For the truss shown the load $P_1$ is comprised of 10k dead load and 5k live load. The load $P_2$ is 8.5k dead load and 8k live load. Compute the factored tension load $P_a$ for member AB and design this 14 ft long member to remain safe according to AISC-LRFD. The gusset plate is 3/4-inch thick. Use a pair of angles assuming a single gage line of four 3/4-inch bolts in standard holes as shown. Select the lightest weight 2L section based on strength requirements with regard to gross section yielding and net section fracture. Check design for stiffness requirements and adjust if needed. If individual angle does not have sufficient stiffness for the 14-ft effective length, specify appropriate filler plate location. Assume 3-inch bolt spacing, 1.5-inch end spacing, and check for block shear rupture. If design is not adequate for block shear determine the required minimum bolt spacing, keeping the end distance 1.5 inches. Use A572 Grade 50 steel.
Factored Loads:
\[ P_1 = 1.2(10^k) + 1.6(5^k) = 20^k \]
\[ P_2 = 1.2(8.5^k) + 1.6(8^k) = 23^k \]

Analyze truss under factored loads:

\[ A_x = 132^k \]

From equilibrium of joint A; \[ A_x = \frac{T_{AB}}{\text{ultimate}} = 132^k \]

\[
\begin{align*}
\{ 132^k & \leq 0.9(50)A_g \\
132^k & \leq 0.75(65)A_e
\end{align*}
\
\]

\[ A_g_{\text{required}} = \frac{132}{0.9(50)} = 2.93 \text{ in}^2 \]

\[ A_e_{\text{required}} = \frac{132}{0.75(65)} = 2.71 \text{ in}^2 \]

\[ \text{Required} = \frac{14(12)}{300} = 0.056 \text{ in} \] \[ \text{Stiffness requirement (AISC B7)} \]

\[ A_e = U A_n \text{ (AISC Chapter D specs)} \]

\[ U = 1 - \frac{E}{L_c} \]

\[ L_c = \text{length of connection} = 3 \times 3 = 9'' \]

\[ U \leq 0.9 \]

Effective hole diameter \[ d = \frac{3}{4}'' + \frac{1}{8}'' = \frac{7}{8}'' \]

Assume \[ U = 0.85 \]

The total area of 2 angles required based on gross section yielding was \[ A_g = 2.93 \text{ in}^2 \]

Based on net section fracture, it is \[ A_n + 2td \]

\[ A_g \geq \frac{A_e}{0.85} + 2td \]

\[ \text{One hole per angle} \]
<table>
<thead>
<tr>
<th>Double Angle Selection</th>
<th>$A_g = 2.93$</th>
<th>$A_e = 2.71$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$t$</td>
<td>$2td$</td>
<td>$\frac{A_e}{0.85} + 2td$</td>
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<td>-----------</td>
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</tr>
<tr>
<td>$\frac{3}{16}$</td>
<td>0.328</td>
<td>3.516</td>
</tr>
<tr>
<td>$\frac{1}{4}$</td>
<td>0.438</td>
<td>3.626</td>
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</tr>
<tr>
<td>$\frac{5}{16}$</td>
<td>0.547</td>
<td>3.558</td>
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</table>

\[ \therefore \text{ Use } 3\frac{1}{2} \times 2\frac{1}{2} \times \frac{5}{16} - 2L \text{ A 572 Grade 50.} \]

based on gross section yielding, net section fracture and stiffness requirements. Alternate design is $2L - 4 \times 3\frac{1}{2} \times \frac{1}{4}$ A572 Grade 50. Check also block shear rupture. Assume long legs back to back (LHBB).
\[ \frac{1}{2} \text{ in } 3'' \text{ in } 3'' \]

\[ \begin{array}{c}
\frac{1}{2} + 2 \text{ tension} \\
\frac{1}{2} + 2 \text{ shear} \\
\end{array} \rightarrow T \\
\]

