2016 AISC Standards

Specification for Structural Steel Buildings

&

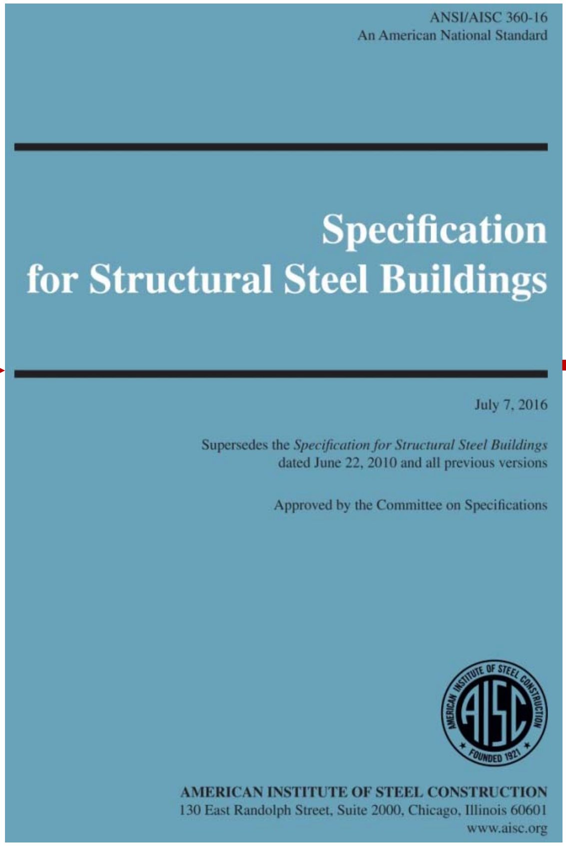
Code of Standard Practice for Steel Buildings and Bridges

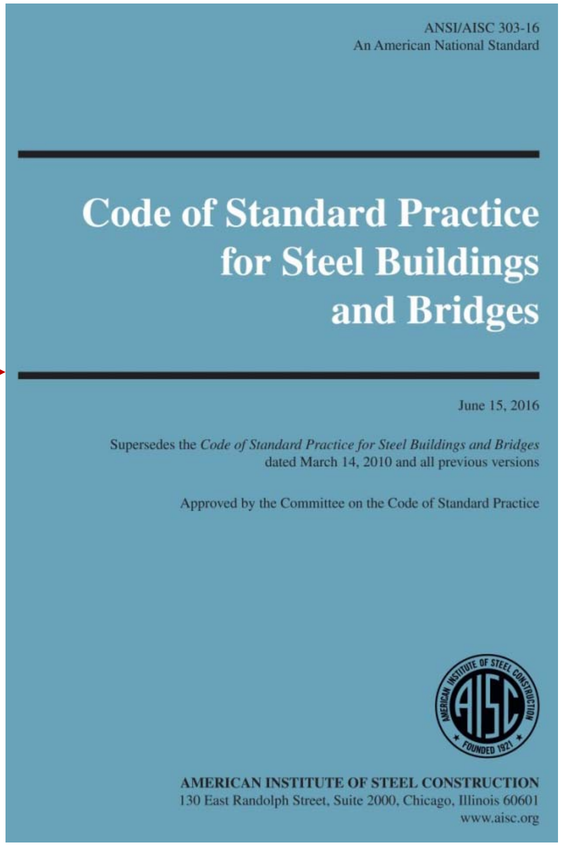
Eric Bolin
Staff Engineer

June 1, 2017

2016 AISC Standards

2018 *INTERNATIONAL BUILDING CODE*





2016 AISC Standards

ANSI

American National Standards Institute

2016 AISC Standards

AISC Committee on Code of Standard Practice

- *Code of Standard Practice for Steel Buildings and Bridges* (ANSI/AISC 303-16)

AISC Committee on Specifications

- *Specification for Structural Steel Buildings* (ANSI/AISC 360-16)
- *Seismic Provisions for Structural Steel Buildings* (ANSI/AISC 341-16)
- *Specification for Safety Related Steel Structures for Nuclear Facilities* (ANSI/AISC N690-17)
- *New standard for Evaluation and Retrofit for Seismic Applications*

2016 AISC Standards: AISC 360-16

AISC Committee on Specifications

TASK COMMITTEES	
TC 1 – Coordination	**TC 7** – Evaluation & Repair
TC2 - Editorial/Economy/Efficiency/ Practical Use	**AISI/AISC Fire Committee**--Design for Fire Conditions
TC 3 – Loads, Analysis & Stability	**TC 9** – Seismic Systems
TC 4 – Member Design	**TC 10** – Materials, Fabrication, Erection & Inspection
TC 5 – Composite Design	**TC 11** – Nuclear Facilities Design
TC 6 – Connection Design	**TC 12** – Quality Certification and Quality Assurance

2016 AISC Standards: AISC 360-16

AISC Committee on Specifications

Mission Statement:

Develop the practice-oriented specification for structural steel buildings that provides for:

- Life safety
- Economical building systems
- Predictable behavior and response
- Efficient use

2016 AISC Standards: AISC 360-16

AISC Committee on Specifications

Goals for 2016 Specification:

- Implement only essential changes
- Coordinate with other standards
- Reflect new research
- More efficient designs
- Broaden scope or fix omissions
- Improve usability/transparency
- Improve editorial content

2016 AISC Standards: AISC 360-16

2016 Specification for Structural Steel Buildings

Chapter A - General Provisions

Chapter B - Design Requirements

Chapter C - Design for Stability

Chapter D - Design of Members for Tension

Chapter E - Design of Members for Compression

Chapter F - Design of Members for Flexure

Chapter G - Design of Members for Shear

Chapter H - Design of Members for Combined Forces and Torsion

2016 AISC Standards: AISC 360-16

2016 Specification for Structural Steel Buildings

Chapter I - Design of Composite Members

Chapter J - Design of Connections

Chapter K - ~~Design of HSS and Box Member Connections~~ Additional Requirements for HSS and Box-Section Connections

Chapter L - Design for Serviceability

Chapter M - Fabrication and Erection

Chapter N - Quality Control and Quality Assurance

2016 AISC Standards: AISC 360-16

2016 Specification for Structural Steel Buildings

Appendix 1. Design by ~~Inelastic~~ Advanced Analysis

Appendix 2. Design for Ponding

Appendix 3. ~~Design for~~ Fatigue

Appendix 4. Structural Design for Fire Conditions

Appendix 5. Evaluation of Existing Structures

Appendix 6. Member Stability Bracing ~~for Columns and Beams~~

Appendix 7. Alternative Methods of Design for Stability

Appendix 8. Approximate Second-Order Analysis

2016 AISC Standards: AISC 360-16

Chapter A – General Provisions

Section A.2 Referenced Specifications, Codes and Standards

Updated references:

- ASCE 7 (2016)
- AWS D1.1 (2015)
- RCSC Specification (2014)
- ACI 318 (2014)

2016 AISC Standards: AISC 360-16

Chapter A – General Provisions

Section A.2 Referenced Specifications, Codes and Standards

New HSS standards ASTM A1065 and A1085:

- Round and rectangular HSS shapes with 50 ksi yield strength
- Design wall thickness = Nominal wall thickness

2016 AISC Standards: AISC 360-16

Chapter A – General Provisions

Section A.2 Referenced Specifications, Codes and Standards

ASTM F3125 - New “umbrella” bolt standard

- Incorporates A325, A325M, A490, A490M, F1825 and F2280
- Increased bolt pretension values for 1-1/8” diameter and larger A325 bolts.
- New designation:

ASTM A325 → ASTM F3125 Grade A325

2016 AISC Standards: AISC 360-16

Chapter A – General Provisions

Section A.2 Referenced Specifications, Codes and Standards

New “extra” high strength bolts:

- ASTM F3043: Twist-off “TC” style bolt
- ASTM F3111: Heavy hex head bolt

2016 AISC Standards: AISC 360-16

Chapter A – General Provisions

Section A.2 Referenced Specifications, Codes and Standards

New filler metal standard AWS A5.36:

- Flux and metal cored electrodes
- Will supersede AWS A5.20 and A5.29

2016 AISC Standards: AISC 360-16

Chapter B – Design Requirements

Section B3.9 Design for Structural Integrity

Provisions for structural integrity were added for cases when required by applicable building code.

