NAVIGATING THE NEW AISC STEEL CONSTRUCTION MANUAL

Presented by Cynthia J. Duncan, AISC

Committee on Manuals

Mission
Update and maintain AISC manuals and accompanying design examples in response to revisions in AISC standards and inquiries from within the Committee and the steel construction industry

Roster
28 Members (fabricators, connection designers, detailers, educators, consulting engineers)
5 Emeritus Members
Steel Solutions Center

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Part 2. General Design Considerations
Part 3. Design of Flexural Members
Part 4. Design of Compression Members
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Part 6. Design of Members Subject to Combined Forces
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  • 2014 RCSC Specification for Structural Joints Using High-Strength Bolts
  • 2016 AISC Code of Standard Practice for Steel Buildings & Bridges

Part 17. Misc. Data and Mathematical Information
Part 1. Dimensions and Properties

- New shapes:
  - W-shapes (& corresponding WT-shapes)
  - HP-shape
  - Angles
  - HSS
  - Pipe

W-Shapes | HP-Shapes | Angles
--- | --- | ---
W40x655 | HP12x89 | L12x12x1-3/8
W36x925 | | L12x12x1-1/4
W36x853 | | L12x12x1-1/8
W36x802 | | L12x12x1
W36x723 | | L10x10x1-3/8
W21x275 | | L10x10x1-1/4
W21x248 | | L10x10x1-1/8
W21x223 | | L10x10x1
W14x873 | | L10x10x7/8
W14x808 | | L10x10x3/4

& corresponding WT-shapes
Part 1. Dimensions and Properties

- New shapes
- Updated fillet radii \( k_{det}, k_1, T \) affected

### Table 1-1

<table>
<thead>
<tr>
<th>Shape</th>
<th>Area, ( A )</th>
<th>Depth, ( d )</th>
<th>Web</th>
<th>Flange</th>
<th>Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>in.²</td>
<td>in.</td>
<td>in.</td>
<td>in.</td>
<td>in.</td>
</tr>
<tr>
<td>HSS22x22x7/8, 3/4</td>
<td>96.5</td>
<td>44.0</td>
<td>44</td>
<td>1.03</td>
<td>1</td>
</tr>
<tr>
<td>HSS20x20x7/8, 3/4</td>
<td>85.4</td>
<td>43.6</td>
<td>43.6</td>
<td>0.865</td>
<td>1</td>
</tr>
<tr>
<td>HSS18x18x7/8, 3/4</td>
<td>77.2</td>
<td>43.3</td>
<td>43.3</td>
<td>0.785</td>
<td>1</td>
</tr>
<tr>
<td>HSS12x12x3/4</td>
<td>67.6</td>
<td>42.9</td>
<td>42.9</td>
<td>0.710</td>
<td>1</td>
</tr>
</tbody>
</table>

Pipe 26, 24, 20, 18, 16, 14 (std and x-strong)
& Pipe 12, 10 (xx-strong)
Part 1. Dimensions and Properties

• New shapes
• Updated fillet radii $k_{det}$, $k_1$, $T$ affected
• Larger separation for new double angles (2L12 and 2L10)
Part 1. Dimensions and Properties

- New shapes
- Updated fillet radii
- Larger separation for double angles (2L12 and 2L10)
- Check material availability: See www.aisc.org
- V15.0 Database

Part 2. General Design Considerations

- Table 2-4: Applicable ASTM Specifications for Various Structural Shapes
- Table 2-5: Applicable ASTM Specifications for Plate
- Table 2-7: Summary of Surface Preparation Stds
### Part 2. General Design Considerations

#### Table 2-4
**Applicable ASTM Specifications for Various Structural Shapes**

<table>
<thead>
<tr>
<th>Steel Type</th>
<th>ASTM Designation</th>
<th>$F_y$ Yield Stress (ksi)</th>
<th>$F_u$ Tensile Stress (ksi)</th>
<th>Applicable Shape Series</th>
<th>HSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A36</td>
<td>36</td>
<td>58–80&lt;sup&gt;1&lt;/sup&gt;</td>
<td></td>
<td>W, M, S, HP, C, MC, L</td>
<td></td>
</tr>
<tr>
<td>A53 Gr. B</td>
<td>35</td>
<td>58</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gr. B</td>
<td>42</td>
<td>58</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A50</td>
<td>46</td>
<td>58</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gr. C</td>
<td>46</td>
<td>62</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gr. A</td>
<td>36</td>
<td>58</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Table 2-5
**Applicable ASTM Specifications for Plates and Bars**

