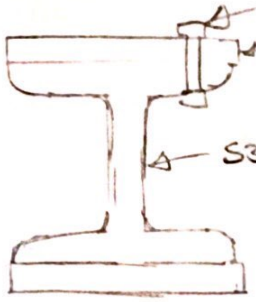
ENGR 213 HW#6 | Due 5/13/20 | Sean Lai

CH6 : 5, 7, 15, 18, 21, 23, 29, 38

6.5:

Given:



$\tau_{all} = 90\ MPa$

$\hookrightarrow I = 94.9 \cdot 10^6\ mm^4,\ d = 305$

Find: $\bar{V}$

Solution:
$$q = \frac{VQ}{I} \longrightarrow V = \frac{qI}{Q}$$

$$I = 94.9 \cdot 10^6 + 2 \cdot \left[\tfrac{1}{12}(200)(16)^3 + (16)(200)\left(8 + \frac{305}{2}\right)^2\right] = 2.6 \cdot 10^8\ mm^4$$

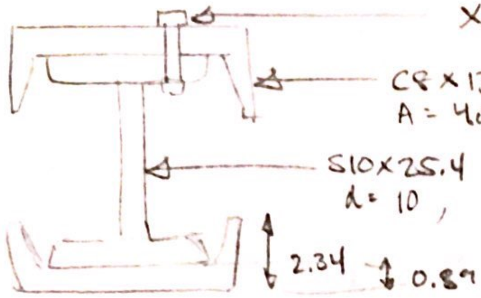
$$q = \frac{\Delta H}{\Delta x} = \frac{\tau_{all} \cdot A_{bolt}}{bolt} \cdot \frac{2\ bolts}{120\ mm},\quad A_{bolt} = \pi (9mm)^2$$

$$\rightarrow V = \frac{2\tau_{all} \cdot A_{bolt} \cdot I}{120mm \cdot Q} \qquad Q = \left(\frac{305}{2} + 8\right) \cdot (16 \cdot 200) = 5.14 \cdot 10^5\ mm^3$$

$$= \frac{2 \cdot 90 N/mm^2 \cdot \pi \cdot (9mm^2) \cdot 2.6 \cdot 10^8\ mm^4}{120mm \cdot 5.14 \cdot 10^5\ mm^3}$$

$$\boxed{V = 1.931 \cdot 10^5\ N}$$

6.7:



X4 $\varnothing$ 0.75", every 5"

C8 × 13.7
A = 4.04 in²
$\bar{x}$ = 0.533

V = 30 kips

S10 × 25.4
d = 10,

Find: τ_{ave}

Solution:

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

$$I = (123 + 2(1.52 + 4.04(5 + 0.39 - 0.533)^2 = 315 \text{ in}^4$$

$$Q = 4.04 \cdot 5 = 19.54$$

$$\rightarrow q = \frac{30 \text{ kips} \cdot 19.54 \text{ in}^3}{315}$$

$$q = 1.861 \text{ kip/in}$$

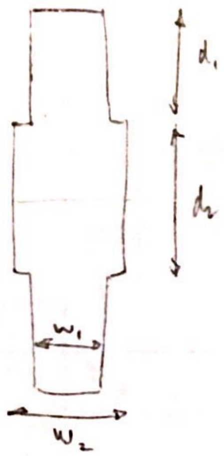
$$q = \frac{\tau_{ave} \cdot A_{bolt}}{\cancel{bolt}} \cdot \frac{2\ \cancel{bolts}}{5 \text{in}}, \quad A_{bolt} = \pi(0.75)^2$$

$$\rightarrow \tau = \frac{5''}{2} q \cdot \frac{1}{A}$$

$$\tau = 10.53 \text{ ksi}$$

6.15:

Given:



$d_1 = 2in$, $d_2 = 4in$
$w_1 = 1.5in$, $w_2 = 2.5in$

$\tau_{all} = 150$ psi

Find: $\overline{V}$

Solution: $I = \frac{1}{12} w_2 \cdot d_2^3 + 2\left(\frac{1}{12} w_1 d_1^3 + w_1 d_1 \left(\frac{d_2}{2} + d_1\right)^2\right)$

$I = 69.33 in^4$

$\tau = \frac{VQ}{It} \longrightarrow V = \frac{\tau I t}{Q}$

at center, $V = \frac{\tau I w_2}{\left(d_1 w_1 + \frac{d_2 w_2}{2}\right) \cdot \bar{y}}$

