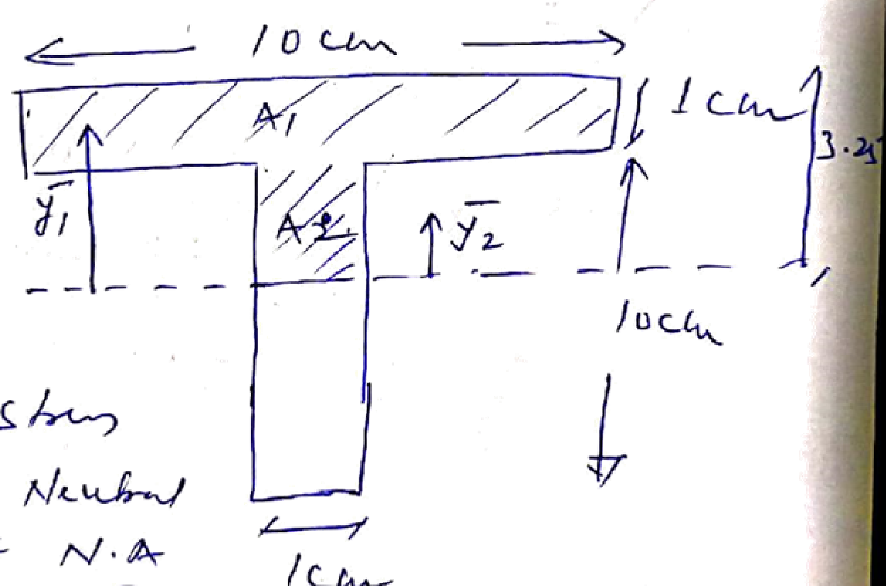
Department of Civil Engineering
Katihar Engineering College, Katihar

Subject : Introduction to Solid Mechanics
Topic : Shear Stress in Beam
Lecture : 05
Course Instructor : Prof. Rashid Mustafa

P-1. A T-beam (X-section shown in figure) is simply supported at ends over span of 7m. It is subjected to UDL of 6 kN/m.
Calculate maximum shear stress in flange at the ends.

$I_{xx} = 235.42 \text{ cm}^4$

Centroid at 3.25 cm from Top.



$$\tau = \frac{V}{IB}(A\bar{y})$$

→ Max^m shear stress occurs at the Neutral axis bcz at N.A B will be min^m & $A\bar{y}$ will be max.

I = Moment of Inertia

A = Area above the section where shear stress to be computed

$\bar{y}$ = Distance of Centroid of A from NA

B = Width of section

$$I = 23542000 \ mm^4$$

$$A\bar{y} = (100 \times 10)\, 27.5 + (22.5 \times 10) \times \frac{22.5}{2}$$

$$A\bar{y} = 30031.25 \ mm^3$$

$$B = 10 \ mm$$

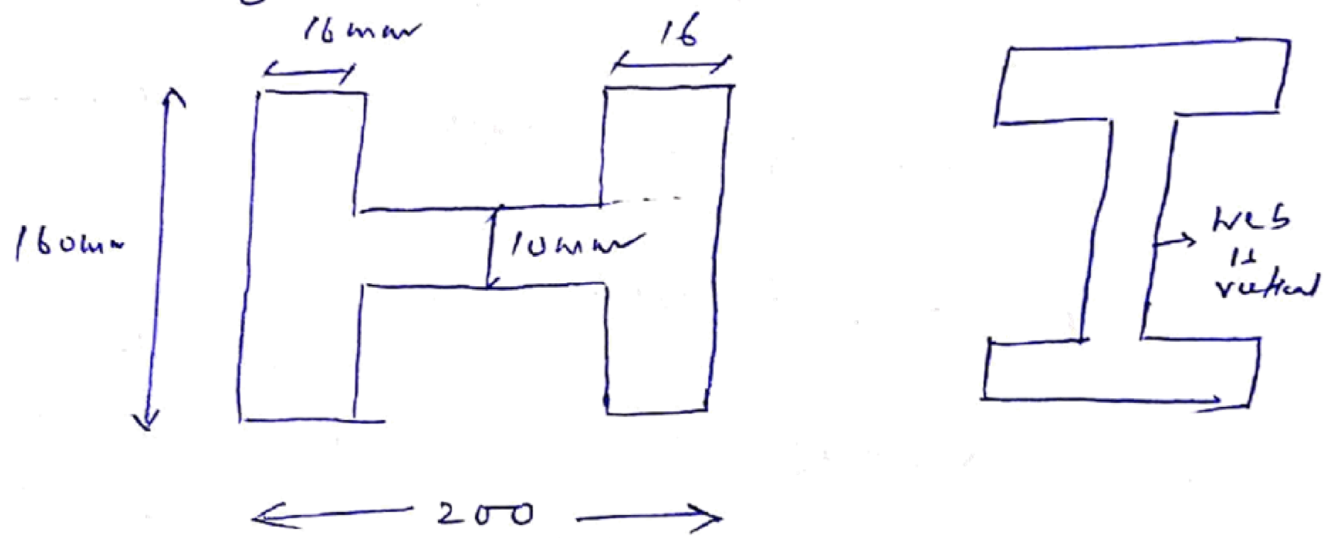
$$\tau_{max} = \frac{V}{IB} \cdot A\bar{y}$$

