PDHonline Course S147 (8 PDH)

Engineered Wood Construction Guide

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Chapter 12

WOOD STRUCTURE DESIGN REQUIREMENTS

12.1 GENERAL:

12.1.1 Scope: The design and construction of wood *structures* to resist seismic forces and the material used therein shall comply with the requirements of this chapter.

12.1.2 Reference Documents: The quality, testing, design, and construction of members and their fastenings in wood systems that resist seismic forces shall conform to the requirements of the reference documents listed in this section except as modified by the provisions of this chapter.

12.1.2.1 Engineered Wood Construction:

ASCE 16	American Society of Civil Engineers (ASCE), *Load and Resistance Factor Standard for Engineered Wood Construction*, including supplements, ASCE 16, 1995.
APA Y510T	American Plywood Association (APA), *Plywood Design Specifications* 1998
APA N375B	American Plywood Association (APA), *Design Capacities of APA Performance-Rated Structural-Use Panels*, N375B, 1995
APA E315H	American Plywood Association (APA), *Diaphragms*, Research Report 138, 1991

12.1.2.2 Conventional Light-Frame Construction:

CABO Code	Council of American Building Officials (CABO), *One- and Two-Family Dwelling Code*, 1995
NFoPA T903	National Forest and Paper Association (NFoPA), *Span Tables for Joists and Rafters*, T903, 1992

12.1.2.3 Materials Standards:

PS 20	U.S. Department of Commerce, Natioanal Institute of Standards and Technology, *American Softwood Lumber Standard*, PS 20, 1999
ANSI/AITC A190.1	American National Standards Institute/American Institute of Timber Construction (ANSI/AITC), *American National Standard for Wood Products Structural Glues Laminated Timber*, A190.1, 1992
ASTM D5055-95A	American Society of Testing and Materials (ASTM), *Standard Specification for Establishing and Monitoring Structural Capacities of Prefabricated Wood I-Joists*, D5055-95A, 1995

PS 1	U.S. Department of Commerce, National Institute of Standards and Technology, *Construction and Industrial Plywood American,* PS 1, 1995
PS 2	U.S. Department of Commerce, Natioanal Institute of Standards and Technology, *Performance Standard for Wood-Based Structural-use Panels,* PS 2, 1992
ANSI 05.1	American National Standards Institute (ANSI), *Wood Poles,* ANSI 05.1, 1992
ANSI A208.1	American National Standards Institute (ANSI), *Wood Particleboard,* ANSI A208.1, 1992
AWPA C1, 2, 3, 9, 28	American Wood Preservers Association (AWPA), *Preservative Treatment by Pressure Process,* AWPA C1, 1991; C2 and C3, 1991; C9, 1990; and C28, 1991

12.1.3 Notations:

D = Reference resistance.

D' = Adjusted resistance.

h = The height of a shear wall measured as:

1. The maximum clear height from top of foundation to bottom of diaphragm framing above or
2. The maximum clear height from top of diaphragm to bottom of diaphragm framing above.

l = The dimension of a diaphragm perpendicular to the direction of application of force. For open-front *structures*, l is the length from the edge of the diaphragm at the open front to the vertical resisting elements parallel to the direction of the applied force. For a cantilevered diaphragm, l is the length of the cantilever.

w = The width of a diaphragm or shear wall in the direction of application of force measured as the sheathed dimension of the shear wall or diaphragm.

λ = Time effect factor.

ϕ = Resistance factor.

$\lambda\phi D$ = Factored resistance.

12.2 DESIGN METHODS: Design of wood *structures* to resist seismic forces shall be by one of the methods described in Sec. 12.2.1 and 12.2.2.

12.2.1 Engineered Wood Design: Engineered design of wood *structures* shall use load and resistance factor design (LRFD) and shall be in accordance with this chapter and the reference documents specified in Sec. 12.1.2.1.

12.2.2 Conventional Light-Frame Construction: Where permitted by Sec.12.7 and 12.8, wood *structures* shall be permitted to be constructed in accordance with the provisions of Sec. 12.5.

12.2.2.1 When a structure of otherwise conventional construction contains structural elements not conforming to Sec.12.5, those elements shall be designed in accordance with Sec. 12.2.1 and force resistance and stiffness shall be maintained.

12.3 GENERAL DESIGN REQUIREMENTS FOR ENGINEERED WOOD CONSTRUCTION:

12.3.1 General: The proportioning, design, and detailing of engineered wood systems, members, and connections shall be in accordance with the reference documents except as modified by this section.

12.3.2 Shear Resistance Based on Principles of Mechanics: Shear resistance of *diaphragms* and *shear walls* shall be permitted to be calculated by principles of mechanics using values of fastener strength and sheathing shear resistance provided consideration is given to the combined fastener and sheathing performance under cyclic loading.

12.3.3 Deformation Compatibility Requirements: Deformation compatibility of connections within and between structural elements shall be considered in design such that the deformation of each element and connection comprising the *seismic-force-resisting system* is compatible with the deformations of the other seismic-force-resisting elements and connections and with the overall system. See Sec. 5.2.8 for story drift limitations.

12.3.4 Framing Requirements: All 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 all end bearing capacity. Column and post end connections shall be fastened to resist lateral and net induced uplift forces.

Shear wall and diaphragm boundary elements shall be provided to transmit the design tension and compression forces. *Diaphragm* and *shear wall* sheathing shall not be used to splice *boundary elements*. *Diaphragm chords* and *drag struts* shall be placed in, or tangent to, the plane of the *diaphragm* framing unless it can be demonstrated that the moments, shears, and deflections and deformations, considering eccentricities resulting from other configurations, can be tolerated without exceeding the adjusted resistance and drift limits.

12.3.5 Sheathing Requirements: Wood structural panel sheathing shall have nominal sheet sizes of 4 ft by 8 ft (1200 mm by 2400 mm) or larger except where reduced widths are permitted per Sec. 12.4.1.3 and 12.4.2.6. Sheathing fasteners shall be placed at least 3/8 in. (10 mm) from ends and edges of boards and sheets. It is advised that the edge distance be increased where possible to reduce the potential for splitting of the framing and nail pull through in the sheathing. Sheathing nails or other approved sheathing connectors shall be driven flush with the surface of the sheathing.

Where wood structural panel sheathing is used as the exposed finish on the exterior of outside walls, it shall have an exterior exposure durability classification. Where wood structural panel sheathing is used on the exterior of outside walls but not as the exposed finish, it shall be of a

type manufactured with exterior glue. Where wood structural panel sheathing is used elsewhere, it shall be of a type manufactured with intermediate or exterior glue.

Panel materials other than wood structural panel sheathing have no recognized capacity for seismic-force resistance and are not permitted as part of the *seismic-force-resisting system* except in conventional light-frame construction, Sec.12.5.

12.3.6 Wood Members Resisting Horizontal Seismic Forces Contributed by Masonry and Concrete: Wood *shear walls*, *diaphragms*, horizontal trusses, and other members shall not be used to resist horizontal seismic forces contributed by masonry or concrete construction in *structures* over one story in height.

Exceptions:

1. Wood floor and roof members shall be permitted to be used in horizontal trusses and *diaphragms* to resist horizontal seismic forces (including those due to masonry veneer, fireplaces, and chimneys) provided such forces do not result in *torsional force distribution* through the truss or *diaphragm*.
2. Vertical wood structural panel sheathed *shear walls* shall be permitted to be used to provide resistance to seismic forces in two-story *structures* of masonry or concrete construction provided the following requirements are met:
    a. Story-to-story wall heights shall not exceed 12 ft (3660 mm).
    b. *Diaphragms* shall not be considered to transmit lateral forces by *torsional force distribution* or cantilever past the outermost supporting *shear wall*.
    c. Combined deflections of *diaphragms* and *shear walls* shall not permit per story drift of supported masonry or concrete walls to exceed the limits of Table 5.2.8.
    d. Wood structural panel sheathing in *diaphragms* shall have all unsupported edges blocked. Wood structural panel sheathing for both stories of *shear walls* shall have all unsupported edges blocked and, for the lower story, shall have a minimum thickness of 15/32 inch (12 mm).
    e. There shall be no out-of-plane horizontal offsets between the first and second stories of wood structural panel *shear walls*.

12.4 DIAPHRAGMS AND SHEAR WALLS:

12.4.1 Diaphragms:

12.4.1.1 Horizontal Distribution of Shear: *Diaphragms* shall be defined as flexible for the purposes of distribution of story shear and torsional moment when the maximum lateral deformation of the *diaphragm* is more than two times the average story drift of the associated story determined by comparing the computed maximum in-plane deflection of the *diaphragm* itself under lateral load with the story drift of adjoining vertical-resisting elements under equivalent tributary lateral load. Other *diaphragms* shall be defined as rigid. Design of *structures* with rigid *diaphragms* shall include the *structure* configuration requirements of Sec. 5.2.3.1 and the horizontal shear distribution requirements of Sec. 5.4.4.

Open-front *structures* with rigid wood *diaphragms* resulting in *torsional force distribution* shall be permitted provided the *length, l,* of the *diaphragm* normal to the open side does not exceed 25 ft (7620 mm), the *diaphragm* sheathing conforms to Sec.12.4.1.3 through 12.4.1.5, and the *l/w* ratio (as shown in Figure 12.4.1.1-1) is less than 1/1 for one-story *structures* or 1/1.5 for *structures* over one story in height.

Exception: Where calculations show that *diaphragm* deflections can be tolerated, the *length, l,* normal to the open end shall be permitted to be increased to a *l/w* ratio not greater than 1.5/1 when sheathed in conformance with Sec. 12.4.1.3 or 12.4.3.5 or to 1/1 when sheathed in conformance with Sec. 12.4.1.4.

Rigid wood *diaphragms* shall be permitted to cantilever past the outermost supporting *shear wall* (or other vertical resisting element) a *length, l,* of not more than 25 ft (7620 mm) or two thirds of the *diaphragm width, w,* whichever is the smaller. Figure 12.4.1.1-2 illustrates the dimensions of *l* and *w* for a cantilevered *diaphragm*.

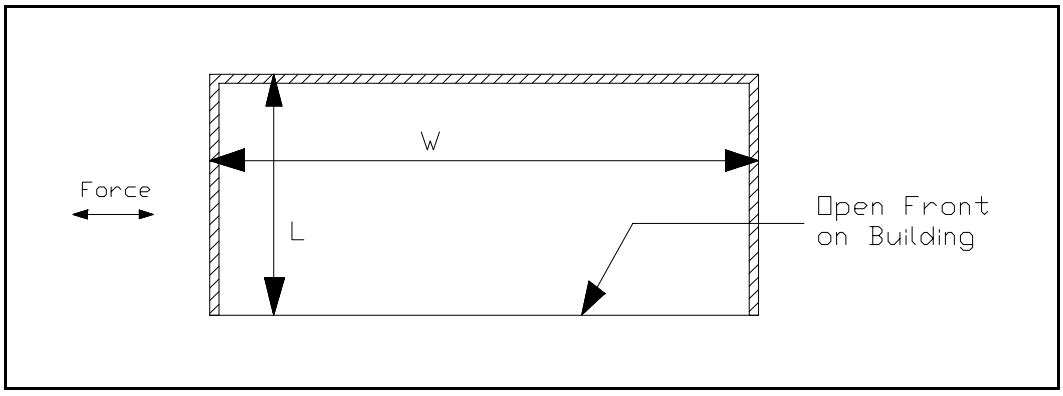

FIGURE 12.4.1.1-1 Diaphragm length and width for plan view of open front building.

