CMGT 350

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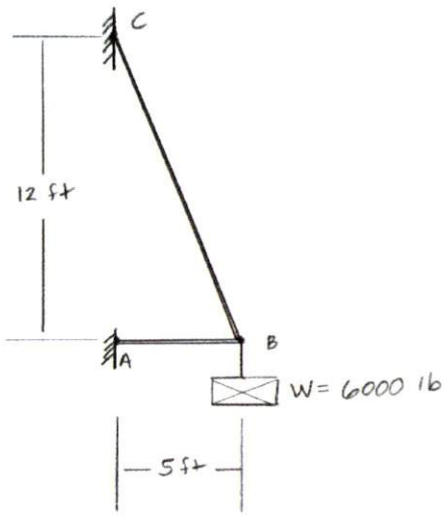
Final Exam (Patricio's Exam)

Fall 2020

Name: Solution

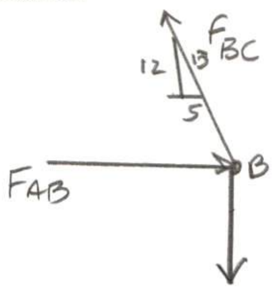
1. The allowable tensile stress of the steel cable is 12,000 psi. Find the diameter of the cable, to the nearest sixteenth of an inch.



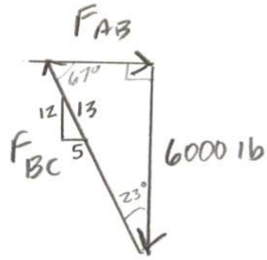
$\cos 23^\circ = \frac{6000\ lb}{F_{BC}}$

$F_{BC} = 6500\ lb$

Solution.



FBD



Force - Triangle

$$\frac{F_{BC}}{13} = \frac{6000\ lb}{12}$$

$$F_{BC} = 6500\ lb$$

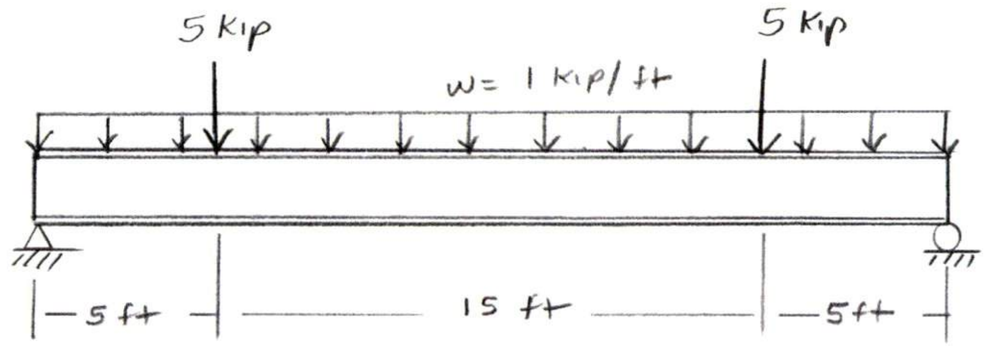
$$\sigma_{BC} = \frac{F_{BC}}{A}$$

$$A = \frac{6500\ lb}{12{,}000\ psi} = \frac{\pi d^2}{4}$$

$$d = \sqrt{\frac{4(6500\ lb)}{12{,}000\ psi\ (\pi)}} = 0.83\ in$$

use, $d = \frac{14}{16}$ in

2. A wide-flange steel beam is loaded as shown. Assuming a maximum allowable deflection of 1/240 of the span length and a depth requirement of 18-in nominal, select the most economical section. Use A36 steel.



Step 1.
A36 Steel

$\sigma_{allow} = 24$ ksi

$\tau_{allow} = 14.5$ ksi

$L = 25\text{ ft}\left(\frac{12\text{ in}}{\text{ft}}\right) = 300\text{ in.}$

$w = 1$ kip/ft

$P = 5$ kip
$a = 5$ ft

Step 2. Table 13-1, case 3 and case 4

$$V_{MAX} = P + \frac{wL}{2} = 5\text{ kip} + \frac{1\text{ kip/ft}\,(25\text{ ft})}{2} = 17.5\text{ kip}$$

$$M_{MAX} = Pa + \frac{wL^2}{8} = 5\text{ kip}(5\text{ ft}) + \frac{1\text{ kip/ft}\,(25\text{ ft})^2}{8} = 103.125\text{ kip}\cdot\text{ft}$$

Step 3.

