

## CHAPTER 22

# STEEL

### SECTION BC 2201 GENERAL

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

### SECTION BC 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.

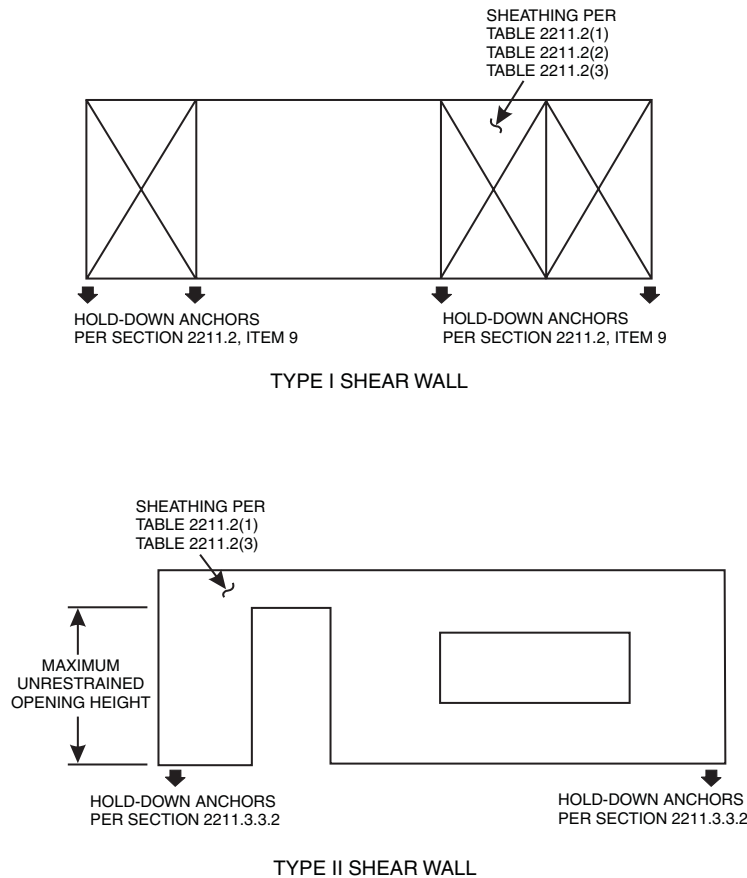
**STEEL CONSTRUCTION, COLD-FORMED.** That type of construction made up entirely or in part of steel structural members cold formed to shape from sheet or strip steel such as roof deck, floor and wall panels, studs, floor joists, roof joists and other structural elements.

**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).



**FIGURE 2202.1**  
**TYPE I AND TYPE II SHEAR WALLS**

**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 meanings shown herein.

$\phi$  = Resistance factor (see Section 2211.2.1).

$\Omega$  = Factor of safety (see Section 2211.2.1).

$\Omega_o$  = System over-strength factor (see Section 1617.6).

$C_o$  = Shear resistance adjustment factor from Table 2211.3.

$\Sigma L_i$  = 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 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 a diaphragm to bottom of diaphragm framing above.

$\gamma$  = 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.

tion shall be applied thoroughly and evenly to dry surfaces which have been cleaned of loose mill scale, loose rust, weld slag flux deposit, dirt, and other foreign matter. Oil and grease deposits shall be removed. Surfaces inaccessible after assembly shall be treated as required by this section prior to assembly. Structural steel that will remain exposed to the weather or to a corrosive atmosphere shall receive an additional coat of metal protection of another color after erection, except for types of structural steels that have been specifically intended for use under exposure to the weather without protection. All abrasions to, or deteriorations of, the protective coating shall be spot painted.

**Exceptions:** Surfaces of structural steel shall not be required to receive metal protection when the structural steel is used under the conditions listed below. However, these surfaces shall be cleaned of oil and grease by solvent cleaners and be cleaned of dirt and other foreign material by thorough brushing with a fiber brush.

