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 engrs.)
5 Emeritus Members
Steel Solutions Center

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Part 16. Standards
  • 2016 AISC Specification for Structural Steel Buildings
  • 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

<table>
<thead>
<tr>
<th>W-Shapes</th>
<th>HP-Shapes</th>
<th>Angles</th>
</tr>
</thead>
<tbody>
<tr>
<td>W40x655</td>
<td>HP12x89</td>
<td>L12x12x1-3/8</td>
</tr>
<tr>
<td>W36x925</td>
<td></td>
<td>L12x12x1-1/4</td>
</tr>
<tr>
<td>W36x853</td>
<td></td>
<td>L12x12x1-1/8</td>
</tr>
<tr>
<td>W36x802</td>
<td></td>
<td>L12x12x1</td>
</tr>
<tr>
<td>W36x723</td>
<td></td>
<td>L10x10x1-3/8</td>
</tr>
<tr>
<td>W21x275</td>
<td></td>
<td>L10x10x1-1/4</td>
</tr>
<tr>
<td>W21x248</td>
<td></td>
<td>L10x10x1-1/8</td>
</tr>
<tr>
<td>W21x223</td>
<td></td>
<td>L10x10x1</td>
</tr>
<tr>
<td>W14x873</td>
<td></td>
<td>L10x10x7/8</td>
</tr>
<tr>
<td>W14x808</td>
<td></td>
<td>L10x10x3/4</td>
</tr>
</tbody>
</table>

& corresponding WT-shapes & corresponding 2Ls
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 Thickness, ( t_w )</th>
<th>Flange Thickness, ( t_f )</th>
<th>Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>W40x200</td>
<td>98.5</td>
<td>44.9</td>
<td>14</td>
<td>1.23</td>
<td>16</td>
</tr>
<tr>
<td>W50x200</td>
<td>98.5</td>
<td>44.9</td>
<td>14</td>
<td>1.23</td>
<td>16</td>
</tr>
<tr>
<td>W60x200</td>
<td>98.5</td>
<td>44.9</td>
<td>14</td>
<td>1.23</td>
<td>16</td>
</tr>
<tr>
<td>W70x200</td>
<td>98.5</td>
<td>44.9</td>
<td>14</td>
<td>1.23</td>
<td>16</td>
</tr>
<tr>
<td>W80x200</td>
<td>98.5</td>
<td>44.9</td>
<td>14</td>
<td>1.23</td>
<td>16</td>
</tr>
<tr>
<td>W90x200</td>
<td>98.5</td>
<td>44.9</td>
<td>14</td>
<td>1.23</td>
<td>16</td>
</tr>
<tr>
<td>W100x200</td>
<td>98.5</td>
<td>44.9</td>
<td>14</td>
<td>1.23</td>
<td>16</td>
</tr>
<tr>
<td>W110x200</td>
<td>98.5</td>
<td>44.9</td>
<td>14</td>
<td>1.23</td>
<td>16</td>
</tr>
<tr>
<td>W120x200</td>
<td>98.5</td>
<td>44.9</td>
<td>14</td>
<td>1.23</td>
<td>16</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
- 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 Standards
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>$F_p$ Tensile Stress (ksi)</th>
<th>Applicable Shape Series</th>
<th>HSS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$W$</td>
<td>$M$</td>
<td>$S$</td>
<td>$HP$</td>
</tr>
<tr>
<td>A36</td>
<td></td>
<td>35</td>
<td>35</td>
<td>56-60</td>
<td></td>
</tr>
<tr>
<td>A53 Gr. B</td>
<td></td>
<td>35</td>
<td>35</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Gr. B</td>
<td></td>
<td>42</td>
<td>42</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td>Gr. C</td>
<td></td>
<td>46</td>
<td>46</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td>Gr. A</td>
<td></td>
<td>40</td>
<td>40</td>
<td>58</td>
<td></td>
</tr>
</tbody>
</table>