Included cases:

- Column splices
- Beam/girder end connections
- End connections for members bracing columns

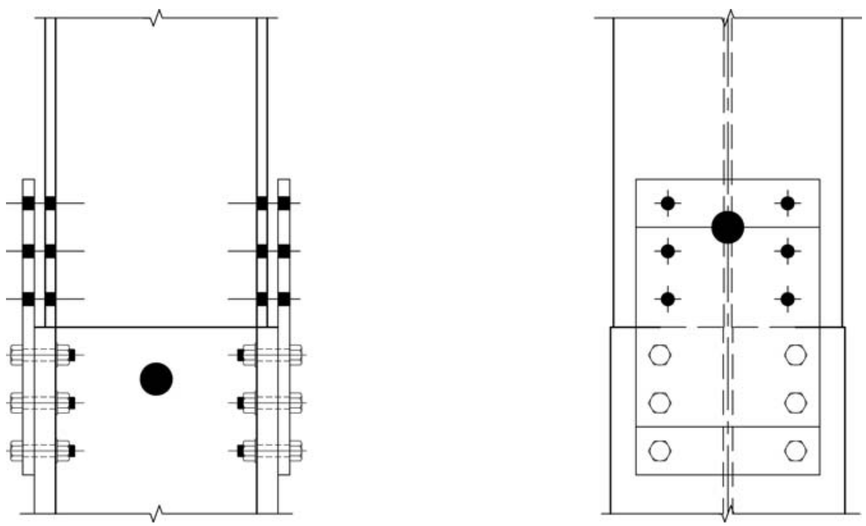
2016 AISC Standards: AISC 360-16

Chapter B – Design Requirements

Section B3.9 Design for Structural Integrity

Column splices:

$T_n \geq (D + L)$ for area tributary to column below



2016 AISC Standards: AISC 360-16

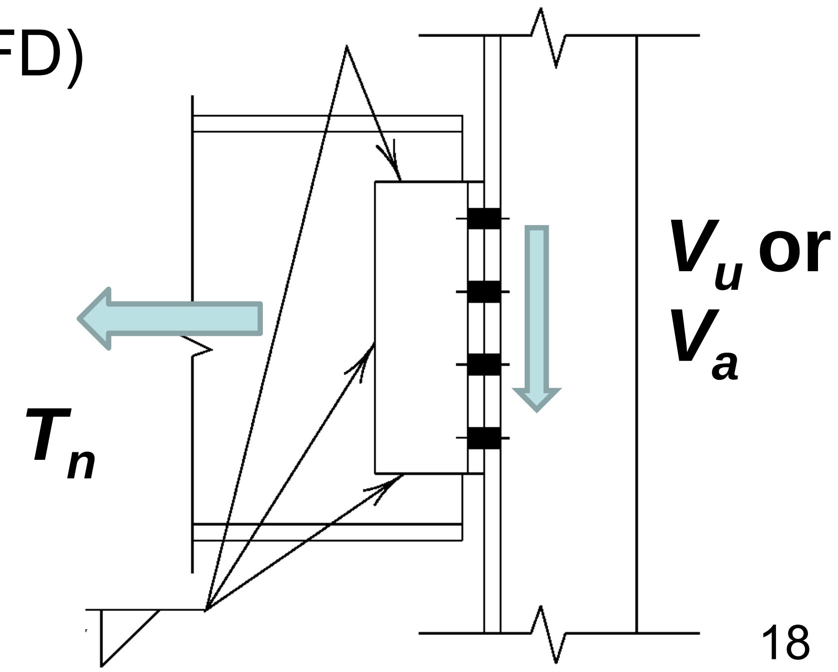
Chapter B – Design Requirements

Section B3.9 Design for Structural Integrity

Beam/girder end connections:

$T_{n,min}$ = (2/3) V_u ≥ 10 kips (LRFD)

$T_{n,\,min} = V_a$ ≥ 10 kips (ASD)



2016 AISC Standards: AISC 360-16

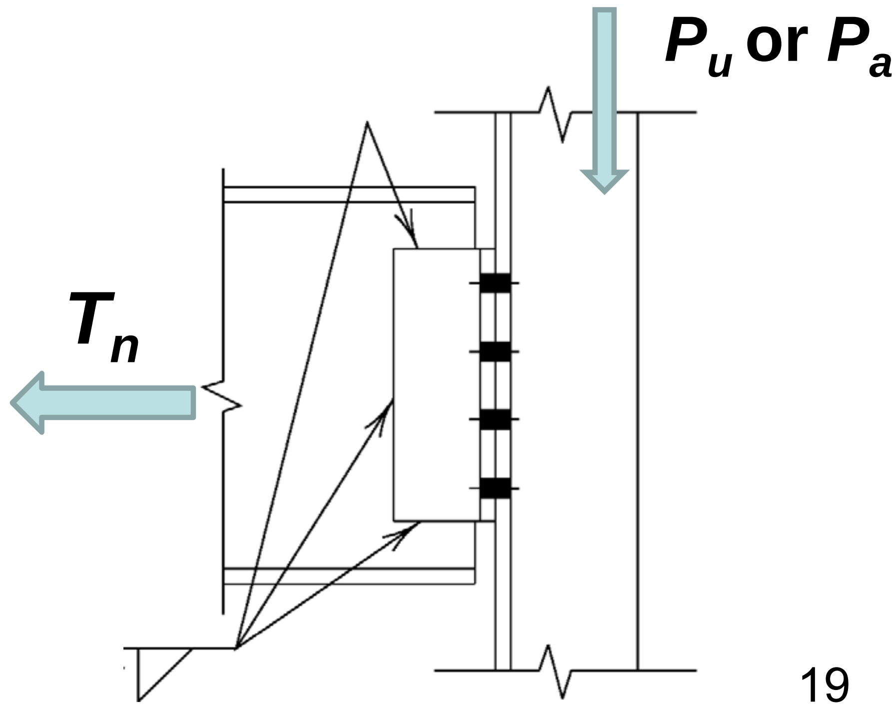
Chapter B – Design Requirements

Section B3.9 Design for Structural Integrity

End connections of members bracing columns:

$$T_n \geq 0.01(2/3)P_u \text{ (LRFD)}$$

$$T_n \geq 0.01P_a \quad \text{(ASD)}$$



2016 AISC Standards: AISC 360-16

Chapter B – Design Requirements

Section B3.10 Design for Ponding

The roof system shall be investigated through structural analysis to ensure strength and stability under ponding conditions, unless the roof surface is ~~provided with a slope of ¼ in. per ft or greater toward points of free drainage or an adequate system of drainage is provided~~ configured to prevent the accumulation of water.

