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"On my honor, as an Aggie, I have neither given nor received unauthorized aid on this exam."

__________________________________________
Signature of student

Please do not open this exam until you are told to do so.
Problem 1) 40 points. A C12x30 of appropriate steel has been cut in half along its length and its web bolted to a gusset plate as shown. The bolts are 5/8" diameter. Use $x_1 = 1.5''$, $x_2 = 3''$, $y_1 = 2.5''$ and $y_2 = 1''$. Determine the maximum design tensile strength of the half-channel. There is a blank sheet next if needed for calculations.

Use A36 steel

\[
\begin{align*}
F_y &= 36 \\
F_u &= 58
\end{align*}
\]

\[\Phi \sigma_n = 0.9(\Phi) = 0.9(36) = 32.4\text{ ksi}\]

\[\Phi \sigma_n = 0.9(\Phi)(3.5) = 142.72 \text{ ksi}\]

Check $G_S Y$:

\[\Phi \sigma_n = (4.405)(0.9)(3.6) = 142.72 \text{ ksi}\]

NSF:

\[A_n = 4.405 - 2 \left( \frac{5}{8} + \frac{3}{8} \right) = 3.64\]

\[U = 1 - \frac{1}{2} = 0.5\]

\[A_e = A_n U = 3.64 \times 0.5 = 1.82\]

\[\Phi \sigma_n = A_e F_u (1.75) = (3.231)(58)(1.75) = 140.55 \text{ ksi}\]

BSR

\[A_{gy} = (7.5(0.510)) = 3.825\]

\[A_{ny} = (7.5(0.510) - 2.5(0.5)(0.510)) = 2.869\]

\[A_{nt} = (3.5(0.510) - 1.5(0.5)(0.510)) = 1.2113\]

\[\Phi \sigma_n (A_{ny} + A_{nt} + U_{os} F_u A_{nt}) = \Phi (0.6 F_y A_{gy} + U_{os} F_u A_{nt})
\]

\[0.75(0.6)(58)(2.869) + 1.5(2)(1.2113) = 75(0.6)(36)(3.825) + 1(58)(1.2113)) = 127.57\]

BSR: $\Phi \sigma_n = 114.06$ \[\Phi \sigma_n = 114.06\]

Controlling: $\Phi \sigma_n = 114.06$
Problem 2) 30 points For the frame shown, all beams are W12x50 and all columns are W10x100, of appropriate steel. Determine the effective length factor for column RN. H1 = 12 feet, H2 = 20 feet, D1 = 16 feet.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>12'</td>
<td>H1</td>
<td></td>
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</tr>
<tr>
<td>12'</td>
<td>H1</td>
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<tr>
<td>20'</td>
<td>H2</td>
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</tr>
<tr>
<td>20'</td>
<td>H2</td>
<td></td>
<td></td>
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</tbody>
</table>

Columns:
W10 x100
I = 683

Girders:
W12 x50
I = 391

Cannot use stiffness reduction factor because we don't know load.

\[ G_n = \frac{\varepsilon (\delta_L)_{col}}{\varepsilon (\delta_L)_{gir}} = \frac{\left( \frac{683}{20} \right) + \left( \frac{683}{20} \right)}{2 \left( \frac{391}{16} \right)} = 1.275 \]

\[ G_R = 1.0 \text{ for fixed support} \]

From side ways uninhibited alignment sheet

\[ K = 1.357 \text{ (exact solution)} \]
SIDESWAY UNINHIBITED
Problem 3) 30 points. The total length of the column shown is 20 feet, both ends are pinned, and there is bracing in the weak direction at a point 12 feet from the top. The service live load is 300 kips and the service dead load is 100 kips. Using A992 steel and the available column load tables, select the lightest shape.

\[ P_u = 1.2(100) + 1.6(300) = 600 \]

\[ F_y = 50 \]

\[ (KL)_y = 1(12') = 12' \]

Try W8 x 67 \[ \Phi P_n = 0.32 \]

Check strong axis:

\[ \frac{KL_x}{(f_{yw})} = \frac{1(20')}{1.75} = 11.43' \text{ still OK} \]

Try W10 x 60 \[ \Phi P_n = 0.31 \]

Check strong axis:

\[ \frac{KL_x}{(f_{yw})} = \frac{1(20')}{1.71} = 11.70' \text{ still OK} \]

Try W12 x 58 \[ \Phi P_n = 0.03 \]

Check strong axis:

\[ \frac{KL_x}{(f_{yw})} = \frac{1(20')}{2.10} = 9.52' \text{ still OK} \]

Try W14 x 61 \[ \Phi P_n \nRightarrow \text{ not lighter than W12 x 58} \]

There is no indicated (c) on tables so there will be no local buckling.

