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North American Standard for Cold-Formed Steel Framing -- Truss Design, 2012 Edition

American Iron and Steel Institute

AISI S214-12

American
Iron and Steel
Institute

AISI STANDARD

North American Standard for Cold-Formed Steel Framing— Truss Design

2012 Edition

DISCLAIMER

The material contained herein has been developed by the American Iron and Steel Institute (AISI) 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 (AISI) Committee on Framing Standards has developed AISI S214-12, *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 edition supersedes the previous edition, designated as AISI S214-2007, and Supplement 2, designated as AISI S214-07/S2-08.

The major changes in this edition include:

(1) *Truss* responsibility provisions were extracted from Section I1 of AISI S202-2011, *Code of Standard Practice for Cold-Formed Steel Structural Framing*, and renumbered as Chapter B in this standard, and

(2) Section D1, Materials, was revised as a result of the consolidations and clarifications between AISI cold-formed steel framing standards regarding applicable materials.

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.

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NORTH AMERICAN STANDARD FOR COLD-FORMED STEEL FRAMING – TRUSS DESIGN 2012 EDITION

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.

The responsibilities defined in this standard are not intended to preclude alternate provisions as agreed upon by the parties involved.

This standard includes Sections A through G in their entirety.

A2 Definitions

In this standard, “shall” is used to express a mandatory requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the standard. Provisions described as “permitted” are optional, and the election to use such provisions is at the discretion of the user.

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

The following definitions are extracted from AISI S202, Section A2:

Building Designer. *Owner* of the building or the person that *contracts* with the *owner* for the design of the framing structural system or who is responsible for the preparation of the *construction documents*. When mandated by the legal requirements, the *building designer* shall be a *registered design professional* (e.g., architect or structural engineer-of-record). Also referred to as owner’s representative for design, but hereinafter will be referred to as *building designer*.

Construction Documents. Written, graphic and pictorial documents prepared or assembled for describing the design (including the framing structural system), location and physical characteristics of the elements of a building necessary to obtain a building permit and construct a building.

Contract. The legally recognized agreement between two parties which defines, among other items, the responsibilities of the parties involved in bidding, purchasing, designing, supplying, and installing *CFS framing*.

Contractor. *Owner* of the building, or the person that *contracts* with the *owner*, who constructs or manages the construction of the building in accordance with the *construction documents*. Also referred to as owner’s representative for construction, but hereinafter will be referred to as *contractor*.

Owner. The individual or entity organizing and financing the design and construction of the project.

Owner's Representative. The *owner* or individual designated contractually to act for the *owner*. Referred to as *building designer* when referencing owner's representative for design. Referred to as *contractor* when referencing owner's representative for construction.

Registered Design Professional. Architect or engineer who is licensed to practice their respective design profession as defined by the legal requirements of the jurisdiction in which the building is to be constructed.

Truss Placement Diagram. Illustration identifying the assumed location of each *truss*.

Truss Submittal Package. Package consisting of each individual *truss design drawing*, and, as applicable, the *truss placement diagram*, the cover/truss index sheet, permanent individual *truss member* restraint/bracing details designed in accordance with generally accepted engineering practice, applicable permanent individual *truss member* restraint/bracing details, and any other structural details germane to the *trusses*.

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 as part of the requirements of this document.

1. American Iron and Steel Institute (AISI), 25 Massachusetts Avenue NW, Suite 800, Washington, DC 20001:

   AISI S100-12, *North American Specification for the Design of Cold-Formed Steel Structural Members*

   AISI S200-12, *North American Standard for Cold-Formed Steel Framing - General Provisions*

   AISI S202-11, *Code of Standard Practice for Cold-Formed Steel Structural Framing*

   AISI S902-08, *Stub-Column Test Method for Effective Area of Cold-Formed Steel Columns*

   AISI S905-08, *Test Methods for Mechanically Fastened Cold-Formed Steel Connections*

2. American Society of Civil Engineers, 1801 Alexander Bell Drive, Reston, VA 20191:

   ASCE 7-10, *Minimum Design Loads for Buildings and Other Structures*, Including Supplement No. 1

3. ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959:

   ASTM A500/A500M-10a, *Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes*

   ASTM A653-08/A653M-11, *Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process*

ASTM A1003/A1003M-11, *Standard Specification for Sheet Steel, Carbon, Metallic and Non-Metallic Coated for Cold-Formed Framing Members*

4. Canadian Standards Association, 5060 Spectrum Way, Mississauga, Ontario, Canada L4W 5N6:

   CAN/CSA-S136-12, *North American Specification for the Design of Cold-Formed Steel Structural Members*, Canadian Standards Association, Mississauga, Ontario, Canada.

5. National Research Council of Canada, 1200 Montréal Road, Ottawa, Ontario, Canada K1A OR6.

   NBCC 2010, *National Building Code of Canada*, 2010 Edition

B. TRUSS RESPONSIBILITIES

Truss responsibilities shall be in accordance with Section I1 of AISI S202, which is extracted into Chapter B as follows:

[Beginning of Extraction of Section I1 of AISI S202]

B Truss Responsibilities

B1 Design of Trusses

Trusses shall be designed in accordance with one of the following methods:

(a) **Designed by a Design Professional.** If the *building designer* or a delegated *registered design professional* designs the *trusses*, all design criteria, details and specifications with respect to the *trusses* shall be indicated on the *construction documents* or *contract* as required by the *applicable building code*.

(b) **Designed by a *Truss Design Engineer* or *Truss Designer*.** *Truss* design shall be in accordance with Sections B2.1, B2.2 and B2.3.

B2 Responsibilities of Truss Design Engineer/Truss Designer

B2.1 Preparation of Truss Design Drawings

B2.1.1 Truss Design Engineer

The *truss design engineer* shall supervise the preparation of the *truss design drawings* based on the *truss* design criteria and requirements set forth in the *construction documents*, or as otherwise set forth in writing by the *building designer*, as supplied to the *truss design engineer* by the *contract* or through the *truss manufacturer*.

B2.1.2 Truss Designer

The *truss designer* shall be responsible for the individual *truss* component design and the preparation of the *truss design drawings* based on the *truss* design criteria and requirements set forth in the *construction documents,* or as otherwise set forth in writing by the *building designer* as supplied to the *truss designer* by the *truss manufacturer*.

B2.2 Truss Design Criteria, Assumptions and Calculations

The *truss designer* shall make available, as part of the *truss submittal package*, upon request by the *owner's representative* or building official, design calculations, including the following:

(a) Loads and load combinations considered,

(b) Axial forces, moments, and shears resulting from the applied loads and load combinations, and

(c) Design assumptions.

B2.3 Truss Design Drawings

The *truss design drawings* shall consist of the individual *truss design drawings* and referenced details, if any. The *truss design drawings* shall be part of the *truss submittal package* and include, at a minimum, the information specified below:

(1) *Applicable building code* used for design, unless specified on a cover/truss index sheet,

(2) Slope or depth, span, and spacing,
(3) Number of plies if greater than one,
(4) Bearing locations and minimum bearing lengths,
(5) Design loading(s) as applicable, including:
  (a) Top chord roof or floor live load,
  (b) Top chord roof snow load,
  (c) Top chord dead load,
  (d) Bottom chord live load,
  (e) Bottom chord dead load,
  (f) Additional loads and locations,
  (g) Environmental design loads (e.g., wind and snow) and all applicable factors as required to calculate the *truss* loads, and
  (h) Other lateral loads, including drag strut loads.
(6) Reaction forces and direction, including maximum downward, lateral and uplift reaction forces, where applicable, based on *nominal* [*specified*] *loads*,
(7) Location of all *truss member* connections,
(8) *Gusset plate* locations, sizes, and material specifications,
(9) Fastening type, size, quantities, and locations,
(10) Shape and material specification for each *truss member*,
(11) Maximum axial compressive and tension forces in all truss members based on nominal [specified] loads,
(12) Truss-to-truss connection and truss field assembly requirements,
(13) Calculated span-to-deflection ratio or maximum vertical and horizontal deflection for nominal [specified] live and total load, as applicable,
(14) Locations of required permanent individual truss member restraint in accordance with Section B6(a) or B6(c), if required, and
(15) Design and details for individual truss member reinforcement in accordance with Section B6(b), if required.

B2.4 Truss Design Drawings Seal and Signature

Where required by the *building designer* or the authority having jurisdiction, each individual *truss design drawing* shall bear the seal and signature of the *truss design engineer*. When an individual *truss design drawing* has multiple pages, only the first page shall be required to be signed and sealed by the *truss design engineer*. When a cover/truss index sheet is used, it shall be the only document required to be signed and sealed by the *truss design engineer*.

B3 Responsibilities of Truss Manufacturer

B3.1 Truss Design Criteria and Requirements

The *truss manufacturer* shall obtain the *truss* design criteria and requirements from the *construction documents*.