2016 AISC Standards: AISC 360-16

Chapter D – Design of Members for Tension

Table D3.1, Revised Shear Lag Factor, *U*

Tensile yielding

$$P_n = F_y A_g \qquad \text{(Eq. D2-1)}$$

Tensile rupture

$$P_n = F_u A_e \qquad \text{(Eq. D2-2)}$$

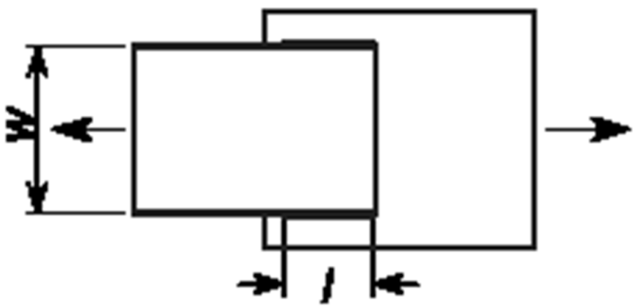
$$A_e = A_n U \qquad \text{(Eq. D3-1)}$$

2016 AISC Standards: AISC 360-16

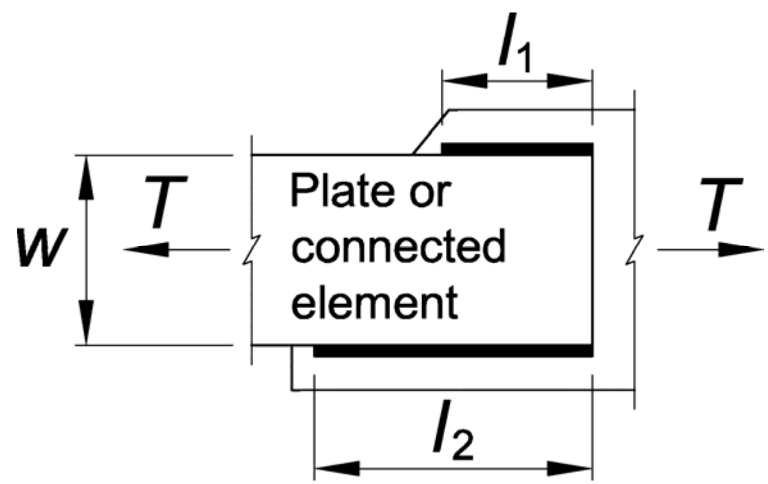
Chapter D – Design of Members for Tension

Table D3.1, Revised Shear Lag Factor, *U*

Case 4:



2010



2016

2016 AISC Standards: AISC 360-16

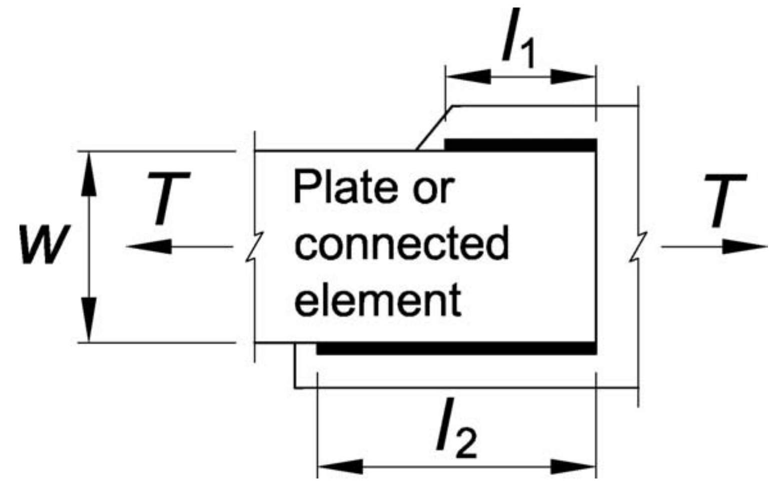
Chapter D – Design of Members for Tension

Table D3.1, Revised Shear Lag Factor, *U*

Case 4:

$$U = \frac{3l^2}{3l^2 + w^2}\left(1 - \frac{\bar{x}}{l}\right)$$

$$l = \frac{l_1 + l_2}{2}$$



where l_1 and l_2 shall not be less than 4 times the weld size.

2016 AISC Standards: AISC 360-16

Chapter E – Design of Members for Compression

- **Revised effective length term:**

$$KL \longrightarrow L_c$$

- **Slender element procedure, no longer uses the *Q* factors**

2016 AISC Standards: AISC 360-16

Chapter E – Design of Members for Compression

Section E7 Members with Slender Elements

For $\lambda > \lambda_r$

2010:

$P_n = F_{cr} A_g$

F_{cr} based on a Q factor given in Section E7

2016:

$P_n = F_{cr} A_e$

$A_e = \Sigma$ (effective areas of cross-section elements based on reduced effective widths, b_e….)

2016 AISC Standards: AISC 360-16

Chapter E – Design of Members for Compression

Section E7 Members with Slender Elements

For $\lambda > \lambda_r$

λ	**Effective Width, b_e**
$\leq \lambda_r \sqrt{\dfrac{F_y}{F_{cr}}}$	b
$> \lambda_r \sqrt{\dfrac{F_y}{F_{cr}}}$	$b\left(1 - c_1\sqrt{\dfrac{F_{el}}{F_{cr}}}\right)\sqrt{\dfrac{F_{el}}{F_{cr}}}$

2016 AISC Standards: AISC 360-16

Section E7 Members with Slender Elements

For $\lambda > \lambda_r$

$$F_{el} = \left(c_2 \frac{\lambda_r}{\lambda} \right)^2 F_y$$

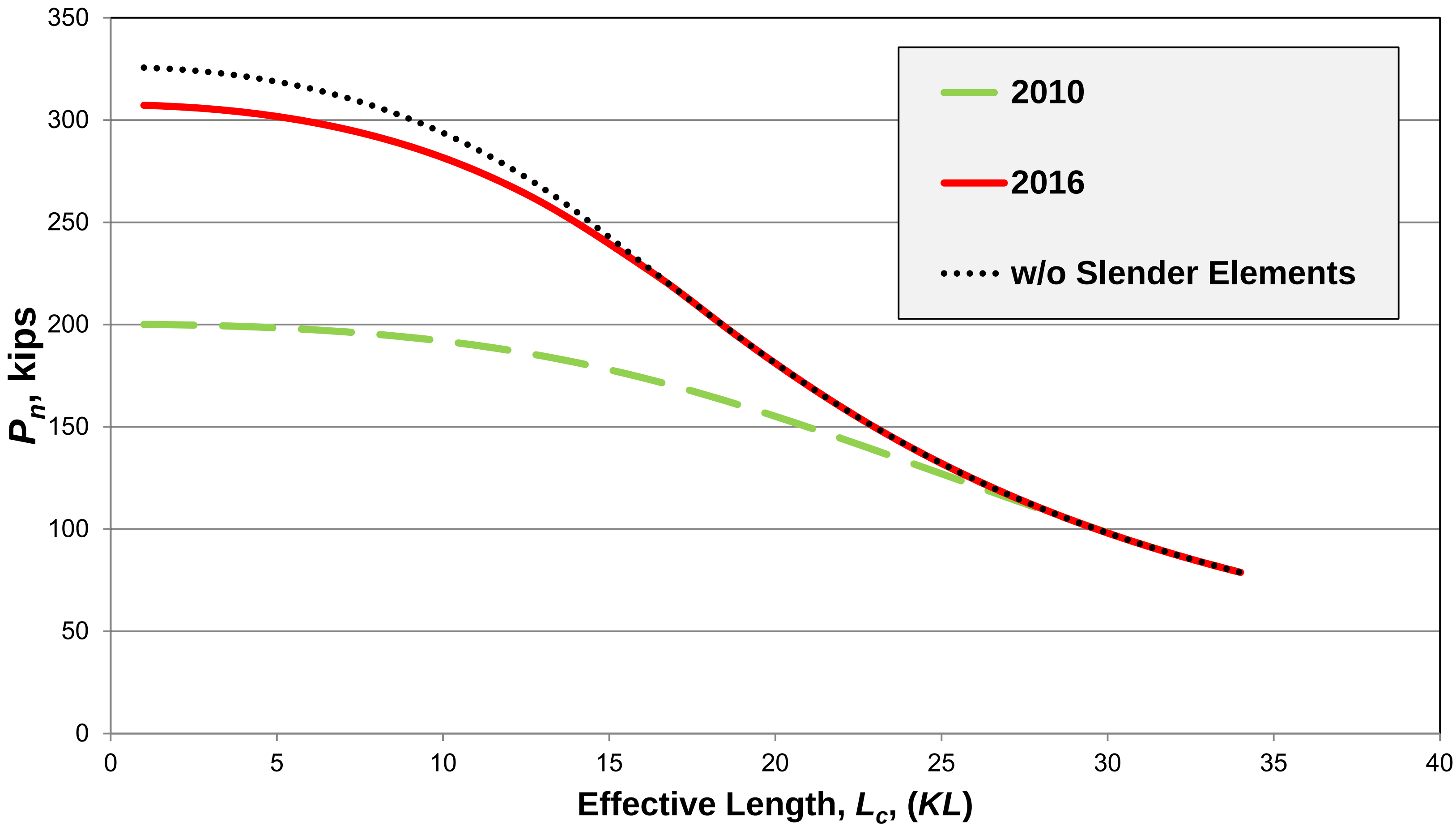
Table E7.1
Effective Width Imperfection Adjustment Factors c_1 and c_2

