AISI S210—07 (2012)

American Iron and Steel Institute

AISI STANDARD

North American Standard for Cold-Formed Steel Framing—Floor and Roof System Design

2007 Edition (Reaffirmed 2012)

Endorsed by

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DISCLAIMER

The material contained herein has been developed by the American Iron and Steel Institute Committee on Framing Standards. The Committee has made a diligent effort to present accurate, reliable, and useful information on cold-formed steel framing design and installation. The Committee acknowledges and is grateful for the contributions of the numerous researchers, engineers, and others who have contributed to the body of knowledge on the subject. Specific references are included in the *Commentary*.

With anticipated improvements in understanding of the behavior of cold-formed steel framing and the continuing development of new technology, this material will become dated. It is anticipated that AISI will publish updates of this material as new information becomes available, but this cannot be guaranteed.

The materials set forth herein are for general purposes only. They are not a substitute for competent professional advice. Application of this information to a specific project should be reviewed by a design professional. Indeed, in many jurisdictions, such review is required by law. Anyone making use of the information set forth herein does so at their own risk and assumes any and all liability arising therefrom.

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PREFACE

The American Iron and Steel Institute Committee on Framing Standards has developed AISI S210, the *North American Standard for Cold-Formed Steel Framing – Floor and Roof System Design*, to provide technical information and specifications for designing floor and roof systems made from cold-formed steel. This standard is intended for adoption and use in the United States, Canada and Mexico.

This standard provides an integrated treatment of Allowable Strength Design (ASD), Load and Resistance Factor Design (LRFD), and Limit States Design (LSD). This is accomplished by including the appropriate resistance factors (ϕ) for use with LRFD and LSD, and the appropriate factors of safety (Ω) for use with ASD. It should be noted that LSD is limited to Canada and LRFD and ASD are limited to Mexico and the United States.

The Committee acknowledges and is grateful for the contributions of the numerous engineers, researchers, producers and others who have contributed to the body of knowledge on the subjects. The Committee wishes to also express their appreciation for the support of the Steel Framing Alliance and the Canadian Sheet Steel Building Institute.

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NORTH AMERICAN STANDARD FOR COLD-FORMED STEEL FRAMING – FLOOR AND ROOF SYSTEM DESIGN

A. GENERAL

A1 Scope

The design and installation of *cold-formed steel* framing for floor and roof systems in buildings shall be in accordance with AISI S100 [CSA S136] and AISI S200, except as modified by the provisions of this standard. Alternatively *cold-formed steel* framing for floor and roof systems in buildings shall be permitted to be designed solely in accordance with AISI S100 [CSA S136].

This standard shall not preclude the use of other materials, assemblies, structures or designs not meeting the criteria herein, when the other materials, assemblies, structures or designs demonstrate equivalent performance for the intended use to those specified in this standard. Where there is a conflict between this standard and other reference documents, the requirements contained within this standard shall govern.

This standard shall include Sections A through C inclusive.

A2 Definitions

Where terms appear in this standard in italics, such terms shall have meaning as defined in AISI S200. Terms included in square brackets are specific to *LSD* terminology. Terms not italicized shall have the ordinary accepted meaning in the context for which they are intended.

A3 Loads and Load Combinations

Buildings or other structures and all parts therein shall be designed to safely support all loads that are expected to affect the structure during its life in accordance with the *applicable building code*. In the absence of an *applicable building code*, the loads, forces, and combinations of loads shall be in accordance with accepted engineering practice for the geographical area under consideration as specified by the applicable sections of *Minimum Design Loads for Buildings and Other Structures* (ASCE 7) in the United States and Mexico, and the *National Building Code of Canada* (NBCC) in Canada.

A4 Referenced Documents

The following documents or portions thereof are referenced within this standard and shall be considered part of the requirements of this document.

