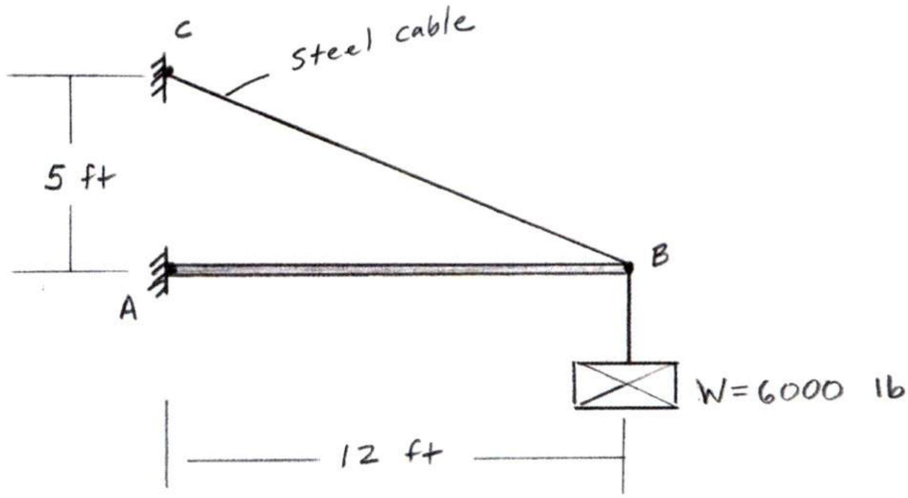
CMGT 350 **Final Exam** **Fall 2020**

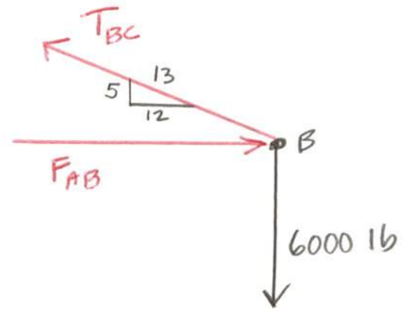
Show all Work for Full Credit

Name: Solution

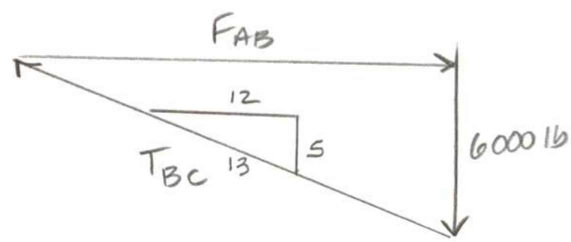
1. The allowable tensile stress of the steel cable is 12,000 psi. Find the diameter of the cable, to the nearest sixteenth of an inch.



Solution.



FBD



Force-Triangle

$$\frac{T_{BC}}{13} = \frac{6000\ lb}{5}$$

$$T_{BC} = \frac{13}{5}(6000\ lb) = 15{,}600\ lb$$

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

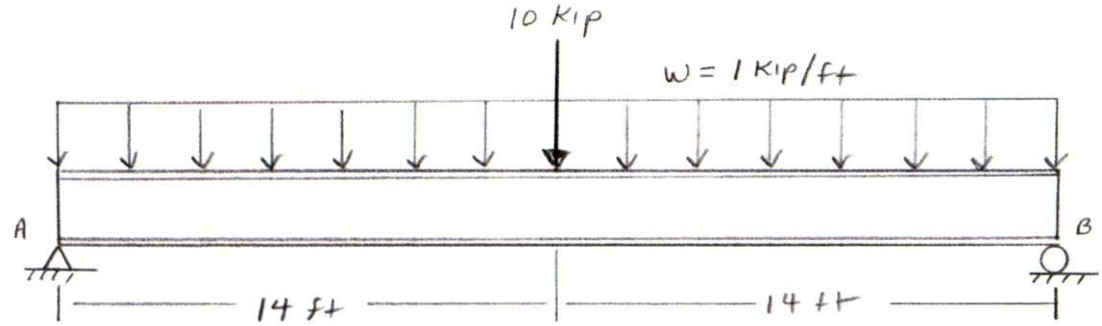
$$A = \frac{15{,}600\ lb}{12{,}000\ psi} = \frac{\pi d^2}{4}$$

$$d = \sqrt{\frac{4(15{,}600\ lb)}{12{,}000\ psi\ (\pi)}} = 1.2866\ in$$

$$= 1.5/16\ in$$

use, $d = 1\ 5/16$ 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

$L = 28\text{ ft}\left(\frac{12\text{in}}{\text{ft}}\right) = 336$ in.