B3.2 Communication to Truss Design Engineer

The *truss manufacturer* shall communicate the *truss* design criteria and requirements to the *truss design engineer* or *truss designer*, as applicable.

B3.3 Truss Placement Diagram

Where required by the *construction documents* or *contract*, the *truss manufacturer* shall prepare the *truss placement diagram* that identifies the assumed location for each individually designated *truss* and references the corresponding *truss design drawing*. The *truss placement diagram* is permitted to include identifying marks for other products, including structural elements, so that they may be more easily identified by the *contractor* during field installation. When the *truss placement diagram* serves only as a guide for *truss* installation and requires no engineering input, it does not require the seal of any *truss design engineer* or *registered design professional*.

B3.4 Truss Submittal Package

Where required by the *construction documents*, *contract* or the building official, the *truss manufacturer* shall provide the appropriate *truss submittal package* for review or approval to one or more of the following: *building designer,* building official or *contractor* in accordance with Section D3 of AISI S202.

B3.5 Reliance on Construction Documents

The *truss manufacturer* is permitted to rely on the accuracy and completeness of information furnished in the *construction documents* or otherwise furnished in writing by the *building designer* or *contractor*.

B4 Responsibilities of Building Designer

B4.1 Preparation of Construction Documents

The *construction documents* shall be prepared by the *building designer* and shall be of sufficient clarity to indicate the location, nature and extent of the work proposed in accordance with the *applicable building code*.

B4.2 Deferred Submittals

The *building designer* shall list the deferred submittals on the *construction documents*. The *building designer* shall review deferred submittals in accordance with Section B4.3.

B4.3 Review Submittal Packages

The *building designer* shall review the *truss submittal package*. All such submittals shall include a notation indicating that they have been reviewed.

B4.4 Required Information in Construction Documents

The *building designer*, through the *construction documents*, shall provide information sufficiently accurate and reliable to be used for facilitating the supply of the structural elements and other information for developing the design of the *trusses* for the building, and shall provide the following:

(1) All *truss* and structural element orientations and locations,

(2) Information to fully determine all *truss* profiles,

(3) All structural element and *truss* support locations and bearing conditions,

(4) The location, direction, and magnitude of all dead, live, and lateral loads

applicable to each *truss* including, but not limited to, loads attributable to: roof, floor, partition, mechanical, fire sprinkler, attic storage, rain and ponding, wind, snow (including snow drift and unbalanced snow), seismic, and any other loads on the *truss*;

(5) All *truss* anchorage required to resist uplift, gravity, and lateral loads by specifying either
  (a) Pre-engineered anchors or fasteners, or
  (b) Methods designed by a registered design professional;

(6) *Truss*-to-structural element connections, but not *truss*-to-*truss* connections, by specifying either
  (a) Pre-engineered anchors or fasteners, or
  (b) Methods designed by a registered design professional;

(7) Permanent building stability *bracing*, including *truss* anchorage connections to the permanent building stability *bracing*,

(8) Criteria related to serviceability issues, including:
  (a) Allowable vertical, horizontal or other required deflection criteria;
  (b) Any dead load and live load deflection criteria for flat roofs subject to ponding loads;
  (c) Any differential deflection criteria from *truss*-to-*truss* or *truss*-to-adjacent structural member;
  (d) Any deflection and vibration criteria for floor *trusses*, including any strongback bridging requirements or any dead load and live load deflection criteria for floor *trusses* supporting stone or ceramic tile finishes; and
  (e) Anticipated moisture, temperature, corrosive chemicals and gases expected to affect the *trusses* and requirements for any additional corrosion protection.

B4.5 Permanent Individual Truss Member Restraint/Bracing

The *building designer* is permitted to specify the method of the permanent individual *truss member* restraint/bracing in accordance with Section B6.

B5 Responsibilities of Contractor

B5.1 Information Provided to Truss Manufacturer

The *contractor* shall provide to the *truss manufacturer* a copy of all *construction documents* pertinent to the framing structural system and the design of the *trusses* (i.e., framing plans, specifications, details, structural notes) and the name of the *building designer* if not noted on the *construction documents*.

Amended *construction documents*, upon approval through the plan review/permitting process, shall be immediately communicated to the *truss manufacturer*.

B5.2 Information Provided to Building Designer

The *contractor*, after approving the *truss submittal package*, shall forward the *truss submittal package* for review by the *building designer*.

B5.3 Truss Submittal Package Review

The *contractor* shall not proceed with the *truss* installation until the *truss submittal package* has been reviewed by the *building designer*.

B5.4 Means and Methods

The *contractor* is responsible for the construction means, methods, techniques, sequences, procedures, programs, and safety in connection with the receipt, storage, handling, installation, restraining, and bracing of the *trusses*.

B5.5 Truss Installation

The *contractor* shall ensure that the building support conditions are of sufficient strength and stability to accommodate the loads applied during the *truss* installation process. *Truss* installation shall comply with installation tolerances shown in the standard industry details. Permanent individual *truss member* restraint/bracing for the completed building in accordance with Section B6 and any other construction work related directly or indirectly to the *trusses* shall be installed by the *contractor*.

B5.6 Alterations to Trusses

Truss members and components shall not be cut, notched, drilled, spliced or otherwise altered in any way without written concurrence and acceptance of any *registered design professional*. Alterations resulting in the addition of loads to any member (i.e., HVAC equipment, piping, additional roofing or insulation, etc.) shall not be permitted without verification by the *truss design engineer* or *truss designer* that the *truss* is capable of supporting such additional loading.

B6 Design of Permanent Individual Truss Member Restraint/Bracing

Where permanent individual *truss member* restraint/bracing is required, it shall be accomplished by one of the following methods:

(a) **Standard Industry Details.** Standard industry permanent individual *truss member* restraint/bracing details supplied in accordance with B3.4.

(b) **Substitution with Reinforcement.** *Truss member* reinforcement designed by the *truss design engineer* or *truss designer* to eliminate the need for permanent individual *truss member* restraint/bracing. The permanent individual *truss member* reinforcement design and details shall be noted/shown on the *truss* design drawings or on supplemental *truss member* buckling reinforcement details provided by the *truss design engineer* or *truss designer*.

(c) **Project-Specific Design.** A project-specific permanent individual *truss member* restraint/bracing design by any *registered design professional*, as specified in the *contracts* or *construction documents*, and supplied in accordance with B3.4.

[End of Extraction of Section I1 of AISI S202]

C. RESERVED

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 ASTM A1003/A1003M type H or ASTM A653/A653M type SS, HSLAS, or HSLAS-F. *Cold-formed steel* welded tubing utilized in steel *truss* construction shall comply with ASTM A500.

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 is 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 *nominal* axial *strength* [*resistance*] determination, the effective length, KL, shall be determined by rational analysis, testing, or the following design assumptions as appropriate:

(a) For *C-shape chord members* with the x-axis as 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 alternative, 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* with the x-axis as 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 alternative, L_t shall be the distance between the points of contraflexure with K_t taken as unity.

(c) For *Z-shapes* with the x-axis as 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 (152 mm), 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 (152 mm), 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 *nominal* bending *strength* [*resistance*] determination, the effective length, KL, shall be determined by rational analysis, testing, or the following design assumptions as appropriate:

(a) Where sheathing is attached to the compression flange, $M_n = S_eF_y$ in accordance with Section C3.1.1 of AISI S100 [CSA S136].

(b) Where purlins are attached to the compression flange between *panel points*, $M_n = S_cF_c$ 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* determined in accordance with D4.2.1 and KL_x and KL_t for *hat-shapes* taken as the distance between purlins.

(c) Where sheathing or purlins are attached to the tension flange and the compression flange is laterally unbraced, $M_n = S_cF_c$ 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* determined in accordance with D4.2.1 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:

For *ASD*:

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

where

P = *required* compressive axial *strength*

M_x = *required* flexural *strength*

R = *required* concentrated load *strength*

P_{no} = *nominal* axial *strength* computed at f = F_y

M_{nxo} = *nominal* flexural *strength* computed at f = F_y

R_n = *nominal* interior one-flange web crippling *strength*

Ω = 1.95

For *LRFD* and *LSD*:

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

where

$\overline{P}$ = *required* compressive axial *strength* [axial force due to *factored loads*]

$\overline{M}_x$ = *required* flexural *strength* [moment due to *factored loads*]

$\overline{R}$ = *required* concentrated load *strength* [concentrated load due to *factored loads*]

P_{no} = *nominal* axial *strength* [*resistance*] computed at f = F_y

M_{nxo} = *nominal* flexural *strength* [*resistance*] computed at f = F_y

R_n = *nominal* interior one-flange loading web crippling *strength* [*resistance*]

ϕ = 0.85 for *LRFD*

= 0.80 for *LSD*

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:

For *ASD*:

$$\frac{\Omega_c RP}{P_n}+\frac{\Omega_b C_{my} RPe}{M_{ny}\alpha_y}\leq 1.0 \qquad (Eq.\ D4.4\text{-}1)$$

For *LRFD* and *LSD*:

$$\frac{R\overline{P}}{\phi_c P_n} + \frac{C_{my} R \overline{P} e}{\phi_b M_{ny} \alpha_y} \leq 1.0 \qquad (Eq.\ D4.4\text{-}2)$$

where

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

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, Ω_b, Ω_c, C_{my}, M_{ny}, $\overline{P}$, ϕ_c, ϕ_b and α_y shall be as defined in accordance with Section C5.2.1 (*ASD*) or C5.2.2 (*LRFD* and *LSD*) of AISI S100 [CSA S136].

