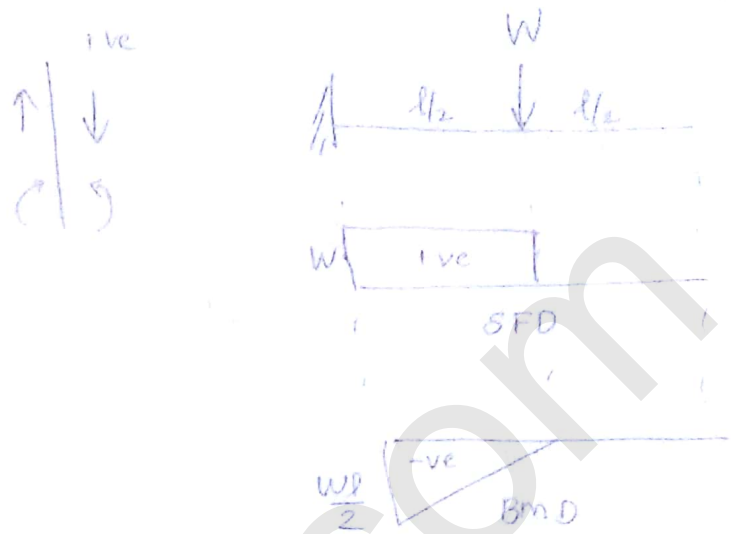


- 4 a) Draw BMD and SFD for a cantilever beam subjected to central concentrated load (7.5)



- b) Draw the BMD and SFD for a simply supported beam with udl over the entire span (7.5)

Reactions

$$R_A + R_B = wl$$

$$R_A \times l - wl \times \frac{l}{2} = 0$$

$$R_A = \frac{wl}{2}$$

$$R_B = \frac{wl}{2}$$

Calculation of SF

$$SF_x = -\frac{wl}{2} + wx \quad (\text{at } l/2)$$

$$SF_{x=l/2} = -\frac{wl}{2} + \frac{wl}{2} = 0$$

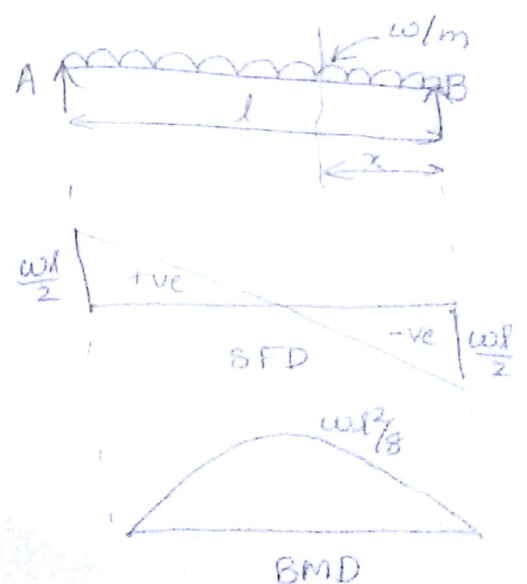
$$SF = 0 \text{ at } x \quad -\frac{wl}{2} + wx = 0$$

$$x = \frac{l}{2}$$

Calculation of BM

$$BM_x = \frac{wl}{2}x - \frac{wx^2}{2} \quad (\text{at } l/2)$$

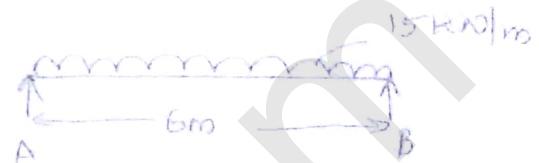
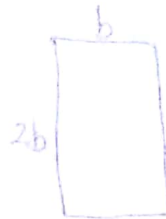
$$BM_{x=l/2} = \frac{wl^2}{8} - \frac{wl^2}{8} = \frac{wl^2}{8}$$



5a) A rectangular timber joist of 6m span has to carry a load of 15 kN/m. Find the dimensions of the joist if the maximum permissible stress is limited to 8 N/mm<sup>2</sup>. The depth of the joist has to be twice the breadth (15)

$$\sigma_p = 8 \text{ N/mm}^2$$

$$d = 2b$$



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

$$I = \frac{b \times (2b)^3}{12} = \frac{8b^4}{12} = \frac{2}{3}b^4$$

$$M = \frac{wl^2}{8} = \frac{15 \times 1000}{1000} \times \frac{6000^2}{8} = 67.5 \times 10^6 \text{ Nmm}$$

$$8 = \frac{67.5 \times 10^6 \times b}{\frac{2}{3}b^4}$$

$$= \frac{3 \times 67.5 \times 10^6}{2 \times b^3}$$

$$b^3 = \frac{3 \times 67.5 \times 10^6}{8 \times 2}$$

$$= 12656250$$

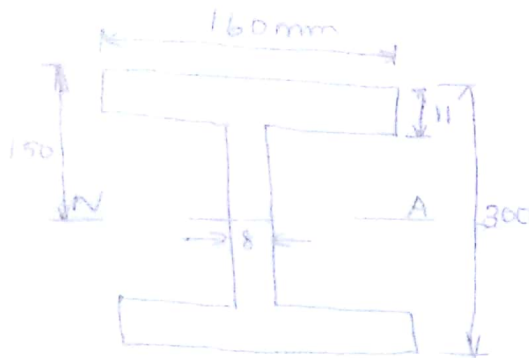
$$b = 233.04 \text{ mm}$$

$$\approx 235 \text{ mm}$$

$$d = 2b = 470 \text{ mm}$$

$$\underline{\underline{235 \times 470 \text{ mm}^2}}$$

- 5 b) A 300mm x 160mm rolled steel joist of I section has flanges 11mm thick and web 8mm thick. Find the safe uniformly distributed load that the section will carry over a span of 5m if the permissible stress is limited to 120 N/mm<sup>2</sup>. (15)



