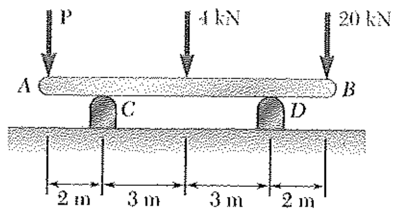
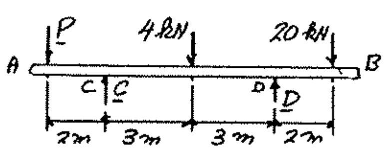


PROBLEM 4.13

The maximum allowable value of each of the reactions is 50 kN, and each reaction must be directed upward. Neglecting the weight of the beam, determine the range of values of P for which the beam is safe.

SOLUTION

Free-Body Diagram:



$$+\circlearrowleft \Sigma M_C = 0: \quad P(2\text{ m}) - (4\text{ kN})(3\text{ m}) - (20\text{ kN})(8\text{ m}) + D(6\text{ m}) = 0$$

$$P = 86\text{ kN} - 3D \qquad (1)$$

$$+\circlearrowleft \Sigma M_D = 0: \quad P(8\text{ m}) + (4\text{ kN})(3\text{ m}) - (20\text{ kN})(2\text{ m}) - C(6\text{ m}) = 0$$

$$P = 3.5\text{ kN} + 0.75C \qquad (2)$$

For $C \geq 0$, from (2): $P \geq 3.50\text{ kN}$ ◁

For $D \geq 0$, from (1): $P \leq 86.0\text{ kN}$ ◁

For $C \leq 50\text{ kN}$, from (2):

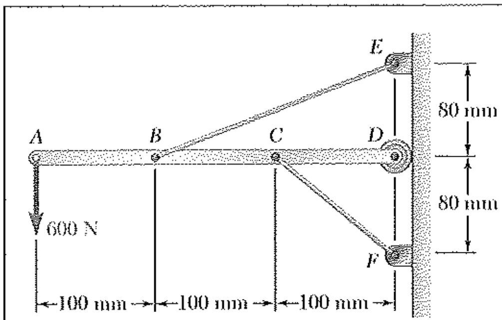
$$P \leq 3.5\text{ kN} + 0.75(50\text{ kN})$$
$$P \leq 41.0\text{ kN}$$ ◁

For $D \leq 50\text{ kN}$, from (1):

$$P \geq 86\text{ kN} - 3(50\text{ kN})$$
$$P \geq -64.0\text{ kN}$$ ◁

Comparing the four criteria, we find

$$3.50\text{ kN} \leq P \leq 41.0\text{ kN}$$ ◀



PROBLEM 4.38

Determine the tension in each cable and the reaction at D.

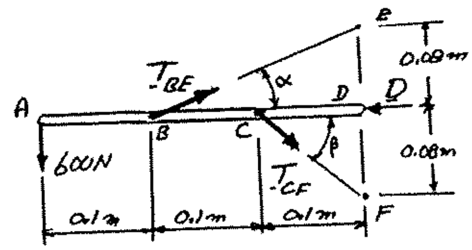
SOLUTION

$$\tan\alpha = \frac{0.08\text{ m}}{0.2\text{ m}}$$

$$\alpha = 21.80^\circ$$

$$\tan\beta = \frac{0.08\text{ m}}{0.1\text{ m}}$$

$$\beta = 38.66^\circ$$



$+\circlearrowleft \Sigma M_B = 0$: $(600\text{ N})(0.1\text{ m}) - (T_{CF}\sin 38.66^\circ)(0.1\text{ m}) = 0$

$T_{CF} = 960.47\text{ N}$ $\qquad$ $T_{CF} = 96.0\text{ N}$ ◀

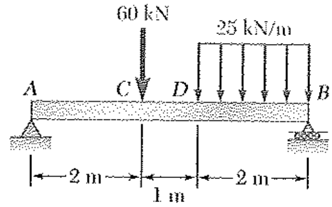
$+\circlearrowleft \Sigma M_C = 0$: $(600\text{ N})(0.2\text{ m}) - (T_{BE}\sin 21.80^\circ)(0.1\text{ m}) = 0$

$T_{BE} = 3231.1\text{ N}$ $\qquad$ $T_{BE} = 3230\text{ N}$ ◀

$\xrightarrow{+} \Sigma F_y = 0$: $T_{BE}\cos\alpha + T_{CF}\cos\beta - D = 0$

$$(3231.1\text{ N})\cos 21.80^\circ + (960.47\text{ N})\cos 38.66^\circ - D = 0$$

$D = 3750.03\text{ N}$ $\qquad$ $\mathbf{D} = 3750\text{ N} \longleftarrow$ ◀

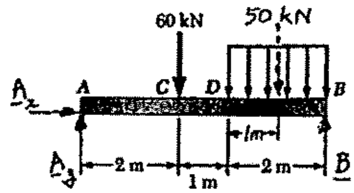


PROBLEM 7.39

For the beam and loading shown, (*a*) draw the shear and bending-moment diagrams, (*b*) determine the maximum absolute values of the shear and bending moment.

