



tongue-and-groove decking shall comply with Sections 2304.8.5.1 through 2304.8.5.3.

❖ The section covers 3- and 4-inch-thick (76 and 102 mm) tongue-and-groove boards used for decking (see Figure 2304.8.5.1).

2304.8.5.1 General. Three-inch (76 mm) and four-inch (102 mm) decking shall have a maximum moisture content of 19 percent. Decking shall be machined with a double tongue-and-groove pattern. Decking pieces shall be interconnected and nailed to the supports.

❖ As Figure 2304.8.5.1 illustrates, 3- and 4-inch-thick (76 and 102 mm) tongue-and-groove boards have a pair of tongues and a pair of grooves in each board.

2304.8.5.2 Nailing. Each piece shall be toenailed at each support with one 40d common nail and face-nailed with one 60d common nail. Courses shall be spiked to each other with 8-inch (203 mm) spikes at maximum intervals of 30 inches (762 mm) through predrilled edge holes penetrating to a depth of approximately 4 inches (102 mm). One spike shall be installed at a distance not exceeding 10 inches (254 mm) from the end of each piece.

❖ For the floor to distribute loads and act as a unit, fastening is critical; therefore, it is prescribed in this section.

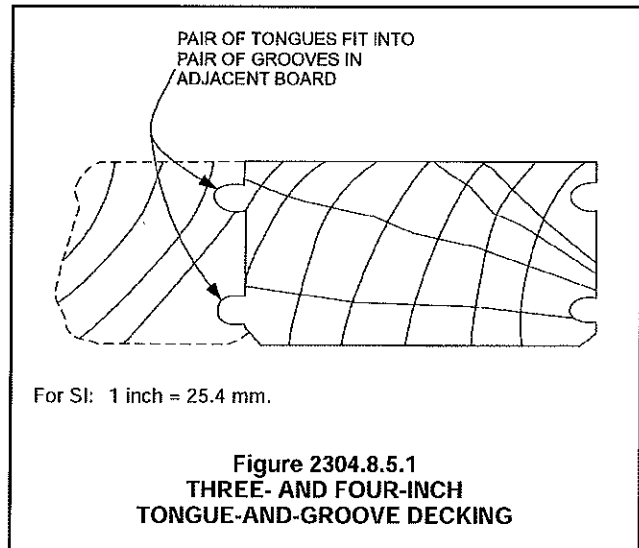
2304.8.5.3 Controlled random pattern. There shall be a minimum distance of 48 inches (1219 mm) between end joints in adjacent courses. Pieces not bearing on a support are permitted to be located in interior bays provided the adjacent pieces in the same course continue over the support for at least 24 inches (610 mm). This condition shall not occur more than once in every six courses in each interior bay.

❖ These requirements are specific to the layup of tongue-and-groove decking and are in addition to the general limitations stated in Section 2304.8.2.5.

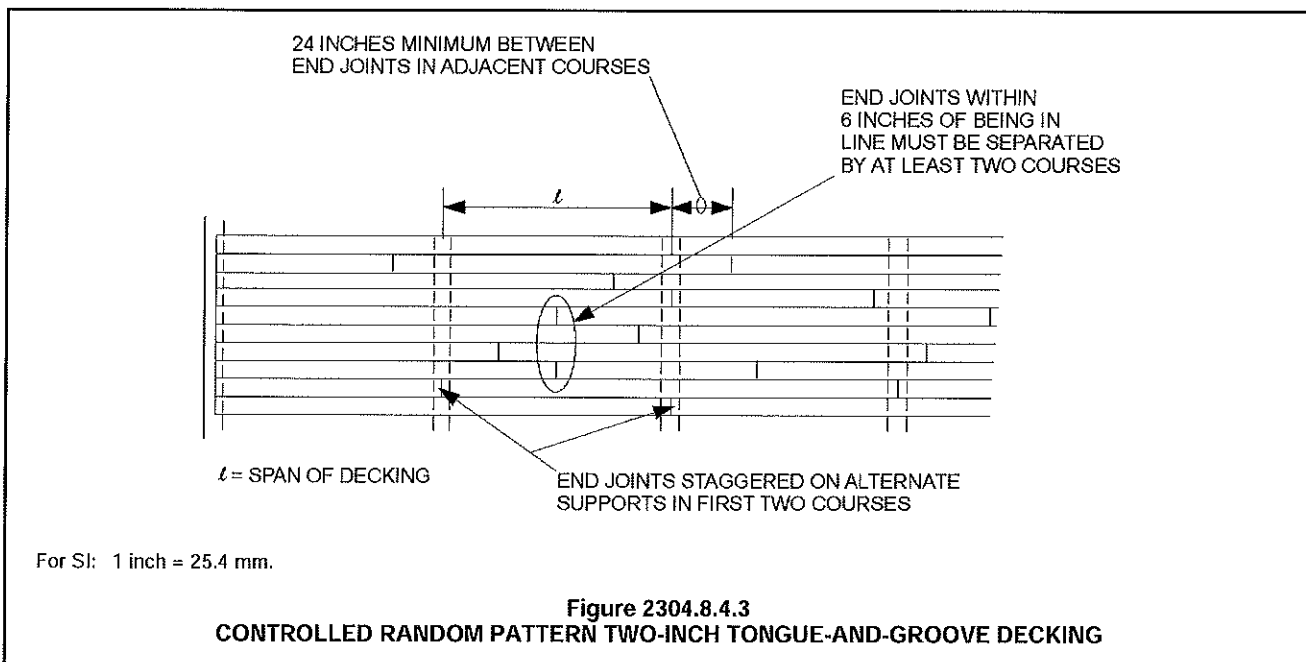
2304.9 Connectors and fasteners. Connectors and fasteners shall comply with the applicable provisions of Sections 2304.9.1 through 2304.9.7.

❖ The section contains requirements for connectors and fasteners used to connect wood members, including nails, staples, joist hangers, clips and framing anchors.

Section 2301.2 gives alternative design methodologies for wood construction: (1) the ASD method; (2) the LRFD method, and (3) conventional light-frame methodologies that are embodied in Section 2308 of the code. Both ASD and LRFD are covered in the AF&PA NDS and SDPWS. If conventional construction provisions are used and there is no design provided by means of the ASD or LRFD methodologies, then the prescriptive fastening of Table 2304.9.1 is



**Figure 2304.8.5.1
THREE- AND FOUR-INCH
TONGUE-AND-GROOVE DECKING**



**Figure 2304.8.4.3
CONTROLLED RANDOM PATTERN TWO-INCH TONGUE-AND-GROOVE DECKING**

typically all that is required; however, when the structure is designed by the ASD or LRFD methods, fastening must comply with the applicable design standard as well as the minimum prescriptive fastenings specified in Table 2304.9.1.

2304.9.1 Fastener requirements. Connections for wood members shall be designed in accordance with the appropriate methodology in Section 2301.2. The number and size of fasteners connecting wood members shall not be less than that set forth in Table 2304.9.1.

❖ Section 2301.2 gives alternative design methodologies for wood construction: (1) the ASD method; (2) the LRFD method and (3) conventional light-frame methodologies that are embodied in Section 2308 of the code. If conventional provisions are used and there is no design being conducted by means of the ASD or LRFD methodologies, then the prescriptive fastening of Table 2304.9.1 is all that is required; however, when the ASD or LRFD methods are used, fastening must comply with the associated design standard as well as the prescriptive fastenings specified in Table 2304.9.1.

TABLE 2304.9.1. See page 23-26.

❖ This table provides the minimum fastening requirements for all light wood-framed construction, regardless of the design method used. Familiarity with the terms and configurations of conventional frame construction is necessary to apply this table. All members identified within this table are commonly described in any available wood design or construction manual. See Figure 2304.9.1 for an illustration of certain nail types.

2304.9.2 Sheathing fasteners. Sheathing nails or other *approved* sheathing connectors shall be driven so that their head or crown is flush with the surface of the sheathing.

❖ This requirement is a matter of workmanship (see Figure 2304.9.2 for an illustration of a nail driven to fasten sheathing properly). Protruding nails that are not fully driven do not provide the intended connecting capacity and could be hazardous. Likewise, nails that are overdriven into structural sheathing may not perform as expected. Framing installation in the field is often less than perfect and fasteners can be overdriven to a point where the top layer of sheathing is fractured and crushed beneath the nail head. An occasional overdriven nail is common and may not be significant; however, as the percentage of overdriven fasteners increases, the issue raised is at what point does this adversely affect the stiffness and shear capacity of a diaphragm or shear wall elements. The APA has recognized that this is a common occurrence and has made a guideline available at no cost on its website (www.apawood.org). Another condition to be aware of in sheathing nailing is where the depth of the supporting member is less than the length of a

commonly used fastener, such as in a case where sheathing will be applied over the top of flat decking. Shorter nails are available for these situations, but the holding and shear capacities are typically reduced.

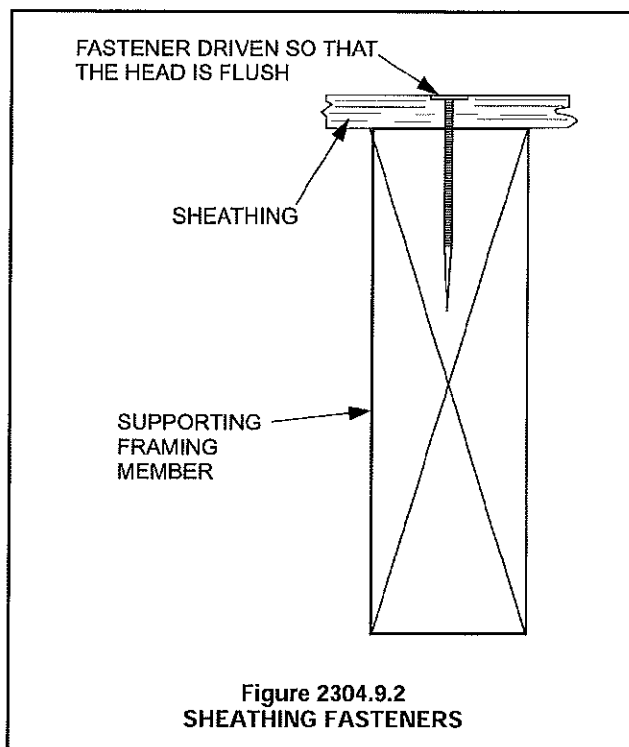


Figure 2304.9.2
SHEATHING FASTENERS

2304.9.3 Joist hangers and framing anchors. Connections depending on joist hangers or framing anchors, ties and other mechanical fastenings not otherwise covered are permitted where *approved*. The vertical load-bearing capacity, torsional moment capacity and deflection characteristics of joist hangers shall be determined in accordance with Section 1716.1.