Structures with rigid wood *diaphragms* having a torsional irregularity in accordance with Table 5.2.3.2, Item 1, shall meet the following requirements: The *l/w* ratio shall not exceed 1/1 for one-story *structures* or 1/1.5 for *structures* greater than one story in height where *l* is the dimension parallel to the load direction for which the irregularity exists.

Exception: Where calculations demonstrate that the *diaphragm* deflections can be tolerated, the width is permitted to be increased and the *l/w* ratio may be increased to 1.5/1 when sheathed in conformance with Sec. 12.4.1.3 or to 1/1 when sheathed in conformance with Sec 12.4.1.4 or 12.4.1.5.

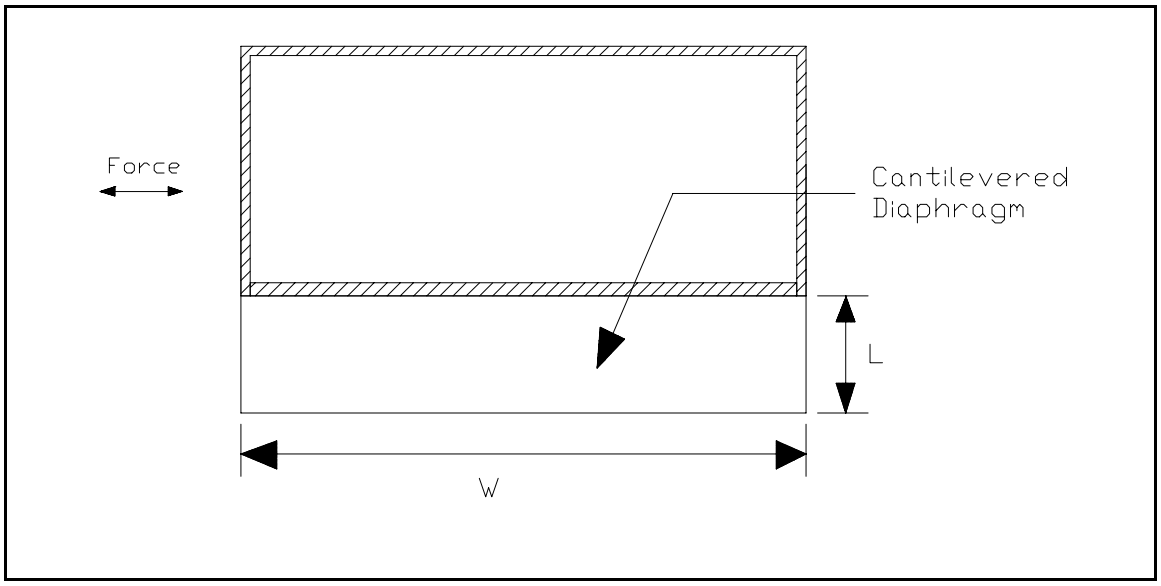

FIGURE 12.4.1.1-2 Diaphragm length and width for plan view of cantilevered diaphragm.

12.4.1.2 Aspect Ratio: The aspect ratio *l/w* of a diaphragm shall not be more than 4/1 for blocked wood structural panel diaphragms or 3/1 for unblocked wood structural panel diaphragms, single diagonally sheathed lumber diaphragms, and double diagonally sheathed lumber diaphragms.

12.4.1.3 Wood Structural Panel Sheathing: *Diaphragms* and *shear walls* sheathed with wood structural panel sheathing shall be permitted to be used to resist seismic forces based on the factored shear resistance, $\lambda\phi D$, set forth in Tables 12.4.3-1a and b. Where diaphragms are designated as blocked in Tables 12.4.3-1a and b, all joints in sheathing shall occur over framing members of the width prescribed in the tables.

The size and spacing of fasteners at wood structure panel sheathing boundaries, wood structural panel sheet edges, and intermediate supports shall be as given in Tables 12.4.3-1a and b Sheathing shall be arranged so that the width shall not be less than 2 ft (600 mm).

12.4.1.4 Single Diagonally Sheathed Lumber *Diaphragms*: The factored shear resistance, $\lambda\phi D$, of 0.22 Klf (3.2 kN/m) is permitted for single diagonally sheathed lumber diaphragms. Single diagonally sheathed lumber *diaphragms* shall consist of 1-by (actual ¾ in., 19 mm) sheathing boards laid at an angle of approximately 45 degrees (0.8 rad) to supports. Common nails at each intermediate support shall be two 8d (0.131 x 2½ in., 3 x 64 mm) for 1 by 6 (actual ¾ in by 5½ in., 19 mm by 140 mm) and three 8d (0.131 x 2½ in., 3 x 64 mm) for 1 by 8 (actual ¾ in. by 7½ in., 19 mm by 190 mm) boards. One additional nail shall be provided in each board at *diaphragm* boundaries. For box nails of the same penny weight, one additional nail shall be provided in each board at each intermediate support and two additional nails shall be provided in each board at *diaphragm* wall boundaries. End joints in adjacent boards shall be separated by at least one framing space between supports. Single diagonally sheathed lumber *diaphragms* shall be permitted to consist of 2-by (actual 1½ in., 38 mm) sheathing boards where 16d (0.131 by 2½ in., 3 by 64 mm) nails are substituted for 8d (0.131 by 2½ in., 3 x 64 mm) nails, end joints are

located as above, and the support is not less than 3 in. (actual 2½ in., 64 mm) width or 4 in. (actual 3½ in., 89 mm) depth.

12.4.1.5 Double Diagonally Sheathed Lumber *Diaphragms*: Double diagonally sheathed lumber *diaphragms* conform to the requirements for single diagonally sheathed lumber *diaphragms* in Sec. 12.4.1.4 and the requirements of this section, and shall be permitted to be used to resist seismic forces based on the factored shear resistance, $\lambda\phi D$, of 0.66 Klf (9.6 kN/m).

Double diagonally sheathed lumber *diaphragms* shall be sheathed with two layers of diagonal boards placed perpendicular to each other on the same face of the supports. Each *chord* shall be designed for the axial force induced and for flexure between supports due to a uniform load equal to 50 percent of the shear per foot in the *diaphragm*

12.4.2 Shear Walls:

12.4.2.1 Summing Shear Capacities: The shear values for shear panels of different capacities applied to the same side of the wall are not cumulative except as allowed in Tables 12.4.3-2a and 12.4.3.2b. The shear values for material of the same capacity applied to both faces of the same wall are cumulative. Where the material capacities are not equal, the allowable shear shall be either two times the smaller shear capacity or the capacity of the stronger side, whichever is greater. Summing shear capacities of dissimilar materials applied to opposite faces or to the same wall line is not allowed.

12.4.2.2 Adhesives: Adhesive attachment of shear wall sheathing is not permitted.

> **Exception:** Approved adhesive attachment systems shall be permitted in *Seismic Design Category* B where $R = 1.5$ and $\Omega_0 = 2.5$ unless other values are approved.

12.4.2.3 Aspect Ratio: The shear wall aspect ratio, h/w, shall not exceed 2/1. See Sec. 12.1.3 for definitions of w and h.

> **Exception:** Shear wall aspect ratios greater than 2/1, but not exceeding 3.5/1, shall be permitted provided the factored shear resistance values in Tables 12.4.3-2a and 12.4.3-2b are multiplied by $2w/h$.

12.4.2.4 Shear Wall Anchorage: Where net uplift is induced, tie-down (hold-down) devices shall be used. Tie-down (hold-down) devices shall be attached to the end posts with nails, screws, or other fasteners. All tie-down devices shall be used only where the uplift resistance values are based on cyclic testing of wall assemblies and the test results indicate that the tie-down device does not reduce the stiffness, ductility, or capacity of the *shear wall* when compared to nailed-on devices. Nominal strength of the tie-down assemblies shall be equal to or greater than the forces resulting from factored resistance values of Tables 12.4.3-2a and 12.4.3-2b times $\Omega_o/1.3$. The nominal strength of the tie-down device shall be defined as the average maximum test load the device can resist under cyclic testing without connection failure by either metal or wood failure. The stiffness of the tie-down assemblies shall be such as to prevent premature failure of the sheathing fasteners, and the effect of the tie-down displacement shall be included in drift calculations. End posts shall be selected such that failure across the net section of the post is not a limit state for the connection of the tie-down.

Foundation anchor bolts shall have a plate washer under each nut. The minimum plate washer sizes are as follows:

Bolt size	Plate washer size for shear walls
2 and 5/8 in. (13 and 16 mm)	1/4x3x3 in. (6x75x75 mm)
3/4, 7/8, and 1 in. (19, 22, and 25 mm)	3/8x3x3 in. (10x75x75 mm)

Hole diameters in the plate washer 3/16 in. (5 mm) larger than the bolt diameter are permitted provided that a standard cut washer is placed between the plate washer and the nut. Foundation anchor bolt embedment shall conform to the requirements of Chapters 6 and 8.

Bolts shall be placed a maximum of 2 in. (50 mm) from the sheathed side of wall sheathed on one face. Walls sheathed on both faces shall have the bolts staggered with the bolt a maximum of 2 in. (50 mm) from either side of the wall. Alternatively, for wall sheathed on both faces, the bolts shall be placed at the center of the foundation sill with the edge of the plate washer within 2 in. (13 mm) of each face of the wall. The plate washer width shall be a minimum of 3 in. (75 mm) and the plate thickness shall be determined by analysis using the upward force on the plate equal to the tension capacity of the bolt.

Anchor bolt and tie-down nuts shall be tightened without crushing the wood, and provision for preventing nuts from loosening shall be made just prior to covering the framing.

12.4.2.5 Framing: All framing used for shear wall construction shall conform to PS 20 for 2-by (1.5 in., 38 mm) or larger members.

12.4.2.6 Wood Structural Panel Sheathing: Shear walls sheathed with wood structural panel sheathing shall be permitted to be used to resist seismic forces based on the factored shear resistance, $\lambda\phi D$, set forth in Tables 12.4.2-6a and 12.4.2-6b.

The size and spacing of fasteners at wood structural panel sheathing boundaries, wood structural panel sheet edges, and intermediate supports shall be as given in Tables 12.4.2-6a and b.

All panel sheathing joints shall occur over studs or blocking. Sheathing shall be arranged so that the width shall not be less than 2 ft (600mm).

> **Exception:** For sheathing attached with the long direction of the panels perpendicular to the studs, a single sheathing panel with a minimum vertical dimension of 1 ft (300 mm) and a minimum horizontal dimension of 4 ft (1200 mm) is permitted to be used if it is located at mid-height of the wall, and is fully blocked and nailed.

12.4.2.7 Single Diagonally Sheathed Lumber Shear Walls: Single diagonally sheathed lumber diaphragms are permitted using the construction and resistance provisions of Sec. 12.4.1.4.

12.4.2.8 Double Diagonally Sheathed Lumber Shear Walls: Double diagonally sheathed lumber diaphragms are permitted using the construction and resistance provisions of Sec. 12.4.1.5.