Slender Element	c_1	c_2
Stiffened elements except walls of square and rectangular HSS	0.18	**1.31**
Walls of square and rectangular HSS	0.20	**1.38**
All other elements	**0.22**	**1.49**

2016 AISC Standards: AISC 360-16

2016 vs. 2010 Compressive Strength Comparison

WT15x45 (slender stem) - F_y = 50 ksi



2016 AISC Standards: AISC 360-16

Chapter F – Design of Members for Flexure

Section F7 Square and Rectangular HSS and Box Sections

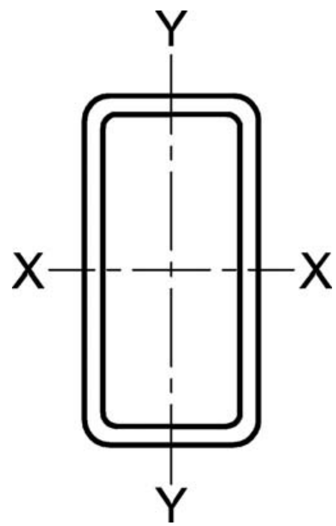
Web local buckling - compact webs

(1) Compression flange yielding

$$M_n = R_{pg} F_y S$$

(2) Compression flange local buckling

$$M_n = R_{pg} F_{cr} S_{xc}$$



Where R_{pg} is the bending strength reduction factor defined in Section F5.2

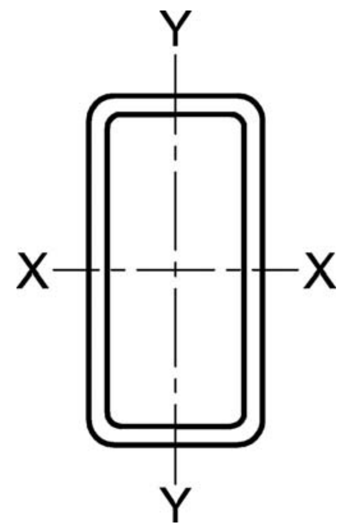
2016 AISC Standards: AISC 360-16

Chapter F – Design of Members for Flexure

Section F7 Square and Rectangular HSS and Box Sections

Lateral-torsional buckling

- Rectangular section bent about major axis only
- Typically deflection will control for HSS shapes



2016 AISC Standards: AISC 360-16

Chapter F – Design of Members for Flexure

Section F9 Tees and Double Angles Loaded in the Plane of Symmetry

Stem or angle leg in tension

Stem or angle leg in compression

2016 AISC Standards: AISC 360-16

Chapter F – Design of Members for Flexure

Section F9 Tees and Double Angles Loaded in the Plane of Symmetry

Flexural strength, M_n, is the minimum of:

1. Yielding—2016 includes case for 2L
2. Lateral-torsional buckling (LTB) of tee stems and 2L legs—Revised
3. Flange local buckling—2016 includes 2L
4. Local buckling of tee stems and 2L legs—Revised & 2016 includes 2L

2016 AISC Standards: AISC 360-16

Chapter F – Design of Members for Flexure

Section F9 Tees and Double Angles Loaded in the Plane of Symmetry

1. Yielding: $M_n = M_p$

   (a) Tee stems and web legs in tension

   $$M_p = F_y Z_x \leq 1.6 M_y \qquad \text{(F9-2)}$$

   (b) Tee stems in compression

   $$M_p = M_y \qquad \text{(F9-4)}$$

   (c) 2Ls with web legs in compression

   $$M_p = 1.5 M_y \qquad \text{(F9-5)}$$

2016 AISC Standards: AISC 360-16

Chapter F – Design of Members for Flexure

Section F9 Tees and Double Angles Loaded in the Plane of Symmetry

2. Lateral-Torsional Buckling

(a) Stem/legs in tension

For $L_p < L_b \leq L_r$

$$M_n = M_p - (M_p - M_y)\left(\frac{L_b - L_p}{L_r - L_p}\right)$$

2016 AISC Standards: AISC 360-16

Chapter F – Design of Members for Flexure

Section F9 Tees and Double Angles Loaded in the Plane of Symmetry

2. Lateral-Torsional Buckling

(a) Stem/legs in tension

For $L_b > L_r$:

Same Eqn.

$$M_{cr} = \frac{1.95E}{L_b}\sqrt{I_y J}\left(B + \sqrt{1 + B^2}\right) \qquad (2016)$$

$$M_{cr} = \frac{\pi\sqrt{EI_y GJ}}{L_b}\left(B + \sqrt{1 + B^2}\right) \qquad (2010)$$

2016 AISC Standards: AISC 360-16

Chapter F – Design of Members for Flexure

Section F9 Tees and Double Angles Loaded in the Plane of Symmetry

4. Local Buckling—tee stems in flexural compression

$$M_n = F_{cr}S_x$$

Table B4.1b—Case 14:

$$\lambda_r = 1.52\sqrt{\frac{E}{F_y}} \quad (2016)$$

$$\lambda_r = 1.03\sqrt{\frac{E}{F_y}} \quad (2010)$$

2016 AISC Standards: AISC 360-16

Chapter F – Design of Members for Flexure

Section F9 Tees and Double Angles Loaded in the Plane of Symmetry

4. Local Buckling—tee stems in flexural compression

$$M_n = F_{cr}S_x$$

When $\lambda_p < \lambda \leq \lambda_r$

$$F_{cr} = \left(1.43 - 0.515\frac{d}{t_w}\sqrt{\frac{F_y}{E}}\right)F_y \qquad (2016)$$

$$F_{cr} = \left[2.55 - 1.84\frac{d}{t_w}\sqrt{\frac{F_y}{E}}\right]F_y \qquad (2010)$$

