D101-09

American
Iron and Steel
Institute

AISI DESIGN TOOL

Design Flowchart for Using the 2007 Edition of the North American Cold-Formed Steel Specification and the 2008 Edition of the AISI Cold-Formed Steel Design Manual

2009

The material contained herein has been developed by the American Iron and Steel Institute Committee on Specifications. The organization and the Committee have made a diligent effort to present accurate, reliable, and useful information on cold-formed steel design. The Committees acknowledge and are grateful for the contributions of the numerous researchers, engineers, and others who have contributed to the body of knowledge on the subject.

With anticipated improvements in understanding of the behavior of cold-formed steel and the continuing development of new technology, this material may eventually become dated. It is anticipated that future editions of this flowchart will update this material as new information becomes available, but this cannot be guaranteed.

The materials set forth herein are for general information only. They are not a substitute for competent professional advice. Application of this information to a specific project should be reviewed by a registered professional engineer. Indeed, in most 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 resulting liability arising therefrom.

First Publish, September 2009

Produced by American Iron and Steel Institute

Design Flowchart for Using the 2007 Edition of the North American Specification and the 2008 Edition of the AISI Cold-Formed Steel Design Manual

- Overview of *North American Specification for the Design of Cold-Formed Steel Structural Members,* 2007 Edition
- Overview of AISI *Cold-Formed Steel Design Manual*, 2008 Edition
- Overall Consideration of Cold-Formed Steel Design
- Flow Chart I(a), Compression Member Strength Determination
- Flow Chart I(b), Compression Member Strength Using AISI Cold-Formed Steel Design Manual
- Flow Chart II(a), Flexural Strength of Members with an I-, C-, or Z- Section, a Boxed Section or an Angle Bending about the Symmetric Axis
- Flow Chart II(b), Flexural Strength of Members with C- and Z-Sections Using AISI *Cold-Formed Steel Design Manual*
- Chart III, Bult-Up Members

Overview of North American Specification for the
Design of Cold-Formed Steel Structural Members, 2007 Edition

The 2007 edition of the *North American Specification for the Design of Cold-Formed Steel structural Members* has been accepted in the US by ANSI as the American National Standard, accepted in Canada by Canadian Standard Associations, and indorsed by CANACERO in Mexico. The design provisions that are applicable to all three countries are included in Chapters A to G, and Appendices 1 and 2. The provisions applicable to individual country are included in Appendices A (for US and Mexico) and B (for Canada). Table 1 below summaries the contents included in each chapter and appendix. As compared to the 2001 edition of the *North American Cold-Formed Steel Specification*, the major changes are summaries in the Preface of the 2007 *Specification* or in the Technical Bulletin, Volume 16, Number 2, in Fall 2007, published by Wei-Wen Yu Center for Cold-Formed Steel Structures.

Table 1, Summary of the North American Cold-Formed Steel Specification, 2007 Edition

Title/ Applicable to	**Content**
Chapter A, General Provisions / Applicable to all three countries (except those noted by "☜")	Provides general design considerations with the following major sections: A1, Scope, Applicability, and Definitions A2, Material A3, Loads A4, Allowable Strength Design A5, Load and Resistance Factor Design A6, Limit States Design A7, Yield Stress and Strength Increase from Cold Work of Forming A8, Serviceability A9, Referenced Documents
Chapter B, Elements / Applicable to all three countries (except those noted by "☜")	Determines effective width of an element (segment) with consideration of the element's edge support conditions (edge stiffened or unstiffened), stress magnitude, and variation. Once the effective elements are determined, the effective section properties (A_e, S_e, I_e) can be calculated. The major sections included in this chapter are B1, Dimension Limits and Considerations B2, Effective Widths of Stiffened Elements B3, Effective Widths of Unstiffened Elements B4, Effective Widths of Uniformly Compressed Elements with a Simple Lip Edge Stiffener B5, Effective Widths of Stiffened Elements with Single or Multiple Intermediate Stiffeners or Edge Stiffened Elements with Intermediate Stiffener(s)

Continue

Chapter C, Members / Applicable to all three countries (except those noted by "☜")	Determines the member strengths, provides corresponding safety and resistance factors, and supplies interaction checks. The major sections included in this chapter are C1, Properties of Sections C2, Tension Members C3, Flexural Members C3.1, Bending C3.2, Shear C3.3, Combined Bending and Shear C3.4, Web Crippling C3.5, Combined Bending and Web Crippling C3.6 Combined Bending and Torsional Loading C3.7, Stiffeners C4, Concentrically Loaded Compression Members C4.1, Nominal Strength for Yielding, Flexural, Flexural-Torsionl and Torsional Buckling C4.2, Distortional Buckling Strength [Resistance] C5, Combined Axial Load and Bending
Chapter D, Structural Assemblies and Systems/ Applicable to all three countries (except those noted by "☜")	Provides fastener spacing and strength requirements for built-up sections, general lateral bracing requirements, and provisions for cold-formed steel systems. The major sections included are D1, Built-Up Sections D2, Mixed Systems D3, Lateral and Stability Bracing D4, Cold-Formed Steel Light-Frame Construction D5, Floor, Roof or Wall Steel Diaphragm Construction D6, Metal Roof and Wall Systems
Chapter E, Connections and Joints / Applicable to all three countries (except those noted by "☜")	Provides design provisions for welded, bolted, screwed connections. The chapter includes the following major sections: E1, General Provisions E2, Welded Connections E3, Bolted Connections E4, Screw Connections E5, Rupture E6, Connections to Other Materials
Chapter F, Tests and Special Cases / Applicable to all three countries	Provides means of determining structural performance through testing. The chapter provides statistic data and methodology for determining a resistance factor for different type of components. The major sections included are F1, Tests for Determining Structural Performance F2, Tests for Confirming Structural Performance F3, Tests for Determining Mechanical Properties
Chapter G, Design of Cold-Formed Steel Structural Members and Connections for Cyclic Loading (Fatigue) / Applicable to all three countries	Provides design provisions for members subjected to cyclic loading (fatigue). The major sections include G1, General G2, Calculation of Maximum Stresses and Stress Ranges G3, Design Stress Range G4, Bolts and Threaded Parts G5, Special Fabrication Requirements

