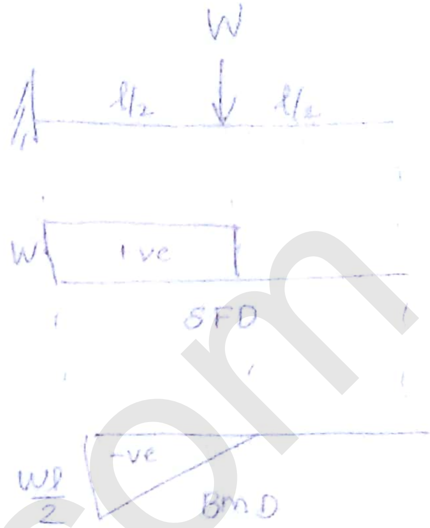
4 a) Draw BMD and SFD for a cantilever beam subjected to central concentrated load (7.5)



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

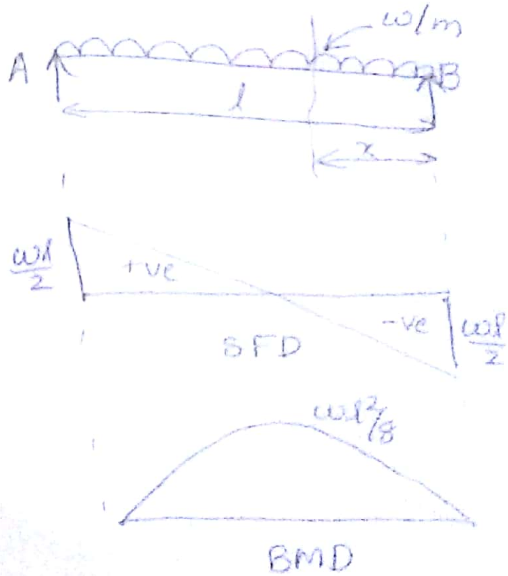
<u>Reactions</u>

$R_A + R_B = \omega l$

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

$R_A = \frac{\omega l}{2}$

$R_B = \frac{\omega l}{2}$



<u>Calculation of SF</u>

$SF_x = -\frac{\omega l}{2} + \omega x$ (st line)

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

$SF = 0$ at x $\quad -\frac{\omega l}{2} + \omega x = 0$

$x = l/2$

<u>Calculation of BM</u>

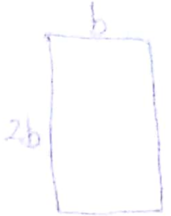
$BM_x = \frac{\omega l}{2} x - \frac{\omega x^2}{2}$ (Parabola)

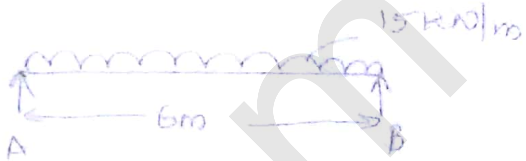
$BM_{x=l/2} = \frac{\omega l^2}{4} - \frac{\omega l^2}{8} = \frac{\omega l^2}{8}$

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/mm². The depth of the joist has to be twice the width. (15)

$\sigma_p = 8\ N/mm^2$

$d = 2b$





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

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

$$M = \frac{wl^2}{8} = \frac{15 \times 1000}{1000} \times \frac{6000^2}{8} = 67.5 \times 10^6\ N\,mm$$

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

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

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

$$= 12656250$$

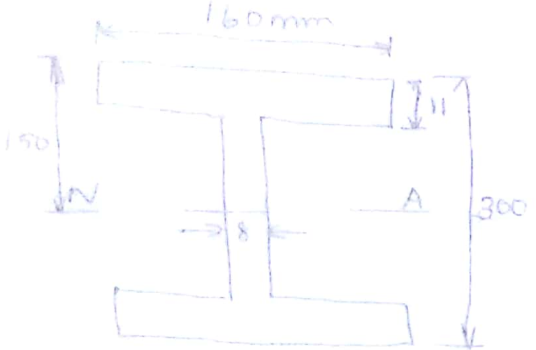
$$b = 233.04\ mm$$

$$\approx 235\ mm$$

$$d = 2b = 470\ mm$$

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

5 b) A 300mm × 160mm rolled steel joist of I section has flanges 11 mm thick and web 8 mm 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/mm² (7.5)



$\sigma_p = 120\ N/mm^2$

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

$$= 73533973.33 + 14323301.33$$

$$= 87857274.66\ mm^4$$

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

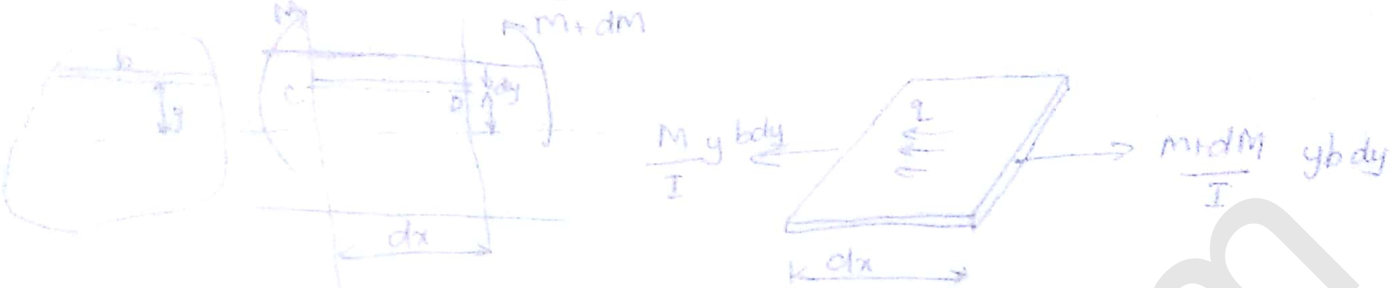
$$w \times \frac{5000^2}{8} = \frac{120 \times 87857274.66}{150}$$

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

$$= 22.5\ N/mm$$

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

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



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

III^ly force on the right side due to bending $= \frac{M+dM}{I} y\, bdy$

Unbalanced force $= \frac{dM}{I} y\, bdy$

Total unbalanced force above CD $= \int_y^{y'} \frac{dM}{I} y\, bdy$

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

$$\text{ie} \quad q\, b\, dx = \int_y^{y'} \frac{dM}{I} y\, bdy$$

$$\therefore q = \frac{dM}{dx} \frac{1}{bI} \int_y^{y'} ya$$

$$\text{but } \frac{dM}{dx} = F \qquad \int_y^{y'} ya = a\bar{y}$$

$$\therefore q = \frac{F a\bar{y}}{Ib}$$

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 homogenous, 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

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

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.

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

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

$\delta = 6.4\,mm$

$P = 60 \times 1000\,N$

$l = 5m = 5000\,mm$

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

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

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

For column with both ends pinned $l_e = l$

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

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

$= 106434.96\ mm^4$

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

$= 2570.8\ N$

$= \underline{\underline{2.57\ KN}}$