1. AISI S100-07, *North American Specification for the Design of Cold-Formed Steel Structural Members,* American Iron and Steel Institute, Washington, DC.
2. AISI S200-07, *North American Standard for Cold-Formed Steel Framing – General Provisions*, American Iron and Steel Institute, Washington, DC.
3. AISI S213-07, *North American Standard for Cold-Formed Steel Framing – Lateral Design*, American Iron and Steel Institute, Washington, DC.

4. AISI S214-07, *North American Standard for Cold-Formed Steel Framing – Truss Design*, American Iron and Steel Institute, Washington, DC.

5. ASCE 7-05 Including Supplement 1, *Minimum Design Loads for Buildings and Other Structures*, American Society of Civil Engineers, Reston, VA.

6. CAN/CSA S136-07, *North American Specification for the Design of Cold-Formed Steel Structural Members*, Canadian Standards Association, Mississauga, Ontario, Canada.

7. NBCC 2005, *National Building Code of Canada, 2005 Edition*, National Research Council of Canada, Ottawa, Ontario, Canada.

B. DESIGN

Except as modified or supplemented in this standard, strength determinations shall be in accordance with AISI S100 [CSA S136].

B1 Member Design

Floor joists, *ceiling joists* and *roof rafters* shall be designed either on the basis of discretely braced design or on the basis of continuously braced design. *Webs* shall be solid, have holes that satisfy AISI S100 [CSA S136], or have holes that are reinforced in accordance with an *approved* design.

(a) Discretely Braced Design. Floor and roof assemblies using discretely braced design shall be designed neglecting the structural bracing and/or composite-action contribution of attached sheathing or deck. Discretely braced design shall include assemblies where the sheathing or deck is not attached directly to structural members.

(b) Continuously Braced Design. The continuously braced design provisions of this standard shall be limited to *floor joists*, *ceiling joists* and *roof rafters* having the following limitations, unless noted otherwise in Section B1:

(1) Maximum *web* depth = 14 inches (356 mm)
(2) Maximum *design thickness* = 0.1242 inches (3.155 mm)
(3) Minimum design *yield strength*, F_y = 33 ksi (230 MPa)
(4) Maximum design *yield strength*, F_y = 50 ksi (345 MPa)

When continuously braced design is used, the engineering drawings shall identify the sheathing or deck as a structural element.

B1.1 Properties of Sections

The properties of sections shall be determined in accordance with conventional methods of structural design. Properties shall be full cross section properties, except where use of a reduced cross section or effective design width is required by AISI S100 [CSA S136].

B1.2 Floor Joist Design

B1.2.1 Bending

(a) Discretely Braced Design. Flexure alone shall be evaluated by using Section C3.1.2 of AISI S100 [CSA S136].

(b) Continuously Braced Design. Where *structural sheathing* or steel deck is attached to the top *flange* of the *floor joist* in accordance with Section B4.1 of this standard and the bottom *flange* is braced in accordance with Section B4.2 of this standard, flexure alone shall be evaluated by using Section C3.1.1 of AISI S100 [CSA S136].

B1.2.2 Shear

Shear alone shall be evaluated by using Section C3.2 of AISI S100 [CSA S136].

B1.2.3 Web Crippling

Web crippling alone shall be evaluated by using Section C3.4 of AISI S100 [CSA S136], unless a *bearing stiffener* is used in accordance with the requirements of Section B3.1 of this standard.

B1.2.4 Bending and Shear

The combination of flexure and shear shall be evaluated by using Section C3.3 of AISI S100 [CSA S136].

B1.2.5 Bending and Web Crippling

The combination of flexure and web crippling shall be evaluated by using Section C3.5 of AISI S100 [CSA S136], unless a *bearing stiffener* is used in accordance with the requirements of Section B3.1 of this standard.

B1.3 Ceiling Joist Design

B1.3.1 Axial Load

Axial load alone shall be evaluated by using Section C2 (tension) and Section C4 (compression) of AISI S100 [CSA S136], as applicable.

