6A (5th)

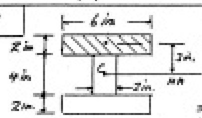
6-22

$\frac{1}{\rho} = \frac{M}{EI}$ & $\sigma = \frac{Mc}{I}$ so $M = \frac{I\sigma}{c}$

$\frac{1}{\rho} = \frac{I\sigma/c}{EI} \rightarrow \sigma = \frac{Ec}{\rho}$

$\sigma = \frac{(29\times10^6)(.009)}{(4+.009)} = \underline{61.5\times10^3 \text{ psi}}$

5.2



$I = \frac{1}{12}6(8)^3 - \frac{1}{12}(6-2)(4)^3$

$I = 234.67 \text{ in}^4$

$Q = (2\cdot6)(3) = 36 \text{ in}^3$

$s = 2\text{ in.}$ Shear/nail = 150 lb

$q = \frac{(150 \text{ lb})}{2 \text{ in}} = 50 \text{ lb/in}$

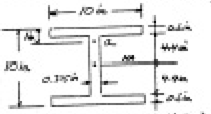
$q = \frac{VQ}{I}$; $50 \text{ lb/in} = \frac{V(36 \text{ in}^3)}{234.67 \text{ in}^4}$; $V = 326 \text{ lb}$ ◄

6B

5.10

AT SECTION n-n: $V = 45$ kips

$M = (45 \text{ kips})(2 \text{ ft}) = 90 \text{ kip}\cdot\text{ft} = 1080 \text{ kip}\cdot\text{in}$



$I = \frac{1}{12}(10)^4 - \frac{1}{12}(10-0.375)(8.8)^3$

$I = 286.736 \text{ in}^4$

$c = 5 \text{ in}$

(a) $\sigma = \frac{Mc}{I} = \frac{(1080 \text{ kip}\cdot\text{in})(5 \text{ in})}{286.736 \text{ in}^4}$ $\sigma = 18.83 \text{ ksi}$ ◄

(b)

$Q = (10 \text{ in}\times0.6 \text{ in})(4.7 \text{ in}) + (0.4 \text{ in}\times0.375 \text{ in})(4.2 \text{ in}) = 28.83 \text{ in}^3$

$\tau_b = \frac{VQ}{It} = \frac{(45 \text{ kips})(28.83 \text{ in}^3)}{(286.736 \text{ in}^4)(0.375 \text{ in})} = 12.065 \text{ ksi}$; $\tau_b = 12.07 \text{ ksi}$ ◄

(c) τ_{max} @ NA

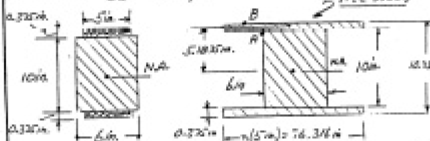
$Q = (10 \text{ in}\times0.6 \text{ in})(4.7 \text{ in}) + (4.4 \text{ in}\times0.375 \text{ in})(2.2 \text{ in}) = 31.83 \text{ in}^3$

$\tau_m = \frac{VQ}{It} = \frac{(45 \text{ kips})(31.83 \text{ in}^3)}{(286.736 \text{ in}^4)(0.375 \text{ in})} = 13.321 \text{ ksi}$ $\tau_m = 13.32 \text{ ksi}$ ◄

4.38

$n = \frac{E_s}{E_w} = \frac{29\times10^6 \text{ psi}}{1.9\times10^6 \text{ psi}} = 15.2632$

TRANSFORMED SECTION: ALL WOOD



$I = \frac{1}{12}(6)(10)^3 + 2\left[\frac{1}{12}(76.316)(0.375)^3 + (76.316\times0.375)(5.1875)^2\right]$

$I = 2020.7 \text{ in}^4$

MAX STRESS IN WOOD OCCURS AT A: $y_A = 5 \text{ in}$

FOR $(\sigma_A)_{wood} = 1800 \text{ psi}$

$M = \sigma_A\left(\frac{I}{y_A}\right) = (1800 \text{ psi})\frac{2020.7 \text{ in}^4}{5 \text{ in}} = 727 \text{ kip}\cdot\text{in}$ ◁

MAX STRESS IN STEEL OCCURS AT B: $y_B = 5.375 \text{ in}$

FOR $(\sigma_B)_{steel} = 24 \text{ ksi}$

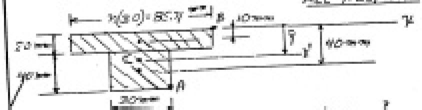
$M = \frac{\sigma_B}{n}\left(\frac{I}{y_B}\right) = \frac{24 \text{ ksi}}{15.2632}\left(\frac{2020.7 \text{ in}^4}{5.375 \text{ in}}\right) = 591 \text{ kip}\cdot\text{in}$ ◄

