CHAPTER 22

STEEL

SECTION 2201 GENERAL

2201.1 Scope: The provisions of this chapter shall govern the materials, quality, design, fabrication and erection of steel used structurally in buildings or structures.

SECTION 2202 DEFINITIONS AND NOMENCLATURE

2202.1 Definitions: The following words and terms shall, for the purposes of this chapter and as used elsewhere in this code, have the meaning shown herein.

ADJUSTED SHEAR RESISTANCE. In Type II shear walls, the unadjusted shear resistance multiplied by the shear resistance adjustment factors of Table 2211.3.

STEEL CONSTRUCTION, COLD-FORMED: That type of construction made up entirely, or in part, of steel structural members cold formed to shape from sheet or strip steel such as roof deck, floor and wall panels, studs, floor joists, roof joists and other structural elements.

STEEL JOIST. Any steel structural member of a building or structure made of hot-rolled or cold-formed solid or open-web sections, or riveted or welded bars, strip or sheet steel members, or slotted and expanded, or otherwise deformed rolled sections.

STEEL MEMBER, STRUCTURAL: Any steel structural member of a building or structure consisting of a rolled steel structural shape other than cold-formed steel, or steel joist members.

TYPE I SHEAR WALL. A wall designed to resist in-plane lateral forces that is fully sheathed and provided with hold-down anchors at each end of the wall segment. Type I walls are permitted to have openings where detailing for force transfer around the openings is provided (see Figure 2202.1).

TYPE II SHEAR WALL. A wall designed to resist in-plane lateral forces that is sheathed with wood structural panel or sheet steel that contains openings, that have not been specifically designed and detailed for force transfer around wall openings. Hold-down anchors for Type II shear walls are only required at the ends of the wall (see Figure 2202.1).

TYPE II SHEAR WALL SEGMENT. A section of shear wall with full-height sheathing and which meets the aspect ratio limits of Section 2211.3.2(3).

UNADJUSTED SHEAR RESISTANCE. In Type II walls, the unadjusted shear resistance is based on the design shear and the limitations of Section 2211.3.1.

2202.2 Nomenclature: The following symbols shall, for the purposes of this chapter and as used elsewhere in this code, have the meaning shown herein.

ϕ = Resistance factor (Section 2211.6).

Ω = Factor of safety (Section 2211.6).

Ω_O = System overstrength factor (see Section 1615).

C_o = Shear resistance adjustment factor from Table 2211.3.

ΣL_i = Sum of widths of Type II shear wall segments, feet (mm/1,000).

C = Compression chord uplift force, lbs (kN).

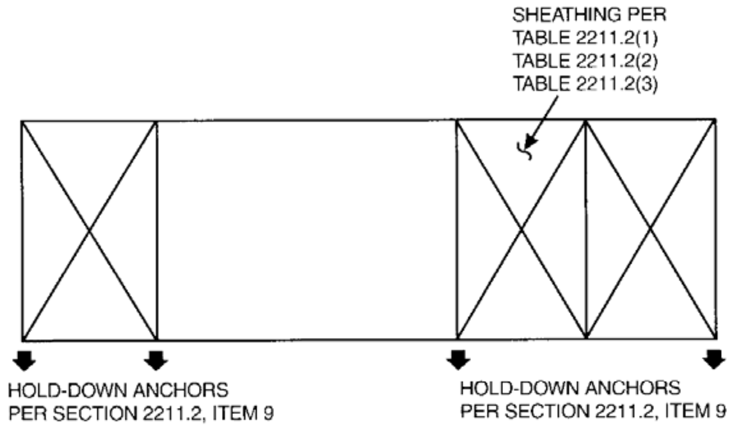
V = Shear force in Type II shear wall, lbs (kN).

h = The height of a shear wall or wall pier measured as:

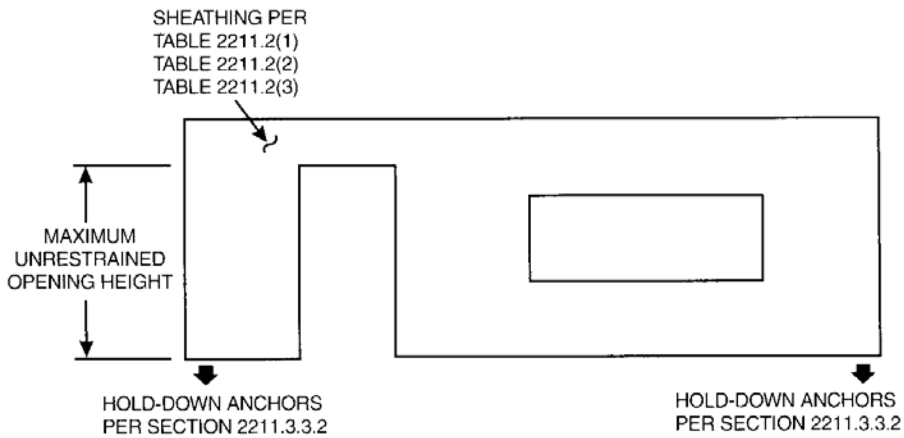
1. For a shear wall, the maximum clear height from top of foundation to bottom of diaphragm framing above or, the maximum clear height from top of a diaphragm to bottom of diaphragm framing above.
2. For a wall pier, the clear height of the shortest adjacent opening

v = Unit shear force, plf (kN/m).

