CMGT 350 **Exam #3** **Fall 2021**

Show all work for full credit. You may work with ONE other person.

Due: December 7, 2021

Name: Solution

3. A nominal size 8 x 16 CA Redwood beam of rectangular cross section is used in an 18-ft simple span. Determine the maximum allowable uniform load w applied to the entire span that the beam can carry. The allowable deflect is L/360

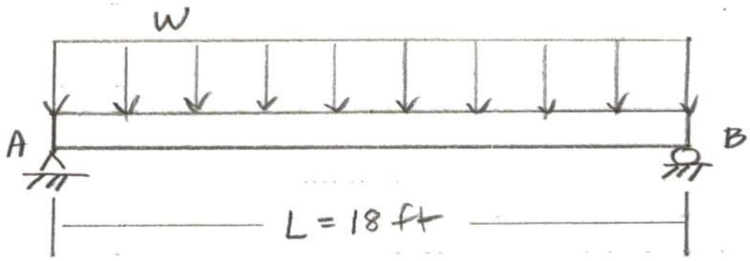


Table 15-2, CA Redwood

$\sigma_{allow} = 1350$ psi

$\tau_{allow} = 100$ psi

$L = 18\text{ ft} \times \frac{12\text{ in}}{\text{ft}} = 216\text{ in}$

$\delta_{allow} = \frac{L}{360} = \frac{216\text{ in}}{360} = 0.6\text{ in}$

Table A-6(a)

Nominal 8 x 16

$S = 300\text{ in}^3$

$I = 2327\text{ in}^4$

$A = 116\text{ in}^2$

Table A-7(a)

$E = 1.3 \times 10^3$ ksi

Deflection

Table 16-1, Case 7

$\delta_{MAX} = \frac{5wL^4}{384EI}$

$w = \frac{384EI(0.6\text{ in})}{5L^4}$

$w = \frac{384(1300\text{ ksi})(2327\text{ in}^4)(0.6\text{ in})}{5(216\text{ in})^4}$

$= \frac{696{,}983{,}040\text{ Kip}}{10{,}883{,}911{,}680\text{ in}}$

$= 0.064\text{ Kip/in} \times \frac{12\text{ in}}{\text{ft}} \times \frac{1000\text{ lb}}{\text{Kip}}$

$= 768.5\text{ lb/ft}$

Check Bending Moment and Shear Stress

Bending Moment

Table 13-1, case 4

$$M_{MAX} = \frac{wL^2}{8}$$

$$\sigma_{MAX} = \frac{M}{S} = \frac{\frac{w(216\,in)^2}{8}}{300\,in^3} = 1350\ lb/in^2$$