SOLUTION

Free body: Entire beam



$+\circlearrowleft \Sigma M_A = 0$: $B(5\text{ m}) - (60\text{ kN})(2\text{ m}) - (50\text{ kN})(4\text{ m}) = 0$

$B = +64.0\text{ kN}$ $\qquad$ $\mathbf{B} = 64.0\text{ kN}\uparrow \triangleleft$

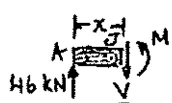
$\Sigma F_x = 0$: $A_x = 0$

$+\uparrow \Sigma F_y = 0$: $A_y + 64.0\text{ kN} - 6.0\text{ kN} - 50\text{ kN} = 0$

$A_y = +46.0\text{ kN}$ $\qquad$ $\mathbf{A} = 46.0\text{ kN}\uparrow \triangleleft$

(*a*) Shear and bending-moment diagrams.

From *A* to *C*:



$+\uparrow \Sigma F_y = 0$: $46 - V = 0$ $\qquad$ $V = +46\text{ kN} \triangleleft$

$+\circlearrowleft \Sigma M_y = 0$: $M - 46x = 0$ $\qquad$ $M = (46x)\text{kN}\cdot\text{m} \triangleleft$

From *C* to *D*:

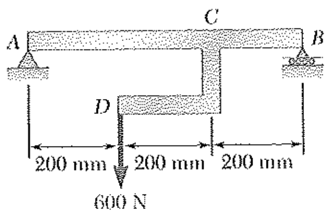
$+\uparrow \Sigma F_y = 0$: $46 - 60 - V = 0$ $\qquad$ $V = -14\text{ kN} \triangleleft$

$+\circlearrowleft \Sigma M_j = 0$: $M - 46x + 60(x-2) = 0$

$M = (120 - 14x)\text{kN}\cdot\text{m}$

For $\qquad x = 2\text{ m}$: $M_C = +92.0\text{ kN}\cdot\text{m}$ $\triangleleft$

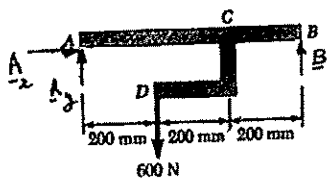
For $\qquad x = 3\text{ m}$: $M_D = +78.0\text{ kN}\cdot\text{m}$ $\triangleleft$



PROBLEM 7.49

Draw the shear and bending-moment diagrams for the beam AB, and determine the shear and bending moment (a) just to the left of C, (b) just to the right of C.

SOLUTION



Free body: Entire beam

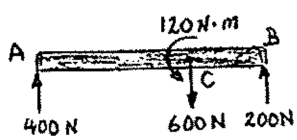
$$+\circlearrowleft \Sigma M_A = 0: \quad B(0.6\text{ m}) - (600\text{ N})(0.2\text{ m}) = 0$$

$$B = +200\text{ N} \qquad \mathbf{B} = 200\text{ N}\uparrow \triangleleft$$

$$\Sigma F_x = 0: \quad A_x = 0$$

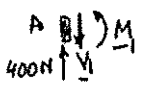
$$+\uparrow \Sigma F_y = 0: \quad A_y - 600\text{ N} + 200\text{ N} = 0$$

$$A_y = +400\text{ N} \qquad \mathbf{A} = 400\text{ N}\uparrow \triangleleft$$



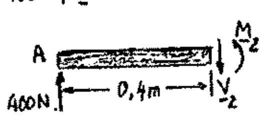
We replace the 600-N load by an equivalent force-couple system at C

Just to the right of A:



$$V_1 = +400\text{ N}, \quad M_1 = 0 \triangleleft$$

(a) Just to the left of C:



$$V_2 = +400\text{ N} \blacktriangleleft$$

$$M_2 = (400\text{ N})(0.4\text{ m}) \qquad M_2 = +160.0\text{ N}\cdot\text{m} \blacktriangleleft$$

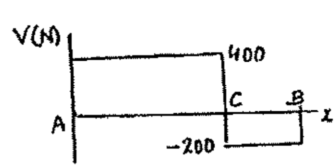
(b) Just to the right of C:

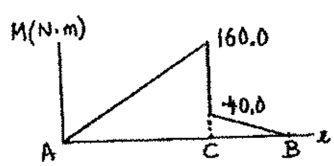
$$V_3 = -200\text{ N} \blacktriangleleft$$

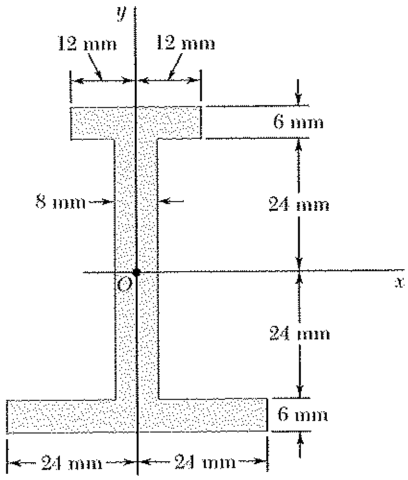
$$M_3 = (200\text{ N})(0.2\text{ m}) \qquad M_3 = +40.0\text{ N}\cdot\text{m} \blacktriangleleft$$

Just to the left of B:

$$V_4 = -200\text{ N}, \quad M_4 = 0 \triangleleft$$







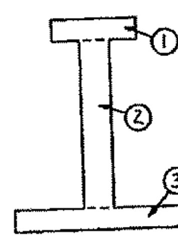
PROBLEM 9.31

Determine the moment of inertia and the radius of gyration of the shaded area with respect to the x axis.