❖ This section recognizes the use of premanufactured joist and framing anchors as an alternative to conventional fastening. These items are engineered components and must be used in accordance with the manufacturer's instructions and design specifications. Hangers and framing anchors specified by the manufacturer must have load capacities and torsional requirements developed in accordance with the test methods outlined in Section 1711.1. All fasteners required to make the framing anchor or hanger adequately support the design load are specified by the manufacturer, who also must describe any limitations that the designer or contractor needs to consider when using the product. In order to facilitate approval of these products, many hardware manufacturers have ICC Evaluation Service Reports (ESRs) that provide design values and other detailed information for properly installing their framing anchors.

**TABLE 2304.9.1
FASTENING SCHEDULE**

CONNECTION	FASTENING ^{a,m}	LOCATION
1. Joist to sill or girder	3 - 8d common (2½" × 0.131") 3 - 3" × 0.131" nails 3 - 3" 14 gage staples	toenail
2. Bridging to joist	2 - 8d common (2½" × 0.131") 2 - 3" × 0.131" nails 2 - 3" 14 gage staples	toenail each end
3. 1" × 6" subfloor or less to each joist	2 - 8d common (2½" × 0.131")	face nail
4. Wider than 1" × 6" subfloor to each joist	3 - 8d common (2½" × 0.131")	face nail
5. 2" subfloor to joist or girder	2 - 16d common (3½" × 0.162")	blind and face nail
6. Sole plate to joist or blocking	16d (3½" × 0.135") at 16" o.c. 3" × 0.131" nails at 8" o.c. 3" 14 gage staples at 12" o.c.	typical face nail
Sole plate to joist or blocking at braced wall panel	3 - 16d (3½" × 0.135") at 16" o.c. 4 - 3" × 0.131" nails at 16" o.c. 4 - 3" 14 gage staples at 16" o.c.	braced wall panels
7. Top plate to stud	2 - 16d common (3½" × 0.162") 3 - 3" × 0.131" nails 3 - 3" 14 gage staples	end nail
8. Stud to sole plate	4 - 8d common (2½" × 0.131") 4 - 3" × 0.131" nails 3 - 3" 14 gage staples	toenail
	2 - 16d common (3½" × 0.162") 3 - 3" × 0.131" nails 3 - 3" 14 gage staples	end nail
9. Double studs	16d (3½" × 0.135") at 24" o.c. 3" × 0.131" nail at 8" o.c. 3" 14 gage staple at 8" o.c.	face nail
10. Double top plates	16d (3½" × 0.135") at 16" o.c. 3" × 0.131" nail at 12" o.c. 3" 14 gage staple at 12" o.c.	typical face nail
Double top plates	8 - 16d common (3½" × 0.162") 12 - 3" × 0.131" nails 12 - 3" 14 gage staples	lap splice
11. Blocking between joists or rafters to top plate	3 - 8d common (2½" × 0.131") 3 - 3" × 0.131" nails 3 - 3" 14 gage staples	toenail
12. Rim joist to top plate	8d (2½" × 0.131") at 6" o.c. 3" × 0.131" nail at 6" o.c. 3" 14 gage staple at 6" o.c.	toenail
13. Top plates, laps and intersections	2 - 16d common (3½" × 0.162") 3 - 3" × 0.131" nails 3 - 3" 14 gage staples	face nail
14. Continuous header, two pieces	16d common (3½" × 0.162")	16" o.c. along edge
15. Ceiling joists to plate	3 - 8d common (2½" × 0.131") 5 - 3" × 0.131" nails 5 - 3" 14 gage staples	toenail
16. Continuous header to stud	4 - 8d common (2½" × 0.131")	toenail

(continued)

TABLE 2304.9.1—continued
FASTENING SCHEDULE

CONNECTION	FASTENING ^{a,m}	LOCATION
17. Ceiling joists, laps over partitions (see Section 2308.10.4.1, Table 2308.10.4.1)	3 - 16d common ($3\frac{1}{2}$ " \times 0.162") minimum, Table 2308.10.4.1 4 - 3" \times 0.131" nails 4 - 3" 14 gage staples	face nail
18. Ceiling joists to parallel rafters (see Section 2308.10.4.1, Table 2308.10.4.1)	3 - 16d common ($3\frac{1}{2}$ " \times 0.162") minimum, Table 2308.10.4.1 4 - 3" \times 0.131" nails 4 - 3" 14 gage staples	face nail
19. Rafter to plate (see Section 2308.10.1, Table 2308.10.1)	3 - 8d common ($2\frac{1}{2}$ " \times 0.131") 3 - 3" \times 0.131" nails 3 - 3" 14 gage staples	toenail
20. 1" diagonal brace to each stud and plate	2 - 8d common ($2\frac{1}{2}$ " \times 0.131") 2 - 3" \times 0.131" nails 3 - 3" 14 gage staples	face nail
21. 1" \times 8" sheathing to each bearing	3 - 8d common ($2\frac{1}{2}$ " \times 0.131")	face nail
22. Wider than 1" \times 8" sheathing to each bearing	3 - 8d common ($2\frac{1}{2}$ " \times 0.131")	face nail
23. Built-up corner studs	16d common ($3\frac{1}{2}$ " \times 0.162") 3" \times 0.131" nails 3" 14 gage staples	24" o.c. 16" o.c. 16" o.c.
24. Built-up girder and beams	20d common (4" \times 0.192") 32" o.c. 3" \times 0.131" nail at 24" o.c. 3" 14 gage staple at 24" o.c.	face nail at top and bottom stag- gered on opposite sides
	2 - 20d common (4" \times 0.192") 3 - 3" \times 0.131" nails 3 - 3" 14 gage staples	face nail at ends and at each splice
25. 2" planks	16d common ($3\frac{1}{2}$ " \times 0.162")	at each bearing
26. Collar tie to rafter	3 - 10d common (3" \times 0.148") 4 - 3" \times 0.131" nails 4 - 3" 14 gage staples	face nail
27. Jack rafter to hip	3 - 10d common (3" \times 0.148") 4 - 3" \times 0.131" nails 4 - 3" 14 gage staples	toenail
	2 - 16d common ($3\frac{1}{2}$ " \times 0.162") 3 - 3" \times 0.131" nails 3 - 3" 14 gage staples	face nail
28. Roof rafter to 2-by ridge beam	2 - 16d common ($3\frac{1}{2}$ " \times 0.162") 3 - 3" \times 0.131" nails 3 - 3" 14 gage staples	toenail
	2 - 16d common ($3\frac{1}{2}$ " \times 0.162") 3 - 3" \times 0.131" nails 3 - 3" 14 gage staples	face nail
29. Joist to band joist	3 - 16d common ($3\frac{1}{2}$ " \times 0.162") 4 - 3" \times 0.131" nails 4 - 3" 14 gage staples	face nail

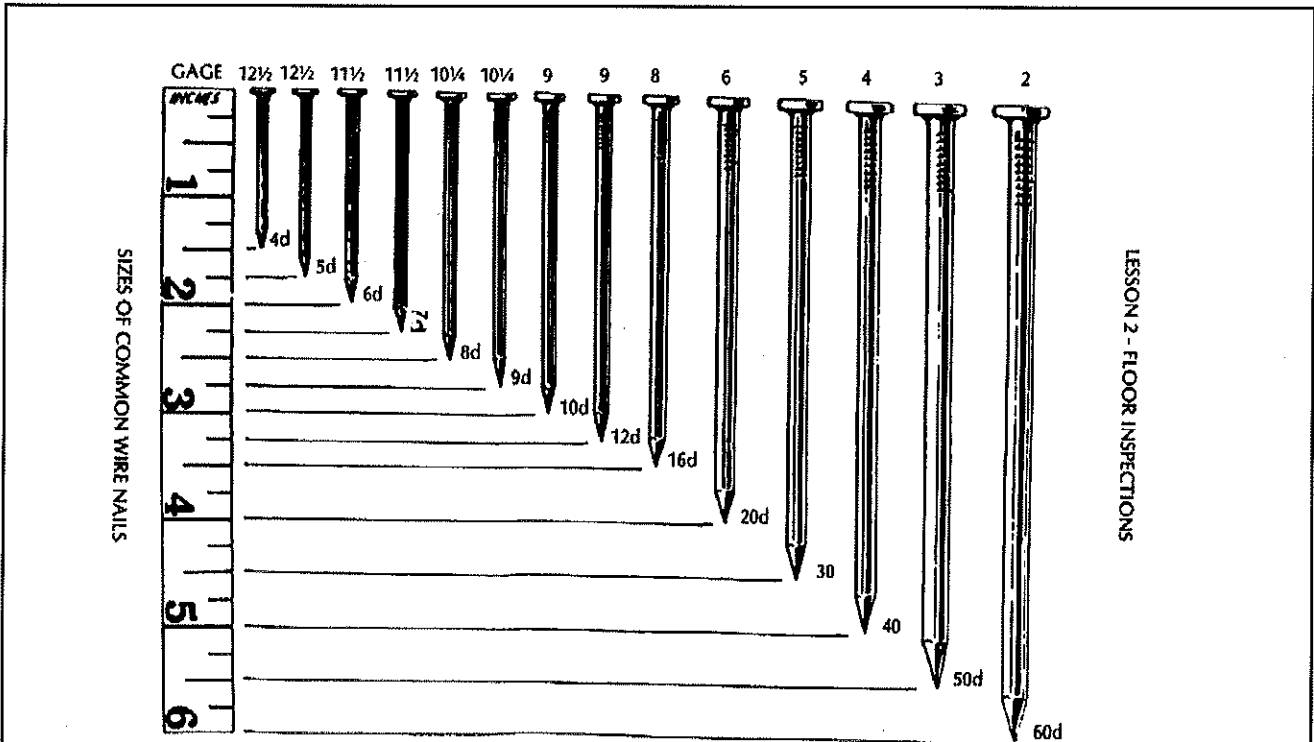
(continued)