1. Structural steel that is encased in concrete (other than cinder concrete) or surfaces that abut concrete (other than cinder concrete) at interior locations.
2. Structural steel encased in noncorrosive fire-resistant materials that are bonded or secured to the steel surfaces by approved means.
3. Surfaces of structural steel that are to be riveted, bolted or welded together; provided, however, that parts of structural members left unpainted because of welding, bolting or riveting operations are not exempted from painting and shall receive a field application of approved metal protection.
4. Surfaces of structural steel within 2 inches (51 mm) of field welds shall be free of protective coatings that would prevent proper welding or produce objectionable fumes while welding is being done.
5. Surfaces of structural steel that have been machine finished.
6. Surfaces of types of structural steel that have been specifically approved for use without metal protection.
7. Structural steel members that are completely concealed by interior finish such as lath and plaster, and masonry, need not be painted except that where such members are subject to condensation from piping, are in shower or steam rooms, are exposed to chemical fumes or are exposed to other conditions of potentially aggressive corrosion.

## SECTION BC 2203 IDENTIFICATION AND PROTECTION OF STEEL FOR STRUCTURAL PURPOSES

**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.

**2203.2 Protection.** Painting of structural steel shall comply with the requirements contained in either the *AISC Load and Resistance Factor Design Specification for Structural Steel Buildings* (AISC-LRFD), *AISC Specification for Structural Steel Buildings—Allowable Stress Design* (AISC 335) or *AISC Specification for the Design of Steel Hollow Structural Sections* (AISC-HSS). Individual structural members and assembled panels of cold-formed steel construction, except where fabricated of approved corrosion-resistant steel or of steel having a corrosion-resistant or other approved coating, shall be protected against corrosion with an approved coat of paint, enamel or other approved protection.

**2203.2.1 Protection of structural steel.** All structural steel shall receive one coat of paint, zinc, or bituminous coating, or equivalent metal protection before erection. The protec-

## SECTION BC 2204 CONNECTIONS

**2204.1 Welding.** The details of design, workmanship and technique for welding, inspection of welding and qualification of welding operators shall conform to the requirements of the specifications listed in Sections 2205, 2206, 2207, 2209 and 2210. Special inspection of welding shall be provided where required by Section 1704.

**2204.1.1 Tack welds.** Tack welds, which are later incorporated into finished welds carrying calculated stress, shall not be considered as structural welds.

**2204.2 Bolting.** The design, installation and inspection of bolts shall be in accordance with the requirements of the specifications listed in Sections 2205, 2206, 2209 and 2210. Special inspection of the installation of high-strength bolts shall be provided where required by Section 1704.

**2204.2.1 Anchor rods.** Anchor rods shall be set accurately to the pattern and dimensions called for on the plans. The protrusion of the threaded ends through the connected material shall be sufficient to fully engage the threads of the nuts, but shall not be greater than the length of the threads on the bolts.

## SECTION BC 2205 STRUCTURAL STEEL

**2205.1 General.** The design, fabrication and erection of structural steel for buildings and structures shall be in accordance with either the 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 2205.2.

**2205.1.1 Structural steel.** Material for use as structural steel not listed in AISC-LRFD and AISC 335 may be used in accordance with AISC-LRFD and AISC 335 when approved by the commissioner for such use.

**2205.2 Seismic requirements for steel structures.** The design of structural steel structures to resist seismic forces shall be in accordance with the provisions of Section 2205.2.1 or 2205.2.2 for the appropriate seismic design category.

**2205.2.1 Seismic Design Category B or C.** Structural steel structures assigned to Seismic Design Category B or C, in accordance with Section 1616, shall be of any construction permitted in Section 2205. An *R* factor as set forth in Section 1617.6 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 use the *R* factor in Section 1617.6 designated for “steel systems not detailed for seismic.”

Prequalified moment connections detailed in FEMA 350 (FEMA 2000a) may be considered as prequalified with regard to AISC 341 requirements for Special Moment Frames (SMFs), Intermediate Moment Frames (IMF's), and link-to-column connections of Eccentrically Braced Frames (EBFs)‡.

**2205.2.2 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 or Part III.

**2205.3 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. An *R* factor as set forth in Section 1617.6 for the appropriate composite steel and concrete system is permitted where the structure is

designed and detailed in accordance with the provisions of AISC 341, Part II. In Seismic Design Category B or above, the design of such systems shall conform to the requirements of AISC 341, Part II.

**2205.3.1 Seismic Design Category D.** Composite structures are permitted in Seismic Design Categories D, subject to the limitations in Section 1617.6, 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 the commissioner's approval. Where composite elements or connections are required to sustain inelastic deformations, the substantiating evidence shall be based on cyclic testing.

