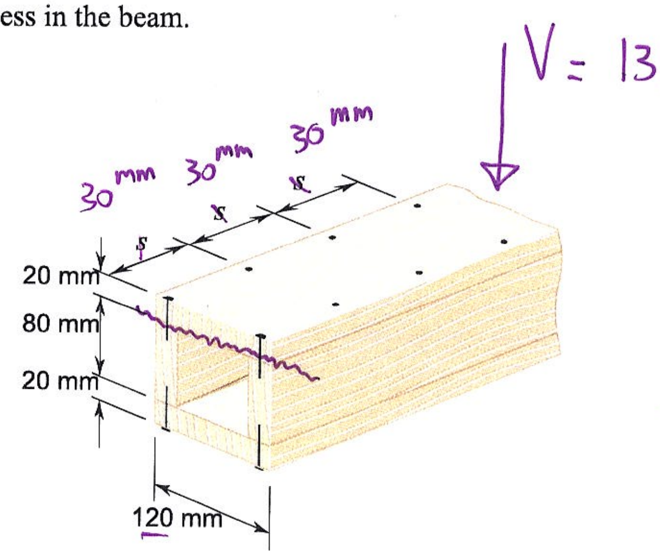
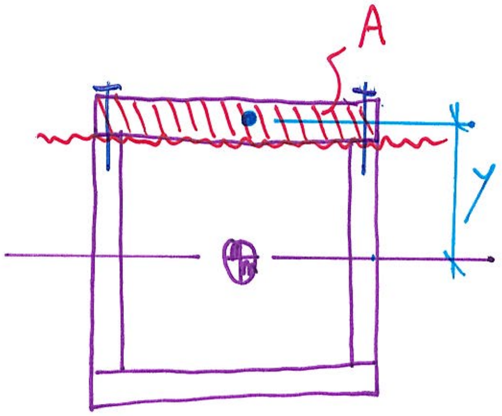
Do not round intermediate calculations. Give your final answer(s) to three significant figures.

3-25-2020

1/5

A square box beam is made of two 20 × 80–mm planks and two 20 × 120–mm planks nailed together as shown. Knowing that the spacing between the nails is $s = 30$ mm and the vertical shear in the beam is $V = 1339$ N, determine (*a*) the shearing force in each nail, (*b*) the maximum shearing stress in the beam.





(*a*) F_{nail} = ☐ N

(*b*) τ_{max} = ☐ kPa

$$Q = Ay = (2400 \text{ mm}^2)(50 \text{mm}) = 120{,}000 \text{ mm}^3$$

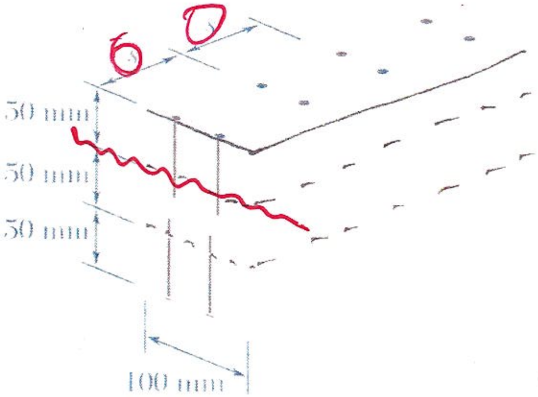
$$A = (120^{\text{mm}})(20^{\text{mm}}) = 2400 \text{ mm}^2$$

$$y = 40^{\text{mm}} + 10^{\text{mm}} = 50^{\text{mm}}$$

$$I = \Sigma(\bar{I} + Ad^2) = \frac{1}{12}\left[(120^{\text{mm}})(120^{\text{mm}})^3 - (80^{\text{mm}})(80^{\text{mm}})^3\right]$$

$$I_{\text{total}} = 1.3867 \text{ E}7 \text{ mm}^4$$

3-25-2020
2/5



$$q_{Req'd} = \frac{VQ}{I}$$

$$q_{Avail} = \frac{nF}{s}$$

force each fastener can resist

# of fasteners through cut

$$q_{Avail} = \boxed{\frac{nF}{s} = \frac{VQ}{I}} = q_{Req'd}$$

spacing of fasteners

⊥ to the direction of the cut

∥ to the length of the member

3-25-2020

3/5

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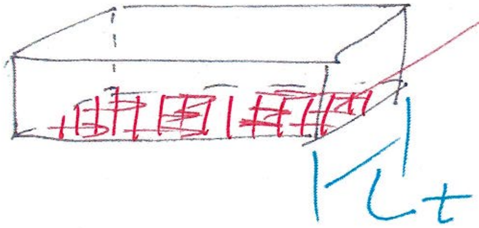
CVEN 305-301 Topic Shearing Stress Date 7/9/15

Mechanics of Solids Page 8 of



$$\tau = \frac{VQ}{I\cancel{t}}$$

$$\tau t = \frac{VQ}{I\cancel{t}} \quad \cancel{t}$$

q

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

shear flow

shearing stress $\frac{lb}{in^2}$

shear flow $\frac{lb}{in}$

q req'd

⇓

enforce that plane sections remain plane

(a)

$$q_{req'd} = \frac{VQ}{I} = \frac{(1339\ N)(120{,}000\ mm^3)}{(1.3867E7\ mm^4)} = 11.6\ \frac{N}{mm}$$

"shear flow"

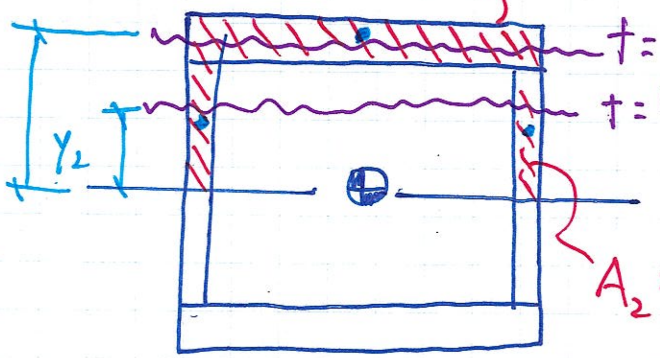
$$q_{avail} = \frac{nF}{s}$$

solve for this

$$\Rightarrow \quad F_{nail} = \frac{qs}{n} = \frac{(11.6\ N/mm)(30\ mm)}{(2\ nails)} = \underline{\underline{173.8\ N/nail}}$$

(b) $\tau_{max} = \dfrac{V Q_{max}}{I\, t_{min}}$; Q_{max} occurs when taken about the neutral axis & t is Minimum

$A_1 = 2400\ mm^2$



$t = 120^{mm}$

$t = 40^{mm}$

$$Q = A_1 y_1 + A_2 y_2$$

$$= (2400\ mm^2)(50^{mm}) + (1600\ mm^2)(20\ mm) = 152{,}000\ mm^3$$

$A_2 = 2(20^{mm})(40^{mm}) = 1600\ mm^2$

$$\tau_{max} = \frac{(1339^{N})(152{,}060\ mm^3)}{(1.3867E7\ mm^4)(40\ mm)} = 0.367\ MPa \rightarrow \underline{\underline{367\ kPa}}$$