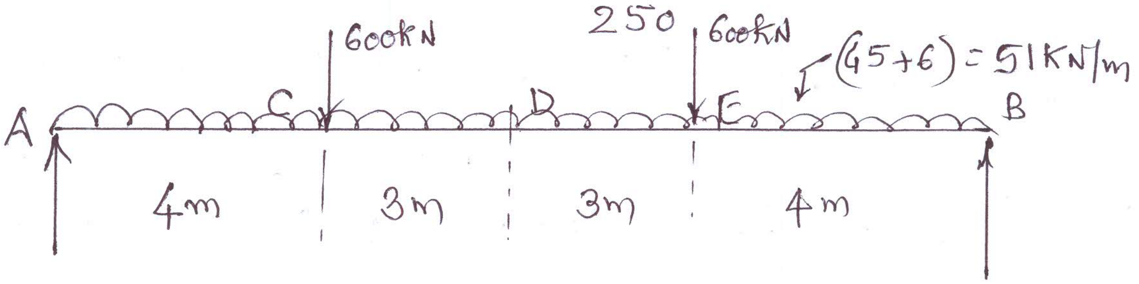
1. **Design of welded plate girder:**

(a) S_w = Self wt = $\frac{\text{Total load}}{250}$ = 6 kN/m.



$V = \frac{wl}{2} = 1135.5$ kN, $M = \frac{wl}{2} * 7 - 600 \times 3 = 4274.25$ kN.m

$d_w = \left(\frac{kM}{f_y}\right)^{0.33} = 1352.4 \simeq 1400$ mm, (10) Mark

(b) $M_d = \frac{\beta_b Z_p f_y}{\gamma_{m0}} \geq M_u$.

$Z_p = \Sigma a\bar{y} = 2\{420 \times 25 \times 712.5 + 20 \times 700 \times 350\}$

$= 24.76 \times 10^6\ mm^3$

(c) $\tau_{cr,e} = \frac{K_v \cdot \pi^2 E}{12(1-\mu^2)\left(\frac{d}{t_w}\right)^2} = 262.66$

$\lambda_w = 0.75$,

$V_d = \frac{V_{cr}}{\gamma_{m0}} = 3675$ kN > 1135.5 kN Safe. (15) Mark

(b) Design of intermediate Stiffeners:

$$\tau_b = \left[1 - 0.8(\lambda_w - 0.8)\right]\frac{f_{yw}}{\sqrt{3}} = 144.34\ N/mm^2$$

$$V_{cr} = A_v \cdot \tau_b = 4014.5 \times 10^3 N > 1135.5 kN,\ \text{Safe.}$$

$$F = \frac{Va\bar{y}}{I_{xx}} = 557.4\ N/mm = 2\left(0.707 \times 1mm \times \frac{410}{\sqrt{3} * 1.25}\right)$$

$$S = 2.10mm$$

$$CF = 4,\quad S_{act} = 2.1 \times 4 = 8.4 \simeq 10mm$$

$$C = 1.50d = 2100\ mm > \sqrt{2},$$

$$I = I_{xx} = \frac{b(2h+20)^3}{12} = 8.4 \times 10^6\ mm^4$$

15 Mark

Solving, $2h = 212.70mm$ or $h = (86.35 + 20) = 106.35mm$

Check

$$F = \frac{(t_w)^2}{5b_s} = \frac{(20)^2}{5 \times 110} = 727.27\ N/mm = 4\left[0.707 \times S \times 1 * \frac{410}{\sqrt{3} \times 1.25}\right]$$

$$S = \frac{727.27}{530.24} = 1.37mm$$

$$S_{act} = 4 \times 1.37 = 5.2mm \simeq 6mm.$$

10 Mark

Qn. 2. Design of Counter fort R/W:

$$D_f = \frac{160}{16}\left[\frac{1-\sin 33^\circ}{1+\sin 33^\circ}\right]^2 = 0.87 \simeq 1m.$$

$H = h_1 + 1 = 7m$, $K_a = \frac{1-\sin\phi}{1+\sin\phi} = \frac{1}{3} \simeq 0.29$

$$M = \frac{\omega l^2}{10} = 27.6 \times 10^9 \text{ N-mm}$$

$V = 0.6\,\omega l = 55.2 \times 10^3 N$, $V_4 = 1.5V.$

$$(d)_{req} = \sqrt{(0.138 f_{ck}\, b)^{-1} \times M_4} = 109.55 \text{ mm}.$$ (10) Marks

$D = (d) + 60 = 170 mm.$

$f = \frac{\Sigma W}{b'}\left[1 \pm \frac{6e}{b'}\right]$, $f_{max} = 109.8 \text{ kN/m}^2$

$f_{min} = 80.9 \text{ kN/m}^2$

$FOS = \frac{\mu \Sigma W}{P_H} \geq 1.5$ Safe.

$$(M_u)_{Stem} = 41.40 \times 10^6 = 0.87 f_y A_{st} d \left[1 - \frac{A_{st} \cdot f_y}{bd f_{ck}}\right]$$

Solving, $A_{st} = 298 mm^2$

Min Steel = $0.12\% \, bD = 540 mm^2$ ✓ (10 Marks)

b) CF Design: $M = \left(\frac{P}{h} * \frac{h}{3}\right) * l = 647.68$ kN-m

$$(M_u)_{CF} = 1.5M = 971.51 \text{ kN-m}$$

$$\frac{A_{st}}{bd} = \frac{0.85}{f_y} \Rightarrow A_{st} = 2709.75 \text{ mm}^2$$

6 No' of 25mm ϕ.

(c) Design of links: $A_{st} = \frac{F}{0.87 f_y} = 492.70 \text{ mm}^2$.

Provide 10mm ϕ - 2 legged Stirrups @ 150mm c/c

(15 Marks)

(d) Design of Stem:

$$\omega = \omega_1 + \omega_2 - \omega_3 = 39.53 \text{ kN/m}$$

$$M_u = \frac{\omega l^2}{10} \times 1.5 = 53.34 \text{ kN-m} = 0.138 f_{ck} bd^2$$

$$d = 124.34 \text{ mm} < 595 \text{ mm Safe.}$$

Further, $53.34 \times 10^6 = 0.87 f_y A_{st} d \left[1 - \frac{A_{st} f_y}{bd f_{ck}}\right]$

$A_{st} = 250.04 \text{ mm}^2$, @ 10mm ϕ @ 140mm c/c (15 Marks)