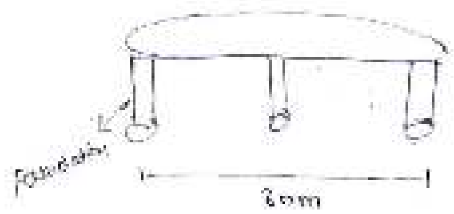
UNIT - I

→ Component of Bridge :-

→ load consider on bridge : Pg - 39, 40 (D.J Victor)
(i) Dead load
2) Live load

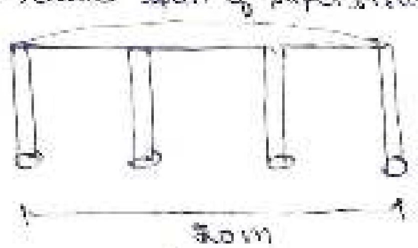
⇒ Economical span :-
Total cost of superstructure of one span is equal to the cost of sub-structure of same span.

Example



Cost of super > cost of sub

to equal this.
We will reduce span of superstructure or provide more foundation



⇓

cost of super = cost of sub-structure.

Scour Depth : - Pg. 32 (D.J Victor)

Impact factor:-

IRC class A or B loading :-

$$\text{Impact factor} = \frac{A}{(B+L)}$$

A = constant value
For R.C.C bridge A = 4.5 or B = 6
For steel bridge A = 9 or B = 13.5

For span less than 3m

Impactor factor

for R.C.C bridge = ·5

for steel bridge = ·545

When span exceede 45m, impact factor for

R.C.C bridge = 0.088

steel bridge = 0.154

IRC class AA

When span greater than 9m, impact factor for

Tracked vehicle = 10% taken for 9–40 m

Pg no 46

Type of Bearing :-

Pg-(414-418)

1. Fixed bearing.
2. Expansion bearing.

1. Fixed Bearing :- 1. It permit rotation while preventing expansion

2. Expansion Bearing :- 2. It accomodate both horizontal moment & rotation.

Type of bearing is to be selected depend upon type of

In case of major bridge cost of bearing are in the range of 10 to 15% of total cost. In case of culvert no special bearing are required. A thick layer of kraft paper is provided b/w slab and bed block.

2. Expansion Bearing :-

Types :-

(a) Sliding plate bearings :-
(b) Sliding cum rocker bearing :-
(c) Steel roller cum rocker bearing :-
(d) R-C rocker cum rocker bearing :-
e) Elastomeric bearing.

Fix-type Bearing :-

(a) Steel rocker bearing.
(b) R-C hinged rocker bearing.

Culvert :

Unit-2

Step-1 ⇒ Assume depth of slab, W.C, width of road if not given, Calculate L_{eff}.

Step-2 ⇒ B.M → from D.L =

$$B.M = \frac{WL_{eff}^2}{8} = B.M_{D.L}$$

B.M from live load (L.L) =

For max. B.M Load should place near to centre.

(a) class AA Tracked Vehicle
(b) class AA Wheeled Vehicle
(c) class A loading
(d) class 70R Loading

} Maximum

Step-3 ⇒ Maximum B.M

$$Max.\ B.M = B.M_{DL} + B.M_{LL}$$

Step-4 ⇒ $Max.\ B.M = Qbd_{req}^2$

$d_{req} = ?$

Apply check ⇒ $d_{assumed} > d_{required}$.

Step 5 Reinforcement in Both direction :

(1) M.O.R_s = Max. B.M

$$A_{st} \cdot \sigma_{st} \cdot j \cdot d = B.M$$

Distribution steel

$$B.M = 0.3\ B.M_{DL} + 0.2\ B.M_{LL}$$

↓

$$B.M = A_{st} \cdot \sigma_{st} \cdot J \cdot d$$

Ques: Design R.C.C slab culvert given data for straight highway:

Width = 12m, No footpath provided.

Material M-25, Fe 415.

Clean span = 5m

Wearing Course = 56 mm thick asphaltic concrete.