$$w = \frac{1350\,\frac{lb}{in^2}(300\,in^3)(8)}{(216\,in)^2}$$

$$= 69.4\ lb/in \times 12\ in/ft$$

$$= 833\ lb/ft$$

Shear

Table 13-1, case 4

$$\tau_{MAX} = 1.5\,\frac{V}{A} \qquad V_{MAX} = \frac{wL}{2}$$

$$\frac{1.5\,wL}{2A} = 100\ lb/in^2$$

$$w = \frac{2(116\,in^2)(100\,lb/in^2)}{1.5(216\,in)}$$

$$= 71.6\ lb/in \times \frac{12\,in}{ft}$$

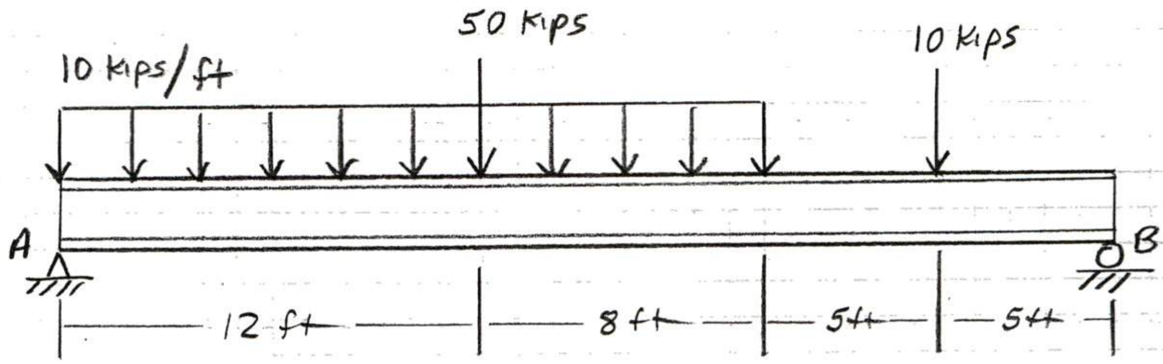
$$= 859.3\ lb/ft$$

Deflection Governs

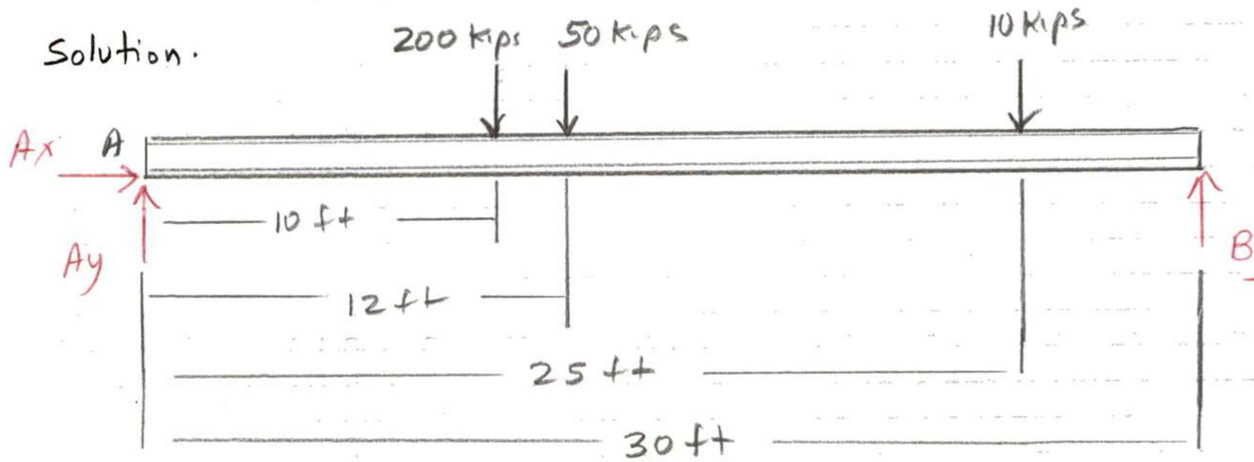
(Beam wt)

$$W = 768.5\ lb/ft - 32.3\ lb/ft = 736.2\ lb/ft$$

4. A simple beam has a span of 30-ft with the load shown. The beam is braced laterally throughout its length. Select the lightest W shape for A36 steel to carry the load.



Solution.



FBD – Entire Beam

Equilibrium Equations

$[\Sigma F_x = 0]$ $A_x = 0$

$+\circlearrowright [\Sigma M_A = 0]$ $-200\text{ kips}(10\text{ ft}) - 50\text{ kips}(12\text{ ft}) - 10\text{ kips}(25\text{ ft}) + B_y(30\text{ ft}) = 0$

$$B_y = \frac{2850\text{ kip}\cdot\text{ft}}{30\text{ ft}} = 95\text{ kips}\uparrow$$

$[\Sigma F_y = 0]$ $A_y - 200\text{ kips} - 50\text{ kips} - 10\text{ kips} + B_y = 0$

$$A_y = 260\text{ kips} - 95\text{ kips} = 165\text{ kips}\uparrow$$

Step 1. Knowns

$L = 30$ ft

A36 Steel

$\sigma_{allow} = 24$ ksi

$\tau_{allow} = 14.5$ ksi

Step 2.

$V_{MAX} = 165$ kips

$M_{MAX} = 1260 \text{ kip}\cdot\text{ft} \times \frac{12\text{ in}}{\text{ft}} = 15{,}120 \text{ kip}\cdot\text{in}$

Step 3.

$$S_{req} = \frac{M_{MAX}}{\sigma_{allow}} = \frac{1260 \text{ kip}\cdot\text{ft} \times \frac{12\text{ in}}{\text{ft}}}{24 \text{ kip/in}^2} = 630 \text{ in}^3$$

Step 4. Find W shapes

Table A-1(a)

Select, W 33×201 $\quad S = 684 \text{ in}^3$ (Lightest)