SOLUTION

First note that

$$A = A_1 + A_2 + A_3$$
$$= [(24)(6) + (8)(48) + (48)(6)]\ \text{mm}^2$$
$$= (144 + 384 + 288)\ \text{mm}^2$$
$$= 816\ \text{mm}^2$$



Now $\qquad I_x = (I_x)_1 + (I_x)_2 + (I_x)_3$

where

$$(I_x)_1 = \frac{1}{12}(24\ \text{mm})(6\ \text{mm})^3 + (144\ \text{mm}^2)(27\ \text{mm})^2$$
$$= (432 + 104{,}976)\ \text{mm}^4$$
$$= 105{,}408\ \text{mm}^4$$

$$(I_x)_2 = \frac{1}{12}(8\ \text{mm})(48\ \text{mm})^3 = 73{,}728\ \text{mm}^4$$

$$(I_x)_3 = \frac{1}{12}(48\ \text{mm})(6\ \text{mm})^3 + (288\ \text{mm}^2)(27\ \text{mm})^2$$
$$= (864 + 209{,}952)\ \text{mm}^4 = 210{,}816\ \text{mm}^4$$

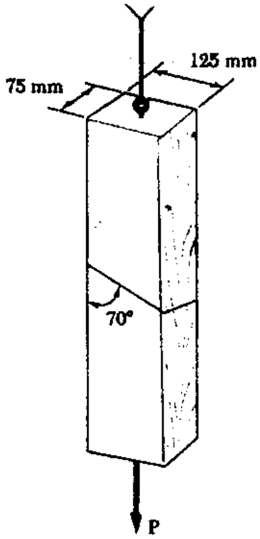
Then $\qquad I_x = (105{,}408 + 73{,}728 + 210{,}816)\ \text{mm}^4$

$$= 389{,}952\ \text{mm}^4 \qquad \text{or} \quad I_x = 390 \times 10^3\ \text{mm}^4 \blacktriangleleft$$

and $\qquad k_x^2 = \frac{I_x}{A} = \frac{389{,}952\ \text{mm}^4}{816\ \text{mm}^2} \qquad \text{or} \quad k_x = 21.9\ \text{mm} \blacktriangleleft$

PROBLEM 1.29

1.29 The 6- kN load **P** is supported by two wooden members of 75 × 125- mm uniform rectangular cross section which are joined by the simple glued scarf splice shown. Determine the normal and shearing stresses in the glued splice.



SOLUTION

$P = 6\times10^3$ N $\qquad \theta = 90° - 70° = 20°$

$A_o = (0.075)(0.125) = 9.375\times10^{-3}\ m^2$

$$\sigma = \frac{P}{A_o}\cos^2\theta = \frac{(6\times10^3)\cos^2 20°}{9.375\times10^{-3}} = 565\times10^3$$

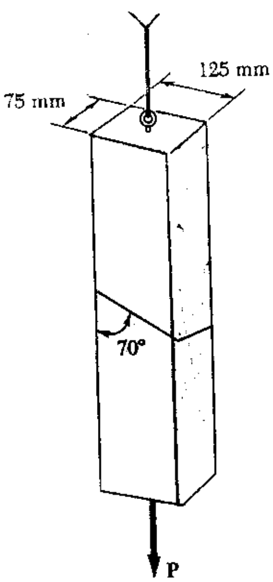
$$\sigma = 565 \text{ kPa}$$

$$\tau = \frac{P}{2A_o}\sin 2\theta = \frac{(6\times10^3)\sin 40°}{(2)(9.375\times10^{-3})} = 206\times10^3$$

$$\tau = 206 \text{ kPa}$$

PROBLEM 1.30

1.30 Two wooden members of 75 × 125- mm uniform rectangular cross section are joined by the simple glued scarf splice shown. Knowing that the maximum allowable tensile stress in the glued splice is 500 kPa, determine (*a*) the largest load **P** which can be safely supported, (*b*) the corresponding shearing stress in the splice.



SOLUTION

$A_o = (0.075)(0.125) = 9.375\times10^{-3}\ m^2$

$\theta = 90° - 70° = 20° \qquad \sigma = 500\times10^3$ Pa

$$\sigma = \frac{P}{A_o}\cos^2\theta$$

$$P = \frac{A_o\sigma}{\cos^2\theta} = \frac{(9.375\times10^{-3})(500\times10^3)}{\cos^2 20°} = 5.3085\times10^3$$

(a) $\qquad P = 5.31$ kN

$$\tau = \frac{P\sin 2\theta}{2A_o} = \frac{(5.3085\times10^3)\sin 40°}{(2)(9.375\times10^{-3})} = 181.99\times10^3$$

(b) $\qquad \tau = 182.0$ kPa