When computing the *available strength* [*factored resistance*], the effective lengths, K_xL_x, K_yL_y and K_tL_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 is 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 is 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 node 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 C3.2.1-6 or C3.2.1-7 with "a" taken as the smaller of the distance between the fastener groups, or center-to-center of the *web members*.

D5 Gusset Plate Design

The *nominal* axial compressive *strength* [*resistance*], P_n, of thin, flat *gusset plates* shall be calculated as follows:

$$P_n = R_g b t F_y \quad (Eq.\ D5\text{-}1)$$

where

$$R_g = \left(0.47\frac{W_{min}}{L_{eff}} + 0.3\right) \quad \text{for } \frac{W_{min}}{L_{eff}} \le 1.5 \quad (Eq.\ D5\text{-}2)$$

$$= 1.0 \quad \text{for } \frac{W_{min}}{L_{eff}} > 1.5$$

b = effective width determined in accordance with AISI S100 [CSA S136] Section B2.1 with $f=F_y$, k=4 and $w=W_{min}$
F_y = specified minimum *yield strength*
t = *design thickness* of *gusset plate*
Ω_c = 2.50 for *ASD*
ϕ_c = 0.60 for *LRFD*
= 0.50 for *LSD*

W_{min} shall be taken as the lesser of the actual *gusset plate* width or Whitmore section, which shall be determined using a spread-out angle of 30° along both sides of the connection, beginning at the first row of fasteners in the connection. L_{eff} shall be taken as the average length between the last rows of fasteners of adjacent *truss members* in the connection.

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

Gusset Plate Design Thickness:	0.0566 inch to 0.1017 inch (1.438 mm to 2.583 mm)
Gusset Plate Design *Yield Strength*:	33 ksi to 50 ksi (228 MPa to 345 MPa)
W_{min} / L_{eff} Ratio:	0.8 to 6.0
Chord Member-to-Gusset Plate Fastener Pattern:	Minimum of two rows with two fasteners per row

The *nominal* axial tensile *strength* [*resistance*] of thin, flat *gusset plates* shall be calculated in accordance with the requirements of Section C2 of AISI S100 [CSA S136].

D6 Connection Design

D6.1 Fastening Methods

Fastening systems shall be approved by the *truss designer*. Screw, bolt, and weld connections shall be designed in accordance with AISI S100 [CSA S136]. For connections using other fastener types, design values shall be determined by testing in accordance with Section F1 of AISI S100 [CSA S136].

For other fastening methods, the manufacturer's specifications shall be followed.

D6.2 Coped Connections for C-Shaped Sections

Coping is permitted at *pitch break* and *heel* connections in accordance with the *truss* design.

(a) At a coped *heel* connection with a coped *flange* and a *bearing stiffener* having a moment of inertia (I_{min}) greater than or equal to 0.161 in.^{4} (67,000 mm^4), the *available* shear *strength* [*factored resistance*] shall be calculated in accordance with AISI S100 [CSA S136] Section C3.2 and reduced by the following factor, R:

$$R = 0.976 - \frac{0.556c}{h} - \frac{0.532d_c}{h} \leq 1.0 \quad (Eq.\ D6.2\text{-}1)$$

where

c = length of cope

d_c = depth of cope

h = flat width of *web* of section being coped

I_{min} = moment of inertia computed with respect to an axis parallel to the *web* of the *chord member*

t = *design thickness* of section being coped

(b) At a coped *heel* connection with a coped *flange* where a *bearing stiffener* has a moment of inertia (I_{min}) less than 0.161 in.^{4} (67,000 mm^4), the computed *available strength* [*factored resistance*] at the *heel* is governed by web crippling in accordance with AISI S100 [CSA S136] Section C3.4 and shall be reduced by the following factor, R:

$$R = 1.036 - \frac{0.668c}{h} - \frac{0.0505d_c}{h} \leq 1.0 \quad (Eq.\ D6.2\text{-}2)$$

Equations D6.2-1 and D6.2-2 shall be applicable within the following limitations:

$h/t \leq 200$,

$0.10 < c/h < 1.0$, and

$0.10 < d_c/h < 0.4$

D7 Serviceability

Serviceability requirements, as defined in AISI S100 [CSA S136], shall be determined by the *building designer* or *applicable building code*. When computing *truss* deflections, it is permitted to use the full cross-sectional area of the *truss members*.

E. QUALITY CRITERIA FOR STEEL TRUSSES

E1 Manufacturing Quality Criteria

The *truss manufacturer* shall manufacture the *trusses* in accordance with the final *truss design drawings*, using the quality criteria required by the manufacturer's quality control program unless more stringent quality criteria are required by the owner in writing or through the *construction documents*.

E2 Member Identification

Truss chord members and *web members* shall be identified in accordance with the Product Identification requirements for framing members defined in AISI S200.

E3 Assembly

Trusses shall have steel members that are accurately cut, in accordance with the *truss* design, so that the assembled *truss* is made by close-fitting steel members. The maximum gap between *web members* shall not exceed ½ inch (12.7 mm) unless approved by the *truss design engineer* or *truss designer*. The location of *chord members*, *web members*, and joints shall be as specified in the *truss* design.

Truss dimensions which vary from the *truss* design shall not exceed the tolerances shown in Table E8. Inaccuracies exceeding these allowable tolerances shall be acceptable upon approval and follow-up documentation by the *truss design engineer* or *truss designer*. Any shop modifications or repairs shall be documented by the *truss design engineer* or *truss designer*.

Table E8
Manufacturing Tolerances for Finished Truss Units

Length[1]	**Variance from Design Dimensions**
Up to 30 ft (9.14 m)	½ inch (12.7 mm)
Over 30 feet (9.14 m)	¾ inch (19.1 mm)
Height[2]	**Variance from Design Dimensions**
Up to 5 feet (1.52 m)	¼ inch (6.4 mm)
Over 5 feet (1.52 m)	½ inch (12.7 mm)

[1] Length, for manufacturing tolerance purposes, is the overall length of the *truss* unit, excluding overhangs, and extensions.

[2] Height, for manufacturing tolerance purposes, is the overall height of the *truss* unit measured from the top of the top *chord member* to the bottom of the bottom *chord member* at the highest point of the *truss*, excluding projections above the top *chord member* and below the bottom *chord member*, overhangs, and extensions.

F. TRUSS INSTALLATION

F1 Installation Tolerances

F1.1 Straightness

Trusses shall not be installed with an overall bow or bow in any *chord member* or panel which exceeds the lesser of L/200 or 2 inches (50.8 mm), where L is the length of the *truss*, *chord member*, or panel in inches.

F1.2 Plumbness

Trusses shall not be installed with a variation from plumb (vertical tolerance) at any point along the length of the *truss* from top to bottom which exceeds 1/50 of the depth of the *truss* at that point or 2 inches (50.8 mm), whichever is less, unless *trusses* are specifically designed to be installed out of plumb.

F1.3 Top Chord Bearing Trusses

For top chord bearing *trusses*, a maximum gap tolerance between the inside of the bearing and the first diagonal or vertical *web member* shall be specified in the design.

G. TEST METHODS

Tests, when required as defined below, shall be conducted under the supervision of a *design professional* in accordance with this standard.

(a) For *cold-formed steel truss* components (*chord members* and *web members*) for which the *nominal strength* [*resistance*] cannot be computed according to this standard or its specific references, performance tests shall be performed in accordance with Section G1.

(b) For *cold-formed steel truss* connections for which the *nominal strength* [*resistance*] cannot be computed according to this standard or its specific references, performance tests shall be performed in accordance with AISI S905.

(c) For *cold-formed steel trusses* for which the *nominal strength* [*resistance*] can be computed according to this standard and its specific references or determined on the basis of component performance tests in accordance with Section G1, and when it must be demonstrated that the strength [*resistance*] is not less than the *nominal strength* [*resistance*] specified in this standard or its specific references, confirmatory tests shall be performed in accordance with Section G2.

(d) For *cold-formed steel trusses* for which the *nominal strength* [*resistance*] cannot be computed according to this standard and its specific references or determined on the basis of component performance tests in accordance with Section G1, performance tests shall be performed in accordance with Section G3.

G1 Component Structural Performance Load Test

G1.1 Flexural Test

Flexural tests shall be performed to define the positive or negative flexural *strength* [*resistance*] of the cross-section of a *truss member* for *static load*.