$$S_{req} = \frac{M_{MAX}}{\sigma_{allow}} = \frac{103.125\text{ kip}\cdot\text{ft}\left(\frac{12\text{ in}}{\text{ft}}\right)}{24\text{ ksi}} = 51.6\text{ in.}^3$$

Step 4. Table A-1(a)

Select W 18 × 35 $S = 57.6\text{ in}^3$

check

$$M_{wt} = \frac{wL^2}{8} = \frac{35\text{ lb/ft}\,(25\text{ ft})^2}{8} = 2734.375\text{ lb}\cdot\text{ft}\left(\frac{\text{kip}}{1000\text{ lb}}\right) = 2.73\text{ kip}\cdot\text{ft}$$

$$\frac{M_{wt}}{M_{MAX}} = \frac{2.73\text{ kip}\cdot\text{ft}}{103.125\text{ kip}\cdot\text{ft}} = 0.027 = 2.7\%$$

$$\frac{\text{Extra } S}{S_{req}} = \frac{57.6\text{ in}^3 - 51.6\text{ in}^3}{51.6\text{ in}^3} = 0.116 = 11.6\% > 2.7\% \checkmark$$

ok, bending

Step 5- Check Shear Stress

W 18 x 35

$d = 17.70$ in

$t_w = 0.300$ in

$$\tau_{avg} = \frac{V_{max}}{d t_w} = \frac{17.5\text{ kip}}{17.70\text{ in}(0.300\text{ in})} = 3.3\text{ ksi} < \tau_{allow} = 14.5\text{ ksi}$$

✓ok, Shear

Step 6- Check Deflection

$$\delta_{allow} = \frac{L}{240} = \frac{300\text{ in}}{240} = 1.25\text{ in}$$

W18x35

$I = 510\text{ in}^4$

$E = 30 \times 10^3$ ksi

$$\begin{aligned} w = &\ 1000\text{ lb/ft} \\ + &\ 35\text{ lb/ft} \\ \hline &\ 1035\text{ lb/ft} \end{aligned}$$

$$\delta_{max} = \frac{PL^3}{48EI} + \frac{5wL^4}{384EI}$$

$$= \frac{10\text{ kips}(150\text{ in})^3}{48(30\,000\text{ ksi})(510\text{ in}^4)} + \frac{5\left(1.035\frac{\text{kip}}{\text{ft}}\right)\left(\frac{\text{ft}}{12\text{in}}\right)(300\text{ in})^4}{384(30\,000\text{ ksi})(510\text{ in}^4)}$$

