ROUND BRANCH TO RECTANGULAR CHORD CONNECTIONS

Round HSS sections may be selected as branch members in a truss as they offer an efficient distribution of steel about its centroidal axis, and may be the aesthetic preference for a design team. However, specialized profiling is required when connecting circular shapes together. The ends of round HSS branches require labor intensive cutting to the match the shape of the truss chord. Therefore, connecting round HSS branches to rectangular HSS chords can be more advantageous than round HSS chords in that profiling is less complex, particularly for round HSS sections that are smaller than the rectangular HSS chord.

AISC 360-10 Table K2.1 can be used to check limits of applicability of the round HSS branch members.

AISC 360-10 Table K2.2 can be used to check limits of applicability and local limit states of the rectangular HSS chords. To account for round HSS branches, replace the rectangular HSS branch overall width, $B_b$, and height, $H_b$, with the round HSS diameter, $D_b$. Refer to CIDECT Design Guide 3 Table 4.1 for additional information.

Example 4-1.7 illustrates how to determine the adequacy of a K-connection consisting of round HSS branch members connecting to a rectangular HSS chord.
ROUND BRANCH TO RECTANGULAR CHORD CONNECTIONS EXAMPLE

Verify the adequacy of the K-connection shown in the figure below. The chord member is a rectangular HSS member and the branches are round HSS members. All members are ASTM A1085 steel. The loads on members are shown in the figure. Assume the welds are strong enough to develop the yield strength of the connected branch wall at all locations around the branch.

Material Properties

<table>
<thead>
<tr>
<th>Member Type</th>
<th>Material</th>
<th>$F_y$</th>
<th>$F_u$</th>
</tr>
</thead>
<tbody>
<tr>
<td>HSS chord member</td>
<td>ASTM A1085</td>
<td>50 ksi</td>
<td>65 ksi</td>
</tr>
<tr>
<td>HSS branch members</td>
<td>ASTM A1085</td>
<td>50 ksi</td>
<td>65 ksi</td>
</tr>
</tbody>
</table>

Geometric Properties

<table>
<thead>
<tr>
<th>Section</th>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>HSS 8 x 8 x $\frac{1}{2}$</td>
<td>$H = B$</td>
<td>8 in</td>
</tr>
<tr>
<td></td>
<td>$t$</td>
<td>0.5 in</td>
</tr>
<tr>
<td>HSS 6.625 x 0.375</td>
<td>$D_0$</td>
<td>6.625 in</td>
</tr>
<tr>
<td></td>
<td>$t$</td>
<td>0.375 in</td>
</tr>
</tbody>
</table>

Solution:

Limits of Applicability in AISC 360-10 Table K2.2A apply for rectangular HSS

Limits of Applicability in AISC 360-10 Table K2.1A apply for round HSS sections

$$l_{ov} = \text{overlapped length measured along the connecting face of the chord beneath the two branches from geometry}$$

$$l_p = \text{projected length of the overlapping branch on the chord}$$
For round branches and rectangular chord:

$$l_{ov} = \left[ \frac{H_{bi}}{2\sin(\theta_{bi})} + \frac{H_{bj}}{2\sin(\theta_{bj})} \right] - \left[ \frac{e + H/2}{\sin(\theta_{bj}) \sin(\theta_{bi})} \sin (\theta_{bj} + \theta_{bi}) \right]$$

$$l_{ov} = \left[ \frac{D_{b1}}{2\sin(\theta_{b1})} + \frac{D_{b2}}{2\sin(\theta_{b2})} \right] - \left[ \frac{e + H/2}{\sin(\theta_{b1}) \sin(\theta_{b2})} \sin (\theta_{b1} + \theta_{b2}) \right]$$

$$l_{ov} = \left[ \frac{6.625 \text{ in}}{2\sin(45^\circ)} + \frac{6.625 \text{ in}}{2\sin(45^\circ)} \right] - \left[ \frac{-1.668 \text{ in} + 8 \text{ in}/2}{\sin(45^\circ) \sin(45^\circ)} \right]$$

$$l_{ov} = 4.706 \text{ in}$$

$$l_p = \frac{6.625 \text{ in}}{\sin(45^\circ)} = 9.369 \text{ in}$$

$$O_v = \frac{l_{ov}}{l_p} \times 100\% = \frac{4.706 \text{ in}}{9.369 \text{ in}} = 50.23\%$$

$$-0.55 \leq e = -1.668 \text{ in} / 8 \text{ in} = -0.2 \leq 0.25 \quad \text{OK}$$

$$\theta_{bj} = \theta_{bi} = 45^\circ > 30^\circ \quad \text{OK}$$

$$B/t = 8 \text{ in} / 0.5 \text{ in} = 16 \leq 30 \quad \text{OK}$$

$$H/t = 8 \text{ in} / 0.5 \text{ in} = 21.333 \leq 35 \quad \text{OK}$$

For tension member branch, $D_b/B = 6.625 \text{ in} / 8 \text{ in} = 0.828 > 0.25 \quad \text{OK}$