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



TYPE 1 SHEAR WALL



TYPE II SHEAR WALL

FIGURE 2202.1
TYPE I AND TYPE II SHEAR WALLS

SECTION 2203 IDENTIFICATION

2203.1 Identification: Steel furnished for structural load-carrying purposes shall be properly identified for conformity to the ordered grade in accordance with the specified ASTM standard or other specification and the provisions of this chapter. Steel that is not readily identifiable as to grade from marking and test records shall be tested to determine conformity to such standards.

SECTION 2204 – NOT USED

SECTION 2205 STRUCTURAL STEEL

2205.1 General: The design, fabrication and erection of structural steel for buildings and structures shall be in accordance with either AISC-LRFD, AISC 335 or AISC-HSS. Where required, the seismic design of steel structures shall be in accordance with the additional provisions of Section 2205.3.

2205.2 Shop drawings: Complete shop drawings shall be prepared in compliance with the best modern practice in advance of the actual fabrication. Such drawings shall clearly distinguish between shop and field rivets, bolts and welds in all connections and details, and shall also clearly identify steel grades, bolt types and sizes, weld types and sizes, locations and dimensions and all information necessary for proper fabrication and installation of the steel members.

2205.3 Seismic requirements for steel structures. The design of structural steel structures to resist seismic forces shall be in accordance with the provisions of Section 2205.3 for the appropriate seismic design category. Seismic Design Categories A, E and F are not applicable in Massachusetts. The provisions of AISC 341 are fully applicable to all structural steel structures in Massachusetts, regardless of Seismic Design Category, except as noted otherwise in Section 2205.3.

2205.3.1 Seismic Design Category B or C. Structural steel structures assigned to Seismic Design Category B or C in accordance with Section 1615 shall be of any construction permitted in MA Table 9.5.2.2 of Section 1615. An *R* factor as set forth in MA Table 9.5.2.2 of Section 1615 for the appropriate steel system is permitted where the structure is designed and detailed in accordance with the provisions of AISC 341, Parts I and III. Systems not detailed in accordance with the above shall comply with the requirements for "8. Structural Steel Systems Not Specifically Detailed For Seismic Resistance" in MA Table 9.5.2.2 of Section 1615, and the connections resisting seismic forces shall be designed for two times the computed forces and moments resulting from seismic load in combination with other loads, as applicable.

2205.3.2 Seismic Design Category D. Structural steel structures assigned to Seismic Design Category D shall be designed and detailed in accordance with AISC 341, Part I.

2205.3.3 Special Concentric Braced Frames: The following revisions to AISC 341 shall apply to Part I Section 13 Special Concentric Braced Frames (SCBF):

13.2 Bracing Members

13.2a Slenderness

Bracing members shall have $Kl/r \leq 4\sqrt{E_s/F_y}$

Exception: Braces with $4\sqrt{E_s/F_y} < Kl/r \leq 200$ are permitted in frames in which the available strength of the column is at least equal to the maximum load transferred to the column considering R_y (LRFD) or $(1/1.5)R_y$ (ASD), as appropriate, times the nominal strength of the connecting brace elements of the building. Column forces need not exceed those determined by inelastic analysis, nor the maximum load effects that can be developed by the system.

13.4a V-Type and Inverted-V-Type Bracing. Revise clause (4) as follows:

(4) Both flanges of the beam shall be laterally braced, with a maximum spacing of $L_b = L_{pd}$, as specified by Equations F1-17 and F1-18 of the AISC LRFD Specification. Lateral bracing shall meet the provisions of Section C3.4a Lateral Bracing, for Nodal Bracing, using $C_d = 1.0$, of the AISC LRFD Specification. As a minimum, one set of lateral braces is required at the point of intersection of the V-type (or Inverted-V-type) bracing, unless the beam has sufficient out-of-plane strength and stiffness to insure stability between adjacent brace points.

2205.3.4 Ordinary Concentric Braced Frames. The following revisions to AISC 341 shall apply to Part I Section 14 Ordinary Concentric Braced Frames (OCBF).

