



AISI S214–07



**American  
Iron and Steel  
Institute**

# **AISI** STANDARD

## **North American Standard for Cold-Formed Steel Framing– Truss Design**

2007 Edition

**Revision of AISI/COFS/TRUSS–2004**

Endorsed by:



**Steel Framing Alliance™**



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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.

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## PREFACE

The American Iron and Steel Institute Committee on Framing Standards has developed AISI S214, the *North American Standard For Cold-Formed Steel Framing - Truss Design*, to provide technical information and specifications on cold-formed steel truss construction. 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 ( $\phi$ ) for use with LRFD and LSD, and the appropriate safety factors ( $\Omega$ ) 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 – TRUSS DESIGN

## A. GENERAL

### A1 Scope

The design of *cold-formed steel trusses* for load carrying purposes in buildings shall be in accordance with AISI S100 [CSA S136] and AISI S200, except as modified by the provisions of this standard. This standard shall also apply to manufacturing, quality criteria, installation and testing as they relate to the design of *cold-formed steel trusses*.

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 G 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 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 S902-02, *Stub-Column Test Method for Effective Area of Cold-Formed Steel Columns*, American Iron and Steel Institute, Washington, DC.
4. AISI S905-02, *Test Methods for Mechanically Fastened Cold-Formed Steel Connections*, American Iron and Steel Institute, Washington, DC.
5. ASCE 7-05 Including Supplement No. 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 RESPONSIBILITIES

The professional design responsibilities defined by this standard shall not preclude alternate provisions as agreed upon by the parties involved.

### B1 Truss Designer

The *truss designer's* responsibility shall be in accordance with the statutes and regulations governing the professional registration and certification of *design professionals* of the jurisdiction where the *truss* is to be incorporated into the building project.

The *truss designer* shall make available, upon request, comprehensive design calculations, including the following:

- (1) loads and load combinations considered
- (2) axial forces, moments, and shears resulting from the applied loads and load combinations
- (3) design assumptions

The *truss* design drawings shall include, as a minimum, the following:

- (1) slope, depth, span, and spacing of the *truss*
- (2) bearing locations and minimum bearing lengths
- (3) design loading(s)
- (4) *nominal [specified]* reaction forces and direction
- (5) location of all *truss* connections
- (6) *gusset plate* locations, sizes, and material specifications
- (7) fastener type, size, quantities, and locations
- (8) shape and material specification for each component
- (9) maximum *nominal [specified]* compressive force in all *truss* members
- (10) locations of required permanent *truss* member bracing
- (11) connection requirements for:
  - *truss-to-truss* girder
  - *truss* ply-to-ply
  - field assembly of *trusses*
- (12) calculated deflection ratio and/or maximum deflection for *nominal [specified]* live and total *load*

### B2 Building Designer

The *building designer's* responsibility shall include, but shall not be limited to, foundation design, structural member sizing, load transfer, bearing conditions, and the structure's compliance with applicable codes.

The *building designer* shall specify the following:

- (1) design loads in accordance with Section C
- (2) roof profile and geometry
- (3) bearing conditions
- (4) temperature and moisture environment for the intended end use
- (5) any special requirements or considerations to be taken in the *truss* design

The *building designer* shall provide for the following in the design and detailing of the building:

- (1) horizontal, vertical, or other *truss* deflection due to design loads
- (2) *truss* movement due to temperature changes
- (3) *truss* supports and anchorage accommodating horizontal, vertical, or other reactions or displacements
- (4) permanent *truss* bracing to resist wind, seismic, and any other lateral forces acting perpendicular to the plane of the *truss*
- (5) permanent lateral bracing as specified by the *truss designer*

## C. LOADING

The loads and load combinations to be used in the design of *cold-formed steel trusses* shall be determined by the *building designer* in accordance with the *applicable building code*. In the absence of an *applicable building code*, the loads, 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.

### C1 Construction Loads

Construction load used in design shall be determined by the *building designer* in accordance with the *applicable building code* and construction practices. In the absence of such a governing code, the *building designer* shall determine the construction load.

### C2 Other Loads

The *building designer* shall specify any applicable loads in addition to those in this chapter.

## D. TRUSS DESIGN

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

### D1 Materials

Sheet steel materials utilized in steel *truss* construction shall comply with the requirements for *structural members* defined in AISI S200 or AISI S100 [CSA S136].

### D2 Corrosion Protection

*Truss* members, including *gusset plates*, shall have corrosion protection as required by AISI S200.