$$= 0.045956\text{ in} + 0.59455\text{ in}$$

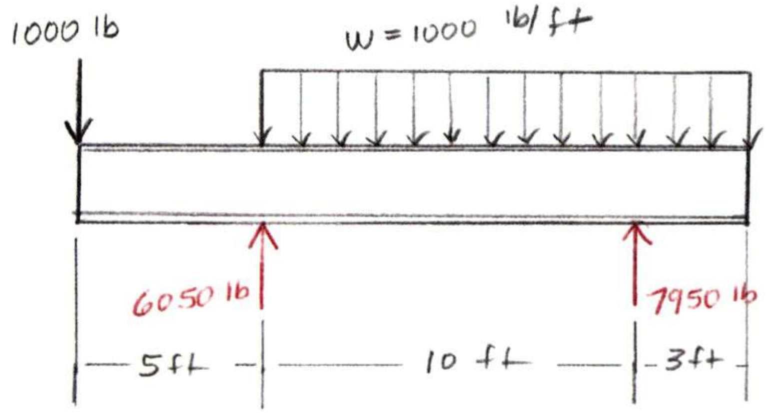
$$= 0.641\text{ in}$$

$$\delta_{max} = 0.641\text{ in} < \delta_{allow} = 1.25\text{ in}$$

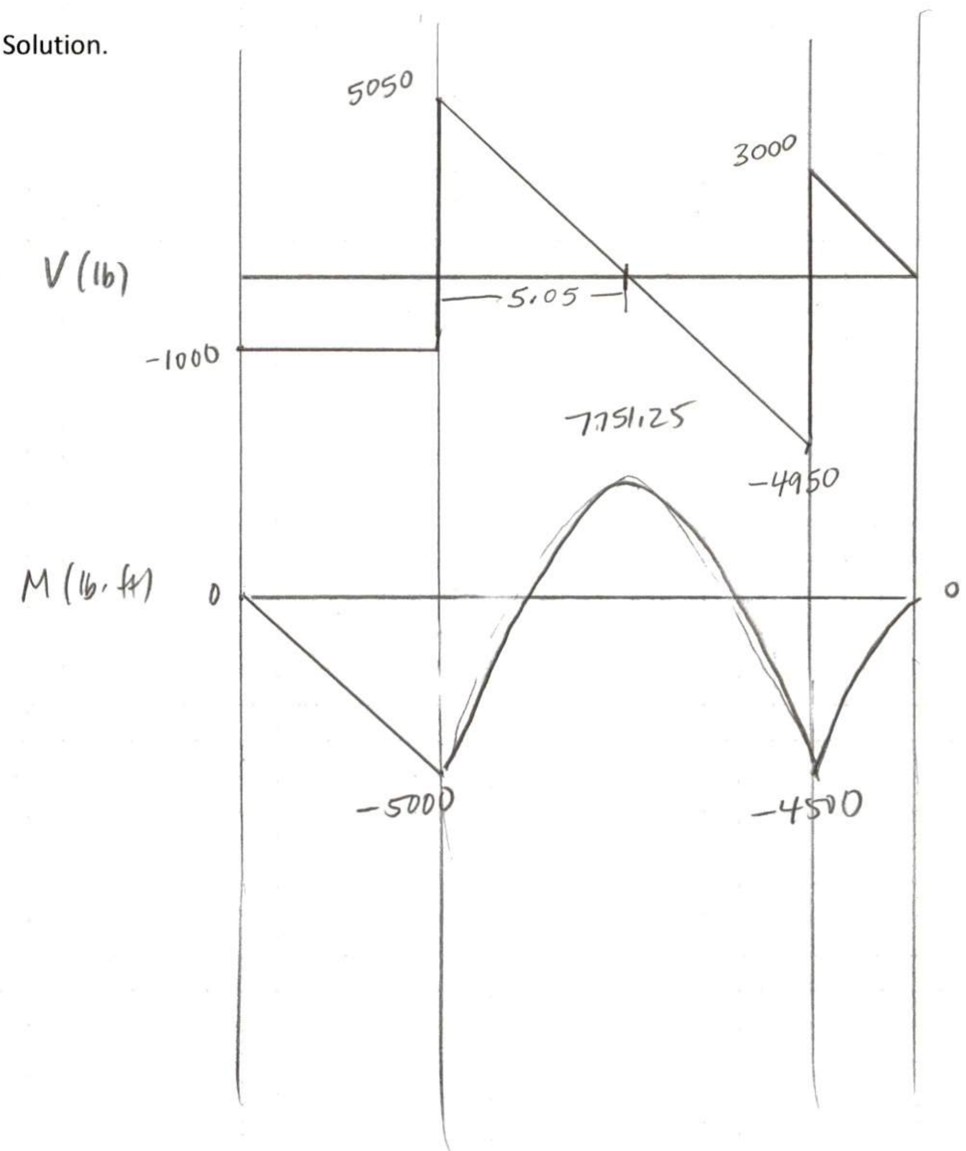
✓ ok, for deflection

$$\boxed{\text{Use, W 18x35}}$$

3. Draw the shear and bending moment diagrams for the beam due to the loading shown. Locate the section(s) with zero shear and determine the moment(s) at the section(s).



Solution.



