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Internal Assessment Test 3 – Dec. 2022

Sub:	Design of RC and Steel Structure				Sub Code:	18CV72	Branch	Civil
Date:	27/12/2022	Duration:	90 min's	Max Marks: 50	Sem / Sec:	7A		OBE

Answer ONE FULL Questions **Note: Use of IS 456:2000 is permitted, Assume missing data suitably.**		MARKS	CO	RBT
1	Design a welded plate girder for an effective span of 14 m. Imposed load on the girder consist of UDL 45 kN/m in addition to 2-point loads each of magnitude 400kN, placed at 3m on either side of the mid span point of the girder. Design i. Mid span cross section, ii. Curtailment of flange plates, iii. Intermediate stiffeners, iv. End bearing and bearing stiffeners	[50]	CO3	L4
Or				
2	Design a gantry girder to be used in an industrial building carrying an electrically operated overhead travelling crane, for the following data • Centre to Centre between distance between gantry rails or span of crane girders 25 m, Centre to Centre distance between columns (span of gantry girder) 8 m, Crane capacity 200 kN • Self-weight of the crane girder excluding trolley 150 kN at centre or (150/25 = 6kN/m), • Self-weight of the crab or trolley, electric motor, hook, etc. 75 kN, Approximate minimum approach of the crane hook to the gantry girder 1.0 m, Wheel base 3.5 m, Self-weight of rail section 300 N/m =0.3kN/m, Diameter of crane wheels 150 mm, Height of rail 105 mm, Steel is of grade Fe 410. Design also the field welded connection if required. The support bracket connection need not be designed.	[50]	CO2	L2

Paper 3

CI CCI HOD

For "Plastic" & "Compact" condition

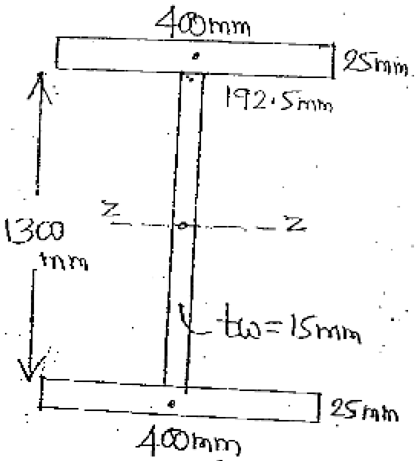
$$\left(\frac{b}{t_f}\right) < 8.4\varepsilon$$
$$< 9.4\varepsilon$$

Table ② Page 18

Using $\left(\frac{b}{t_f}\right) = 8.4\varepsilon$ $\left(\frac{192.5}{8.4 \times 1}\right) = t_f$

$\therefore t_f = 22.92 mm$

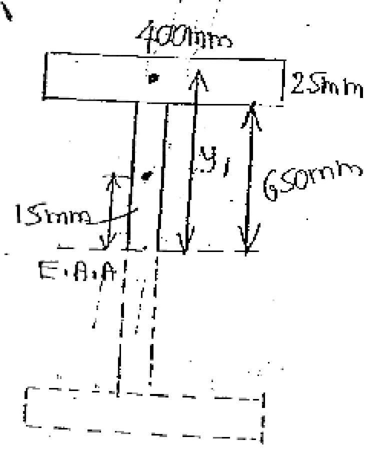
Provide **Flange — $b_f \times t_f = 400mm \times 25mm$**



$$I_{zz} = \frac{400 \times 1350^3}{12} - 2\left[\frac{192.5 \times 1300^3}{12}\right]$$

$$\boxed{I_{zz} = 1.152 \times 10^{10} mm^4}$$

Plastic Modulus $\boxed{Z_p = \Sigma a\bar{y}}$



$$Z_p = 2\left[(400 \times 25)\left(650 + \frac{25}{2}\right) + (15 \times 650)\frac{650}{2}\right]$$

$$\boxed{Z_p = 19.58 \times 10^6 mm^3}$$

(c) Check for "Moment of Resistance": (P-53)

Design Bending Strength } = $M_d = \frac{\beta_b \cdot Z_p \cdot f_y}{\gamma_{mo}}$

Take $\beta = 1$ (For Plastic or Compact

$M_d = \frac{(1)(19.58 \times 10^6)(250)}{1.10} = 4450 \times 10^6$ N-mm

$= 4450$ kN-m

> External Mome

$= 4274.25$ kN-m

(Safe)

Note:- If $M_d < M$, then increase the thickness of Flange.