12.4.2.9 Shear Walls With Openings Designed for Force Transfer Around Openings: Where structural-use panel shear walls with openings are designed for force transfer around the openings, the aspect ratio, *h/w*, limitations of Sec. 12.4.2.3 shall apply to the overall shear wall including openings and to each wall pier at the side of an opening. The height of a wall pier shall be defined as the clear height of the pier at the side of an opening. The width of a wall pier shall be defined as the sheathed width of the pier. Design and detailing of *boundary elements* around the opening shall be provided in accordance with Sec. 12.2.1 or ASCE 16. The width of a wall pier shall not be less than 2 ft (610mm).

12.4.3 Perforated Shear Walls: The provisions of Sec. 12.4.3 shall be permitted to be used for the design of perforated shear walls.

12.4.3.1 Definitions:

Adjusted shear resistance: The unadjusted factored shear resistance multiplied by the shear resistance adjustment factors of Table 12.4.3-1.

Perforated shear wall: A wood structural panel sheathed wall with openings but not specifically designed and detailed for force transfer around wall openings.

Perforated shear wall segment: A section of shear wall with full height sheathing that meets the aspect ratio limits of Sec. 12.4.2.3.

Unadjusted factored shear resistance: The factored shear resistance set forth in Tables 12.4.2-6a and 12.4.2-6b when the aspect ratio of any perforated shear wall segment used in calculation of perforated shear wall resistance does not exceed 2/1. When the aspect ratio of any perforated shear wall segment used in calculation of perforated shear wall resistance is greater than 2/1, but not exceeding 3.5/1, the unadjusted factored shear resistance shall be the factored shear resistance set forth in Tables 12.4.2-6a and 12.4.2-6b multiplied by 2*w/h*.

12.4.3.2 Limitations: The following limitations shall apply to the use of Sec. 12.4.4:

a. A perforated shear wall segment shall be located at each end of a perforated shear wall. Openings shall be permitted to occur beyond the ends of the perforated shear wall, however the width of such openings shall not be included in the width of the perforated shear wall.

b. The factored shear resistance set fort in Tables 12.4.2-6a and 12.4.2-6b shall not exceed 0.64 klf (9.4 kN/m).

c. A perforated shear wall shall not have out of plane (horizontal) offsets. Where out of plane offsets occur, portions of the wall on each side of the offset shall be considered as separate perforated shear walls.

d. Collectors for shear transfer shall be provided through the full length of the perforated shear wall**.**

e. A perforated shear wall shall have uniform top of wall and bottom of wall elevations. Perforated shear walls not having uniform elevations shall be designed by other methods.

f. Perforated shear wall height, *h*, shall not exceed 20 ft.

12.4.3.3 Perforated Shear Wall Resistance: The resistance of a perforated shear wall shall be calculated in accordance with the following:

12.4.3.3.1 Percent full height sheathing: The percent of full height sheathing shall be calculated as the sum of widths of perforated shear wall segments divided by the total width of the perforated shear wall including openings.

12.4.3.3.2 Maximum opening height ratio: The maximum opening height ratio shall be calculated by dividing the maximum opening clear height by the shear wall height, *h*.

12.4.3.3.3 Adjusted shear resistance: The adjusted shear resistance shall be calculated by multiplying the unadjusted factored shear resistance by the shear resistance adjustment factors of Table 12.4.4-1. For intermediate percentages of full height sheathing the values in Table 12.4.4-1 are permitted to be interpolated.

12.4.3.3.4 Perforated shear wall resistance: The perforated shear wall resistance shall be equal to the adjusted shear resistance times the sum of the widths of the perforated shear wall segments.

12.4.3.4 Anchorage and Load Path: Design of perforated shear wall anchorage and load path shall conform to the requirements of this section or shall be calculated using principles of mechanics. Except as modified by this section, wall framing, sheathing, sheathing attachment, and fastener schedules shall conform to the requirements of 12.4.2.6 and Tables 12.4.3-2a and 12.4.3-2b.

12.4.3.4.1 Uplift anchorage at perforated shear wall ends: Anchorage for uplift forces due to overturning shall be provided at each end of the perforated shear wall. The uplift anchorage shall conform to the requirements of Sec. 12.4.2.4 using the factored resistance values set forth in Tables 12.4.2-6a and 12.4.2-6b times $\Omega_0/1.3$.

12.4.3.4.2 Anchorage for in-plane shear: The unit shear force ,*v*, transmitted into the top of a perforated shear wall, out of the base of the perforated shear wall at full height sheathing, and into collectors (drag struts) connecting shear wall segments, shall be calculated in accordance with the following:

$$v = \frac{V}{C_o \sum L_i}$$

where:

v = unit shear force (klf, kN/m),

V = shear force in perforated shear wall (kips, kN),

h = shear wall height (ft, mm/1000),

C_o = shear resistance adjustment factor from Table 12.4.4-1, and

ΣL_i = sum of widths of perforated shear wall segments (ft, mm/1000).

12.4.3.4.3 Uplift anchorage between perforated shear wall ends: In addition to the requirements of Sec. 12.4.4.4.1, perforated shear wall bottom plates at full height sheathing shall be anchored for a uniform uplift force, *t*, equal to the unit shear force, *v*, determined in Sec. 12.4.4.4.2.

12.4.3.4.4. Compression chords: Each end of each perforated shear wall segment shall be designed for a compression force, *C*, from each story calculated in accordance with the following:

$$C = V h / (C_o \sum L_i)$$

where:

C = compression chord force (kips, kN),

V = shear force in perforated shear wall (kips, kN),

h = shear wall height (ft, mm/1000),

C_o = shear resistance adjustment factor from Table 12.4.4-1, and

$\sum L_i$ = sum of widths of shear wall segments (ft, mm/1000).

12.4.3.4.5. Load path: A load path to the foundation shall be provided for each uplift force, *T* and *t*, for each shear force, *v*, and for each compression force, *C*. Elements resisting shear wall forces contributed by multiple stories shall be designed for the sum of forces contributed by each story.

TABLE 12.4.3-1 Shear Resistance Adjustment Factor, C_o

Wall Height (*h*)	Maximum Opening Height Ratio[a] and Height				
	***h*/3**	***h*/2**	**2*h*/3**	**5*h*/6**	***h***
8'-0" (2440 mm)	2'-8" (810 mm)	4'-0" (1220 mm)	5'-4" (1630 mm)	6'-8" (2030 mm)	8'-0" (2440 mm)
10'-0" (3050 mm)	3'-4" (1020 mm)	5'-0" (1530 mm)	6'-8" (2030 mm)	8'-4" (2540 mm)	10'-0" (3050 mm)
Percent Full-Height Sheathing[b]	**Shear Resistance Adjustment Factor**				
10%	1.00	0.69	0.53	0.43	0.36
20%	1.00	0.71	0.56	0.45	0.38
30%	1.00	0.74	0.59	0.49	0.42
40%	1.00	0.77	0.63	0.53	0.45
50%	1.00	0.80	0.67	0.57	0.50
60%	1.00	0.83	0.71	0.63	0.56
70%	1.00	0.87	0.77	0.69	0.63
80%	1.00	0.91	0.83	0.77	0.71
90%	1.00	0.95	0.91	0.87	0.83
100%	1.00	1.00	1.00	1.00	1.00

[a] See Sec. 12.4.3.3.2.

[b] See Sec. 12.4.3.3.1.

12.5 CONVENTIONAL LIGHT-FRAME CONSTRUCTION:

12.5.1 Scope: Conventional light-frame construction is a system constructed entirely of repetitive horizontal and vertical wood light-framing members selected from tables in NFoPA T903 and conforming to the framing and bracing requirements of the CABO Code except as modified by the provisions in this section. *Structures* with concrete or masonry walls above the basement *story* shall not be considered to be conventional light-frame construction. Construction with concrete and masonry basement walls shall be in accordance with the CABO Code or equivalent. Conventional light-frame construction is limited to *structures* with bearing wall heights not exceeding 10 ft (3 m) and the number of stories prescribed in Table 12.5.1-1. The gravity dead load of the construction is limited to 15 psf (720 Pa) for roofs and exterior walls and 10 psf (480 Pa) for floors and partitions and the gravity live load is limited to 40 psf (1915 Pa).

Exceptions: Masonry veneer is acceptable for:

1. The first *story above grade* or the first two stories above grade when the lowest story has concrete or masonry walls of *Seismic Design Category* B and C *structures.*
2. The first two stories above grade or the first three stories above grade when the lowest story has concrete or masonry walls of Seismic Design Category B *structures,* provided structural use panel wall bracing is used and the length of bracing provided is 1.5 times the length required by Table 12.5.2-1.

The requirements of this section are based on platform construction. Other framing systems must have equivalent detailing to ensure force transfer, continuity, and compatible deformation.

When a *structure* of otherwise conventional light-frame construction contains structural elements not conforming to Sec. 12.5, those elements shall have an engineered design to resist the forces specified in Chapter 5 in accordance with Sec. 12.2.2.1.

12.5.1.1 Irregular Structures: Irregular *structures* in *Seismic Design Categories* C and D of conventional light-frame construction shall have an engineered *lateral-force-resisting system* designed to resist the forces specified in Chapter 5 in accordance with Sec. 12.2.1. A *structure* shall be considered to have an irregularity when one or more of the conditions described in Sec. 12.5.1.1.1 to 12.5.1.1.7 are present.

12.5.1.1.1: A *structure* shall be considered to have an irregularity when exterior *braced wall panels* are not in one plane vertically from the foundation to the uppermost *story* in which they are required. See Figure 12.5.1.1.1-1.

Exceptions: Floors with cantilevers or setbacks not exceeding four times the nominal depth of the floor joists (see Figure 12.5.1.1.1-2) are permitted to support *braced wall panels* provided:

1. Floor joists are 2 in. by 10 in. (actual 1½ by 9¼ in., 38 by 235 mm) or larger and spaced not more than 16 inches (405 mm) on center.
2. The ratio of the back span to the cantilever is at least 2 to 1.
3. Floor joists at ends of *braced wall panels* are doubled.
4. A continuous rim joist is connected to the ends of all cantilevered joists. The rim joist shall be permitted to be spliced using a metal tie not less than 0.058 in. (2 mm) (16 galvanized gage) and 1½ in. (38 mm) wide fastened with six 16d (0.162 by 3½ in, 4 by 89 mm) common nails on each side. Steel used shall have a minimum yield of 33,000 psi (228 MPa) such as ASTM 653 Grade 330 structural quality or ASTM A446 Grade A galvanized steel.
5. Gravity loads carried by joists at setbacks or the end of cantilevered joists are limited to single *story* uniform wall and roof loads and the reactions from headers having a span of 8 ft (2440 mm) or less.

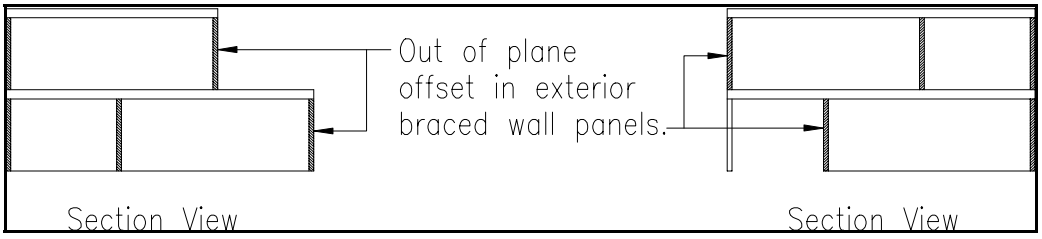

FIGURE 12.5.1.1.1-1 Out-of-plane exterior walls irregularity.

