

WOOD STRUCTURAL PANEL SHEAR WALLS

This part of the Shear Walls section will discuss the components of wood structural shear walls, their correct installation and the effects on seismic performance when they are improperly installed. The components examined will be lumber, sheathing, and fasteners. Holdown devices and shear transfer connections will be discussed in the next section, *Connections*.

How to Install the Lumber

USE THE PROPER LUMBER SPECIES

The lumber of choice in California for new construction is usually douglas fir-larch. Some hem-fir is used for pressure treated sill plates. Older buildings used foundation grade redwood for sill plates and some used redwood for all framing members. Shear walls constructed with hem-fir or redwood are weaker than shear walls constructed with douglas fir-larch.

Density of the lumber species determines how well the sheathing fasteners will hold. Shear walls constructed with lower density lumber do not hold fasteners as well as shear wall constructed with denser lumber. The Uniform Building Code requires an 18% strength reduction for walls built with the less-dense hem-fir and a 35% reduction for open grain redwood. The following table shows some of the different allowable shears based on the species of the lumber framing.

Wood Structural Panel		Common Nail Size	Nail Spacing at Panel Edges	Allowable Shears, lbs./ft. Based on Lumber Species		
Panel Grade	Thickness			Douglas fir-larch	Hem-Fir	Redwood Open Grain
Structural 1	15/32 inch	8d	4	430	355	280
Structural 1	15/32 inch	8d	3	550	450	360
Structural 1	15/32 inch	10d	3	665	545	430

Table 3- Effect of Lumber Species on Strength

There are two types of redwood species for strength considerations: open grain and close grain. Because lumber in a covered structure is not always visible or accessible, verification of the grain pattern in existing buildings may be difficult or unreliable. For this reason, structural designers commonly use the 35% reduction for the less dense open grain. When verification of the denser close grain is possible, shear wall strength values may use a 18% reduction like hem fir. Older buildings are more likely to have close grain from old growth trees.



Fig. 3. 20 Stronger Douglas Fir-Larch



Fig. 3. 21 Weaker Hem Fir



Fig 3.22 Earthquake damage with 2 inch adjoining stud

DETERMINE EXISTING LUMBER SPECIES

Structural designers normally assume that existing lumber is douglas fir-larch. When retrofit work uncovers existing redwood or hem fir lumber, contractors and inspectors should notify the structural designer so that additional shear wall strength can be provided. Otherwise, hem fir framing will provide only 82 percent and the redwood will provide only 65 percent of the shear wall strength intended. (Figs. 3.20 & 3.21)

Prescriptive standards for retrofit work generally do not consider the effect of different lumber species. Although not required in such standards, additional sheathing fasteners are recommended for the softer lumber species. The use of 10d commons at 3 inches on center in redwood or 8d common at 3 inches on center in hem-fir is equivalent to the a prescriptive standard of 8d commons at 4 inches on center in douglas fir-larch framing. See the shaded portions in Table 3- Effect of Lumber Species on Strength.

When termite or fungus damage requires the repair or replacement of existing framing members, contractors should use douglas fir-larch lumber to replace all studs, blocking, sill and top plates. Douglas fir-larch should be used for both pressure treated and non-pressure treated lumber. *Denser lumber always means better fastener strength and as a result, stronger shear walls.*

USE THE PROPER SIZE STUD

The 1994 Uniform Building Code requires 3-inch nominal width (2½ net) framing at adjoining panel edges when 6d, 8d and 10d short nails are spaced 2 inches on center or 10d long nails are spaced 3 inches or less on center. Original diaphragm testing by the American Plywood Association (APA) showed that framing members split at ultimate loads when sheathing nails are closely spaced. APA Tests also showed that shear walls are 17% stronger when 3-inch framing is used throughout.

The minimum edge distance for common nails is 5/8 for 6d, ¾ for 8d and 7/8 for 10d. This edge distance should be provided in all framing members and blocking. If an engineer were to use this UBC criteria to design the connection of two adjoining pieces of sheathing to a framing member, nail edge distance requirements in the framing member and sheathing would always require a minimum 3-inch nominal width framing member. Although thicker framing members are not always required by the minimum standards of the building code, using 3-inch nominal width framing at ALL adjoining panel edges will generally increase shear wall strength.

Sometimes it is difficult to install 3-inch nominal width framing in existing construction. An acceptable alternative to 3-inch nominal width framing is to bolt a new stud to the existing stud at the adjoining panel edge. The number of bolts required depends on the shear wall strength and lumber species. For the prescriptive standard, connecting the two studs with ½ inch bolts at 12 inches on center or 5/8 bolts at 16 inches on center will properly join the studs.

INSTALL PROPER SIZE BLOCKING

All of California and portions of Washington, Oregon, Nevada, Utah, Idaho, Montana, and Wyoming are in Seismic Zones 3 or 4. For shear walls in these seismic zones, all edges of wood structural panels must be fastened to framing members or blocking. Blocking must be provided when adjoining panel edges are unsupported between framing members. This situation occurs when the wall heights exceed available panel lengths, panels are installed horizontally, around wall openings or at existing cripple walls. When sheathing panel edges are not fastened, the shear wall is only one-third as strong when all edges are fastened. (Figs 3.23 & 3.24)

Just like vertical studs, the nailing surface of the blocking for adjoining panels should be a minimum of 2½ width to provide proper fastener edge distance in the sheathing and blocking. However, unlike framing members, blocking can be installed *flatly if it provides the minimum penetration depth for the fasteners*. Flat installation of blocking provides more nailing surface and better edge distances.

When blocking is installed flatly, a minimum thickness of 1½-inch lumber should be used to nail sheathing with 6d and 8d common nails. Larger nails, like the 10d common, require 1¾-inch thick lumber to provide the full strength of the nail. When 1½-inch flat blocking is used for 10d common nails, shear walls will lose 16 percent of their strength.