<table>
<thead>
<tr>
<th>Steel Type</th>
<th>ASTM Designation</th>
<th>$F_y$ Yield Stress (ksi)</th>
<th>$F_u$ Tensile Stress (ksi)</th>
<th>Plates and Bars, in.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A36</td>
<td>32</td>
<td>58–80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gr. C</td>
<td>30</td>
<td>55–75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gr. D</td>
<td>33</td>
<td>60–80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gr. 50</td>
<td>50</td>
<td>65–100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gr. 55</td>
<td>55</td>
<td>70–100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A709</td>
<td>36</td>
<td>55–80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gr. 42</td>
<td>42</td>
<td>60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gr. 55</td>
<td>55</td>
<td>70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gr. 60</td>
<td>60</td>
<td>75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gr. 65</td>
<td>65</td>
<td>80</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Part 2. General Design Considerations

**Table 2-7**
Summary of Surface Preparation Standards

<table>
<thead>
<tr>
<th>SSPC Standard No.</th>
<th>Title</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSPC-SP 14/NACE No. 8*</td>
<td>Industrial Blast Cleaning</td>
<td>Between SP 7 (brush-off) and SP 6 (commercial); the intent is to remove as much coating as possible; tightly adhering contaminants can remain….</td>
</tr>
<tr>
<td>SSPC-SP 15</td>
<td>Commercial-Grade Power-Tool Cleaning</td>
<td>Between SP 3 AND SP 11; complete removal of all visible oil, grease, dirt, rust, coating, mill scale, ….</td>
</tr>
<tr>
<td>SSPC-SP 16</td>
<td>Brush-Off Blast Cleaning of Coated and Uncoated Galv. Steel, Stainless Steel, and Non-ferrous Metals</td>
<td>Requirements for removing loose contaminants and coating from coated and uncoated galvanized steel, stainless steels, and non-ferrous metals; cleaned surface is free of all visible oil, grease, dirt, rust, coating, mill scale, ….</td>
</tr>
</tbody>
</table>

Part 3. Design of Flexural Members

- Incorporates new W-shapes in all existing tables (50 ksi)
Part 3. Design of Flexural Members

• Incorporates new W-shapes in all existing tables
• Footnote for noncompact or slender sections:
  “…tabulated values have been adjusted accordingly”
  (also in Part 4 tables)

• Table 3-19, Composite beam table footnote:
  “Ductility (slip capacity) of shear connection at the beam/concrete interface may control minimum $\sum Q_n$ value per AISC Spec. Sect. I3.2d.”
Part 3. Design of Flexural Members

- Incorporates new W-shapes in all existing tables
- Footnote for noncompact or slender sections:
  “…tabulated values have been adjusted accordingly”
- Table 3-19, Composite beam table footnote:
  “Ductility (slip capacity) of shear connection at the beam/concrete interface may control minimum $\Sigma Q_n$ value per AISC Spec. Sect. I3.2d.”
- Tables 3-16 and 3-17, Available Shear Stress, plate girders
Part 4. Design of Compression Members

• Eliminated $K$ factor in tables/discussion
• Clarifies $C_w = 0$ is used in WT column tables
• Chapter E revisions reflected in tables
  - Slender members
  - Double angles use more general $F_{cry}$ equation
• Removed Tables 4-13 to 4-20: Composite Columns
• W-shape column tables: added 65 and 70 ksi for some

![Table 4-1b](image)

<table>
<thead>
<tr>
<th>Shape</th>
<th>472°</th>
<th>608°</th>
<th>730°</th>
<th>665°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design</td>
<td>ASD</td>
<td>LRFD</td>
<td>ASD</td>
<td>LRFD</td>
</tr>
<tr>
<td>0</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
</tr>
</tbody>
</table>

![Table 4-1c](image)

<table>
<thead>
<tr>
<th>Shape</th>
<th>472°</th>
<th>608°</th>
<th>730°</th>
<th>665°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design</td>
<td>ASD</td>
<td>LRFD</td>
<td>ASD</td>
<td>LRFD</td>
</tr>
<tr>
<td>0</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
</tr>
</tbody>
</table>
Part 6. Design of Members Subject to Combined Forces