TABLE 2304.9.1—continued
FASTENING SCHEDULE

CONNECTION	FASTENING ^{a,m}		LOCATION
30. Ledger strip	3 - 16d common ($3\frac{1}{2}$ " \times 0.162") 4 - 3" \times 0.131" nails 4 - 3" 14 gage staples		face nail at each joist
31. Wood structural panels and particleboard ^b Subfloor, roof and wall sheathing (to framing)	$\frac{1}{2}$ " and less $\frac{19}{32}$ " to $\frac{3}{4}$ " $\frac{7}{8}$ " to 1" $1\frac{1}{8}$ " to $1\frac{1}{4}$ "	6d ^{c,j} $2\frac{3}{8}$ " \times 0.113" nail ⁿ $1\frac{3}{4}$ " 16 gage ^o 8d ^d or 6d ^e $2\frac{3}{8}$ " \times 0.113" nail ^p 2" 16 gage ^p 8d ^c 10d ^d or 8d ^c	
Single floor (combination subfloor-underlay- ment to framing)	$\frac{3}{4}$ " and less $\frac{7}{8}$ " to 1" $1\frac{1}{8}$ " to $1\frac{1}{4}$ "	6d ^e 8d ^e 10d ^d or 8d ^c	
32. Panel siding (to framing)	$\frac{1}{2}$ " or less $\frac{5}{8}$ "	6d ^f 8d ^f	
33. Fiberboard sheathing ^g	$\frac{1}{2}$ " $\frac{25}{32}$ "	No. 11 gage roofing nail ^h 6d common nail (2 " \times 0.113") No. 16 gage staple ⁱ No. 11 gage roofing nail ^h 8d common nail ($2\frac{1}{2}$ " \times 0.131") No. 16 gage staple ⁱ	
34. Interior paneling	$\frac{1}{4}$ " $\frac{3}{8}$ "	4d ^j 6d ^k	

For SI: 1 inch = 25.4 mm.

- a. Common or box nails are permitted to be used except where otherwise stated.
- b. Nails spaced at 6 inches on center at edges, 12 inches at intermediate supports except 6 inches at supports where spans are 48 inches or more. For nailing of wood structural panel and particleboard diaphragms and shear walls, refer to Section 2305. Nails for wall sheathing are permitted to be common, box or casing.
- c. Common or deformed shank (6d - 2" \times 0.113"; 8d - $2\frac{1}{2}$ " \times 0.131"; 10d - 3" \times 0.148").
- d. Common (6d - 2" \times 0.113"; 8d - $2\frac{1}{2}$ " \times 0.131"; 10d - 3" \times 0.148").
- e. Deformed shank (6d - 2" \times 0.113"; 8d - $2\frac{1}{2}$ " \times 0.131"; 10d - 3" \times 0.148").
- f. Corrosion-resistant siding (6d - $1\frac{7}{8}$ " \times 0.106"; 8d - $2\frac{3}{8}$ " \times 0.128") or casing (6d - 2" \times 0.099"; 8d - $2\frac{1}{2}$ " \times 0.113") nail.
- g. Fasteners spaced 3 inches on center at exterior edges and 6 inches on center at intermediate supports, when used as structural sheathing. Spacing shall be 6 inches on center on the edges and 12 inches on center at intermediate supports for nonstructural applications.
- h. Corrosion-resistant roofing nails with $\frac{7}{16}$ -inch-diameter head and $1\frac{1}{2}$ -inch length for $\frac{1}{2}$ -inch sheathing and $1\frac{3}{4}$ -inch length for $\frac{25}{32}$ -inch sheathing.
- i. Corrosion-resistant staples with nominal $\frac{7}{16}$ -inch crown or 1-inch crown and $1\frac{1}{4}$ -inch length for $\frac{1}{2}$ -inch sheathing and $1\frac{1}{2}$ -inch length for $\frac{25}{32}$ -inch sheathing. Panel supports at 16 inches (20 inches if strength axis in the long direction of the panel, unless otherwise marked).
- j. Casing ($1\frac{1}{2}$ " \times 0.080") or finish ($1\frac{1}{2}$ " \times 0.072") nails spaced 6 inches on panel edges, 12 inches at intermediate supports.
- k. Panel supports at 24 inches. Casing or finish nails spaced 6 inches on panel edges, 12 inches at intermediate supports.
- l. For roof sheathing applications, 8d nails ($2\frac{1}{2}$ " \times 0.113") are the minimum required for wood structural panels.
- m. Staples shall have a minimum crown width of $\frac{7}{16}$ inch.
- n. For roof sheathing applications, fasteners spaced 4 inches on center at edges, 8 inches at intermediate supports.
- o. Fasteners spaced 4 inches on center at edges, 8 inches at intermediate supports for subfloor and wall sheathing and 3 inches on center at edges, 6 inches at intermediate supports for roof sheathing.
- p. Fasteners spaced 4 inches on center at edges, 8 inches at intermediate supports.



LESSON 2 - FLOOR INSPECTIONS

	CASING HEAD WOOD SIDING NAIL
	SINKER HEAD WOOD SIDING NAIL
	GENERAL PURPOSE FINISH NAIL
	ROOFING NAIL
	WOOD SHINGLE NAIL
	WOOD SHAKE NAIL
	GYPSUM LATH NAIL
	INSULATED SIDING NAIL
	SPIRAL-THREADED ROOFING NAIL WITH NEOPRENE WASHER
	ANNULAR-RING ROOFING NAIL WITH NEOPRENE WASHER
	SPIRAL-THREADED ROOFING NAIL FOR ASPHALT SHINGLES AND SHAKES
	ANNULAR-RING ROOFING NAIL FOR ASPHALT SHINGLES AND SHAKES
	SPIRAL-THREADED CASING HEAD WOOD SIDING NAIL
	ANNULAR-RING PLYWOOD SIDING NAIL FOR APPLYING ASBESTOS SHINGLES AND SHAKES OVER PLYWOOD SHEATHING
	ANNULAR-RING PLYWOOD ROOFING NAIL FOR APPLYING WOOD OR ASPHALT SHINGLES OVER PLYWOOD SHEATHING
	} ASBESTOS SHINGLE NAILS
	ANNULAR-RING GYPSUM BOARD DRYWALL NAIL
	SPIRAL-THREADED INSULATED SIDING FACE NAIL

BASIC FASTENER STYLE GUIDE

ROUND-HEAD NAILS (P-Nails)	MODIFIED ROUND-HEAD NAILS (P-Nails)	T-NAILS (P-Nails)	STAPLES
CORRUGATED FASTENERS	TYING FASTENERS	RING SHANK	SCREW SHANK

Figure 2304.9.1
STANDARD NAILS AND STAPLES
 Independent Nail Packing Co., Bridgewater, MA

2304.9.4 Other fasteners. Clips, staples, glues and other approved methods of fastening are permitted where approved.

❖ Clips, staples, glues and other methods of fastening are permitted where approved. In addition to joist hangers and typical fastening in accordance with Table 2304.9.1, there are other fastening methods that can be approved by the building official, provided there is sufficient evidence to demonstrate their adequacy. This section is included in the code to address the fact that new fasteners and connection methods are continually being developed, which necessitates that the building official give consideration to viable alternatives. In general, other fasteners or fastening systems that are not specifically covered by the code can be approved under the alternative materials, design and methods of construction specified in Section 104.11. In order to facilitate approval of alternative products that are not specified in the code, many product manufacturers work with ICC Evaluation Service to develop acceptance criteria and, ultimately, ESRs. These include detailed information to assist the building official in determining code compliance and help the inspector verify proper installation in the field.

2304.9.5 Fasteners and connectors in contact with preservative-treated and fire-retardant-treated wood. Fasteners, including nuts and washers, and connectors in contact with *preservative-treated* and *fire-retardant-treated* wood shall be in accordance with Sections 2304.9.5.1 through 2304.9.5.4. The coating weights for zinc-coated fasteners shall be in accordance with ASTM A 153.

❖ Corrosion-resistant fasteners are typically required for use in treated wood. This applies to fire-retardant-treated wood as well as preservative-treated wood. Some chemicals used to preservative treat or fire-retardant treat wood can have a corrosive effect on fasteners. This is a concern since significant corrosion will adversely affect the fastener's strength.

2304.9.5.1 Fasteners and connectors for preservative-treated wood. Fasteners, including nuts and washers, in contact with *preservative-treated* wood shall be of hot-dipped zinc-coated galvanized steel, stainless steel, silicon bronze or copper. Fasteners other than nails, timber rivets, wood screws and lag screws shall be permitted to be of mechanically deposited zinc-coated steel with coating weights in accordance with ASTM B 695, Class 55 minimum. Connectors that are used in exterior applications and in contact with *preservative-treated* wood shall have coating types and weights in accordance with the treated wood or connector manufacturer's recommendations. In the absence of manufacturer's recommendations, a minimum of ASTM A 653, type G185 zinc-coated galvanized steel, or equivalent, shall be used.

Exception: Plain carbon steel fasteners, including nuts and washers, in SBX/DOT and zinc borate *preservative-*

treated wood in an interior, dry environment shall be permitted.

❖ Where there are concerns with decay or potential termite damage, the code requires either a naturally durable species of wood or wood that is treated with a preservative. Since the discontinuation of chromated copper arsenate for preservative-treated wood in residential or general consumer products, alternative preservative treatments have been necessary. Studies show that some of these are more corrosive to steel anchors and connectors. Corrosion-resistant fasteners are typically required for use in preservative-treated wood. This includes materials such as stainless steel or copper. Carbon steel typically must be galvanized. The exception is based on reports that show sodium borate disodium octaborate tetrahydrate (SBX/DOT) and zinc borate to be somewhat less corrosive than other alternative preservative treatments. In an interior location where moisture is not a concern, wood treated with these preservatives allows the use of plain carbon steel fasteners.