Blocking is also provided in shear walls when shear walls are designed with openings. Blocks are installed between the studs in line with the top and bottom of the openings. Metal straps are nailed to the blocks to reinforce the opening. These metal straps usually require 2½-inch minimum width blocking for the 2 rows of 16d common or sinker nails. When the metal straps are fastened with 16d common nails, the blocking must also be at least 2 inches thick. When 1½-inch flat blocking is used for 16d common nails, opening reinforcement straps will lose 23 percent of their strength. (Fig. 3-25 & Fig. 3.26)



Fig. 3.25 Reinforced Window Openings in Shear Wall



Fig. 3.23 - Cripple Wall Blocking



Fig. 3.24 - 3 Inch Blocking



Fig. 3.26 Blocking for Reinforcement

PROPERLY LOCATE THE HOLDOWN STUD

The length of a shear wall is measured horizontally along the sheathing between wall ends or the framing members with holdown devices. Studs for holdown devices should be located as far apart as practical. Framing members for holdown devices should not be notched for larger obstructions like plumbing or countersunk for washers or bolt heads.



Fig. 3.27 - Too Close to Wall End



Fig. 3.28 - Too Far From Shear Wall End



Fig. 3.29 - Acceptable Holdown Location for Shear Walls at Corner

**USE THE PROPER LUMBER GRADE
& SIZE OF HOLDOWN STUDS**

When an engineer designs the connection of a holdown device to a framing member, the grade and size of the lumber helps determine how much uplift the framing member can take. For example, *Construction* grade 2 x 4 studs can take a maximum 4,540 pounds of seismic uplift. *Stud* grade 2 x 4 studs can take only 3,140 pounds. The maximum seismic uplift for *Stud* grade 4 x 4 studs is 7,330 pounds. The grade of douglas fir-larch for the holdown stud can determine the available strength of a holdown devices. The shaded portions in Table 4 show when the lumber grade or species controls the allowable value.

When holdown devices are installed on new framing members, contractors and inspectors should verify that the proper grade and size of lumber is used. Otherwise, the holdown may be attached to a framing member that is too weak to resist the required uplift. This will result in lower shear wall strengths.

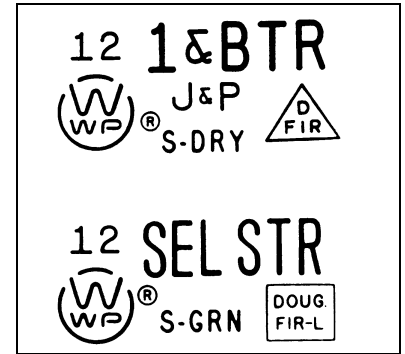


Fig. 3.30 - Lumber Grade

Holdown Product	Stud Size	Douglas Fir-Larch Grade	Catalog Value	Tension, lbs	Compression, lbs		
				Net Section	8 Ft. Stud	Sill or Sole Plate	
						Hem fir	DF-L
HD 8A	4 x 4	No. 1	7,460	12,078	7,695	4,961	7,656
		No. 2		10,288	7,209		
		Construction		7,753	6,840		
		Standard		4,473	6,327		
		Stud		5,905	5,965		

Table 4-Effect of Lumber Grade on Holdown Capacity

AVOID MECHANICAL PENETRATIONS

Many wood frame residences have poor coordination of structural and mechanical installations. Structural designs are completed and approved long before mechanical subcontractors begin to design their systems. Residential mechanical designs often call for penetrations in shear walls. These penetrations can seriously weaken shear walls and stricter notching and cutting limits should be followed than given in the building code for non-shear walls.

As a result of buildings damaged in the Northridge Earthquake, the City of Los Angeles amended its building code to provide stricter limits on mechanical penetrations in wood frame shear walls. These limits effectively remove large electrical conduits, plumbing and heat vents from wood frame shear walls. The following code section and illustration from the Los Angeles Building Code show the recommended limits.



Fig. 3.31 Unregulated Penetrations



Fig. 3..32-Regulated Penetrations

2314.5.8 Mechanical Penetration of Wood Shear Walls and Plate Members. The maximum accumulated length of openings in a shear wall shall not exceed 20% of the wall length. Plumbing, electrical, and other mechanical penetrations of the top or bottom plate framing members shall be limited to Figure 23-1-Y-1.

EXCEPTION: Openings or penetrations may exceed this amount where designed and shown on the approved drawings.

