walls provide the primary lateral resistance to wind and earthquake loads. Even in frame type houses (e.g., post-beam construction), the exterior walls provide most of the lateral stability to the house. Although this course focuses on wood light-frame construction, alternatives such as cold-formed steel, masonry, and concrete construction are used in many regions of the country. The reader is referred to the sections on masonry and concrete construction later in this chapter for some guidance on the use of these materials. For cold-formed steel construction, the reader is referred to the American Iron and Steel Institute's (AISI) industry standard for prescriptive cold-formed steel construction, *Standard for Cold-formed Steel Framing Prescriptive Method for One- and Two-Family Dwellings* (2001).

Light-frame walls provide resistance to sliding, overturning, and racking loads induced in the house by an earthquake as illustrated in Figure 1-1. The walls are the principle element for transmitting the loads from the upper stories and roof to the foundation. The concept of how these loads are transferred between the major components of the house is illustrated in Figure 1-2, and the action of the individual wall segments resisting the lateral loads is illustrated in Figure 1-3. Wood light-frame walls typically consist of the lumber framing covered by sheathing material that is attached to the wood framing with nails, staples, or screws. Figure 1-4 illustrates the components of a wall that is sheathed with wood structural panels (OSB or plywood) on the outside and gypsum wallboard on the inside. The figure also shows the addition of hold-down connectors to the framing, which are required by the *IRC* for some specific bracing configurations. When used, hold-down connectors increase the strength and stiffness of the wall segment.

Four different bracing wall configurations and eight methods (materials) are recognized by the *IRC.* The bracing wall configurations include:

- *IRC* Section R602.10.3 braced wall panels (Figure 1-5a),
- *IRC* Section R602.10.5 continuous (wood) structural panel sheathing (Figure 1-5b),
- *IRC* Section 602.10.6 alternate braced wall panels (similar to Figure 1-5c), and
- Wood structural panel sheathed walls with hold-down connections as required by the exceptions in *IRC* Section R703.7 when stone or masonry veneer is used (Figure 1-5c).

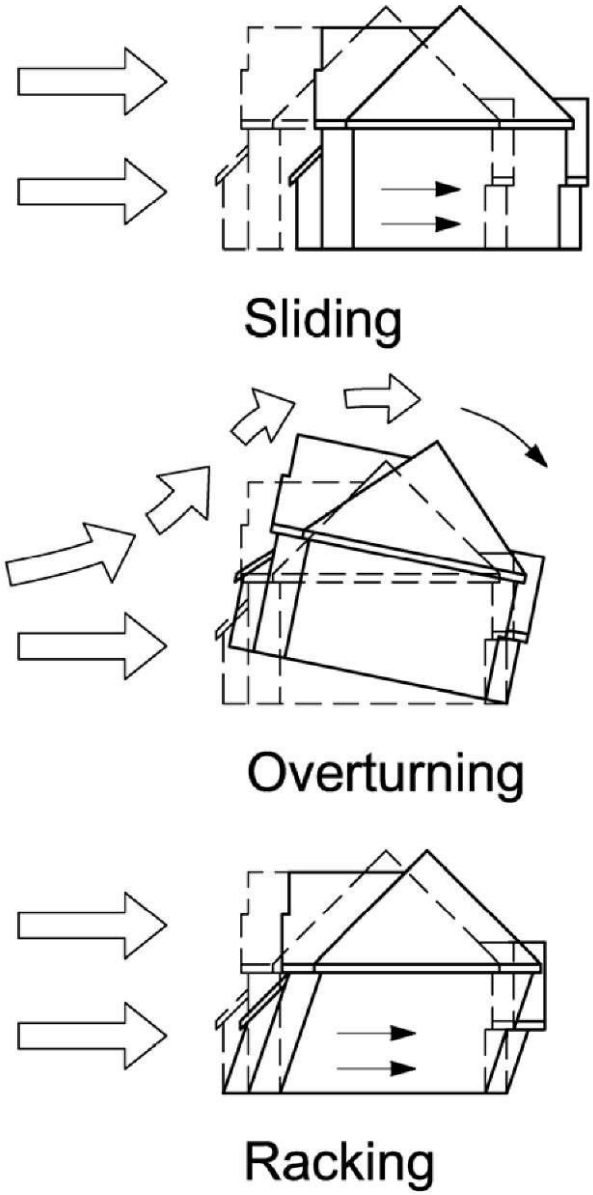

Figure 1-1 Sliding, overturning, and racking action resisted by walls and foundation.

