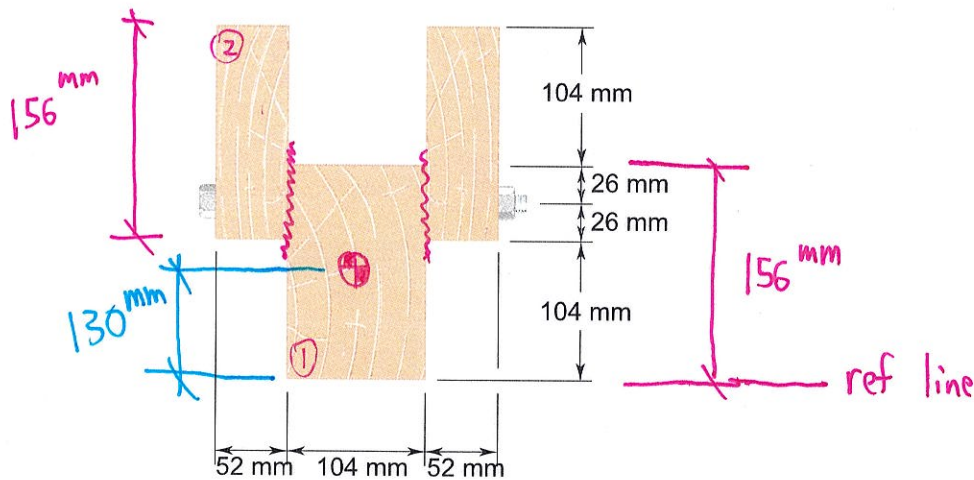


Do not round intermediate calculations. Give your final answer(s) to three significant figures.

A beam consists of three planks connected as shown by steel bolts with a longitudinal spacing of 234 mm. Knowing that the shear in the beam is vertical and equal to  $V = 4 \text{ kN}$  and that the allowable average shearing stress in each bolt is  $40 \text{ MPa}$ , determine the smallest permissible bolt diameter that can be used.

3-27-2020

1/3

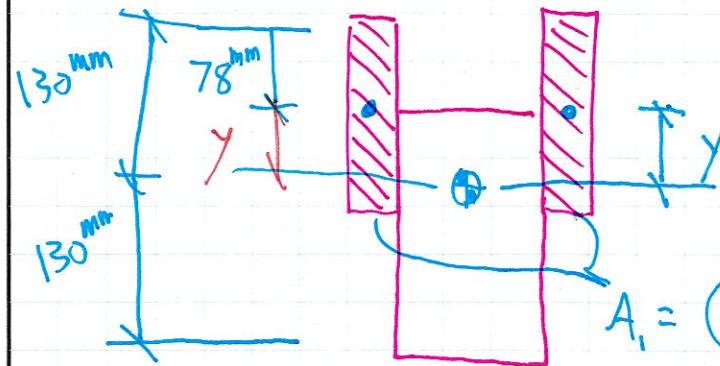


$d_{\text{bolt}} = \boxed{\phantom{000}} \text{ mm}$

$$\bar{y} = \frac{(156 \text{ mm})(104 \text{ mm})(78 \text{ mm}) + (2)(156 \text{ mm})(52 \text{ mm})(182 \text{ mm})}{(156 \text{ mm})(104 \text{ mm}) + (2)(156 \text{ mm})(52 \text{ mm})} = 130 \text{ mm}$$

$$I = \left[ \underbrace{\frac{1}{12}(104 \text{ mm})(156 \text{ mm})^3}_{\bar{I}_1} + \underbrace{(156 \text{ mm})(104 \text{ mm})}_{A_1} \underbrace{(78 \text{ mm} - 130 \text{ mm})^2}_{d_1^2} \right] \textcircled{1} + 2 \left[ \underbrace{\frac{1}{12}(52 \text{ mm})(156 \text{ mm})^3}_{\bar{I}_2} + \underbrace{(52 \text{ mm})(156 \text{ mm})}_{A_2} \underbrace{(182 \text{ mm} - 130 \text{ mm})^2}_{d_2^2} \right] \textcircled{2}$$

$$I = 153,543,936 \text{ mm}^4$$



$$Q = A_y = 16,224 \text{ mm}^2 (52 \text{ mm}) = 843,648 \text{ mm}^3$$

$$y = 130 \text{ mm} - 78 \text{ mm} = 52 \text{ mm}$$

$$A_i = (2)(156 \text{ mm})(52 \text{ mm}) = 16,224 \text{ mm}^2$$

$$q_{\text{req'd}} = \frac{VQ}{I}$$

$$q_{\text{avail}} = \frac{nF}{s}$$

$$\frac{nF}{s} = \frac{VQ}{I}$$

$$\frac{(2) F_{\text{bolt}}}{234 \text{ mm}} = \frac{(4 \times 10^3 \text{ N})(843,648 \text{ mm}^3)}{(153,543,936 \text{ mm}^4)}$$



$$F_{\text{bolt}} = 2571.4 \text{ N}$$

$$\tau_{\text{bolt}} = \frac{F_{\text{bolt}}}{A_{\text{bolt}}}$$

$$A_{\text{bolt}} = \frac{\pi}{4} d^2$$

$$\tau_{\text{bolt}} = \frac{V_{\text{bolt}}}{\frac{\pi}{4} d^2} \Rightarrow d = \sqrt{\frac{4 V_{\text{bolt}}}{\pi \tau_{\text{bolt}}}}$$

$$d \geq \sqrt{\frac{4 (2571.4 \text{ N})}{\pi (40 \text{ MPa})}} = 9.05 \text{ mm}$$