1) DO NOT put your completed work on the desk next to you or anywhere else where it can be seen. If I come by and see it I will confiscate it and give you zero credit for that problem. Place it face down on your desk under your existing work. Please take this instruction very seriously.

2) Please remove your hat. If it is part of your head, turn it around backwards.

3) Please note that if your work not legible, or if I cannot follow your logic at a glance, it will receive zero credit.

Problem 1) Select the lightest A992 steel beam to carry the loads placed as shown. The concentrated load \( P \) consists of 20k dead and 40k live. The uniform load is 2k/ft dead and 3k/ft live. \( L_1 = 10' \), \( L_2 = 20' \). The beam is braced at the ends and at the center of the beam. You may omit web shear, web crippling, stuff like that on this problem.

Problem 2) Determine \( M_p \) for the beam shown. \( y_1 = 2'' \), \( y_2 = 6'' \), \( x_1 = 1.5'' \), \( x_2 = 3'' \). The steel is A36, and the holes shown in the beam are half ellipses.

Problem 3) Design a base plate for a W14x211 column supporting a factored axial load of 1000 kips. The support will be a 36"x36" square 3.5 ksi concrete footing. Use A242 steel, and make the plate square in 2 inch increments, with a multiple of 1/8 inch thickness.
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Problem 1) Determine $M_p$ for the beam shown. $y_1 = 3''$, $y_2 = 8''$, $x_1 = 2.5''$, $x_2 = 5''$. The steel is A992, and the holes shown in the beam are parabolic.

Problem 2) Design a base plate for a W14x145 column supporting a factored axial load of 900 kips. The support will be a 32"x32" square 4 ksi concrete footing. Use A242 steel, and make the plate square in 2 inch increments, with a multiple of 1/8 inch thickness.

Problem 3) Select the lightest A992 steel beam to carry the loads placed as shown. The uniform load is 3k/ft live and 2k/ft dead. The concentrated load $P$ consists of 40k live and 20k dead. $L_1 = 20'$, $L_2 = 10'$. The beam is braced at the ends and at the center of the beam. You may omit web shear, web crippling, stuff like that on this problem.
\[ P_{\text{dead}} = 20k \quad P_{\text{live}} = 40k \]

\[ W_{\text{dead}} = 2k/ft \quad W_{\text{live}} = 3k/ft \]

\[ 1.2(20) + 1.6(40) = 88k \]

\[ 2(1.2) + 3(1.6) = 7.2k/ft \]

\[ 10' \mid 5' \mid 15' \mid 88k \]

\[ 10' \quad 20' \quad 137.33k \]

\[ 166.67k \]

\[ 94.67 \]

\[ 66.67 \]

\[ 137.33 \]

\[ 7.2k/ft \]

\[ M_{\text{max}} = \frac{(66.67 + 94.67)(10')}{2} + \frac{(6.67)(0.93)}{2} = 1309.8 \text{k-ft} \]

\[ \Delta 3.75 \]

\[ M_a = 166.67(3.75) - 7.2k/ft(3.75) \left( \frac{3.75}{2} \right) = 574.4 \text{k-ft} \]

\[ 7.2k/ft \]

\[ (10.5' - 7.5') \]

\[ M_B = 166.67(7.5') - 7.2(7.5')^2 = 1047.5 \text{k-ft} \]
Phony moment = \[
\frac{1309.8 \text{ kft}}{1.248} = 1049.52 \text{ kft}
\]

Add weight of beam = \[
\frac{WL^2}{8} = \frac{(0.108 \text{ kft})(30')^2}{8} = 12.15 \text{ kft}
\]

M = \[
\frac{1309.8 + 12.15}{1.248} = 1059 \text{ kft}
\]

W30 x 108 still works, pg 5-84

Check \[
\phi M_p > = 1309.8 + 12.15 = 1322 \text{ kft}
\]

Pg 5-45 no good at 1300 kft

Next lightest from pg 5-45: W30 x 116

Next lightest from pg 5-84: W27 x 114

Insufficient \[
\phi M_p
\]

Try W30 x 116:

M = \[
1309.8 + \frac{(0.114 \text{ kft})(30')^2}{8} = 1322.63 \text{ kft}
\]

LTB: Pg 5-84, 1322.63/1.248 = 1059 kft OK

\[
\phi M_p \text{ of Pg 5-45} = 1420 \text{ kft OK}
\]
### Design of SQUARE column base plate thickness:

<table>
<thead>
<tr>
<th>Steel plate:</th>
<th>Fy = 42 ksi</th>
<th>Steel plate:</th>
<th>Fy = 42 ksi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Column: W14x211</td>
<td>bf = 15.8 inches</td>
<td>Column: W14x145</td>
<td>bf = 15.5 inches</td>
</tr>
<tr>
<td>d = 15.7 inches</td>
<td>Load Pu = 1000 kips</td>
<td>d = 14.8 inches</td>
<td>Load Pu = 900 kips</td>
</tr>
<tr>
<td>Square Footing: B = 36 inches on each side</td>
<td>fc' = 3.5 ksi</td>
<td>Square Footing: B = 32 inches on each side</td>
<td>fc' = 4 ksi</td>
</tr>
</tbody>
</table>

**IF sqrt(A2/A1) < 2:**
- Plate Size A1 = 242.169 square inches
- Check sqrt(A2/A1) max=2: 2.31336 ratio

**IF sqrt(A2/A1) >= 2:**
- Plate Size A1 = 280.112 square inches
- Check sqrt(A2/A1) max=2: 2.15098 ratio

**Required plate area = 280.112 square inches**
- Minimum plate size = 16.7365 inches
- Actual plate size used = 18 inches

**Actual plate size used = 16 inches**
- m = 1.5425 inches
- n = 2.68 inches
- lambda = 0.89724 ratio
- X = 0.55788 ratio
- n' = 3.93748 inches

**lambda used (1 is conservative) = 1**
- t = 1.59116 inches thick

**lambda used (1 is conservative) = 1**
- t = 1.63308 inches thick

---

**Quiz #1**

**Quiz #2**
**Quiz #1**

\[ P_u = 900 \text{ kips} \]

1. Compute required beam area
   \[ f_c p > P_u \Rightarrow f_c (0.85) f_c A_c \sqrt{A_p/A_1} > P_u \]
   \[ 0.6 (0.85) (4) (A_c) \sqrt{(32)^2/A_1} > 900 \quad A_1 = 190.07 \text{ in}^2 \]

- Check \( \sqrt{A_p/A_1} = 2.32 > 2 \) (N.6.)

\[ A_1 = \frac{A_0}{4} = 256 \text{ in}^2 \]

- Also the plate must be at least as large as the column
  \[ b \times d = 15.5 (14.8) = 229.4 < 256 \text{ (OK)} \]

- Try \( b = 16 \text{ in} \times 16 = 256 \text{ in}^2 \)

\[ m = \frac{N - 0.85d}{2} = \frac{16 - 0.85 (14.8)}{2} = 0.97 \]

\[ n = \frac{B - 0.864}{2} = \frac{16 - 0.864 (15.5)}{2} = 1.8 \text{ in} \]

\[ n' = \frac{1}{8} \sqrt{d b} = \frac{1}{4} \sqrt{15.5 (14.8)} = 3.79 \text{ in} \]

- Let \( \lambda = 1 \) (considerable)

\[ l = \max (m, n, n') = 3.79 \text{ in} \]

\[ t = 3.79 \sqrt{\frac{1000}{0.9 (14.8) (42)}} = 1.63 \approx 1.75 \]

Use PL 1/4 x 16 x 16 / Good
If designed End Beam Bearing Plates instead of column base plate:

<table>
<thead>
<tr>
<th>Beam</th>
<th>W14x211</th>
<th>Plate Fy = 42 ksi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam Fy</td>
<td>50 ksi</td>
<td></td>
</tr>
<tr>
<td>d</td>
<td>15.7 inches</td>
<td></td>
</tr>
<tr>
<td>tw</td>
<td>0.98 inches</td>
<td></td>
</tr>
<tr>
<td>tf</td>
<td>1.52 inches</td>
<td></td>
</tr>
<tr>
<td>k</td>
<td>2.16 inches</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reaction</td>
<td>1000 kips to be carried</td>
<td></td>
</tr>
</tbody>
</table>

Required minimum N = 15.00816 inches \( \text{ <-- To prevent web yielding} \)

Assuming N/d > 0.2:

\[
\phi_i 0.4 \times tw^2 = 0.28812 \\
\sqrt{E \times Fy \times tf/tw} = 1499.66 \\
(tw/tf)^1.5 = 0.517695 \\
\]

Required minimum N = 10.750 inches \( \text{ <-- To prevent web crippling} \)