FIGURE 23-I-Y-1

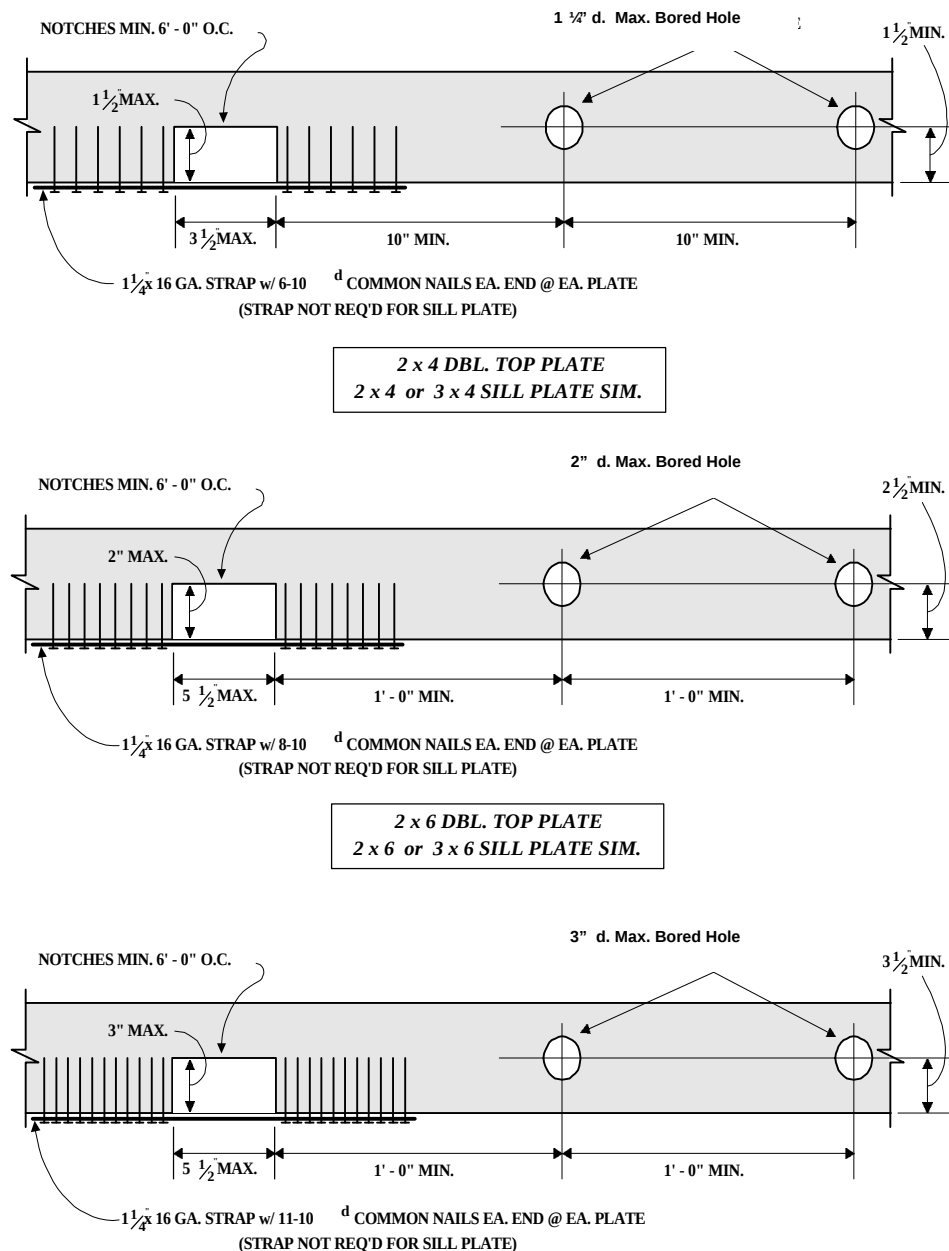


Fig. 3.33- Non-Engineered Limits for Mechanical Penetrations

EVALUATE EXISTING LUMBER

Both the existing and new framing should be free of wood decay. Wood decay is frequently referred to as dry rot. This is a misnomer. Rotted wood may be dry when it is found, but wood actually rots when it is too wet. Fungi that feed on the carbohydrates, cellulose, and lignin that make up the wood primarily cause rot. Such fungi are always present in wood but require high moisture content to become destructive. When wood dries out, the fungi cease to deteriorate the wood fibers. (Fig. 3.34)

When the retrofit work is being performed, the contractor should check for sources of water intrusion and wood-earth clearances. Water should not continuously saturate wood and any wood should be at least 6 inches above any soil. When existing soils are regraded to provide proper wood-earth separation, contractors should be careful not to create new drainage problems or undermine any existing footings. If adequate separation between earth and wood cannot be provided, the contractor should seek the advice of the building official and engineer or architect.



Fig. 3.34 Wood Decay

Termites, powder post beetles, and other animal organisms can also seriously weaken a structure. Infestation should be treated by a properly licensed and experienced pest control service before the retrofit work begins. Damaged wall framing should be removed and replaced. (Fig. 3.35)



Fig. 3.35 Termite Damage

PROVIDE ADEQUATE VENTILATION

Adequate ventilation is one of the best ways to minimize potential wood decay in the crawl space. Unless the crawl space is mechanically ventilated, the UBC requires 1 square foot of vent openings in the cripple walls for every 150 square feet of under-floor area. To provide cross ventilation, these openings should be spaced evenly on at least two sides of the crawl space. New sheathing should not reduce or cover existing ventilation openings. Additional ventilation should be added when wood decay is present under prevailing conditions (Fig. 3.36).



Fig. 3.36 Crawl Space Ventilation

HOW TO INSTALL THE SHEATHING

USE THE SPECIFIED WOOD STRUCTURAL PANEL

All types of wood structural panel sheathing have the same allowable shear strengths in the UBC. Wood structural panels include all veneer plywood, composite panels, oriented strand board and waferboard. The most common structural panels are plywood and oriented strand board. When the term “*wood structural panel*” is specified, the contractor may use oriented strand board or plywood panels of the required thickness and grade.

ORIENTED STRAND BOARD

Oriented Strand Board (OSB) is a mat-formed panel product made of strands bonded with exterior type resins under heat and pressure. OSB panels consist of four or five layered mats. Most mills use uniformly thick strands up to 4-1/4" long and 1" wide. Exterior or surface layers consist of strands aligned in the long panel direction. Inner-layer layers consist of cross or randomly aligned strands. OSB's strength comes mainly from the uninterrupted wood fiber, interleaving of the long strands or wafers and degree of orientation of wafers or strands in the