The base requirements limit galvanized steel to the hot-dipped process. The hot-dip galvanizing process has the relative advantage of being very insensitive to process variables. Though mechanically galvanized fasteners can perform equally to hot-dipped galvanized fasteners, the mechanical galvanizing process, if not performed properly, may produce fasteners whose corrosion resistance does not equal that of hot-dipped galvanized fasteners. Mechanical galvanizing is very common for screws, and in fact is possibly the only way to deposit a thick zinc coating on them. Wood screws and lag screws are frequently installed in predrilled holes, so abrasion of the finish is not the same problem as for nails. Because mechanical galvanizing is a preferred method for certain fastener types, the code recognizes this process where it is appropriate.

Guidance is given for connectors that are in contact with preservative-treated wood and used in exterior applications. The primary requirement is to follow the manufacturer's recommendations. Where none are given, the minimum coating must be G185 in accordance with ASTM A 653, which is the minimum coating currently recommended by many manufacturers.

2304.9.5.2 Fastenings for wood foundations. Fastenings, including nuts and washers, for wood foundations shall be as required in AF&PA PWF.

❖ AF&PA *Permanent Wood Foundation (PWF) Design Specification* requires specific types of corrosion-resistant nails for locations below grade and above grade in wood foundations, based on the increased exposure to moisture in below-grade applications as well as the corrosive nature of preservative treatments.

2304.9.5.3 Fasteners for fire-retardant-treated wood used in exterior applications or wet or damp locations. Fasteners, including nuts and washers, for *fire-retardant-treated wood* used in exterior applications or wet or damp locations shall be of hot-dipped zinc-coated galvanized steel, stainless steel, silicon bronze or copper. Fasteners other than nails, timber rivets, wood screws and lag screws shall be permitted to be of mechanically deposited zinc-coated steel with coating weights in accordance with ASTM B 695, Class 55 minimum.

❖ Corrosion-resistant fasteners are required for fire-retardant-treated wood in exterior applications or other locations subject to moisture. The base requirements limit galvanized steel to the hot-dipped process. Because mechanical galvanizing is a preferred method for certain fastener types, the code recognizes this process where it is deemed appropriate.

2304.9.5.4 Fasteners for fire-retardant-treated wood used in interior applications. Fasteners, including nuts and washers, for *fire-retardant-treated wood* used in interior locations shall be in accordance with the manufacturer's recommendations. In the absence of manufacturer's recommendations, Section 2304.9.5.3 shall apply.

❖ The primary requirement for fasteners in fire-retardant-treated wood used on the interior is to follow the manufacturer's recommendations. Where none are given, the requirements for exterior applications apply.

2304.9.6 Load path. Where wall framing members are not continuous from foundation sill to roof, the members shall be secured to ensure a continuous load path. Where required, sheet metal clamps, ties or clips shall be formed of galvanized steel or other *approved* corrosion-resistant material not less than 0.040 inch (1.01 mm) nominal thickness.

❖ In conventional construction, the minimum fastening required by Table 2304.9.1 is intended to provide a continuous connection between framing elements as required by this section. If the loads on the building exceed the parameters established in Section 2308.2, the building, in total or in part, must be designed in accordance with the ASD or LRFD methodologies and the connections must be designed in accordance with those standards, providing continuity of load support throughout the structure. The designed connections may incorporate engineered tie or strap components with capacities specified by the manufacturer. This section specifies the minimum thickness of sheet metal for fabricated straps or ties to 0.04-inch (1.01 mm) nominal, which is common among manufacturers. Designers and contractors must keep in mind that a wood-framed building is simply a huge assembly of multiple independent parts all connected together to form a complete structural system. When a building is subject to external forces, each independent part has a tendency to move into a different position and this tendency must be controlled by having a complete path to deliver the imposed forces into the ground. This load path may

be comprised of hangers from a beam to a column, metal straps from an upper-level stud to a lower-level stud or from hold-down anchors into the concrete, etc. There are countless applications and load path possibilities, but the overall concept is that every individual piece must be adequately fastened to some adjacent piece to form the complete structure.

2304.9.7 Framing requirements. Wood columns and posts shall be framed to provide full end bearing. Alternatively, column-and-post end connections shall be designed to resist the full compressive loads, neglecting end-bearing capacity. Column-and-post end connections shall be fastened to resist lateral and net induced uplift forces.

❖ This section requires that the framing workmanship be such that the ends of wood columns and posts, including studs, bear completely atop the supporting member, whether it be a wood sill plate or a metal base connector. If it does not bear fully on the entire cross section, then design calculations are necessary in order to show that the bearing method provided will be capable of supporting the loads without using end bearing capacity. It also requires a positive connection (not merely a friction connection) to resist incidental lateral forces and any anticipated uplift forces. For instance, a wood column supporting beams in the basement of a structure could not simply bear on the concrete pad beneath it without some means of positive anchorage to the concrete in order to prevent it from accidentally being displaced on impact by a person or an object. If the combination of loads on the structure could result in uplift forces, then an adequate connection designed to resist uplift would also be required. This section is a further extension of the philosophy outlined in Section 2304.9.6.

2304.10 Heavy timber construction. Where a structure or portion thereof is required to be of Type IV construction by other provisions of this code, the building elements therein shall comply with the applicable provisions of Sections 2304.10.1 through 2304.10.5.

❖ Heavy timber construction is classified as Type IV construction in Chapter 6. It is described in Section 602.4 as that type of construction where the exterior walls are of noncombustible materials and the interior building elements are of solid or laminated wood without concealed spaces. It originated in New England to serve the needs of the growing textile industry. As the industry modernized, the need for larger open space, unobstructed by columns, gradually reduced the demand for this type of construction.

Today, due primarily to its architectural aesthetic value, heavy timber construction is used in many other occupancies. It is commonly used for assembly and mercantile buildings, such as schools, churches, auditoriums, gymnasiums and supermarkets.

The provisions of this section must be used in conjunction with the minimum dimensional requirements specified in Section 602.4. A structural analysis must be performed to verify that the minimum dimensions

TABLE 2306.4.1
 ALLOWABLE SHEAR (POUNDS PER FOOT) FOR WOOD STRUCTURAL PANEL SHEAR WALLS WITH
 FRAMING OF DOUGLAS FIR-LARCH OR SOUTHERN PINE^a FOR WIND OR SEISMIC LOADING^{b, c, d, e, f, g}

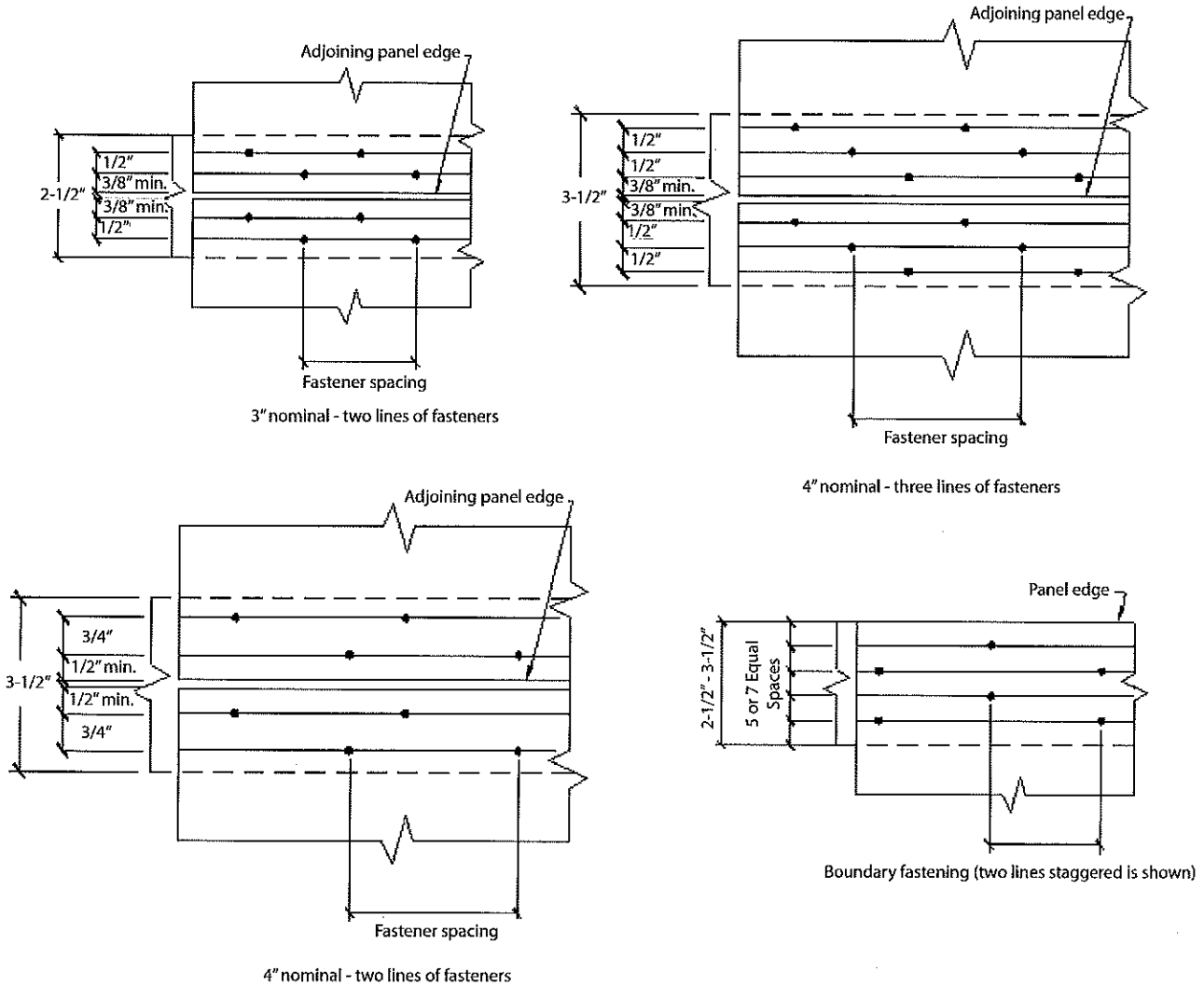
PANEL GRADE	MINIMUM NOMINAL PANEL THICKNESS (inch)	MINIMUM FASTENER PENETRATION IN FRAMING (inches)	PANELS APPLIED DIRECT TO FRAMING				PANELS APPLIED OVER 1/2" OR 5/8" GYPSUM SHEATHING							
			6	4	3	2 ^e	6	4	3	2 ^e				
			NAIL (common or galvanized box or staple size) ^g				NAIL (common or galvanized box or staple size) ^g							
Structural I Sheathing	5/16	1 1/4	200	300	390	510	200	300	390	510	200	300	390	510
		1	165	245	325	415	125	185	245	315	125	185	245	315
	3/8	1 3/8	230 ^d	360 ^d	460 ^d	610 ^d	280	430	550 ^d	730	280	430	550 ^d	730
		1	155	235	315	400	155	235	310	400	155	235	310	400
	7/16	1 1/2	255 ^d	395 ^d	505 ^d	670 ^d	280	430	550 ^d	730	280	430	550 ^d	730
		1	170	260	345	440	155	235	310	400	155	235	310	400
	15/32	1 3/8	280	430	550	730	280	430	550 ^d	730	280	430	550 ^d	730
		1	185	280	375	475	155	235	300	400	155	235	300	400
	5/16 or 1/4	1 1/2	340	510	665 ^f	870	—	—	—	—	—	—	—	—
		1 1/2	180	270	350	450	180	270	350	450	180	270	350	450
	3/8	1	145	220	295	375	110	165	220	285	110	165	220	285
		1 1/4	200	300	390	510	200	300	390	510	200	300	390	510
7/16	1 3/8	220 ^d	320 ^d	410 ^d	530 ^d	260	380	490 ^d	640	260	380	490 ^d	640	
	1	140	210	280	360	140	210	280	360	140	210	280	360	
15/32	1 1/2	240 ^d	350 ^d	450 ^d	585 ^d	260	380	490 ^d	640	260	380	490 ^d	640	
	1	155	230	310	395	140	210	280	360	140	210	280	360	
19/32	1 3/8	260	380	490	640	260	380	490 ^d	640	260	380	490 ^d	640	
	1 1/2	310	460	600 ^f	770	—	—	—	—	—	—	—	—	
5/16	1	170	255	335	430	140	210	280	360	140	210	280	360	
	1 1/2	340	510	665 ^f	870	—	—	—	—	—	—	—	—	
3/8	1	185	280	375	475	140	210	280	360	140	210	280	360	
	1 1/4	240	350	450	585 ^d	260	380	490 ^d	640	260	380	490 ^d	640	
			Nail Size (galvanized casing)				Nail Size (galvanized casing)							
			6d (2" x 0.099")				8d (2 1/2" x 0.113")							
			8d (2 1/2" x 0.113")				10d (3" x 0.128")							