### D3 Analysis

In lieu of a rational analysis to define joint flexibility, the following analysis model assumptions shall be used:

- (1) *Chord members* are continuous, except members are assumed to have pinned connections at the *heel*, *pitch breaks*, and *chord splices*.
- (2) *Web members* are assumed to have pinned connections at each end.

Use of a specific joint stiffness other than the complete rotational freedom of a pin for a connection shall be permitted if the connection is designed for the forces resulting from a structural analysis with this specific joint stiffness.

### D4 Member Design

#### D4.1 Properties of Sections

For *C-shapes* and other simple cross section geometries, the properties of sections shall be determined in accordance with conventional methods of structural design. Properties shall be based on full cross section properties, except where use of a reduced cross section or effective design width is required by AISI S100 [CSA S136]. For other cross section geometries, properties shall be based on tests in accordance with Section G1.

#### D4.2 Compression Chord Members

The compression *chord member* shall be evaluated for axial load alone using Section C4 of AISI S100 [CSA S136], bending alone using Section C3.1 of AISI S100 [CSA S136] and combined axial load and bending using Section C5.2 of AISI S100 [CSA S136].

**D4.2.1** For axial load strength determination, the effective length,  $KL$ , shall be determined by rational analysis, testing, or the following design assumptions as appropriate:

- (a) For *C-shapes* the x-axis is the axis of symmetry.  $L_x$  shall be equal to the distance between *panel points*, and  $C_m$  shall be taken as 0.85, unless an analysis is performed to justify another value. Where the *chord member* is continuous over at least one intermediate *panel point* and where sheathing is directly attached to the *chord member*,  $K_x$  shall be taken as 0.75. Otherwise,  $K_x$  shall be taken as unity. As an alternative,  $L_x$  shall be the distance between points of contraflexure with  $C_m$

and  $K_x$  taken as unity. Where sheathing is attached to the *chord member*,  $L_y$  shall be equal to the distance between sheathing connectors and  $K_y$  shall be taken as 0.75. Where purlins are attached to the *chord member*,  $L_y$  shall be the distance between purlins with  $K_y$  equal to unity.  $L_t$  shall be equal to the distance between *panel points*. Where the *chord member* is continuous over at least one intermediate *panel point* between the *heel* and *pitch break* and where sheathing is directly attached to the *chord member*,  $K_t$  shall be taken as 0.75. Otherwise,  $K_t$  shall be taken as unity. As an alternate,  $L_t$  shall be the distance between points of contraflexure with  $K_t$  taken as unity.

Where:

- $C_m$  = end moment coefficient in interaction formula
- $K_t$  = effective length factor for torsion
- $K_x$  = effective length factor for buckling about x-axis
- $K_y$  = effective length factor for buckling about y-axis
- $L_t$  = unbraced length of compression member for torsion
- $L_x$  = unbraced length of compression member for bending about x-axis
- $L_y$  = unbraced length of compression member for bending about y-axis

- (b) For *hat-shapes* the x-axis is the axis of symmetry. Where sheathing is attached to the *chord member*,  $L_x$  shall be equal to the distance between sheathing connectors and  $K_x$  shall be taken as 0.75. Where purlins are attached to the *chord member*,  $L_x$  shall be the distance between purlins with  $K_x$  equal to unity.  $L_y$  shall be equal to the distance between *panel points*, and  $C_m$  shall be taken as 0.85, unless an analysis is performed to justify another value. Where the *chord member* is continuous over at least one intermediate *panel point* and where sheathing is directly attached to the *chord member*,  $K_y$  shall be taken as 0.75. Otherwise,  $K_y$  shall be taken as unity. As an alternative,  $L_y$  shall be the distance between points of contraflexure with  $C_m$  and  $K_y$  taken as unity.  $L_t$  shall be equal to the distance between sheathing connectors or purlin spacing. Where the *chord member* is continuous over at least one intermediate *panel point* between the *heel* and *pitch break* and where sheathing is directly attached to the *chord member*,  $K_t$  shall be taken as 0.75. Otherwise,  $K_t$  shall be taken as unity. As an alternate,  $L_t$  shall be the distance between the points of contraflexure with  $K_t$  taken as unity.
- (c) For *Z-shapes* the x-axis is out of the plane of the *truss*,  $L_x$  shall be equal to the distance between *panel points*, and  $C_m$  shall be taken as 0.85, unless an analysis is performed to justify another value. Where the *chord member* is continuous over at least one intermediate *panel point* and where sheathing is directly attached to the *chord member*,  $K_x$  shall be taken as 0.75. Otherwise,  $K_x$  shall be taken as unity. As an alternative,  $L_x$  shall be the distance between points of contraflexure with  $C_m$  and  $K_x$  taken as unity. Where sheathing is attached to the *chord member*,  $L_y$  shall be equal to the distance between sheathing connectors and  $K_y$  shall be taken as 0.75. Where purlins are attached to the *chord member*,  $L_y$  shall be the distance between purlins with  $K_y$  equal to unity. Where the *chord member* depth is less than 6 inches,  $L_t$  shall be equal to the distance between sheathing connectors or purlin spacing. For *Z-shapes* where the *chord member* depth is greater than or equal to 6 inches,  $L_t$  shall be equal to the distance between *panel points*. Where the *chord member* is continuous over at least one intermediate *panel point* between the *heel* and *pitch break* and where sheathing is directly attached to the *chord member*,