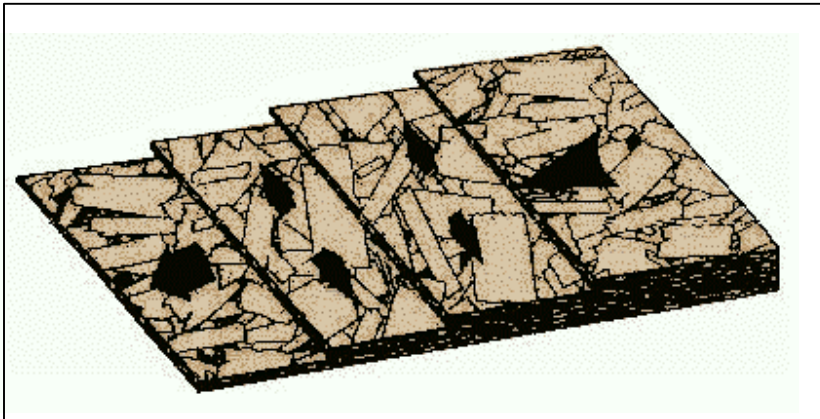


Fig 3.37 - Oriented Strand Board Panel Construction

surface layers. (Fig. 3.37)

Question: *Can I substitute oriented strand board for plywood sheathing?*

Answer: Some designers will specify plywood panels for sheathing because oriented strand board expands more than plywood when exposed to moisture. Wetting and expansion can cause fasteners to fracture the surface of the sheathing. Fasteners whose heads are below the surface of the sheathing due to panel expansion will cause premature failure of the shear wall during seismic loading. *When plywood is specified, no substitutions of the less costly OSB should be made without the approval of the structural designer and local building department.*

Professional engineers and architects can and often should design to more than the minimum standards of the building code. When they do, their specifications must be followed. For example, California law states that licensed architects are not responsible for damages caused by unauthorized changes to their plans or specifications. This provision includes changes made by plan reviewers and building inspectors without the architect's consent.

PLYWOOD

Plywood is a panel of laminated veneers (plies) constructed in an odd number of layers. Layers may consist of one or more plies laminated with parallel grain direction. Each layer is positioned perpendicular to the adjacent layer to equalize strain, reduce splitting, and minimize warping. Outer layers generally have the outer layers oriented parallel to the long dimension of the panel. Plywood must have a minimum number of plies and layers for each thickness range. For example, 15/32 inch Structural 1 plywood must have at least 4 plies and 3 layers. Non-Structural 1 plywood of the same thickness can have 3 plies. (Fig. 3.38)

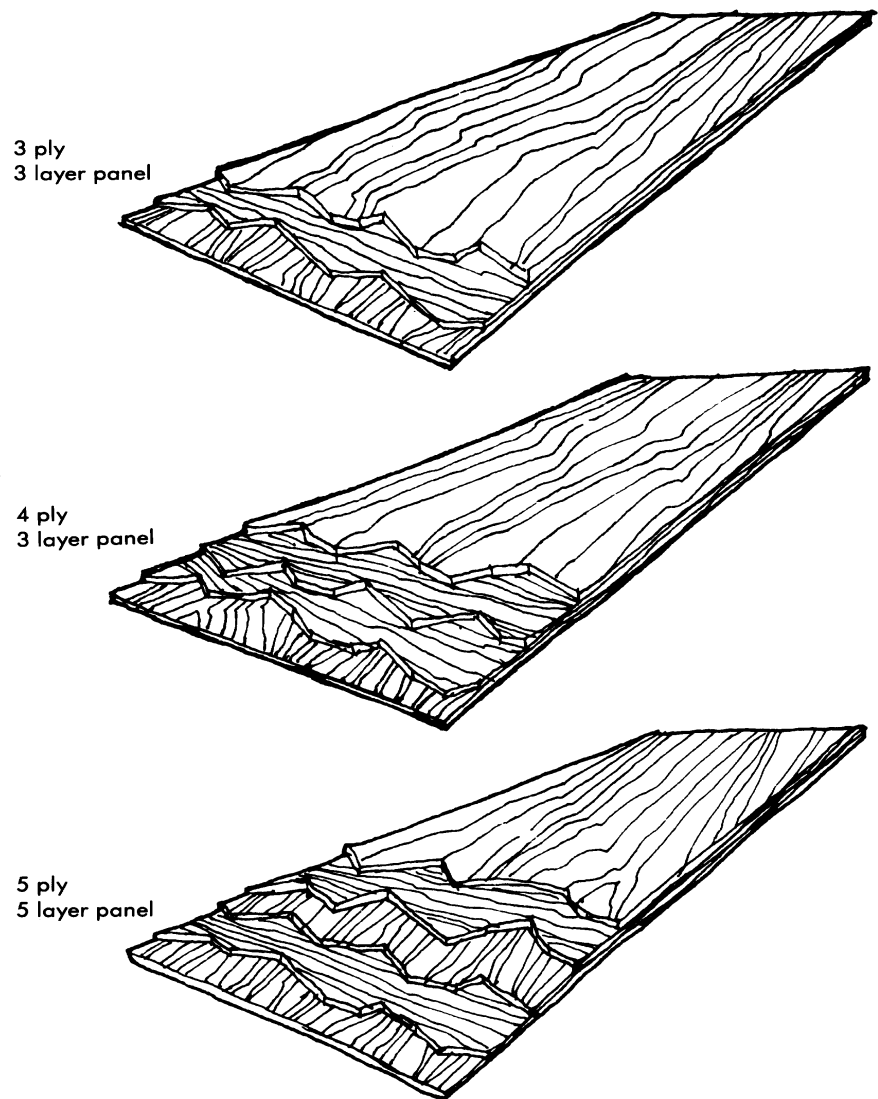


Fig. 3.38 - Plywood Panel Construction

USE THE PROPER THICKNESS & NUMBER OF PLIES

Normally, the strength of shear walls sheathed with wood structural panels comes from the strength of the sheathing fasteners. However, instead of fastener failure, some shear walls constructed with 3/8-inch plywood tore at their inner ply seam during the Northridge Earthquake. This is the first time this type of failure was documented. Using thicker panels with additional plies should allow fasteners to reach their strength limit before the sheathing prematurely tears.