$w = 1$ Kip/ft

$P = 10$ Kip

Step 2. Table 13-1, Case 1 and Case 4

$$V_{MAX} = \frac{P}{2} + \frac{wL}{2} = \frac{10\text{ Kip}}{2} + \frac{1\text{ Kip/ft}(28\text{ ft})}{2} = 19\text{ Kip}$$

$$M_{MAX} = \frac{PL}{4} + \frac{wL^2}{8} = \frac{10\text{ Kip}(28\text{ ft})}{4} + \frac{1\text{ Kip/ft}(28\text{ ft})^2}{8} = 168\text{ Kip}\cdot\text{ft}$$

Step 3.

$$S_{req} = \frac{M_{MAX}}{\sigma_{allow}} = \frac{168\text{ Kip}\cdot\text{ft}\left(\frac{12\text{in}}{\text{ft}}\right)}{24\text{ ksi}} = 84\text{ in.}^3$$

Step 4. Table A-1(a)

Select, W 18 × 50 $\quad S = 88.9\text{ in.}^3$

check

$$M_{wt} = \frac{wL^2}{8} = \frac{50\text{ lb/ft}(28\text{ ft})^2}{8} = 4900\text{ lb}\cdot\text{ft}\left(\frac{\text{Kip}}{1000\text{ lb}}\right) = 4.9\text{ Kip}\cdot\text{ft}$$

$$\frac{M_{wt}}{M_{MAX}} = \frac{4.9\text{ Kip}\cdot\text{ft}}{168\text{ Kip}\cdot\text{ft}} = 0.029 = 2.9\%$$

$$\frac{\text{Extra } S}{S_{req}} = \frac{88.9\,in^3 - 84\,in^3}{88.9\,in^3} = 0.055 = 5.5\% > 2.9\%$$

✓ ok, bending

Step 5. Check Shear Stress

W 18 × 50

$d = 17.99$ in

$t_w = 0.355$ in

$$\tau_{avg} = \frac{V_{MAX}}{d\,t_w} = \frac{19\ Kip}{17.99\,in\,(0.355\,in)} = 3\ ksi < \tau_{allow} = 14.5\ ksi$$

✓ ok, Shear

Step 6. Check Deflection

W 18×50

$I = 800\ in^4$

$E = 30 \times 10^3$ ksi

$$\delta_{allow} = \frac{L}{240} = \frac{336\ in}{240} = 1.4\ in$$

$w = 1000$ lb/ft

$+\ 50$ lb/ft

1050 lb/ft

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

$$= \frac{10\ Kip\,(336\,in)^3}{48(30{,}000\ ksi)(800\,in^4)} + \frac{5\,(1.05\ Kip/ft)\left(\frac{ft}{12\,in}\right)(336\,in)^4}{384\,(30{,}000\ ksi)(800\,in^4)}$$