14.2 Strength Delete existing text and replace with the following:

14.2 Bracing Members Bracing members shall meet the requirements of Section 8.2.

Exception: HSS braces that are filled with concrete need not comply with this provision.

Bracing members in V, or inverted-V configurations shall have $Kl/r \leq 4\sqrt{E_s/F_y}$.

14.3 Add new paragraph as follows:

14.3 Special Bracing Configuration Requirements

K-Type braced frames are not permitted for OCBF.

Beams in V-type and inverted-V-type OCBF shall be continuous at bracing connections away from the beam-column connection and shall meet the following requirements:

(1) The required strength shall be determined based on the load combinations of the applicable building code assuming that the braces provide no support of dead and live loads. For load combinations that include earthquake effects, the earthquake effect, E, on the member shall be determined as follows:

(a) The forces in braces in tension shall be assumed to be equal to $R_yF_yA_g$. For V-type and inverted-V-type OCBF, the forces in braces in tension need not exceed the maximum force that can be developed by the system.

(b) The forces in braces in compression shall be assumed to be equal to $0.3P_n$.

(2) Both flanges of the beam shall be laterally braced, with a maximum spacing of $L_b = L_{pd}$, as specified by Equations F1-17 and F1-18 of the AISC LRFD Specification. Lateral bracing shall meet the provisions of Section C3.4a Lateral Bracing, for Nodal Bracing, using C_d=1.0, of the AISC LRFD Specification. As a minimum, one set of lateral braces is required at the point of intersection of the V-type (or inverted-V-type) bracing ,unless the beam has sufficient out-of-plane strength and stiffness to insure stability between adjacent brace points.

14.4 Add new paragraph as follows:

14.4 Bracing Connections

The required strength of bracing connections shall be determined as follows:

(1) For the limit state of bolt slip, the required strength of bracing connections shall be that determined using the load combinations stipulated by the applicable building code, not including the amplified seismic load.

(2) For other limit states, the required strength of bracing connections is the expected yield strength, in tension, of the brace, determined as $R_yF_yA_g$. (LRFD) or $R_yF_yA_g$./1.5 (ASD), as appropriate.

Exception: The required strength of the brace connection need not exceed either of the following:

(a) The maximum force that can be developed by the system.

(b) A load effect based upon using the amplified seismic load.

2205.4 Seismic requirements for composite construction. The design, construction and quality of composite steel and concrete components that resist seismic forces shall conform to the requirements of the AISC LRFD and ACI 318. The design of such systems shall also conform to the requirements of AISC 341, Part II.

2205.4.1 Seismic Design Category D. Composite structures are permitted in Seismic Design Category D, subject to the limitations in Section 1615, where substantiating evidence is provided to demonstrate that the proposed system will perform as intended by AISC 341, Part II. The substantiating evidence shall be subject to building official approval. Where composite elements or connections are required to sustain inelastic deformations, the substantiating evidence shall be based on cyclic testing.

SECTION 2206 STEEL JOISTS

2206.1 General: The design, manufacturing and use of open web steel joists and joist girders shall be in accordance with one of the following Steel Joist Institute specifications.

1. Standard Specifications for Open Web Steel Joists, K Series.
2. Standard Specifications for Longspan Steel Joists, LH Series, DLH Series, and SLH Series.
3. Standard Specifications for Joist Girders.

Where steel joists and/or joist girders are part of the building's seismic load resisting system, the provisions of Section 2205.3 or 2211 shall apply.

SECTION 2207 STEEL CABLE STRUCTURES

2207.1 General: The design, fabrication, and erection including related connections, and protective coatings of steel cables for buildings shall be in accordance with ASCE 19.

2207.2 Seismic Requirements for Steel Cable: The design strength of steel cables shall be determined by the provisions of ASCE 19 except as modified by these provisions.

1. A load factor of 1.1 shall be applied to the prestress force included in T_3 and T_4 as defined in Section 3.12.
2. In Section 3.2.1, Item (c) shall be replaced with "1.5 T3" and Item (d) shall be replaced with "1.5 T_4".

SECTION 2208 STEEL STORAGE RACKS

2208.1 Storage racks. The design, testing and utilization of industrial steel storage racks shall be in accordance with the *RMI Specification for the Design, Testing and Utilization of Industrial Steel Storage Racks*. Racks in the scope of this specification include industrial pallet racks, movable shelf racks and stacker racks, and does not apply to other types of racks, such as drive-in and drive-through racks, cantilever racks, portable racks or rack buildings. The seismic design of storage racks shall be in accordance with the provisions of Section 9.6.2.9 of ASCE 7.