2016 AISC Standards: AISC 360-16

Chapter F – Design of Members for Flexure

Section F9 Tees and Double Angles Loaded in the Plane of Symmetry

4. Local Buckling—tee stems in flexural compression

$$M_n = F_{cr} S_x$$

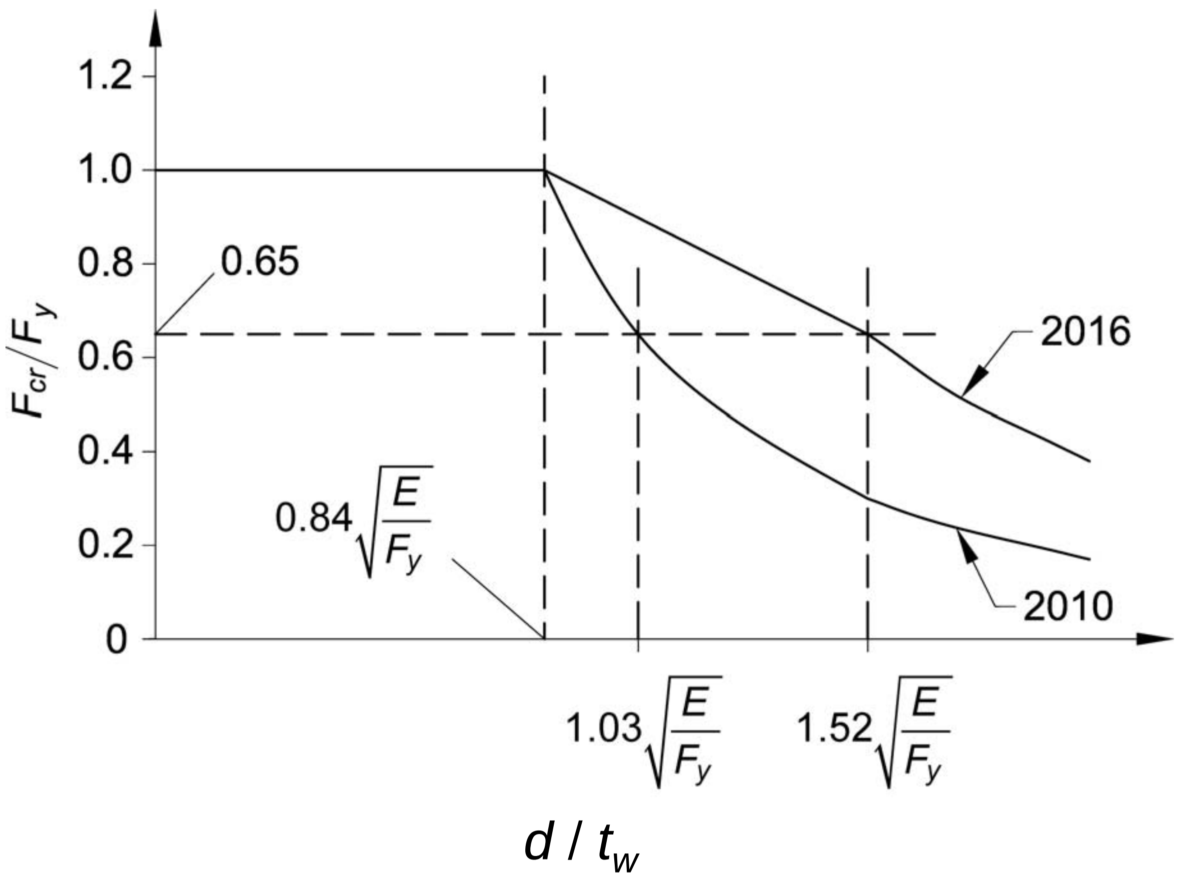
When $\lambda_r < \lambda$

$$F_{cr} = \frac{0.69E}{\left(\frac{d}{t_w}\right)^2} \quad \text{(2016)}$$

$$F_{cr} = \frac{1.52E}{\left(\frac{d}{t_w}\right)^2} \quad \text{(2010)}$$

2016 vs. 2010 Comparison

Local Buckling—tee stems in flexural compression



2016 AISC Standards: AISC 360-16

Chapter G – Design of Members for Shear

Section G2.1 I-Shaped Members without Tension Field Action

- Increased strength by accounting for some post-buckling strength of web
- Accordingly increased requirements for stiffeners

Section G2.1 I-Shaped Members with Tension Field Action

- Expanded tension field action beyond the limits found in 2010

2016 AISC Standards: AISC 360-16

Chapter I – Design of Composite Members

Material limitations (Sect. I1.3)

- Increased maximum reinforcing steel strength to 80 ksi

Concrete filled axially loaded members

- Clarifies that longitudinal reinforcement is not required (Sect. I2.2a)
- If longitudinal reinforcement is provided, transverse reinforcement is not required for strength
- Updated direct bond interaction provisions (Sect. I6.3c)

2016 AISC Standards: AISC 360-16

Chapter I – Design of Composite Members

Stiffness for calculation of req'd strengths (Sect. I1.5)

- Provides criteria to apply the direct analysis method to composite members
- Research by M.D. Denavit, J.F. Hajjar, T. Perea, and R.T. Leon

Effect of ductility at beam/slab interface must be considered (Sect. I3.2d)- see *Commentary*

2016 AISC Standards: AISC 360-16

Chapter J – Design of Connections

Section J1 General Provisions

Bolts in combination with welds at shear connections:

2010 – Not permitted except with bolts sharing load with longitudinally loaded fillet welds. Bolt strength may not exceed 50% of available bearing strength.

2016 – Permitted where strain compatibility considered. Bolts must be installed to slip critical and follow other requirements of Section J1.8.

2016 AISC Standards: AISC 360-16

Chapter J – Design of Connections

Section J3 Bolts and Threaded Parts

New ASTM F3125 bolt standard

- Group A: A325, A325M, F1852
  and ASTM A354 Grade BC
- Group B: A490, A490M, F2280
  and ASTM A354 Grade BD

New extra high-strength bolts

- Group C: F3043 and F3111

2016 AISC Standards: AISC 360-16

Chapter J – Design of Connections

Section J3 Bolts and Threaded Parts

TABLE J3.1
Minimum Bolt Pretension, kips*

Bolt Size, in.	Group A (e.g., A325 Bolts)	Group B (e.g., A490 Bolts)
1/2	12	15
5/8	19	24
3/4	28	35
7/8	39	49
1	51	64
1 1/8	~~56~~ 64	80
1 1/4	~~71~~ 81	102
1 3/8	~~85~~ 97	121
1 1/2	~~103~~ 118	148

2016 AISC Standards: AISC 360-16

Chapter J – Design of Connections

Section J3 Bolts and Threaded Parts

Change in minimum bolt hole size (Sect. J3)

- Standard holes for 1” diameter bolts and larger

$$d_h = d_b + 1/16\text{”} \quad (2010)$$

$$d_h = d_b + 1/8\text{”} \quad (2016)$$

2016 AISC Standards: AISC 360-16

Chapter J – Design of Connections

Section J3 Bolts and Threaded Parts

New clear distance between bolts in Section J3.3:

The distance between centers of standard, oversized or slotted holes shall not be less than 2-2/3 times the nominal diameter, *d*, of the fasteners. However, the clear distance between bolt holes or slots shall not be less than *d*.