Appendix 1, Design of Cold-Formed Steel Structural Members Using Direct Strength Method / Applicable to all three countries	Provides an alternative procedure for determining the strength and the stiffness of cold-formed steel members and also for members with configurations not covered by the current *Specification* Chapters A to G. The major sections include: 1.1, General Provisions 1.1.1, Applicability 1.1.2, Elastic Buckling 1.1.3, Serviceability Determination 1.2, Members 1.2.1, Column Design 1.2.2, Beam Design
Appendix 2, Second-Order Analysis/ Applicable to all three countries	Provides an alternative procedure for considering the second order effect in members subjected to compression and bending. Major sections include: 2.1, General Requirements 2.2, Design and Analysis Constraint 2.2.1, General 2.2.2, Types of Analysis 2.2.3, Reduced Axial and Flexural Stiffnesses 2.2.4, Notional Loads
Appendix A / Applicable to the US and Mexico only	Includes design provisions applicable only to the United States and Mexico.
Appendix B / Applicable to Canada only	Includes design provisions applicable only to Canada

Overview of AISI Cold-Formed Steel Design Manual, 2008 Edition

To help users better understand and fully utilize the 2007 edition of the *North American Specification*, AISI has published the *Cold-Formed Steel Design Manual*, 2008 edition. The *Cold-Formed Steel Design Manual* includes six major parts. The materials included in each part are summarized in Table II below.

Table II, Summary of AISI Cold-Formed Steel Design Manual, 2008 Edition

Title	Content
Part I- Dimensions and Properties	This part provides summary of the scope and principal tensile properties of ASTM material specifications referenced in the *Specification*, gross section properties C, Z, angle and hat sections, formulas and examples for determining the gross section properties. The major sections included are 1, Steels – Availability and Properties 2, Representative Cold Formed Steel Sections (include SSMA sections and representative cold-formed steel sections) 3, Calculation of Section Properties (17 examples are included)
Part II – Beam Design	The part provides tables and charts for cold-formed steel beam effective section properties, nominal strengths, and examples. The major sections included are: 1, Bending 1.1 Notes on the Tables 1.2 Beam Property Tables (Nominal shear strength, V_n, and bending strength of braced beams, M_{nxo}, effective section modulus, S_e, and effective moment of inertia for calculating deflection, I_e) 1.3 Distortional Buckling Flexural Strength Tables (Critical unbraced length, L_{cr}; Stiffness, $k_{\phi fe}$, $\tilde{k}_{\phi fg}$, $k_{\phi we}$, $\tilde{k}_{\phi wg}$; F_d/β; and $M_n(\beta=1)$) 1.4 Calculation of L_u 1.5 Notes on Charts 1.6 Beam Charts (C- and Z- section members nominal bending strength with respect to unbraced length) 2, Combined Bending and Shear (Tables are provided for SSMA and representative sections) 3, Web Crippling (Web crippling strengths under different loading conditions and bearing lengths) 4, Example Problems II-1,Four Span Continuous C-Purlin Attached to Through Fastened Roof-LRFD II-2, Four Span Continuous Z-Purlin Attached to Through Fastened Roof-ASD II-3, C-Section Without Lips Braced at Mid-Span II-4, Distortional Buckling of C-section II-5, C-Section Without Lips in Week Axis Bending II-6, Fully Braced Hat Section II-7, Tubular Section – Round II-8, Tubular Section – Rectangular II-9, C-Section with Openings II-10, C-Section with Combined Bending and Torsional Loading II-11, Web Crippling II-12, Web-Stiffened C-Section by the Direct Strength Method – Flexure

Part III – Column Design	This part provides tables of braced column strengths, unbraced column strengths and design examples. The major sections include: 1, Concentrically Loaded Columns 1.1, Notes on the Tables 1.2, Nominal Axial Strength Tables – Braced Columns 1.3, Distortional Buckling Axial Strength Tables (Critical unbraced length, L_{cr}; Stiffness, $k_{\phi fe}$, $\tilde{k}_{\phi fg}$, $k_{\phi we}$, $\tilde{k}_{\phi wg}$; F_d; and $P_n(L_m \geq L_{cr})$) 1.3, Nominal Axial Strength Tables – Unbraced Columns 2, Example Problems III-1, Braced C-Section With Lips – Bending and Compression III-2, C-Section With Lips with Holes – Compression III-3, C-Section Subject to Distortional Buckling - Compression III-4, Unbraced Equal Leg Angle With Lips – Compression III-5, Tubular Section – Round – Bending and Compression III-6, Stiffened Z-Section with One Flange Through Fastened to Deck or Sheathing – Compression III-7, Stiffened Z-Section with One Flange Fastened to a Standing Seam Roof - Compression III-8, Hat Section – Bending and Compression III-9, I Section – Built-Up from Channels III-10, Square HSS Section – Bending and Compression III-11, Frame Design by Second Order Analysis III-12, Web-Stiffened C-Section by the Direct Strength Method – Compression
Part IV – Connection Design	This part provides tables for connection design. Major sections include: 1, Welds 1.1, Notes on the Tables 1.2, Welded Connection Design Tables Fillet Welds - Shear of Sheet Resistance (“Spot”) - Welds Shear Strength Arc Spot Welds - Shear of Sheet(s) Welded to a Thicker Supporting Member Arc Spot Welds - Shear of Sheet Welded to an Identical Sheet Arc Spot Welds - Tension 2, Bolts 2.1, Notes of the Tables 2.2, Bolted Connection Design Tables Bolts - Tension Bolts - Shear Bolts - Bearing on Inside Sheet of Double Shear Connections – Bolt Hole Deformation Not Considered Bolts - Bearing on Outside Sheets of Connections With Washers on Both Sides – Bolt Hole Deformation Not Considered Bolts - Bearing on Outside Sheets of Connections Without Washers on Both Sides – Bolt Hole Deformation No Considered 3, Screws 3.1, Notes and Tables 3.2, Screwed Connection Design Tables Screws - Shear of Sheet (F_u = 45 ksi) Representative Thickness Screws - Shear of Sheet (F_u = 65 ksi) Representative Thickness Screws - Shear of Sheet (F_u = 45 ksi) SSMA Design Thickness