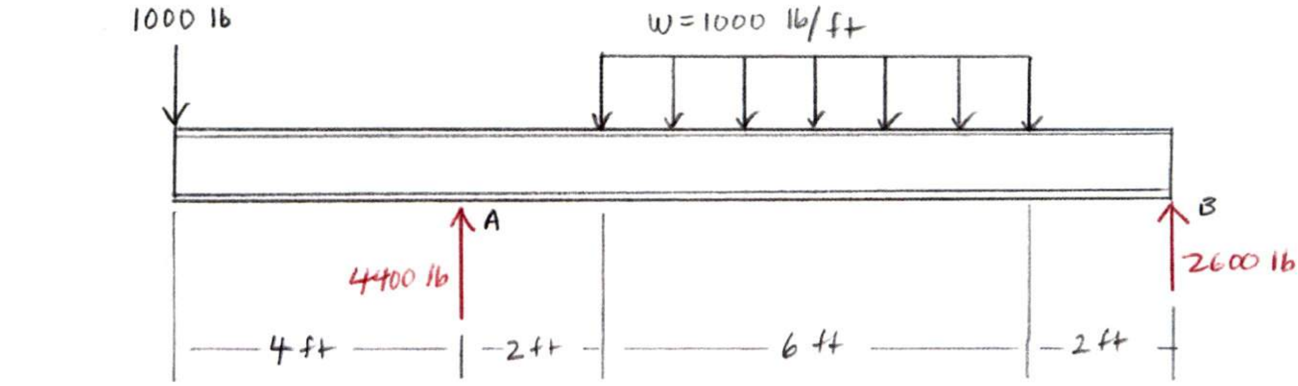
$$= 0.32928\ in + 0.605052\ in$$

$$= 0.934\ in$$

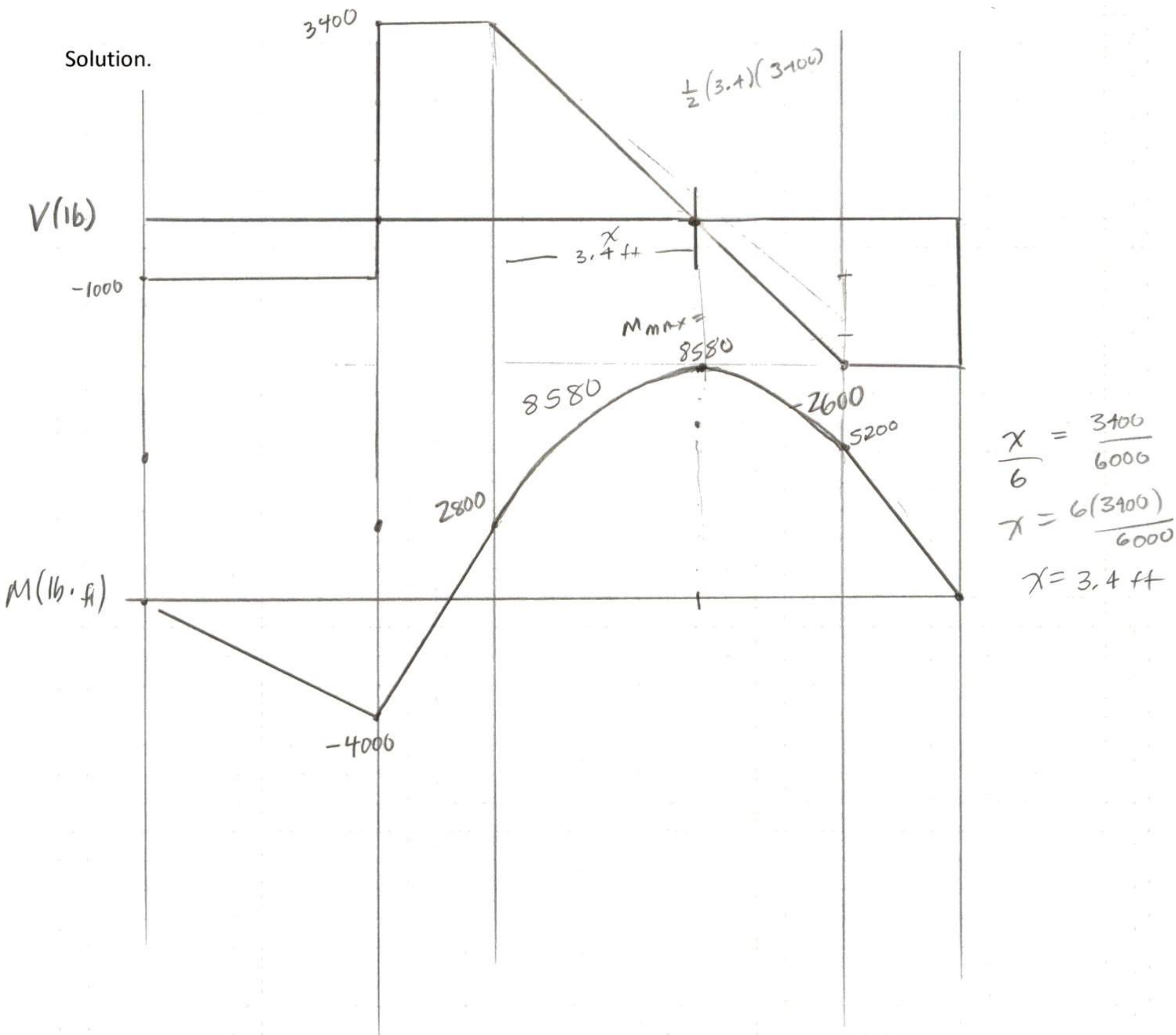
$$\delta_{MAX} = 0.934\ in < \delta_{allow} = 1.4\ in$$