(continued)

Figure 4C High Load Diaphragm

4

LATERAL FORCE-RESISTING SYSTEMS



Note: Space adjoining panel edge joists 1/8". Minimum spacing between lines of fasteners is 3/8"

to framing members and blocking of more than 1-1/2" are specified at 3" on center or less at adjoining panel edges.

4. Wood structural panels shall conform to the requirements for their type in DOC PS1 or PS2.

4.2.7.1.2 High Load Blocked Diaphragms: All joints in sheathing shall occur over and be fastened to common framing members or common blocking. The size and spacing of fasteners at wood-frame diaphragm boundaries and panel edges shall be as prescribed in Table 4.2B and Figure 4C. The diaphragms shall be constructed as follows:

1. Panels shall not be less than 4' x 8' except at boundaries and changes in framing where minimum panel dimension shall be 24" unless all edges of the undersized panels are supported by and fastened to framing members or blocking.
2. Nails shall be located at least 3/8" from panel edges but not less than distances shown in Figure 4C. Maximum nail spacing at panel edges shall be 6" on center. Nails along intermediate framing members for panels shall be the same size as installed at the panel edges. Maximum nail spacing shall be 6" on center when support spacing of greater than 32" on center is specified. Maximum nail spacing shall be 12" on center for specified support spacing of 32" on center or less.
3. In diaphragm boundary members, lines of fasteners shall be equally spaced and fasteners within each line shall be staggered where spacing is 3" on center or less.
4. The width of the nailed face of framing members and blocking shall be 3" nominal or greater. The width of the nailed face not located at boundaries or adjoining panel edges shall be 2" nominal or greater.
5. Wood structural panels shall conform to the requirements for their type in DOC PS1 or PS2.

4.2.7.1.3 Unblocked Diaphragms: Where diaphragms are designated as unblocked, the diaphragms shall be constructed as specified in 4.2.7.1.1, except that blocking between supporting structural members at panel edges shall not be required. The size and spacing

of fasteners at wood-frame diaphragm boundaries and panel edges shall be as prescribed in Table 4.2C.

4.2.7.2 Diaphragms Diagonally Sheathed with Single-Layer of Lumber: Single diagonally sheathed lumber diaphragms shall be permitted to be used to resist seismic and wind forces. Single diagonally sheathed lumber diaphragms shall be constructed of minimum 1" thick nominal sheathing boards or 2" thick nominal lumber laid at an angle of approximately 45° to the supports. End joints in adjacent boards shall be separated by at least one joist space and there shall be at least two boards between joints on the same support. Nailing of diagonally sheathed lumber diaphragms shall be in accordance with Table 4.2D. Single diagonally sheathed lumber diaphragms shall be permitted to consist of 2" nominal lumber (1-1/2" thick) where the supports are not less than 3" nominal (2-1/2" thick) in width or 4" nominal (3-1/2" deep) in depth

4.2.7.3 Diaphragms Diagonally Sheathed with Double-Layer of Lumber: Double diagonally sheathed lumber diaphragms shall be permitted to be used to resist seismic and wind forces. Double diagonally sheathed lumber diaphragms shall be constructed of two layers of diagonal sheathing boards laid perpendicular to each other on the same face of the supporting members. Each chord shall be considered as a beam with uniform load per foot equal to 50% of the unit shear due to diaphragm action. The load shall be assumed as acting normal to the chord in the plane of the diaphragm in either direction. Nailing of diagonally sheathed lumber diaphragms shall be in accordance with Table 4.2D

4.2.7.4 Diaphragms Horizontally Sheathed with Single-Layer of Lumber: Horizontally sheathed lumber diaphragms shall be permitted to be used to resist seismic and wind forces. Horizontally sheathed lumber diaphragms shall be constructed of minimum 1" thick nominal sheathing boards or minimum 2" thick nominal lumber laid perpendicular to the supports. End joints in adjacent boards shall be separated by at least one joist space and there shall be at least two boards between joints on the same support. Nailing of horizontally sheathed lumber diaphragms shall be in accordance with Table 4.2D.

Table 4.2A Nominal Unit Shear Capacities for Wood-Frame Diaphragms

Blocked Wood Structural Panel Diaphragms ^{1,2,3,4}		SEISMIC						WIND										
		A			B			A			B							
Sheathing Grade	Common Nail Size	Minimum Fastener Penetration in Framing Member or Blocking (in.)	Minimum or Nominal Panel Thickness (in.)	Minimum or Nailed Face Panel Edges and Boundaries (in.)	Nail Spacing (in.) at diaphragm boundaries (all cases), at continuous panel edges parallel to load (Cases 3 & 4), and at all panel edges (Cases 5 & 6)													
					6		4		2-1/2		6		4					
Structural I	8d	1-3/8	3/8	2	6		4		2		6		4		2			
					V _s (plf)	G _s (kips/in.)	V _s (plf)	G _s (kips/in.)	V _s (plf)	G _s (kips/in.)	V _s (plf)	G _s (kips/in.)	V _s (plf)	G _s (kips/in.)	V _s (plf)	G _s (kips/in.)	V _s (plf)	G _s (kips/in.)
Sheathing and Single-Floor	10d	1-1/2	5/16	2	OSB PLY	500	8.5	7.5	750	OSB PLY	840	20	15	520	700	1050	1175	
					OSB PLY	560	7.0	6.0	840	OSB PLY	950	17	13	590	785	1175	1330	
					OSB PLY	720	9.0	7.5	1060	OSB PLY	1200	21	15	755	1010	1485	1680	
					OSB PLY	800	7.5	6.5	1200	OSB PLY	1350	18	13	840	1120	1680	1890	
					OSB PLY	850	15	12	1280	OSB PLY	1460	31	21	885	1190	1790	2045	
					OSB PLY	960	12	9.5	1440	OSB PLY	1640	26	18	1010	1345	2015	2295	
	6d	1-1/4	5/16	3/8	2	OSB PLY	500	7.0	6.0	670	OSB PLY	760	21	13	475	630	940	1065
						OSB PLY	560	7.0	6.0	750	OSB PLY	860	17	12	520	700	1050	1175
						OSB PLY	720	9.0	6.0	760	OSB PLY	880	17	12	590	785	1175	1330
						OSB PLY	800	7.5	5.0	840	OSB PLY	950	14	10	670	895	1345	1525
						OSB PLY	850	15	5.0	960	OSB PLY	1090	21	13	755	1010	1510	1710
						OSB PLY	960	12	5.0	1080	OSB PLY	1220	18	12	800	1065	1510	1805
8d	1-3/8	7/16	2	2	OSB PLY	680	8.5	7.0	1010	OSB PLY	1150	20	12	715	950	1415	1610	
					OSB PLY	720	7.5	6.5	1060	OSB PLY	1200	19	13	755	1010	1485	1680	
					OSB PLY	800	6.0	5.5	1200	OSB PLY	1350	15	11	840	1120	1680	1890	
					OSB PLY	850	15	11	1150	OSB PLY	1310	33	18	870	1080	1610	1835	
					OSB PLY	860	12	9.5	1300	OSB PLY	1470	28	16	910	1205	1820	2060	
					OSB PLY	960	10	8.0	1440	OSB PLY	1640	24	15	1010	1345	2015	2295	

- Nominal unit shear capacities shall be adjusted in accordance with 4.2.3 to determine ASD allowable unit shear capacity and LRFD factored unit resistance. For general construction requirements see 4.2.6. For specific requirements, see 4.2.7.1 for wood structural panel diaphragms. See Appendix A for common nail dimensions.
- For species and grades of framing other than Douglas-Fir-Larch or Southern Pine, reduced nominal unit shear capacities shall be determined by multiplying the tabulated nominal unit shear capacity by the Specific Gravity Adjustment Factor = $[1-(0.5-G)]$, where G = Specific Gravity of the framing lumber from the *NDS* (Table 11.3.2A). The Specific Gravity Adjustment Factor shall not be greater than 1.
- Apparent shear stiffness values, G_s , are based on nail slip in framing with moisture content less than or equal to 19% at time of fabrication and panel stiffness values for diaphragms constructed with either OSB or 3-ply plywood panels. When 4-ply or 5-ply plywood panels or composite panels are used, G_s values shall be permitted to be increased by 1.2.
- Where moisture content of the framing is greater than 19% at time of fabrication, G_s values shall be multiplied by 0.5.