- **New** Tables 6-1a & 6-1b: *Limiting Width-to-Thickness Ratios*

## Table 6-1a

Width-to-Thickness Ratios: Compression Elements

<table>
<thead>
<tr>
<th>Case</th>
<th>Description of Element</th>
<th>$f_y$, ksi</th>
<th>$\lambda_r$</th>
<th>$\lambda_{cr}$</th>
<th>$\lambda_{st}$</th>
<th>$\lambda_{ps}$</th>
<th>$\lambda_{rs}$</th>
</tr>
</thead>
</table>
| 1    | Elements
| 1   | Flanges of rolled I-shaped sections, plates projecting from rolled I-shaped sections, outstanding legs of pairs of angles connected with continuous contact, flanges of channels, and flanges of tees | b/t        | 15.9      | 14.7        | 13.5        |              |             |

Table 6-2:

Available Strength for Members Subject to Axial, Shear, Flexural and Combined Forces, W-Shapes
Example—Table 6-2

Given: W14x99, ASTM A992, pinned ends \((K = 1.0)\),

\[ L_{cx} = L_{cy} = L_b = 14 \text{ ft} \]

Check shape for combined loading using LRFD, with required strengths as follows:

- \(P_u = 400\) kips
- \(M_{ux} = 250\) kip-ft
- \(M_{uy} = 80.0\) kip-ft
Example—Table 6-2

Solution:

\[ \phi_c P_n = 1130 \text{ kips} \]
\[ \phi_b M_{nx} = 642 \text{ kip-ft} \]
Example—Table 6-2

Solution:
\[
\frac{P_u}{P_c} = \frac{400 \text{ kips}}{1130 \text{ kips}} = 0.354
\]
Because \( \frac{P_u}{P_c} \geq 0.2 \), use Spec. Eq. H1-1a:

\[
\frac{P_r}{P_c} + \frac{8}{9} \left( \frac{M_{rx}}{M_{cx}} + \frac{M_{ry}}{M_{cy}} \right) \leq 1.0
\]

\[
\frac{400 \text{ kips}}{1130 \text{ kips}} + \frac{8}{9} \left( \frac{250 \text{ kip-ft}}{642 \text{ kip-ft}} + \frac{80.0 \text{ kip-ft}}{311 \text{ kip-ft}} \right) = 0.928 < 1.0 \quad \text{o.k.}
\]

Part 6. Design of Members Subject to Combined Forces

- New Tables 6-1a & 6-1b: Limiting Width-to-Thickness Ratios
- New Table 6-2: Available Strength for Members Subject to Axial, Shear, Flexural and Combined Forces, W-Shapes
- Tables 6-3, 6-4 and 6-5: Cross-Section Strength Equations & Properties for Encased W-Shapes, Filled Rectangular HSS, Filled Round HSS

M. Denavit et al., *Engineering Journal*, 2015
Part 7. Design Considerations for Bolts

- Figure 7-10. Permitted coatings for structural fasteners

<table>
<thead>
<tr>
<th>ASTM Designation</th>
<th>Fastener Description</th>
<th>Coating Type</th>
<th>Mechanical Galvanizing, ASTM B695</th>
<th>Hot Dip Galvanizing, ASTM F2329</th>
<th>Zinc/Aluminum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gr. A325</td>
<td>Heavy hex, $F_y = 120$ ksi</td>
<td>Class 55</td>
<td>50 μm</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Gr. F1852</td>
<td>Tension control, $F_y = 120$ ksi</td>
<td>Class 55</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Gr. A490</td>
<td>Heavy hex, $F_y = 150$ ksi</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Gr. F2280</td>
<td>Tension control, $F_y = 150$ ksi</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>A449</td>
<td>Heavy hex, $F_y = 90, 105$ and 120 ksi</td>
<td>Class 55</td>
<td>50 μm</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>A354 BC</td>
<td>Heavy hex, $F_y = 115$ ksi and 125 ksi</td>
<td>Class 55</td>
<td>50 μm</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>A354 BD</td>
<td>Heavy hex, $F_y = 140$ ksi and 150 ksi</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

- Indicates this coating is not qualified.

* See ASTM F3125 Table 1.1 for approved zinc/aluminum coating standards and grades.