$$V = \frac{wL}{2} = \frac{6 \times 7}{2} = 21 \ kN$$

$$\tau_{max} = \frac{21 \times 10^3}{2354200 \times 10} \times 30031.25$$

$$= 26.79 \ N/mm^2$$

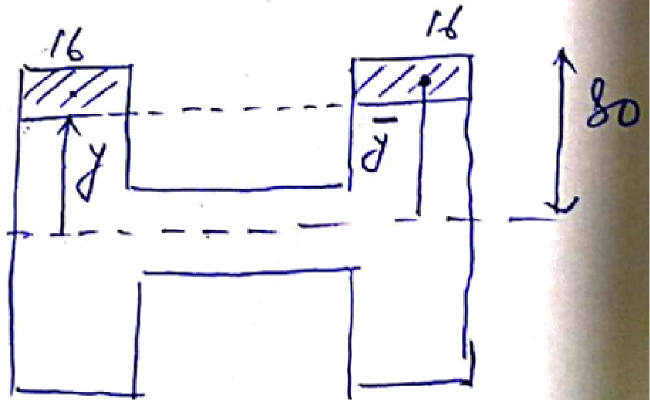
P-2. A steel beam of I-section, 200mm deep and 160 mm wide has 16 mm thick flanges and 10mm thick web. The beam is subjected to a shear force of 200kN. Draw the shear stress distribution if the web of the beam is kept horizontal.



$$\text{Moment of Inertia } (I) = \frac{16\times160^3}{12} + \frac{(200-16-16)\times10^3}{12} + \frac{16\times160^3}{12}$$

$$= 10.9367\times10^6 \text{ mm}^4$$

Shear stress in flange:



$$A = 16\times(80-y)\times2$$

$$B = 2\times16 = 32 \text{ mm}$$

$$\bar{y} = y + \frac{80-y}{2} = \left(\frac{y+80}{2}\right)$$

$$\tau = \frac{V}{IB} \cdot A\bar{y}$$

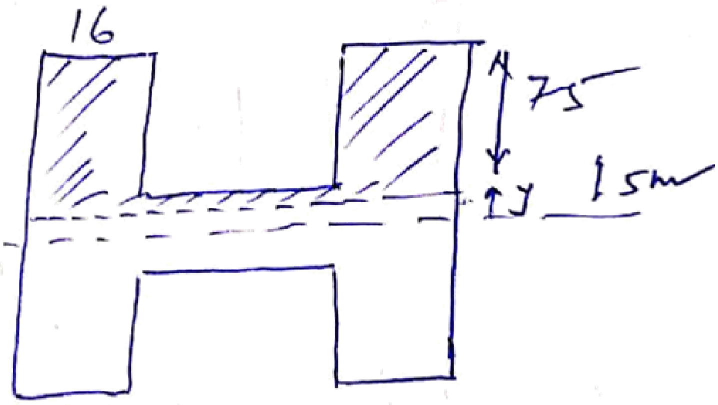
$$= \frac{200 \times 10^3}{10.9367 \times 10^6 \times 32} \times 2 \times 16 \times (80 - y) \times \frac{(80+y)}{2}$$