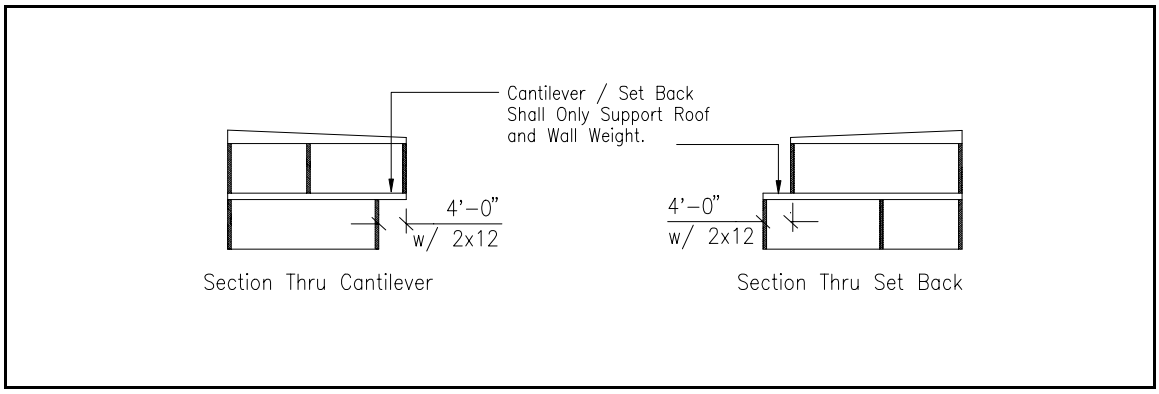

FIGURE 12.5.1.1.1-2 Cantilever/setback irregularity for exterior walls.

12.5.1.1.2: A *structure* shall be considered to have an irregularity when a section of floor or roof is not laterally supported by *braced wall lines* on all edges. See Figure 12.5.1.1.2-1.

Exception: Portions of roofs or floors that do not support *braced wall panels* above shall be permitted to extend up to 6 ft (1830 mm) beyond a *braced wall line*. See Figure 12.5.1.1.2-2.

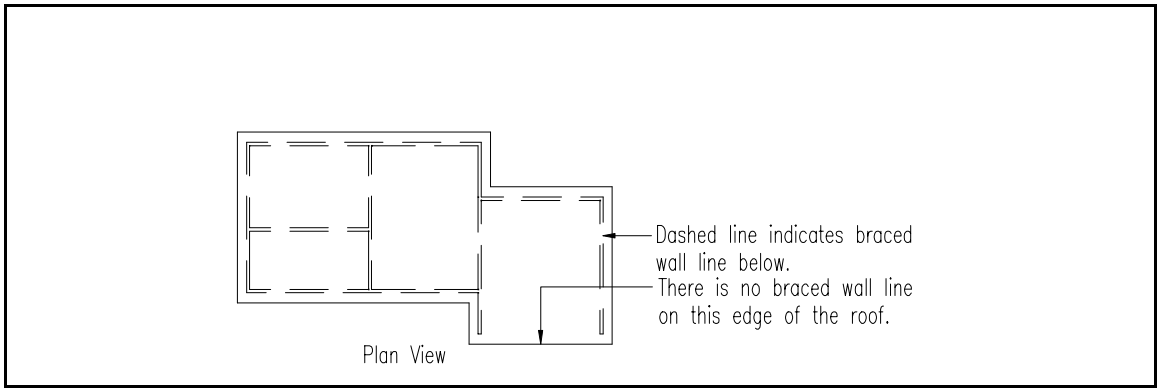

FIGURE 12.5.1.1.2-1 Unsupported diaphragm irregularity.

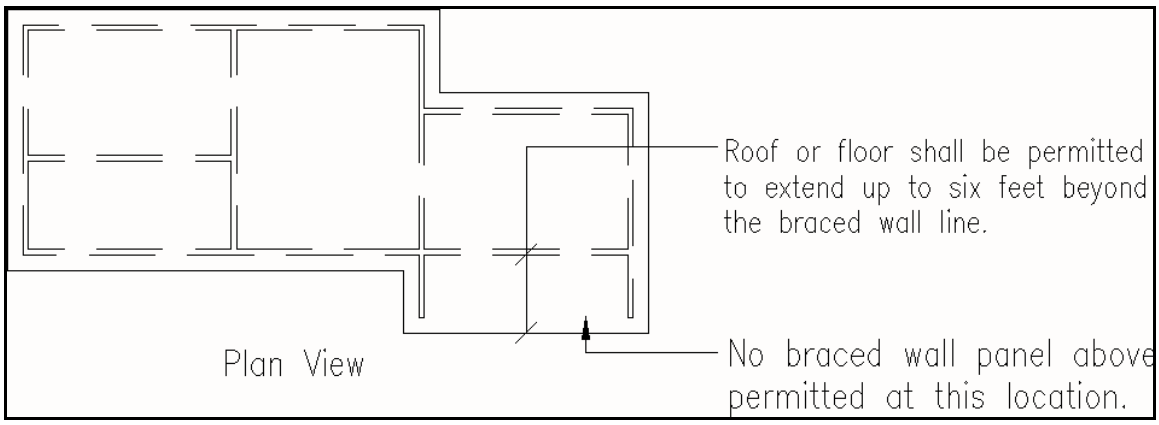

FIGURE 12.5.1.1.2-2 Allowable cantilevered diaphragm.

12.5.1.1.3: A *structure* shall be considered to have an irregularity when the end of a required *braced wall panel* extends more than 1 ft (305 mm) over an opening in the wall below. This requirement is applicable to *braced wall panels* offset in plane and to *braced wall panels* offset out of plane as permitted by the exception to Sec. 12.5.1.1.1. See Figure 12.5.1.1.3.

Exception: *Braced wall panels* shall be permitted to extend over an opening not more than 8 ft (2440 mm) in width when the header is a 4-in. by 12-in. (actual 3½ by 11¼ in., 89 by 286 mm) or larger member.

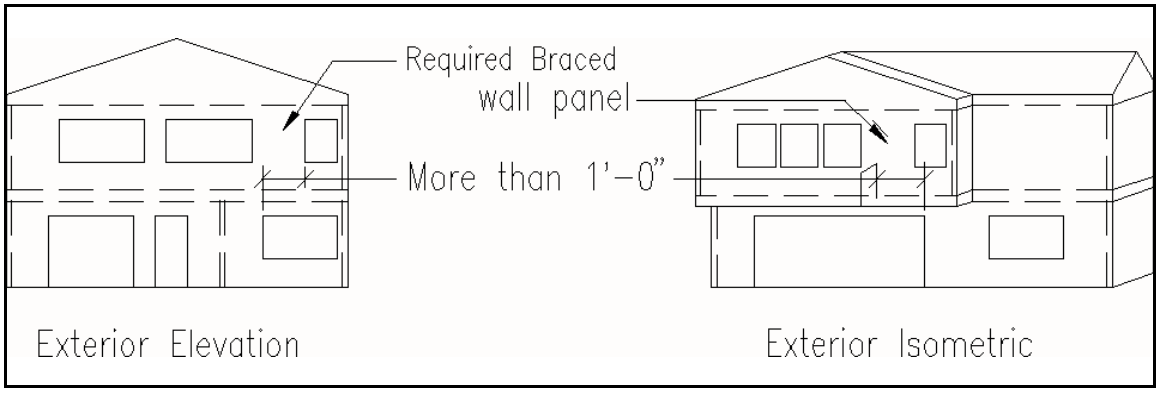

FIGURE 12.5.1.1.3 Opening in wall below irregularity.

12.5.1.1.4: A *structure* shall be considered to have an irregularity when portions of a floor level are vertically offset such that the framing members on either side of the offset cannot be lapped or tied together in an approved manner. See Figure 12.5.1.1.4.

Exception: Framing supported directly by foundations.

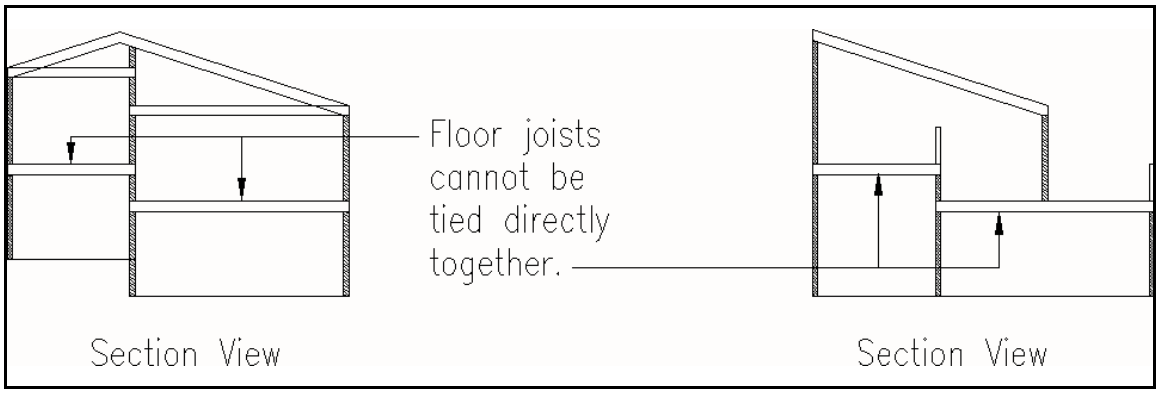

FIGURE 12.5.1.1.4 Vertical offset irregularity.

12.5.1.1.5: A *structure* shall be considered to have an irregularity when *braced wall lines* are not perpendicular to each other. See Figure 12.5.1.1.5

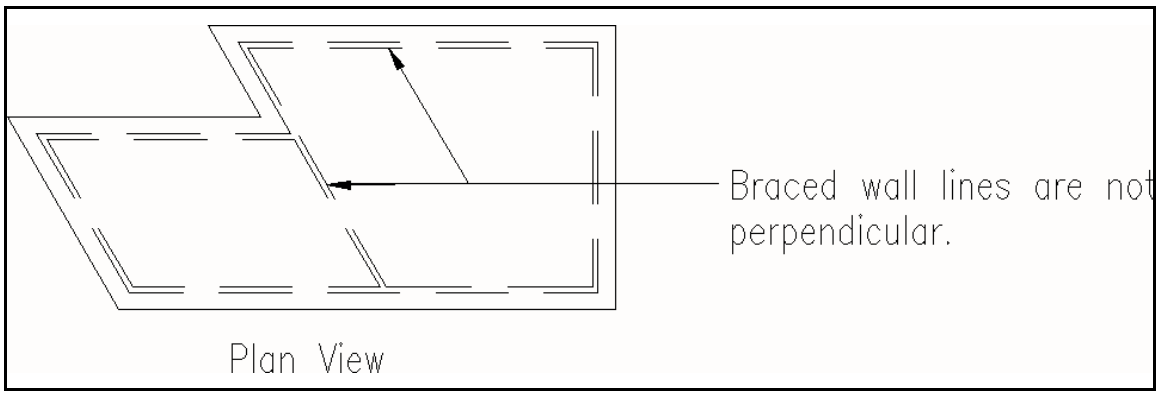

FIGURE 12.5.1.1.5 Nonperpendicular wall irregularity.