(d) Check for "Shear Resistance": (P-59-60)

Design shear Force $V_d = \frac{V_n}{\gamma_{mo}}$

(18)

Where $V_n = V_{cr} = A_v \cdot \tau_b$

A_v = Shear Area = $d \times t_w$ (For Welded)

$= 1300 \times 15 = 19500$ mm²

$\therefore$ $\boxed{V_{cr} = A_b \times \tau_b} = 19500 \times 130.48$

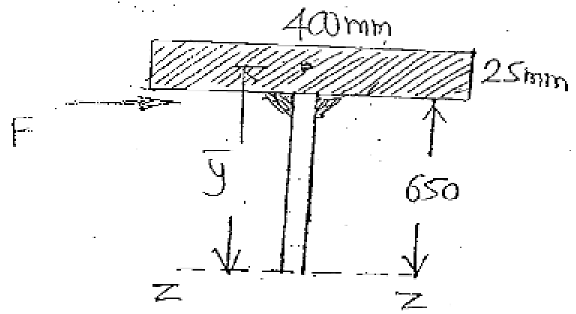
$= 2544.3 \times 10^3 \text{ N}$

$\therefore$ Design Shear Force $\Big\} = \boxed{V_d = \dfrac{V_{cr}}{\gamma_{m0}}} = \dfrac{2544.3}{1.10}$

$V_d = \underline{\underline{2313.0 \text{ kN}}} > \text{External S.F} = 1135.5 \text{ kN}$

(Safe)

(c) Connection of "Flange to Web":



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Horizontal shear at the Junction $\Big\} = \boxed{F = \dfrac{V \cdot a\bar{y}}{I_z}}$ N/mm ☆

$F = \dfrac{(1135.5 \times 10^3)(400 \times 25)(650 + \frac{25}{2})}{1.152 \times 10^{10}} = \boxed{653.0 \text{ N/mm}}$

Force per mm length.

Equating above force with strength of weld per mm length.

$$653\ N/mm = \left[(0.7S)(l)\left(\frac{f_u}{\sqrt{3}\,\gamma_{mw}}\right)\right]2$$

$$= \left[(0.7 \times S)(1mm)\frac{410}{\sqrt{3} \times 1.25}\right]2 \leftarrow \text{Both sides welding.}$$

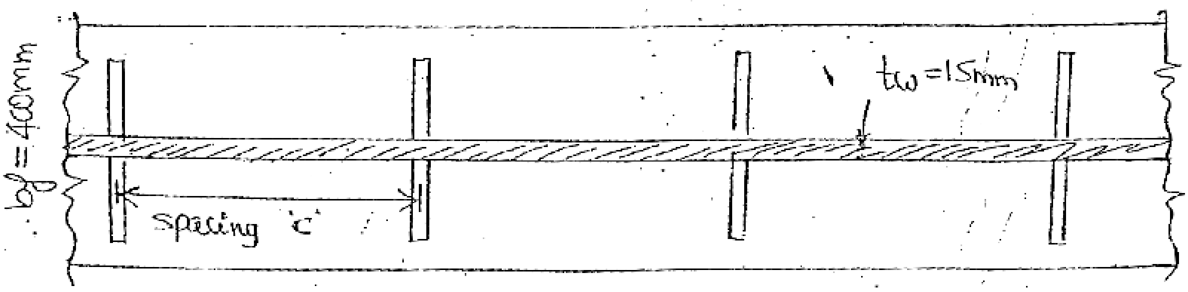
∴ Size of weld S = 2.46 mm

Provide Min. size S = 5mm

— x —

Date 21/03/10

(2) Design of Intermediate Stiffeners:



(i) Ratio → $\left(\frac{d}{t_w}\right) = \left(\frac{1300}{15}\right) = 86.67 > 67$

Hence provide I.S. {The ratio should not exceed 67}

Provide I.S. of size 80mm X 8mm

on either side of Web.

(IV) Connection of I.S. to the Web :

Force required for the connection $= \left\{ \frac{t_w^2}{5 b_s} \right\}$ Page 67

KN/mm

$t_w = 15mm$, b_s = Stiffener out standing $= 80mm$

$\therefore$ Force $= \frac{(15)^2}{5 \times 80} = 0.563$ KN/mm

$= 563$ N/mm →

Equating to the strength of the weld per mm

$563 \text{ N/mm} = \left[0.7 \times S \times l \times \frac{f_u}{\sqrt{3} \, \gamma_{mw}} \right] 4$ ↖ Four side welding

$= \left[0.7 \times S \times 1mm \times \frac{410}{\sqrt{3} \times 1.25} \right] \times 4$

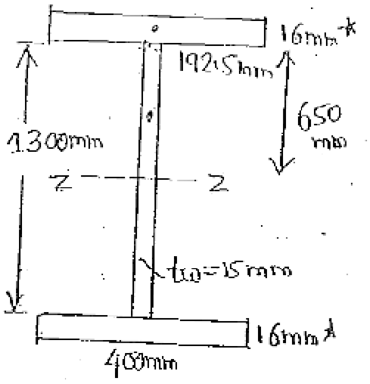
$\therefore \quad S = 1.06mm$

Provide Min. size of Weld = 3mm, — Continuous Weld.