Effective span	Slab thickness Centre	Slab thickness Edge
3.0	450	300
4.0	500	350
5.0	550	400
6.0	600	450

Pg. No - 112

Pg-No ⇒ 41, 43, 45 ⇒ class AA
class A or B
70R loading

Pg-No ⇒ 39 ⇒ Loads

IRC specification for live load :-

IRC - Class AA ⇒ • Tracked • Wheeled

Class A or B ⇒

70R loading ⇒

Assume slab thickness = 550 mm

Using 20mm dia. bar

clear cover = 50mm

$= 550 - \left(\frac{\phi}{2} + 50\right)$

$= 550 - \left(\frac{20}{2} + 50\right) = 550 - (10+50)$

$= 490$ mm

Width of bearing = 400mm

Eff. span = (clear span + Eff. depth)

= or (Lc + Bearing)

$= 5 + \frac{490}{1000} = \underline{5.49}$ m

$= 5 + \frac{400}{1000} = \underline{5.4}$ m

[taking least Values from this]

Eff. span = 5.4 m

<u>Dead load :</u>

$= \left[\frac{550+400}{2}\right]\frac{1}{1000} \times 25\ kN/m^2$

11.40 kN/m²

Pg-110 → D.L for wearing coat = $2 KN/m^2$

- Total Dead load = 11.40 + 2 = 13.40 KN/m^2

$$B.M_{D.L} = \frac{wL^2}{8}$$

$$= \frac{13.40 \times 5.4^2}{8} = 48.8 \ KN\text{-}m$$

Impact load :→

span 5 to 9m

Tracked Vehicle = 25 - 10 %

Wheeled = 25 %

For tracked vehicle

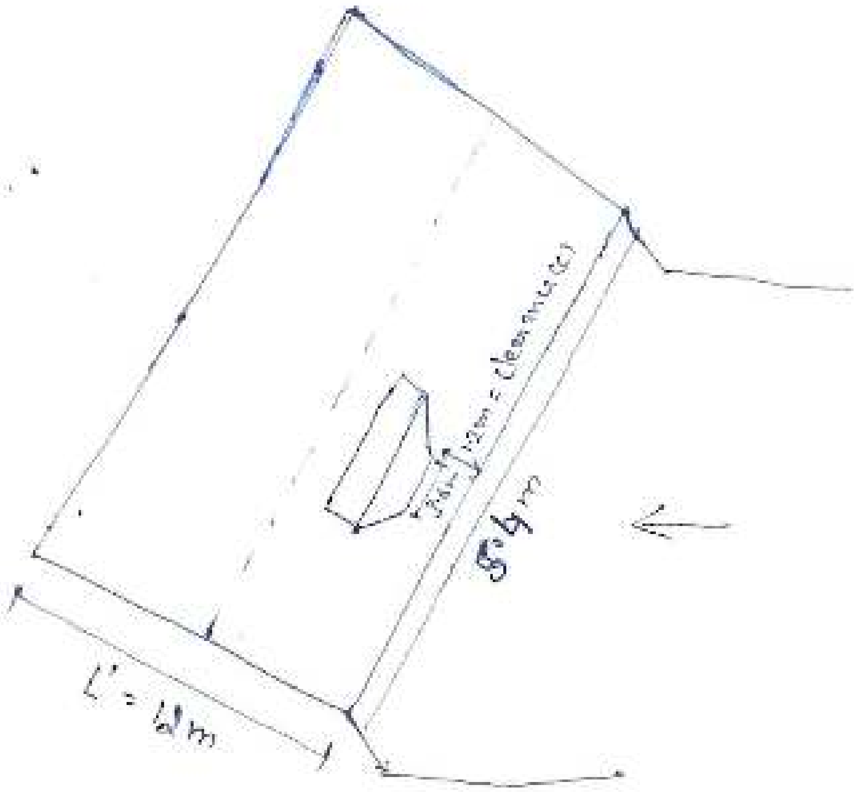
Now impact load for 5.4m span than we can calculate the value by interplotation -

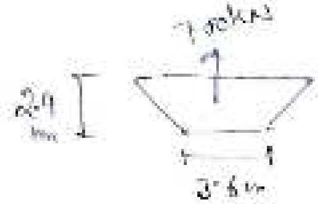
$$\overset{5.4}{5 \ — \ 9}$$

$$25 \ — \ 10$$

$$= 25 - \frac{(25-10)(5.4-5)}{(9-5)}$$

$$= 25 - \frac{15 \times 0.4}{4} = 23.5$$





~~Total~~ For tracked ~~Vehicle~~ load :