12.5.1.1.6 Diaphragm Openings: A *structure* shall be considered to have an irregularity when openings in floor and roof *diaphragms* having a maximum dimension greater than 50 percent of the distance between lines of bracing or an area greater than 25 percent of the area between orthogonal pairs of *braced wall lines* are present. See Figure 12.5.1.1.6.

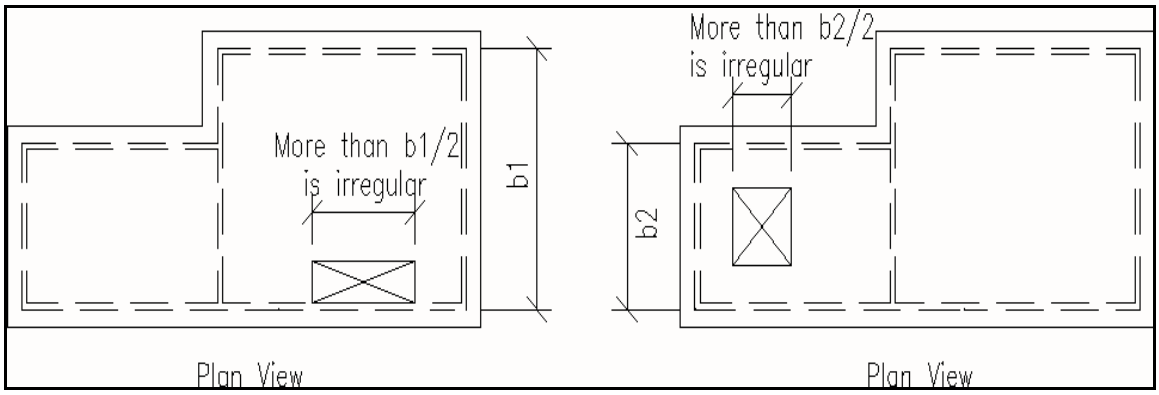

FIGURE 12.5.1.1.6 Diaphragm opening irregularity.

12.5.1.1.7 Stepped Foundation: A *structure* shall be considered to have an irregularity when the shear walls of a single story vary in height more than 6 ft (1800 mm).

12.5.2 Braced Walls: The following are the minimum braced wall requirements.

12.5.2.1 Spacing Between Braced Wall Lines: Interior and exterior *braced wall lines* shall be located at the spacing indicated in Table 12.5.1-1.

12.5.2.2 Braced Wall Line Sheathing Requirements: All b*raced wall lines* shall be braced by one of the types of sheathing prescribed in Table 12.5.2-1. The required sum of lengths of *braced wall panels* at each *braced wall line* is prescribed in Table 12.5.2-1. *Braced wall panels* shall be distributed along the length of the *braced wall line* with sheathing placed at each end of the wall or partition or as near thereto as possible. To be considered effective as bracing, each *braced wall panel* shall conform to Sec. 602.9 of the CABO Code. All panel sheathing joints shall occur over studs or blocking. Sheathing shall be fastened to all studs and top and bottom plates and at panel edges occurring over blocking. All wall framing to which sheathing used for bracing is applied shall be 2-by (actual 1½ in., 38 mm) or larger members.

Cripple walls shall be braced as required for *braced wall lines* and shall be considered an additional *story*. Where interior post and girder framing is used, the capacity of the *braced wall panels* at exterior *cripple walls* shall be increased to compensate for length of interior braced wall eliminated by increasing the length of the sheathing or increasing the number of fasteners.

12.5.2.3 Attachment:

12.5.2.3.1: Nailing of *braced wall panel* sheathing shall be not less than the minimum included in Tables 12.4.2-6a and 12.4.2-6b or as prescribed in Table 12.5.2-1.

12.5.2.3.2: Nailing for diagonal boards shall be as prescribed in Sec. 12.4.3.3 and 12.4.3.4.

12.5.2.3.3 : Adhesive attachment of wall sheathing is not permitted.

12.5.3 Detailing Requirements: The following requirements for framing and connection details shall apply as a minimum.

12.5.3.1 Wall Anchorage: Anchorage of *braced wall line* sills to concrete or masonry foundations shall be provided. Such anchorage shall conform to the requirements in Figure 403.1a of Sec. 403 of the CABO code except that such anchors shall be spaced at not more than 4 ft (1220 mm) on center for *structures* over two stories in height. For *Seismic Design Categories* C, D and E, plate washers, a minimum of ¼ in. by 3 in. by 3 in. in size, shall be provided between the foundation sill plate and the nut. Other anchorage devices having equivalent capacity shall be permitted.

12.5.3.2 Top Plates: Stud walls shall be capped with double-top plates installed to provide overlapping at corners and intersections. End joints in double-top plates shall be offset at least 4 ft (1220 mm). Single top plates shall be permitted to be used when they are spliced by framing devices providing capacity equivalent to the lapped splice prescribed for double top plates.

12.5.3.3 Bottom Plates: Studs shall have full bearing on a 2-by (actual 1½ in., 38 mm) or larger plate or sill having a width at least equal to the width of the studs.

12.5.3.4 Braced Wall Panel Connections: Accommodations shall be made to transfer forces from roofs and floors to *braced wall panels* and from the *braced wall panels* in upper stories to the *braced wall panels* in the *story* below. Where platform framing is used, such transfer at *braced wall panels* shall be accomplished in accordance with the following:

1. All *braced wall panel* top and bottom plates shall be fastened to joists, rafters, or full depth blocking. *Braced wall panels* shall be extended and fastened to roof framing at intervals not to exceed 50 ft (15.2 m).

   Exception: Where roof trusses are used, provisions shall be made to transfer lateral forces from the roof diaphragm to the braced wall

2. Bottom plate fastening to joist or blocking below shall be with not less than 3-16d (0.162 by 3½ in., 4 by 89 mm) nails at sixteen inches on center.

3. Blocking shall be nailed to the top plate below with not less than 3-8d (0.131 by 2½ in., 3 by 64 mm) toenails per block.

4. Joists parallel to the top plates shall be nailed to the top plate with not less than 8d (0.131 by 2½ in., 3 by 64 mm) toenails at 6 in. (150 mm) on center.

In addition, top plate laps shall be nailed with not less than 8-16d (0.162 by 3½ in., 4 by 89 mm) face nails on each side.

12.5.3.5 Foundations Supporting Braced Wall Panels: For *structures* with maximum plan dimensions not over 50 ft (15250 mm) foundations supporting *braced wall panels* are required at exterior walls only. *Structures* with plan dimensions greater than 50 ft (15250 mm) shall, in addition, have foundations supporting all required interior *braced wall panels*. Foundation to braced wall connections shall be made at every foundation supporting a *braced wall panel*. The connections shall be distributed along the length of the *braced wall line*. Where all-wood foundations are used, the force transfer shall be determined based on calculation and shall have capacity greater than or equal to the connections required by Sec. 12.5.3.1.

12.5.3.6 Stepped Footings: Where the height of a required *braced wall panel* extending from foundation to floor above varies more than 4 ft. (1220 mm) (see Figure 12.5.3.6), the following construction shall be used:

a. Where only the bottom of the footing is stepped and the lowest floor framing rests directly on a sill bolted to the footings, the requirements of Sec. 12.5.3.1 shall apply.

b. Where the lowest floor framing rests directly on a sill bolted to a footing not less than 8 ft (2440 mm) in length along a line of bracing, the line shall be considered to be braced. The double plate of the cripple stud wall beyond the segment of footing extending to the lowest framed floor shall be spliced to the sill plate with metal ties, one on each side of the sill and plate not less than 0.058 in. (16 gage, 2mm) by 1.5 in. (38 mm) wide by 4.8 in. (122 mm) with eight 16d (0.162 by 3.5 in., 4 by 89 mm) common nails on each side of the splice location (see Figure 12.5.3.6). Steel used shall have a minimum yield of 33,000 psi (228 MPa) such as ASTM 653 Grade 330 structural quality or ASTM A446 Grade A galvanized steel.

c. Where *cripple walls* occur between the top of the footing and the lowest floor framing, the bracing requirements for a *story* shall apply.

12.5.3.7 Detailing for Openings in Diaphragms: For openings with a dimension greater than 4 ft (1220 mm) or openings in *structures* in *Seismic Design Categories* D and E, the following minimum detail shall be provided. Blocking shall be provided beyond headers and metal ties not less than 0.058 in. (16 gage, 2 mm) by 1.5 in. (38 mm) wide by 4.8 in. (122 mm) with eight 16d (0.162 by 3.5 in., 4 by 89 mm) common nails on each side of the header-joist intersection (see Figure 12.5.3.7). Steel used shall have a minimum yield of 33,000 psi (228 MPa) such as ASTM 653 Grade 330 structural quality or ASTM A446 Grade A galvanized steel.

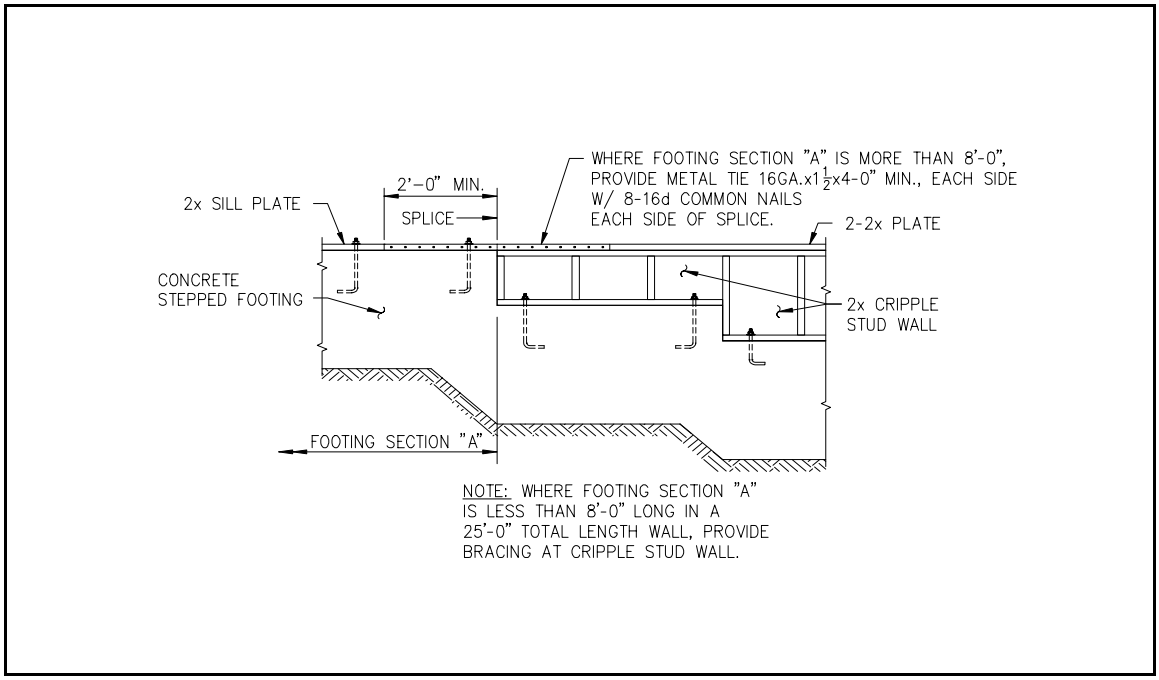

FIGURE 12.5.3.6 Stepped footing detail.