The minimum recommended thickness for wood structural panels is 15/32 of an inch. For this thickness, both four-ply and five-ply plywood panels are commonly available. Five-ply panels provide five plies and five layers while four-ply panels provide four plies and three layers. The more plies and layers that are used in plywood, the more overlapping occurs of defects and inner ply seams. For this reason, some prescriptive standards recommend the use of five-ply panel construction for plywood.

The following panel information was furnished by a major plywood wholesaler and conforms to UBC Standard 23-2 (PS 1-83).

3-ply panel construction is used on 3/8 inch Structural 1, 3/8-inch C-D Exposure 1 and 1/2-inch C-D Exposure 1.

4-ply panel construction is used on 1/2-inch Structural 1 (Southern Pine) and 5/8-inch C-D Exposure 1

5-ply panel construction is used on 1/2-inch Structural 1 (Douglas Fir) and 5/8-inch Structural 1.

The panel thickness shown is nominal. Use 3/8 for 11/32, 1/2 for 15/32 and 19/32 for 5/8-inch thickness.

Structural 1 plywood in 1/2-inch thickness is normally available in 4-ply (Southern pine) panel construction because it is less expensive than the 5-ply (Douglas fir). C-D Exposure 1 allows 3-ply in 5/8-inch thickness under UBC STD. 25-9 but manufacturers typically construct the panel with 4 plies to obtain the required thickness.

USE THE PROPER PANEL GRADE

The recommended panel grade for shear wall construction is Structural 1. Structural 1 is the premium grade of CDX and OSB panels. Structural 1 Rated Sheathing has increased cross-panel strength and shear properties and all plies use special improved grades. The allowable panel rigidity of Structural 1 is almost twice other structurally rated sheathing. Because of its properties, Structural 1 shear walls are ten percent stronger than other similar fastened structural use sheathing. (Fig. 3.39)

The common phrase CDX refers to a plywood panel constructed with exterior glue that has C grade veneer on its face and D grade veneer on its back. This typical construction panel is used for subfloors and roofs. Roofs and floors generally have several panels resisting the seismic forces and therefore require lower shear strength. In contrast, shear walls generally use few panels to resist these same forces and the demand on individual panel strength and stiffness is greater than floors or roofs. *For retrofit work, remember to install each panel with the grade stamp visible for the building inspector.*

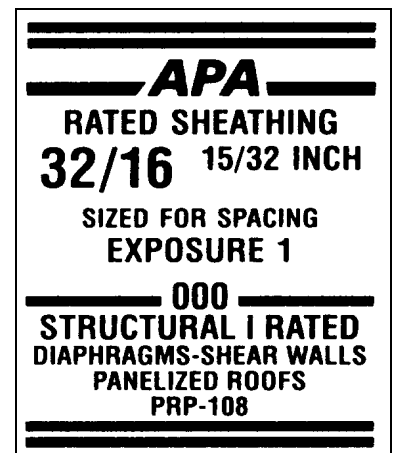


Fig. 3.39 Panel Grade Stamp

LOCATE PANEL ON THE CENTER OF FRAMING MEMBER & BLOCKING

Panel edges should be centered on all framing members with a 1/8-inch space between them. The spacing allows for future panel expansion and contraction from moisture and temperature changes. If panels are not properly spaced, expansion will cause buckling. Buckling reduces shear wall performance and can damage wall finishes.

Panel edges should be centered on framing members and blocking to provide proper fastener edge distance in both the lumber and sheathing. The greater the fastener edge distances in the lumber and sheathing, the better the shear wall will perform. Fasteners installed too close to the edge of the sheathing, blocking or framing member have no value.

Question: *Do I Need to Install the Sheathing Perpendicular to the Framing Members?*

Answer: Unlike unblocked floor and roof diaphragms, shear wall strength values in the UBC do not change with orientation of the panel. Either vertical or horizontal placement of the individual panel is acceptable. Most panels are installed vertically to avoid the added expense of blocking. (Fig. 3.40)

Question: *Can I Place the Sheathing on the Inside of the Wall?*

Answer: Sheathing for shear walls may be placed on either the interior or exterior face of the wall framing. Wood structural panel sheathing is usually placed on the exterior for new construction and the interior for retrofit work. For new construction, work of other trades, like insulation and electrical is generally easier when the interior is accessible. For retrofit work, the interior wall surfaces are usually cheaper to replace. The shear wall will have the same strength with the sheathing on either side of the wall.