B1.3.2 Bending

(a) Discretely Braced Design. Flexure alone shall be evaluated by using Section C3.1.2 of AISI S100 [CSA S136].

(b) Continuously Braced Design. Where *structural sheathing* or steel deck is attached to the top *flange* of the *ceiling joist* in accordance with Section B4.1 of this standard and the bottom *flange* is braced in accordance with Section B4.2 of this standard, flexure alone for gravity loading shall be evaluated by using Section C3.1.1 of AISI S100 [CSA S136] and flexure alone for uplift loading shall be evaluated by using Section C3.1.2 and D6.1.1 of AISI S100 [CSA S136].

B1.3.3 Shear

Shear alone shall be evaluated by using Section C3.2 of AISI S100 [CSA S136].

B1.3.4 Web Crippling

Web crippling alone shall be evaluated by using Section C3.4 of AISI S100 [CSA S136], unless a *bearing stiffener* is used in accordance with the requirements of Section B3.1 of this standard.

B1.3.5 Axial Load and Bending

The combination of axial load and bending shall be evaluated by using Section C5 of AISI S100 [CSA S136].

B1.3.6 Bending and Shear

The combination of flexure and shear shall be evaluated by using Section C3.3 of AISI S100 [CSA S136].

B1.3.7 Bending and Web Crippling

The combination of flexure and web crippling shall be evaluated by using Section C3.5 of AISI S100 [CSA S136], unless a *bearing stiffener* is used in accordance with the requirements of Section B3.1 of this standard.

B1.4 Roof Rafter Design

B1.4.1 Axial Load

Axial load alone shall be evaluated by using Section C2 (tension) and Section C4 (compression) of AISI S100 [CSA S136], as applicable.

B1.4.2 Bending

(a) Discretely Braced Design. Flexure alone shall be evaluated by using Section C3.1.2 of AISI S100 [CSA S136].

(b) Continuously Braced Design. Where *structural sheathing* or steel deck is attached to the top *flange* of the *roof rafter* in accordance with Section B4.1 of this standard and the bottom *flange* is braced in accordance with Section B4.2 of this standard, flexure alone for gravity loading shall be evaluated by using Section C3.1.1 of AISI S100 [CSA S136] and flexure alone for uplift loading shall be evaluated by using Section C3.1.2 and D6.1.1 of AISI S100 [CSA S136]. Where *structural sheathing* or steel deck is attached to both *flanges* of the *roof rafter* in accordance with Section B4.1 of this standard, flexure alone for gravity or uplift loading shall be evaluated by using Section C3.1.1 of AISI S100 [CSA S136].

B1.4.3 Shear

Shear alone shall be evaluated by using Section C3.2 of AISI S100 [CSA S136].

B1.4.4 Web Crippling

Web crippling alone shall be evaluated by using Section C3.4 of AISI S100 [CSA S136], unless a *bearing stiffener* is used in accordance with the requirements of Section B3.1 of this standard.

B1.4.5 Axial Load and Bending

The combination of axial load and bending shall be evaluated by using Section C5 of AISI S100 [CSA S136].

B1.4.6 Bending and Shear

The combination of flexure and shear shall be evaluated by using Section C3.3 of AISI S100 [CSA S136].

B1.4.7 Bending and Web Crippling

The combination of flexure and web crippling shall be evaluated by using Section C3.5 of AISI S100 [CSA S136], unless a *bearing stiffener* is used in accordance with the requirements of Section B3.1 of this standard.

B1.5 Built-up Section Design

Built-up sections shall be evaluated by using Section D1 of AISI S100 [CSA S136].

B2 Floor and Roof Truss Design

Floor and roof *trusses* shall be designed in accordance with AISI S214.

B3 Connection Design

B3.1 Bearing Stiffeners

Bearing stiffeners, other than clip angle *bearing stiffeners*, shall be designed in accordance with Section C3.6.1 or Section C3.6.2 of AISI S100 [CSA S136]. Clip angle *bearing stiffeners*, as permitted in Section B1.2.3 of this standard, shall be designed in accordance with Section B3.1.1.