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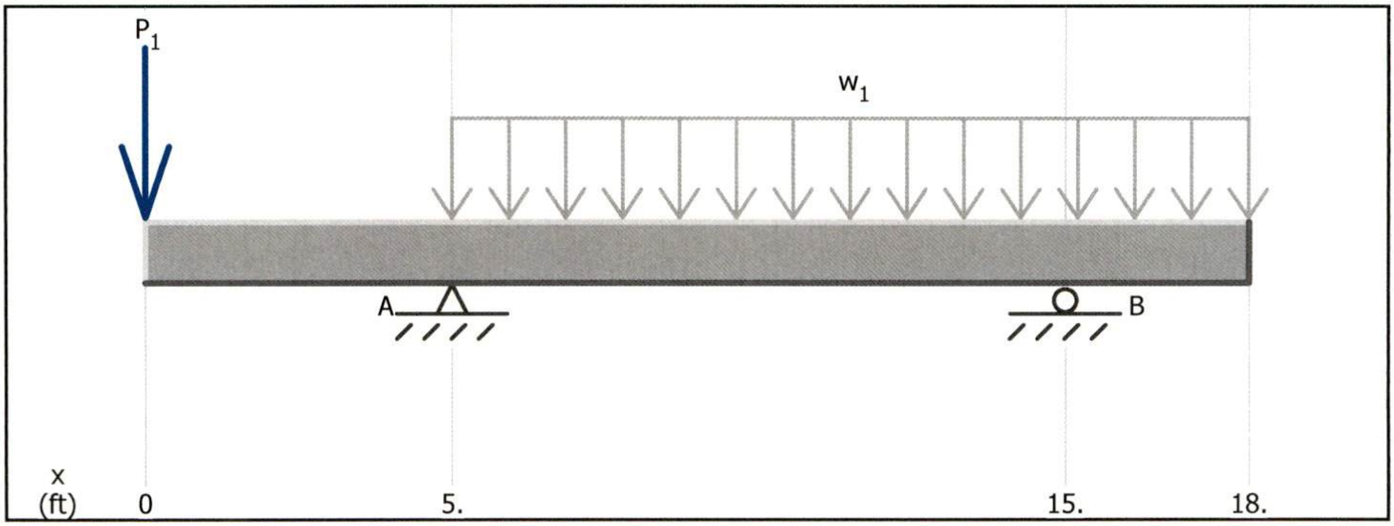
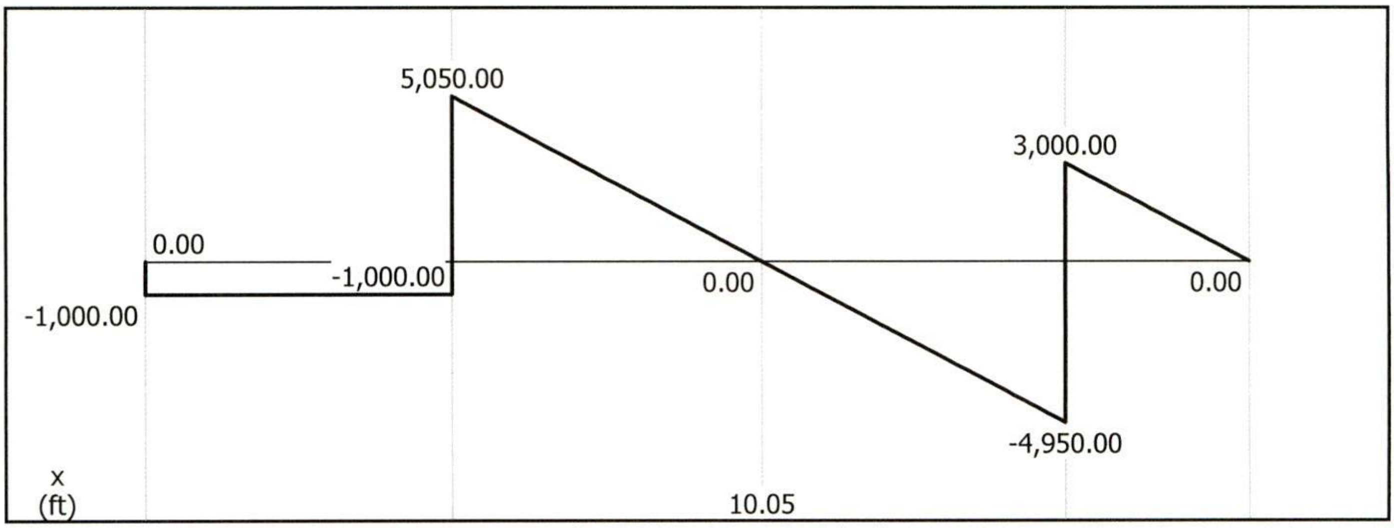