\[ 0.6 \left( \frac{F_u A_{nv}}{0.332} \right) \left( \frac{10.5 - 3.5(\frac{7}{3})}{16} \right) = 90.64 \text{ k} \]

\[ F_u A_{nt} = 65 \left( \frac{1.5 - 0.5(\frac{7}{3})}{16} \right) = 21.5 \text{ k} \]

\[ 0.6 F_y A_{gr} = 0.6 \left( \frac{(50)(10.5)}{16} \right) = 98.44 \text{ k} \]

\[ \phi R_n = \phi [0.6 F_u A_{nv} + F_u A_{nt}] \leq \phi [0.6 F_y A_{gr} + F_u A_{nt}] \]

\[ \phi R_n = 0.75 [90.64 + 21.5] = 84.105 \text{ k} \rightarrow \text{controls} \]

\[ \phi R_n = 0.75 [98.44 + 21.5] = 89.96 \text{ k} \]

Block shear capacity for 2L is \[ 2(84.105) = 168.21 \text{ k} \]

\[ \phi R_n = 168.21^k > F_u = 132^k \quad \text{OK} \]

\[ \sqrt{2L - 3\frac{1}{2} \times 2\frac{1}{2} \times \frac{5}{16}} \quad \text{A572 Grade 50} \]

\[ \text{Satisfy all design requirements} \]

Check \( r_z \) of individual \( L = 3\frac{1}{2} \times 2\frac{1}{2} \times \frac{5}{16} \) for filler plate spacing:

\[ r_z = 0.538 \rightarrow l_{max} = 300 \quad r_z = 161.4'' = 13.45' \]

it is close. If we subtract the connected lengths \[ 2(10.5) = 21'' \], the unsupported length is \[ 14 \times 12 - 21 = 147'' \] which is less than 161.4'' so it is acceptable. Otherwise, we would need to add a filler plate \[ 6'' \times 3\frac{1}{2}'' \times \frac{3}{4}'' \] at mid-length, with 2 bolts at 3'' spacing.
Note that the alternate design 2L 4 x 3\(\frac{1}{2}\) x \(\frac{1}{4}\) satisfies the stiffness requirement for the entire length of the member for each angle individually. Since \(\frac{1}{2} = 0.723 > 0.56\) required.

Check Block Shear Rupture for 2L 4 x 3\(\frac{1}{2}\) x \(\frac{1}{4}\)

![Diagram of block shear rupture]

0.6 \(F_u A_{nv}\) = 0.6 \((65)(10.5 - 3.5(\frac{7}{8}))\) \(\frac{1}{4}\) = 72.516 k

\(F_u A_{nt}\) = 65 \((1.5 - 0.5(\frac{7}{8}))\) \(\frac{1}{4}\) = 17.266 k

0.6 \(F_y A_{gv}\) = 0.6 \((60)(10.5(\frac{1}{4}))\) = 78.75 k

\(\Phi R_n = \Phi [0.6 F_u A_{nv} + F_u A_{nt}] \leq \Phi [0.6 F_y A_{gv} + F_u A_{nt}]\) Eq. (34.5)

\(\Phi R_n = 0.75 [72.516 + 17.266] = 67.34 k \leq \) controls

\(\Phi R_n = 0.75 [78.75 + 17.266] = \)

\(\Phi R_n = 67.34 (2) = 134.7 k \geq 132 k \text{ OK}\)

2L 4 x 3\(\frac{1}{2}\) x \(\frac{1}{4}\) satisfies all design requirements.

\(A_g = 1.81 (2) = 3.62 \text{ in}^2\) provided is slightly higher than that for 2L 3\(\frac{1}{2}\) x 2\(\frac{1}{2}\) x \(\frac{5}{16}\) is \(A_g = 1.78 (2) = 2.56 \text{ in}^2\).

However, the increased stiffness of 2L 4 x 3\(\frac{1}{2}\) x \(\frac{1}{4}\) is desirable.