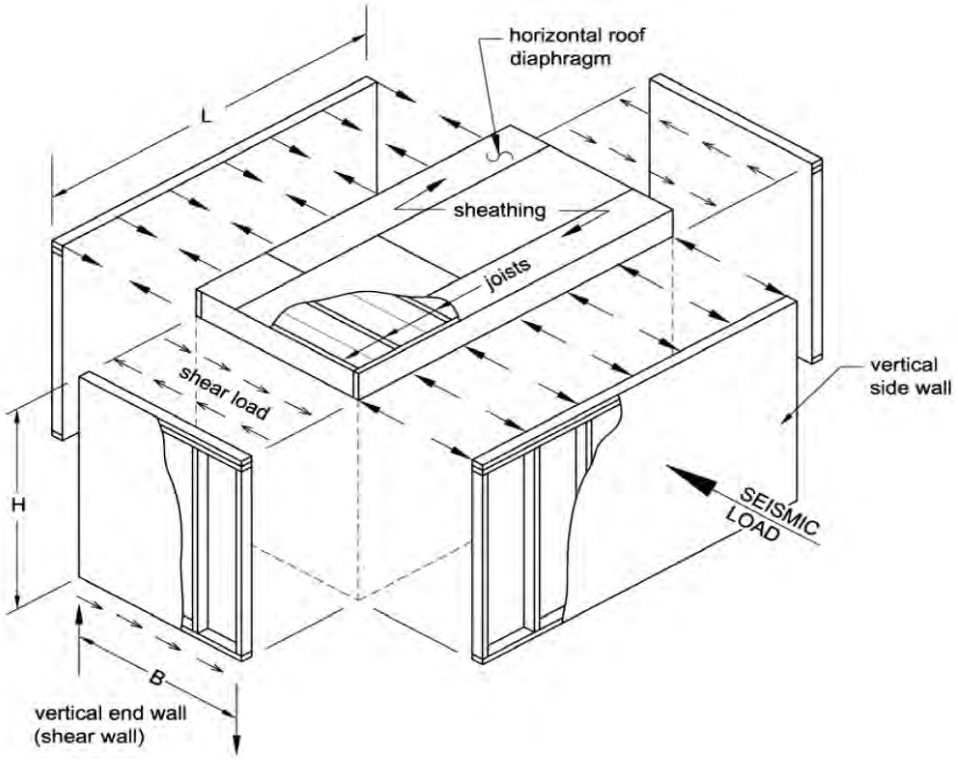

Figure 1-2. Exploded view of house illustrating load paths

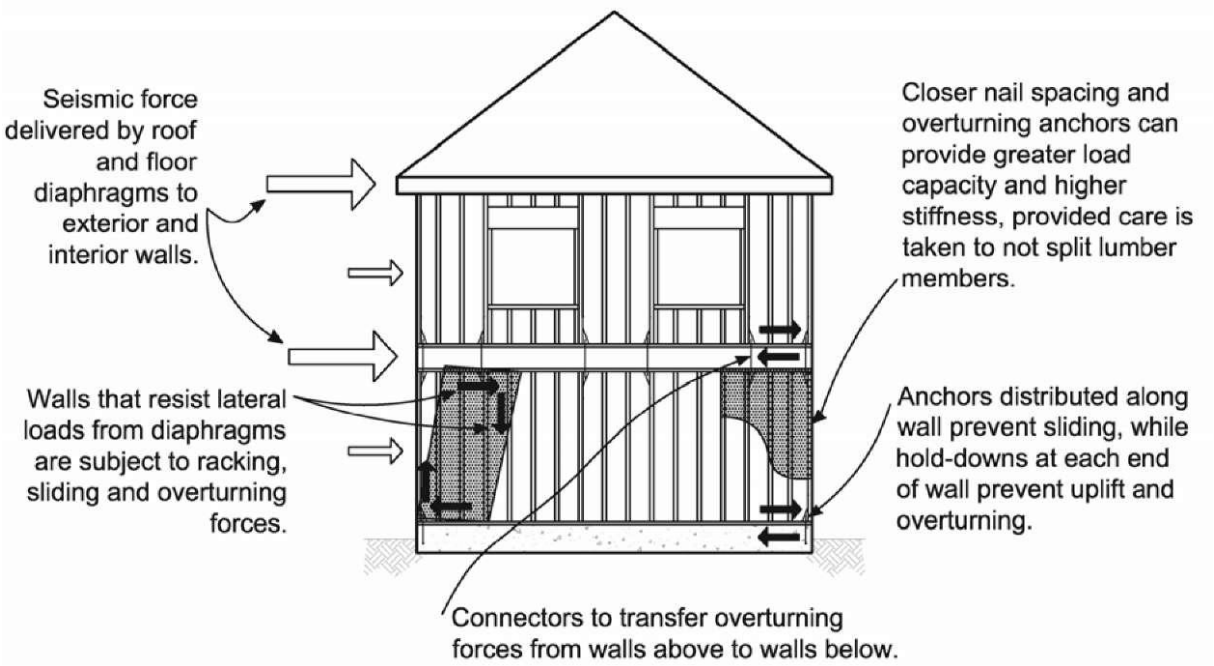

Figure 1-3. Wall action for resisting lateral loads

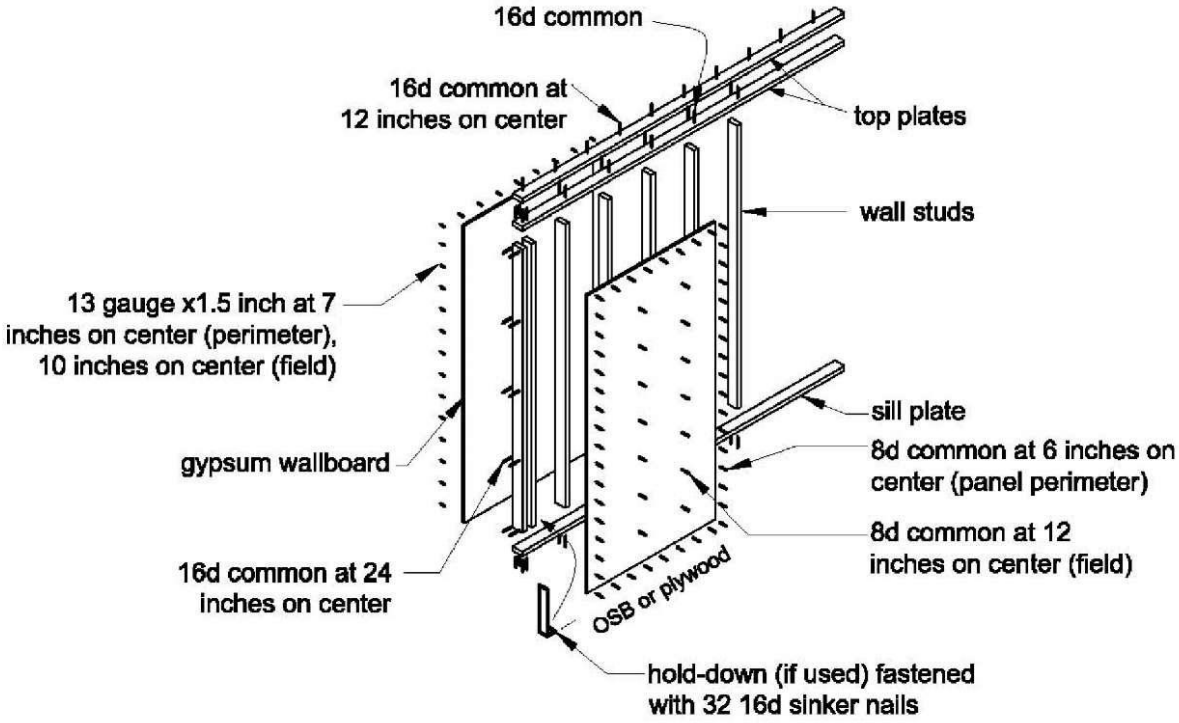

Figure 1-3. Wall action for resisting lateral loads

Differences in these bracing wall configurations include sheathing materials, minimum bracing length, extent of sheathing, and anchorage at the wall base. Differences in overturning anchorage for walls are shown in Figure 1-5.