$700 + \frac{23.5}{100} \times 700$

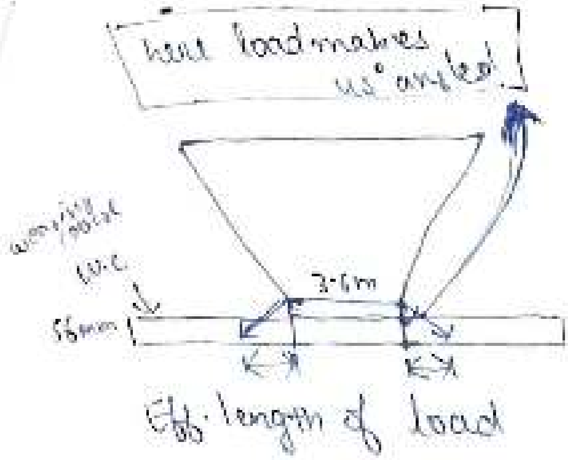
$= 700(1 + .235)$

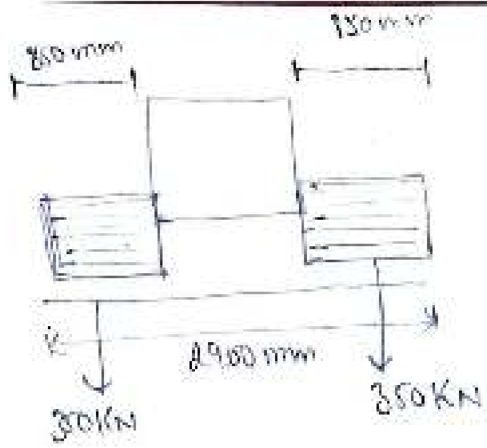
Total load $= 700 \times 1.235$

$= 864.5$

From page No. 41

(clearance) $C = 1.2m$



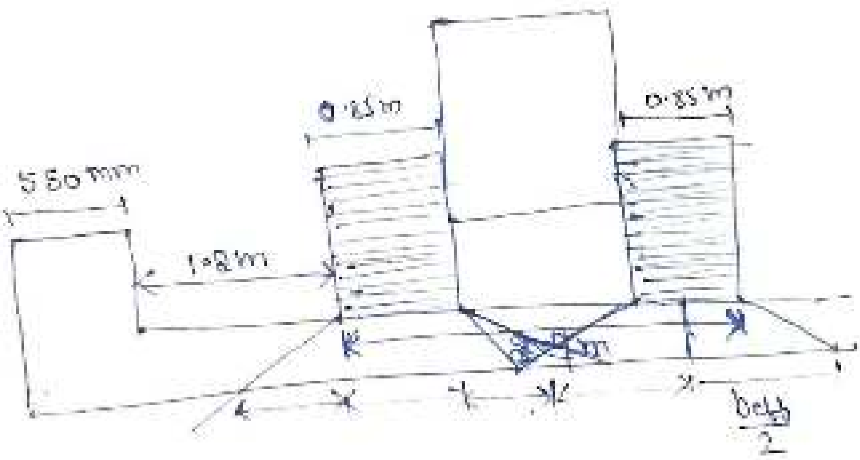


Effective length of load :- $3.6m + 2(ts + w.c)$

$$= 3.6 + 2\left(\frac{56}{1000} + \frac{550}{1000}\right)$$

$$= 4.812 \text{ m}$$

550 mm = slab thickness (assumed)



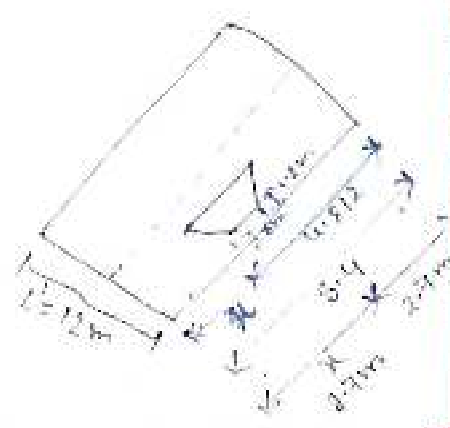
Eff. width of load :-

$$b_{eff} = K \cdot x \left[1 - \frac{x}{L}\right] + bw$$

Now K = 5.4 – 4.812

x = 2.7 m

L = 5.4 m



$$b_w = \left(\frac{850}{1000} + \frac{2\times 56}{1000}\right)$$

$$= (\text{wheel width} + 2\cdot W\cdot C)$$

Now put these values:-

$$b_{eff} = 3\times 2.7\left[1-\frac{2.7}{5.4}\right] + \left[\frac{850}{1000}+\frac{2\times 56}{1000}\right]$$