B3.1.1 Clip Angle Bearing Stiffeners

The nominal web crippling capacity of a *floor joist* connected to a *rim track* using a clip angle *bearing stiffener* shall be in accordance with the following:

$$P_n = 0.9 (P_j + P_t + 0.5A_gF_y) \quad (Eq.\ B3.1.1\text{-}1)$$

Where:

P_j = End-two-flange web crippling capacity of the *floor joist*
P_t = Interior-two-flange web crippling capacity of the *rim track*
A_g = Gross area of the clip angle *bearing stiffener*
F_y = *Yield strength* of clip angle
Ω_c = 1.80 for ASD
ϕ_c = 0.85 for LRFD
ϕ_c = 0.70 for LSD

The above equation shall be valid within the following range of parameters:

<u>Floor Joist and Rim Track</u>	
Design Thickness	0.0451″ to 0.1017″ (1.146 mm to 2.583 mm)
Design Yield Strength	33 ksi to 50 ksi (228 MPa to 345 MPa)
Nominal Depth of Joist	8″ to 12″ (203 mm to 305 mm)
Minimum Bearing Width	1½″ (38.1 mm)
<u>Clip Angle Bearing Stiffener</u>	
Size	1½″x 1½″ (38.1 mm x 38.1 mm)
Design Thickness	0.0312″ to 0.0713″ (0.792 mm to 1.811 mm)
Design Yield Strength	33 ksi to 50 ksi (228 MPa to 345 MPa)
Minimum Length	*Floor Joist* depth minus 3/8″ (9.5 mm)
<u>Installation</u>	
Minimum Screw Size	No. 8 for angle design thickness ≤ 0.0566″ (1.438 mm) and No. 10 for thicker angles
Minimum Fasteners	3 screws connecting legs of *bearing stiffener* to *joist* and *rim track web*, in accordance with Figure B3-2

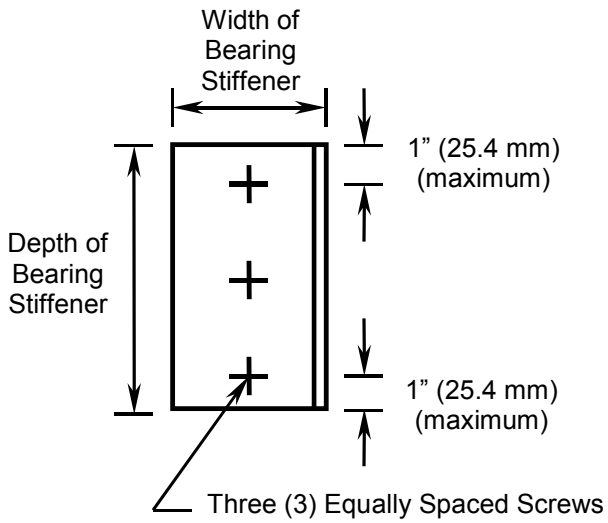

Figure B3-2 Fastening of Clip Angle Bearing Stiffener

B4 Bracing Design

Bracing members shall be designed in accordance with Section D3 of AISI S100 [CSA S136], unless *bracing* is provided that satisfies the following requirements:

(1) In continuously braced design, the sheathing or deck shall consist of a minimum of 3/8 inch (9.5 mm) wood *structural sheathing* that complies with DOC PS 1, DOC PS 2, CSA O437 or CSA O325, or steel deck with a minimum profile depth of 9/16" (14.3 mm) and a minimum thickness of 0.0269" (0.683 mm). The sheathing or deck shall be attached with minimum No. 8 screws at a maximum 12 inches (305 mm) on center.