STEEL CONTROLS

4.40

$n = \frac{E_s}{E_a} = \frac{200 \text{ GPa}}{70 \text{ GPa}} = 2.857$

TRANSFORMED SECTION ALL ALUMINUM



$\bar{Y} = \frac{\Sigma A\bar{y}}{\Sigma A} = \frac{(85.71\times20)(10) + (30\times40)(40)}{(85.71\times20) + (30\times40)} = \frac{65\,142 \text{ mm}^3}{2914.2 \text{ mm}^2} = 22.353 \text{ mm}$

$I_{x'} = \Sigma\left(\frac{1}{12}bh^3 + Ad^2\right)$

$= \left[\frac{1}{12}(85.71)(20)^3 + (85.71\times20)(22.353-10)^2\right] + \left[\frac{1}{12}(30)(40)^3 + (30\times40)(40-22.353)^2\right]$

$= 857.42\times10^3 \text{ mm}^4 = 857.42\times10^{-9} \text{ m}^4$

(a) MAX STRESS IN ALUMINUM OCCURS AT A: $M = 1500 \text{ N}\cdot\text{m}$

$y_A = 60 \text{ mm} - \bar{Y} = 60 - 22.353 = 37.647 \text{ mm}$

$\sigma_{alum} = M\frac{y_A}{I} = (1500 \text{ N}\cdot\text{m})\frac{0.037647 \text{ m}}{857.42\times10^{-9} \text{ m}^4}$; $\sigma_{alum} = 66.2 \text{ MPa}$ ◄

(b) MAX STRESS IN STEEL OCCURS AT B: $y_B = \bar{Y} = 0.022353 \text{ m}$

$\sigma_{steel} = -nM\frac{y_B}{I} = -(2.857)(1500 \text{ N}\cdot\text{m})\frac{0.022353 \text{ m}}{857.42\times10^{-9} \text{ m}^4}$; $\sigma_{steel} = -111.7 \text{ MPa}$ ◄

4.46

$n = \frac{E_s}{E_c} = \frac{200 \text{ GPa}}{20 \text{ GPa}} = 10$

$A_s = 3\left[\frac{\pi}{4}(24 \text{ mm})^2\right] = 1357.2 \text{ mm}^2$ $nA_s = 10A_s = 13\,572 \text{ mm}^2$

TRANSFORMED SECTION ALL CONCRETE

FIRST MOMENT OF AREA

$225x\left(\frac{x}{2}\right) - (13\,572)(450 - x) = 0$

$x = 180.36 \text{ mm}$

$I = \frac{1}{3}(225)(180.36)^3 + (13\,572)(450 - 180.36)^2$

$I = 1426.8\times10^6 \text{ mm}^4 = 1426.8\times10^{-6} \text{ m}^4$

FOR CONCRETE: $\sigma_{all} = 10 \text{ MPa}$ $c = x = 0.18036 \text{ m}$

$M = \sigma\frac{I}{c} = (10 \text{ MPa})\frac{1426.8\times10^{-6} \text{ m}^4}{0.18036 \text{ m}}$; $M = 79.1 \text{ kN}\cdot\text{m}$ ◁

FOR STEEL: $\sigma_{all} = 150 \text{ MPa}$

$c = 450 - x = 269.64 \text{ mm} = 0.26964 \text{ m}$

$M = \frac{\sigma_{steel}}{n}\cdot\frac{I}{c} = \frac{150 \text{ MPa}}{10}\cdot\frac{1426.8\times10^{-6} \text{ m}^4}{0.26964 \text{ m}}$; $M = 79.4 \text{ kN}\cdot\text{m}$ ◁

WE CHOOSE THE SMALLER M, CONCRETE CONTROLS

$M = 79.1 \text{ kN}\cdot\text{m}$ ◄

6B (Cont)

~~4.61~~

$D = 6\,in.$

$d = 4\,in.$ M

$\sigma_{max} = \sigma_{all} = 10\,ksi$

$t = 0.75\,in.$

(a) For $r = 1\,in.$: $\frac{r}{d} = \frac{1\,in.}{4\,in.} = 0.25$ $\frac{D}{d} = \frac{6\,in.}{4\,in.} = 1.5$

From Fig 4.27, page 208 $K = 1.42$

$\sigma_m = K\frac{Mc}{I}$; $M = \frac{\sigma_m}{K}\cdot\frac{I}{c} = \left(\frac{10\,ksi}{1.42}\right)\frac{\frac{1}{12}(0.75\,in.)(4\,in.)^3}{2\,in.}$

$\sigma_m = 14.1\,kip\cdot in.$ ◀

(b) For $r = \frac{1}{2}\,in.$: $\frac{r}{d} = \frac{0.5\,in.}{4\,in.} = 0.125$ $D/d = 1.5$

From Fig 4.27, page 208 $K = 1.72$

$M = \frac{\sigma_m}{K}\cdot\frac{I}{c} = \left(\frac{10\,ksi}{1.72}\right)\left(\frac{\frac{1}{12}(0.75\,in.)(4\,in.)^3}{2\,in.}\right)$

$\sigma_m = 11.6\,kip\cdot in.$ ◀