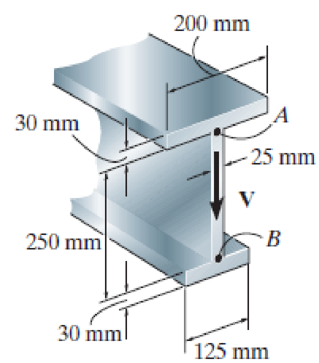
7–6. If the beam is subjected to a shear of $V = 15$ kN, determine the web's shear stress at A and B. Indicate the shear-stress components on a volume element located at these points. Show that the neutral axis is located at $\bar{y} = 0.1747$ m from the bottom and $I_{NA} = 0.2182(10^{-3})$ m^4.



$$\bar{y} = \frac{(0.015)(0.125)(0.03) + (0.155)(0.025)(0.25) + (0.295)(0.2)(0.03)}{0.125(0.03) + (0.025)(0.25) + (0.2)(0.03)} = 0.1747 \text{ m}$$

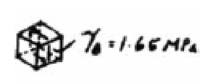
$$I = \frac{1}{12}(0.125)(0.03^3) + 0.125(0.03)(0.1747 - 0.015)^2$$

$$+ \frac{1}{12}(0.025)(0.25^3) + 0.25(0.025)(0.1747 - 0.155)^2$$

$$+ \frac{1}{12}(0.2)(0.03^3) + 0.2(0.03)(0.295 - 0.1747)^2 = 0.218182\,(10^{-3}) \text{ m}^4$$

$$Q_A = \bar{y}A'_A = (0.310 - 0.015 - 0.1747)(0.2)(0.03) = 0.7219\,(10^{-3}) \text{ m}^3$$

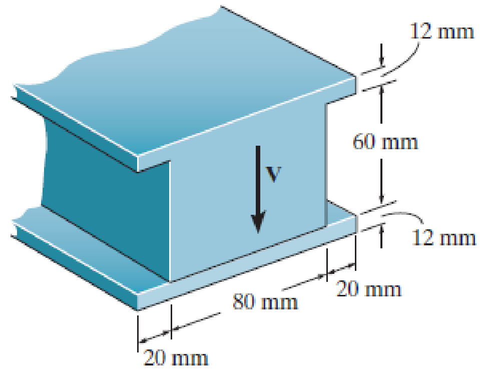
$$Q_B = \bar{y}A'_B = (0.1747 - 0.015)(0.125)(0.03) = 0.59883\,(10^{-3}) \text{ m}^3$$



$$\tau_A = \frac{VQ_A}{I\,t} = \frac{15(10^3)(0.7219)(10^{-3})}{0.218182(10^{-3})(0.025)} = 1.99 \text{ MPa} \qquad \textbf{Ans.}$$

$$\tau_B = \frac{VQ_B}{I\,t} = \frac{15(10^3)(0.59883)(10^{-3})}{0.218182(10^{-3})0.025)} = 1.65 \text{ MPa} \qquad \textbf{Ans.}$$

7–14. Determine the maximum shear force V that the strut can support if the allowable shear stress for the material is $\tau_{allow} = 40$ MPa.



Section Properties:

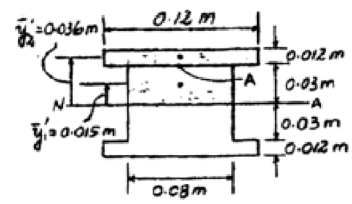
$$I_{NA} = \frac{1}{12}(0.12)\left(0.084^3\right) - \frac{1}{12}(0.04)\left(0.06^3\right)$$

$$= 5.20704\left(10^{-6}\right)\ \text{m}^4$$

$$Q_{max} = \Sigma \overline{y}' A'$$

$$= 0.015(0.08)(0.03) + 0.036(0.012)(0.12)$$

$$= 87.84\left(10^{-6}\right)\ \text{m}^3$$



Allowable shear stress: Maximum shear stress occurs at the point where the neutral axis passes through the section.