**2205.4 Composite members.** In addition to the provisions for composite members in Referenced Standards AISC-LRFD and AISC 335, the following provisions shall be used:

**2205.4.1 Heavy vehicle loads.** Composite construction used for members subject to heavy vehicle loads (excluding passenger cars), shall be designed for moving loads and shall be proportioned in accordance with the requirements for Highway Bridges, AASHTO HB-16 REV 02, *Standard Specification for Highway Bridges*.

**2205.4.2 Concrete encased beams.** Where the design strength of concrete-encased structural steel beams is determined from the plastic stress distribution of the structural steel beam alone in accordance with AISC-LRFD or from AISC 335 where the allowable bending stress of the structural steel beam alone is used, the yield stress of the structural steel shall not exceed 36 ksi (250 Mpa), the steel beam depth shall not exceed 40 inches (1016 mm), the concrete compressive strength shall not be less than 3,000 psi (20 685 kPa) and the concrete aggregate shall conform with ASTM C33.

**2205.4.3 Special cases.** Where special cases for composite construction are considered in accordance with AISC-LRFD and AISC 335, test programs shall be satisfactory to the commissioner.

**2205.5 Ponding.** In addition to the provisions of AISC-LRFD and AISC 335, in flat roof systems [slope less than 1 degree (0.02 rad)] where secondary members are made up of members of materials other than steel, the depth of the structural steel members shall not be less than  $f_b/600$  times the span length whether designed as simple or continuous.  $f_b$  shall be taken as the computed bending stress of the structural steel member.

**2205.6 Fabrication, erection and quality control.** In addition to the provisions for fabrication, erection and quality control in AISC-LRFD and AISC 335, the following provisions shall be used.

**2205.6.1 Shop drawings.** Shop drawings shall include the location of oversized, short slotted and long slotted holes.

**2205.6.2 Field connections.** Field connections shall meet the requirements for corresponding types of shop connections described in AISC-LRFD and AISC 335. No holes, copes or cuts of any type shall be made to facilitate erection unless specifically shown on the shop drawings or authorized in writing by the engineer or architect of record.

**2205.6.3 Handling and storing materials.** All structural steel members shall be shipped and handled in a manner that will not cause injury to protective coatings or permanent deformations of the members. Structural steel members shall not be dropped, thrown, or dragged. Any bends, crimps or other evidence of permanent deformations shall be straightened by methods approved by the engineer or architect of record or the piece shall be rejected. Materials shall be stored out of contact with the ground, kept clean, and protected against damage and corrosion.

#### 2205.6.4 Structural steel erection.

**2205.6.4.1 Placing of structural members.** During the placing of a structural member, the load shall not be released from the hoisting rope until the member is securely supported.

Open web steel joists that are hoisted singly shall be transferred from their place of storage directly to their permanent location and safely secured. No load shall be placed on open web steel joists until they are permanently fastened in place.

**2205.6.4.2 Tag lines.** While structural members or assemblies are being hoisted, tag lines shall be used to prevent uncontrolled movement.

**2205.6.4.3 Erection of trusses.** All trusses shall be laterally braced or guyed as necessary for the safety of the structure.

**2205.6.4.4 Erection of frames.** All structural frames shall be properly braced with shores or guyed cables and turnbuckles as necessary for the safety of the structure.

**2205.6.4.5 Permanent flooring and steel erection in tiered buildings.** The permanent floors of such buildings or other structures shall be installed as soon as possible as the erection of structural steel members progresses. In no case shall there be more than eight stories, floors or equivalent levels or 120 feet (36 576 mm), whichever is less, between the erection floor and the uppermost permanent floor.

### SECTION BC 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 and Deep Longspan Steel joists, DLH Series.*
3. *Standard Specifications for Joist Girders.*

Where required, the seismic design of buildings shall be in accordance with the additional provisions of Section 2205.2 or 2211.

**2206.2 Painting.** Open web steel joists shall be painted. The shop coat shall be applied at the place of manufacture. All abrasions shall be touched up at the job site with the same material.

Steel joists that remain exposed to the weather or a corrosive atmosphere shall receive an additional coat of metal protection of another color after erection, except for types of structural steels that have been specifically approved for use under exposure to the weather without metal protection.

**2206.3 Limitations of use.** Open web steel joists shall be prohibited in high-rise buildings until the commissioner promulgates rules establishing minimum acceptable fireproofing methods.

### SECTION BC 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.

**2207.1.1 Protection of steel cables.** The minimum protection of all wires or strands used in building structures shall be a Class "A" coating as defined in ASTM A 586 and ASTM A 603, whether the cable is used on the interior or exterior.