G1.1.1 Number of Test Specimens

The minimum number of test specimens shall be in accordance with Section F1 of AISI S100 [CSA S136].

G1.1.2 Materials

The test specimens shall be representative of those intended for use in the final product. Physical and material properties of the steel shall be determined in accordance with Section F3 of AISI S100 [CSA S136].

G1.1.3 Test Apparatus

The test apparatus and procedures employed shall produce a failure consistent with the purpose.

G1.1.4 Load and Deflection Measuring Devices

The load measuring device or devices used shall be capable of measuring loads to an accuracy of ±2% of the design load.

The deflection measuring devices, if employed, shall avoid magnification of deflection readings due to a movement of supports during loading. When deflection measuring systems that do not compensate for support settlement are used, measurement of support displacement under load shall be required in order to obtain an accurate load-deflection response. Deflection readings and measuring devices shall have an accuracy of 0.01 inches (0.25 mm).

G1.1.5 Loading Procedures

Load shall be applied and load measurements shall be taken. The maximum loading rate shall not exceed a corresponding applied stress rate of 3 ksi (20.7 MPa) of gross cross-sectional area per minute.

G1.1.6 Interpretation of Test Results

Evaluation of the test results shall be made in accordance with Section F1 of AISI S100 [CSA S136].

G1.1.7 Report

The report shall identify the testing laboratory, laboratory address, laboratory personnel involved in conducting the test, and the *design professional* in responsible charge.

The report shall consist of a description of all specimen components, including drawings defining actual and nominal geometry, material specifications, material properties, test results describing the actual physical properties of each component, and the sources of supply. Differences between the actual and the nominal dimensions and material properties shall be noted in the report. The report shall also indicate those modifications made to the test apparatus and any deviations made to the test procedure and their influence on the results of the test.

The test report shall also contain a sketch or photograph of the test setup, the latest calibration date and accuracy of the equipment used, the signature and engineering seal of the *design professional* responsible for the test, and a tabulation of all raw and evaluated test data.

All graphs resulting from the test evaluation procedure shall be included in the test report.

G1.2 Compression Test

Compression tests shall be performed to define the compressive strength [resistance], excluding overall buckling, of a *truss member* for *static load*. AISI S902 shall be considered as an acceptable test method. Alternative test methods shall be acceptable when approved by the *truss designer*.

G2 Full-Scale Confirmatory Load Test

G2.1 Test Specimen

For the purpose of this test, a test specimen shall be considered to consist of a full-scale *truss* assembly representative of those intended for use in the final product.

G2.2 Number of Test Specimens

A single confirmatory load test shall be considered as meeting the required minimum number of test specimens.

G2.3 Materials

The materials contained within the test specimen shall be representative of those intended for use in the final product. Physical and material properties of the steel shall be determined according to Section F3 of AISI S100 [CSA S136].

G2.4 Fabrication

Fabrication of the test specimen shall be representative of that intended for the finished product.

G2.5 Test Apparatus

A test shall consist of a single *truss*, pair of *trusses*, or multiple *trusses*.

A single *truss* shall be tested in either a vertical position (normal or inverted) or in a horizontal position. A pair of *trusses* or multiple *trusses* shall be tested in a vertical position (normal or inverted).

The self-weight of the *truss* shall be included in the total load applied to *trusses* that are tested in a vertical position to compensate for the effect of dead loads and gravity.

Reaction supports shall provide clearance above the ground or restraint frame to allow for normal displacements, ease of loading, instrumentation, and to provide room for observations and measurements. Supports shall have strength and stiffness to resist deformations during tests.

Support reaction hardware shall be typical of that planned for use in the completed structure or as required to satisfy the intent of the tests.

Lateral support shall be provided beneath a single *truss* when tested horizontally to keep the test *truss* flat and to minimize any adverse lateral displacement caused by gravity. Lateral support shall be provided for single, paired, or multiple *trusses* when tested vertically to minimize adverse lateral displacement and prevent buckling of the assembly. Where lateral support is used, it shall not interfere with the free in-plane displacement of the *truss* or *truss* assembly. The components of the test *truss* shall not be laterally supported in a manner that will exceed that intended in a representative installation.

When loads are applied using dead weight, such as sand, masonry units, or water, the dead load material shall be positioned to prevent arching action.

When loads are applied using water, the water shall be compartmentalized into cells to prevent a non-uniform load as the *truss* deflects.

G2.6 Load and Deflection Measuring Devices

When multiple *trusses* are tested as an assembly, load-measuring devices shall be located beneath each *truss* support. The load measuring device or devices used shall be capable of measuring loads to an accuracy of ±2% of the design load.

The deflection measuring devices, if employed, shall avoid magnification of deflection readings due to a movement of supports during loading. When deflection-measuring systems that do not compensate for support settlement are used, measurement of support displacement under load shall be required in order to obtain an accurate load-deflection response. Deflection readings and measuring devices shall have an accuracy of the greater of ±2% of design load deflection or 0.01 inches (0.25 mm).

G2.7 Loading Procedures

Each of the increments of test load shall not exceed 1/5 of the *nominal* [*specified*] *load*.

When a test to confirm design deflections is required, the test load shall be applied up to the *nominal* [*specified*] *load*. This load shall be held for no less than five (5) minutes, at which time deflection readings shall be recorded. When testing *trusses* in pairs, the deflections of two *trusses* at corresponding locations are permitted to be averaged. Support displacement under load shall be measured to obtain an accurate load-deflection response when deflection-measuring systems that do not compensate for support settlement are used.

The test load shall be applied up to the *nominal* [*specified*] *load* times 1.65 and held for no less than five (5) minutes and then the confirmatory test shall be considered complete.

G2.8 Interpretation of Test Results

The confirmatory test shall be deemed successful if the test specimen complies with the loading requirements in Section G2.7. When a test to confirm design deflections is required, the test shall be deemed successful if the measured deflections of the test specimen do not exceed the design (dead plus live load) deflection limit.

G2.9 Report

The report shall identify the testing laboratory, laboratory address, laboratory personnel involved in conducting the test, and the *design professional* in responsible charge.

The report shall consist of a description of all specimen components, including drawings defining actual and nominal geometry, material specifications, material properties test results describing the actual physical properties of each component, and the sources of supply. Differences between the actual and the nominal dimensions and material properties shall be noted in the report. The report shall also indicate those modifications made to the test apparatus and any deviations made to the test procedure and their influence on the results of the test.

The test report shall also contain a sketch or photograph of the test setup, the latest calibration date and accuracy of the equipment used, the signature and engineering seal of the *design professional* responsible for the test, and a tabulation of all raw and evaluated test data.

All graphs resulting from the test evaluation procedure shall be included in the test report.

G3 Full-Scale Structural Performance Load Test

G3.1 Test Specimen

For the purpose of this test, a test specimen shall be considered to consist of a full-scale *truss* assembly representative of those intended for use in the final product.

G3.2 Number of Test Specimens

Performance testing of three identical test specimens shall be considered as meeting the required minimum number of test specimens.

G3.3 Materials

The materials contained within the test specimen shall be representative of those intended for use in the final product. Physical and material properties of the steel shall be determined according to Section F3 of AISI S100 [CSA S136].

G3.4 Fabrication

Fabrication of the test specimen shall be representative of that intended for the finished product.

G3.5 Test Apparatus

A test shall consist of a single *truss*, pair of *trusses* or multiple *trusses*.

A single *truss* shall be tested in either a vertical position (normal or inverted) or in a horizontal position. A pair of *trusses* or multiple *trusses* shall be tested in a vertical position (normal or inverted).

The self-weight of the *truss* shall be included in the total load applied to *trusses* that are tested in a vertical position to compensate for the effect of dead loads and gravity.

Reaction supports shall provide sufficient clearance above the ground or restraint frame to allow for displacements, loading, instrumentation, and to provide room for observations and measurements. Supports shall have strength and stiffness to resist deformations during tests.

Support reaction hardware shall be typical of that planned for use in the completed structure or as required to satisfy the intent of the tests.

Lateral support shall be provided beneath a single *truss* when tested horizontally to keep the test *truss* flat and to minimize any adverse lateral displacement caused by gravity. Lateral support shall be provided for single, paired or multiple *trusses* when tested vertically to minimize adverse lateral displacement and prevent buckling of the assembly. Where lateral support is used, it shall not interfere with the free in-plane displacement of the *truss* or *truss* assembly. The components of the test *truss* shall not be laterally supported in a manner that will exceed that intended in a representative installation.

When loads are applied using dead weight, such as sand, masonry units, or water, the dead load material shall be positioned to prevent arching action.

When loads are applied using water, the water shall be compartmentalized into cells to prevent a non-uniform load as the *truss* deflects.

G3.6 Load and Deflection Measuring Devices

When multiple *trusses* are tested as an assembly, load-measuring devices shall be located beneath each *truss* support. The load measuring device or devices used shall be capable of measuring loads to an accuracy of ±2% of the design load.