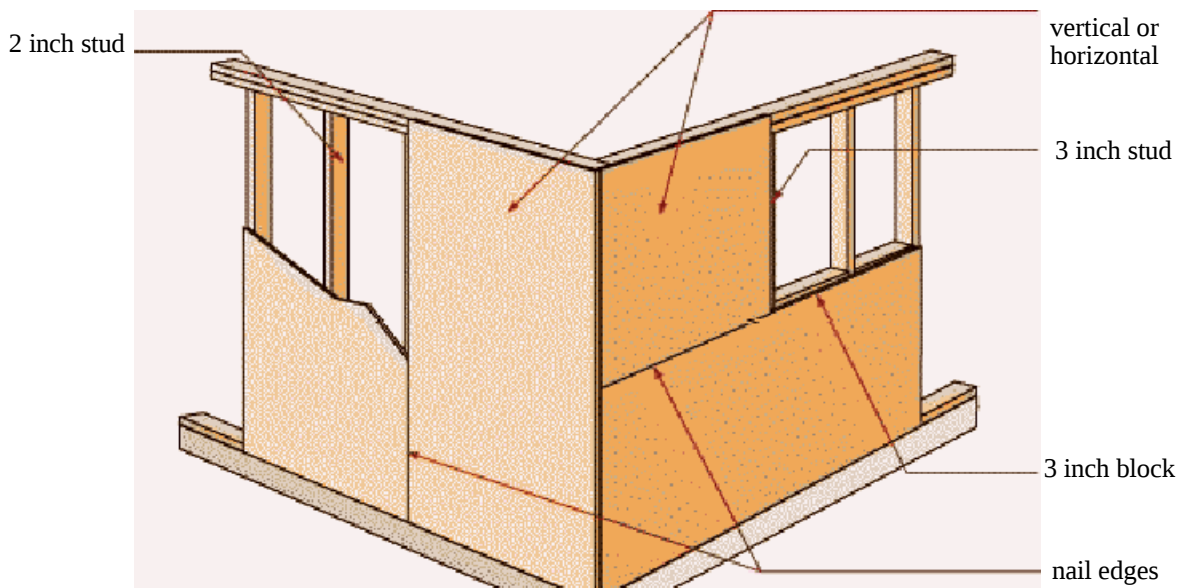


Fig. 3.40 - Install Sheathing Vertical or Horizontal

USE THE PROPER SIZE PANEL

Although the Uniform Building Code does not prescribe minimum dimensions for individual panels on shear walls, a minimum width of 24 inches is recommended to prevent any one local defect affecting performance. This criterion is used for floor loads and is recommended for shear walls.

To follow the 1997 UBC recommendations of 2:1 aspect ratios in Seismic Zones 3 and 4, contractors should always install at least one full 4' x 8' panel on any standard eight-foot high shear wall. When the length of the shear wall exceeds four feet, the end panels should be at least 24 inches.

MARK LOCATION OF STUDS ON PANELS

Retrofit work is usually done from one side of the wall. Panels are held in place with a few nails until volume nailing is done later. Unlike new construction, the number of fasteners that do not properly connect to the framing members or blocking cannot easily be determined after the sheathing is in place. To reduce the chance of improper fastening, contractors should mark the center of all framing members, blocking and holdown end studs during sheathing installation. After all panels are in place, a chalk line can be snapped on the panels, which makes proper volume fastening easy.

**MAINTAIN FIRE RESISTIVE AND
SOUND-RATED CONSTRUCTION**

When retrofit work replaces existing wall finishes, any fire resistive construction must be maintained. One-hour fire resistive and sound-rated construction is required at walls separating dwelling units in the same building. One-hour fire-resistive construction is also required throughout three story apartments and when two story apartments have more than 3,000 square feet on the second floor. Some apartments may also use two-hour walls to get more allowable floor area. When these conditions exist, all required components of the wall assembly must be replaced. The addition of plywood or OSB panels will not affect the fire rating when attached directly to the framing and covered with the appropriate fire-resistive materials.

**PROVIDE VENTILATION AT
CRIPPLE WALL SHEATHING**

Many older homes do not have building paper under their horizontal siding around the crawl space. This permits water to enter the cripple wall stud cavity. *Circular ventilation holes should be cut in the sheathing when new sheathing is placed on the inside face of the cripple wall.* Prescriptive standards specify the size and spacing of the ventilation holes. The holes will permit water vapor to escape and will permit inspectors to observe and test anchor bolts. Screens should be installed over the ventilation holes to prevent animals from nesting in the newly sheathed stud cavities. (Fig. 3.41)

New sheathing should not block existing vents. Where sheathing must be placed where a ventilation or other opening is located, cut an opening for the vent, install blocking around the vent opening and extend the length of shear wall the width of the vent opening to the nearest stud.

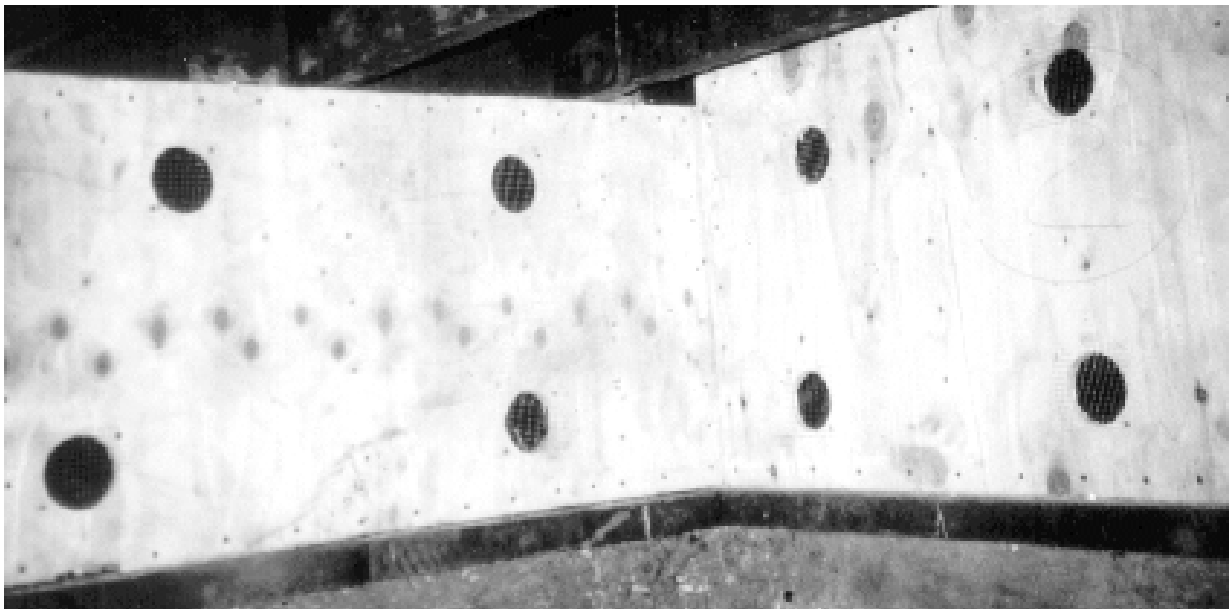


Fig. 3.41-Cripple Wall Ventilation

HOW TO INSTALL THE FASTENERS

USE COMMON NAILS

Nails are the preferred fasteners for several reasons. They cost less to install than screws and are easier to install in volume due to pneumatic tools commonly known as nail guns. Engineers prefer nails because they are generally more ductile than screws. Better ductility mean better absorption of seismic energy. When screw withdrawal properties are desirable, such as for floor sheathing, ring-shank or screw-shank nails can be used instead.