$K_t$  shall be taken as 0.75. Otherwise,  $K_t$  shall be taken as unity. As an alternative,  $L_t$  shall be equal to the distance between points of contraflexure with  $K_t$  taken as unity.

**D4.2.2** For bending strength determination, the effective length,  $KL$ , shall be determined by rational analysis, testing, or the following design assumptions as appropriate:

- Where sheathing is attached to the compression flange,  $M_n$  for the compression *chord member* shall be taken as  $S_e F_y$  in accordance with Section C3.1.1 of AISI S100 [CSA S136].
- Where purlins are attached to the compression flange between *panel points*,  $M_n = S_c F_c$  in accordance with Section C3.1.2.1 of AISI S100 [CSA S136] with  $KL_y$  and  $KL_t$  for *C-shapes* and *Z-shapes* and  $KL_x$  and  $KL_t$  for *hat-shapes* taken as the distance between purlins.
- Where sheathing or purlins are attached to the tension flange and the compression flange is laterally unbraced,  $M_n$  shall be taken as  $S_c F_c$  in accordance with Section C3.1.2.1 of AISI S100 [CSA S136]. For continuous span *chord members*  $M_n$  in the region of the *panel point* shall be determined with  $KL_y$  and  $KL_t$  for *C-shapes* and *Z-shapes* and  $KL_x$  and  $KL_t$  for *hat-shapes* taken as the distance between the *panel point* and the point of contraflexure and  $C_b$  shall be taken as unity. For simple and continuous span *chord members*,  $M_n$  in the mid-span region shall be determined with the effective length taken as the distance between *panel points* and  $C_b$  shall be computed in accordance with Section C3.1.2.1 of AISI S100 [CSA S136].

Where:

- $C_b$  = bending coefficient dependent on moment gradient
- $F_c$  = critical buckling stress
- $F_y$  = *yield strength* used for design
- $K_t$  = effective length factor for torsion
- $K_x$  = effective length factor for buckling about x-axis
- $K_y$  = effective length factor for buckling about y-axis
- $L_t$  = unbraced length of compression member for torsion
- $L_x$  = unbraced length of compression member for bending about x-axis
- $L_y$  = unbraced length of compression member for bending about y-axis
- $M_n$  = *nominal flexural strength [resistance]*
- $S_c$  = elastic section modulus of effective section calculated relative to extreme compression fiber at  $F_c$
- $S_e$  = elastic section modulus of effective section calculated relative to extreme compression fiber at  $F_y$

**D4.2.3** When a *C-shaped* section compression *chord member* is subject to concentrated load at a *panel point*, the interaction of axial compression, bending and web crippling shall be considered as follows:

$$\text{For ASD: } \frac{P}{P_{no}} + \frac{M}{M_{nxo}} + \frac{R}{R_n} \leq \frac{1.49}{\Omega} \quad (\text{Eq. D4.2.3-1})$$

Where:

$$\begin{aligned}
 P &= \text{required compressive axial strength} \\
 M_x &= \text{required flexural strength} \\
 R &= \text{required concentrated load strength} \\
 P_{no} &= \text{nominal axial strength computed at } f = F_y \\
 M_{nxo} &= \text{nominal flexural strength computed at } f = F_y \\
 R_n &= \text{nominal interior one-flange web crippling strength} \\
 \Omega &= 1.95
 \end{aligned}$$

For LRFD and LSD:

$$\frac{\bar{P}}{P_{no}} + \frac{\bar{M}_x}{M_{nxo}} + \frac{\bar{R}}{R_n} \leq 1.49\phi \quad (\text{Eq. D4.2.3-2})$$

Where:

$$\begin{aligned}
 \bar{P} &= \text{required [factored] compressive axial strength [resistance]} \\
 \bar{M}_x &= \text{required [factored] flexural strength [resistance]} \\
 \bar{R} &= \text{required [factored] concentrated load strength [resistance]} \\
 P_{no} &= \text{nominal axial strength [resistance] computed at } f = F_y \\
 M_{nxo} &= \text{nominal flexural strength [resistance] computed at } f = F_y \\
 R_n &= \text{nominal interior one-flange web crippling strength [resistance]} \\
 \phi &= 0.85 \text{ for LRFD} \\
 \phi &= 0.80 \text{ for LSD}
 \end{aligned}$$

