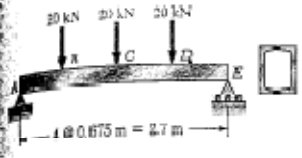
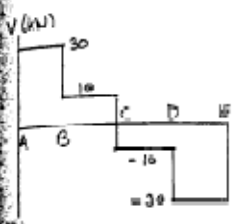
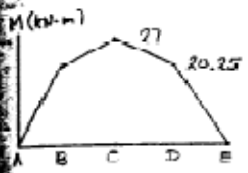
Problem 5.81

5.81 Two metric rolled-steel channels are to be welded along their edges and used to support the loading shown. Knowing that the allowable normal stress for the steel used is 150 MPa, determine the most economical channels that can be used.







By symmetry, $A = E$

$+\uparrow \Sigma F_y = 0$: $A + E - 20 - 20 - 20 = 0$

$A = E = 30$ kN

Shears: A to B. $V = 30$ kN

B to C. $V = 30 - 20 = 10$ kN

C to D. $V = 10 - 20 = -10$ kN

D to E. $V = -10 - 20 = -30$ kN

Areas: A to B. $(0.675)(30) = 20.25$ kN·m

B to C. $(0.675)(10) = 6.75$ kN·m

C to D. $(0.675)(-10) = -6.75$ kN·m

D to E. $(0.675)(-30) = -20.25$ kN·m

Bending moments: $M_A = 0$

$M_B = 0 + 20.25 = 20.25$ kN·m

$M_C = 20.25 + 6.75 = 27$ kN·m

$M_D = 27 - 6.75 = 20.25$ kN·m

$M_E = 20.25 - 20.25 = 0$

Maximum $|M| = 27$ kN·m $= 27 \times 10^3$ N·m

$\sigma_{all} = 150$ MPa $= 150 \times 10^6$ Pa

For a section consisting of two channels,

$$S_{min} = \frac{|M|}{\sigma_{all}} = \frac{27 \times 10^3}{150 \times 10^6} = 180 \times 10^{-6}\ m^3 = 180 \times 10^3\ mm^3$$

For each channel, $S_{min} = \left(\frac{1}{2}\right)(180 \times 10^3) = 90 \times 10^3$ mm³

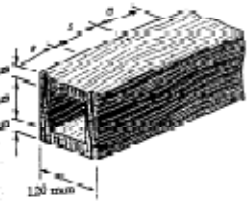
Shape	S (10^3 mm³)
C 180 × 14.6	99.2 ←
C 150 × 19.3	93.6

Lightest channel section

C 180 × 14.6

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Problem 6.2

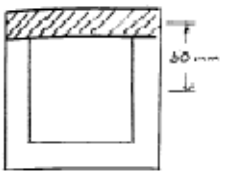


6.2 A square box beam is made of two 20 × 80-mm planks and two 20 × 120-mm planks nailed together as shown. Knowing that the spacing between the nails is $s = 30$ mm and that the vertical shear in the beam is $V = 1200$ N, determine (*a*) the shearing force in each nail, (*b*) the maximum shearing stress in the beam.

$$I = \frac{1}{12} b_1 h_1^3 - \frac{1}{12} b_2 h_2^3$$

$$= \frac{1}{12}(120)(120)^3 - \frac{1}{12}(80)(80)^3 = 13.8667 \times 10^5 \text{ mm}^4$$

$$= 13.8667 \times 10^{-6} \text{ m}^4$$



(a) $A_1 = (120)(20) = 2400 \text{ mm}^2$

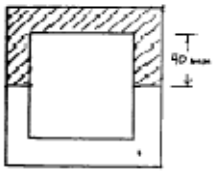
$\bar{y}_1 = 60 \text{ mm}$

$Q_1 = A_1 \bar{y}_1 = 120 \times 10^3 \text{ mm}^3 = 120 \times 10^{-6} \text{ m}^3$

$$q = \frac{VQ_1}{I} = \frac{(1200)(120 \times 10^{-6})}{13.8667 \times 10^{-6}} = 10.385 \times 10^3 \text{ N/m}$$

$q s = 2 F_{\text{nail}}$

$$F_{\text{nail}} = \frac{qs}{2} = \frac{(10.385 \times 10^3)(30 \times 10^{-3})}{2} = 155.8 \text{ N}$$



(b) $Q = Q_1 + (2)(20)(40)(20)$

$= 120 \times 10^3 + 32 \times 10^3 = 152 \times 10^3 \text{ mm}^3$

$= 152 \times 10^{-6} \text{ m}^3$

$$\tau_{\max} = \frac{VQ}{It} = \frac{(1200)(152 \times 10^{-6})}{(13.8667 \times 10^{-6})(2 \times 20 \times 10^{-3})}$$

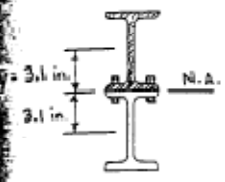
$= 329 \times 10^3 \text{ Pa}$ 329 kPa

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Problem 6.5

6.5 The composite beam shown is fabricated by connecting two W6 × 20 rolled-steel members, using bolts of $\frac{5}{8}$ in. diameter spaced longitudinally every 6 in. Knowing that the average allowable shearing stress in the bolts is 10.5 ksi, determine the largest allowable vertical shear in the beam.





W 6 × 20: $A = 5.87\ \text{in}^2$, $d = 6.20\ \text{in.}$, $I_x = 41.4\ \text{in}^4$

$\bar{y} = \frac{1}{2}d = 3.1\ \text{in.}$

Composite 2: $I = 2\left[41.4 + (5.87)(3.1)^2\right]$

$= 195.621\ \text{in}^4$

$Q = A\bar{y} = (5.87)(3.1) = 18.197\ \text{in}^3$

Bolts: $d = \frac{5}{8}\ \text{in.}$, $\tau_{all} = 10.5\ \text{ksi}$, $s = 6\ \text{in.}$

$A_{bolt} = \frac{\pi}{4}\left(\frac{5}{8}\right)^2 = 0.30680\ \text{in}^2$

$F_{bolt} = \tau_{all} A_{bolt} = (10.5)(0.30680) = 3.2214\ \text{kips}$

$q = \frac{2F_{bolt}}{s} = \frac{(2)(3.2214)}{6} = 1.07380\ \text{kips/in}$

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

$V = \frac{Iq}{Q} = \frac{(195.621)(1.07380)}{18.197}$ $V = 11.54\ \text{kips}$

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