$$= 5.012\ m$$

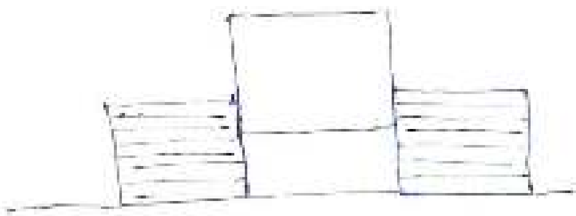
Pg.No. 420

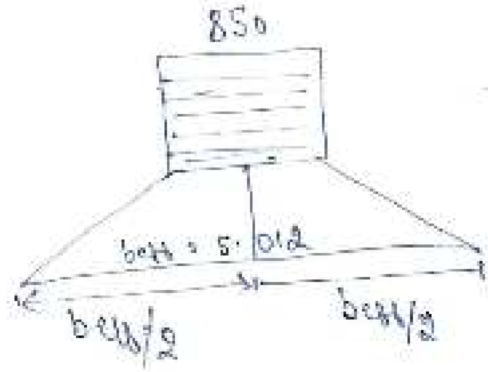
Value of K

$$\frac{L'}{L} = \frac{12}{5.4} = 2.22$$

Now

K = simply supported = 3

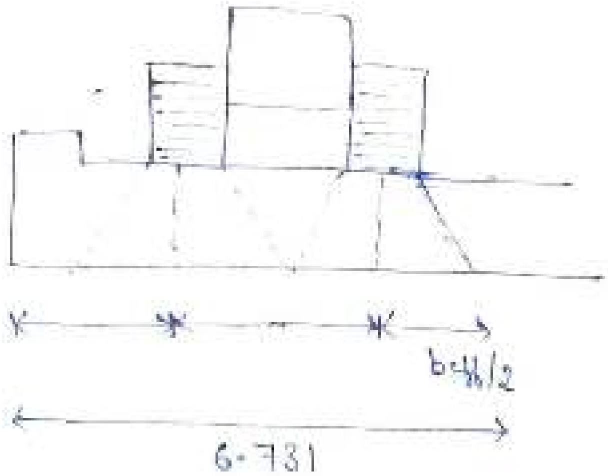




Wheeled Vehicle effective length:

$$L = 150\,mm + 2(t_s + t_w) > 1200$$ ([illegible])

$$L = 250\,mm + 2(t_s + t_w) \Rightarrow$$ class A 114 kN



beff/2 इसलिए करते हैं cause हमें पीछे वाली dispersion length पता है कि कितना load कितनी length में distribute हो रहा है और load distribution कि जितना side में हमें dispersion length पता हो उतना beff/2 लेते हैं

Avg. intensity of load,

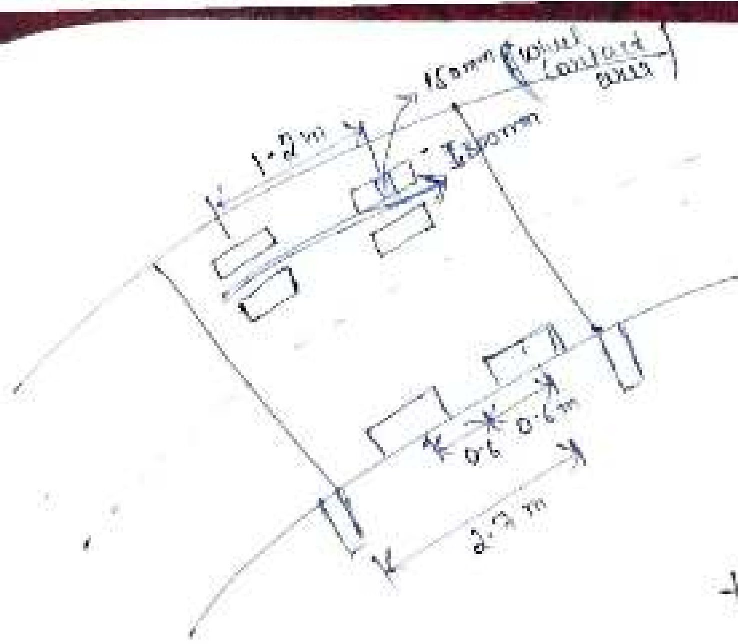
$$= \frac{\text{Total load}}{\text{Area}}$$