✓ ok for Deflection

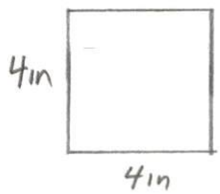
3. Draw the shear and bending moment diagrams for the beam due to the loading shown. Locate the section(s) with zero shear and determine the moment(s) at the section(s).

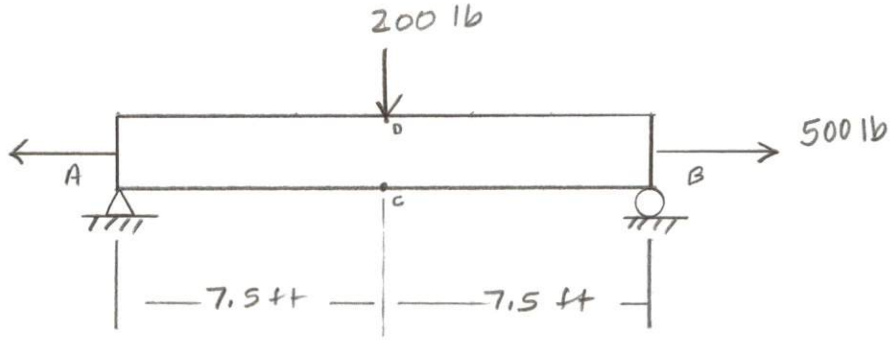


Solution.



4. A nominal size 4x4 has a simple span of 15-ft. The beam is subjected to a tensile axial load of 500 lb acting at the centroid and a concentrated load of 200 lb at midspan. Determine the maximum compressive and tensile stresses in the beam.





$A = 12.3 \text{ in}^2$

$S = 7.15 \text{ in.}^3$

Axial Load

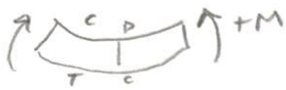
$\sigma_1 = \dfrac{P}{A} = \dfrac{500 \text{ lb}}{12.3 \text{ in}^2} = 40.65 \text{ psi}$ (constant tensile stress throughout the beam)

Bending Load

$M_{MAX} = \dfrac{PL}{4} = \dfrac{200 \text{ lb}(15 \text{ ft})}{4} = 750 \text{ lb.ft}$

$\sigma_2 = \dfrac{M_{MAX}}{S} = \dfrac{750 \text{ lb.ft}\left(\frac{12 \text{ in}}{\text{ft}}\right)}{7.15 \text{ in}^3} = 1259 \text{ psi}$

BOTTOM OF Beam



$\sigma_C = \sigma_1 + \sigma_2 = 41 \text{ psi} + 1259 \text{ psi} = 1300 \text{ psi (T)}$

TOP OF Beam

$\sigma_D = \sigma_1 - \sigma_2 = 41 \text{ psi} - 1259 \text{ psi} = -1218 \text{ psi (C)}$

$\sigma_{MAX}^{(C)} = 1218 \text{ psi}$

$\sigma_{MAX}^{(T)} = 1300 \text{ psi}$