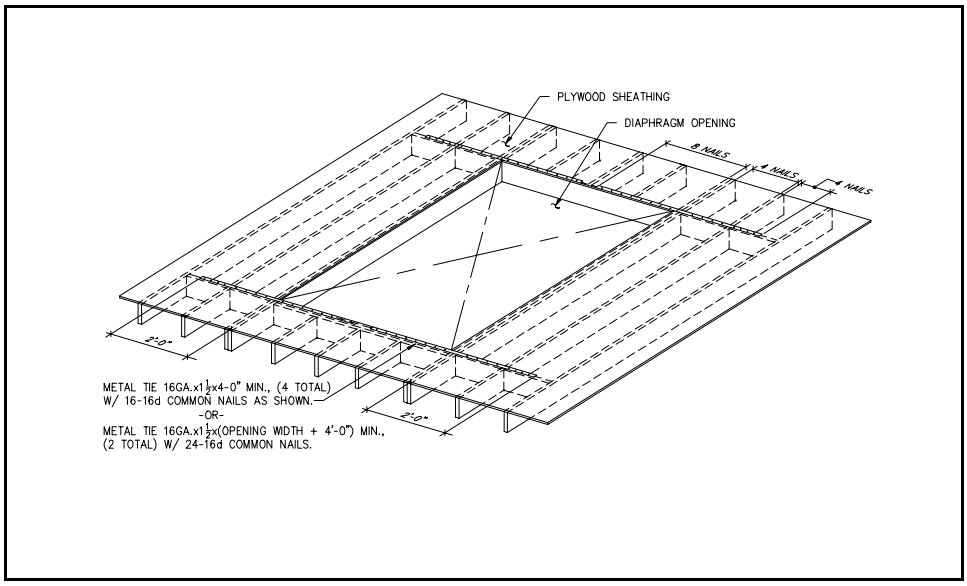

FIGURE 12.5.3.7 Detail for diaphragm opening.

12.6 SEISMIC DESIGN CATEGORY A: *Structures* assigned to *Seismic Design Category* A are permitted to be designed and constructed using any applicable materials and procedures permitted in the reference documents and, in addition, shall conform to the requirements of Sec. 5.2.6.1.2. *Structures* constructed in compliance with Sec. 12.5 are deemed to comply with Sec. 5.2.6.1.2.

Exceptions:

1. Where Sec. 1.2.1, Exception 1, is applicable, one- and two-family detached dwellings are exempt from the requirements of the *Provisions*.
2. Where Sec. 1.2.1, Exception 2, is applicable, one- and two-family dwellings that are designed and constructed in accordance with the conventional construction requirements of Sec. 12.5 are exempt from other requirements of the *Provisions.*

12.7 SEISMIC DESIGN CATEGORIES B, C, AND D: *Structures* assigned to *Seismic Design Categories* B, C, and D shall conform to the requirements of this section, and Sec. 5.2.6.1.2.

Exceptions:

1. Where Sec. 1.2.1, Exception 1, is applicable, one- and two-family detached dwellings are exempt from the requirements of the *Provisions*.
2. Where Sec. 1.2.1, Exception 2, is applicable, one- and two-family dwellings that are designed and constructed in accordance with the conventional construction requirements of Sec. 12.5 are exempt from other requirements of the *Provisions.*

12.7.1 Conventional Light-Frame Construction: Conventional light-frame construction shall meet the requirements of Sec. 12.5. Alternatively, such *structures* shall meet the requirements of Sec. 12.7.2. See Sec. 12.2.2.1 for design of nonconventional elements.

12.7.2 Engineered Construction: All engineered wood construction shall meet the requirements of Sec. 12.3 and 12.4.

12.8 SEISMIC DESIGN CATEGORIES E AND F: *Structures* assigned to *Seismic Design Categories* E and F shall conform to all of the requirements for engineered construction in accordance with Sec. 12.3 and 12.4 and to the additional requirements of this section.

Exception: *Structures* assigned to *Seismic Use Group* I that are designed and constructed in accordance with the requirements of Sec. 12.5 are permitted.

12.8.1 Limitations: *Structures* shall comply with the requirements given below.

12.8.1.1 Unblocked *structural-use panel* sheathing *diaphragms* shall not be considered to be part of the *seismic-force-resisting system*. *Structural-use panel* sheathing used for *diaphragms* and *shear walls* that are part of the *seismic-force-resisting system* shall be applied directly to the framing members.

Exception: *Structural-use panel* sheathing may be used as a *diaphragm* when fastened over solid lumber planking or laminated decking provided the panel joints and lumber planking or laminated decking joints do not coincide.

12.8.1.2 In addition to the requirements of Sec. 12.3.4.1, the factored shear resistance, $\lambda\phi D$, for *structural-use panel* sheathed *shear walls* used to resist seismic forces in *structures* with concrete or masonry walls shall be one-half the values set forth in Tables 12.4.3-2a and 12.4.3-2b.

TABLE 12.4.3-1a Factored Shear Resistance in Kips per Foot for Horizontal Wood Diaphragms with Framing Members of Douglas Fir-Larch or Southern Pine for Seismic Loading[a,b]

Panel Grade	Fastener[c]		Minimum nominal panel thick-ness (in.)	Minimum nominal width of framing (in.)	Lines of fasteners	Blocked Diaphragms							Unblocked Diaphragms[d]	
	Type	Minimum penetration in framing (in.)				Fastener spacing at diaphragm boundaries (all cases), at continuous panel edges parallel to load (Cases 3 and 4) and at all panel edges (Cases 5 and 6)[e]							Fastener spacing at 6 in. centers at supported edges	
						6	4		2-1/2[f]		2[f]			
						Spacing per line at other panel edges (in.)							Case 1	Cases 2, 3 4, 5, and 6
						6	6	4	4	3	3	2		
Structural I	6d common	1-1/4	3/8	2	1	0.24	0.33	---	0.49	---	0.55	---	0.21	0.16
				3	1	0.27	0.36	---	0.55	---	0.62	---	0.24	0.18
	8d common	1-3/8	3/8	2	1	0.35	0.47	---	0.69	---	0.78	---	0.31	0.23
				3	1	0.39	0.52	---	0.78	---	0.88	---	0.34	0.26
	10d[g] common	1-1/2	15/32	2	1	0.42	0.55	---	0.83	---	0.95	---	0.37	0.28
				3	1	0.47	0.62	---	0.94	---	1.07	---	0.42	0.31
	10d[g] common	1-1/2	23/32	3	2	---	0.85	1.13	1.22	1.60	---	---	---	---
				4	2	---	0.98	1.27	1.40	1.83	---	---	---	---
				4	3	---	1.22	1.70	1.79	2.35	---	---	---	---
	14 gauge staples	2	23/32	3	2	---	0.78	0.78	1.09	1.17	1.35	1.56	---	---
				4	3	---	1.09	1.17	1.48	1.76	1.87	2.34	---	---
Sheathing, single floor and other grades covered in Ref. 9-10 and 9-11	6d common	1-1/4	3/8	2	1	0.24	0.33	---	0.49	---	0.55	---	0.21	0.16
				3	1	0.27	0.36	---	0.55	---	0.62	---	0.24	0.18
	8d common	1-3/8	3/8	2	1	0.31	0.42	---	0.62	---	0.71	---	0.28	0.21
				3	1	0.35	0.47	---	0.70	---	0.79	---	0.31	0.23
			7/16	2	1	0.33	0.44	---	0.66	---	0.75	---	0.30	0.22
				3	1	0.37	0.49	---	0.74	---	0.84	---	0.33	0.25
			15/32	2	1	0.35	0.47	---	0.69	---	0.78	---	0.31	0.23
				3	1	0.39	0.52	---	0.78	---	0.88	---	0.34	0.26
	10d[g] common	1-1/2	15/32	2	1	0.38	0.50	---	0.75	---	0.85	---	0.33	0.25
				3	1	0.42	0.56	---	0.85	---	0.96	---	0.38	0.28
			19/32	2	1	.042	0.55	---	0.83	---	0.95	---	0.37	0.28
				3	1	0.47	0.62	---	0.94	---	1.07	---	0.42	0.31
			23/32	3	2	---	0.84	1.13	1.22	1.59	---	---	---	---
				4	2	---	0.98	1.27	1.40	1.81	---	---	---	---
				4	3	---	1.22	1.70	1.78	1.96	---	---	---	---
	14 gauge staples	2	23/32	3	2	---	0.78	0.78	1.07	1.17	1.33	1.56	---	---
				4	3	---	1.07	1.17	1.46	1.76	1.82	1.96	---	---

NOTES for TABLE 12.4.3-1a

[a] $\lambda = 1.0$ $\varphi = 0.65$

[b] *l/w* shall not be more than 4/1 for blocked diaphragms or more than 3/1 for unblocked diaphragms. For framing members of other species set forth in Ref. 12-1, Table 12A, with the range of specific gravity (SG) noted, allowable shear values shall be calculated for all panel grades by multiplying the values from the table above for nail size and actual panel grade by the following factor: Specific Gravity Adjustment Factor = (1-(0.5 - SG)), Where SG = Specific Gravity of the framing lumber. This adjustment factor shall not be greater than 1.

[c] Space nails along intermediate framing members at 12 in. centers except where spans are greater than 32 in..; space nails at 6 in. centers.

[d] Blocked values are permitted to be used for 1-1/8 in. panels with tongue-and-groove edges where 1 in. by 3/8 in.. crown by No. 16 gauge staples are driven through the tongue-and-groove edges 3/8 in. from the panel edge so as to penetrate the tongue. Staples shall be spaced at one half the boundary nail spacing for Cases 1 and 2 and at one third the boundary nail spacing for Cases 3 through 6.

[e] Maximum shear for Cases 3 through 6 is limited to 1500 pounds per foot.

[f] For values listed for 2 in. nominal framing member width, the framing members at adjoining panel edges shall be 3 in. nominal width. Nails at panel edges shall be placed in two lines at these locations.

[g] Framing at adjoining panel edges shall be 3 in. nominal or wider and nails shall be staggered where 10d nails having penetration into framing of more than 1-5/8 in. are spaced 3 in. or less on center.