(3) Curtailment of Flange Plate :

The Bending moment is maximum at mid span and it decreases towards the support. Hence, from the economical point of view decrease the thickness of flange plate as moment decreases called curtailment of flange plate. [Standard Thickness of Plate 6mm, 8, 10, 12, 14, 16, 18, 20, 22, 25, 28, 30, 32, 40]

Reduce the thickness of Flange plate from 25mm to 16mm



Plastic Modulus $Z_p = \Sigma a\bar{y}$

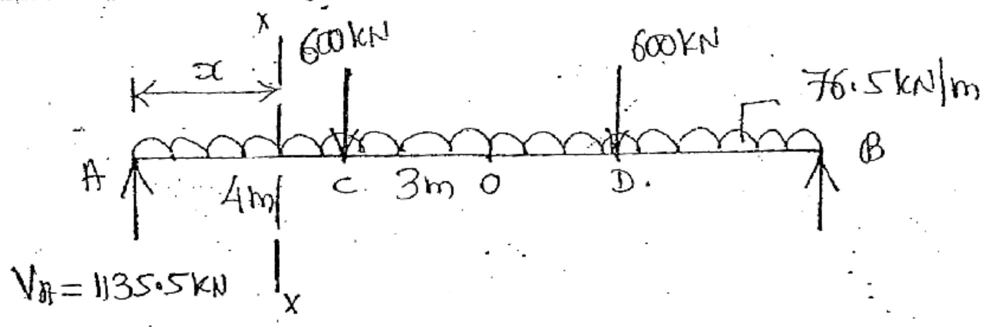
$$Z_p = 2\left[(400 \times 16)\left(650 + \frac{16}{2}\right) + (15 \times 650)\frac{650}{2}\right]$$

$$Z_p = 14.76 \times 10^6 \text{ mm}^3 \quad (21)$$

∴ Design Bending Strength $= M_d = \dfrac{\beta_b \cdot Z_p \cdot f_y}{\gamma_{mo}}$ Page (53)

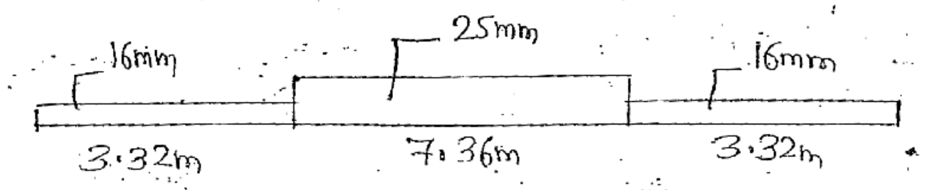
$$= \frac{(1)(14.76 \times 10^6)\, 250}{1.10} = 3355 \times 10^6 \text{ N-mm}$$

$$= \boxed{3355 \text{ kN-m}}$$



$$M_{xx} = 1135.5x - 76.5 \times x \times \frac{x}{2} = 3355 \text{ kN-m}$$

$\therefore$ $x = 3.32$ m from ends.

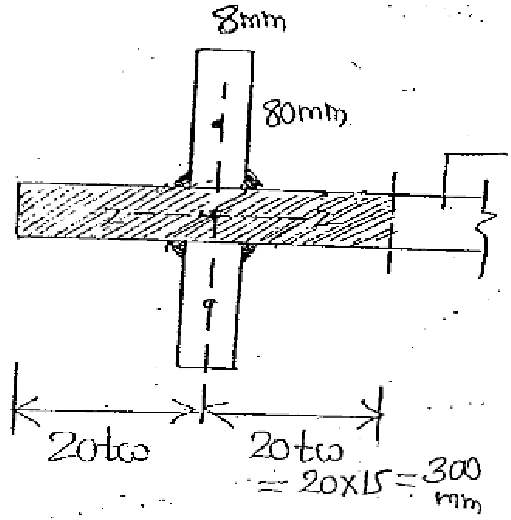


HW Try one more curtailment

Reduce from 25mm to 20mm

Calculate Zp, Md & x

Let us provide E.B.S. plates of size 80mm X 8mm (Assumed)



Area =
r_z = , r_y =
∴ r_{min} =
$\lambda = \frac{le}{r_{min}}$
f_{cd} =
∴ Load P = Ae·fcd

Area = $2(8 \times 80) + 600 \times 15 = 10280 mm^2$

$$I_{zz} = 2\left[\frac{8 \times 80^3}{12} + (8 \times 80)\left(\frac{80}{2} + \frac{15}{2}\right)^2\right] + \left[\frac{600 \times 15^3}{12} + 0\right] = 3.74 \times 10^6 mm^4 = I_{min}$$

$$\therefore r_{min} = \sqrt{\frac{I_{min}}{A}} = \sqrt{\frac{3.74 \times 10^6}{10280}} = 19.07 mm$$

$$\lambda = \frac{le}{r_{min}} = \frac{0.7d}{r_{min}} = \frac{0.7 \times 1300}{19.07} = \boxed{47.72}$$

From Table 9(c) → $f_{cd} = 186.42 N/mm^2$

Load $P = A_e \cdot f_{cd} = (10280)(186.42)$ (23)

$= 1916.4 \times 10^3 N > 1135.5 kN$

(Safe)

(III) Connection :-

$$\left.\begin{array}{l}\text{Force per mm height}\\ \text{of Web}\end{array}\right\} = \frac{\text{Reaction}}{d} = \frac{1135.5\times10^3 N}{1300 mm}$$

$$= \boxed{873.46\ N/mm} \rightarrow$$

Equating the above force with strength of weld per mm

$$873.46\ N/mm = 4\left[(0.7\times S)(1mm)\frac{410}{\sqrt{3}\times1.25}\right]$$

$$\therefore S = 1.64 mm$$

Provide Min. Size of Weld = 3mm

==x==x==

$\therefore F_w = (150 + 40) \times 15 \times \frac{250}{1.10} = 647.72 \times 10^3 N$

< Reaction = 1135.5 kN

Hence provide E.B.S.