$$\tau = \cancel{8.3198}\ 9.143 \times 10^{-3} (80^2 - y^2)$$

~~When y = 0~~ When $y = 5$ mm

$$\tau_{junction} = \cancel{9.143 \times 10^{-3}}\ 58.29 \text{ N/mm}^2$$

Shear stress in web



$$A = 2 \times 16 \times 75 + 200 \times (5 - y)$$

$B = 200$ mm

$$\bar{y} = \frac{A_1\bar{y}_1 + A_2\bar{y}_2}{A_1 + A_2}$$

$$A\bar{y} = \frac{2 \times 16 \times 75 \times (5 + 37.5) + 200 \times (5-y)\left(\frac{5+y}{2}\right)}{2 \times 16 \times 75 + 200 \times (5-y)}$$

$$A\bar{y} = 104500 - 100y^2$$

$$\tau = \frac{V}{IB} \cdot A\bar{y}$$

$$= \frac{200 \times 10^3 \times (104500 - 100y^2)}{10.9367 \times 10^6 \times 200}$$

$$\tau_{junction} = 9.1435 \times 10^{-3} (1045 - y^2)$$

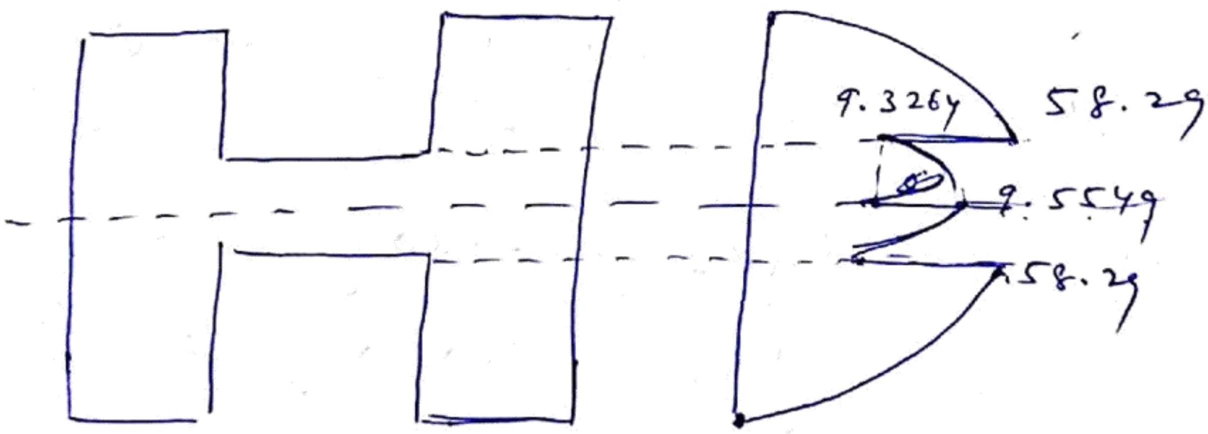
$$= 9.4135 \times 10^{-3} (1045 - 5^2)$$

$$= 9.3264 \ N/mm^2$$

Shear stress at Centroid ($y = 0$)