Most structural designers specify common nails because of their improved strength and stiffness over box, cooler or sinker nails. Common nails have larger nail shank diameters than other nails. Although hot-dip galvanized box nails may be used for plywood sidings, *common nails are recommended to fasten wood structural panel shear walls.* (Fig. 3.42)

Hand driven nails typically come in boxes labeled with the nail type. Boxes with nails for nail guns sometimes show only the length, diameter and finish. *To verify the use of common nails, contractors and building inspectors must be familiar with nail diameter requirements.* For example, if a gun nail box says 2-3/8 x.113 Smooth instead of 2-3/8 x.131 Smooth, the fastener is a 8d cooler nail instead of the 8d common. This is a common construction error. Nail sizes and diameters are shown in the Appendix.

USE THE PROPER LENGTH OF COMMON NAIL

Shortened 10d common nails, commonly referred to as *short or plywood nails*, come in three lengths: 2-1/8, 2¼ & 2-3/8-inches. Only 11/32-inch thick panels can use the shortest nail, 2-1/8-inch. Panels with thicknesses from 3/8-inch to 15/32-inch can use the 2¼-inch length nail. Panel thicknesses from ½-inch to 19/32-inch require the 2-3/8-inch length nail. Panel thickness equal to 5/8-inch or thicker must use the full length 10d common (3 inches).

Question: *Can I Use Shortened 10d Common Nails?*

Answer: Unless otherwise specified, shortened 10d common nails, may fasten wood structural panels in shear walls if they meet the minimum penetration requirements. All nails must provide a minimum of 12 diameters penetration into the framing member or blocking.

Because of their shallower penetration, short nails are less likely to split framing members but are more likely to withdraw. *Check with the structural designer before using these shortened nails.*



Fig. 3.42 Box Label for Common Nails

WHY COMMON NAILS ARE IMPORTANT

Because the head sizes of common and box nails are nearly identical, wood structural panel sheathing fastened with these nails will reach the same ultimate strength. The advantage of using common nails to fasten sheathing is generally stiffness and not strength. Common nails have less slip than box nails due to their increased shank diameter. Because shear walls must provide both strength and stiffness, the use of box, cooler or sinker nails will reduce the performance of the shear wall.

UBC Table 23-I-G, which uses stiffness to determine the allowable load values, can be used to make the following stiffness comparison. For sheathing, four common nails provide the same stiffness as five box or cooler nails. When shear walls are constructed with box, sinker, or cooler nails, it will take 25% more nails to make up the difference. However, additional nailing must follow the requirements for minimum spacing and framing member sizes.

When additional nailing creates spacing of 6d or 8d at 2 inches on center or 10d at 3 inches on center, 3 inch nominal width framing members are required at all adjoining panel edges. When the original common nail spacing was equal or less than 6d at 2 inches, 8d at 2½ inches or 10d at 3 inches, additional nails cannot be used because of minimum spacing requirements. In these cases, additional sheathing must be provided and is usually installed on the other side of the same wall. *Remember, it is easier in the long run to do it right the first time.*

COMPARISON OF COMMON VS. BOX NAILS								
Nail Size	Length, inches	Shank Diameter, decimal inch		Minimum Spacing and Penetration, inches		Allowable Lateral Load, pounds		
		Common Nail	Box Nail	Common Nail	Box Nail	Common Nail	Box Nail	Box vs. Common
6d	2	0.113	0.099	1¼	1c	63	51	0.81
8d	2½	0.131	0.113	1½	1¼	78	63	0.81
10d	3	0.148	0.128	1e	1½	94	76	0.81

Table 5 - Performance Losses for Nail Substitutions

USE FULL HEADED NAILS

Most Contractors use nail guns to fasten wood structural panel sheathing (Fig. 3.43). The nails used in these tools come in clips that may or may not have full heads. Some manufacturers clip the nail head to form clips with the nail shanks side by side. This arrangement allows more nails per clip, reduces the frequency of reloading and avoids intershank plastic from disabling the tool. Other manufacturers use plastic to hold the individual nails far enough apart to allow for full heads (Fig. 3.44).

Although present building code accepts altered heads, there are good reasons to believe they are not as strong as full headed nails. Examination of plywood shear walls damaged in the Northridge Earthquake showed the importance of nail head size. Shear wall failure occurred at the panel edges. The panel edge either failed by punching through at the nail head or withdrawal of the nail itself in panel buckling. In both cases, the nail head size was a significant element in the mode of failure. The smaller the nail heads size, the easier a panel can buckle off the framing. (Fig. 3.45)

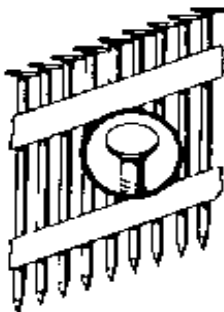


Fig. 3.43 Sample Nail Gun with Flush Attachment



Fig. 3.45 Earthquake Damaged Shear Wall

Round-Head Nails
(P-Nails)



Modified
Round-Head Nails
(P-Nails)

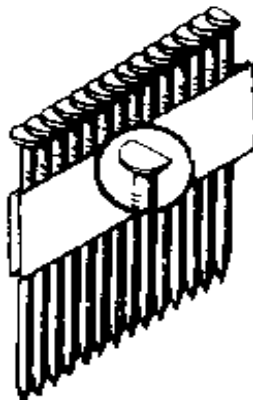


Fig. 3.44 Nail Head Differences

Tests that established the strengths of wood structural panel shear walls used hand driven nails with full heads. Some tests used casing nails. These tests showed that shear walls with 8d casing nails are only 62 percent as strong as ones with 8d box nails. Though the shank diameters of the two nails are the same, the head area of the casing nail is only 27 percent of the box nail.

