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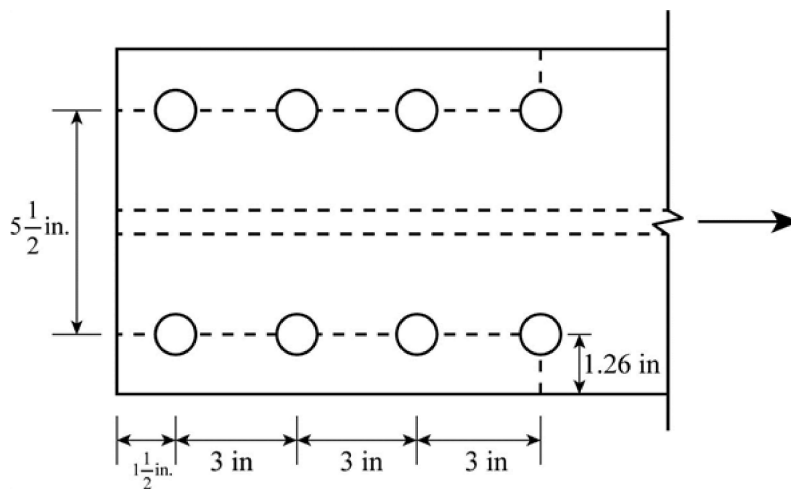
# Unified Design of Steel Structures | (0th Edition)

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## Step-by-step solution

### Step 1 of 9

Show the geometry of block shear failure of the as in Figure (1).



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### Step 2 of 9

Get the value of flange width,  $b_f$  and flange thickness,  $t_f$  of the section from Table 1-8 "WT dimensions" in AISC steel construction manual.

$$b_f = 8.01 \text{ in.}$$

$$t_f = 0.515 \text{ in.}$$

The distance between the outer edge and the center of bolt (each row) is 1.255 in.

$$\left[ \frac{(8.01 \text{ in.} - 5.5 \text{ in.})}{2} \right]$$

There are two stretches of shear failure path and two stretches of tensile failure path.

The length of single shear failure path,  $l_v$  is 10.5 in. and the total length of tensile path,  $l_t$  is 2.51 in.

$$l_v = 3 \text{ in.} + 3 \text{ in.} + 3 \text{ in.} + 1.5 \text{ in.}$$

$$l_v = 10.5 \text{ in.}$$

$$l_t = 1.255 \text{ in.} + 1.255 \text{ in.}$$

$$l_t = 2.51 \text{ in.}$$

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### Step 3 of 9

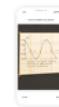
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$A_{gv} = 2 \times (10.5 \text{ in.} \times 0.515 \text{ in.})$ $= 10.815 \text{ in.}^2$ <p>-----</p> <p><a href="#">Comment</a></p>		
<p style="text-align: center;"><b>Step 4 of 9</b></p> <p>Calculate the effective hole size, <math>d_e</math>.</p> $d_e = d + \frac{1}{16} \text{ in.} + \frac{1}{16} \text{ in.}$ <p>Here, <math>d</math> is the diameter of bolt.</p> <p>Here, <math>1/16 \text{ in.}</math> added for the needs of fabrication and <math>1/16 \text{ in.}</math> for erection tolerance.</p> <p>Substitute <math>3/4 \text{ in.}</math> for <math>d</math>.</p> $d_e = \frac{3}{4} + \frac{1}{16} + \frac{1}{16}$ $= \frac{7}{8} \text{ in.}$ <p>-----</p> <p><a href="#">Comment</a></p>		
<p style="text-align: center;"><b>Step 5 of 9</b></p> <p>Calculate the net area in the shear <math>A_{nv}</math>.</p> $A_{nv} = 2(l_v - nd_e)t$ <p>Here, <math>n</math> is the bolts involved in shear resistance.</p> <p>Here, 3.5 indicates the bolts in the cross section. Three bolts will completely participate whereas the fourth bolt will partially participate in shear resistance.</p> <p>Substitute 10.5 in. for <math>l_v</math>, 3.25 for <math>n</math>, <math>7/8 \text{ in.}</math> for <math>d_e</math>, and 0.515 in. for <math>t</math>.</p> $A_{nv} = 2 \times \left( 10.5 \text{ in.} - 3.5 \times \frac{7}{8} \text{ in.} \right) \times 0.515 \text{ in.}$ $= 7.661 \text{ in.}^2$ <p>-----</p> <p><a href="#">Comment</a></p>		
<p style="text-align: center;"><b>Step 6 of 9</b></p> <p>Calculate the net area in the tension <math>A_{nt}</math>.</p> $A_{nt} = (l_t - n \times d_e)t$ <p>Substitute 2.51 in. for <math>l_t</math>, 1 for <math>n</math>, <math>7/8 \text{ in.}</math> for <math>d_e</math>, and 0.515 in. for <math>t</math>.</p> $A_{nt} = \left( 2.51 \text{ in.} - 1 \times \frac{7}{8} \text{ in.} \right) \times 0.515 \text{ in.}$ $= 0.842 \text{ in.}^2$ <p>-----</p> <p><a href="#">Comment</a></p>		
<p style="text-align: center;"><b>Step 7 of 9</b></p>		



Chapter 4, Problem 46P

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For tension members, the value of  $U_{bs}$  is 1.0.

Substitute 65 ksi for  $F_u$ ,  $7.661 \text{ in.}^2$  for  $A_{nv}$ , 1 for  $U_{bs}$ ,  $0.842 \text{ in.}^2$  for  $A_{nt}$ , 50 ksi for  $F_y$ , and  $10.815 \text{ in.}^2$  for  $A_{gv}$ .

$$R_n = \min \left\{ \begin{array}{l} \left[ 0.6 \times 65 \text{ ksi} \times 7.661 \text{ in.}^2 + 1 \times 65 \text{ ksi} \times 0.842 \text{ in.}^2 \right], \\ \left[ 0.6 \times 50 \text{ ksi} \times 10.815 \text{ in.}^2 + 1 \times 65 \text{ ksi} \times 0.842 \text{ in.}^2 \right] \end{array} \right\}$$

$$= \min (353.51 \text{ kips}, 379.18 \text{ kips})$$

$$= 353.51 \text{ kips}$$

The available block shear strength of the section is **353.51 kips**.

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#### Step 8 of 9

a)

LRFD:

Determine the design strength of the section for LRFD,  $\phi R_n$

Here,  $\phi$  is the shear resisting factor.

Substitute 0.75 for  $\phi$  and 353.51 kips for  $R_n$ .

$$\phi R_n = 0.75 \times 353.51$$

$$= 265.13 \text{ kips}$$

Therefore, the design strength of the section for LRFD is **265.13 kips**.

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#### Step 9 of 9

b)

ASD:

Determine the allowable strength of the section for ASD,  $R_n/\Omega$ .

Here,  $\Omega$  is the safety factor

Substitute 2 for  $\Omega$  and 353.51 kips for  $R_n$  to get:

$$\frac{R_n}{\Omega} = \frac{353.51}{2}$$

$$= 176.75 \text{ kips}$$

Therefore, the allowable strength of the section for ASD is **176.75 kips**.

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