(ii) Area of E.B.S. Page (68)

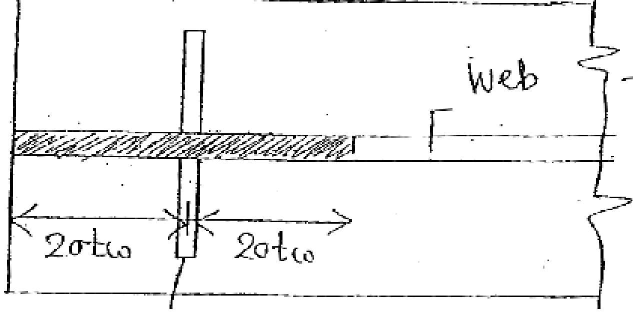
$$F_{psd} = \frac{A_q \cdot f_{yq}}{(0.8 \gamma_{m0})} \geq F_x \text{ (Reaction)} = 1135.5 kN$$

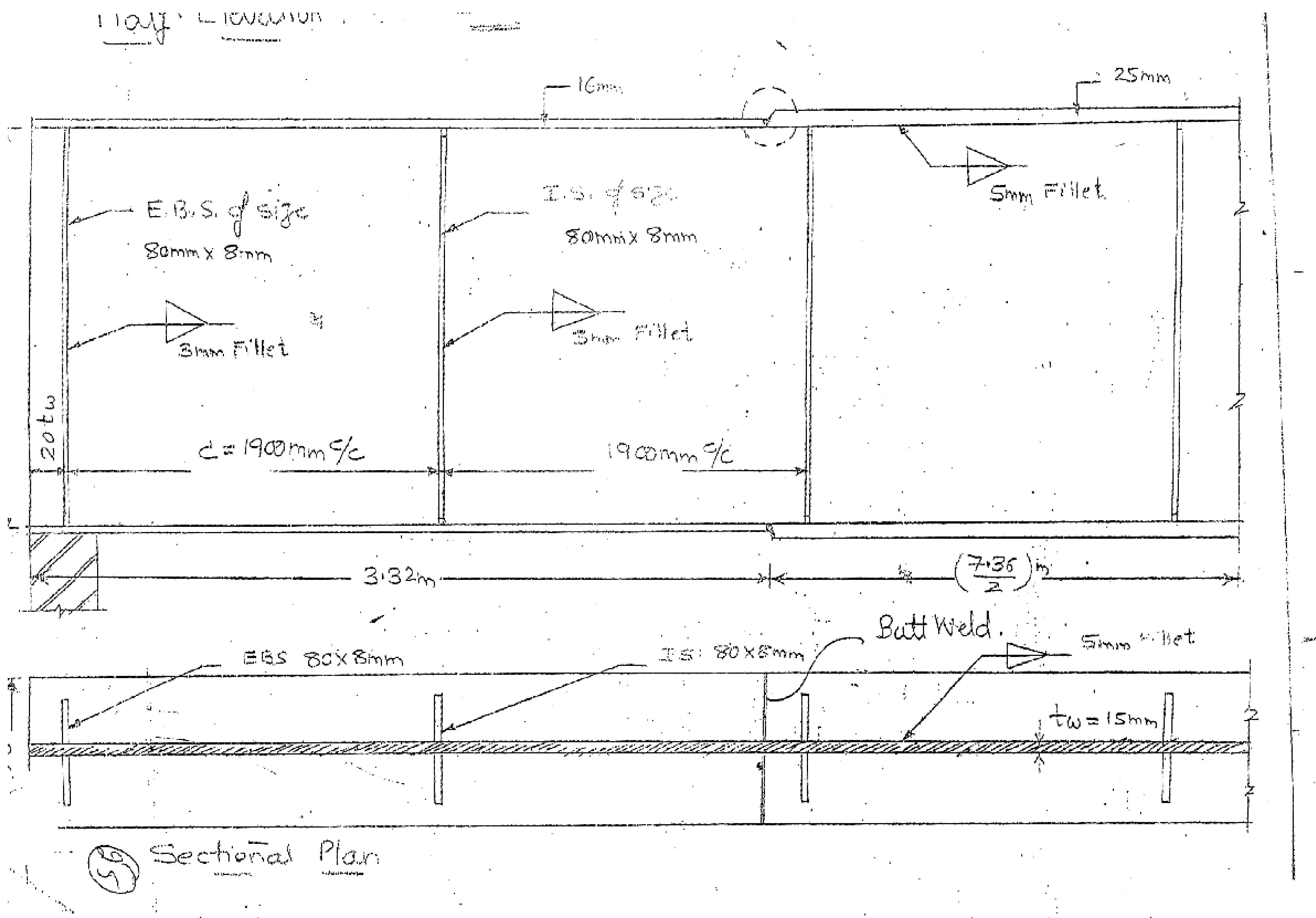
$$\therefore \frac{A_q \times 250}{0.8 \times 1.10} = 1135.5 \times 10^3$$

$\therefore A_q = 3997 mm^2 \approx 4000 mm^2$

The E.B.S. are designed like a compression member subjected to reaction and effective height is "0.7d."