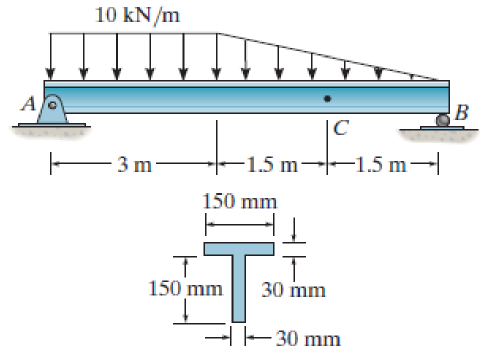
Applying the shear formula

$$\tau_{max} = \tau_{allow} = \frac{VQ_{max}}{It}$$

$$40\left(10^6\right) = \frac{V(87.84)(10^{-6})}{5.20704(10^{-6})(0.08)}$$

$$V = 189\,692\text{ N} = 190\text{ kN} \qquad \textbf{Ans.}$$

*7–24. Determine the maximum shear stress in the T-beam at the critical section where the internal shear force is maximum.



The FBD of the beam is shown in Fig. *a*,

The shear diagram is shown in Fig. *b*. As indicated, $V_{max} = 27.5$ kN

The neutral axis passes through centroid *c* of the cross-section, Fig. *c*.

$$\bar{y} = \frac{\Sigma \tilde{y} A}{\Sigma A} = \frac{0.075(0.15)(0.03) + 0.165(0.03)(0.15)}{0.15(0.03) + 0.03(0.15)}$$

$$= 0.12 \text{ m}$$

$$I = \frac{1}{12}(0.03)(0.15^3) + 0.03(0.15)(0.12 - 0.075)^2$$

$$+ \frac{1}{12}(0.15)(0.03^3) + 0.15(0.03)(0.165 - 0.12)^2$$

$$= 27.0(10^{-6}) \text{ m}^4$$

From Fig. *d*,

$$Q_{max} = \bar{y}'A' = 0.06(0.12)(0.03)$$

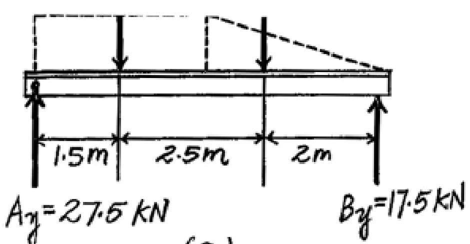
$$= 0.216\,(10^{-3}) \text{ m}^3$$

The maximum shear stress occurs at points on the neutral axis since Q is maximum and thickness $t = 0.03$ m is the smallest.

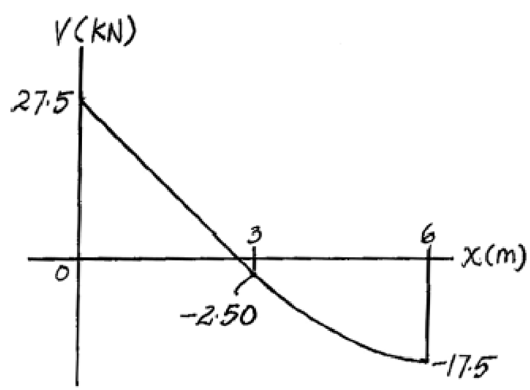
$$\tau_{max} = \frac{V_{max} Q_{max}}{It} = \frac{27.5(10^3)\left[0.216(10^{-3})\right]}{27.0(10^{-6})(0.03)}$$

$$= 7.333(10^6) \text{ Pa}$$

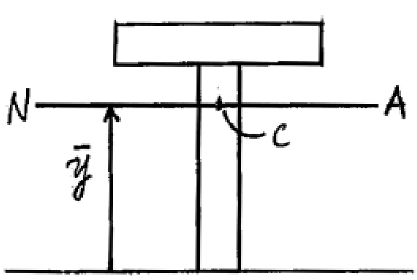
$$= 7.33 \text{ MPa} \qquad \textbf{Ans.}$$



