⇒ Design a S.S.B of effective span 18m, to carry a factored load of 70KN/m, & depth of beam is restricted to 500mm.

S.S.B, $l = 12m$
factored load = 70KN/m
depth ≯ 500.

⇒ (1) Load Calculation:

T.L (given) = 70KN/m

⇒ (2) B.M Calculation:

$$\text{Max B.M} = \text{S.S.B} = \frac{wl^2}{8} = \frac{70 \times 12^2}{8} = 1260\ \text{KNm}$$

$$= 126 \times 10^6\ \text{Nmm}$$

⇒ (3) S.F Calculation (V):

$$\text{Max S.F (V) S.S.B} = \frac{wl}{2} = \frac{70 \times 12}{2} = 420\ \text{KN}.$$

⇒ (4) Calculation of section Modulus:

$$Z_p = \frac{M\gamma_{mo}}{f_y}$$

$$= \frac{126 \times 10^6 \times 1.1}{250} = 554400\ mm^2$$

$Z_p = 554400\ mm^2$ (required)

⇒ (5) Selection of I section:

Since, depth of section is restricted to 500mm,

∴ Choose any section upto the depth of 500mm.

ISMB 400 section was choosen.

with suitable flange plate over the flange

⇒ (6) Check for Shear:

$$V_d = h t_w f_y$$

$$M_{dv} = M_d + \beta_b (M_d - M_{fd})$$

$$= 1547.32 \times 10^6 - 1 (1547.32 \times 10^6 - 1.47 \times 10^9)$$

$$= 1.47 \times 10^9 \text{ Nmm}$$

$$= 1470 \times 10^6 \text{ mm} > 1260 \times 10^6 \text{ (Step 1)}$$

$M_{dv} > M$.

Hence Safe.

⇒(9) Check for deflection:

$$\delta = \frac{5wL^4}{384 E I_{zz}} < \frac{L}{240}$$ → (IS 800 Table-6)

$w \rightarrow$ working load $= \frac{70}{1.5} = 46.67 \text{ N/m}$

$I_{zz} = I_{zz}$ of ISMB 100 + I_{zz} of plate

(ISMB 100 — steel table)

$$+ 2 \times A_p \times \left(\frac{\text{ht of plate}}{2}\right)^2$$

$$= 20458.4 \times 10^4 + 2 (320 \times 20) \left(\frac{400+20}{2}\right)^2$$

$$= 144.36 \times 10^7 \text{ mm}^4$$

$$\delta = \frac{5 \times 46.67 \times (12000)^4}{384 \times 2 \times 10^5 \times 144.36 \times 10^7}$$

$$\boxed{\delta = 43.64 \text{ mm}}$$

⇒(8) Check for deflection:

cls: 8.7.3.1, Pg.no 87.

$$\boxed{f_{cd,w} = (b_1 + h_1)\, t_w \times f_{cd}}$$

↳ not in code

To find f_{cd}, Pg.no 42 Table (9C)

Find $\frac{K_L}{r}$

$110 \rightarrow 94.6$

$120 \rightarrow 83.7$ $\Rightarrow 112.56 \Rightarrow 92.03 N/mm^2$

Assume, $b_1 = h = 400mm$

$$n = \frac{h}{2} = \frac{400}{2} = 200$$

$$f_{cd}, w = (400 + 200) \times 8.9 \times 92.03$$

$$= 491 \times 10^3 N > V \rightarrow (420 \times 10^3)$$

Step 1

(9) Check for web crippling :

Cl. 8.7.4 $\rightarrow$ pg. no - 64

$$F_w = \frac{(b_1 + n_2)\, t_w \cdot f_{yw}}{\gamma_{mo}}$$

$$n_2 \Rightarrow 2.5(t_f + r_1) = 2.5(14 + 16) = 75$$

$$F_w = \frac{(200 + 75) \times 8.9 \times 250}{1.1}$$

$$= 859.6 \times 10^3 N > 420 \times 10^3 N (V)$$

$0.6V_d = 0.6 \times 467143$

$= 280286\ N \quad > V\ (420 \times 10^3\ N)$

$V > 0.6V_d$

Ref ⇒ 8.2.1.3

$M_d = M_{dv}$ (pg no 70)

(2) Classification of Section:

$b = \frac{b_f}{2} = 70mm$

$d = D - 2(t_f + r_1)$

$= 400 - 2(16+14) = 340mm$

$\frac{b}{t_f} = \frac{70}{16} = 4.375 < 9.4\varepsilon$

$\frac{d}{t_w} = \frac{340}{8.9} = 38.2 < 84\varepsilon$

∴ So, the section is plastic

⇒ (6) Check for BM:

$M = M_{dv}$

$M_{dv} = M_d - \beta_b(M_d - M_{fd}) \leq \frac{1.2 Z_e f_y}{\gamma_{mo}}$

where, $M_d = \frac{\beta_b Z_p f_y}{\gamma_{mo}}, \quad \beta_b = 1$

$(Z_p)_{provided} = Z_p$ of I-section + Z_p of cover plate

(Steel table) ($Z_p = A_p \times h$)

$= 1176.2 \times 10^3 + (320 \times 40)(400+40)$

$= 6808200mm$

$M_d = 1 \times 6808200 - \left[(400-32) \times 8.9\right) \times \left(\frac{400}{}\right.$