Along with E.B.S. plates, the part of the web (20t_w on either side) also carry reactions.

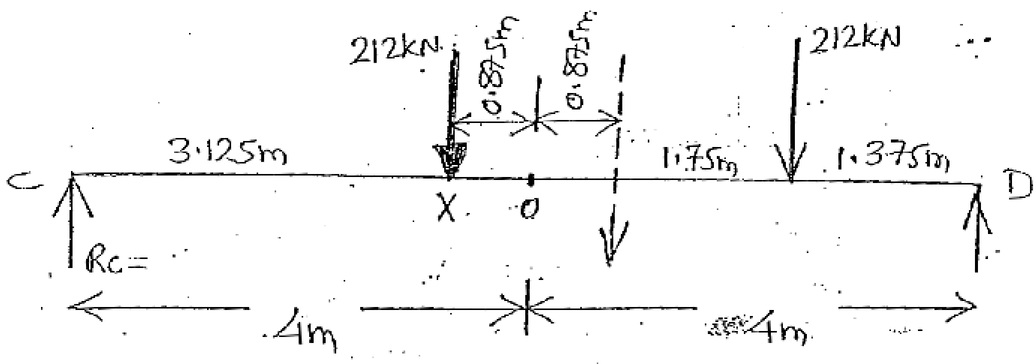



Half Elevation
16mm
25mm
E.B.S. of size
80mm x 8mm
I.S. of size
80mm x 8mm
5mm Fillet
3mm Fillet
3mm Fillet
20tw
d = 1900mm c/c
1900mm c/c
3.32m
(7.36/2)m
Butt Weld.
EBS 80X8mm
I.S: 80X8mm
5mm Fillet
tw = 15mm
Sectional Plan

Sol^2 (a) Load calculation

Max. reaction in crane bridge occurs when the trolley along with hook if it is towards left or right with a minimum hook distance 1m.

"Later take moment under the wheel load which is very close to mid span."



$\sum M_D = 0, \quad R_C \times 8 - 212 \times 1.375 - 212(1.375 + 1.75 + 1.75) =$

$R_C = 165.63 \text{ kN}$

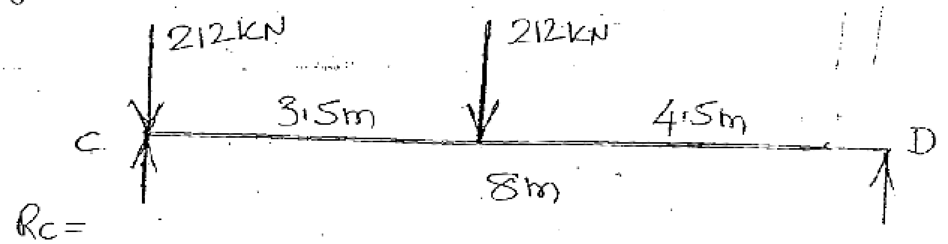
$\therefore \left. M_{max} \right)_X = R_C \times 3.125 = 165.63 \times 3.125 = 517.6 \text{k}$

$\therefore$ Factored Moment $\boxed{M = 776.4 \text{ kN-m}}$

Max. Shear Force :

"The arrangement of wheel load for Max. SF is, Two wheel loads is placed either complete left or right side of the span."

(28)



$\Sigma M_D = 0$

$R_C \times 8 - 212 \times 4.5 - 212 \times 8 = 0$

$\therefore V_{max} = R_C = 331.25\ kN$

$\therefore$ Factored S.F $\boxed{V = 496.88\ kN}$

(c). "Horizontal load" & Its "Moment":

A lateral load is developed due to the application of brakes or the sudden acceleration of the trolley.

It is taken 10% of lifted weight and trolley weight.

$\therefore$ Horizontal Force $= \dfrac{\frac{10}{100}[200 + 75]}{4 \text{ wheels}}$

$= 6.875\ kN \approx 7\ kN$

$\therefore$ Factored Force $= 10.5\ kN$

$\therefore$ Moment Due to Horizontal load $= \dfrac{776.4}{212 \times 1.5} \times 10.5 = \boxed{25.64\ kN\text{-}m}$

↑ load factor

$I_z = 1.765 \times 10^9 \, mm^4$

Increase the above value by 30% approximately

$= 1.30 \times 1.765 \times 10^9 = 2.295 \times 10^9 \, mm^4$

$= 229500 \, cm^4$

From steel Table Try suitable section.