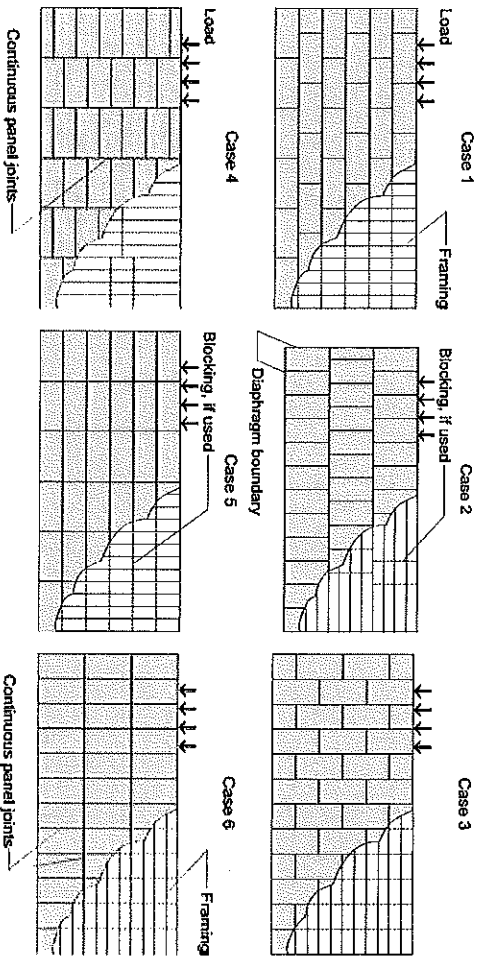
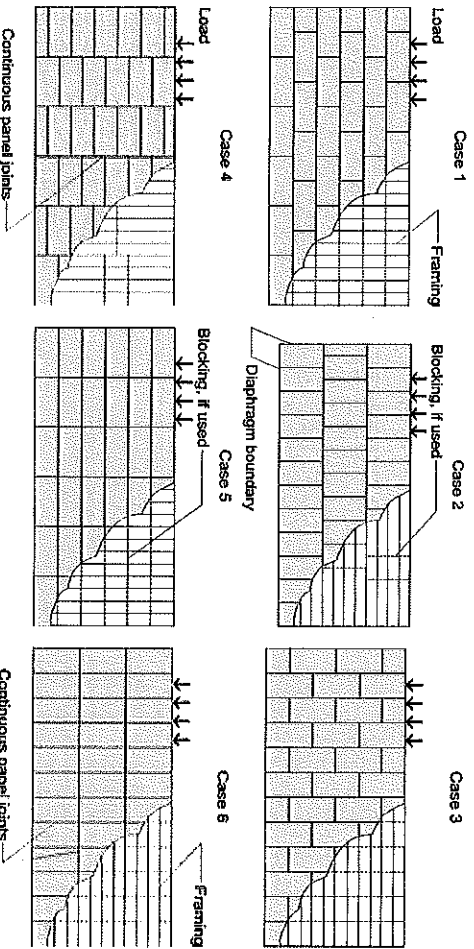


Table 4.2B Nominal Unit Shear Capacities for Wood-Frame Diaphragms
Blocked Wood Structural Panel Diaphragms Utilizing Multiple Rows of Fasteners (High Load Diaphragms)^{1,2,3,4}

Sheathing Grade	Common Nail Size	Minimum Fastener Penetration in Framing Member or Blocking (in.)	Minimum Nominal Panel Thickness (in.)	Minimum Width of Nail Face at Adjoining Panel Edges and Boundaries (in.)	Lines of Fasteners	SEISMIC												WIND							
						Nail Spacing (in.) at diaphragm boundaries (all cases), at continuous panel edges parallel to load (Cases 3 & 4), and at all panel edges (Cases 5 & 6)						Nail Spacing (in.) at other panel edges (Cases 1, 2, 3, & 4)						Nail Spacing (in.) at diaphragm boundaries (all cases), at continuous panel edges parallel to load (Cases 3 & 4), and at all panel edges (Cases 5 & 6)			Nail Spacing (in.) at other panel edges (Cases 1, 2, 3, & 4)				
						4	4	2-1/2	2-1/2	2-1/2	4	4	4	4	4	4	4	4	4	4	4	4	3		
V_s (plf)	G_s (kips/in.)	V_s (plf)	G_s (kips/in.)	V_s (plf)	G_s (kips/in.)	V_s (plf)	G_s (kips/in.)	V_s (plf)	G_s (kips/in.)	V_s (plf)	G_s (kips/in.)	V_s (plf)	G_s (kips/in.)	V_s (plf)	G_s (kips/in.)	V_s (plf)	G_s (kips/in.)	V_s (plf)	G_s (kips/in.)	V_s (plf)	G_s (kips/in.)				
Structural I	10d	1-1/2	19/32	4	3	OSB	PLY	OSB	PLY	OSB	PLY	OSB	PLY	OSB	PLY	OSB	PLY	OSB	PLY	OSB	PLY	OSB	PLY	OSB	PLY
						40	24	1630	55	28	1750	50	27	2300	56	29	1695	2280	2450	3220					
						33	21	1830	48	27	2010	44	25	2580	51	28	1960	2660	2815	3610					
						30	21	2440	61	30	2570	59	30	2790	70	32	2460	3415	3500	3905					
						36	23	1760	52	29	1870	47	27	2510	54	29	1875	2465	2700	3515					
						29	20	1960	46	27	2220	48	27	2880	48	27	2185	2770	3110	4030					
						47	27	2640	60	31	2810	57	32	3580	64	32	2700	3685	3935	5010					
						33	22	1910	50	29	2100	45	27	2730	53	30	2045	2675	2940	3820					
						26	19	2140	43	27	2420	37	24	3130	45	27	2386	2955	3390	4390					
						45	27	2860	59	32	3050	56	31	3800	68	34	2940	4005	4270	5340					
						43	21	1450	55	23	1530	53	23	2020	58	24	1470	2030	2140	2830					
						36	19	1690	50	22	1750	48	21	2210	55	23	1695	2280	2450	3085					
1530	53	23	2170	62	24	2250	51	24	2390	72	26	2140	3040	3165	3945										
1300	34	1870	49	23	1870	45	22	2450	52	23	1820	2410	2620	3430											
1510	27	1930	43	21	2160	37	20	2740	46	22	2115	2700	3025	3835											
1870	45	22	2580	57	24	2730	55	24	2970	68	26	2620	3610	3820	4160										
1420	30	18	2040	42	22	2040	42	22	2670	50	24	1960	2620	2855	3740										
1650	24	16	2100	40	21	2350	34	20	2880	45	23	2310	2940	3290	4045										
2040	42	22	2800	56	25	2960	53	25	3130	71	28	2855	3920	4145	4980										

- Nominal unit shear capacities shall be adjusted in accordance with 4.2.3 to determine ASD allowable unit shear capacity and LRFD factored unit resistance. For general construction requirements see 4.2.6. For specific requirements, see 4.2.7.1 for wood structural panel diaphragms. See Appendix A for common nail dimensions.
- For species and grades of framing other than Douglas-fir-Larch or Southern Pine, reduced nominal unit shear capacities shall be determined by multiplying the tabulated nominal unit shear capacity by the Specific Gravity Adjustment Factor = $[1-(0.5-G)]$, where G = Specific Gravity of the framing lumber from the *NDS* (Table 11.3.2A). The Specific Gravity Adjustment Factor shall not be greater than 1.
- Apparent shear stiffness values, G_s , are based on nail slip in framing with moisture content less than or equal to 19% at time of fabrication and panel stiffness values for diaphragms constructed with either OSB or 3-ply plywood panels. When 4-ply or 5-ply plywood panels or composite panels are used, G_s values shall be permitted to be increased by 1.2.
- Where moisture content of the framing is greater than 19% at time of fabrication, G_s values shall be multiplied by 0.5.



SYSTEMS UTILIZING FORCE TRANSFER



Table 4.2C Nominal Unit Shear Capacities for Wood-Frame Diaphragms

Unblocked Wood Structural Panel Diaphragms^{1,2,3,4}

Sheathing Grade	Common Nail Size	Minimum Fastener Penetration in Framing (in.)	Minimum Nominal Panel Thickness (in.)	Minimum Nominal Width of Nailed Face at Supported Edges and Boundaries (in.)	A				B			
					SEISMIC				WIND			
					6 in. Nail Spacing at diaphragm boundaries and supporting members				6 in. Nail Spacing at diaphragm boundaries and supporting members			
Case 1					Cases 2,3,4,5,6				Case 1		Cases 2,3,4,5,6	
					V_s (plf)	G_s (kips/in.)	OSB PLY	V_s (plf)	G_s (kips/in.)	OSB PLY	V_w (plf)	V_w (plf)
Structural I	6d	1-1/4	5/16	2	330	9.0	7.0	250	6.0	4.5	460	350
					370	7.0	6.0	280	4.5	4.0	520	390
	8d	1-3/8	3/8	2	480	8.5	7.0	360	6.0	4.5	670	505
					530	7.5	6.0	400	5.0	4.0	740	560
	10d	1-1/2	15/32	2	570	14	10	430	9.5	7.0	800	600
					640	12	9.0	480	8.0	6.0	895	670
	6d	1-1/4	5/16	2	300	9.0	6.5	220	6.0	4.0	420	310
					340	7.0	5.5	250	5.0	3.5	475	350
	8d	1-1/4	3/8	2	330	7.5	5.5	250	5.0	4.0	460	350
					370	6.0	4.5	280	4.0	3.0	520	390
	10d	1-1/2	3/8	2	430	9.0	6.5	320	6.0	4.5	600	450
					480	7.5	5.5	360	5.0	3.5	670	505
Sheathing and Single-Floor	8d	1-3/8	7/16	2	460	8.5	6.0	340	5.5	4.0	645	475
					510	7.0	5.5	380	4.5	3.5	715	530
	15/32	2	480	7.5	5.5	360	5.0	4.0	670	505		
			530	6.5	5.0	400	4.0	3.5	740	560		
	10d	1-1/2	15/32	2	510	15	9.0	380	10	6.0	715	530
					580	12	8.0	430	8.0	5.5	810	600
19/32	2	570	13	8.5	430	8.5	5.5	800	600			
		640	10	7.5	480	7.0	5.0	895	670			