	Screws - Shear of Sheet (F_u = 65 ksi) SSMA Design Thickness Screws - Pull-Out (F_u = 45 ksi) Representative Thickness Screws - Pull-Out (F_u = 65 ksi) Representative Thickness Screws - Pull-Out (F_u = 45 ksi) SSMA Design Thickness Screws - Pull-Out (F_u = 65 ksi) SSMA Design Thickness Hex Head Screws - Pull-Over (F_u = 45 ksi) Representative Thickness Hex Head Screws - Pull-Over (F_u = 65 ksi) Representative Thickness Hex Head Screws - Pull-Over (F_u = 45 ksi) SSMA Design Thickness Hex Head Screws - Pull-Over (F_u = 65 ksi) SSMA Design Thickness 4, Example Problems 4.1, Weld Examples IV-1, Flat Section with Fillet Welded Lap Connection IV-2, Flat Section with Arc Spot Welded Connection IV-3, Flat Section with Arc Seam Welded Connection IV-4, Flat Section with Flare Bevel Groove Weld IV-5, Flat Section with Groove Welded Butt Joint 4.2, Bolt Example IV-6, Flat Section with Bolted Connection VI-7, Bolted Connection with Consideration of Shear Lag 4.3 Screw Example IV-8, Screwed Connection
Part V – Supplementary Information	This part provides: 1, *Specification* Cross Reference 2, Laterally Unbraced Compression Flanges 3, Torsional-Flexural Buckling of Non-Symmetric Shapes 4, Suggested Cold-Formed Steel Structural Framing, Engineering, Fabrication, and Erection Procedures for Quality Construction
Part VI – Test Methods	Fourteen AISI test procedures are provided. The major sections include: 1, Test Methods S901-08 Rotational-Lateral Stiffness Test Methods for Beam-to-Panel Assemblies. S902-08 Stub-Column Test Method for Effective Area of Cold-Formed Steel Columns S903-08 Standard Methods for Determination of Uniform and Local Ductility S904-08 Standard Test Methods for Determining the Tensile and Shear Strength of Screws S905-08 Test Methods for Mechanically Fastened Cold-Formed Steel Connections S906-08 Standard Procedures for Panel and Anchor Structural Tests S907-08 Test Standard for Cantilever Test Method for Cold-Formed Steel Diaphragms S908-08 Base Test Method for Purlins Supporting a Standing Seam Roof System S909-08 Standard Test Method for Determining the Web Crippling Strength of Cold-Formed Steel Beams S910-08 Test Method for Distortional Buckling of Cold-Formed Steel Hat Shaped Compression Members S911-08 Method for Flexural Testing Cold-Formed Steel Hat Shaped Beams S912-08 Test Procedures for Determining a Strength Value of A Roof Panel-to-Purlin-to-Anchorage Device Connection S913-08 Test Standard for Hold-Downs Attached to Cold-Formed Steel

	Structural Framing S914-08 Test Standard for Joist Connectors Attached to Cold-Formed Steel Structural Framing 2, Bibliography of Test Procedures Pertinent to Cold-Formed Steel 3, Example Problem VI-1, Computing ϕ and Ω Factors from Test Data

Overall Consideration of Cold-Formed Steel Design

Following steps should be considered in cold-formed steel member design:

1. Calculate the loads and load combinations according to an applicable building code. In the absence of a building code, ASCE 7 should be used. Perform structural analysis to determine member forces.
2. Layout the lateral bracing for preventing buckling of members. The bracing needs to be designed with consideration of the strength and the stiffness in accordance with *Specification* D3.3.
3. If the member* is subjected to compression force, determine and check the compression strength based on Flow Charts I(a) and I(b) provided in this document.
4. If the member* is subjected to bending,
   - Determine and check the flexural strength based on Flow Charts II(a) and II(b) in this document, if applicable (or use *Design Manual* Charts II-1a to II-3b and Tables II-7 to II-9).
   - Determine the shear strength based on *Specification* C3.2 (or use *Design Manual* Tables II-1 to II-6) and check the strength based on *Specification* A4.1 or A5.1
   - Perform bending and shear interaction check based on *Specification* C3.3 (or use *Design Manual* Tables II-10a to II-12b).
   - Calculate web crippling strength for the sections at the supports and locations with concentrated loads based on *Specification* C3.4.1 (without web openings) and C3.4.2 (with web openings) (or use *Design Manual* II-13 to II-16)
   - Perform bending and web crippling check based on *Specification* C3.5.
5. If the member is subjected to tension,
   - Determine the tension strength based on *Specification* C2
6. If the member is subject to both bending and compression, perform bending and compression interaction check per *Specification* C5.2.
7. If the member is subjected to tension and bending, perform bending and tension interaction check per *Specification* C5.1.
8. Anchorage design for metal roofs with or without slops. The design should follow *Specification* D6.3.1 (note: A publication, *Design Guide for Purlin Anchorage in Metal Building Roof System*, has been developed for detailed design procedures and examples.)
9. If an unsheathed flexural member subjected to torsion (could be due to loading that not go through the shear center), *Specification* Section C3.6 should be considered. (also see *Design Manual* example II-10.)
10. Check member connection strengths with consideration of bearing strength of connected members, shear or/and tension of connectors, and pull-over and pull-out as applicable for fasteners and edge distance requirements:
    - For welded connections, determine strengths per E2 (also see *Design Manual* Tables IV-1 to IV-5),
    - For bolted connections, determine strength per E3 (also see *Design Manual* Tables IV-6 to IV-8c), and
    - For screw connections, determine the strength per E4 (also see *Design Manual* Tables IV-9a – IV-11d).