The deflection measuring devices, if employed, shall avoid magnification of deflection readings due to a movement of supports during loading. When deflection-measuring systems that do not compensate for support settlement are used, measurement of support displacement under load shall be required in order to obtain an accurate load-deflection response. Deflection readings and measuring devices shall have an accuracy of 0.01 inches (0.25 mm).

G3.7 Loading Procedures

Each of the increments of test load shall not exceed 1/5 of the *nominal* [*specified*] *load*.

When a test to confirm design deflections is required, the test load shall be applied up to the *nominal* [*specified*] load. This load shall be held for no less than five (5) minutes, at which time deflection readings shall be recorded. When testing *trusses* in pairs, the deflections of two *trusses* at corresponding locations are permitted to be averaged. Support displacement under load shall be measured to obtain an accurate load-deflection response when deflection-measuring systems that do not compensate for support settlement are used.

The test load shall be applied up to the *nominal* [*specified*] load times the factor of safety and held for no less than five (5) minutes and then the performance test shall be considered complete.

The *resistance factor* or *safety factor* for the performance test shall be determined in accordance with Section F1 of AISI S100 [CSA S136].

G3.8 Interpretation of Test Results

The performance test shall be deemed successful if the test specimen complies with the loading requirements in Section G3.7. When a test to confirm design deflections is required, the test shall be deemed successful if the measured deflections of the test specimen do not exceed the design (dead plus live load) deflection limit.

G3.9 Report

The report shall identify the testing laboratory, laboratory address, laboratory personnel involved in conducting the test and the *design professional* in responsible charge.

The report shall consist of a description of all specimen components, including drawings defining actual and nominal geometry, material specifications, material properties test results describing the actual physical properties of each component, and the sources of supply. Differences between the actual and the nominal dimensions and material properties shall be noted in the report. The report shall also indicate those modifications made to the test apparatus and any deviations made to the test procedure and their influence on the results of the test.

The test report shall also contain a sketch or photograph of the test setup, the latest calibration date and accuracy of the equipment used, the signature and engineering seal of the *design professional* responsible for the test, and a tabulation of all raw and evaluated test data.

All graphs resulting from the test evaluation procedure shall be included in the test report.

AISI S214-12-C

American Iron and Steel Institute

AISI STANDARD

Commentary on North American Standard for Cold-Formed Steel Framing— Truss Design

2012 Edition

DISCLAIMER

The material contained herein has been developed by the American Iron and Steel Institute (AISI) 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 this *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

This *Commentary* is intended to facilitate the use and provide an understanding of the background of AISI S214, *North American Standard for Cold-Formed Steel Framing - Truss Design*. The *Commentary* illustrates the substance and limitations of the various provisions of the standard. This *Commentary* edition supersedes the *Commentary* on the 2007 Edition of AISI S214.

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 Limit States Design (LSD) terminology.

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COMMENTARY ON THE NORTH AMERICAN STANDARD FOR COLD-FORMED STEEL FRAMING – TRUSS DESIGN

A. GENERAL

A1 Scope

AISI S214 (AISI, 2012c) applies to the design, quality assurance, installation and testing of *cold-formed steel trusses* used for load-carrying purposes in buildings. The standard does not preclude the use of other *cold-formed steel* members, assemblies, structures, or designs when they demonstrate equivalent performance for the intended use to those specified in the standard.

Cold-formed steel trusses are planar structural components. Structural performance depends on the *trusses* being installed vertically, in-plane, and at specific spacing, and being properly fabricated and braced. The standard describes the materials used in a *cold-formed steel truss*, as well as design, fabrication, and bracing procedures for *truss* members.

This standard is intended to serve as a supplement to AISI S100 [CSA S136], (AISI, 2012a; CSA, 2012). This standard is also intended to be used in conjunction with AISI S200 (AISI, 2012b).

A2 Definitions

The following commentary is extracted from AISI S202, Section A2 for the term, *Building Designer*:

Commentary:

The term “framing structural system” is commonly understood to mean a completed combination of structural elements, trusses, connections and other systems which serve to support the self-weight of the building and the specified loads. The definition for *Building Designer* in this standard is in line with other industry standards.

B. TRUSS RESPONSIBILITIES

The standard adopts Section I1 of AISI S202 (AISI, 2011a) for the responsibilities of the individuals and organizations involved in the design, fabrication and installation of *cold-formed steel trusses*. Alternative provisions, as agreed upon by the involved parties, are permitted.

Truss responsibility requirements have been extracted from Section I1 of AISI S202 (AISI, 2011a) into this standard for the convenience of users.

C. LOADING

The standard does not establish the appropriate loading requirements for which a *truss* should be designed. In most cases, these loads are adequately covered by the *applicable building code* or standard. In the absence of such a code, the loads, forces, and combinations of loads should be in accordance with accepted engineering practice for the geographical area under consideration as specified by the applicable sections of the American Society of Civil Engineers' *Minimum Design Loads for Buildings and Other Structures,* ASCE 7 (ASCE, 2010) in the United States and Mexico, and the *National Building Code of Canada* (NBCC, 2010) in Canada.

Currently, ASCE 7 (ASCE, 2010) 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.

D. TRUSS DESIGN

The provisions contained in this section of the standard address the various design aspects related to *truss* strength [resistance]. The strength [resistance] determinations required by the standard are in accordance with either the *Allowable Strength Design* (*ASD*), *Load and Resistance Factor Design* (*LRFD*) or *Limit States Design* (*LSD*) methods given by AISI S100 [CSA S136], (AISI, 2012; CSA, 2012), except where additional research studies have indicated that an alternative approach is warranted.

D3 Analysis

The structural analysis requirements contained in the standard are based on available information pertaining to the behavior of *cold-formed steel C-shaped* section *truss* assemblies (Harper, 1995; LaBoube and Yu, 1998). These requirements do not preclude the use of more rigorous analysis or design assumptions as determined by rational analysis or testing.

D4 Member Design

D4.1 Properties of Sections

AISI S100 [CSA S136] has been shown to be highly reliable for determining the design cross-section properties of *C-shapes* and other simple geometries. For more complex shapes, such as those utilizing longitudinal stiffeners, AISI S100 [CSA S136] Direct Strength Method design provisions may be used to estimate load-carrying capacity. Tests in accordance with Section F1 of AISI S100 [CSA S136] can also be used.

D4.2 Compression Chord Members

When subjected to gravity load, the compression *chord member* may experience the combined effects of bending and axial compression. The design for combined load effects is governed by Section C5.2 of AISI S100 [CSA S136].

Engineering design specifications recognize the need for using rational analysis or test to define an effective length factor. The standard permits the use of either rational analysis or testing.

Based on research on *C-shaped* section *trusses* conducted at the University of Missouri-Rolla (UMR), (Harper, 1995; Ibrahim, 1998), it was determined that the unbraced lengths, L_x and L_t, may be taken as equal to the distance between the panel points. It was also discovered that where structural sheathing is attached to the *chord member* and where the compression *chord member* is continuous over at least one intermediate panel point, and is continuous from the *heel* to the *pitch break*, *heel*-to-*heel* (in the case of a parallel chord *truss*), or breakpoint of a *truss*, L_y may be taken as the distance between sheathing connectors. Engineering judgment indicates that where sheathing is not attached to the top *chord member*, L_y may be taken as the distance between panel points.

In the *cold-formed steel truss* industry, the sheathing is used as a structural component and the connection spacing of the sheathing to the *cold-formed steel* member is a design consideration. Therefore, sheathing connector spacing is indeed a structural requirement and that is why the spacing of the connector is used when designing the *truss* chords for compression when there is structural sheathing applied.

The UMR research also determined that for a structurally sheathed *C-shaped* section *truss* where the compression *chord member* is continuous over at least one intermediate panel point, and is continuous from the *heel* to the *pitch break*, or breakpoint of a *truss,* K_x, K_y, and K_t may be taken as 0.75. For other compression *chord members*, based on engineering judgment, K_x, K_y, and K_t should be taken as unity.

An alternative design assumption for *chord members* in compression, based on engineering practice and judgment, is to assume that the effective length be taken as the distance between two adjacent points of contraflexure. In such case, the effective length factor and C_m should be taken as unity.

The required effective length factors and unbraced lengths given in the standard for hat shapes are based on engineering judgment. The *Z-shape* requirements are based on proprietary testing.

Consistent with AISI S100 [CSA S136], the end moment coefficient, C_m, should be taken as 0.85, unless a more rigorous analysis is performed to justify another value.

Requirements in the standard for the evaluation of the bending strength are based on engineering judgment.