- Nominal unit shear capacities shall be adjusted in accordance with 4.2.3 to determine ASD allowable unit shear capacity and LRFD factored unit resistance. For general construction requirements see 4.2.6. For specific requirements, see 4.2.7.1 for wood structural panel diaphragms. See Appendix A for common nail dimensions.
- For species and grades of framing other than Douglas-Fir-Larch or Southern Pine, reduced nominal unit shear capacities shall be determined by multiplying the tabulated nominal unit shear capacity by the Specific Gravity Adjustment Factor = $[1-(0.5-G)]$, where G = Specific Gravity of the framing lumber from the *MDS* (Table 11.3.2A). The Specific Gravity Adjustment Factor shall not be greater than 1.
- Apparent shear stiffness values G_s are based on nail slip in framing with moisture content less than or equal to 19% at time of fabrication and panel stiffness values for diaphragms constructed with either OSB or 3-ply plywood panels. When 4-ply or 5-ply plywood panels or composite panels are used, G_s values shall be permitted to be increased by 1.2.
- Where moisture content of the framing is greater than 19% at time of fabrication, G_s values shall be multiplied by 0.5.

Table 4.2D Nominal Unit Shear Capacities for Wood-Frame Diaphragms

Lumber Diaphragms¹

Sheathing Material	Sheathing Nominal Dimensions	Type, Size, and Number of Nails per Board		SEISMIC		WIND	
		Nailing at Intermediate and End Bearing Supports (Nails/board/support)	Nailing at Boundary Members (Nails/board/end)	V_s (plf)	G_a (kips/ft)	V_w (plf)	
Horizontal Lumber Sheathing	1x6 1x8 2x6 2x8	2-8d common nails (3-8d box nails) 3-8d common nails (4-8d box nails) 2-16d common nails (3-16d box nails) 3-16d common nails (4-16d box nails)	3-8d common nails (5-8d box nails) 4-8d common nails (6-8d box nails) 3-16d common nails (5-16d box nails) 4-16d common nails (6-16d box nails)	100	1.5	140	
Diagonal Lumber Sheathing	1x6 1x8 2x6 2x8	2-8d common nails (3-8d box nails) 3-8d common nails (4-8d box nails) 2-16d common nails (3-16d box nails) 3-16d common nails (4-16d box nails)	3-8d common nails (5-8d box nails) 4-8d common nails (6-8d box nails) 3-16d common nails (5-16d box nails) 4-16d common nails (6-16d box nails)	600	6.0	840	
Double Diagonal Lumber Sheathing	1x6 1x8 2x6 2x8	2-8d common nails (3-8d box nails) 3-8d common nails (4-8d box nails) 2-16d common nails (3-16d box nails) 3-16d common nails (4-16d box nails)	3-8d common nails (5-8d box nails) 4-8d common nails (6-8d box nails) 3-16d common nails (5-16d box nails) 4-16d common nails (6-16d box nails)	1200	9.5	1680	

1. Nominal unit shear capacities shall be adjusted in accordance with 4.2.3 to determine ASD allowable unit shear capacity and LRFD factored unit resistance. For general construction requirements see 4.2.6. For specific requirements, see 4.2.7.2 for diaphragms diagonally sheathed with a single-layer of lumber, see 4.2.7.3 for diaphragms diagonally sheathed with a double-layer of lumber, and see 4.2.7.4 for diaphragms horizontally sheathed with a single-layer of lumber. See Appendix A for common and box nail dimensions.

Table 4.3A Nominal Unit Shear Capacities for Wood-Frame Shear Walls^{1,3,6,7}

Sheathing Material	Minimum Nominal Panel Thickness (in.)	Minimum Fastener Penetration in Framing Member or Blocking (in.)	Fastener Type & Size	SEISMIC										WIND					
				Panel Edge Fastener Spacing (in.)					Panel Edge Fastener Spacing (in.)					Panel Edge Fastener Spacing (in.)					
				6	4	3	2	6	4	3	2	6	4	3	2				
	V_s (plf)	G_s (kips/in.)	V_s (plf)	G_s (kips/in.)	V_s (plf)	G_s (kips/in.)	V_s (plf)	G_s (kips/in.)	V_s (plf)	G_s (kips/in.)	V_u (plf)	V_u (plf)	V_u (plf)	V_u (plf)					
Wood Structural Panels - ^{4,5} Structural	5/16	1-1/4	6d	OSB	PLY	OSB	PLY	OSB	PLY	OSB	PLY	OSB	PLY	OSB	PLY				
				400	13	10	600	18	13	780	23	16	1020	35	22	560	840	1090	1430
				460	19	14	720	24	17	920	30	20	1220	43	24	645	1010	1290	1710
				510	16	13	790	21	16	1010	27	19	1340	40	24	715	1105	1415	1875
Wood Structural Panels - ^{4,5} Sheathing	15/32	1-1/2	10d	OSB	PLY	OSB	PLY	OSB	PLY	OSB	PLY	OSB	PLY	OSB	PLY				
				680	22	16	1020	29	20	1330	36	22	1740	51	28	950	1430	1860	2435
				360	13	9.5	540	18	12	700	24	14	900	37	18	505	755	980	1260
				400	11	8.5	600	15	11	790	20	13	1020	32	17	560	840	1090	1430
Wood Structural Panels - ^{4,5} Sheathing	3/8	1-3/8	8d	OSB	PLY	OSB	PLY	OSB	PLY	OSB	PLY	OSB	PLY	OSB	PLY				
				440	17	12	640	25	15	820	31	17	1060	45	20	615	895	1150	1485
				480	15	11	700	22	14	900	28	17	1170	42	21	670	980	1260	1640
				520	13	10	760	19	13	980	25	15	1280	39	20	730	1065	1370	1790
Plywood Sliding	5/16	1-1/4	6d	OSB	PLY	OSB	PLY	OSB	PLY	OSB	PLY	OSB	PLY	OSB	PLY				
				280	13	13	420	16	16	550	17	17	720	21	21	390	560	770	1010
				320	16	16	480	18	18	620	20	20	820	22	22	450	670	870	1150
				240	15	15	360	17	17	460	19	19	600	22	22	335	505	645	840
Particleboard Sheathing - (M-S "Exterior Glue" and M-2 "Exterior Glue")	3/8	1-1/2	8d	OSB	PLY	OSB	PLY	OSB	PLY	OSB	PLY	OSB	PLY	OSB	PLY				
				260	18	18	380	20	20	480	21	21	630	23	23	365	530	670	880
				280	18	18	420	20	22	540	22	22	700	24	24	390	590	755	980
				370	21	21	550	23	23	720	24	24	920	25	25	520	770	1010	1290
Structural Fiberboard Sheathing	1/2	1-1/2	10d	OSB	PLY	OSB	PLY	OSB	PLY	OSB	PLY	OSB	PLY	OSB	PLY				
				400	21	21	610	23	23	790	24	24	1040	26	26	560	855	1105	1455
				340	4.0	4.0	460	5.0	5.0	460	5.0	5.0	520	5.5	5.5	475	645	730	730
				340	4.0	4.0	460	5.0	5.0	460	5.0	5.0	520	5.5	5.5	475	645	730	730

- Nominal unit shear values shall be adjusted in accordance with 4.3.3 to determine ASD allowable unit shear capacity and LRFD factored unit resistance. For general construction requirements see 4.3.6. For specific requirements, see 4.3.7.1 for wood structural panel shear walls, 4.3.7.2 for particleboard shear walls, and 4.3.7.3 for fiberboard shear walls. See Appendix A for common and box nail dimensions.
- Shears are permitted to be increased to values shown for 15/32 inch sheathing with some nailing provided (a) studs are spaced a maximum of 16 inches on center, or (b) panels are applied with long dimension across studs.
- For species and grades of framing other than Douglas-Fir-Larch or Southern Pine, reduced nominal unit shear capacities shall be determined by multiplying the tabulated nominal unit shear capacity by the Specific Gravity Adjustment Factor = $[1 - (0.5 - G)]$, where G = Specific Gravity of the framing lumber from the NDS (Table 11.3.2A). The Specific Gravity Adjustment Factor shall not be greater than 1.
- Apparent shear stiffness values G_p are based on nail slip in framing with moisture content less than or equal to 19% at time of fabrication and panel stiffness values for shear walls constructed with either OSB or 3-ply plywood panels. When 4-ply or 5-ply plywood panels or composite panels are used, G_p values shall be permitted to be increased by 1.2.
- Where moisture content of the framing is greater than 19% at time of fabrication, G_p values shall be multiplied by 0.5.
- Where panels are applied on both faces of a shear wall and nail spacing is less than 6" on center on either side, panel joints shall be offset to fall on different framing members. Alternatively, the width of the nailed face of framing members shall be 3" nominal or greater at adjoining panel edges and nails at all panel edges shall be staggered.
- Galvanized nails shall be hot-dipped or umbled.