Try

ISWB-500 @ 95.2 kg/m

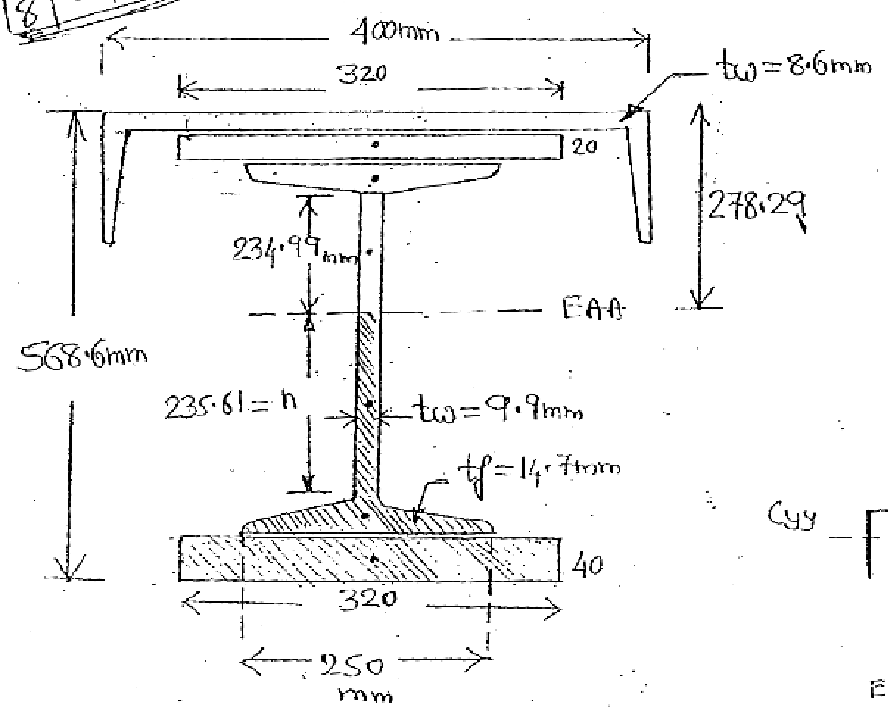
ISMC-400 @ 49.4 kg/m

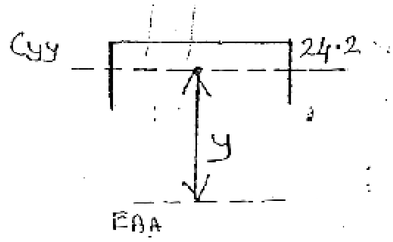
Top cover plate → 320x20mm

Bottom —"— → 320x40mm

18/04/10

Total $I_z = I_x = 230194.5 \, cm^4$





Overall Properties

$I_{xx} = I_{zz} = 230194.5 \times 10^4 mm^4$

Area $= 376.15 \times 100 mm^2$

$C_{xx} = 283.7 mm$ (From Top) & $C_{xx} = 284.9 mm$ (Bottom)

$r_{yy} = 9.57 cm = 95.7 mm$.

ISMC-400 : Area $= 6293 mm^2$, $C_{yy} = 24.2 mm$

ISWB-500 : Area $= 121.22 \times 100 mm^2$

Location of Equal Area Axis.

Area of shaded portion $= \frac{1}{2}$ (Total Area)

$$(9.9 \times h) + (250 \times 14.7) + (320 \times 40) = \frac{1}{2}[376.15 \times 100]$$

$$\therefore \boxed{h = 235.61 mm}$$

Plastic Modulus $Z_p = \Sigma a\bar{y}$

(30)

$$Z_p = (320 \times 40)\left(235.61 + 14.7 + \frac{40}{2}\right) + (250 \times 14.7)\left(235.61 + \frac{14.7}{2}\right)$$
$$+ (9.9 \times 235.61)\frac{235.61}{2} + (234.99 \times 9.9)\frac{234.99}{2}$$
$$+ (250 \times 14.7)\left(234.99 + \frac{14.7}{2}\right) + (320 \times 20)\left(234.99 + 14.7 + \frac{20}{2}\right)$$
$$+ (6293)(278.29 - 24.2) = 9.05 \times 10^6 mm^3$$

↑ Area of channel ↑ C...

(e) Check for "Moment of Resistance":

for "Laterally Un supported" Beam

Design Bending strength } = $M_d = \beta_b \cdot Z_p \cdot f_{bd}$ Page (54)

For Rolled steel section $\alpha_{LT} = 0.21$

$E = 2 \times 10^5 \ N/mm^2$

$L_{LT} = 8m = 8000mm$ (Gantry girder span)

$r_y = 95.7mm$ for whole section.

t_f = Average or Mean Thickness of Flange

Top Flange = 33.8mm = t_f

Bottom Flange = 51.5mm

h_f = c/c distance between Flanges.

h_f = overall depth $- \frac{1}{2}$(Top + Bottom mean thickness)

$= 568.6 - \frac{1}{2}(33.8 + 51.5) = 525.95mm$

$$f_{cr,b} = \frac{1.1\pi^2 E}{(L_{LT}/r_y)^2}\left[1 + \frac{1}{20}\left(\frac{(L_{LT}/r_y)}{(h_f/t_f)}\right)^2\right]^{0.5}$$ Page (54)

$$f_{crb} = \frac{1.1 \pi^2 \times 2\times10^5}{\left(\frac{8000}{95.7}\right)^2}\left[1 + \frac{1}{20}\left(\frac{8000/95.7}{525.95/33.8}\right)^2\right]^{0.5}$$

$f_{crb} = 485.65 \ N/mm^2$

∴ From Table 13(a) P-55

∴ Design Bending Comp. Stress $\} = f_{bd} = 187.96 \ N/mm^2$

∴ $M_d = \beta_b \cdot Z_p \cdot f_{cbd} = (1)(9.05\times10^6)(187.96)$

∴ $M_d = 1701.3\times10^6$ N-mm > 776.4 kN-m moment

(Safe).