Ibrahim et al. (1998) determined that when a *C-shaped* section compression *chord member* is subjected to concentrated load at a panel point, the interaction of axial compression, bending and web crippling must be considered. The researchers proposed the following *ASD* interaction equation:

$$\frac{P}{P_{no}} + \frac{M}{M_{nxo}} + \frac{R}{R_n} \le \frac{1.49}{\Omega} \qquad (Eq.\ D4.2.3\text{-}1)$$

where

P = compression axial load

M = bending moment

R = concentrated load

P_{no} = *nominal* axial *strength* [*resistance*] computed at $f = F_y$

M_{nxo}= *nominal* flexural *strength* [*resistance*] computed at $f = F_y$

R_n = *nominal* interior one-flange web crippling *strength* [*resistance*]

Ω = *safety factor*, 1.95

The values of P and M are to be determined by structural analysis for the panel point in question, where R is the applied concentrated load at the panel point. The *nominal strengths* [*resistances*] are to be computed using AISI S100 [CSA S136]. Based on a statistical analysis consistent with *load and resistance factor design*, the *safety factor* was determined. The standard also includes a similar equation applicable to the *LRFD* and *LSD* methods.

D4.3 Tension Chord Members

The design requirements prescribed by the standard for tension *chord members* are based on experience and engineering judgment.

D4.4 Compression Web Members

The behavior of a compression *web member* is a function of the connection of the *web member* to the *chord member*. For example, a common connection detail of *C-shaped chord* and *web members* is to attach the respective members back-to-back through their *webs*. Such a connection detail creates an eccentric loading condition in the *web member*. When an axial load is applied to a *truss web member* in this type of *truss* construction, this eccentric loading condition will produce a bending moment in the member that is acting out-of-plane to the *truss*. This bending moment needs to be analyzed using Section D4.4 of this standard. In addition to the check in this standard, a compression *web member* is to be analyzed with the axial load alone using Section C4 of AISI S100 [CSA S136].

Researchers at the University of Missouri-Rolla (Rieman, 1996; Ibrahim et al., 1998) determined that for a *C-shaped* compression *web member* that is attached through its *web* element, the interaction of axial compression and out-of-plane bending may be determined by the following *ASD* interaction equation,

$$\frac{\Omega_c RP}{P_n} + \frac{\Omega_b C_{my} RPe}{M_{ny}\alpha_y} \leq 1.0 \qquad (Eq.\ D4.4\text{-}1)$$

where

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

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*

Other variables are defined in Section C5.2.1 of AISI S100 [CSA S136].

The parameter R is an experimentally determined reduction imposed on the axial load. The equation is a fit to the average test data, which is a common practice in *cold-formed steel* research. To recognize the lower limit on the tested L/r ratio, the standard stipulates $R \geq 0.6$. The intent of R is to recognize the increased significance of the bending effect, compared to the axial effect for longer length *web members*. Unique to the application of the interaction equation is the determination of the *nominal* axial *strength* [*resistance*] based on flexural buckling alone. Research showed that the minor axis bending, which resulted from the eccentrically applied axial load, created a member deflection that enabled only flexural buckling. Thus, the behavior of the *web member* was determined predominantly by bending resulting from the eccentric load. The parameters P, Ω_b, Ω_c, C_{my}, M_{ny} and α_y are defined in accordance with Section C5.2.1 of AISI S100 [CSA S136]. The standard also includes a similar equation applicable to the *LRFD* and *LSD* methods.

For compression *web member* cross-sections other than a *C-shape* attached through its *web* element, which has symmetry of loading, the axial compression load may be taken as acting through the centroid of the section.

When computing the *available strength* [*factored resistance*], the effective lengths, K_xL_x, K_yL_y and K_tL_t, may be taken as the distance between the centers of the member's end connection patterns. This assumption is consistent with the analysis approach used by UMR researchers (Rieman, 1996; Ibrahim et al., 1998).

D4.5 Tension Web Members

Tension *web members* may experience a reduction in load-carrying capacity when subjected to combined axial load and bending. For *C-shaped* sections, this may be attributed to the dominant behavior being that of bending resulting from the eccentric load. However, testing has not documented that the combined loading compromises the integrity of the tension member. Therefore, for a tension *web member* connected to the *web* element of a *chord member*, or connected to a *gusset plate*, the standard permits the axial tension load to be taken as acting through the centroid of the *web member's* cross-section.

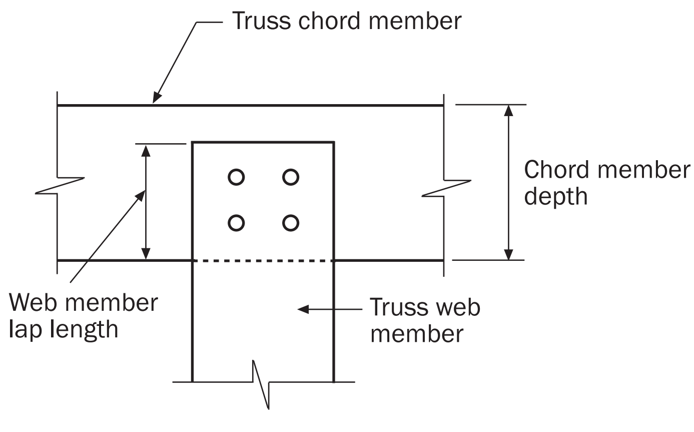
D4.6 Eccentricity in Joints

The standard does not specify the use of a multiple or single node structural analysis model to account for the effects of eccentricity in joints. The *truss* stiffness will differ based on whether a multiple or single node analysis is performed. When a multiple node analysis is used, a node should be placed at each *web member* location where the centerline of the *web member* meets the centerline of the *chord member*. When performing a single node analysis, additional design considerations may be necessary. For example, eccentricity created by the spatial relationship of the *web members* and the *chord member* at a joint may generate additional moments, shears, and/or axial forces. Such moments and forces may be directly reflected in a multiple node analysis model. Thus, when using a single node analysis model, a secondary analysis and design check of the joint or a load test may be required to justify the design.

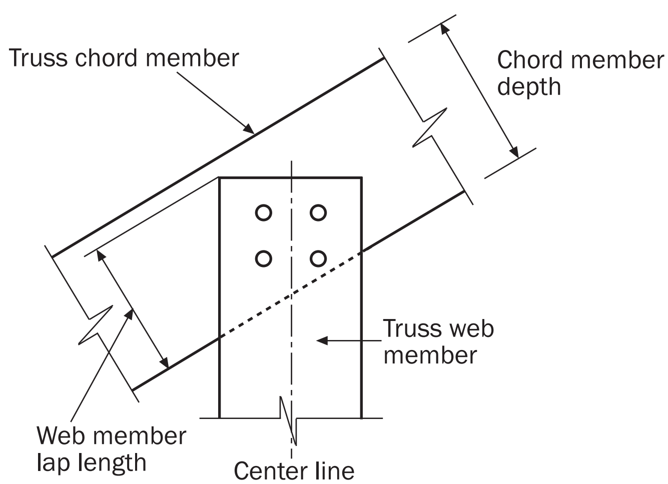
The standard defines a *web member* lap length as 75% of the *chord member* depth. This minimum lap length is assumed, based on engineering judgment, to serve as a *web* shear stiffener for the *chord member*. The *chord member* segment between the assumed stiffeners is to be investigated for combined bending and shear, where a stiffened shear panel is assumed, in accordance with Equation C3.3.1-2 of AISI S100 [CSA S136]. For *truss* configurations having the *web member* lap length less than 75% of the *chord member's* depth, the *chord member* is to be investigated for combined bending and shear in accordance with Equation C3.3.1-1 of AISI S100 [CSA S136]. Refer to Figures D4.6 (a) and D4.6 (b) for a pictorial definition of the term "*web member* lap length" for two configurations of a *truss web member* and *truss chord member* connection. Rational design assumptions for this "*web member* lap length" must be used when other connection geometries are encountered.

Along the length of the *chord member*, at the mid-point between the intersecting *web members*, shear is to be evaluated by Section C3.2 of AISI S100 [CSA S136]. The shear buckling coefficient is taken to be consistent with the assumed shear panel condition at the segment ends as defined by Section C3.2 of AISI S100 [CSA S136].

Based on experience, where screws are used as the connector, a minimum of four screws should be used in a *web member* to *chord member* connection and the screws should be equally distributed in their group.



(a) Web Member Lap Length for Flat Truss Chord



(b) Web Member Lap Length for Sloped Truss Chord

Figure D4.6 Web Member Lap Lengths

D5 Gusset Plate Design

To establish a design methodology for thin *gusset plate* connections in compression, a testing program consisting of 49 specimens was conducted at the University of Missouri-Rolla (Lutz 2004). Two separate models were developed to predict the capacity of the plates. Both plate buckling and column buckling models were studied. Although both models are sufficient for calculating the strength [resistance] of the *gusset plates*, it was recommended that the plate-buckling model be used in design. The plate-buckling model, assuming $f=F_y$, $k=4$ and $w=W_{min}$, provided a better correlation to the test data. A limited number of tests were performed to determine the strength gain in *gusset plates* with edge stiffeners. The results of tests in which both edges of the *gusset plate* parallel to the applied load had edge stiffeners showed an approximate strength increase of 25% for the plates.