SYSTEMS NAILINGS-FORCE-TABLE 4



Table 4.3B Nominal Unit Shear Capacities for Wood-Frame Shear Walls^{1,2,5,6}

Wood Structural Panels Applied over 1/2" or 5/8" Gypsum Wallboard or Gypsum Sheathing Board

Sheathing Material	Minimum Nominal Panel Thickness (in.)	Minimum Fastener Penetration in Framing Member or Blocking (in.)	Fastener Type & Size	A										B					
				SEISMIC										WIND					
				6		4		3		2		6		4		3		2	
Panel Edge Fastener Spacing (in.)		Panel Edge Fastener Spacing (in.)		Panel Edge Fastener Spacing (in.)		Panel Edge Fastener Spacing (in.)		Panel Edge Fastener Spacing (in.)		Panel Edge Fastener Spacing (in.)		Panel Edge Fastener Spacing (in.)		Panel Edge Fastener Spacing (in.)		Panel Edge Fastener Spacing (in.)			
				V_s (plf)	G_s (kips/in.)	V_s (plf)	G_s (kips/in.)	V_s (plf)	G_s (kips/in.)	V_s (plf)	G_s (kips/in.)	V_w (plf)	V_w (plf)	V_w (plf)	V_w (plf)	V_w (plf)	V_w (plf)	V_w (plf)	
Wood Structural Panels - Structural ^{3,4}	5/16	1-1/4	Nail (common or galvanized box)	400	13	10	18	13	780	23	16	1020	35	22	560	840	1090	1430	
				560	14	11	860	18	14	1100	24	17	1460	37	23	785	1205	1540	2045
Wood Structural Panels - Sheathing ^{3,4}	3/8, 7/16, 15/32	1-3/8	10d	360	13	9.5	540	18	12	700	24	14	900	37	18	505	755	980	1260
				400	11	8.5	600	15	11	780	20	13	1020	32	17	560	840	1090	1430
Wood Structural Panels - Sheathing ^{3,4}	3/8, 7/16, 15/32	1-3/8	10d	520	13	10	760	19	13	980	25	15	1280	39	20	730	1085	1370	1790
				280	13	16	420	16	18	550	17	20	720	21	22	390	590	770	1010
Wood Structural Panels - Sheathing ^{3,4}	3/8	1-3/8	Nail (galvanized casing) 8d (2-1/2" x 0.113") 10d (3" x 0.128")	320	16	480	18	620	18	820	20	820	21	22	450	570	870	1150	

- Nominal unit shear capacities shall be adjusted in accordance with 4.3.3 to determine ASD allowable unit shear capacity and LRFD factored unit resistance. For general construction requirements see 4.3.6. For specific requirements, see 4.3.7.1 for wood structural panel shear walls. See Appendix A for common and box nail dimensions.
- For species and grades of framing other than Douglas-Fir-Larch or Southern Pine, reduced nominal unit shear capacities shall be determined by multiplying the tabulated nominal unit shear capacity by the Specific Gravity Adjustment Factor = $[1 - (0.5 - G)]$, where G = Specific Gravity of the framing lumber from the *NDS* (Table 11.3.2A). The Specific Gravity Adjustment Factor shall not be greater than 1.
- Apparent shear stiffness values, G_s , are based on nail slip in framing with moisture content less than or equal to 19% at time of fabrication and panel stiffness values for shear walls constructed with either OSB or 3 ply plywood panels. When 4-ply or 5-ply plywood panels or composite panels are used, G_s values for plywood shall be permitted to be increased by 0.5.
- Where moisture content of the framing is greater than 19% at time of fabrication, G_s values shall be multiplied by 0.5.
- Where panels are applied on both faces of a shear wall and nail spacing is less than 6" on center on either side, panel joints shall be offset to fall on different framing members. Alternatively, the width of the nailed face of framing members shall be 3" nominal or greater at adjoining panel edges and nails at all panel edges shall be staggered.
- Galvanized nails shall be hot-dipped or tumbled.

Table 4.3C Nominal Unit Shear Capacities for Wood-Frame Shear Walls¹

Gypsum and Portland Cement Plaster

Sheathing Material	Material Thickness	Fastener Type & Size ²	Max. Fastener Edge Spacing (in.) ³	Max. Stud Spacing (in.)	Blocked/Unblocked	SEISMIC		WIND	
						V _s (plf)	G _s (kips/ft)	V _w (plf)	
Gypsum wallboard, gypsum base for veneer plaster, or water-resistant gypsum backing board	1/2"	No. 6 Type S or W drywall screws 1-1/4" long	8/12	16	unblocked	120	3.5	120	
						150	4.0	150	
						220	6.0	220	
						200	5.5	200	
						260	6.5	250	
						250	6.5	250	
	5/8"	6d cooler (0.092" x 1-7/8" long, 1/4" head) or wallboard nail (0.0915" x 1-7/8" long, 19/64" head) or 0.120" nail x 1-3/4" long, min 3/8" head	8/12	16	unblocked	140	4.0	140	
						180	5.0	180	
						230	6.0	230	
						290	7.5	280	
						290	7.5	290	
						350	8.5	350	
Gypsum sheathing board	1/2" x 2' x 8'	0.120" nail x 1-3/4" long, 7/16" head, diamond-point, galvanized	8/12	16	unblocked	150	4.0	150	
						350	8.5	350	
						200	5.5	200	
						400	9.5	400	
						150	4.0	150	
						350	8.5	350	
	1/2" x 4'	Base ply—6d cooler (0.092" x 1-7/8" long, 1/4" head) or wallboard nail (0.0915" x 1-7/8" long, 19/64" head) or 0.120" nail x 1-3/4" long, min 3/8" head	8/12	16	blocked	500	11	500	
						150	4.0	150	
						350	8.5	350	
						200	5.5	200	
						400	9.5	400	
						150	4.0	150	
Gypsum lath, plain or perforated with vertical joints staggered	3/8" lath and 1/2" plaster	0.092" x 1-1/8" long, 19/64" head, gypsum wallboard blue nail or 0.120" nail x 1-1/4" long, min 3/8" head	5	16	unblocked	360	9.0	360	
						200	5.5	200	
						400	9.5	400	
						360	9.0	360	
						200	5.5	200	
						400	9.5	400	
Expanded metal or woven wire lath and Portland cement plaster	7/8"	0.120" nail x 1-1/2" long, 7/16" head	6	16	unblocked	360	9.0	360	
						200	5.5	200	

1. Nominal unit shear capacities shall be adjusted in accordance with 4.3.3 to determine ASD allowable unit shear capacity and LRFD factored unit resistance. For general construction requirements see 4.3.6. For specific requirements, see 4.3.7.4.
2. Type S or W drywall screws shall conform to requirements of ASTM C 1002.
3. Where two numbers are given for maximum fastener edge spacing, the first number denotes fastener spacing at the edges and the second number denotes fastener spacing along intermediate framing members.

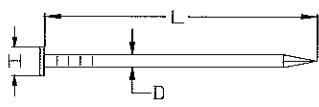
Table 4.3D Nominal Unit Shear Capacities for Wood-Frame Shear Walls¹

Lumber Shear Walls

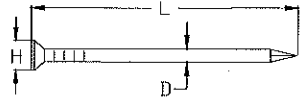
Sheathing Material	Sheathing Nominal Dimensions	Nailing at Intermediate Studs (nails/board/support)	Type, Size, and Number of Nails per Board		A SEISMIC		B WIND	
			Nailing at Shear Wall Boundary Members (nails/board/endl)	Nailing at Shear Wall Boundary Members (nails/board/endl)	V _s (plf)	G _s (kips/ft)	V _w (plf)	
Horizontal Lumber	1x6 & smaller 1x8 & larger	2-8d common nails (3-8d box nails) 3-8d common nails (4-8d box nails)	3-8d common nails (5-8d box nails) 4-8d common nails (6-8d box nails)	100	1.5	140		
Diagonal Lumber	1x6 & smaller 1x8 & larger	2-8d common nails (3-8d box nails) 3-8d common nails (4-8d box nails)	3-8d common nails (5-8d box nails) 4-8d common nails (6-8d box nails)	600	6.0	840		
Double Diagonal Lumber	1x6 & smaller 1x8 & larger	2-8d common nails (3-8d box nails) 3-8d common nails (4-8d box nails)	3-8d common nails (5-8d box nails) 4-8d common nails (6-8d box nails)	1200	10	1680		
Vertical Lumber Siding	1x6 & smaller 1x8 & larger	2-8d common nails (3-8d box nails) 3-8d common nails (4-8d box nails)	3-8d common nails (5-8d box nails) 4-8d common nails (6-8d box nails)	90	1.0	125		

1. Nominal unit shear capacities shall be adjusted in accordance with 4.3.3 to determine ASD allowable unit shear capacity and LRFD factored unit resistance. For general construction requirements see 4.3.6. For specific requirements, see 4.3.7.5 through 4.3.7.8. See Appendix A for common and box nail dimensions.

Table A1 Standard Common, Box, and Sinker Nails¹



Common or Box



Sinker

D = diameter
L = length
H = head diameter

Type		Pennyweight										
		6d	7d	8d	10d	12d	16d	20d	30d	40d	50d	60d
Common	L	2"	2-1/4"	2-1/2"	3"	3-1/4"	3-1/2"	4"	4-1/2"	5"	5-1/2"	6"
	D	0.113"	0.113"	0.131"	0.148"	0.148"	0.162"	0.192"	0.207"	0.225"	0.244"	0.263"
	H	0.266"	0.266"	0.281"	0.312"	0.312"	0.344"	0.406"	0.438"	0.469"	0.5"	0.531"
Box	L	2"	2-1/4"	2-1/2"	3"	3-1/4"	3-1/2"	4"	4-1/2"	5"		
	D	0.099"	0.099"	0.113"	0.128"	0.128"	0.135"	0.148"	0.148"	0.162"		
	H	0.266"	0.266"	0.297"	0.312"	0.312"	0.344"	0.375"	0.375"	0.406"		
Sinker	L	1-7/8"	2-1/8"	2-3/8"	2-7/8"	3-1/8"	3-1/4"	3-3/4"	4-1/4"	4-3/4"		5-3/4"
	D	0.092"	0.099"	0.113"	0.12"	0.135"	0.148"	0.177"	0.192"	0.207"		0.244"
	H	0.234"	0.250"	0.266"	0.281"	0.312"	0.344"	0.375"	0.406"	0.438"		0.5"

1. Tolerances specified in ASTM F 1667. Typical shape of common, box, and sinker nails shown. See ASTM F1667 for other nail types.

Table A2 Standard Cut Washers

Dimensions of Standard Cut Washers ¹			
Nominal Washer Size (in.)	A	B	C
	Inside Diameter (in.)	Outside Diameter (in.)	Thickness (in.)
	Basic	Basic	Basic
3/8	0.438	1.000	0.083
1/2	0.562	1.375	0.109
5/8	0.688	1.750	0.134
3/4	0.812	2.000	0.148
7/8	0.938	2.250	0.165
1	1.062	2.500	0.165

1. For other standard cut washers, see ANSI/ASME B18.22.1. Tolerances are provided in ANSI/ASME B18.22.1.