Table 13-1, case 4

$$M_{WT} = \frac{wL^2}{8} = \frac{201 \text{ lb/ft} (30 \text{ ft})^2}{8} = 22612.5 \text{ lb}\cdot\text{ft} \times \frac{1 \text{ kip}}{1000 \text{ lb}} \times \frac{12 \text{ in}}{\text{ft}}$$

Check Bending

$$= 271.35 \text{ kip}\cdot\text{in}$$

$$\frac{M_{WT}}{M_{MAX}} = \frac{271.35 \text{ kip}\cdot\text{in}}{15{,}120 \text{ kip}\cdot\text{in}} = 0.0179 = 1.79\%$$

$$\frac{\text{Extra } S}{S_{req}} = \frac{684 \text{ in}^3 - 630 \text{ in}^3}{630 \text{ in}^3} = 0.0857 = 8.57\% > 1.79\% \checkmark$$

ok, For Bending

Check Shear

W33×201

$d = 33.68$ in

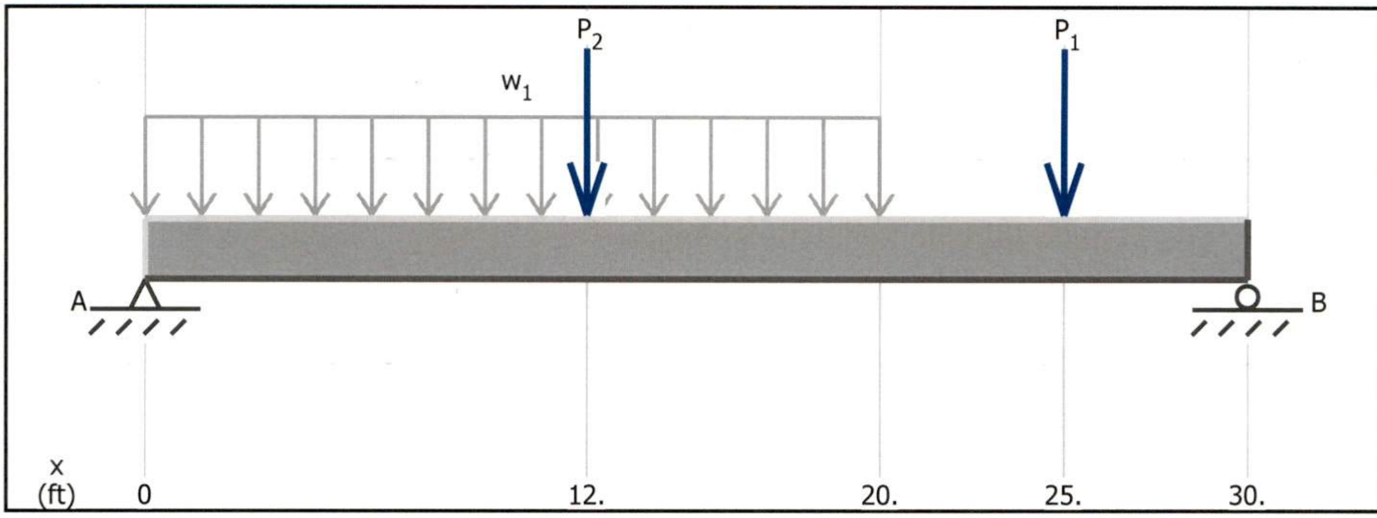
$t_w = 0.715$ in

$$\tau_{AVG} = \frac{V_{MAX}}{d t_w} = \frac{165 \text{ kips}}{33.68 \text{ in} (0.715 \text{ in})} = 6.85 \text{ ksi} < 14.5 \text{ ksi} = \tau_{allow}$$