The *gusset plate* design provisions in the standard require that W_{min} be taken as the lesser of the actual *gusset plate* width or the Whitmore section, which defines a theoretically effective cross-section based on a spread-out angle of 30° along both sides of the connection, beginning at the first row of fasteners in the connection. The first row of fasteners is defined as the row that are the furthest away from the section of *gusset plate* being considered. Figure D5-1 illustrates how W_{min} can be determined for a typical fastener pattern connecting a *truss chord membe*r to a *gusset plate* at a typical *pitch break* connection at the ridge of a roof *truss*. Determining W_{min} for other conditions would be analogous.

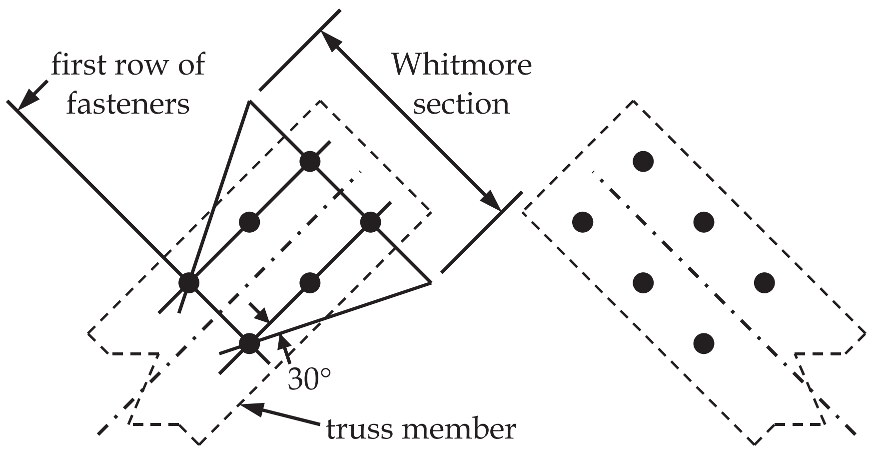
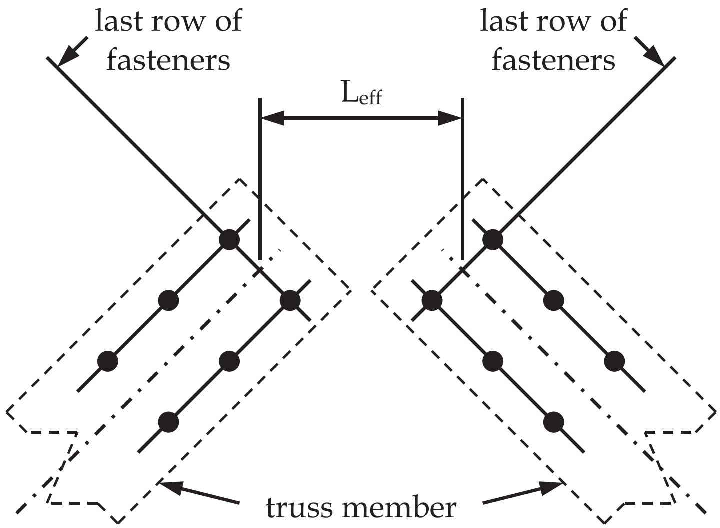


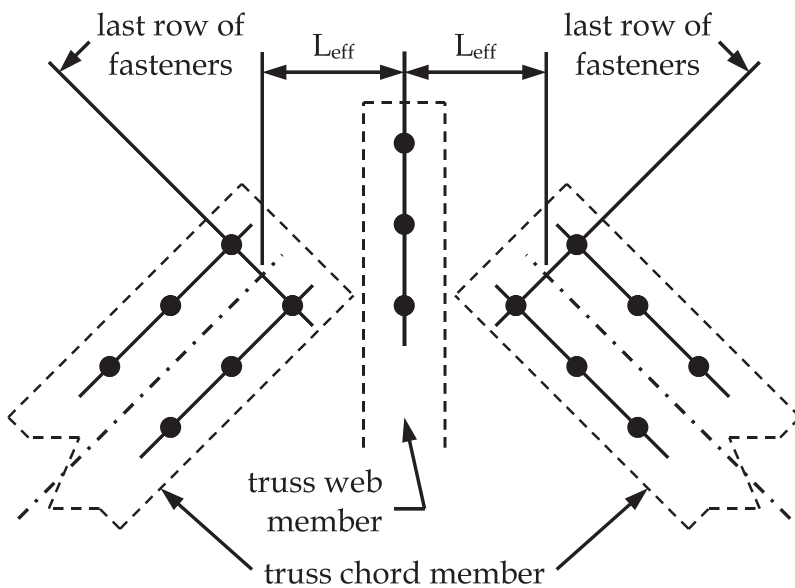
Figure D5-1 Whitmore Plate Width

The *gusset plate* design provisions in the standard require that L_{eff} be taken as the average length between the last rows of fasteners of adjacent *truss* members. Figure D5-2 illustrates how L_{eff} can be determined for a typical *pitch break* connection at the ridge of a roof *truss*. Determining L_{eff} for other conditions would be analogous.

For *gusset plates* in tension, reference is made to the requirements of AISI S100 [CSA S136]. These requirements include checks on the gross and net areas of the *gusset plate*, shear lag and group or tear-out of fasteners. Engineering judgment is required to determine the portion of the *gusset plate* to be included in the gross and net area checks.



(a) Without King Post



(b) With King Post

Figure D5-2 Effective Length for Typical Pitch Break Connection

D6 Connection Design

D6.1 Fastening Methods

Although the common fastening system used by the industry is the self-drilling screw, the standard permits the use of bolts, welds, rivets, clinches, and other technologies as *approved* by the *truss designer*. Screw, bolt, and weld connections are to be designed in accordance with AISI S100 [CSA S136]. If other fastener types such as rivets, clinches, rosettes, adhesives, etc., are to be used in the fabrication of the *truss*, the design values are to be determined by tests, and the *available strength* [*factored resistance*] determined in accordance with Section F1 of AISI S100 [CSA S136].

For the design of connecting elements, such as plates, *gusset plates*, and brackets, reference is made to AISI S100 [CSA S136], which in turn makes reference to Section J4 of AISC 360 (AISC, 2010).

D6.2 Coped Connections for C-Shaped Sections

The design engineer should give special attention to the *heel* and *pitch break* connections of the *truss* to ensure structural integrity of the *truss*.

At a *pitch break*, coped members may be reinforced to prevent *web* buckling of the *chord member*. Attachment of a *track* section of the same thickness as the *chord member*, thus creating a box section, and having a length equal to the depth of the *chord member* has been shown to provide adequate reinforcement (Ibrahim, 1998). Lateral *bracing* is also important to stabilize the *pitch break* from overall buckling. At the *heel*, a *bearing stiffener* may be needed to preclude web crippling (Koka, 1997).

At a *heel* connection, UMR research (Koka, 1997) determined that coping reduces both the shear buckling and web crippling strengths of the coped bottom *chord member*. The UMR research proposed that where a coped *flange* had a *bearing stiffener* with a minimum moment of inertia (I_{min}) of 0.161 in.^{4} (67,000 mm^4), the shear strength could be calculated in accordance with AISI S100 [CSA S136] Section C3.2, but required a reduction as defined by the following factor, R:

$$R = 0.976 + \frac{0.556c}{h} - \frac{0.532d_c}{h} \leq 1.0 \qquad (Eq.\ D6.2\text{-}1)$$

The cited limits in the standard reflect the scope of the experimental study and apply only to connections where the bottom *chord member* is coped.

Where a *bearing stiffener* not having the minimum moment of inertia is used, web crippling controls the *heel* connection strength (Koka, 1997). Therefore, the standard requires that the computed *available* end-one-flange loading web crippling *strength* [*factored resistance*] at the *heel*, as determined by AISI S100 [CSA S136] Section C3.4, be reduced by the following factor:

$$R = 1.036 + \frac{0.668c}{h} - \frac{0.0505d_c}{h} \leq 1.0 \qquad (Eq.\ D6.2\text{-}2)$$

The cited limits in the standard reflect the scope of the experimental study.

Where c = length of cope and d_c = depth of cope as illustrated in Figure D6.2-1. I_{min} of the stiffener is computed with respect to an axis parallel to the *web* of the bottom *chord member*.