#### D4.3 Tension Chord Members

The tension *chord member* shall be evaluated for axial load alone using Section C2 of AISI S100 [CSA S136], bending alone using Section C3.1 of AISI S100 [CSA S136] and combined axial load and bending using Section C5.1 of AISI S100 [CSA S136]. The axial load shall be permitted to be taken as acting through the centroid of the section.

#### D4.4 Compression Web Members

Compression *web members* shall be evaluated for axial load alone using Section C4 of AISI S100 [CSA S136] and combined axial load and bending using Section C5.2 of AISI S100 [CSA S136], and the requirements of this Section, as applicable.

- (a) For a *C-shaped* compression *web member* that is attached at each end through its *web* element back-to-back with the *web* of a *C-shaped* chord member and is not subjected to applied loads between its ends, the interaction of axial compression and out-of-plane bending shall be determined by the following interaction equation,

$$\text{For ASD:} \quad \frac{\Omega_c R_P}{P_n} + \frac{\Omega_b C_{my} R_{Pe}}{M_{ny} \alpha_y} \leq 1.0 \quad (\text{Eq. D4.4-1})$$

For LRFD and LSD:

$$\frac{R_P}{\phi_c P_n} + \frac{C_{my} R_{Pe}}{\phi_b M_{ny} \alpha_y} \leq 1.0 \quad (\text{Eq. D4.4-2})$$



Where:

$$R = -\left(\frac{L/r}{173}\right)^2 + \frac{L/r}{88} - 0.22 \geq 0.6 \quad (\text{Eq. D4.4-3})$$

$L$  = unbraced length of the compression *web member*

$r$  = radius of gyration of the full section about the minor axis

$P_n$  = nominal axial strength [resistance] based on Section C4.1 of AISI S100 [CSA S136]. Only flexural buckling need be considered.

$e$  = eccentricity of compression force with respect to the centroid of the full section of the *web member*

$P$ ,  $\Omega_b$ ,  $\Omega_c$ ,  $C_{my}$ ,  $M_{ny}$ ,  $\bar{P}$ ,  $\phi_c$ ,  $\phi_b$  and  $\alpha_y$  shall be defined in accordance with Section C5.2.1 (ASD) or C5.2.2 (LRFD and LSD) of AISI S100 [CSA S136].

When computing the design strength [resistance], the effective lengths,  $K_x L_x$ ,  $K_y L_y$  and  $K_t L_t$ , shall be taken as the distance between the centers of the member's end connection patterns.

- (b) For other compression *web members* that are concentrically loaded, the axial compression load shall be permitted to be taken as acting through the centroid of the section.
- (c) For other compression *web members* that are not concentrically loaded, proper regard for eccentricity shall be considered.

#### D4.5 Tension Web Members

Tension *web members* shall be evaluated for axial load alone using Section C2 of AISI S100 [CSA S136]. For tension *web members*, which are symmetrically loaded, the axial tension load shall be permitted to be taken as acting through the centroid of the section. For other tension members that are not symmetrically loaded, proper regard for eccentricity shall be considered.

#### D4.6 Eccentricity in Joints

An analysis using multiple nodes or an analysis using single nodes that includes proper regard for the effects of eccentricity shall be performed.

*Chord member* shear and moments in joints shall include the following considerations:

- (a) Where the *web member* lap length is greater than or equal to 75% of the *chord member* depth, the *chord member* shall be investigated for combined bending and shear in accordance with Equation C3.3.1-2 (ASD) or C3.3.2-2 (LRFD and LSD) of AISI S100 [CSA S136]. For *C-shaped* section *trusses* where screws are used as the connector, a minimum of four screws shall be used in the *web member* to *chord member* connection and the screws shall be uniformly distributed in the lapped area.
- (b) Where the *web member* lap length is less than 75% of the *chord member* depth, the *chord member* shall be investigated for combined bending and shear in accordance with Equation C3.3.1-1 (ASD) or C3.3.2-1 (LRFD and LSD) of AISI S100 [CSA S136].

Along the length of the *chord member*, at the mid-point between the intersecting *web members* at a joint, shear shall be evaluated by Section C3.2 of AISI S100 [CSA S136]. The shear buckling coefficient shall be based on either Equation C3.2.1-5 or C3.2.1-6 with “a”