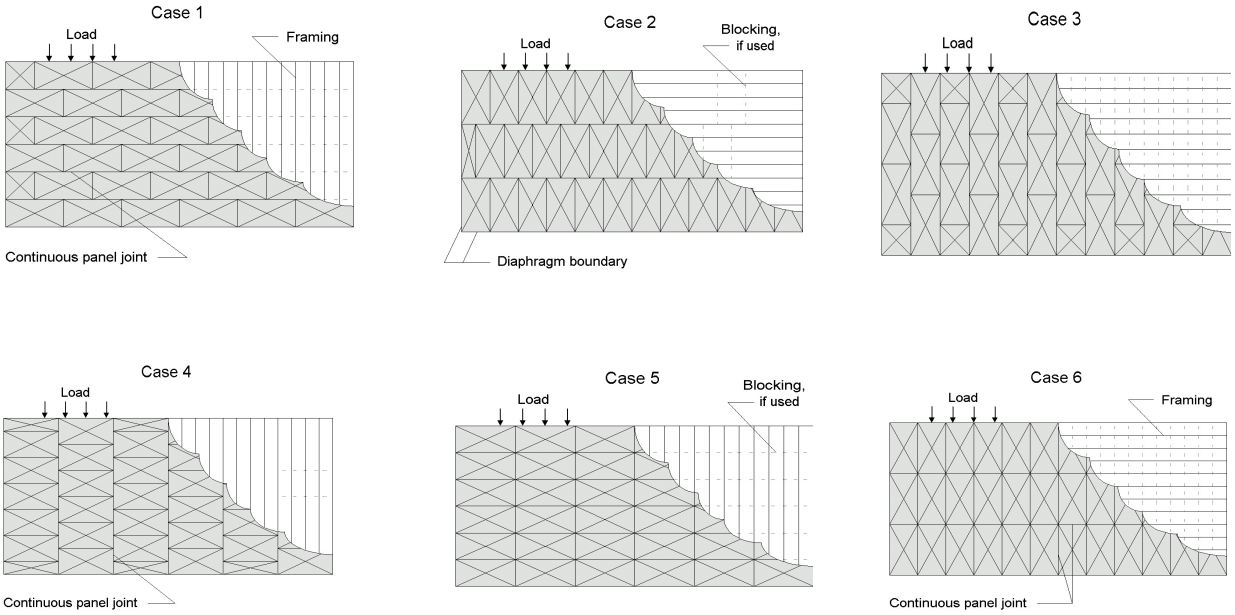

TABLE 12.4.3-1b Factored Shear Resistance in kiloNewtons per Meter for Horizontal Wood Diaphragms with Framing Members of Douglas Fir-Larch or Southern Pine for Seismic Loading[a,b]

Panel Grade	Fastener[c]		Minimum nominal panel thick-ness (mm.)	Minimum nominal width of framing (mm.)	Lines of fasteners	Blocked Diaphragms							Unblocked Diaphragms[d]	
	Type	Minimum penetration in framing (mm.)				Fastener spacing at diaphragm boundaries (all cases), at continuous panel edges parallel to load (Cases 3 and 4) and at all panel edges (Cases 5 and 6) (mm)[e]							Fastener spacing at 150 mm centers at supported edges	
						150	100		65[f]		50[f]			
						Spacing per line at other panel edges (mm.)							Case 1	Cases 2, 3 4, 5, and 6
						150	150	100	100	75	75	50		
Structural I	6d common	32	9.5	50	1	3.5	4.7	---	7.1	---	8.0	---	3.1	2.4
				75	1	4.0	5.3	---	8.0	---	9.0	---	3.5	2.7
	8d common	35	9.5	50	1	5.1	6.8	---	10.1	---	11.4	---	4.6	3.4
				75	1	5.7	7.6	---	11.4	---	12.8	---	5.0	3.8
	10d[g] common	38	12	50	1	6.1	8.1	---	12.1	---	13.8	---	5.4	4.1
				75	1	6.8	9.1	---	13.7	---	15.6	---	6.1	4.6
	10d[g] common	38	18	75	2	---	12.3	16.5	17.8	23.3	---	---	---	---
				100	2	---	14.3	18.6	20.5	26.8	---	---	---	---
				100	3	---	17.8	24.8	26.1	34.1	---	---	---	---
	14 gauge staples	50	18	75	2	---	11.4	11.4	15.9	17.1	19.7	22.8	---	---
				100	3	---	15.9	17.1	21.6	25.6	27.3	34.1	---	---
Sheathing, single floor and other grades covered in Ref. 9-10 and 9-11	6d common	32	9.5	50	1	3.5	4.7	---	7.1	---	8.0	---	3.3	2.4
				75	1	4.0	5.3	---	8.0	---	9.0	---	3.5	2.7
	8d common	35	9.5	50	1	4.6	6.1	---	9.1	---	10.3	---	4.1	3.0
				75	1	5.1	6.8	---	10.2	---	11.6	---	4.6	3.4
			11	50	1	4.8	6.5	---	10.9	---	10.9	---	4.4	3.2
				75	1	5.4	7.2	---	12.2	---	12.2	---	4.8	3.6
			12	50	1	5.1	6.9	---	10.1	---	11.4	---	4.5	3.4
				75	1	5.7	7.6	---	11.4	---	12.8	---	5.0	3.8
	10d[g] common	38	12	50	1	5.5	7.3	---	10.9	---	12.4	---	4.8	3.6
				75	1	6.2	8.2	---	12.3	---	13.9	---	5.5	4.1
			15	50	1	6.1	8.1	---	12.1	---	13.8	---	5.4	4.1
				75	1	6.8	9.1	---	13.7	---	15.6	---	6.1	4.6
			18	75	2	---	12.2	16.5	17.7	23.2	---	---	---	---
				100	2	---	14.2	18.6	20.4	26.5	---	---	---	---
				100	3	---	17.7	24.8	26.4	28.6	---	---	---	---
	14 gauge staples	50	18	75	2	---	11.4	11.4	15.6	17.1	19.4	22.8	---	---
				100	3	---	15.6	17.1	21.2	25.6	26.6	28.6	---	---

NOTES for TABLE 12.4.3-1b

[a] $\lambda = 1.0$ $\varphi = 0.65$

[b] *l/w* shall not be more than 4/1 for blocked diaphragms or more than 3/1 for unblocked diaphragms. For framing members of other species set forth in ASCE 16, Table 12A, with the range of specific gravity (SG) noted, allowable shear values shall be calculated for all panel grades by multiplying the values from the table above for nail size and actual panel grade by the following factor:

Specific Gravity Adjustment Factor = (1-(0.5 - SG)), Where SG = Specific Gravity of the framing lumber. This adjustment factor shall not be greater than 1.

[c] Space nails along intermediate framing members at 300 mm centers except where spans are greater than 810 mm; space nails at 150 mm centers.

[d] Blocked values are permitted to be used for 28.5 mm panels with tongue-and-groove edges where 25 mm by 9 mm crown by No. 16 gauge staples are driven through the tongue-and-groove edges 9 mm. from the panel edge so as to penetrate the tongue. Staples shall be spaced at one half the boundary nail spacing for Cases 1 and 2 and at one third the boundary nail spacing for Cases 3 through 6.

[e] Maximum shear for Cases 3 through 6 is limited to 22.8 kiloNewtons per meter.

[f] For values listed for 50 mm nominal framing member width, the framing members at adjoining panel edges shall be 75 mm nominal width. Nails at panel edges shall be placed in two lines at these locations.

[g] Framing at adjoining panel edges shall be 75 mm nominal or wider and nails shall be staggered where 10d nails having penetration into framing of more than 41 mm are spaced 75 mm or less on center.

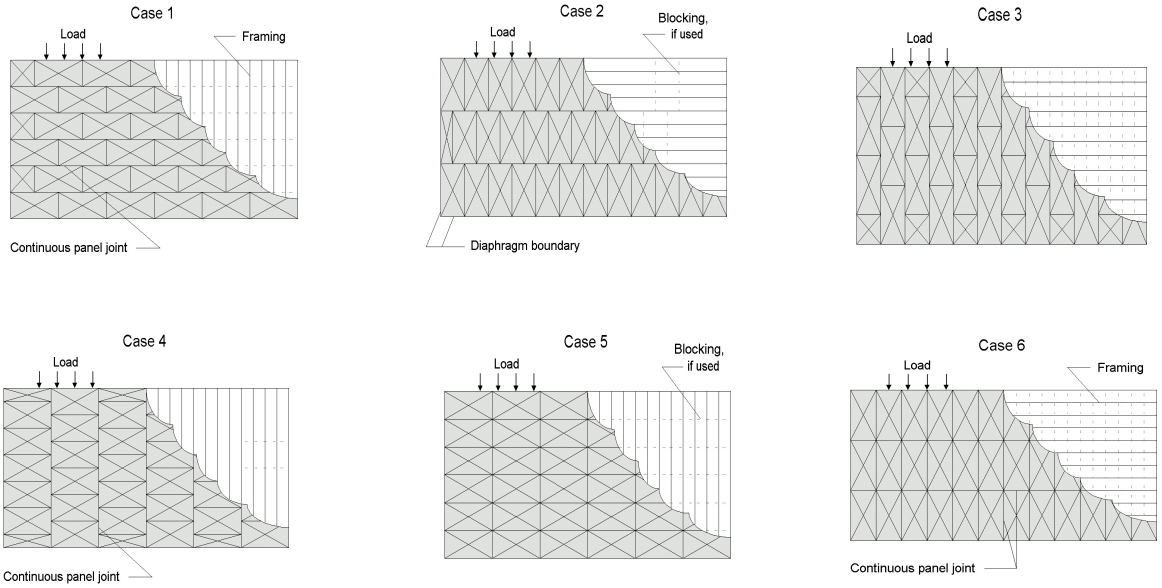

TABLE 12.4.3-2a Factored Shear Resistance in Kips per Foot (KLF) for Seismic Forces on Structural Use Panel Shear Walls with Framing Members of Douglas Fir-Larch or Southern Pine[a,b,c]

Panel Grade	Nail Size (Common or Hot-Dipped Galvanized Box)	Minimum Penetration in Framing (in.)	Panel Thickness (in.)	Panel Applied Direct to Framing Nail Spacing at Panel Edges (in.)				Nail Size (Common or Hot-Dipped Galvanized Box)	Panel Applied Over 1/2 in. or 5/8 in. Gypsum Sheathing Nail Spacing at Panel Edges (in.)			
				6	4	3	2[d]		6	4	3	2[d]
Structural I	6d	1-1/4	3/8	0.26	0.39	0.51	0.66	8d	0.26	0.39	0.51	0.66
	8d	1-3/8	3/8	0.30[f]	0.47[f]	0.60[f]	0.79[f]	10d[e]	0.30[f]	0.47[f]	0.60[f]	0.79[f]
	8d	1-3/8	7/16	0.33[f]	0.51[f]	0.66[f]	0.87[f]	10d[e]	0.33[f]	0.51[f]	0.66[f]	0.87[f]
	8d	1-3/8	15/32	0.36	0.56	0.72	0.95	10d[e]	0.36[f]	0.56[f]	0.72[f]	0.95[f]
	10d[e]	1-1/2	15/32	0.44	0.66	0.86	1.13		-	-	-	-
	14 ga staple	2	3/8	0.19	0.29	0.39	0.58		-	-	-	-
	14 ga staple	2	7/16	0.27	0.40	0.53	0.80		-	-	-	-
Sheathing, Panel Siding and Other Grades Covered in References 9.10 and 9.11	6d	1-1/4	3/8	0.26	0.39	0.51	0.66	8d	0.26	0.39	0.51	0.66
	8d	1-3/8	3/8	0.29[f]	0.42[f]	0.53[f]	0.69[f]	10d[e]	0.29[f]	0.42[f]	0.53[f]	0.69[f]
	8d	1-3/8	7/16	0.31[f]	0.46[f]	0.59[f]	0.76[f]	10d[e]	0.31[f]	0.46[f]	0.59[f]	0.76[f]
	8d	1-3/8	15/32	0.34	0.49	0.64	0.83	10d[e]	0.34[f]	0.49[f]	0.64[f]	0.83[f]
	10d[e]	1-1/2	15/32	0.40	0.60	0.78	1.00		-	-	-	-
	10d[e]	1-1/2	19/32	0.44	0.66	0.86	1.13		-	-	-	-
	14 ga staple	2	3/8	0.17	0.25	0.33	0.50		-	-	-	-
	14 ga staple	2	7/16	0.23	0.36	0.47	0.70		-	-	-	-
	14 ga staple	2	15/32	0.27	0.40	0.53	0.80		-	-	-	-
	(Hot- Dipped Galvanized Casing Nail)							(Hot-Dipped Galvanized Casing Nail)				
Panel Siding as Covered in Reference 9.10	6d	1-1/4	3/8	0.18	0.27	0.36	0.47	8d	0.18	0.27	0.36	0.47
	8d	1-3/8	3/8	0.21	0.31	0.40	0.53	10d[e]	0.21	0.31	0.40	0.53

NOTES for TABLE 12.4.3-2a

[a] $\lambda = 1.0 \quad \phi = 0.65$

[b] All panel edges backed with 2-inch nominal or wider framing. Panels installed either horizontally or vertically. Space nails at 6 in. on center along intermediate framing members for 3/8-in. panels installed with strong axis parallel to studs spaced 24 in. on center and 12 in. on center for other conditions and panel thicknesses. Allowable shear values for fasteners in framing members of other species set forth in Table 12A of ASCE 16 shall be calculated for all grades by multiplying the values by the following factors: 0.82 for species with a specific gravity greater than or equal to 0.42 but less than 0.49 ($0.42 \leq G < 0.49$) and 0.65 for species with a specific gravity less than 0.42 ($G < 0.42$). For panel siding using hot-dipped galvanized casing nails, the shear values shall be the values in the table multiplied by the same factors.