(2) In continuously braced design, *floor joists*, *ceiling joists* and *roof rafters* with simple or continuous spans that exceed 8 feet (2.44 m) shall have the tension *flanges* laterally braced. Each intermediate brace shall be spaced at 8 feet (2.44 m) maximum and shall be designed to resist a required lateral force, P_L, determined in accordance with the following:

(a) For uniform loads:

$$P_L = 1.5(m/d)\,F \qquad (Eq.\ B4\text{-}1)$$

Where:

m = Distance from shear center to mid-plane of *web*
d = Depth of *C-shape* section
F = *w*a
w = Uniform *design load* [*factored load*]
a = Distance between centerline of braces

(b) For concentrated loads:

If $x \le 0.3a$

$$P_L = 1.0(m/d)\,F \qquad (Eq.\ B4\text{-}2)$$

If $0.3a < x < 1.0a$

$$P_L = 1.4(m/d)(1-x/a)\,F \qquad (Eq.\ B4\text{-}3)$$

Where:

m = Distance from shear center to mid-plane of *web*
d = Depth of *C-shape* section
F = Concentrated *design load* [*factored load*]
x = Distance from concentrated load to brace
a = Distance between centerline of braces

(3) In continuously braced design, *floor joists*, *ceiling joists* and *roof rafters* that are continuous over an intermediate support shall be designed in accordance with AISI S100 [CSA S136].

B5 Diaphragm Design

Diaphragms shall be designed in accordance with AISI S213 or an *approved* design or *approved* design standard.

C. INSTALLATION

The members and connections of a floor or roof system shall be installed in accordance with AISI S200.

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1st Printing – October 2007

PREFACE

This *Commentary* is intended to facilitate the use, and provide an understanding of the background, of AISI S210, the *North American Standard for Cold-Formed Steel Framing – Floor and Roof System Design*. The *Commentary* illustrates the substance and limitations of the various provisions of the standard.

In the *Commentary*, sections, equations, figures, and tables are identified by the same notation as used in the standard. Words that are italicized are defined in AISI S200. Terms included in square brackets are specific to LSD terminology.

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COMMENTARY ON THE NORTH AMERICAN STANDARD FOR COLD-FORMED STEEL FRAMING – FLOOR AND ROOF SYSTEM DESIGN

A. GENERAL

A1 Scope

AISI S210 (AISI, 2007c) applies to the design and installation of *cold-formed steel* framing for floor and roof systems in buildings and provides a supplement to AISI S100 [CSA S136], (AISI, 2007a; CSA, 2007).

A3 Loads and Load Combinations

Currently, ASCE 7 (ASCE, 2006) has no geographical-based information on Mexico. Therefore, users with projects in the Mexico should work with the appropriate authority having jurisdiction to determine appropriate loads and load combinations that are consistent with the assumptions and rationale used by ASCE 7.

B. DESIGN

B1 Member Design

The standard permits the design of *floor joists*, *ceiling joists* and *roof rafters* to be based on either a discretely braced design in which discrete braces are provided along the member's length, or based on a continuously braced design in which attached sheathing or deck are attached in accordance with the standard.

The continuously braced design provisions of the standard are limited to *floor joists*, *ceiling joists* and *roof rafters* with dimensions and properties that are within the range of standard products, as defined by AISI S201 (AISI, 2007b). This limitation was deemed appropriate due to the availability of research and field experience with such members.

B3 Connection Design

The standard provides provisions for clip angle bearing stiffeners, based on research at the University of Waterloo (Fox, 2006).

B4 Bracing Design

The continuous bracing and flange bracing provisions of the standard were deemed appropriate due to the availability of research and field experience with such assemblies. The requirements in Section B4(2) were adapted from AISI S100 [CSA S136] requirements for members where neither flange is attached to sheathing.

REFERENCES

(AISI, 2007a), *North American Specification for the Design of Cold-Formed Steel Structural Members*, AISI S100-07, American Iron and Steel Institute, Washington, D.C., 2007.

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