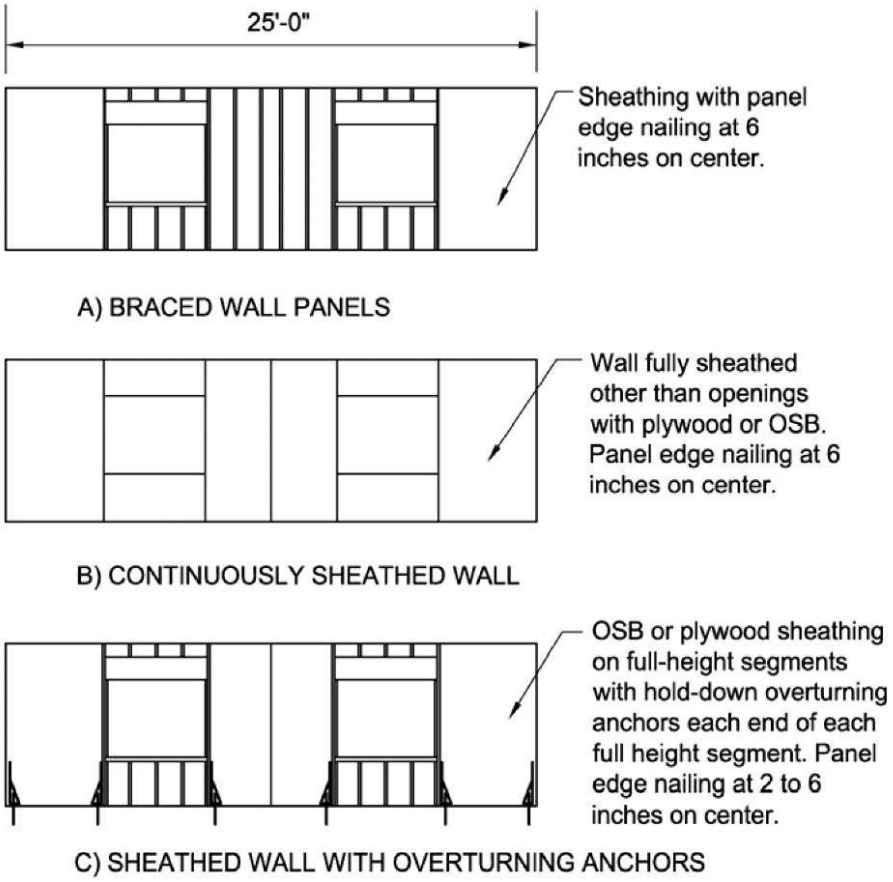

Figure 1-3. Wall action for resisting lateral loads

The braced wall panel *(IRC* Section R602.10.3) is the most commonly used approach. Eight different methods (materials) are recognized by the *IRC* as acceptable bracing. These are called "braced wall panel construction methods" in the *IRC* and are listed in Table 1-1. Method 1, let-in bracing, is not allowed to be used in regions of high earthquake hazard because it often will fail as the walls are racked during an earthquake; therefore, this method is not discussed further in this course.

Of the acceptable braced wall panel materials, wood structural panels and diagonal lumber sheathing are known to perform better than others (i.e., withstand higher deformations while supporting higher loads). Wall panel bracing is required by *IRC* Section R602.10.4 to be provided in 4-foot minimum lengths sheathed on one face for other than Method 5 and either 4-foot lengths sheathed on both faces or 8-foot lengths sheathed on one face for Method 5. Other than with Method 5, this bracing often is provided in 4-foot-long isolated segments along the wall length.

Table 1-1 Braced Wall Panel Construction Methods (Materials) Recognized by the IRC

Construction Method Designation	Sheathing Material
1	Nominal 1x4 inch continuous let-in bracing
2	5/8-inch minimum thickness boards applied diagonally to studs
3	Wood structural panels (OSB or plywood) 5/16-inch minimum thickness
4	½- or 25/32-inch thick structural fiberboard
5	½-inch gypsum wallboard
6	Particleboard sheathing
7	Portland cement plaster
8	Hardboard panel siding

Where braced wall panels use wood structural panel (Method 3) or diagonal lumber (Method 2) sheathing, the panel base anchorage to the supporting floor framing or foundation limits the bracing strength and stiffness. The braced wall panel anchorage includes two critical weak links for uplift: the panel end stud connection and the bottom plate (sole plate) connection. Braced wall panel bottom plates are specified by *IRC* Table R602.3 (1) to be attached to the floor platform using three 16d common (0.162 x 3.5 inch) or 16d box (0.148 x 3.5 inch) nails every 16 inches or are specified by *IRC* Section R403.1.6 to be anchored to the foundation with 1/2-inch-diameter anchor bolts at not more than 6 feet on center. Together, these two weak links cause the wall to fail along the bottom of the wall under relati se walls have a capacity of approximately 150 to 400 plf, wh n value of about 50 to 140 plf maximum).

IRC Section R602.10. hat all exterior wall surfaces on a given sto sheathed with wood structural panel sheathi has greater strength and stiffness than braced wa increased strength and stiffness are due in part above and below windows and doors (wh ritical) and increased overturning capacity due at wall ends. In recognition of the impro s structural panel sheathing, *IRC* Section R be reduced and *IRC* Table R602.10.5 permits slender than would otherwise be permitted.

Wood structural panel wa d, per *IRC* Sections R602.10.6 and R703.7, is oads. This wall configuration is illustrated ng, and hold-down loads for these walls are prescribed, equivalent to engineered shear walls. The alternate braced wall panel p ons of IRC Section R602.10.6 were developed to allow use of