**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 T3 and T4 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 T4"

### SECTION BC 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. Where required, the seismic design of storage racks shall be in accordance with the provisions of Section 9.6.2.9 of ASCE 7.

### SECTION BC 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 2210.

#### 2209.1.1 Other steels.

1. Cold-formed steel not listed in the *North American Specification for the Design of Cold-formed Steel Structural Members* (AISI-NASPEC) may be used in

accordance with AISI-NASPEC when approved by the commissioner for such use.

2. Cold-formed stainless steel not listed in ASCE 8 may be used in accordance with ASCE 8 when approved by the commissioner for such use.

**2209.1.2 Load tests.** The load test requirements of Chapter 17 shall apply in lieu of the load test procedures of Chapter 6.2 of ASCE 8 and Chapter F of AISI-NASPEC.

**2209.1.3 Fabrication and erection.**

1. All materials shall be flat, clean and straight. If straightening or flattening is necessary, it shall be done by a suitable process or method and in a manner that will not injure the material.
2. Profiles used structurally shall conform to the specified dimension. Care shall be taken not to stretch, bend, or otherwise distort parts of the sections unless such forming is an integral part of the design.
3. Components may be cut by slitting, shearing, sawing, or flame cutting. All punched holes and sheared or flame cut edges of material in members subject to calculated stress shall be clean and free from notches and burred edges.
4. Care shall be taken to avoid damage when loading, unloading, and handling members.

**2209.1.4 Special inspection.** The use of cold-formed steel for structural purposes shall be subject to the requirements of special inspection in accordance with Chapter 17.

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

## SECTION BC 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 BC 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.

Light-framed structures assigned to Seismic Design Category B, in accordance with Section 1616, shall be of any construction permitted in Section 2210. An  $R$  factor as set forth in Section 1617.6 for the appropriate steel system is permitted where the lateral design of the structure is in accordance with the provisions of Section 2211.4. Systems not detailed in accordance with Section 2211.4 shall use the  $R$  factor in Section 1617.6 designated for “steel systems not detailed for seismic.”

In Seismic Design Category D, the lateral design of light-framed structures 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 strength values.
2. Boundary members, chords, collectors and connections thereto shall be proportioned to transmit the induced forces.
3. As an alternative to the values in Tables 2211.2(1), 2211.2(2) and 2211.2(3), shear values are permitted to be calculated by the principles of mechanics by using approved fastener values and shear values appropriate for the sheathing material attached.
4. 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.
5. 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.
6. The height of the wall pier ( $h$ ) shall be defined as the clear height of the pier at the side of an opening.
7. The width of a pier ( $w$ ) shall be defined as the sheathed width of the pier.
8. The width of wall piers shall not be less than 24 inches (610 mm).
9. Hold-down anchors shall be provided at each end of a Type I shear wall capable of resisting the design forces.

**TABLE 2211.2(1)**  
**NOMINAL SHEAR VALUES FOR WIND FORCES IN POUNDS PER FOOT FOR SHEAR WALLS**  
**FRAMED WITH COLD-FORMED STEEL STUDS<sup>a</sup>**

ASSEMBLY DESCRIPTION	MAXIMUM HEIGHT/LENGTH RATIO $h/w$	FASTENER SPACING AT PANEL EDGES <sup>b</sup> (inches)				MAXIMUM FRAMING SPACING (inches o.c.)
		6	4	3	2	
<sup>15</sup> / <sub>32</sub> -inch structural 1 sheathing (4-ply) plywood one side	2:1	1,065 <sup>c</sup>	—	—	—	24
<sup>7</sup> / <sub>16</sub> -inch rated sheathing (OSB), one side	2:1	910 <sup>c</sup>	1,410	1,735	1,910	24
<sup>7</sup> / <sub>16</sub> -inch rated sheathing (OSB), one side, oriented perpendicular to framing	2:1	1,020 <sup>c</sup>	—	—	—	24
<sup>7</sup> / <sub>16</sub> -inch rated sheathing (OSB), one side	4:1 <sup>d</sup>	—	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 <sup>d</sup>	—	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 ( $\phi$ ) to determine design strength or divided by the safety factor ( $\Omega$ ) 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 than 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<sup>a,b</sup>**

WALL CONSTRUCTION	MAXIMUM HEIGHT/LENGTH RATIO $h/w$	ORIENTATION	SCREW SPACING (inches)		NOMINAL SHEAR VALUE (plf)
			Edge	Field	
<sup>1</sup> / <sub>2</sub> -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 ( $\phi$ ) to determine design strength or divided by the safety factor ( $\Omega$ ) 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.