$$w = \frac{864.5}{4.812 \times 6.731} = 26.7 \text{ KN/m}^2$$

$$R_a \times 2.7 - M_x - 26.7 \times \frac{4.812}{2}\left(\frac{1}{2} \times \frac{4.812}{2}\right) = 0$$

$$M_x = R_a \times 2.7 - 26.7 \times \left(\frac{4.812}{8}\right)^2$$

M_x



t_c = contact area of one tyre

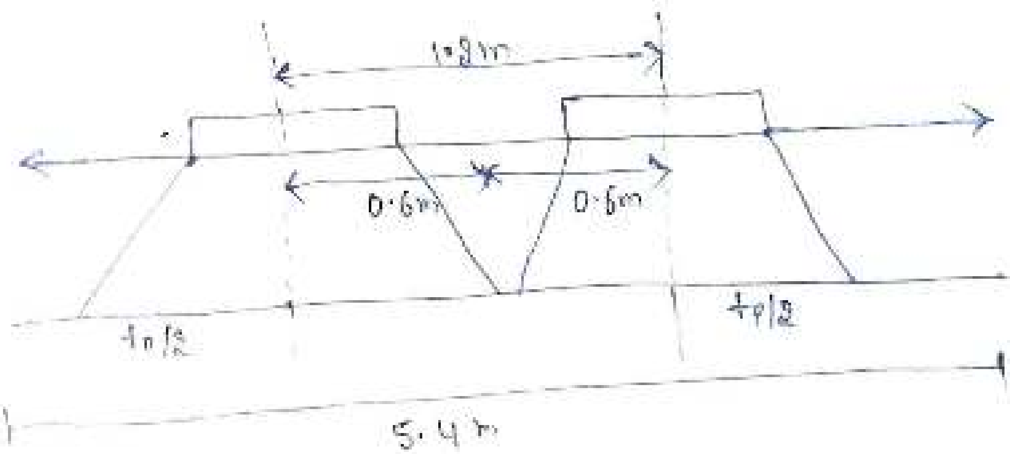
t_p = distributed Pressure

Length wise :-

$$t_p = t_c + 2(t_w + t_s)$$

$t_c = 150mm$, $t_s = 490mm$, $t_w = 56mm$

$$= \frac{150}{1000} + 2\left(\frac{56}{1000} + \frac{490}{1000}\right) = 1242 > 1200 \text{ mm}$$