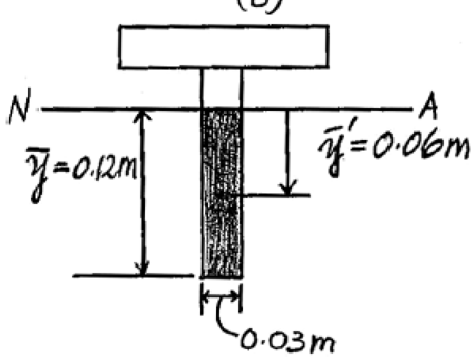
(a)



(b)

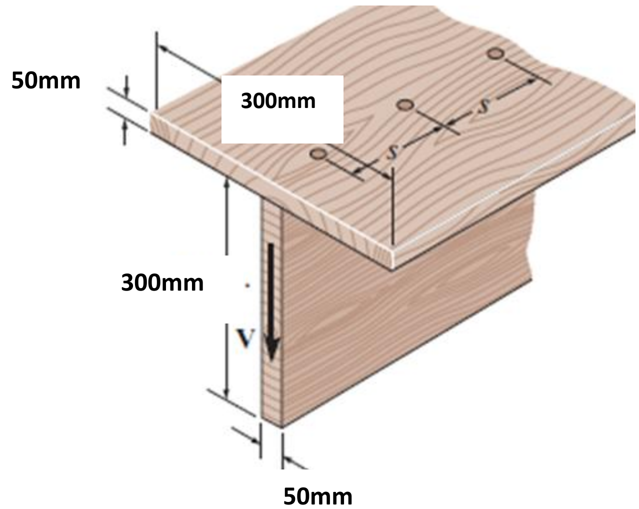


(C)



(d)

7–42. The T-beam is nailed together as shown. If the nails can each support a shear force of 4.5 KN, determine the maximum shear force *V* that the beam can support and the corresponding maximum nail spacing *s* to the nearest multiples of 5 mm. The allowable shear stress for the wood is τ_{allow} = 3 MPa.



$$\bar{y} = \frac{\sum \bar{y}A}{\sum A} = \frac{325 * 50 * 300 + 150 * 300 * 50}{50 * 300 + 50 * 300}$$

$$\bar{\boldsymbol{y}} = \mathbf{237.5\ mm}$$

$$I = \frac{1}{12} * 50 * 300^3 + 50 * 300 * (150 - 237.5)^2 + \frac{1}{12} * 300 * 50^3 + 50 * 300 * (325 - 237.5)^2$$

$$\boldsymbol{I} = \mathbf{345312500\ mm^4}$$

$$Q_{max} = \overline{y_1}A_1' = 118.75 * 237.5 * 50$$

$$\boldsymbol{Q_{max}} = \mathbf{1410156.25\ mm^3}$$

$$Q_A = \overline{y_2}A_2' = 87.5 * 50 * 300$$

$$\boldsymbol{Q_A} = \mathbf{1312500\ mm^3}$$

The maximum shear stress occurs at the points on the neutral axis where *Q* is maximum and t = 50mm

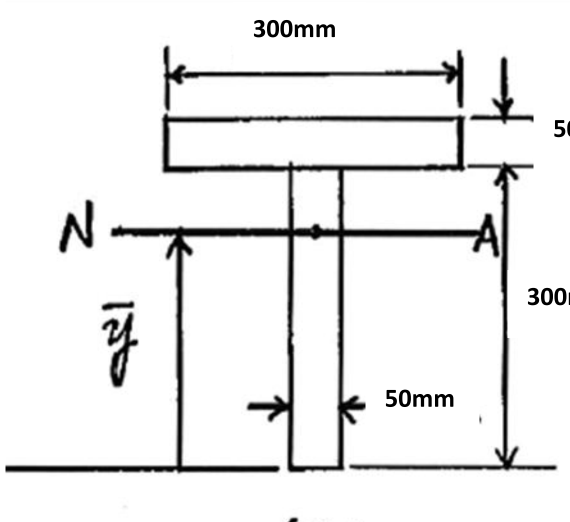
$$\tau_{allow} = \frac{VQ_{max}}{It}; 3 = \frac{V * 1410156.25}{345312500 * 50};$$