**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 ( $\Phi$ ) of 2.5.

Where load and resistance factor design (LRFD) is used, the design strength 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 ( $\Omega$ ) 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 <sup>1</sup>/<sub>8</sub> inches (41 mm) by <sup>3</sup>/<sub>2</sub> inches (89 mm) with a <sup>3</sup>/<sub>8</sub>-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 <sup>1</sup>/<sub>4</sub> inches (32 mm) by <sup>3</sup>/<sub>2</sub> inches (89 mm).

- 3. Both studs and track shall have a minimum uncoated base metal thickness of 33 mils (0.84 mm) 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 <sup>3</sup>/<sub>8</sub> 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  $2w/h$ .
- 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 <sup>1</sup>/<sub>2</sub> 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 A 653 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 strength 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 strength value, are given in Tables 2211.2(1), for wind loads, and 2211.2(3), for seismic loads.
2. Wood structural panels 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 (7.4 mm).
4. Where 7/16-inch (11.1 mm) oriented strand board (OSB) is specified, 15/32-inch (12 mm) structural 1 sheathing (plywood) is permitted.

**TABLE 2211.2(3)  
NOMINAL SHEAR VALUES FOR SEISMIC FORCES IN POUNDS PER FOOT FOR SHEAR WALLS  
FRAMED WITH COLD-FORMED STEEL STUDS<sup>a</sup>**

ASSEMBLY DESCRIPTION	MAXIMUM HEIGHT/LENGTH RATIO h/w	FASTENER SPACING AT PANEL EDGES <sup>b</sup> (inches)				MAXIMUM FRAMING SPACING (inches o.c.)
		6	4	3	2	
15/32-inch Structural 1 Sheathing (4-ply) plywood one side	2:1 <sup>c</sup>	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 <sup>c</sup>	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 <sup>c</sup>	—	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 ( $\phi$ ) to determine design strength or divided by the safety factor ( $\Omega$ ) 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.

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 strength 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. Walls resisting seismic loads shall be subject to the limitations in Section 1617.6.

**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 Type II shear wall.
2. In Seismic Design Categories B, C, and D, the nominal shear values shall be based upon edge screw spacing not less than 4 inches (102 mm) 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 Type II 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 ( $\Sigma L_i$ ) of the Type II 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 ( $\Sigma L_i$ ) of Type II shear wall segments divided by the total width of the Type II shear wall including openings.

**TABLE 2211.3  
SHEAR RESISTANCE ADJUSTMENT FACTOR— $C_s$**

WALL HEIGHT ( $h$ )	MAXIMUM OPENING HEIGHT RATIO <sup>a</sup> 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 <sup>b</sup>	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

For SI: 1 inch = 25.4 mm. 1 foot = 304.8 mm.

a. See Section 2211.3.2, Item 2.

b. See Section 2211.3.2, Item 1.

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) 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  $2w/h$ .

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 Type II 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:

$$v = \frac{V}{C_o \Sigma L_i} \quad \text{(Equation 22-1)}$$

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.
- $\Sigma L_i$  = 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 Type II shear wall ends.** In addition to the requirements of Section 2211.3.3.1, Type II 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 Type II shear wall segment shall be designed for a compression force,  $C$ , from each story calculated in accordance with the following:

$$C = \frac{Vh}{C_o \Sigma L_i} \quad \text{(Equation 22-2)}$$

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.
- $\Sigma L_i$  = 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.

#### 2211.4 Seismic Design Category D.

**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, in buildings assigned to Seismic Design Category D, 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,  $\Omega_o$ , from Section 1617.6. 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,  $\Omega_o$ , from Section 1617.6.

**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 for buildings in Seismic Design

Category D 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 for buildings in Seismic Design Category D 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.

**2211.4.7 Gypsum board panel sheathing.** Gypsum board panel sheathing is permitted to resist seismic loads, subject to the limitations in Table 2211.2(2) and Section 1617.6.

## SECTION BC 2212 MINIMUM THICKNESS OF METAL

**2212.1 General.** All steel of Chapter 22 shall conform to the minimum thickness of metal in accordance with Section 2212.2.