2016 AISC Standards: AISC 360-16

Chapter J – Design of Connections

Section J3 Bolts and Threaded Parts

Revised presentation for bolt bearing/tearout

2010:

Bearing: $R_n = 1.2 l_c t F_u \le 2.4 d t F_u$

2016:

(1) Bearing: $R_n = 1.2 l_c t F_u$

(2) Tearout: $R_n = 2.4 d t F_u$

2016 AISC Standards: AISC 360-16

Chapter J – Design of Connections

Section J10 Flanges and Webs with Concentrated Forces

HSS limit states relocated from Chapter K.

- The Q_f factor added to web crippling and web compression buckling equations

2016 AISC Standards

What's New
In the…

AISC
Code of
Standard Practice for Steel Buildings and Bridges

(ANSI/AISC 303-16)

2016 AISC Standards: AISC 303-16

Code of Standard Practice

ANSI/AISC 303-16

Balanced committee

- Fabricators - 7
- Engineers - 7
- Others – 9
    - General Contractor
    - Code Official
    - Quality Consultant
    - Erector
    - Detailer
    - Architect
    - Attorney

Rigorous public review process

2016 AISC Standards: AISC 303-16

Code of Standard Practice for Steel Buildings and Bridges

1. General Provisions
2. Classification of Materials
3. Design <u>Documents</u>~~Drawings~~ and Specifications
4. <u>Approval Documents</u>~~Shop and Erection Drawings~~
5. Materials
6. Shop Fabrication and Delivery
7. Erection
8. Quality Control
9. Contracts
10. Architecturally Exposed Structural Steel

~~Appendix A. Digital building Product Models~~

2016 AISC Standards: AISC 303-16

Code of Standard Practice

Three Major Revisions in 2016

1: Models

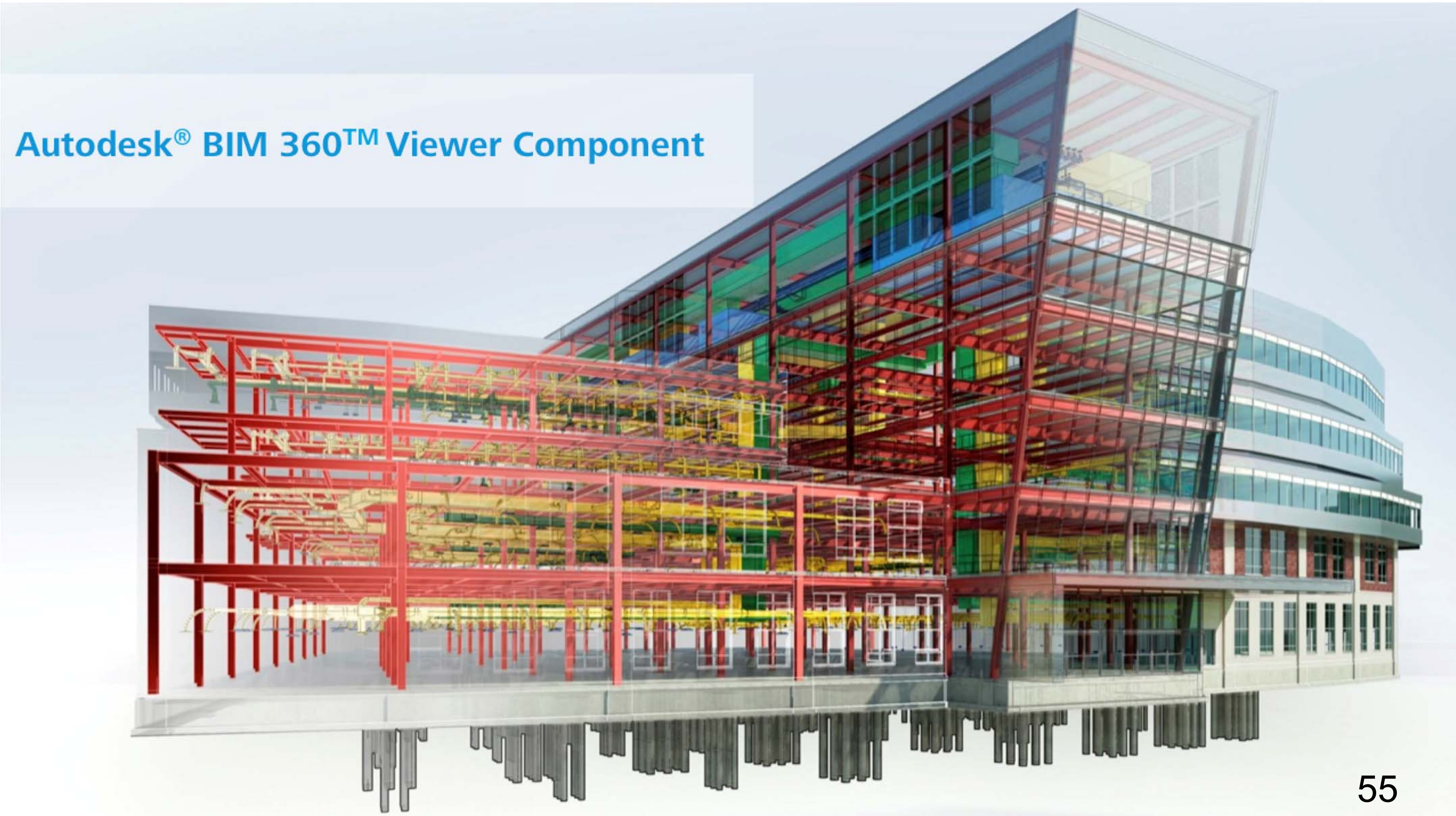
2: Stiffeners

3: Architectural Exposed Structural Steel (AESS)

Code of Standard Practice

1: Models

2016 AISC Standards: AISC 303-16



1: Models

~~2010—design drawings~~

2016-design documents

- *design documents*. The *design drawings*, or where the parties have agreed in the *contract documents* to provide digital model(s), the *design model*. A combination of drawings and digital models also may be provided.

- *design model. A* dimensionally accurate 3D digital model of the structure that conveys the *structural steel* requirements given in Section 3.1 for the building.

1: Models

~~2010—shop drawings~~

2016-fabrication documents

- *fabrication documents.* The *shop drawings*, or where the parties have agreed in the *contract documents* to provide digital model(s), the *fabrication model*. A combination of drawings and digital models also may be provided.

- *fabrication model.* A dimensionally accurate 3D digital model produced to convey the information necessary to fabricate the *structural steel*. This may be the same digital model as the *erection model*, but it is not required to be.

2016 AISC Standards: AISC 303-16

1: Models

~~2010—erection drawings~~

2016-erection documents

- *erection documents*. The *erection drawings*, or where the parties have agreed in the *contract documents* to provide digital model(s), the *erection model*. A combination of drawings and digital models also may be provided.

- *erection model.* A dimensionally accurate 3D digital model produced to convey the information necessary to erect the structural steel. This may be the same digital model as the *fabrication model*, but it is not required to be.

1: Models

~~2010—shop and erection drawings~~

2016- approval documents

- *approval documents*. The *structural steel shop drawings*, *erection drawings*, and *embedment drawings*, or where the parties have agreed in the *contract documents* to provide digital model(s), the *fabrication* and *erection models*. A combination of drawings and digital models also may be provided.