$$\tau_{centroid} = 9.1435 \times 10^{-3} (1045 - 0)$$

$$= 9.5549 \ N/mm^2$$



Shear stress distribution

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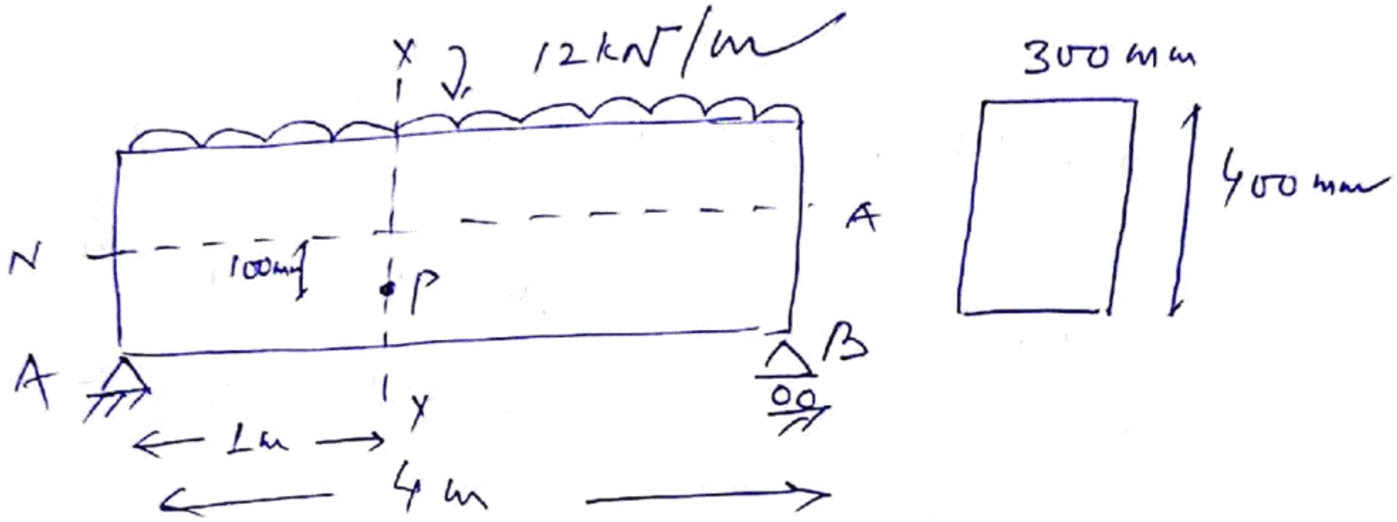
P-3. A simply supported Beam is 4 m long and carries a uniformly distributed load of 12 kN/m over its entire length. The cross-section of the beam is 300 x 400 mm deep. Find the bending stress and shear stress at a point 100 mm below the N A and at $\frac{1}{4}$ of the span.



$$R_A = R_B = \frac{12 \times 4}{2} = 24\ kN$$

$$M_p = R_A \times 1 - 12 \times 1 \times \frac{1}{2}$$

$$= 24 \times 1 - 12 \times 1 \times \frac{1}{2} = 18\ kN\text{-}m$$

Shear force at P $(V_p) = R_A - 12 \times 1$

$$= 24 - 12 = 12\ kN$$

A/c to Bending Eqn

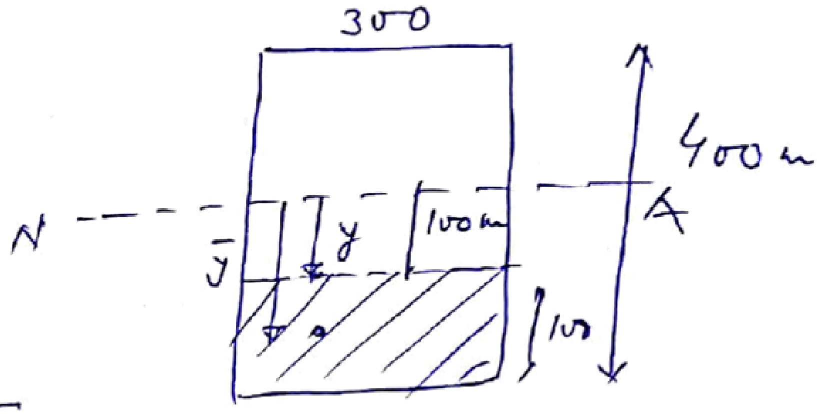
$$\frac{M}{I} = \frac{\sigma}{y} = \frac{E}{R}$$

$$\sigma = \frac{M \cdot y}{I}$$

$$= \frac{18 \times 10^6 \times 100 \times 12}{300 \times 400^3}$$

$$\sigma = 1.125 \ N/mm^2$$

Shear stress



$$\tau = \frac{V}{IB} \cdot A\bar{y}$$

$$B = 300 \ mm$$

$$A\bar{y} = (300 \times 100) \times 150$$

$$\tau = \frac{12 \times 10^3 \times 100 \times 300 \times 150}{\frac{300 \times 400^3}{12} \times 300}$$

$$\tau = 0.1125 \ N/mm^2$$

$$\sigma_{P_1} / \sigma_{P_2} = \frac{\sigma + 0}{2} \pm \sqrt{\left(\frac{\sigma - 0}{2}\right)^2 + \tau^2}$$