SECTION 2209 COLD-FORMED STEEL

2209.1 General: The design of cold-formed carbon and low alloy steel structural members shall be in accordance with the *North American Specification for the Design of Cold-Formed Steel Structural Members* (AISI-NASPEC. The design of cold-formed stainless steel structural members shall be in accordance with ASCE 8. Cold-formed steel light-framed construction shall comply with Section 2209.

2209.2 Composite slabs on steel decks: Composite slabs of concrete and steel deck shall be designed and constructed in accordance with ASCE 3.

2209.3 Seismic Requirements for Steel Deck Diaphragms. The provisions of ASCE 7 Section A9.8.7 are applicable.

2209.4 Protection: Formed steel shall be protected in accordance with Section 2209.4.1 through 2209.4.4.

2209.4.1 Shop Coat: All individual structural members and assembled panels of light gage and formed steel construction, except where fabricated of approved corrosion-resistant metallic steel or of steel having a corrosion-resistant or other approved coating, shall be protected against corrosion with an approved shop coat of paint, enamel or other approved protection.

2209.4.2 Field Coat: After erection where directly exposed to the weather, except where encased in concrete made of non-corrosive aggregates, or where fabricated of approved corrosion-resistant steel, or of galvanized or otherwise adequately protected steel, individual structural members and assembled panels of light gage and formed steel construction shall be given an additional coat of approved protection.

2209.4.3 Siding: Exposed siding or sheeting shall be fabricated of approved corrosion-resistant steel or otherwise protected at the ground level for sufficient height above grade as determined by the depth of average snowfall in the locality, but not less than eight inches (203 mm).

2209.4.4 Protection at Exterior Walls: Floor or roof construction which extends into an exterior wall shall be adequately waterproofed and protected from the weather to prevent corrosion.

2209.5 Tests: Where not capable of design by engineering analysis, tests of the individual or assembled structural units and the connections shall be performed as prescribed in Sections 1626 and 1629.

2209.6 Identification: Each structural member, siding panel, and roof panel of a metal building system, other than hardware items such as bolts, nuts, washers, shims, and rivets, shall be identified by the manufacturer. The identification shall include the manufacturer's name or logo, and the part number or part name consistent with assembly instructions.

SECTION 2210 COLD-FORMED STEEL LIGHT-FRAMED CONSTRUCTION

2210.1 General. The design, installation and construction of cold-formed carbon or low-alloy steel, structural and nonstructural steel framing, shall be in accordance with the *Standard for Cold-Formed Steel Framing—General Provisions, American Iron and Steel Institute* (AISI-General) *and* AISI-NASPEC.

2210.2 Headers. The design and installation of cold-formed steel box and back-to-back headers, and double L-headers used in single-span conditions for load-carrying purposes shall be in accordance with the *Standard for Cold-Formed Steel Framing—Header Design*, American Iron and Steel Institute (AISI-Header), subject to the limitations therein.

2210.3 Trusses. The design, quality assurance, installation and testing of cold-formed steel trusses shall be in accordance with the *Standard for Cold-Formed Steel Framing–Trusses*, American Iron and Steel Institute (AISI-Truss), subject to the limitations therein.

SECTION 2211 COLD-FORMED STEEL LIGHT-FRAMED SHEAR WALLS

2211.1 General. In addition to the requirements of Section 2210, the design of cold-formed steel light-framed shear walls, to resist wind and seismic loads shall be in accordance with the requirements of Section 2211.2 for Type I (segmented) shear walls or Section 2211.3 for Type II (perforated) shear walls.

The lateral design of light-framed structures for seismic forces shall also comply with the requirements in Section 2211.4.

2211.2 Type I shear walls. The design of Type I shear walls, of cold-formed steel light-framed construction, to resist wind and seismic loads, shall be in accordance the requirements of this section.

1. The nominal shear value for Type I shear walls, as shown in Table 2211.2(1) for wind loads, Table 2211.2(2) for wind or seismic loads or Table 2211.2(3) for seismic loads, is permitted to establish allowable shear values or design shear values.

2. Boundary members, chords, collectors and connections thereto shall be proportioned to transmit the induced forces.

3. Type I shear walls sheathed with wood structural or sheet steel panels are permitted to have window openings, between hold-down anchors at each end of a wall segment, where details are provided to account for force transfer around openings.

4. The aspect ratio limitations of Section 2211.2.2, Item 5, shall apply to the entire Type I segment and to each wall pier at the side of each opening.