**2212.2 Exterior members.** All exterior structural steel members exposed to weather shall have a minimum thickness of metal of 0.23 inches (5.8 mm).

### Exceptions:

1. When an approved type of atmospheric corrosion-resistant steel is used.
2. Exposed surfaces are zinc coated with a minimum weight of coating of approximately 0.6 ounces per square foot (0.00156 kg/m<sup>2</sup>) of exposed surface and covered with a protective coating as required by Section 2203.2.
3. Exposed surfaces are protected by other means approved by the commissioner.
4. Temporary construction that will be in place for a period of 1 year or less, provided that all surfaces which are exposed to the weather shall have a protective coating as required by Section 2203.2.
5. Joists or purlins that are exposed to the weather but which do not support more than 200 square feet (19 m<sup>2</sup>) of floor or roof area, and which have a protective coating as required by Section 2203.2.

## SECTION BC 2213 STRUCTURAL INTEGRITY REQUIREMENTS

**2213.1 General.** Steel structures shall be designed to meet all of the requirements of this section. However, details provided for gravity, seismic and wind forces and for other purposes may be regarded as forming part of, or the whole of, these requirements. Detailing provided for one requirement may be counted towards the other requirements.

### Exceptions:

1. One-story structures less than 5,000 square feet (465 m<sup>2</sup>) not to exceed 15 feet (4572 mm) in height.
2. Structures in Group R-3 occupancy not more than three stories in height.

**2213.2 Continuity and ties.** The following requirements shall be met:

1. All bolted connections shall have at least two bolts.
2. Bolted connections of all columns, beams, braces and other structural elements that are part of the lateral load resisting system shall be designed as bearing-type connections with pretensioned bolts or as slip critical connections.
3. End connections of all beams and girders shall have a design axial tension strength equal to the larger of the provided vertical shear strength of the connections at either end, but not less than 10 kips (45 kN). For the design of the connections, the shear force and the axial tensile force need not be considered to act simultaneously. For the purpose of this provision, a connection shall be considered compliant if it meets the following requirements:

- 3.1. For single plate shear connections, the nominal axial tension strength shall be determined for the limit state of bolt bearing, where deformation is not a consideration, on the plate and beam web.
- 3.2. For single angle and double angle shear connections, the nominal tension strength shall be determined for the limit state of bolt bearing, where deformation is not a consideration, on the angles and beam web and for tension yielding on the gross area of the angles.
- 3.3. All other connections shall be designed for the required tension force in accordance with either  $\phi$  AISC-LRFD, AISC 335, or AISC-HSS.

For the purpose of meeting this integrity provision only, bolts in connections with short-slotted holes parallel to the direction of the tension force are permitted. For the purpose of checking bearing, these bolts shall be assumed to be located at the end of the slots.

4. Elements and their connections that brace compression members shall have an available axial tension strength equal to at least 2 percent of the required strength of the compression member being braced, but not less than 10 kips (45 kN). For design of the connections, the shear force and the axial tension force need not be considered to act simultaneously. Where more than one element

braces a compression member in one direction, all elements and connections shall have an available axial tension strength equal to at least 1 percent of the required strength of the compression member but not less than 10 kips (45 kN).

**2213.2.1 Vertical ties.** Column splices shall have an available tension strength at least equal to the largest design gravity load reaction applied to the column at any floor level located within four floors below the splice.

**2213.3 Composite construction.** For steel framing members and/or decking acting compositely with concrete slabs, the following requirements shall be met:

1. Shear studs shall not be less than  $\frac{1}{2}$  inch (12.7 mm) in diameter. The spacing of shear studs shall not be greater than one every 12 inches (305 mm) averaged over the length of the beam.
2. Connections at the discontinuous edges of permanent metal decking to supporting members shall have a minimum connection strength in the direction parallel to the rib of the deck equal to the shear strength of a  $\frac{3}{4}$ -inch (19.1 mm) puddle weld every 12 inches (305 mm) on center.
3. Side lap connections of permanent metal decking shall have a minimum strength equal to the strength of a button punch every 24 inches (610 mm) on center.
4. Welded wire fabric reinforcement in concrete slabs shall be continuous over all supports and in all spans. Minimum area of continuous reinforcement shall be 0.0015 times the area of concrete. The welded wire fabric reinforcement shall have tension splices and be anchored at discontinuous edges.