(d) Check for "Shear Resistance":

Design shear strength $V_d = \frac{V_n}{\gamma_{mo}} = \frac{A_v \cdot f_{yw}}{\sqrt{3} \times \gamma_{mo}}$ P-59.

A_v = Shear area = $h \times t_w$ For Hot Rolled.

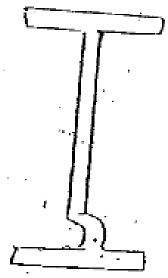
h = overall depth of the section

$A_v = 568.6 \times 9.9 = 5629.14$

$$\therefore V_d = \frac{(5629.14) \times 250}{\sqrt{3} \times 1.10} = 738.63 \times 10^3 \, N$$

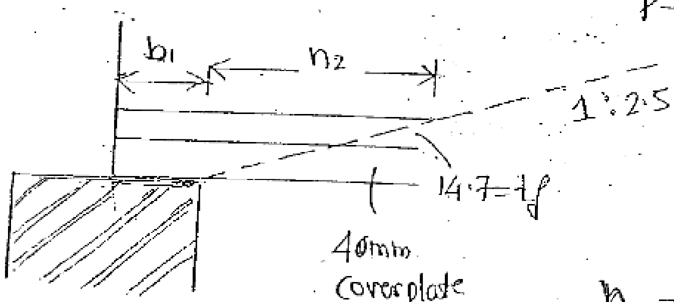
$$> 496.88 \, kN \text{ (SF)}. \text{ Safe}$$

(9) Check for "Web Crippling":



Local capacity of the Web $= F_w = \dfrac{(b_1 + n_2)\, t_w \, f_{yw}}{\gamma_{mo}}$

P– 67



$b_1 = 100mm$ (Assume)

$n_2 = 2.5[40 + 14.7]$

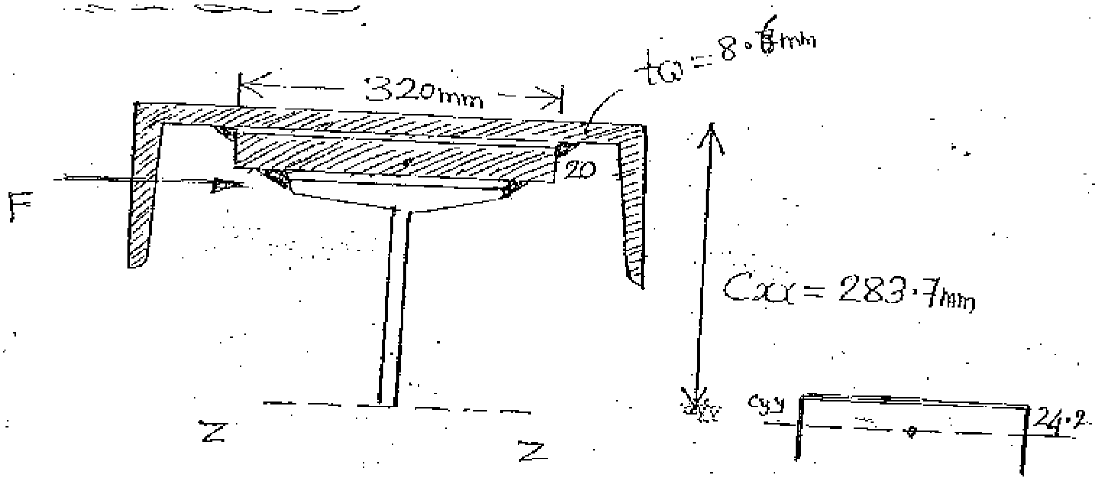
$n_2 = 136.75mm$

$$\therefore F_w = (100 + 136.75) \times 9.9 \times \frac{250}{1.10}$$

$$F_w = 532.68 \, kN > 496.88 \, kN \text{ (S.F)}$$

Safe !!

(i) Connection :



The Force at the Junction $\} = \boxed{F = \dfrac{V \cdot a\bar{y}}{I_Z}}$ N/mm

$$F = \frac{(496.88\times10^3)\left[6293\,(283.7-24.2) + (320\times20)\,(283.7-8.6-10)\right]}{230194.5\times10^4}$$