5. The height of the wall pier (*h*) shall be defined as the clear height of the pier at the side of an opening.

6. The width of a pier (*w*) shall be defined as the sheathed width of the pier.

7. The width of wall piers shall not be less than 24 inches (102 mm).

8. Hold-down anchors shall be provided at each end of a Type I shear wall capable of resisting the design forces.

2211.2.1 Design shear determination. Where allowable stress design (ASD) is used, the allowable shear value shall be determined by dividing the nominal shear value, shown in Tables 2211.2(1), 2211.2(2) and 2211.2(3), by a factor of safety (Ω) of 2.5.

Where load and resistance factor design (LRFD) is used, the design shear value shall be determined by multiplying the nominal shear value, shown in Tables 2211.2(1), 2211.2(2) and 2211.2(3), by a resistance factor (Φ) of 0.55.

2211.2.2 Limitations for systems. The lateral-resistant systems listed in Tables 2211.2(1), 2211.2(2) and 2211.2(3) shall conform to the following requirements:

1. Studs shall be a minimum $1^{5}/_{8}$ inches (41.3 mm) by $3^{1}/_{2}$ inches (89 mm) with a $^{3}/_{8}$-inch (9.5 mm) return lip. As a minimum, studs shall be doubled (back to back) at shear wall ends.

2. Track shall be a minimum $1^{1}/_{4}$ inches (31.8 mm) by $3^{1}/_{2}$ inches (89 mm).

3. Both studs and track shall have a minimum uncoated base metal thickness of 20 gage and shall be of the following grades of structural quality steel: ASTM A 653 SS Grade 33, ASTM A 792 SS Grade 33 or ASTM A 875 SS Grade 33.

4. Fasteners along the edges in shear panels shall be placed not less than $^{3}/_{8}$ inch (9.5 mm) in from panel edges.

5. The height-to-width shear wall aspect ratio (*h/w*) of wall systems shall not exceed the values in Tables 2211.2(1), 2211.2(2) and 2211.2(3). Where the limiting ratio of *h/w* is greater than 2:1, the shear values shall be multiplied by 2*w/h*.

6. Panel thicknesses shown are minimums. Panels less than 12 inches (305 mm) wide shall not be used. All panel edges shall be fully blocked.

7. Where horizontal strap blocking is used to provide edge blocking, it shall be a minimum $1^{1}/_{2}$ inches (38 mm) wide and of the same material and equal or greater thickness as the track and studs.

8. The design shear values for shear panels with different nominal shear values applied to the same side of a wall are not cumulative except as permitted in Tables 2211.2(1), 2211.2(2) and 2211.2(3). For walls with material applied to both faces of the same wall, the design shear value of material of the same capacity is cumulative. Where the material nominal shear values are not equal, the design shear value shall be either two times the design shear value of the material with the smaller values or shall be taken as the value of the stronger side, whichever is greater. Summing shear values of dissimilar material applied to opposite faces or to the same wall line is not allowed unless permitted by Table 2211.2.1.

2211.2.2.1 Sheet steel sheathing. Steel sheets, attached to cold-formed steel framing, are permitted to resist horizontal forces produced by wind or seismic loads.

1. Steel sheets shall have a minimum base metal thickness as shown in Table 2211.2(1) or 2211.2(3), and shall be of the following grades of structural quality steel: ASTM A653 SS Grade 33, ASTM A792 SS Grade 33 or ASTM A 875 SS Grade 33.

2. Nominal shear values, used to establish the allowable shear value or design shear value, are given in Tables 2211.2(1) for wind loads and 2211.2(3) for seismic loads.

3. Steel sheets are permitted to be applied either parallel or perpendicular to framing. All edges of steel sheets shall be attached to framing members, strap blocking or shall be overlapped and attached to each other with screw spacing as required for edges.

4. Screws used to attach steel sheets shall be a minimum No. 8 modified truss head.

2211.2.2.2 Wood structural panel sheathing. Cold-formed steel framed wall systems, sheathed with wood structural panels, are permitted to resist horizontal forces produced by wind or seismic loads subject to the following:

1. Nominal shear values, used to establish the allowable shear value or design shear value, are given in Tables 2211.2(1), for wind loads, and 2211.2(3), for seismic loads.

2. Wood structural panels shall be either plywood or oriented strand board (OSB), as defined in Chapter 23 or its references, shall comply with DOC PS 1 or PS 2 and shall be manufactured using exterior glue.

3. Wood structural panels shall be attached to steel framing with flat-head self-drilling tapping screws with a minimum head diameter of 0.292 inch (8 mm).

4. Where $^{7}/_{16}$-inch oriented strand board (OSB) is specified, $^{15}/_{32}$-inch structural 1 sheathing (plywood) is permitted.

5. Structural panels are permitted to be applied either parallel or perpendicular to framing.

6. Increases of the nominal loads shown in Tables 2211.2(1) and 2211.2(3) shall not be permitted for duration of load as permitted in Chapter 23.