Smaller head areas provide smaller shear wall strengths.

INSTALL NAILS FLUSH TO SHEATHING

Some contractors and inspectors have expressed confusion about the actual meaning of the 1994 UBC language not fracture the surface of the sheathing. The 1997 UBC has clarified the language to state that the head or crown of the nail is flush the surface of the sheathing. Nails installed with their heads resting on but not into the sheathing can cause problems for roofing and other finishes. Nails should be driven so that the top of the nail is flush and not above the surface of the sheathing.

Because nails will try to pull through the thickness of wood structural panel sheathing during an earthquake, nails should be driven flush with the surface of the sheathing and not overdriven. Overdriven nails reduce the shear wall strength by effectively reducing the thickness of the sheathing. At panel edges, overdriven nails allow easier nail punch-through. At intermediate studs, overdriven nails allow easier panel buckling. Nails are commonly overdriven because of excessive air pressure or too long of a driving pin on the nail gun. Hand driven nails are rarely overdriven unless a soft spot in the framing member or blocking exists where the nail is installed. (Fig. 3.46)

When nailing sheathing, Contractors should operate their nail guns within the manufacturer's recommended pressure range and install flush nailing attachments as required. Inspectors should reject all nails driven below the surface of the sheathing. When the spacing and framing member thickness allow, nails should be added to replace any overdriven nails.

PROVIDE PROPER SHEATHING EDGE DISTANCE

When nails are installed too close to the sheathing edge, the shear wall will fail prematurely during seismic loading. The greater the edge distance, the better the sheathing connection will perform. High-strength diaphragms are created when several rows of nails are placed in wide framing members with large edge distances. Although the 1994 UBC only requires $3/8$ inch, the minimum recommended edge distance for sheathing fasteners is $1/2$ inch. This will increase the strength of the connection.

CENTER THE NAILS IN THE FRAMING MEMBERS & BLOCKING

To properly connect sheathing to framing, most nails should be located in the center of the framing member whenever possible. Centering the nail is easy to do on sill plates, sole plates and intermediate studs. Centering nails in the uppermost top plate frequently requires oversized panel sheets. Centering nails in framing members or blocking at adjoining panel edges is impossible. To make up for the inability to center the nails at adjoining panel edges, wider framing members and blocking are recommended at adjoining panel edges.



Fig. 3.46 Nails That Are Too Close to the Panel Edge and/or Overdriven

Most 8-foot walls today are framed at a height of 8 ft-0¾ inch to allow for the gypsum wallboard on the ceiling. As a result, the common 8-foot sheet of wood structural panel sheathing does not span the full height of the wall. Frequently sheathing panels are installed vertically with one end flush to the bottom edge of the sill or sole plate and the other end centered on the uppermost top plate. This situation cannot easily be fixed by adding 3-inch plates. Thicker plates require longer framing nails that are not readily available and are more difficult to install. The best solution is oversized sheets. Both oriented strand board and plywood come in 9 foot and ten-foot lengths. When these lengths are used, shear transfer connections can be eliminated if nailing is provided to the floor or roof-framing members.

CHECK FOR SPLITTING OF LUMBER DURING NAILING

All fasteners in wood must be installed without splitting of the lumber. There are no exceptions. Existing lumber can be very dry and stiff. If needed to prevent splitting, predrilling of holes at 75% of the nail diameter is required.

REMOVE ALL IMPROPERLY INSTALLED NAILS

To allow for proper inspection, all nails that miss, graze or connect to framing members too close to their edges should be removed prior to inspection. These nails have no allowable value and can mislead the Contractor or Inspector into thinking the job was done right. Since the strength of shear walls sheathed with wood structural panels comes mainly from the fasteners, proper fastener location is of primary importance. (Fig. 3-37)

PROVIDE PROPER EDGE NAILING

For the shear wall to reach its intended strength, all sheathing edges of individual panels must be fastened with the edge distance nailing requirements. Intermediate studs must be fastened with the field nailing requirements so that panel buckling does not occur. Remember that the end of a shear wall is where the sheathing stops at either the wall corner or the framing member with the holdown device. *All sheathing must be fastened with the closer edge distance spacing at every framing member that connects to a holdown device.*

The following nail locations apply to all wood structural panels shear walls. Edge Nail refers to the closer nail spacing requirement of Uniform Building Code Table 23-1-K-1. Field nailing should be used on the studs between panel edges except at framing members connected to holdown devices.

TABLE 5- HOW TO NAIL A SHEAR WALL

- Edge Nail the Holdown Stud(s)
- Edge Nail the Upper Top Plate
- Edge Nail the Sill or Sole Plate
- Edge Nail the Blocking for Individual Panel Edges
- Edge Nail the Blocking for Opening Reinforcement
- Field Nail the Studs Between the Panel Edges

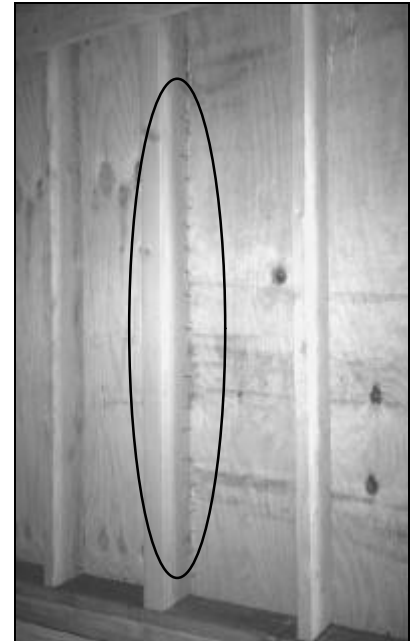


Fig. 3.47 Nails that Missed

NOTES