Note:
*For a member with special cross section (for example with stiffeners in the web or flanges or with complex lips), the Direct Strength Method (provided in *Specification* Appendix 1) may be considered. A publication, *Direct Strength Method Design Guide*, has been developed for providing detailed design procedures and examples, and in the *Design Manual*, examples II-4 and III-12 have also been provided.

Note: *The section numbers referred in the flow charts are the Specification section numbers. The example numbers followed "🛠" are those included in the AISI Cold-Formed Steel Design Manual, 2008 Edition.*

Flow Chart I(a): Compression Member Strength Determination:

Note:

a. For C- or Z-section members having one flange through-fastened to deck or sheathing, refer to *Specification* Section D6.1.3 (also see 🛠Ex. III-6).
b. For C- or Z-section members having standing seam roof panels, refer to *Specification* Section D6.1.4 (also see 🛠Ex. II-7).
c. For Built-up members, refer to Chart III (also see 🛠Ex. III-9).

For a typical compression member design, the following procedure should be considered:

a. Consider strength increase from cold work of forming (A7.2) (also see 🛠Exs. I-15 and III-19) .
b. Determine member strength with consideration of yielding, flexural, lateral-torsional, torsional buckling (C4.1) (also see 🛠Exs. III-1 to III-10):
    - Determine minimum elastic buckling stresses due to yielding, flexural, lateral-torsional, torsional buckling, F_e.
    - Determine the nominal buckling stress, F_n.
    - Calculate the effective area, A_e, based on the stress level $f = F_n$.
    - Calculate the nominal strength $P_{n1} = F_n A_e$.
c. Determine the member strength, P_{n2}, with consideration of distortional buckling per Section C4.2 (also see 🛠Ex. III-3).
d. The member strength is the lesser of member strengths determined per b and c.

Consider strength increase from cold work of forming per *Specification* A7.2, $F_y = F_{ya}$
Note: This step may not need to be considered.

If fully braced

Y → $f=F_y$

N ↓

Determine buckling stress due to Yielding, flexural, flexural-torsional, and torsional buckling (C4.1):

1. Determine the minimum elastic buckling stress:
   a. C4.1.1 for Flexural buckling (🛠Exs. III-1 to III-11)
   b. C4.1.2 for torsonal or flexural-torsional buckling (🛠Exs. III-2, III-3, III-4, III-9)
   c. C4.1.3 for point symmetric sections
   d. C4.1.4 for nonsymmetric sections
   e. C4.1.5 for closed cylindrical or tubular sections (🛠Exs. III-5 and III-10)
   f. Select the minimum stress level calculated based on a to e above as applicable:

$$F_e = \min \text{ (buckling stresses from a to e)}$$

Note: Web openings do not need to be considered in determining the elastic buckling stresses.

2. Determine the nominal buckling stress F_n per C4.1.

$$f = F_n$$

Determine the effective width of flat elements, b_i, at the stress level, f:

a. B2.1 for both edges are stiffened (consider B2.2 if holes exist) (🛠Exs. I-8 to I-14, I-16, II-5, II-8, II-9, III-2, III-10)
b. B3.1 for one of the edges unstiffened (🛠Exs. I-9, I-12, I-13),
c. B4 for element with a simple edge stiffener (🛠Exs. I-8, I-10, I-11, I-13, I-14, III-2)
d. B5 for stiffened element with a single or multiple intermediate stiffeners, and

Calculate the effective area, A_e, by summing effective element areas and the corner areas.

Axial compressive strength due to yielding, flexural, flexural torsional, and torsional:

$$P_{n1} = A_e F_n$$

Allowable strength: $P_{1\_ASD} = P_{n1}/\Omega_c$

Design strength: $P_{1\_LRFD} = \phi_c P_{n1}$

Continue to the next page

Continue from the next page

↓

Determine compression strength due to distortional buckling:

a. Calculate elastic distortional buckling stress per C4.2 (a), (b) or (c) (🛠Ex. III-3)
b. Calculate the nominal buckling strength due to distortion, P_{n2}, per C4.2.
c. Calculate the allowable strength $P_{2\_ASD} = P_{n2}/\Omega_c$ and design strength $P_{2\_LRFD} = \phi_c P_{n2}$.