2211.2.2.3 Gypsum board panel sheathing. Cold-formed steel framed wall systems, sheathed with gypsum board, are permitted to resist horizontal forces produced by wind or seismic loads subject to the following:

1. Nominal shear values, used to establish the allowable shear value or design shear value, are given in Table 2211.2(2).

2. The shear values listed in Table 2211.2(2) shall not be cumulative with the shear values of other materials applied to the same wall unless otherwise permitted herein.

3. The nominal shear values shown are for gypsum board that is applied to both sides of the wall.

4. Where gypsum board is only applied to one side of the wall, the nominal shear values shall be taken as one-half of the value shown.

5. Where gypsum board is applied perpendicular to studs, end joints of adjacent courses of gypsum board sheets shall not occur over the same stud.

6. Screws used to attach gypsum board shall be a minimum No. 6 in accordance with ASTM C 954.

7. The minimum uncoated thickness of light gage framing for shear walls shall be 0.0359 inches.
8. The building shall not be more than 35 feet in height.
9. The shear walls shall not provide lateral load resistance for more than three framed levels (floors or roof). In this context, a pitched roof shall be considered a "level." Where attics are habitable, the pitched roof and attic floor shall be considered separate levels.
10. The location of the shear walls shall be limited to exterior walls, fire walls or fire partitions.
11. The building is not in Seismic Use Group III.
12. The dead load of each level (floor or roof), supported laterally by the shear walls, shall not be more than 25 psf. Where attics are not habitable, the dead load of a pitched roof shall include the dead load of the attic floor.

2211.2.2.4 Sheathing of other materials: Cold-formed steel-framed wall systems sheathed with other than steel sheet sheathing, plywood, OSB, or gypsum board panel sheathing shall not be used to resist horizontal forces produced by wind or seismic loads.

TABLE 2211.2(1)
NOMINAL SHEAR VALUES FOR WIND FORCES IN POUNDS PER FOOT FOR SHEAR WALLS FRAMED WITH COLD-FORMED STEEL STUDS[a]

ASSEMBLY DESCRIPTION	MAXIMUM HEIGHT/LENGTH RATIO *h/w*	FASTENER SPACING AT PANEL EDGES[b] (inches)				MAXIMUM FRAMING SPACING (inches o.c.)
		6	4	3	2	
$^{15}/_{32}$-inch structural 1 sheathing (4-ply) plywood one side	2:1	1,065[c]	—	—	—	24
$^{7}/_{16}$-inch rated sheathing (OSB), one side	2:1	910[c]	1,410	1,735	1,910	24
$^{7}/_{16}$-inch rated sheathing (OSB), one side, oriented perpendicular to framing	2:1	1,020[c]	—	—	—	24
$^{7}/_{16}$-inch rated sheathing (OSB), one side	4:1[d]	—	1,025	1,425	1,825	24
0.018-inch steel sheet, one side	2:1	485	—	—	—	24
0.027-inch steel sheet, one side	4:1[d]	—	1,000	—	—	24

For SI: 1 inch = 25.4 mm, 1 pound per foot = 14.5939 N/m.

a. Nominal shear values shall be multiplied by the resistance factor φ to determine design strength or divided by the safety factor Ω to determine allowable shear values as set forth in Section 2211.2.1.

b. Screws shall be attached to intermediate supports at 12 inches on center unless otherwise shown.

c. Where fully blocked gypsum board is applied to the opposite side of this assembly, in accordance with Table 2211.2(2) with screw spacing at 7 inches o.c. edge and 7 inches o.c. field, these nominal values are permitted to be increased by 30 percent.

d. Where aspect ratio (*h/w*) is greater that 2:1, the design shear shall be reduced as required by Section 2211.2.2, item 5.

TABLE 2211.2(2)
NOMINAL SHEAR VALUES FOR WIND AND SEISMIC FORCES IN POUNDS PER FOOT FOR SHEAR WALLS FRAMED WITH COLD-FORMED STEEL STUDS AND FACED WITH GYPSUM BOARD[a,b]

WALL CONSTRUCTION	MAXIMUM HEIGHT/LENGTH RATIO *h/w*	ORIENTATION	SCREW SPACING (inches)		NOMINAL SHEAR VALUE (plf)
			Edge	Field	
$^{1}/_{2}$-inch gypsum board on both sides of wall; Studs maximum 24 inches o.c.	2:1	Gypsum board applied perpendicular to framing with strap blocking behind the horizontal joint and with solid blocking between the first two end studs	7	7	585
			4	4	850

For SI: 1 inch = 25.4 mm, 1 pound per foot = 14.5939 N/m.

a. Nominal shear values shall be multiplied by the resistance factor φ to determine design strength or divided by the safety factor Ω to determine allowable shear values as set forth in Section 2211.2.1.

b. Walls resisting seismic loads shall be subject to the limitations in Section ~~1617.6~~ 1615.