$$\boxed{F = 718.71\ \text{N/mm}}$$

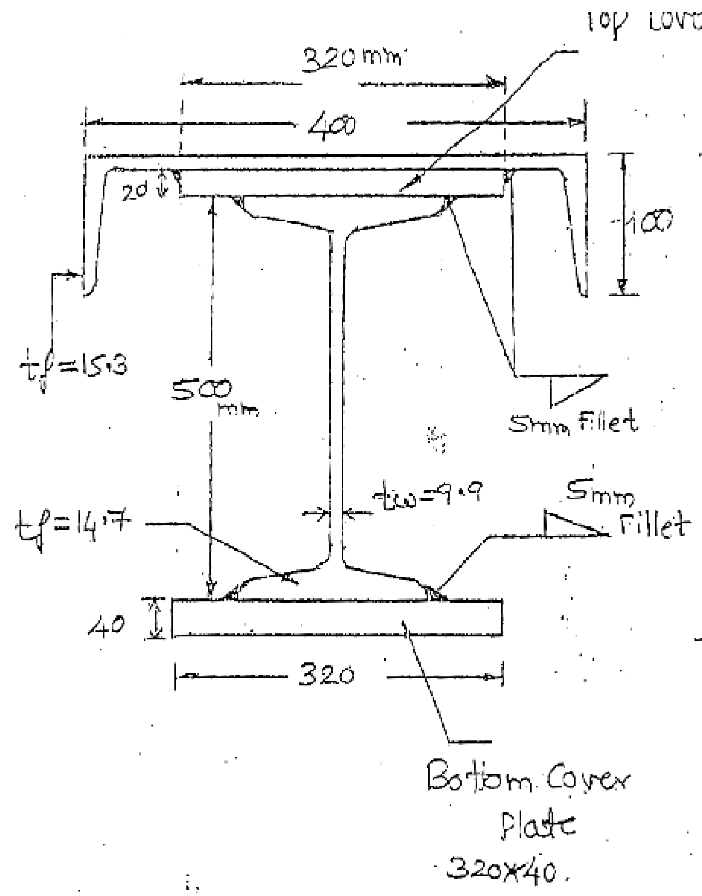
Equating the above force with strength of weld

$$718.71\ \text{N/mm} = 2\left[0.7\times S\times 1\text{mm}\times\frac{410}{\sqrt{3}\times1.25}\right]$$

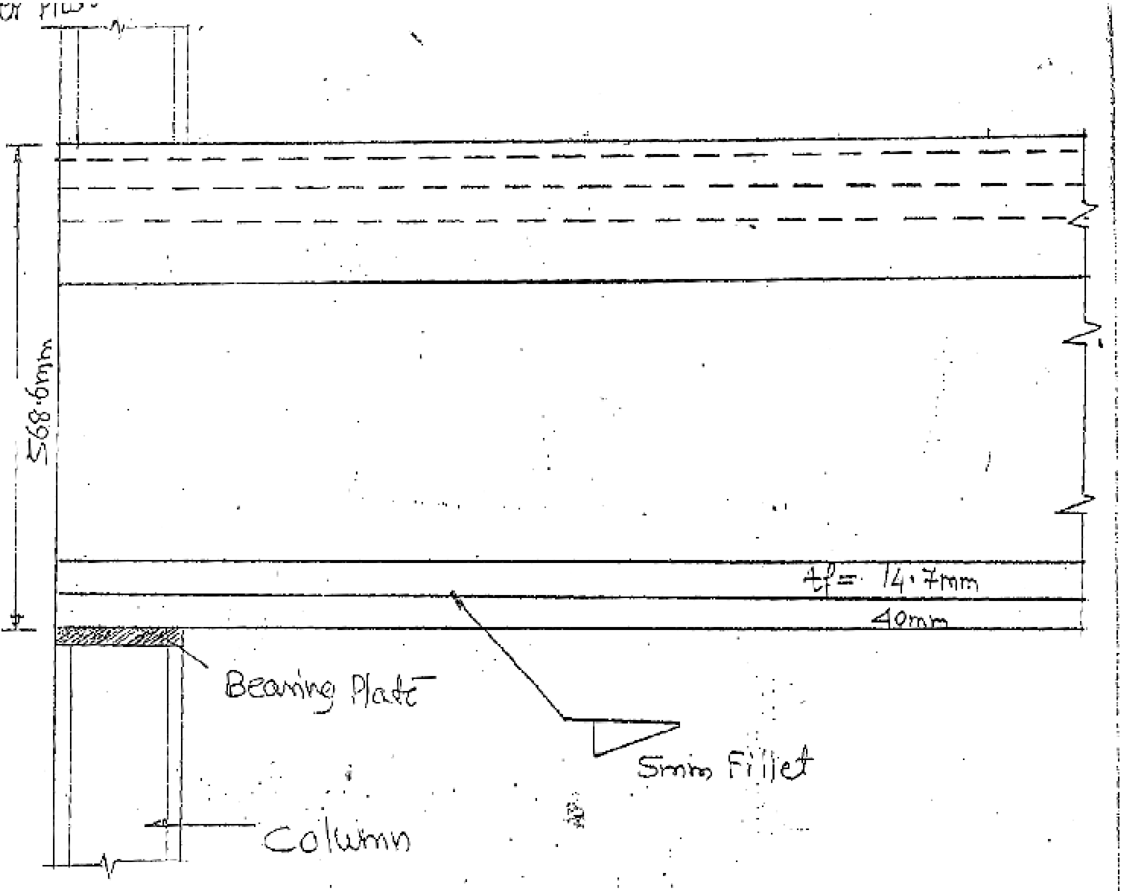
$$\therefore\ S = 2.71\text{mm}$$

Provide Min. 5mm Weld

=== x ===



C/S



Elevation

1 : 5

33

$(50+20) = 70$