1) Design intermediate vertical stiffners and bearing stiffnes for a plate girder whose size of the web is 1800x12mm & size of flange 500x24mm. The girder carries factored UDL of 140 kN/m including self wt overall effective span of 22m. use fe415 steel and adopt limit state method of design

Sol Given data:-

Size of web = 1800x 12mm

Size of flange = 500x24 mm

load w = 140 kN/m

l = 22m

$B.M = \frac{wl^2}{8} = \frac{140 \times 22^2}{8} = $ ~~8.47 kN-m~~ 8470 kN-m

$S.F = \frac{wl}{2} = \frac{140 \times 22}{2} = 1540$ kN

~~daptharf~~

ii) Spacing b/w the vertical Stiffnes ; 'c' :-

Initially lets Assume $c/d = 1.3$

$$\frac{c}{1800} = 1.3$$

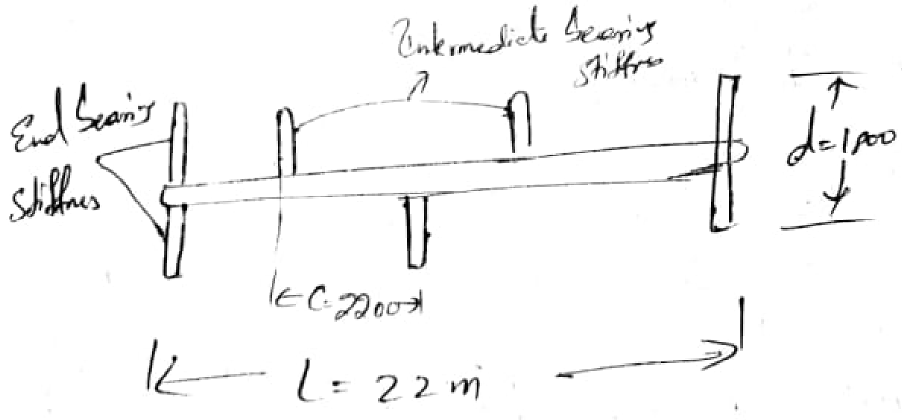
$C = 2340\,mm$

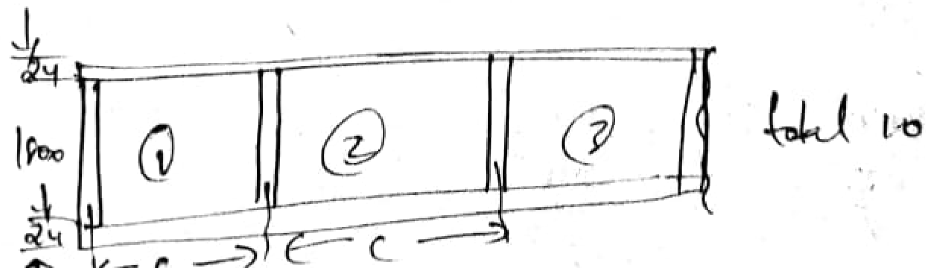
Span = $22 \times 1000 = 22000\,mm = 22 \times 10^3\,mm$

No: of panels = ~~2340~~ $\frac{22000}{2340} = 9.4 \simeq 10$

Spacing of panels = ~~2340/10~~ $\frac{22 \times 10^3}{10} = 2200\,mm$ c/c

Actual $c/d = \frac{2200}{1800} = 1.2 < 1.5$





from Clause 8.6.1.1 (b) when only transfers stiffness provided.

when $3d \geq c \geq d$

$$\frac{d}{t_w} \leq 200\varepsilon$$

$$\frac{1800}{12} = 150 \leq 200\varepsilon$$

2) when $c < 1.5d$

$$\frac{d}{t_w} \leq 345\varepsilon_1$$

$$\frac{1800}{12} = 150 \leq 345$$

Hence both the Conditions are Satisfied.

4) Shear Capacity of web:- (8.4.2.2) Pg:-59.

Simple post Critical method

$V_n = V_{cr}$

$V_{cr} = A_v \tau_b$

$$k_v = 5.35 + \frac{4.0}{(c/d)^2} \quad \text{for } c/d \geq 1 \left[\frac{c}{d} = \frac{2200}{1800} = 1.22 \geq 1\right]$$

$$= 5.35 + \frac{4.0}{\left(\frac{2200}{1800}\right)^2} \quad 5.35 + \frac{4.0}{1.22^2}$$

$$= 8.037$$

=

$$\tau_{cr.c} = \frac{k_v \pi^2 E}{12(1-\mu^2)\left[d/t_w\right]^2}$$

$$= \frac{8.037 \times \pi^2 \times 2.0\times10^5}{12\left(1-0.3^2\right)\left[1400/12\right]^2}$$

$$= 64.43 \, N/mm^2$$

$$\lambda_w = \sqrt{\frac{f_y}{\sqrt{3}\,\tau_{cr}}}$$

$$= \sqrt{\frac{250}{\sqrt{3} \times 64.43}}$$

$$\lambda_w = 1.496$$

when $\lambda_w \geq 1.2$ $\tau_b = \left(f_y / \sqrt{3}\,\lambda_w^2\right)$

$$\tau_b = \frac{250}{\sqrt{3}\times1.496^2} = 64.49 \, N/mm^2$$

$$V_{cr} = A_v \tau_b$$

$$= (1400\times12)\times(64.49)$$

$$= 1392.9 \text{ kN} < 1540 \text{ kN}$$

As V_{cr} < shear force provide intermediate web stiffener.