$$\boldsymbol{V} = \mathbf{36731\ N} \qquad \boldsymbol{Ans.}$$

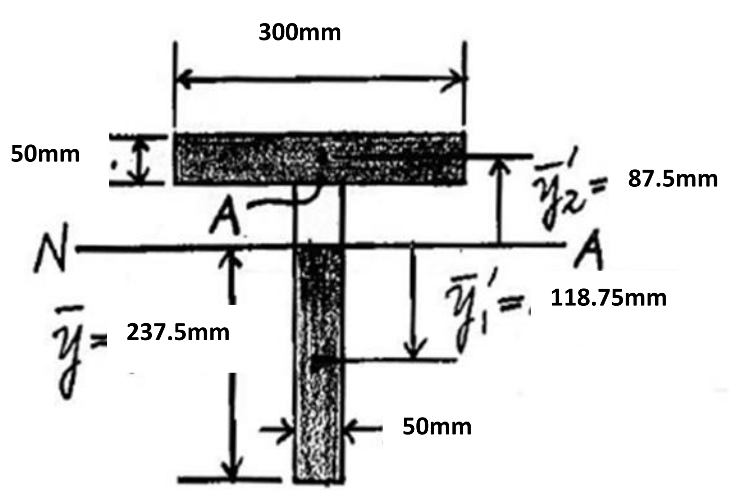
$$q_{allow} = \frac{F}{s} = 4.5 * \frac{1000}{s} N/mm$$

$$q_{allow} = \frac{VQ_A}{I}; \ 4.5 * \frac{1000}{s} = \frac{36731 * 1312500}{345312500}$$

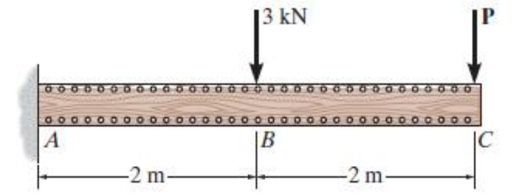
$$\boldsymbol{s} = \mathbf{32.23\ mm} \qquad \boldsymbol{Ans.}$$

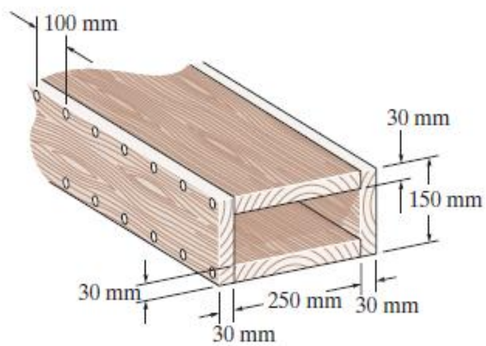


(a)



•**7–45.** The beam is constructed from four boards which are nailed together. If the nails are on both sides of the beam and each can resist a shear of 3 kN, determine the maximum load P that can be applied to the end of the beam.





Support Reactions: As shown on FBD.

Internal Shear Force: As shown on shear diagram, $V_{AB} = (P + 3)$ kN.

Section Properties:

$$I_{NA} = \frac{1}{12}(0.31)\left(0.15^3\right) - \frac{1}{12}(0.25)\left(0.09^3\right)$$
$$= 72.0\left(10^{-6}\right)\ \text{m}^4$$

$$Q = \bar{y}'A' = 0.06(0.25)(0.03) = 0.450\left(10^{-3}\right)\ \text{m}^3$$

Shear Flow: There are two rows of nails. Hence the allowable shear flow is $q = \frac{3(2)}{0.1} = 60.0$ kN/m.

$$q = \frac{VQ}{I}$$

$$60.0\left(10^3\right) = \frac{(P + 3)(10^3)0.450(10^{-3})}{72.0(10^{-6})}$$

$$P = 6.60\ \text{kN}$$ **Ans.**