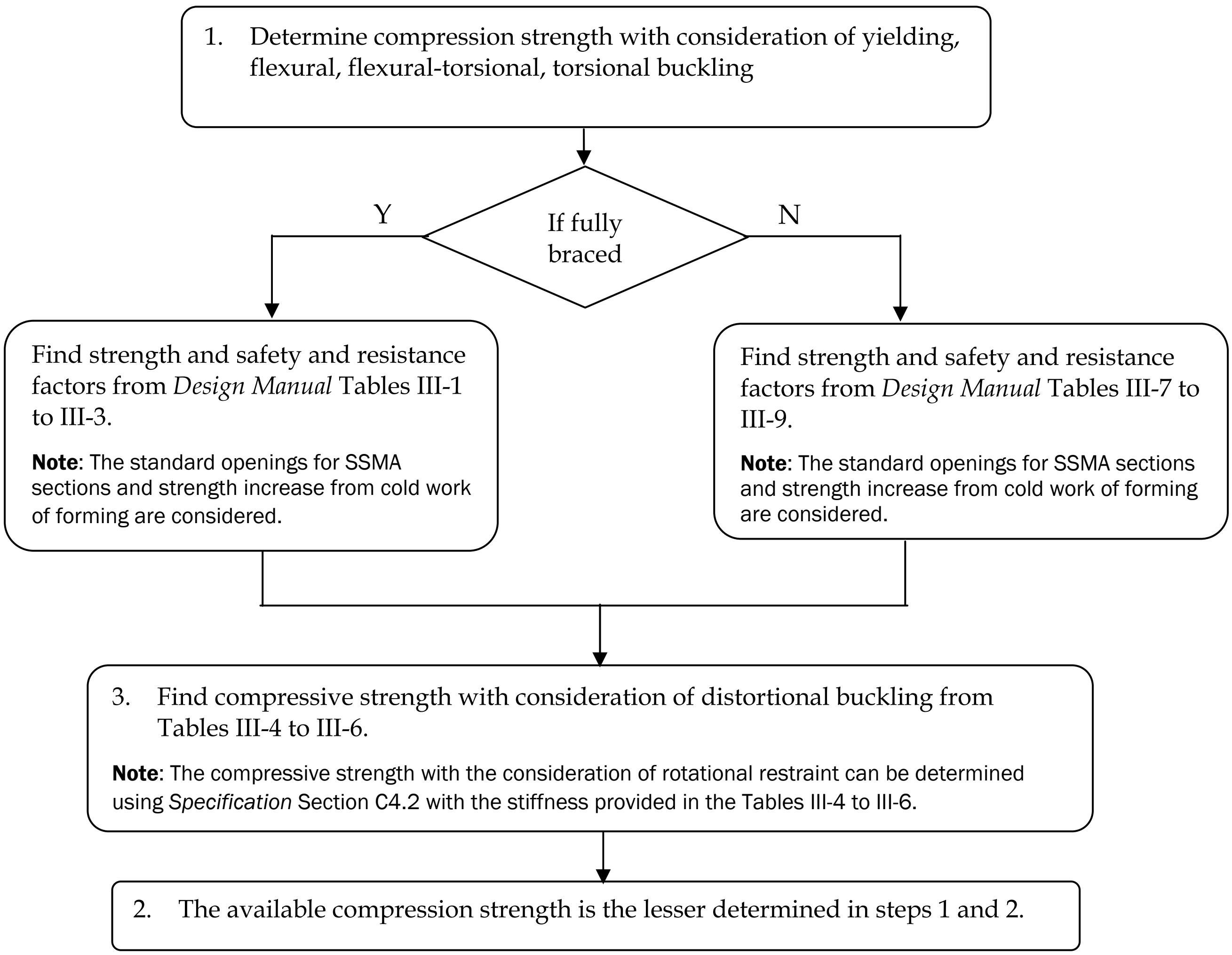
↓

The compression strength is the minimum of the strengths due to yielding, flexural, flexural-torsional, and torsional bucklings, and distortional buckling:
$P_{ASD} = \min(P_{1\_ASD}, P_{2\_ASD})$; $P_{LRFD} = \min(P_{1\_LRFD}, P_{2\_LRFD})$

↓

Design Check:
Required Strength Compression (force due to external loads and load combinations) ≤ Available Strength

Flow Chart I(b): Compression Member Strength Using AISI Cold-Formed Steel Design Manual



Flow Chart II(a): Flexural Strength of Members with an I-, C-, or Z- Section, a Boxed Section or an Angle Bending about the Symmetric Axis

Chart II provides design guide for members under the following conditions*:

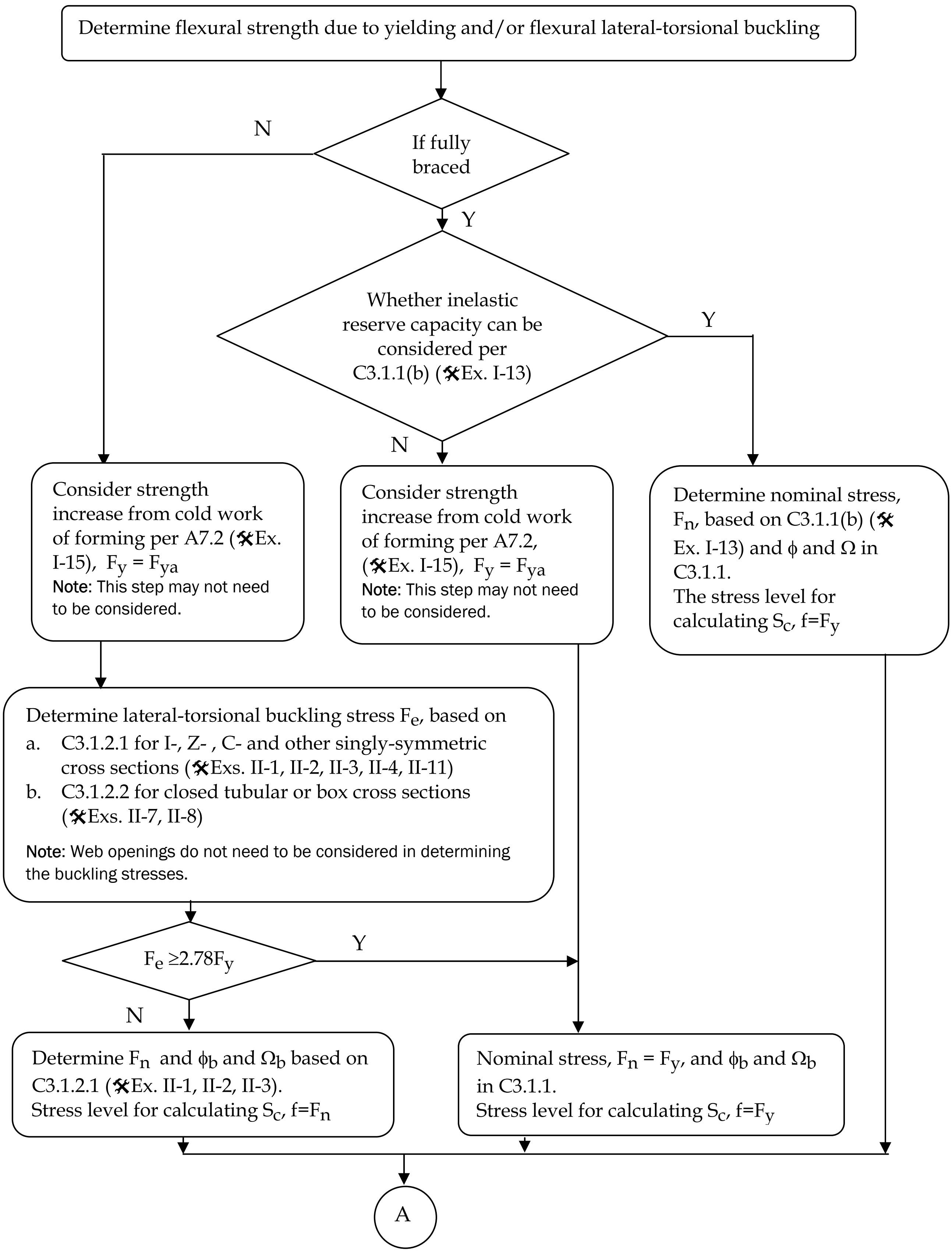
a. Z-section bending about the centroidal axis that is perpendicular to the web
b. C-sections bending about both principal axes
c. Symmetric Angles bending about the symmetric axis
d. Boxed sections
e. Hat sections with lips in tension, which can be treated the same as C-section bending about the weak axis.

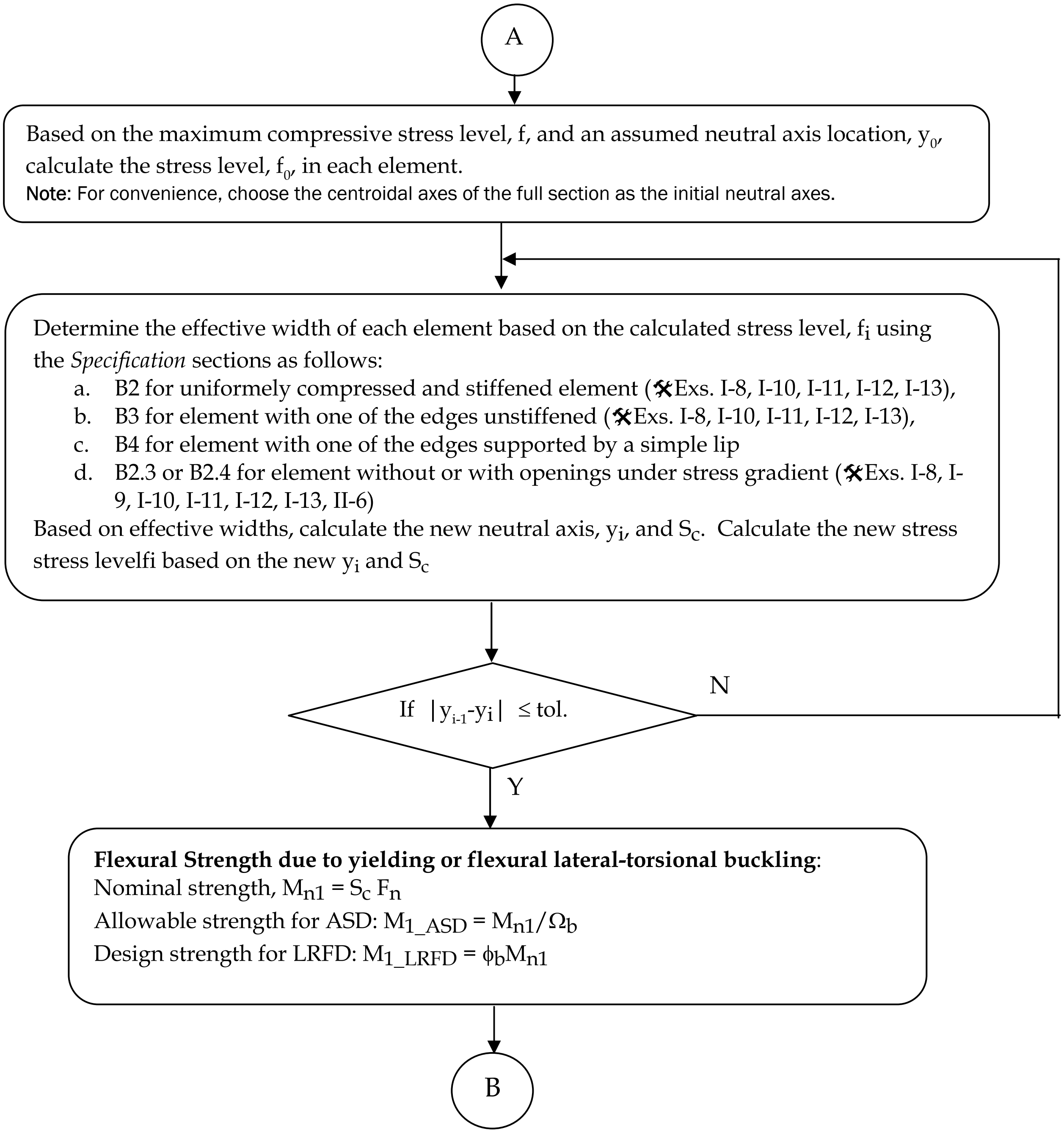
The following design procedure may be considered:

1. Consider strength increase from cold work of forming per *Specification* Section A7.2,
2. Determine flexural strength due to yielding per *Specification* Section C3.1.1,
3. Determine the flexural lateral-torsional buckling strength per C3.1.2:
    a. Determine the elastic buckling stress level, F_e, due to lateral torsional-buckling,
    b. Determine the nominal stress F_n,
    c. Determine the effective section properties S_c and I_c based on nominal stress F_n. Iterations may be needed, and
    d. Calculate the available flexural lateral-torsional strength.
4. Determine the available distortional buckling strength per C3.1.4, and
5. The available flexural strength is the minimum from 2, 3, and 4.

Chart II on the next page illustrates the design procedure outlined above.

Note:
* For conditions not listed, the Direct Strength Method may be considered.


Determine flexural strength due to yielding and/or flexural lateral-torsional buckling
If fully braced
N
Y
Whether inelastic reserve capacity can be considered per C3.1.1(b) (Ex. I-13)
Y
N
Consider strength increase from cold work of forming per A7.2 (Ex. I-15), $F_y = F_{ya}$
Note: This step may not need to be considered.
Consider strength increase from cold work of forming per A7.2, (Ex. I-15), $F_y = F_{ya}$
Note: This step may not need to be considered.
Determine nominal stress, F_n, based on C3.1.1(b) (Ex. I-13) and ϕ and Ω in C3.1.1.
The stress level for calculating S_c, $f=F_y$
Determine lateral-torsional buckling stress F_e, based on
a. C3.1.2.1 for I-, Z- , C- and other singly-symmetric cross sections (Exs. II-1, II-2, II-3, II-4, II-11)
b. C3.1.2.2 for closed tubular or box cross sections (Exs. II-7, II-8)
Note: Web openings do not need to be considered in determining the buckling stresses.
$F_e \geq 2.78F_y$
Y
N
Determine F_n and ϕ_b and Ω_b based on C3.1.2.1 (Ex. II-1, II-2, II-3).
Stress level for calculating S_c, $f=F_n$
Nominal stress, $F_n = F_y$, and ϕ_b and Ω_b in C3.1.1.
Stress level for calculating S_c, $f=F_y$
A


A
Based on the maximum compressive stress level, f, and an assumed neutral axis location, y_0, calculate the stress level, f_0, in each element.
Note: For convenience, choose the centroidal axes of the full section as the initial neutral axes.
Determine the effective width of each element based on the calculated stress level, f_i using the *Specification* sections as follows:
a. B2 for uniformely compressed and stiffened element (⚒Exs. I-8, I-10, I-11, I-12, I-13),
b. B3 for element with one of the edges unstiffened (⚒Exs. I-8, I-10, I-11, I-12, I-13),
c. B4 for element with one of the edges supported by a simple lip
d. B2.3 or B2.4 for element without or with openings under stress gradient (⚒Exs. I-8, I-9, I-10, I-11, I-12, I-13, II-6)
Based on effective widths, calculate the new neutral axis, y_i, and S_c. Calculate the new stress stress levelfi based on the new y_i and S_c
If $|y_{i-1}-y_i| \le$ tol.
N
Y
Flexural Strength due to yielding or flexural lateral-torsional buckling:
Nominal strength, $M_{n1} = S_c F_n$
Allowable strength for ASD: $M_{1\_ASD} = M_{n1}/\Omega_b$
Design strength for LRFD: $M_{1\_LRFD} = \phi_b M_{n1}$
B

B

Determine flexural distortional buckling Strength per C3.1.4:

- Use either of subsections C3.1.4(a), (b) and (c) to determine the elastic distortional buckling stress F_d (🛠Exs. II-1, II-2, II-4).

  Note: C3.1.4(a) provides conservative result; C3.1.4 (b) is a manual calculation approach which is applicable only to C and Z sections; and C3.1.4 (c) is applicable to prismatic members with any types of cross sections.
- Calculated the nominal strength M_{n2} per C3.1.4 and