For compression member branch, $D_b/t_b = 6.625 \text{ in} / 0.375 \text{ in} = 17.67 \leq 50 \quad \text{OK}$

$$\leq 0.05 \times \frac{29000 \text{ ksi}}{50 \text{ ksi}} = 29 \quad \text{OK}$$

For chord:

$$0.5 \leq H/B = 8.00 \text{ in} / 8.00 \text{ in} = 1.00 \leq 2.00 \quad \text{OK}$$

$$25\% \leq O_v = 50.23\% \leq 100\% \quad \text{OK}$$

$$F_p = 50 \text{ ksi} \leq 52 \text{ ksi} \quad \text{OK}$$

$$F_p/F_u = 50 \text{ ksi} / 65 \text{ ksi} = 0.77 \leq 0.8 \quad \text{OK}$$
Check the limit state of branch local yielding due to uneven load distribution (per AISC 360-10 Section Table K2.2)

Because $O_v = 50.23\%$ and one transverse face of the overlapping branch is welded to the chord, when $50\% \leq O_v \leq 80\%$

$$P_{n,i} = F_{ybi}t_{bi} \left[ 2H_{bi} - 4t_{bi} + b_{eoi} + b_{eov} \right]$$  \hspace{1cm} \text{[AISC 360-10 Equation K2-18]}

Replace $H_{bi}$ with $D_{bi}$

$$P_{n,i} = F_{ybi}t_{bi} \left[ 2D_{bi} - 4t_{bi} + b_{eoi} + b_{eov} \right]$$

Where

$$b_{eoi} = \frac{10}{B/t} \left[ \frac{F_y \times t}{F_{ybi} \times t_{bi}} \right] \times B_{bi} \leq B_{bi}$$ \hspace{1cm} \text{[AISC 360-10 Equation K2-20]}

Replace $B_{bi}$ by $D_{bi}$

$$b_{eoi} = \frac{10}{B/t} \left[ \frac{F_y \times t}{F_{ybi} \times t_{bi}} \right] \times D_{bi} \leq D_{bi}$$

$$= \frac{10}{8 \text{ in}/0.5 \text{ in}} \left[ \frac{50 \text{ ksi} \times 0.5 \text{ in}}{50 \text{ ksi} \times 0.375 \text{ in}} \right] \times 6.625 \text{ in} = 5.52 \text{ in}$$

$$b_{eov} = \frac{10}{B_{bj}/t_{bj}} \left[ \frac{F_{ybj} \times t_{bj}}{F_{ybi} \times t_{bi}} \right] \times B_{bi} \leq B_{bi}$$ \hspace{1cm} \text{[AISC 360-10 Equation K2-21]}

Replace $B_{bi}$ by $D_{bi}$ and $B_{bj}$ by $D_{bj}$

$$b_{eov} = \frac{10}{D_{bj}/t_{bj}} \left[ \frac{F_{ybj} \times t_{bj}}{F_{ybi} \times t_{bi}} \right] \times D_{bi} \leq D_{bi}$$

$$b_{eov} = \frac{10}{6.625 \text{ in}/0.375 \text{ in}} \left[ \frac{50 \text{ ksi} \times 0.375 \text{ in}}{50 \text{ ksi} \times 0.375 \text{ in}} \right] \times 6.625 \text{ in} = 3.75 \text{ in}$$

$$P_{n1} = P_{n2} = 50 \text{ ksi} \times 0.375 \text{ in} \left[(2 \times 6.625 \text{ in}) - (4 \times 0.375 \text{ in}) + 5.52 \text{ in} + 3.75 \text{ in}\right] = 394 \text{ kips}$$

$$\phi = 0.95$$

$$\phi P_{n1} = P_{n2} = 0.95 \times 394 \text{ k} = 374 \text{ kips} > P_a = 230 \text{ kips} \hspace{1cm} \text{OK}$$