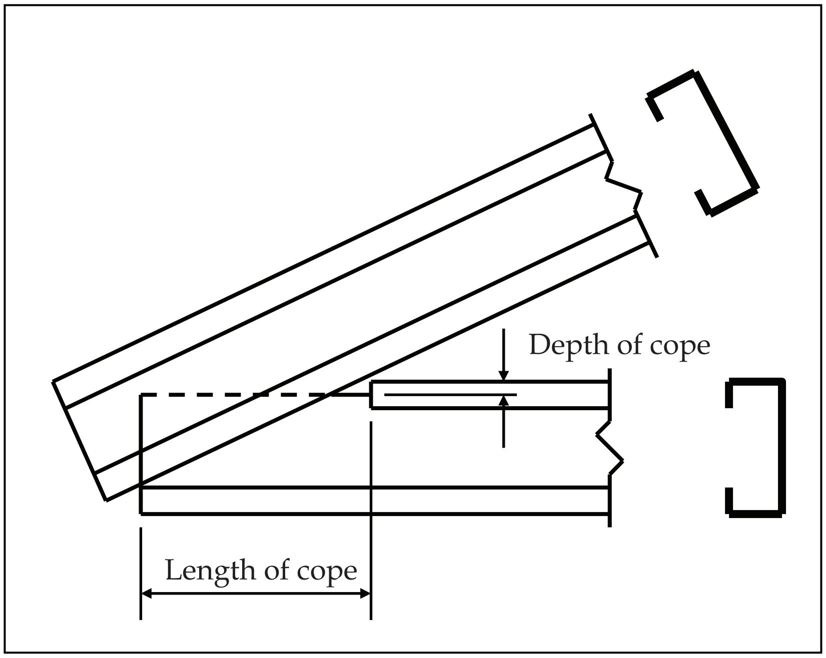


Figure D6.2-1: Definition of Truss Coping Dimensions

D7 Serviceability

Serviceability limits are to be chosen based on the intended function of the structure, and should be evaluated based on realistic loads and load combinations as determined by the *building designer*. Because serviceability limits depend on the function of the structure and the perception of the occupant, it is not possible to specify general limits in the standard. As a guide to the designer, the maximum allowable deflection of the *chord member* of a *truss* resulting from gravity load, excluding dead load, may be taken as the following:

Span/360 for plaster ceilings
Span/240 for flexible type ceilings
Span/180 for no finished ceiling
Span/480 for floor systems

Although the use of a deflection limit has been used to preclude vibration problems in the past, some floor systems may require explicit consideration of the dynamic characteristics of the floor system.

Truss serviceability is evaluated at *nominal* [*specified*] load. When computing *truss* deflections, the standard permits the use of the full cross-sectional area of the *truss* members. The use of full areas is warranted because a *truss* system is a highly indeterminate structural system, and local buckling of an individual member does not appreciably affect the stiffness of the *truss* at design load.

E. QUALITY CRITERIA FOR STEEL TRUSSES

The practices defined herein have been adopted by the standard as commonly accepted practice. In the absence of other instructions in the contract documents, the provisions of Chapter E are the quality standard for the manufacturing processes of steel *trusses* to be used in conjunction with an in-plant quality assurance procedure and a *truss* design.

F. TRUSS INSTALLATION

Cold-formed steel trusses are planar structural components. The structural performance depends on the *trusses* being installed vertically, in-plane, at specified spacing, and being properly braced. The installer is responsible for receipt, storage, erection, installation, field assembly, and *bracing*. The practices defined herein have been adopted by the standard as commonly accepted practice.

F1.1 Straightness

The truss installation tolerances defined in standard Section F1.1 have been used for many years in the prefabricated *truss* industries of both *cold-formed steel* and wood with good success. The tolerances listed in this section are *truss* assembly tolerances and not individual member tolerances. Member tolerances are outlined in AISI S200 (AISI, 2012b). *Cold-formed steel trusses* are typically used with structural sheathing applied to the top chord. This sheathing is designed to support lateral loads and act as a diaphragm. This diaphragm system behavior for *trusses* with the structural sheathing is what also enables the adoption of a seemingly more liberal out-of-straightness.

F1.2 Plumbness

These *truss* installation tolerances defined in the standard Section F1.2 have been used for many years in the prefabricated *truss* industries of both *cold-formed steel* and wood *trusses*.

G. TEST METHODS

Design calculations require the application of *approved* materials and cross-section properties. When calculations are used to define the structural performance of a *truss* assembly, the structural performance may be verified by full-scale test. However, when the structural performance cannot be determined by calculation, the structural performance must be determined by test. This standard provides guidance for both component and full-scale load tests.

G1 Component Structural Performance Load Test

The load test procedures contained in the standard may be used to confirm or define the design methodology for a *chord member* or a *web member* of a *truss* assembly. This test protocol is intended for use in the testing of *truss* assembly components fabricated using *cold-formed steel structural members*.

Because the flexural strength of a *truss* member may be controlled by bending (yielding or buckling), shear, web crippling, or combinations thereof, this test protocol defines what should be considered in regard to a test, and it does not define for the testing agency how to do the test. This leaves the selection of the test fixture and loading medium to the discretion of the testing agency. For details of test apparatus and procedures that have been used for such purposes, but in no way should be regarded as mandatory, see Hetrukul and Yu (1978), LaBoube and Yu (1978a, 1978b, 1982), and Yu (2000).

This protocol also outlines the procedures to be followed to define the compression strength [resistance] of a *truss* component for static load. Because the compression strength [resistance] of a *truss* component may be local buckling or overall column buckling, this procedure defines what to do in regard to performing a test, and it does not tell the testing agency how to do the test. This leaves the selection of the test fixture and loading medium to the discretion of the testing agency.

Load tests can be hazardous to the individuals performing or observing the tests, and also can damage the testing fixtures or the structure housing the test setup due to a sudden release of stored energy at failure. Care should be exercised in the preparation of the test setup to ensure that the failure of a test specimen will not result in a secondary collapse of a structural element not involved in the test.

The number of similar components that should be tested will vary with the desired precision and reliability of the information to be obtained and with the purpose of the test.

Loads may be measured using one or more of the following devices. Pressure gauges or load cells can be incorporated into a hydraulic loading system. These devices must be calibrated with the jacks or cylinders at different positions of piston travel to ensure a true loading history.

Deflection readings may be taken in a variety of ways. One of the simplest methods is by the use of a taut wire or monofilament line stretched between supports in combination with a mirror-scale located at the desired deflection measuring points. When the taut wire method is used, care must be taken to ensure that the wire will remain under tension during the entire test. This can be accomplished by incorporating a spring into the line or by letting one end run over a pulley with a weight attached to the line. Deflections are read on a scale with a mirror backing. The mirror-scale deflection-measuring device is read by visually lining up the top of the wire with its image in the mirror and then reading the scale.

Other commonly used deflection-measuring devices include direct reading micrometer dial gauges, optical levers used to read scales attached to the *truss*, linearly variable differential transformers (LVDTs), or a combination of flexible wire attached at deflection points and monitored remotely through a system of pulleys attached to dial gauges.

G2 Full-Scale Confirmatory Load Test

This test protocol is intended for use in the testing of *truss* assemblies fabricated using *cold-formed steel structural members* and connections. A confirmatory test is performed with the intent of verifying structural performance as defined by calculations in accordance with a recognized specification or standard. Because design is in accordance with a specification or standard, all that is needed is that the tested specimen demonstrates strength [resistance] not less than the applicable calculated strength [resistance].

The test protocol does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this protocol to establish appropriate safety and health practices and to determine the applicability of regulatory limitation prior to use.

A full-scale *truss* test is the test of a structural system. It is generally accepted that a *safety factor* of 1.5 is for overload and nothing above it should be expected in an in-situ test since the other uncertainties may already have been used up. If the test is done under laboratory conditions, 1.65 is a reasonable safety factor since fabrication and erection uncertainties are minimized. This factor of 1.65 is consistent with the recommendations of the Steel Joist Institute.

This protocol outlines the procedures to be followed in the static load testing of load-carrying *truss* assemblies. While the procedure tells what to do, it does not tell the testing agency how to do it. This leaves the selection of the test fixture and loading medium to the discretion of the testing agency.

Full-scale load tests of any large-size specimen such as a *truss* can be hazardous to the individuals performing or observing the tests, and can also damage the testing fixtures or the structure housing the test setup due to a sudden release of stored energy at failure. Care should be exercised in the preparation of the test setup to ensure that the failure of a test specimen will not result in a secondary collapse of a structural element not involved in the test.

The test fixture and load application means should be designed with adequate strength [resistance] and stiffness to ensure that it is the test specimen that is being tested, and not the test fixture.

In a single *truss* test, frequently the support at one end will allow rotation but not translation (a rocker), and the other will allow both rotation and translation (a roller) so as not to induce additional unintentional secondary stresses into the test *truss* as it deforms under load.

The loading devices should result in the desired *truss*-loading situation regardless of whether uniform, concentrated, or a combination of both. The loading system should allow the application of loads during the test to approximate the overall intended in-service load distribution. Care should be taken to avoid eccentrically applied loads unless this type of loading is desired.

G3 Full-Scale Performance Load Test

This test protocol is intended for use in the testing of *truss* assemblies fabricated using *cold-formed steel structural members* and connections when calculation of the safe strength [resistance] cannot be made in accordance with recognized calculation design specifications or standards.

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