TABLE 2211.2(3)
NOMINAL SHEAR VALUES FOR SEISMIC FORCES IN POUNDS PER FOOT FOR SHEAR WALLS FRAMED WITH COLD-FORMED STEEL STUDS[a]

ASSEMBLY DESCRIPTION	MAXIMUM HEIGHT/LENGTH RATIO *h/w*	FASTENER SPACING AT PANEL EDGES[b] (inches)				MAXIMUM FRAMING SPACING (inches o.c.)
		6	4	3	2	
$^{15}/_{32}$-inch Structural 1 Sheathing (4-ply) plywood one side	2:1[c]	780	990	1,465	1,625	24
$^{15}/_{32}$-inch Structural 1 Sheathing (4-ply) plywood one side; end studs 0.043 inch minimum thickness	2:1	—	—	1,775	2,190	24
$^{15}/_{32}$-inch Structural 1 Sheathing (4-ply) plywood one side; all studs and track 0.043 inch minimum thickness	2:1	890	1,330	1,775	2,190	24
$^{7}/_{16}$-inch OSB one side	2:1[c]	700	915	1,275	1,625	24
$^{7}/_{16}$-inch OSB one side end studs, 0.043 inch minimum thickness	2:1	—	—	1,520	2,060	24
0.018-inch minimum thickness steel sheet one side	2:1	390	—	—	—	24
0.027-inch minimum thickness steel sheet one side	2:1[c]	—	1,000	1,085	1,170	24

For SI: 1 inch = 25.4 mm, 1 pound per foot = 14.5939 N/m.

a. Nominal shear values shall be multiplied by the resistance factor φ to determine design strength or divided by the safety factor Ω to determine allowable shear values as set forth in Section 2211.2.1.

b. Screws shall be attached to intermediate supports at 12 inches o.c. unless otherwise shown.

c. In Seismic Design Category A, B and C the aspect ratio (h/w) is permitted to be 4:1 where the design shear is reduced as required by Section 2211.2.2, item 5.

2211.3 Type II shear walls. Type II (Perforated) shear walls sheathed with wood structural panels or sheet steel are permitted to resist wind and seismic loads when designed in accordance with this section. Type II walls shall meet the requirements for Type I walls except as revised by this section.

2211.3.1 Limitations. The following limitations shall apply to the use of Type II shear walls:

1. A Type II shear wall segment, meeting the minimum aspect ratio (*h/w*) of Section 2211.3.2, Item 3, shall be located at each end of a Type II shear wall. Openings shall be permitted to occur beyond the ends of the Type II shear wall; however, the width of such openings shall not be included in the width of the perforated shear wall.

2. The nominal shear values shall be based upon edge screw spacing not less than 4 inches o.c.

3. A Type II 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.

4. Collectors for shear transfer shall be provided through the full length of the Type II shear wall.

5. A Type II shear wall shall have uniform top of wall and bottom of wall elevations. Type II shear walls not having uniform elevations shall be designed by other methods.

6. Type II shear wall height, *h*, shall not exceed 20 feet (6096 mm).

2211.3.2 Type II shear wall resistance. The Type II shear wall resistance shall be equal to the adjusted shear resistance multiplied by the sum of the widths (ΣL_i) of the perforated shear wall segments and shall be calculated in accordance with the following:

1. Percent full-height sheathing. The percent of full-height sheathing shall be calculated as the sum of widths (ΣL_i) of Type II shear wall segments divided by the total width of the Type II shear wall including openings.

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*.

3. Unadjusted shear resistance. The unadjusted shear resistance shall be the design shear values calculated in accordance with Section 2211.2.1 based upon the values in Tables 2211.2(1) and 2211.2(3). The aspect ratio of all Type II shear wall segments used in calculations shall not exceed 2:1.

Exception: Where permitted by Tables 2211.2.1(1) and 2211.2(3), the aspect ratio (*h/w*) of Type II wall segments greater than 2:1, but in no case greater than 4:1, is permitted to be included in the calculation of the unadjusted shear resistance for the wall, provided the values are multiplied by 2*w/h*.

4. Adjusted shear resistance. The adjusted shear resistance shall be calculated by multiplying the unadjusted shear resistance by the shear resistance adjustment factors of Table 2211.3. For intermediate percentages of full-height sheathing, the values are permitted to be determined by interpolation.

2211.3.3 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.