---

Part 2. General Design Considerations

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>$F_p$ Tensile Stress (ksi)</th>
<th>Plates and Bars, in.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$0.75$ to $1.25$ incl.</td>
<td>$1.25$ to $1.5$ incl.</td>
<td>$2$ to $2.5$ incl.</td>
</tr>
<tr>
<td>Carbon</td>
<td>A36</td>
<td>32</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>36</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>A520</td>
<td>Gr. C</td>
<td>30</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gr. D</td>
<td>33</td>
<td>33</td>
<td></td>
</tr>
<tr>
<td>A570</td>
<td>Gr. 50</td>
<td>50</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gr. 55</td>
<td>55</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gr. 60</td>
<td>60</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gr. 65</td>
<td>65</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>A572</td>
<td>Gr. 50</td>
<td>50</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gr. 55</td>
<td>55</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gr. 60</td>
<td>60</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gr. 65</td>
<td>65</td>
<td>65</td>
<td></td>
</tr>
</tbody>
</table>
Part 3. Design of Flexural Members

• Footnote for noncompact sections:
  “...tabulated values have been adjusted accordingly”
  (also in Part 4 column 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 $\sum Q_n$ value per AISC Spec. Sect. I3.2d.”
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**

<table>
<thead>
<tr>
<th>Shape</th>
<th>8(^{2})</th>
<th>8(^{8})</th>
<th>8(^{6})</th>
<th>8(^{5})</th>
<th>8(^{8})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design</td>
<td>ASG</td>
<td>LRFD</td>
<td>ASG</td>
<td>LRFD</td>
<td>ASG</td>
</tr>
<tr>
<td>Lc/(t)</td>
<td>10000</td>
<td>13000</td>
<td>8000</td>
<td>13000</td>
<td>6270</td>
</tr>
</tbody>
</table>

$F_y = 65$ ksi

**Table 4-1c**

<table>
<thead>
<tr>
<th>Shape</th>
<th>8(^{2})</th>
<th>8(^{8})</th>
<th>8(^{6})</th>
<th>8(^{5})</th>
<th>8(^{8})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design</td>
<td>ASG</td>
<td>LRFD</td>
<td>ASG</td>
<td>LRFD</td>
<td>ASG</td>
</tr>
<tr>
<td>Lc/(t)</td>
<td>0</td>
<td>10000</td>
<td>16000</td>
<td>16000</td>
<td>15000</td>
</tr>
</tbody>
</table>

$F_y = 70$ ksi
Part 6. Design of Members Subject to Combined Forces

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

<table>
<thead>
<tr>
<th>Case</th>
<th>Description of Element</th>
<th>Width-to-Thickness Ratio</th>
<th>$F_y$, ksi</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Flanges of rolled I-shaped sections, plates projecting from rolled I-shaped sections, spanning legs of pairs of angles connected with continuous contact, flanges of channels, and flanges of treads</td>
<td>$\lambda_1$, $\lambda_2$, $\lambda_3$, $\lambda_4$, $\lambda_5$</td>
<td></td>
</tr>
</tbody>
</table>

Consistent with Spec. Tables B4.1a and B4.1b

• **New** Table 6-2: *Available Strength for Members Subject to Axial, Shear, Flexural and Combined Forces, W-Shapes*
The Super Table

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:

\[ P_u = 400 \text{ kips} \]
\[ M_{ux} = 250 \text{ kip-ft} \]
\[ M_{uy} = 80.0 \text{ kip-ft} \]
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:

\[ \phi_b M_{ny} = 311 \text{ kip-ft} \]
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:

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

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

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 Eqns & Properties for Encased W-Shapes, Filled Rectangular HSS, Filled Round HSS

Part 7. Design Considerations for Bolts

- Tables 7-14 includes tension-control bolts

<table>
<thead>
<tr>
<th>Measurement</th>
<th>( M_{\text{b}} )</th>
<th>( N_{\text{b}} )</th>
<th>( P )</th>
<th>( V )</th>
<th>( M )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width Across Flats, ( P )</td>
<td>( 2\frac{1}{4} )</td>
<td>( 2\frac{1}{2} )</td>
<td>( 2\frac{3}{4} )</td>
<td>( 3 \frac{3}{4} )</td>
<td>2 2\frac{1}{4} 2\frac{1}{2}</td>
</tr>
<tr>
<td>Overall Diameter, ( D )</td>
<td>( 1\frac{1}{4} )</td>
<td>( 1\frac{1}{2} )</td>
<td>( 1\frac{3}{4} )</td>
<td>( 2 \frac{1}{2} )</td>
<td>-2</td>
</tr>
<tr>
<td>Length</td>
<td>( 1 )</td>
<td>( 1\frac{1}{4} )</td>
<td>( 1\frac{3}{4} )</td>
<td>( 2 \frac{1}{2} )</td>
<td></td>
</tr>
</tbody>
</table>