  Allowable Strength, $M_{2\_ASD} = M_{n2}/\Omega_b$

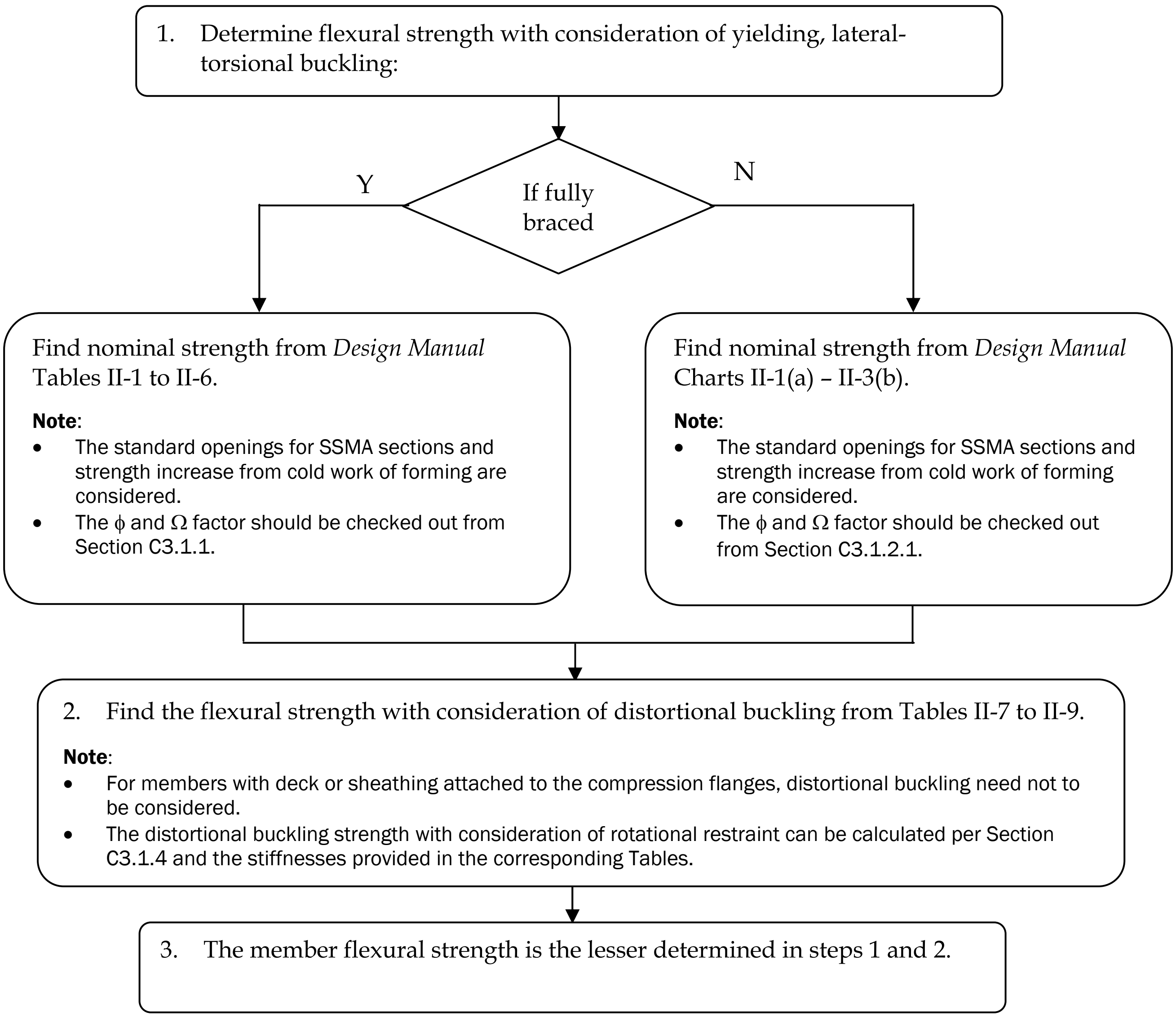
  Design Strength, $M_{2\_LRFD} = \phi M_{n2}$

The available strength of the member:

Allowable strength M_{ASD} = lesser of (M_{1_ASD}, M_{2_ASD})

Design strength M_{LRFD} = lesser of (M_{1_LRFD}, M_{2_LRFD})

Flow Chart II(b): Flexural Member Strength for C- and Z-Sections Using AISI Cold-Formed Steel Design Manual



Special Cases

a. For a member with a through fastened roof attached to deck or sheathing, Section C3.1.1 is used for cross sections with compression flange attached to deck or sheathing and Section D6.1.1 is used for cross sections with tension flange attached to deck or sheathing.
b. For a member with a standing seam roof attached, either Section D6.1.2 (in Appendix A of the *Specification*) or Section C3.1.2.1 can be used for determining the flexural strength.
c. For members with other than C or Z section members or members with stiffeners in either flanges or web, Direct Strength Method is recommended.
d. For hat sections with lips in compression, Direct Strength Method is recommended since distortional buckling is likely to occur to the outstanding legs.

Chart III, Bult-Up Members

The built-up member design needs to consider:

1. adequacy of the connection (D1)
2. strenght of a combined section:
   a. C4.1 and D1.2 for compression
   b. C3.1 for flexural
   c. C2 for tension

The following chart illustrate the design procedure outlined above:

For flexural members with two C-sections to form an I-section (🛠Ex. III-9):

- The maximum spacing of the connectors should be limited by Eq. D1.1-1 (D1.1)
- Determine the flexural strength based on C3.1.2.1 or Flow Chart II.

Note:

- For a uniform spacing, the maximum spacing should be determined based on the maximum load intensity (D1.1)
- The spacing may vary along the beam according to the load intensity.
- Reinforcing cover plates may be welded to the flanges at the points with concentrated load (D1.1).
- Eq. D1.1-1 may also be used for 2 C- sections to form a boxed section even though it is not included in the *Specification* (Cold-Formed Steel Design, 3rd Edition by Wei-Wen Yu).

For a built-up compression member formed by two same sections in contact (🛠Ex. III-9):

- The spacing of the connector, a, is limited per D1.2 such that (the slenderness of the individual member) ≤ 0.5 (governing slenderness ratio of the built-up section) (D1.2)
- Determine the slenderness ratio of the built-up section using Eq. D1.2-1
- Determine the compression strength per Flow Chart I.

Note:

- Special end connection should be considered per D1.2 (2).
- Each connector should be capable to transfer the longitudinal shear force per D1.2 (3).
- The slenderness ratio calculated per Eq. D1.2-1 is for built-up member bent about the axis through the connectors when the section buckles.
- Warping constant, C_W, of the built-up can be assumed as the sum of the individual members.

American Iron and Steel Institute
1140 Connecticut Avenue, NW
Suite 705
Washington, DC 20036
www.steel.org