2211.3.3.1 Anchorage for in-plane shear. The unit shear force ,*v*, transmitted into the top and out of the base of the Type II shear wall full-height sheathing segments, and into collectors (drag struts) connecting shear wall segments, shall be calculated in accordance with the following:

$v = V/C_o \Sigma L_i$ (Equation 22-1)

where:

v = Unit shear force, plf (kN/m).

V = Shear force in Type II shear wall, lbs (kN).

C_o = Shear resistance adjustment factor from Table 2211.3.

ΣL_i = Sum of widths of Type II shear wall segments, feet (mm/1,000).

2211.3.3.2 Uplift anchorage at Type II shear wall ends. Anchorage for uplift forces due to overturning shall be provided at each end of the Type II shear wall. Where seismic loads govern, the uplift anchorage shall be determined in accordance with the requirements of Section 2211.4.3.

2211.3.3.3. Uplift anchorage between perforated shear wall ends. In addition to the requirements of Section 2211.3.3.1, 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 Section 2211.3.3.1.

2211.3.3.4. Compression chords. Vertical elements at 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:

$C = Vh/C_o \Sigma L_i$ (Equation 22-2)

where:

C = Compression chord uplift force, lbs (kN).

V = Shear force in Type II shear wall, lbs (kN).

h = Shear wall height feet, (mm/1,000).

C_o = Shear resistance adjustment factor from Table 2211.3.

ΣL_i = Sum of widths of Type II shear wall segments, feet (mm/1,000).

2211.3.3.5. Load path. A load path to the foundation shall be provided for the uplift shear and compression forces as determined from Sections 2211.3.3.1 through 2211.3.3.4, inclusive. Elements resisting shear wall forces contributed by multiple stories shall be designed for the sum of forces contributed by each story.

TABLE 2211.3
SHEAR RESISTANCE ADJUSTMENT FACTOR—C_o

WALL HEIGHT (*h*)	MAXIMUM OPENING HEIGHT RATIO[a] AND HEIGHT				
	h/3	h/2	2h/3	5h/6	h
8′0″	2′8″	4′0″	5′4″	6′8″	8′0″
10′0″	3′4″	5′0″	6′8″	8′4″	10′0″
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 Section 2211.3.2(2).
b. See Section 2211.3.2(1).

2211.4 Additional seismic design provisions.

2211.4.1 General. In addition to the requirements of Sections 2211.2 and 2211.3, light-framed cold-formed steel wall systems, that resist seismic loads, shall comply with the requirements of this section.

2211.4.2 Connections. Connections for diagonal bracing members, top chord splices, boundary members and collectors shall be designed to develop the lesser of the nominal tensile strength of the member or the design seismic force multiplied by the seismic overstrength factor, Ω_o, from Section 1615. The pull-out resistance of screws shall not be used to resist design seismic forces.

2211.4.3 Anchorage of braced wall segments. Studs or other vertical boundary members at the ends of wall segments, that resist seismic loads, braced with either sheathing or diagonal braces, shall be anchored such that the bottom track is not required to resist uplift by bending of the track web. Both flanges of the studs shall be braced to prevent lateral torsional buckling. Studs or other vertical boundary members and anchorage thereto shall have the nominal strength to resist design seismic force multiplied by the seismic overstrength factor, Ω_o, from Section 1615.

2211.4.4 Sheet steel sheathing. Where steel sheathing provides lateral resistance, the design and construction of such walls shall be in accordance with the additional requirements of this section. Perimeter members at openings shall be provided and shall be detailed to distribute the shearing stresses. Wall studs and track shall have a minimum uncoated base metal thickness of 33 mils (0.84 mm) and shall not have an uncoated base metal thickness greater than 48 mils (1.10 mm). The nominal shear value for light-framed wall systems shall be based upon values from Table 2211.2(3).

2211.4.5 Wood structural panel sheathing. Where wood structural panels provide lateral resistance, the design and construction of such walls shall be in accordance with the additional requirements of this section. Perimeter members at openings shall be provided and shall be detailed to distribute the shearing stresses. Wood sheathing shall not be used to splice these members. Wall studs and track shall have a minimum uncoated base metal thickness of 33 mils (0.84 mm) and shall not have an uncoated base metal thickness greater than 48 mils (1.10 mm). The nominal shear value for light-framed wall systems shall be based upon values from Table 2211.2(3).

2211.4.6 Diagonal bracing. Where diagonal bracing is provided for lateral resistance, provisions shall be made for pretensioning or other methods of installing tension-only bracing shall be used to guard against loose diagonal straps. The *l/r* of the brace is permitted to exceed 200.

SECTION 2212 CAST-STEEL CONSTRUCTION

2212.1 Materials: Steel casting for building construction shall be cast from steel conforming to AISC 335 or AISC LRFD. All castings shall be free from injurious blow holes or other defects which will impair the structural strength.