2: Stiffening

2: Stiffening

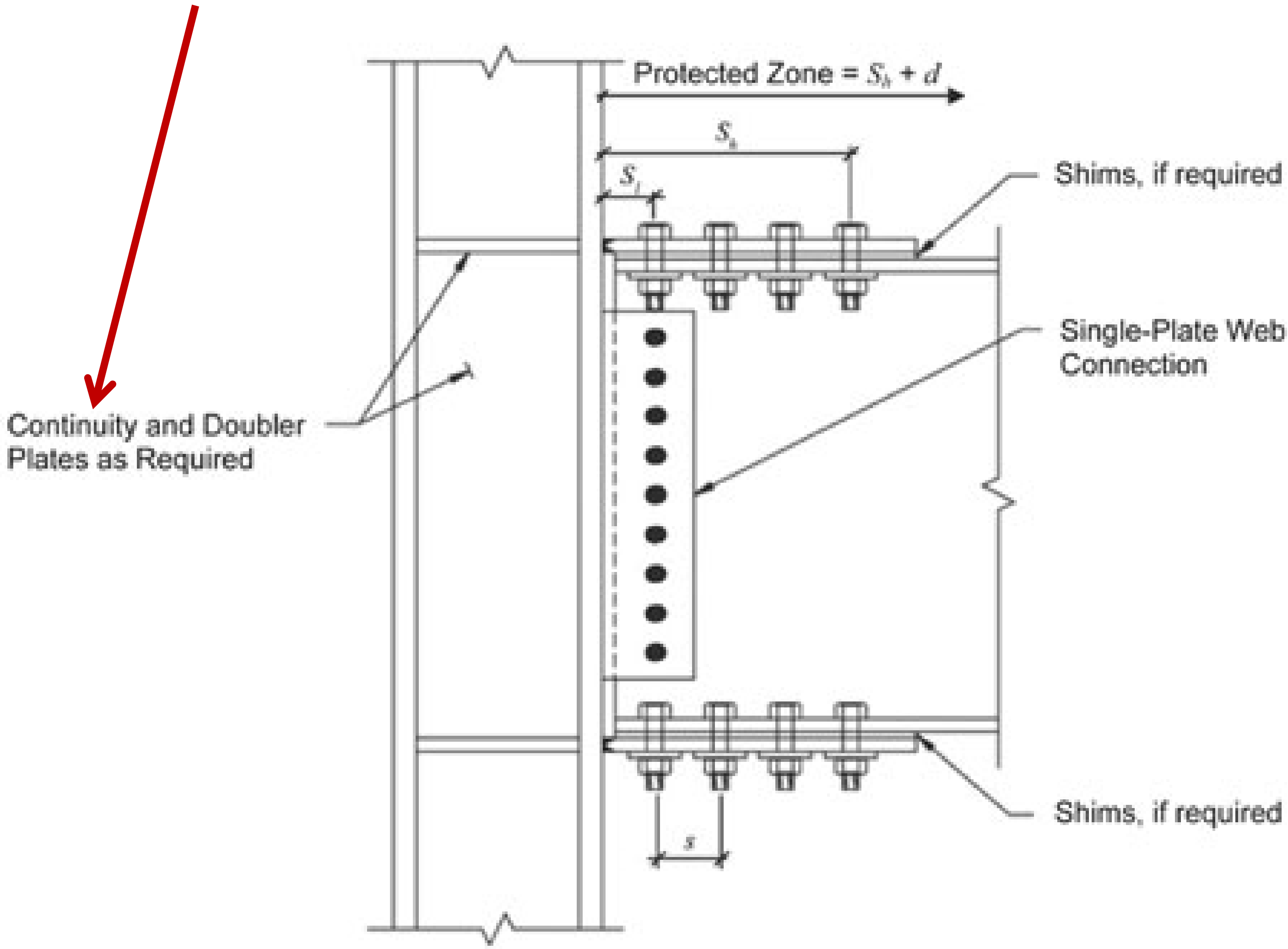
2010

Section 3.1.1: Column stiffeners, bearing stiffeners, etc., must be designed and clearly shown on drawings

Section 3.1.2: Three options for connection design indicated by owner's designated rep. for design (ODRD)

2016 AISC Standards: AISC 303-16

Often missed in connection design



2016 AISC Standards: AISC 303-16

2016

Section 3.1.1

Connection Design Responsibility

Option 1:

ODRD (EOR) provides complete connection design

Option 2:

Steel detailer selects or completes connection design

Option 3:

Licensed engineer working for fabricator provides complete connection design

2016

Section 3.1.2

Connection Stiffening

If Option 1 or 2, ODRD designs stiffening and shows on structural design bid documents

If Option 3A, ODRD designs stiffening and shows on structural design bid documents

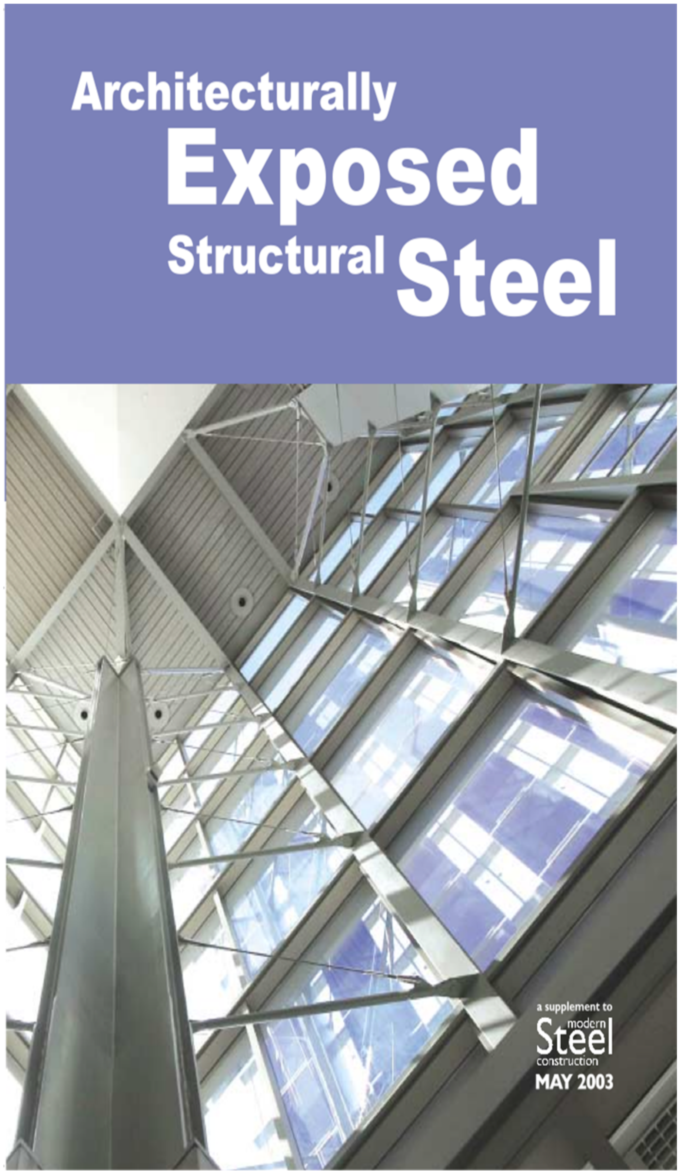
If Option 3B, ODRD provides bidding quantity of items for stiffening (an estimate). If no estimate provided, stiffening will not be included in bid.