[c] Where panels are applied on both faces of a wall and nail spacing is less than 6 inches on center on either side, panel joints shall be offset to fall on different framing members or framing shall be 3-inch nominal or wider and nails on each side of joint shall be staggered.

[d] Framing at adjoining panel edges shall be 3-in. nominal or wider and nails shall be staggered where nails are spaced 2 in. on center.

[e] Framing at adjoining panel edges shall be 3-in. nominal or wider and nails shall be staggered where 10d nails having penetration into framing of more than 1-5/8 in. are spaced 3 in. or less on center.

[f] The values for 3/8-in. and 7/16-in. panels applied directly to framing are permitted to be increased to the values shown for 15/32-in. panels provided studs are spaced a maximum of 16 in. on center or panel is applied with strong axis across studs.

TABLE 12.4.3-2b Factored Shear Resistance in kiloNewtons per Meter (kN/m) for Seismic Forces on Structural Use Panel Shear Walls with Framing Members of Douglas Fir-Larch or Southern Pine[a,b,c]

Panel Grade	Nail Size (Common or Hot-Dipped Galvanized Box)	Minimum Penetration in Framing (mm)	Panel Thickness (mm)	Panel Applied Direct to Framing Nail Spacing at Panel Edges (mm)				Nail Size (Hot-Dipped Common or Galvanized Box)	Panel Applied Over 12.7 mm or 15.9 mm Gypsum Sheathing Nail Spacing at Panel Edges (mm)			
				150	100	75	50		150	100	75	50[d]
Structural I	6d	32	9.5	3.8	5.7	7.4	9.7	8d	3.8	5.7	7.4	9.7
	8d	35	9.5	4.4f	6.8f	8.7f	11.6f	10d[e]	4.4	6.8	8.7	11.6
	8d	35	11	4.8f	7.5f	9.6f	12.7f	10d[e]	4.8	7.5	9.6	12.7
	8d	35	12	5.3	8.2	10.4	13.8	10d[e]	5.3	8.2	10.4	13.8
	10d[e]	38	12	6.5	9.7	12.6	16.5		-	-	-	-
	14 ga staple	50	9.5	2.8	4.3	5.7	8.4		-	-	-	-
	14 ga staple	50	11	3.9	5.8	7.8	11.7		-	-	-	-
Sheathing, Panel Siding and Other Grades Covered in References 9.10 and 9.11	6d	32	10	3.8	5.7	7.4	9.7	8d	3.8	5.7	7.4	9.7
	8d	35	10	4.2f	6.1f	7.8f	10.1f	10d[e]	4.2	6.1	7.8	10.1
	8d	35	11	4.6f	6.6f	8.5f	11.1f	10d[e]	4.6	6.6	8.5	11.1
	8d	35	12	4.9	7.2	9.3	12.1	10d[e]	4.9	7.2	9.3	12.1
	10d[e]	38	12	5.9	8.7	11.4	14.6		-	-	-	-
	10d[e]	38	15	6.5	9.7	12.6	16.5		-	-	-	-
	14 ga staple	50	9.5	2.5	3.7	4.8	7.3		-	-	-	-
	14 ga staple	50	11	3.4	5.2	6.8	10.2		-	-	-	-
	14 ga staple	50	12	3.9	5.8	7.8	11.7		-	-	-	-
Panel Siding as Covered in Reference 9.10	(Hot-Dipped Galvanized Casing Nail)							(Hot-Dipped Galvanized Casing Nail)				
	6d	32	9.5	2.7	4.0	5.2	6.8	8d	2.7	4.0	5.2	6.8
	8d	35	9.5	3.0	4.6	5.9	7.8	10d[e]	3.0	4.6	5.9	7.8

NOTES for TABLE 12.4.3-2b

[a] $\lambda = 1.0 \quad \varphi = 0.65$

[b] All panel edges backed with 38 mm nominal or wider framing. Panels installed either horizontally or vertically. Space nails at 150 mm on center along intermediate framing members for 9 mm panels installed with strong axis parallel to studs spaced 610 mm on center and 305 mm on center for other conditions and panel thicknesses. Allowable shear values for fasteners in framing members of other species set forth in Table 12A of ASCE 16 shall be calculated for all grades by multiplying the values by the following factors: 0.82 for species with a specific gravity greater than or equal to 0.42 but less than 0.49 ($0.42 \leq G < 0.49$) and 0.65 for species with a specific gravity less than 0.42 ($G < 0.42$). For panel siding using hot-dipped galvanized casing nails, the shear values shall be the values in the table multiplied by the same factors.

[c] Where panels are applied on both faces of a wall and nail spacing is less than 610 mm on center on either side, panel joints shall be offset to fall on different framing members or framing shall be 64 mm or wider and nails on each side of joint shall be staggered.

[d] Framing at adjoining panel edges shall be 64 mm or wider and nails shall be staggered where nails are spaced 50 mm on center.

[e] Framing at adjoining panel edges shall be 64 mm or wider and nails shall be staggered where 10d nails having penetration into framing of more than 41 mm are spaced 76 mm or less on center.

[f] The values for 9 mm and 11 mm panels applied directly to framing are permitted to be increased to the values shown for 12 mm panels provided studs are spaced a maximum of 406 mm on center or panel is applied with strong axis across studs.

TABLE 12.5.1-1 Conventional Light-Frame Construction Braced Wall Requirements

Seismic Performance Category	Maximum Distance Between Braced Walls	Maximum Number of *Stories Above Grade* Permitted [a]
A[b]	35 ft (10675 mm)	3
B	35 ft (10675 mm)	3
C	25 ft (7625 mm)	2
D and E (Seismic Use Group I)	25 ft (7625 mm)	1 [c]
E (Seismic Use Group II) and F	Conventional construction not permitted; conformance with Sec. 12.3 required.	

[a] A cripple stud wall is considered to be a *story above grade*. Maximum bearing wall height shall not exceed 10 ft (3050 mm)

[b] See exceptions to Sec. 1.2.1.

[c] Detached one- and two-family dwellings are permitted to be two *stories above grade*.

TABLE 12.5.2-1 Conventional Light-Frame Construction Braced Wall Requirements in Minimum Length of Wall Bracing per Each 25 Lineal Feet (7625 mm) of Braced Wall Line[a]

Story Location	Sheathing Type[b]	$0.125 \le S_{DS} < 0.25$	$0.25 \le S_{DS} < 0.375$	$0.375 \le S_{DS} < 0.50$	$0.50 \le S_{DS} < 0.75$	$0.75 \le S_{DS} < 1.0$[e]
Top or only *story above grade*	G-P[d]	8 ft 0 in. (2440 mm)	8 ft 0 in. (2440 mm)	10 ft 8 in. (3250 mm)	14 ft 8 in. (4470 mm)	18 ft 8 in.[c] (5690 mm)
	S-W	4 ft 0 in. (1220 mm)	4 ft 0 in. (1220 mm)	5 ft 4 in. (1625 mm)	8 ft 0 in. (2440 mm)	9 ft 4 in.[c] (2845 mm)
Story below top *story above grade*	G-P[d]	10 ft 8 in (3250 mm)	14 ft 8 in. (4470 mm)	18 ft 8 in.[c] (6590 mm)	NP	NP
	S-W	5 ft 4 in. (1625 mm)	6 ft 8 in. (2030 mm)	10 ft 8 in.[c] (3250 mm)	13 ft 4 in.[c] (4065 mm)	17 ft 4 in.[c] (5280 mm)
Bottom story of 3 *stories above grade*	G-P[d]	14 ft 8 in. (4470 mm)	Conventional construction not permitted; conformance with Sec. 12.3 required.			
	S-W	8 ft 0 in. (2440 mm)				

[a] Minimum length of panel bracing of one face of wall for S-W sheathing or both faces of wall for G-P sheathing; *h/w* ratio shall not exceed 2/1, except *structures* in *Seismic Design Category* B need only meet the requirements of Sec. 602.9 of the CABO Code. For S-W panel bracing of the same material on two faces of the wall, the minimum length is permitted to be one half the tabulated value but the *h/w* ratio shall not exceed 2/1 and design for uplift is required.

[b] G-P = gypsumboard, fiberboard, particleboard, lath and plaster, or gypsum sheathing boards; S-W = structural-use panels and diagonal wood sheathing. NP = not permitted.

[c] Applies to one- and two-family detached dwellings only.

[d] Nailing shall be as follows:
For ½ in. (13 mm) gypsum board, 5d (0.086 in., 2.2 mm diameter) coolers at 7 in. (178 mm) centers;
For e in. (16mm) gypsum board, 6d (0.092 in. (2.3 mm) diameter) at 7 in (178 mm) centers;
For gypsum sheathing board, 1¾ in. long by 7/16 in. (44 by 11 mm) head, diamond point galvanized at 4 in. (100mm) centers;
For gypsum lath, No. 13 gauge (0.092 in., 2.3 mm) by 1 c in. long, 19/64 in. (29 by 7.5 mm) head, plasterboard at 5 in. (125 mm) centers;
For Portland cement plaster, No. 11 gauge (0.120 in., 3 mm) by 1½ in. long, 7/16 in. head (89 by 11 mm) at 6 in. (150 mm) centers;
For fiberboard and particleboard, No. 11 gauge (0.120 in., 3 mm) by 1½ in. (38 mm) long, 7/16 in. (11 mm) head, galvanized at 3 in. (76 mm) centers.
For structural wood sheathing, the minimum nail size and maximum spacing shall be in accordance with the minimum nails size and maximum spacing allowed for each thickness sheathing in Tables 12.4.3-2a and b.

Nailing as specified above shall occur at all panel edges at studs, at top and bottom plates, and, where occurring, at blocking.

[e] Where $S_{DS} > 1.0$, conventional construction is not permitted.