5) **Design of intermediate stiffness:-**

max outstanding lengths Clause (8.7.2)

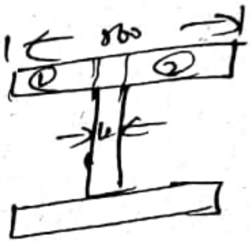
$20 t_q \varepsilon$.

$20 \times 12 \times 1 = 240$ m

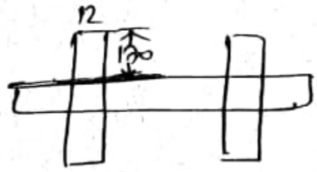
min outstanding lengths $= 14 t_q \varepsilon$

$= 14 \times 12 = 168$ mm

Available width $= \frac{500-12}{2} = 244$



Let us try 170x12mm Section



$$I_s = \frac{12 \times 170^3}{12} + (12 \times 170)\left(\frac{170}{2}\right)^2$$

$$= 19.652 \times 10^6 \text{ mm}^2$$

$I_s \geq \frac{1.5 d^3 t_w^3}{c^2}$ when $c/d < \sqrt{2}$ $\left[\frac{2200}{1800} = 1.22 < 1.41\right]$

$$= \frac{1.5 \times 1800^3 \times 12^3}{2200^2} = 3.123 \times 10^6$$

$19.652 \times 10^6 > 3.123 \times 10^6$

Hence Satisfied.

vi) Buckling Check on i.t.s :-

$$f_q = \frac{V - V_{cr}}{\gamma_{m0}} \leq f_{qd}$$

$$f_{qd} = A_e f_{cd}$$

$$I_{xx} = \left(\frac{12 \times 170^3}{12} + (12 \times 170)\left(\frac{12}{2} + \frac{170}{2}\right)^2\right)$$

$$= 21.806 \times 10^6 \text{ mm}^4$$

radius of gyration $r = \sqrt{\frac{I}{A}}$

$\rightarrow$ A = effective area of stiffeners

$$= \sqrt{\frac{21.806 \times 10^6}{7800}}$$

$$(12 \times 170) + 2 \times 20 \times 12 \times 12$$

$A = 7800 \text{ mm}^2$

$r = 52.82$

$$\frac{KL}{r} = \lambda = \frac{0.7 \times 1800}{52.87}$$

($\frac{KL}{r}$ = Here 'L' is the depth of web)

$= 23.83$

λ	f_{cd}
20	224
23.83	x
30	211

$f_{cd} = 218.92 \text{ N/mm}^2$

$f_{qd} = A_e f_{cd}$

$= 7800 \times 218.92$

$f_{qd} = 1707.64$ kN

$f_q = \frac{V - V_{cr}}{\gamma_{m0}} = \frac{1540 - 1392.9}{1.10}$

$= 133.72$ kN

$133.72 < 1707.64$

$f_q < f_{qd}$

Hence buckling Check is Satisfied.

6) Connection of Sts to web:- (8.7.2.6)

$t_w^2 / 5b_s$

7) Design of end bearing stiffner:-

Local Capacity of web $f_w = \frac{(b_1 + n_2) t_w f_y}{\gamma_{m0}}$

$b_1 = \frac{500 \times \sin 45}{2} = 176.77$ (125) assumed in gen

$n_2 = 2.5 \times t_f = 2.5 \times 24 = 60$ mm

$$\frac{(125+60)\times 12\times 250}{1.10}$$

$F_w = 504.54$ kN < 1540 kN

Hence end bearing stiffener needed

Max width of allowable $\left(\frac{500-12}{2}\right) = 224$ mm

eff outstand $= 14 t_q \varepsilon = 14\times 12$
$= 168$ mm

let us take 170×12 mm as bearing stiffener provided on $\frac{L}{S}$.

$$I_x = 2\left[\frac{12\times 170^3}{12} + (12\times 170)\left(\frac{12}{2}+\frac{170}{2}\right)^2\right]$$

$= 43.612\times 10^6$ mm^4

Area $= 2\times(170\times 12) + 2(20 t_q \times t_q)$
$= 2(20\times 170) + 2(20\times 12\times 12)$
$= 9840$ mm^2

$$r = \sqrt{\frac{I}{A}} = \sqrt{\frac{43.612\times 10^6}{9840}} = 66.57$$

$$\lambda = \frac{kl}{r} = \frac{0.7\times 1800}{66.57} = 18.97$$

10 — 227

18.97 — ?

20 — 224

$f_{cd} = 224.30 \; N/mm^2$

$P_d = A_c f_{cd}$

$= 9840 \times 224.30$

$= 2207.18 > V$

$> 1540 \; kN$

Hence buckling of end bearing stiffness are Satisfied