$\bar{y} = \frac{\frac{d_2}{2} w_2 \cdot \frac{d_2}{4} + d_1 w_1 \cdot \left(\frac{d_2}{2} + \frac{d_1}{2}\right)}{\frac{d_2}{2} w_2 + d_1 w_1}$

$\bar{y} = 1.75$

$V = 1857$ lb

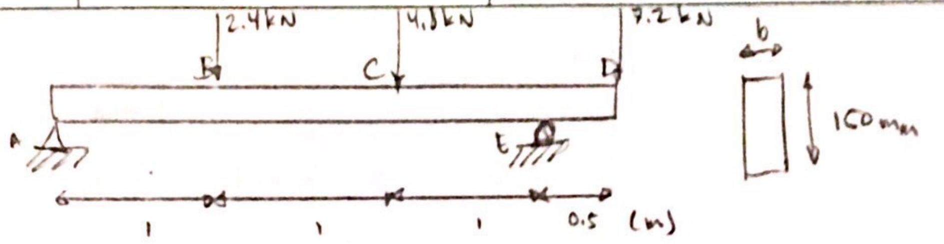
at step-down, $V = \frac{\tau I w_1}{d_1 w_1 \cdot \bar{y}}$

$\bar{y} = \frac{d_2}{2} + \frac{d_1}{2} = 3$

$\boxed{V = 1733 \text{ lb}}$

6.18:

Given:



$\sigma_{all} = 12\text{ MPa}$, $\tau_{all} = 825\text{ kPa}$

Find:

Minimum required b

Solution: ΣF_y: $A_y + E_y = 14.4\text{ kN}$

ΣM_A: $-2.4 - 2(4.8) + E_y(3) - 7.2 \cdot 3.5 = 0$

$\rightarrow$ $E_y = 12.4\text{ kN}$

$A_y = 2.0\text{ kN}$

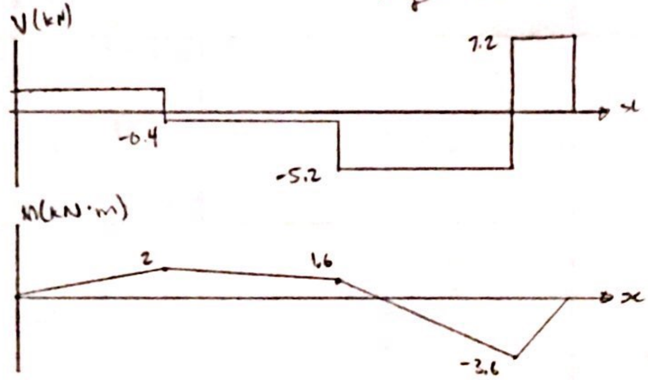
$M_B - 2(1) = 0$

$M_B = 2$

$M_C - 2(2) + 2.4(1) = 0$

$M_C = 1.6$

$M_E - 2(3) + 2.4(2) + 4.8 = 0$



σ: $\sigma = \dfrac{Mc}{I} \longrightarrow I = \dfrac{Mc}{\sigma}$

$$\frac{1}{12} b h^3 = \frac{Mc}{\sigma}$$

$$b = \frac{12 Mc}{\sigma h^3}, \quad c = \frac{h}{2}$$

$$b = \frac{6M}{\sigma h^2}, \quad |M_{max}| = 3.6\text{ kN·m}, \quad h = 0.15\text{ m}$$

$$b = 0.08\text{ m} = 80\text{ mm}$$

τ: $\tau = \dfrac{VQ}{It}$, $t = b$, $I = \frac{1}{12} b h^3$

$$\rightarrow \tau = \frac{VQ}{\frac{1}{12} b^2 h^3}, \quad Q = \underbrace{\left(\frac{h}{2} \cdot b\right)}_{A} \underbrace{\left(\frac{h}{4}\right)}_{\bar{y}}$$

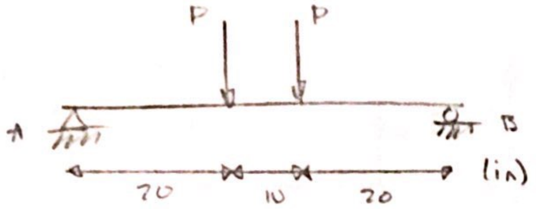
$$\tau = 12 \cdot \frac{V \cdot \frac{h^2}{8} \cdot b}{b^2 h^3}$$

$$\tau = 1.5 \cdot \frac{V}{bh} \longrightarrow b = 1.5 \frac{V}{\tau h}$$

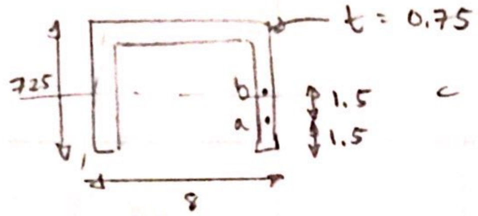
$$\boxed{b = 87.3\text{ mm}}$$

6.21:

Given:



$P = 25$ kips



c

Find: a) τ_a
b) τ_b

Solution: $A_y + B_y = 50$ kips

$\rightarrow A_y = B_y = 25$ kips by symmetry

$\rightarrow V_{max} = 25$ kips

a) $\tau = \frac{VQ}{It}$

$I_c = \left(\frac{1}{12}\cdot 8\cdot 7.25^3\right) - \left(\frac{1}{12}\cdot 6.5\cdot 6.5^3 + \underbrace{6.5\cdot 6.5}_{A}\cdot \underbrace{(0.375)}_{t/2}^2\right)$

$\cancel{I_c = 99.36 \text{ in}^4}$

$\bar{Y} = \frac{(8\cdot 7.25)\cdot\left(\frac{7.25}{2}\right) - (6.5\cdot 6.5)\left(\frac{6.5}{2}\right)}{8\cdot 7.25 - 6.5^2}$

$\bar{Y} = 4.63$ in

$\bar{I} = \left(\frac{1}{12}(1.5\cdot 7.25^3) + (1.5\cdot 7.25)(4.63 - \frac{7.25}{2})^2\right) + \left(\frac{1}{12}(6.5\cdot 0.75^3) + (6.5\cdot 0.75)(7.25 - 4.63 - 0.375)^2\right)$

$\bar{I} = 83.42 \text{ in}^4$

$Q_a = (1.5^2)(4.63 - 0.75) = 8.73 \text{ in}^3$

$\rightarrow \tau_a = \frac{VQ_a}{It}, \quad t = 1.5$

$\boxed{\tau_a = 1.744 \text{ ksi}}$

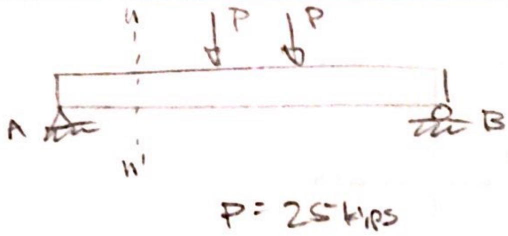
b) $Q_b = (1.5\cdot 3)(4.63 - 1.5) = 14.1 \text{ in}^3$

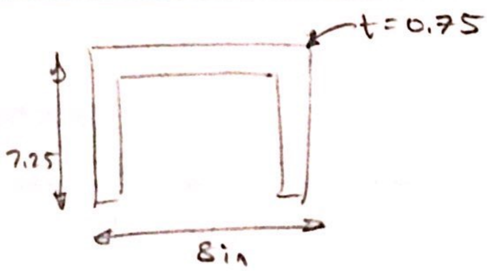
$\rightarrow \tau_b = \frac{VQ_b}{It}, \quad t = 1.5$

$\boxed{\tau_b = 2.817 \text{ ksi}}$

6.23:

Given:





Find: τ_{max} at n-n'

Solution:

$\bar{V} = 25$ kips

from 6.21, $\bar{y} = 4.63$ in , $I = 83.42 \text{ in}^4$

$\bar{Q} = (1.5)\dfrac{(7.25-0.75-4.63)^2}{2} + 8(0.75)(7.25-0.375-4.63)$

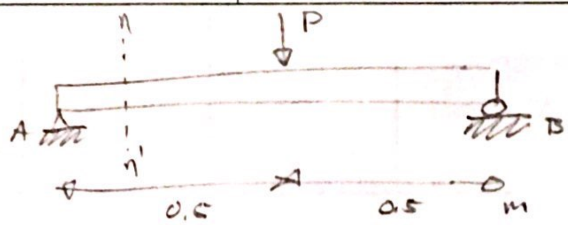
$\bar{Q} = 16.1 \text{ in}^3$

$\tau_{max} = \dfrac{VQ}{It}$, $t = 1.5$ in

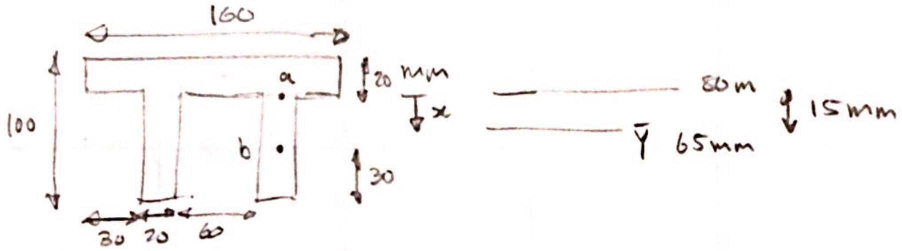
$\boxed{\tau_{max} = 3.217 \text{ ksi}}$

6.2~~3~~4:

Given:



$P = 180\text{kN}$



Find: τ_{max} for n-n'

Solution: $V = P/2 = 90\text{kN}$

$$\bar{Y} = \frac{2(20)(80)(40) + 160(20)(90)}{2(20)(80) + 160(20)} = 65\text{ mm}$$

$$I = \frac{2}{12}(20)(80)^3 + 2(20)(80)(25)^2 + \frac{1}{12}(160)(20)^3 + 160(20)(25)^2$$

$$I = 5.813 \cdot 10^6 \text{ mm}^4$$

$\tau = \frac{VQ}{It}$ → Maximize Q to maximize τ

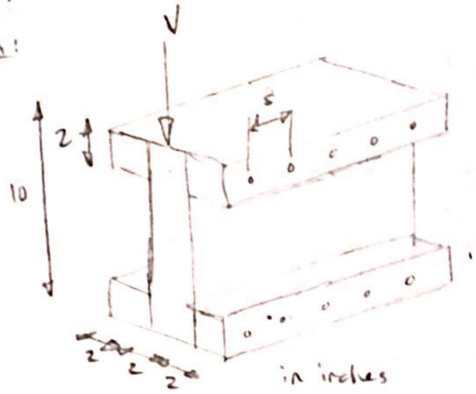
$$Q = \Sigma A\bar{y}$$
$$= 160(20)(25) + 40(15)(7.5)$$
$$= 84.5 \cdot 10^{-6}\text{ m}^3$$

$$\tau_{max} = \frac{VQ}{It}$$

$$\tau_{max} = 32.7\text{MPa}$$

6.29:

Given:



$V = 1200\,lb$

$F_{all} = 75\,lb$

Find: largest s

Solution:

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

$$I = \frac{1}{12}(6)(10)^3 - 2\left(\frac{1}{12}\right)(2)(6)^3 = 428\ in^4$$

$$Q = 2(2)(2)\cdot 4 = 32\ in^3$$

$\rightarrow q = 89.72$

$F = qs$, $F = 2 \cdot F_{all}$, 2 nails per length

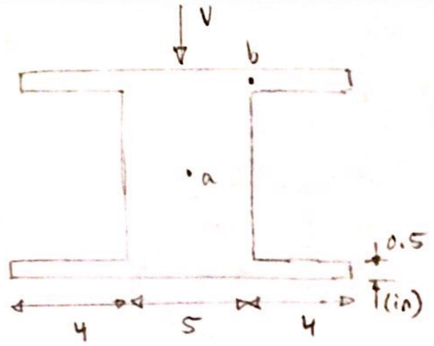
$\rightarrow 150\,lb = q \cdot s$

$$\boxed{s = 1.67\ in}$$

Scanned with CamScanner

6.38:

Given:



$V = 1200\,lb$

Find: a) τ_a

b) τ_b

Solution:

$$I = \frac{1}{12}(13)(8)^3 - \frac{2}{12}(4)(7)^3 = 326 \text{ in}^4$$

a)

$$\bar{Y}_a = \frac{5(3.5)(\frac{3.5}{2}) + 13(0.5)(4-0.25)}{5(3.5) + 13(0.5)} = 2.29 \text{ in}$$

$$Q_a = [5(3.5) + 13(0.5)]\bar{Y}_a$$

$$Q_a = 55 \text{ in}^3$$

$$\tau_a = \frac{VQ_a}{It}, \quad t = 5 \text{ in}$$

$$\boxed{\tau_a = 40.5 \text{ psi}}$$

b)

$$Q_b = (0.5)(4)(3.75) = 15 \text{ in}^3$$

$$\tau_b = \frac{VQ_b}{It}, \quad t = 0.5$$

$$\tau_b = 55.2 \text{ psi}$$