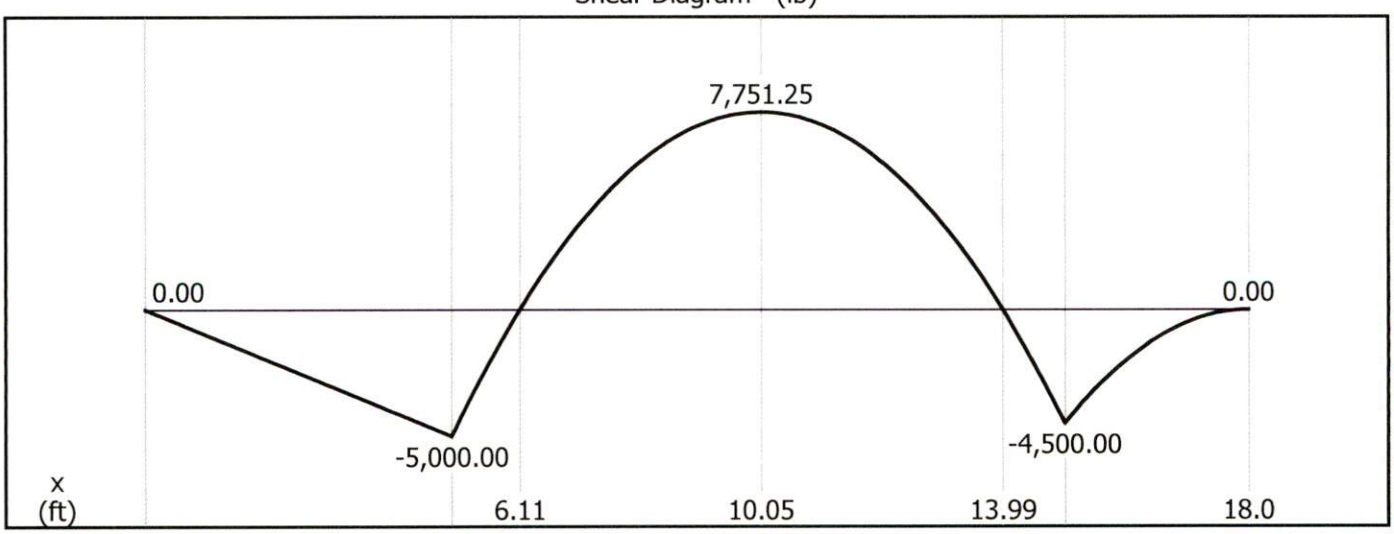
Load Diagram

P_1 = 1000.0 lb (down)
w_1 = 1000.0 lb/ft (down)

A_y = 6,050.00 lb (up)
B_y = 7,950.00 lb (up)

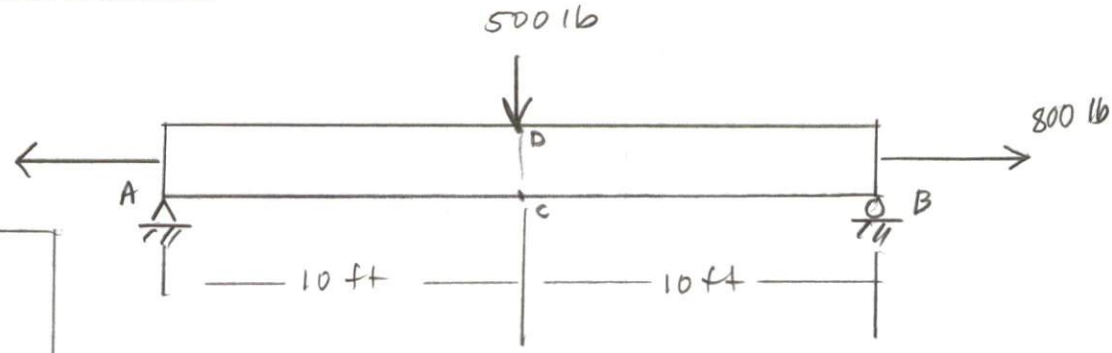


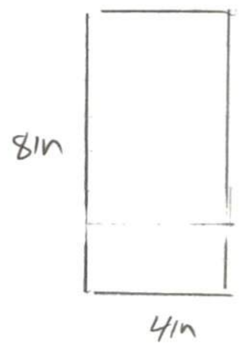
Shear Diagram (lb)



Moment Diagram (lb-ft)

4. A nominal size 4x8 has a simple span of 20-ft. The beam is subjected to a tensile axial load of 800 lb acting at the centroid and a concentrated load of 500 lb at midspan. Determine the maximum compressive and tensile stresses in the beam.





$A = 25.4\ in^2$

$S = 30.7\ in^3$

Axial Load

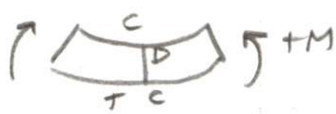
$$\sigma_1 = \frac{P}{A} = \frac{800\ lb}{25.4\ in^2} = 31.5\ psi \quad (T)$$

Bending Load

$$M_{MAX} = \frac{PL}{4} = \frac{500\ lb\ (20\ ft)}{4} = 2500\ lb \cdot ft$$

$$\sigma_2 = \frac{M_{MAX}}{S} = \frac{2500\ lb \cdot ft}{30.7\ in^3} = 81.4\ psi$$

Bottom of Beam



$$\sigma_c = \sigma_1 + \sigma_2 = 31.5\ psi + 81.4\ psi = 113\ psi$$

Top of Beam

$$\sigma_D = \sigma_1 - \sigma_2 = 31.5\ psi - 81.4\ psi = -50\ psi$$

$$\sigma_{MAX}^{(C)} = 50\ psi$$

$$\sigma_{MAX}^{(T)} = 113\ psi$$