$$\sigma_p = 120 \text{ N/mm}^2$$

$$I = \left[ \frac{160 \times 11^3}{12} + 160 \times 11 \times \left(150 - \frac{11}{2}\right)^2 \right] \times 2 + \frac{8 \times (300 - 22)^3}{12}$$

$$= 78533973.33 + 14323301.33$$

$$= 87857274.66 \text{ mm}^4$$

$$\frac{M}{I} = \frac{\sigma}{y} \quad M = \frac{w l^2}{8} = \frac{w \times 5000^2}{8}$$

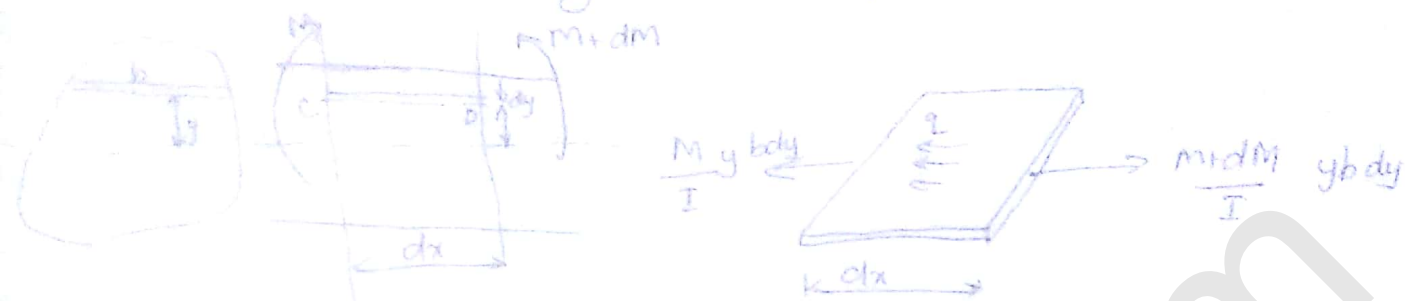
$$w \times \frac{5000^2}{8} = \frac{120 \times 87857274.66}{150}$$

$$w = \frac{70285819.73 \times 8}{5000^2}$$

$$= 22.5 \text{ N/mm}$$

$$= \underline{\underline{22.5 \text{ kN/m}}}$$

6 Derive the expression for shearing stress in a beam section stating the assumptions made.



The force on the element on left side =  $\frac{M}{I} y b dy$

III) force on the right side due to bending =  $\frac{M+dM}{I} y b dy$

Unbalanced force =  $\frac{dM}{I} y b dy$

Total unbalanced force above CD =  $\int_y^{y_t} \frac{dM}{I} y b dy$

This is resisted by shearing stresses acting horizontally on plane at CD.

$$q \cdot b \cdot dx = \int_y^{y_t} \frac{dM}{I} y b dy$$

$$\therefore q = \frac{dM}{dx} \cdot \frac{1}{bI} \int_y^{y_t} y a$$

$$\text{but } \frac{dM}{dx} = F \quad \int_y^{y_t} y a = a \bar{y}$$

$$q = \frac{F a \bar{y}}{I b}$$

### Assumptions

Shear stress is uniform across the width of the beam.

Direction of shear stress is in line with shear force.



9 a) What are the assumptions in Euler's theory

- 1) The material is homogeneous, isotropic & elastic
- 2) The section of column is uniform throughout
- 3) The column is initially straight and is loaded axially
- 4) The column fails by buckling alone
- 5) Self weight of column is neglected

b) Buckling loads for different end conditions

1) Both ends hinged  $P = \frac{\pi^2 EI}{l^2}$

2) One end fixed and the other end free

$$P = \frac{\pi^2 EI}{4l^2}$$

3) Both ends fixed

$$P = \frac{4\pi^2 EI}{l^2}$$

4) One end fixed and the other end hinged

$$P = \frac{2\pi^2 EI}{l^2}$$

$E$  - Young's modulus of the material of column

$I$  - Moment of inertia

$l$  - length of column.

9c) A hollow alloy tube 5m long with diameters 40mm and 25 mm was found to extend 6.4mm under a tensile load of 60kN. Find the buckling load for the tube when used as a strut with both ends pinned.

$$\delta = \frac{Pl}{AE}$$

$$\delta = 6.4 \text{ mm}$$

$$P = 60 \times 1000 \text{ N}$$

$$l = 5 \text{ m} = 5000 \text{ mm}$$

$$A = \frac{\pi}{4} [40^2 - 25^2] = 765.375 \text{ mm}^2$$

$$E = \frac{Pl}{A\delta}$$

$$= \frac{60 \times 1000 \times 5000}{765.375 \times 6.4} = 61244.488 \text{ N/mm}^2$$

For column with both ends pinned  $l_e = l$

$$P_b = \frac{\pi^2 EI}{l^2}$$

$$I = \frac{\pi}{64} [40^4 - 25^4]$$

$$= 106434.96 \text{ mm}^4$$

$$= \frac{\pi^2 \times 61244.488 \times 106434.96}{5000^2}$$

$$= 2570.8 \text{ N}$$

$$= \underline{\underline{2.57 \text{ kN}}}$$