3: Architecturally Exposed Structural Steel (AESS)

3: AESS

Section 10 completely changed

3: AESS



Architecturally
Exposed
Structural Steel
a supplement to
modern Steel construction
MAY 2003

RMSCA

2016 AISC Standards: AISC 303-16

3: AESS

Section 10 completely changed

AESS 1: $
AESS 2: $$
AESS 3: $$$
AESS 4: $$$$
AESS C: $$$$$

2016 AISC Standards: AISC 303-16

3: AESS

AESS 1: Basic elements

AESS 2: Feature elements > 20 ft

AESS 3: Feature elements ≤ 20 ft

AESS 4: Showcase elements w/special surface & edge treatment

AESS C: Custom

2016 AISC Standards AISC 303-16

Some Additional Revisions:

- Lack of tolerances
- Identifying protected zones
- Handling cost of revisions
- Anchor rod placement tolerances

Section 1.10

No zero tolerance.

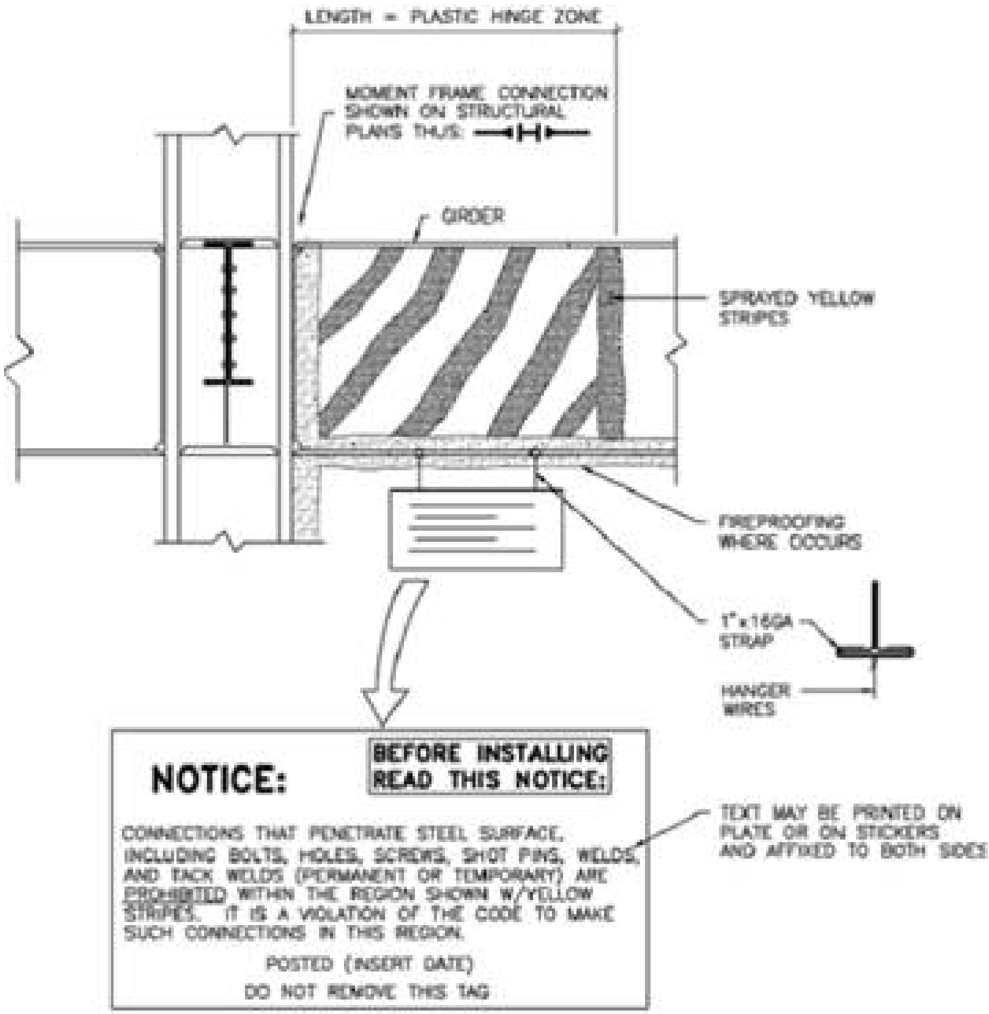
1.10. Tolerances

Tolerances for materials, fabrication and erection shall be as stipulated in Sections 5, 6, 7, and 10. Tolerances absent from this Code or the contract documents shall not be considered zero by default.

2016 AISC Standards: AISC 303-16

Section 1.11

Marking of Protected Zones in High-Seismic Applications



Section 3.2

Now addresses who pays for revisions, if they are necessary, when complete contract documents are not available at the time of design, bidding, detailing or fabrication.

Section 7.5.1

Tolerances for anchor-rod placement have been revised for consistency with the hole sizes provided in the AISC *Manual* and tolerances given in ACI 117.

2016 AISC Standards: AISC 303-16

Code of Standard Practice

Three Major Revisions in 2016

1: Models

2: Stiffeners

3: Architectural Exposed Structural Steel (AESS)

2016 AISC Standards

OTHER UPDATED AISC STANDARDS:

2016 *Seismic Provisions*

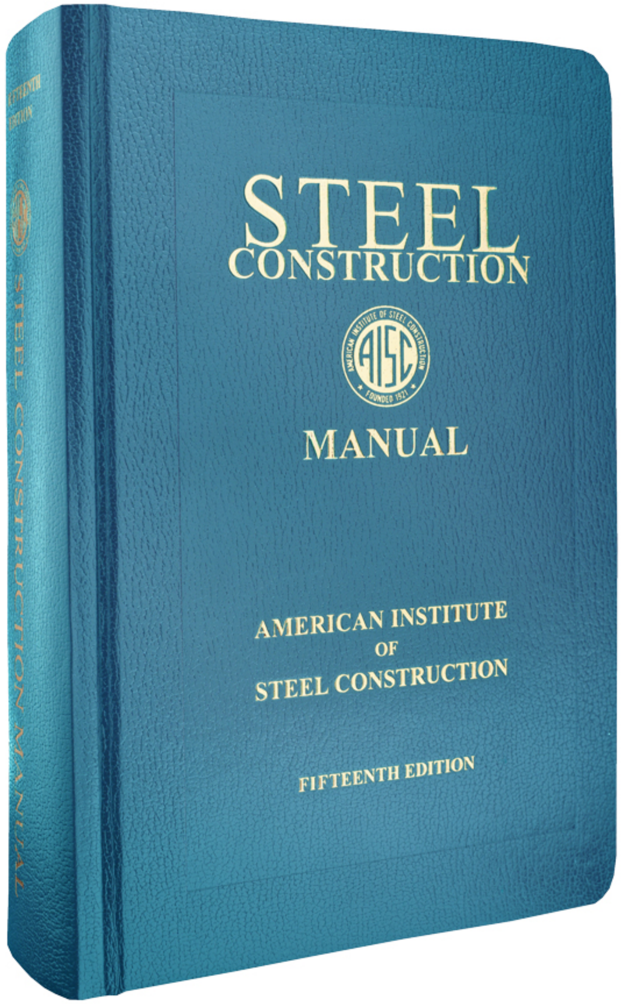
for Structural Steel Buildings

(ANSI/AISC 341-16)

2016 *Prequalified Connections for Special and Intermediate Steel Moment Frames for Seismic Applications*

(ANSI/AISC 358-16)

2016 AISC Standards



2016 AISC Standards AISC 360-16

1. Which of the following is NOT a key change to the 2016 AISC Standards?

a. Revised flexural strength provisions for tees and double angles in the Specification
b. An increase in nominal hole size for 1 inch and greater diameter bolts given in the Specification
c. Significant reorganization of the Specification for Structural Steel Buildings
d. Significant change to Section 10 of the Code of Standard Practice regarding AESS

THANK YOU

There's always a solution in steel.