Use W12 x 58
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Signature of student

Please do not open this exam until you are told to do so.
Problem 1) 30 points. Use A992 steel and the available column load tables to select the lightest shape for an axially loaded column to meet the following specifications. The total length is 22 feet, both ends are pinned, and there is bracing in the weak direction at a point 10 feet from the top. The service dead load is 142 kips and the service live load is 356 kips.

\[ P_u = 1.2(142) + 1.6(356) = 740 \text{ k} \]

KLx = 22 ft  KLy = 12 ft

@ KLx = 12 ft lightest W12

try W12 x 72

\[ \frac{KxL}{rx/ry} = \frac{22}{1.75} = 12.57 \checkmark \]

@ 13 ft, \( \phi P_n = 784 > 740 \) (OK)

try W14

lightest is W14 x 74

\[ \frac{KxL}{rx/ry} = \frac{22}{2.44} = 9.02 \]

@ 10 ft, \( \phi P_n = 826 > 740 \)

Use W12 x 72

\[ L_x = 22 \text{ ft} \]

\[ L_y = 12 \text{ ft} \]

Strong axis

Weak axis

try W10 x

\[ \frac{KxL}{rx/ry} = \frac{22}{1.73} = 12.72 \]

\[ \left\{ \begin{array}{c}
12 \quad 814 \\
13 \quad 783 \\
12.72
\end{array} \right. \]

\( \phi P_n = 791.7 \text{ kips} \)

by interpolating
Column design

\[ K_xL = 22 \text{ ft}, \ K_yL = 12 \text{ ft} \]

\[ P_u = 1.2(142) + 1.6(356) = 740 \text{ k} \]

\[ \rightarrow [4-14] \ \text{Try} \ W14 \times 74 @ 766 \text{ k} \]

Check strong axis buckling:

\[ \frac{K_xL}{K_y/1} = \frac{22}{2.44} = 9.02 \text{ ft} = K_{phoy} \]

9.02 ft < 12 ft used

so strong axis buckling won't occur.

\[ \rightarrow [4-17] \ \text{Try} \ W12 \times 72 @ 807 \text{ k} \]

Strong axis buckling:

\[ K_{phoy} = \frac{K_xL}{K_y/1} = \frac{22 \text{ ft}}{1.75} = 12.57 \text{ ft} \]

Strong axis controls:

Even at 12.57 < 13 ft a W12 \times 72 carries 784 k > 766 k

so W12 \times 72 is OK

\[ \rightarrow [4-19] \ \text{Try} \ W10 \times 77 \text{ (heavier)} \]

\[ \rightarrow [4-21] \ \text{No} \ W8 \times XX \text{ work} \]

Use W12 \times 72
Problem 2) A C10x30

40 points. Of appropriate steel has been cut in half along its length and its web bolted to a gusset plate as shown. The bolts are 5/8" diameter. Use x1 = 1.5", x2 = 3", y1 = 2.5" and y2 = 1". Determine the maximum design tensile strength of the half-channel. There is a blank sheet next if needed for calculations.

Use A36 steel
\( F_y = 36 \)
\( F_u = 58 \)

**Check**

\[ \phi P_n = A_g (1.9) (F_y) = (4.405) (1.9) (36) = 142.7 \text{ K} \]

**NSF:**
\[ A_n = 4.405 - 2 \left( \frac{7}{8} \right) (0.649) = 3.059 \]
\[ U = 1 - \frac{F}{A_n} = 1 - \frac{0.649}{0.60} = 0.892 \]
\[ A_e = A_n U = 3.059 (0.892) = 2.728 \]
\[ \phi P_n = A_e F_u (1.75) = (2.728) (58) (1.75) = 118.76 \text{ K} \]

**BSR**
\[ A_{gr} = (7.5 (0.673)) = 5.04 \text{ in}^2 \]
\[ A_{nv} = (2.5 (0.673) - 2.5 (0.673)) = 3.365 \text{ in}^2 \]
\[ A_{nt} = (3.5 (0.673) - 1.5 (0.673)) = 1.346 \text{ in}^2 \]

\[ \phi (0.6 F_u A_{nv} + U_{os} F_u A_{nt}) \leq \phi (0.6 F_y A_{gr} + U_{os} F_u A_{nt}) \]
\[ 0.75 (0.6 (58) (3.365) + 1.5 (1.346)) \leq 0.75 (0.6 (36) (5.04) + 1 (58) (1.346)) \]
\[ 165.9 \text{ K} \leq 159.7 \text{ K} \]

**BSR:**
\[ \phi P_n = 159.7 \text{ K} \]

Controlling:
\[ \phi P_n = 118.76 \text{ K} \]

"Cannot check BSR on plate because we do not have all the dimensions."
Problem 3) 30 points For the frame shown, $H1 = 14$ feet, $H2 = 26$ feet, $D1 = 20$ feet. All beams are W12x40 and all columns are W10x88, of appropriate steel. Determine the effective length factor for column SO.

\[ G_{10} = \frac{G_e (I/L)_c}{G_e (I/L)_g} \]

For W12x40
\[ I_x = 307 \]
\[ k_x = 5.13 \]
For W10x88
\[ I_x = 534 \]

\[ G_{10} = \left( \frac{534}{26} \right) + \left( \frac{534}{26} \right) \]
\[ = \frac{41.077}{30.7} = 1.33 \]

USING SIDESWAY INHIBITED

\[ k_x = 0.87 \]
SIDESWAY INHIBITED