Actual N/d = 0.685 \( \text{ <-- Assumption correct} \)

Assuming N/d <= 0.2:

\[
\phi_i 0.4 \times tw^2 = 0.28812 \\
\sqrt{E \times Fy \times tf/tw} = 1499.66 \\
3 \times (tw/tf)^1.5 = 1.553084 \\
\]

Required minimum N = 13.287 inches \( \text{ <-- To prevent web crippling} \)

Actual N/d = 0.846 \( \text{ <-- Assumption incorrect} \)

---

Trial bearing plate dimensions:

\[
N \text{ trial} = 24 \text{ inches} \\
Minimum B = 23.343 \text{ inches} \\
\]

Final bearing plate dimensions used:

\[
N = 24 \text{ inches} \\
B = 24 \text{ inches} \\
\text{Plate n} = 9.84 \text{ inches of cantilever} \\
\text{t required} = 2.982 \text{ inches thick} \\
\]
If designed End Beam Bearing Plates instead of column base plate:

<table>
<thead>
<tr>
<th>Beam</th>
<th>W14x145</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam Fy</td>
<td>50 ksi</td>
</tr>
<tr>
<td>d</td>
<td>14.8</td>
</tr>
<tr>
<td>tw</td>
<td>0.68 inches</td>
</tr>
<tr>
<td>tf</td>
<td>1.09 inches</td>
</tr>
<tr>
<td>k</td>
<td>1.69 inches</td>
</tr>
</tbody>
</table>

Plate Fy = 42 ksi
f'c = 4 ksi

Reaction = 900 kips to be carried

Required minimum N = 22.24559 inches <-- To prevent web yielding

Assuming N/d > 0.2:
\[ \phi^*0.4*\text{tw}^2 = 0.13872 \]
\[ \sqrt{E*\text{Fy}*\text{tf}/\text{tw}} = 1524.554 \]
\[ (\text{tw}/\text{tf})^{1.5} = 0.492747 \]

Required minimum N = 25.186 inches <-- To prevent web crippling

Actual N/d = 1.702 <-- Assumption correct

Assuming N/d <= 0.2:
\[ \phi^*0.4*\text{tw}^2 = 0.13872 \]
\[ \sqrt{E*\text{Fy}*\text{tf}/\text{tw}} = 1524.554 \]
\[ 3*(\text{tw}/\text{tf})^{1.5} = 1.47824 \]

Required minimum N = 32.595 inches <-- To prevent web crippling

Actual N/d = 2.202 <-- Assumption incorrect

Trial bearing plate dimensions:
N trial = 26 inches
Minimum B = 16.968 inches

Final bearing plate dimensions used:
N = 26 inches
B = 18 inches
Plate n = 7.31 inches of cantilever
t required = 2.332 inches thick
\[ A_1 = 12.5 \times 10 = 125 \text{ in}^2 \]
\[ y_1 = 12.5/2 = 6.25 \text{ in} \]
\[ A_1 y_1 = 781.25 \text{ in}^3 \]
\[ A_2 = \frac{4}{3} \left(5 \times \frac{8}{4}\right) = 26.67 \text{ in}^2 \]
\[ y_2 = 1.5 + \frac{2}{5}(8) = 4.70 \text{ in} \]
\[ A_2 y_2 = -125.33 \text{ in}^3 \]
\[ Z = (781.25 - 125.33)2 = 1311.83 \text{ in}^3 \]
\[ M_p = \frac{Z F_y}{12} = \frac{1311.83 \times 50}{12} = 5466 \text{ Kft} \]
**Ellipses**

\[ A_1 = 9'' \times 6'' = 54 \text{ in}^2 \]
\[ y_{o1} = 9.12'' \]
\[ A_{1y1} = 243 \text{ in}^3 \]

\[ A_2 = \frac{\pi}{2} ab = \frac{\pi}{2} (6'' \times 3'') = 14.14 \text{ in}^2 \]

\[ y_{o2} = 1 + \frac{4a}{3\pi} = 1 + \frac{4(6'')}{3\pi} = 3.55'' \]

\[ A_{2y2} = -(4.14/\text{in}^2)(3.55'') = -50.14 \text{ in}^3 \]

\[ Z = 2(243 - 50.14) = 385.73 \text{ in}^3 \]

\[ M_p = ZF_y = \frac{385.73 \text{ in}^3 \times 36 \text{ k/in}^2}{12 \text{ in/ft}} \]

\[ = 1157 \text{ KFT} \]