✓ ok, For Shear

Use, W33×201

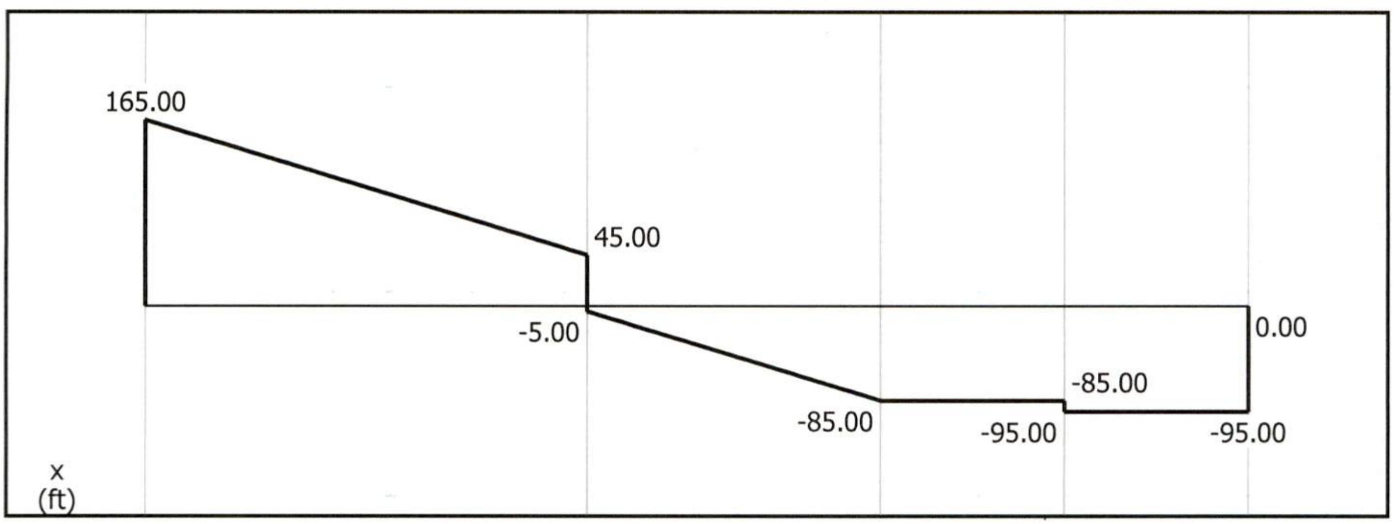
Printout title



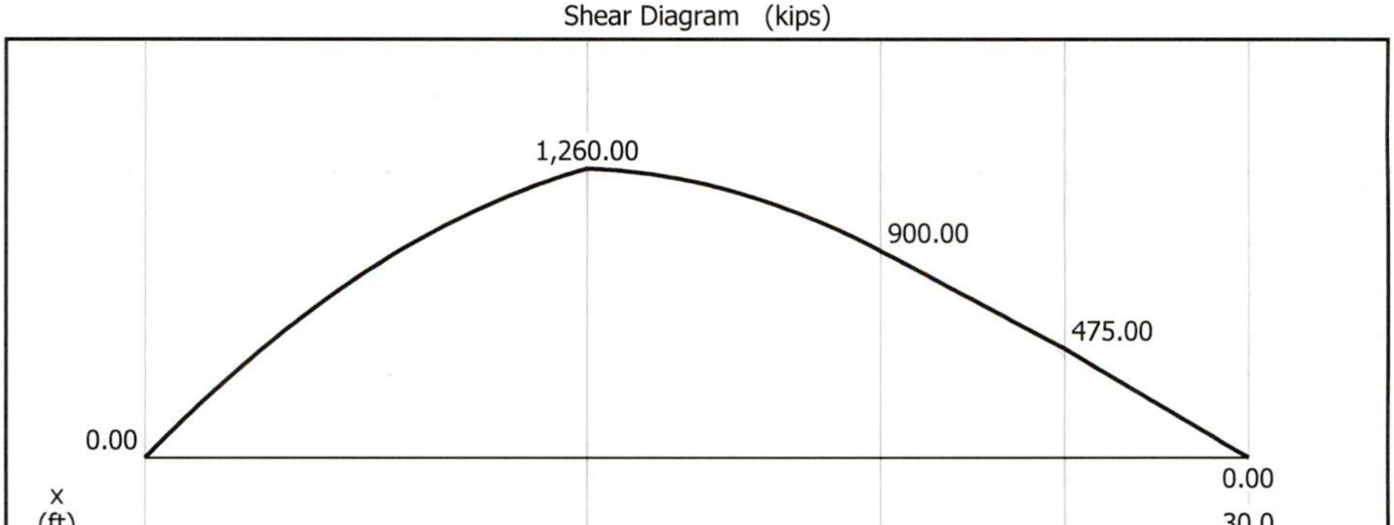
Load Diagram

w_1 = 10.0 kips/ft (down)
P_1 = 10.0 kips (down)
P_2 = 50.0 kips (down)

A_y = 165.00 kips (up)
B_y = 95.00 kips (up)



Shear Diagram (kips)



Moment Diagram (kip-ft)

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