+ Galvanizing of ASTM A354 BD is not prohibited but may cause susceptibility to hydrogen embrittlement. Precautions to avoid embrittlement, such as those in ASTM A145, should be considered.
Part 7. Design Considerations for Bolts

- Figure 7-10. Permitted coatings for structural fasteners
- Tables 7-1, 7-2 and 7-3 incorporate the Group C (200 ksi) bolts

• Tables 7-1, 7-2 and 7-3 includes tension-control bolts
Part 8. Design Considerations for Welds

ECCENTRICALLY LOADED WELD GROUPS
Eccentricity in the Plane of the Faying Surface

1) Instantaneous Center of Rotation Method
2) Elastic Method
3) Plastic Method - new

Plastic Method:

\[ f_v = \frac{V}{l_w} \] (8-12)
\[ f_a = \frac{N}{l_w} \] (8-13)
\[ f_b = \frac{4M}{l_w^2} \] (8-14)
\[ f_w = \sqrt{f_v^2 + (f_a + f_b)^2} \] (8-15)
Part 9. Design of Connecting Elements

• Connecting elements subject to combined loading

2010: \[ f_e = \sqrt{f_x^2 - f_x f_y + f_y^2 + 3f_{xy}^2} \leq F_y \] (9-1)

2016: \[ \frac{M_r}{M_c} + \left(\frac{P_r}{P_c}\right)^2 + \left(\frac{V_r}{V_c}\right)^4 \leq 1.0 \] (9-1)

See Dowswell, 2015; Neal, 1961; Astaneh, 1998

Part 9. Design of Connecting Elements

• Connecting elements subject to combined loading

• Connecting element rupture strength at welds

Fillet weld on one side of element, \( F_{EXX} = 70 \text{ ksi} \)

\[ t_{min} = \frac{0.60F_{EXX} \left(\frac{\sqrt{2}}{2}\right) \left(\frac{D}{16}\right)}{0.6F_u} \]
\[ = \frac{3.09D}{F_u} \] (9-2)

Fillet weld on both sides of element, \( F_{EXX} = 70 \text{ ksi} \)

\[ t_{min} = \frac{6.19D}{F_u} \] (9-3)
Part 9. Design of Connecting Elements

- Connecting elements subject to combined loading
- Coped beam strength
  - No limits on cope length or cope depth
  - Post-yield strength explicitly accounted for

Part 9. Design of Connecting Elements

- Coped beam strength—*top flange only*
  
  When $\lambda \leq \lambda_p$
  
  $$M_n = M_p$$  \hspace{1cm} (9-6)

  When $\lambda_p < \lambda \leq 2\lambda_p$
  
  $$M_n = M_p - (M_p - M_y) \left( \frac{\lambda}{\lambda_p} - 1 \right)$$  \hspace{1cm} (9-7)

  When $\lambda > 2\lambda_p$
  
  $$M_n = F_{cr} S_{net}$$  \hspace{1cm} (9-8)

Where

$$\lambda = \frac{h_o}{t_w}$$

$$\lambda_p = 0.475 \sqrt{\frac{k_t E}{F_y}}$$

$$k_1 = f_k \geq 1.61$$

$$F_{cr} = \frac{0.903 E k_1}{\lambda^2}$$
Part 9. Design of Connecting Elements

- Coped beam strength—*top & bottom flange*

Use *Spec.* Section F11

When \( c_b \geq c_t \):

\[
C_b = \left[ 3 + \ln \left( \frac{L_b}{d} \right) \right] \left( 1 - \frac{d_{ct}}{d} \right) \leq 1.84 \quad (9-15)
\]

When \( c_t > c_b \):

\[
C_b = \left( \frac{c_b}{c_t} \right) \left[ 3 + \ln \left( \frac{L_b}{d} \right) \right] \left( 1 - \frac{d_{ct}}{d} \right) \leq 1.84 \quad (9-16)
\]


---

Part 9. Design of Connecting Elements

- Connecting elements subject to combined loading
- Connecting element rupture strength at welds
- Coped beam strength
- Other Spec. requirements and design considerations
  - Prying action
  - Plate elements subjected to out-of-plane bending
Part 9. Design of Connecting Elements

- Prying action

Prying forces in tee  Typical bolt location  Edge bolt

14th Ed: max 45°
15th Ed: max 60°

Refs: Thornton, 1992; Swanson, 2002;

\[
t_{\min} = \frac{4T_ub'}{\phi pF_u (1 + \delta \alpha')} \quad (9-19a)
\]

\[
t_{\min} = \frac{\Omega 4T_ub'}{pF_u (1 + \delta \alpha')} \quad (9-19b)
\]

\[
\delta = 1 - \frac{d'}{p}
\]

\[
\alpha' = 1.0 \text{ if } \beta \geq 1 \text{ or lesser of } 1 \text{ and } \frac{1}{\delta} \left( \frac{\beta}{1 - \beta} \right) \text{ if } \beta < 1
\]

\[
\beta = \frac{1}{\rho \left( \frac{B_c}{T_r} - 1 \right)}
\]

\[
\rho = \frac{b'}{a'}
\]

\[B_c = \text{available tension per bolt based on tension only or combined tension & shear rupture}\]
Part 9. Design of Connecting Elements
- Plate elements subjected to out-of-plane loads
  
  Also see Spec. Section J10.10.