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
Part 8. Design Considerations for Welds

ECCENTRICALLY LOADED WELD GROUPS

Eccentricity in the Plane of the Faying Surface

Plastic Method:

\[
f_v = \frac{V}{l_w} \quad (8-12)
\]

\[
f_a = \frac{N}{l_w} \quad (8-13)
\]

\[
f_b = \frac{4M}{l_w^2} \quad (8-14)
\]

\[
f_w = \sqrt{f_v^2 + (f_a + f_b)^2} \quad (8-15)
\]

Part 9. Design of Connecting Elements

• Connecting elements subject to combined loading

2010:

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

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

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

• Coped flexural local buckling strength
  —top flange only coped \( (\phi_b M_n, M_n/\Omega_b) \)

When \( \lambda \leq \lambda_p \)
\[ M_n = M_p = F_y Z_{net} \]  \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
\[ \lambda = \frac{h_o}{t_w} \]
\[ \lambda_p = 0.475 \sqrt{\frac{k_1 E}{F_y}} \]
\[ k_1 = f_k \geq 1.61 \]
\[ F_{cr} = \frac{0.903 E k_1}{\lambda^2} \]
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
- 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

\[ t_{\min} = \frac{4T_u b'}{\phi p F_u (1 + \delta \alpha')} \quad (9-19a) \]

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

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

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

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

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

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

\[ \text{Transverse load} \quad \text{In-plane moment} \quad \text{Out-of-plane moment} \]

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

<table>
<thead>
<tr>
<th>Bolt Type</th>
<th>Angle Thickness, in.</th>
<th>( f_y ), ksi</th>
</tr>
</thead>
<tbody>
<tr>
<td>STD</td>
<td>3/4-in.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>300</td>
<td>295</td>
</tr>
<tr>
<td>1</td>
<td>280</td>
<td>275</td>
</tr>
<tr>
<td>3/4</td>
<td>265</td>
<td>260</td>
</tr>
<tr>
<td>B7</td>
<td>250</td>
<td>245</td>
</tr>
<tr>
<td>C7</td>
<td>235</td>
<td>230</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Angle Type</th>
<th>Angle Thickness, in.</th>
<th>( f_y ), ksi</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4-in.</td>
<td></td>
<td>300</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>295</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>280</td>
</tr>
<tr>
<td>3/4</td>
<td></td>
<td>265</td>
</tr>
<tr>
<td>B7</td>
<td></td>
<td>250</td>
</tr>
<tr>
<td>C7</td>
<td></td>
<td>235</td>
</tr>
</tbody>
</table>
Part 10. Design of Simple Shear Connections

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

### 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>
<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>
<td>in.</td>
<td>in.</td>
<td>in.</td>
<td>in.</td>
</tr>
<tr>
<td>13/16</td>
<td>7/8</td>
<td>2</td>
<td>1/4</td>
<td>1/2</td>
<td>2/3</td>
<td>4</td>
<td>1/2</td>
</tr>
<tr>
<td>2 1/16</td>
<td>11/8</td>
<td>3</td>
<td>3/8</td>
<td>2 1/2</td>
<td>3 1/2</td>
<td>5</td>
<td>3/4</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 ecc. loaded bolt grps
Part 9…Increased permitted tributary length for prying
Part 10…Removal of stabilizer plate provisions
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: W-Shapes, 65 and 70 ksi
  HSS, ASTM A1085
  HSS, A500 Gr. C
  Pipe
- New $Z_{net}$ Table for Coped W-shapes

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Thank you!

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