Transverse load  In-plane moment  Out-of-plane moment

Yield-Line Analysis Models

Part 10. Design of Simple Shear Connections


Bolt and Angle Limit States:

Minimum of:
- Total bolt shear on bolt group
- Total slip resistance for slip-critical bolts on bolt group
- Bolt bearing on the angles
- Bolt tearout on the angles
- Shear yielding of the angles
- Shear rupture of the angles
- Block shear rupture of the angles
Bolt and Angle Limit States: 
*Minimum* of:

- \(\sum\) (Effective strengths of individual bolts)

where

Effective strength = MIN: bolt shear, slip resistance for slip-critical bolts, bolt bearing, bolt tearout

- Shear yielding -- angles
- Shear rupture -- angles
- Block shear rupture -- angles

---

Beam Web Limit States (kip/in.):

- Bolt bearing on the web
- Bolt tearout on the web
- Shear yielding of the web
- Shear rupture of the web
- Block shear rupture of the web
Part 10. Design of Simple Shear Connections

- Table 10-1 revised
- Extended single-plate connections: Removed stabilizer plate provision
Part 10. Design of Simple Shear Connections

- Table 10-1 revised
- Single-plate connections: Stabilizer plate requirement
- Table 10-14C: Weld details for skewed single-plate connections

This is “One acceptable design aid for skewed welds....”

- Works for 36- or 50-ksi plates
- Added 5/8-in. plate
### Table 14-2
Recommended Sizes for Washers and Anchor Rod Holes in Base Plates

<table>
<thead>
<tr>
<th>Anchor Rod Diameter</th>
<th>Hole Diameter</th>
<th>Washer Size</th>
<th>Min. Washer Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>in.</td>
<td>in.</td>
<td>in.</td>
<td>in.</td>
</tr>
<tr>
<td>3/4</td>
<td>1 13/16</td>
<td>2</td>
<td>1/4</td>
</tr>
<tr>
<td>7/8</td>
<td>1 1/8</td>
<td>2 1/2</td>
<td>3/16</td>
</tr>
<tr>
<td>1</td>
<td>1 1/8</td>
<td>3</td>
<td>3/8</td>
</tr>
<tr>
<td>1 1/4</td>
<td>2 1/8</td>
<td>3 1/2</td>
<td>1/2</td>
</tr>
</tbody>
</table>

**Notes:**
1. Hole sizes provided are based on anchor rod size and correlate with ACI 117 (ACI, 2010).

... 

4. ASTM F844 washer are permitted instead of plate washers when hole clearances are limited to 5/16 in. for rod diameters up to 1 in., 1/2 in. for rod diameters over 1 in. to 2 in., and 1 in. for rod diameters over 2 in. This exception should not be used unless the general contractor has agreed to meet smaller tolerances for anchor rod placement than those permitted in ACI 117.
In Summary

Part 1…New shape sizes and detailing dimensions
Part 2…ASTM A500 Grade C is preferred for HSS
Part 3…New footnotes
Part 4…W-Shape column tables for 65 and 70 ksi
Part 6…New Super Table 6-2
Part 7…Table 7-14 includes TC bolts dimensions
Part 8…New plastic method for eccentrically loaded bolt groups
Part 9…Increased permitted tributary length for prying
Part 10…Removal of stabilizer plate provisions
Part 13…Additional considerations for HSS-to-HSS truss connections
Part 14…Updated Table 14-2 for improved anchor-rod installation
Design Examples V15.0
Part IV: Additional Resources

• Combined Flexure and Axial Force, W-shapes (Table 6-1, 14th Ed. Manual)
• Filled HSS Column Tables, A500 Gr. C (Tables 4-13 to 4-20, 14th Ed. Manual)
• New Super Table 6-2: W-Shapes, 65 and 70 ksi HSS, ASTM A1085 HSS, A500 Gr. C Pipe
• New $Z_{net}$ Table for Coped W-shapes

Available Summer 2017

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THANK YOU FOR ATTENDING
2017 STRUCTURES CONGRESS

Reminder:
WE LOOK FORWARD TO SEEING YOU NEXT YEAR AT
SEI 2018, April 19-21 IN Ft. Worth, TX!