greater than 1.2m (1200mm) it will overlap the load

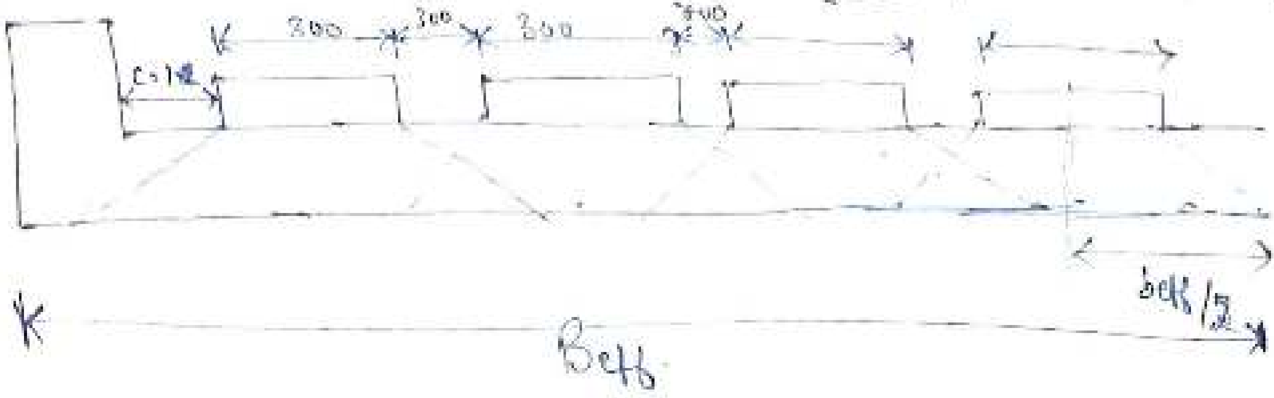
effective length = 1.2 + 1.242 = 2.442

If ≤ 1.2

If > 1.2

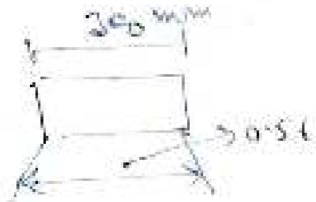
Width Wise :-

IRC Code অনুযায়ী



$$b_{eff} = Kx\left(1-\frac{x}{L}\right) + b_w$$

$K = \frac{L}{[redacted]} = \frac{12}{5.4}$ $\quad x = 2.1$



$b_w = \frac{300}{100} + 2 \times \frac{55}{1000}$

Load = 400N

Impact factor = 25%

Total = 400 × 1.25

$$w_1 = \frac{400 \times 1.25}{L_{eff} \times B_{eff}}$$

Theory :

UNIT-3

Typical form of box girder :-

(a) → Rectangular box with wide cantilever span on either side.

(b) → Trapezoidal box section :

(c) → Two box section which ~~are~~ connected together by bracing.

(d) → One wide box section sub divided into 3 cells.

(e) – Two box section kept wide apart

(f) → one middle box section with one longitudinal girder on either side

The steel box girder is generally acknowledged as efficient and economical form of bridge. The modern use of box girder calls for special care in design and fabrication. Box girder is economical for long span. Example - Rio – NITEROI Bridge in Brazil. with 200m to 300m span.

PLATE GIRDER

Step 3 Impact factor

$CDA = 0.15 + \frac{8}{6+L}$

< 1

Step-4 Shear force :-

① $D.L = \frac{wl}{2} = \frac{14.5 \times 30}{2} = 217.5$ KN

② $L.L = \frac{W}{4} = \frac{2927}{4} = 731.75$ KN

③ Impact (CDA) coefficient of dynamic augment = 0.372 × 731.75

S.F = ① + ② + ③

=

Step-5

Avg. depth $\frac{1}{8}$ to $\frac{1}{10}$ of slab

Web = $\frac{30}{8}$ to $\frac{30}{10}$

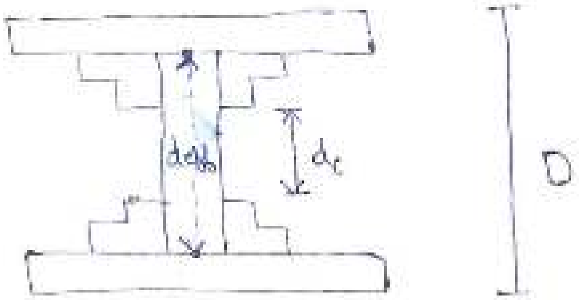


Plate girder

$\Rightarrow$ Economical depth = $5\sqrt[3]{\frac{M}{\sigma_b}}$

[Assume σ_b - 141 $\quad d_c/t_w > 35$

150 $\quad d_c/t_w < 35$]

$\Rightarrow$ Economical depth = $5\sqrt[3]{\frac{8645.2 \times 10^6}{141}}$ = 1970 mm

Thickness of web based upon shear force, - minimum thickness of web for plate girder is 8mm. Let us assume 10mm.

τ_v = avg. shear stress for mild steel - 85 N/mm²

as per I.R.C 24.

$$\tau_v = \frac{V}{h \cdot t_w} \rightarrow 85 = \frac{V}{d \cdot 10\,mm}$$

(h ↓ d)

$$d = \frac{1221.5 \times 10^3}{85 \times 10} = 1437$$

$$d = 1437$$

$$d \cong 1600 \times 10$$

d t_w

A_w

Step- Flange plate :-

$$A_F = \frac{M}{\sigma_b \cdot d} - \frac{A_w}{6}$$

$$= \frac{8648.2 \times 10^6}{141 \times 1600} - \frac{1600 \times 10}{6} = \underline{35654\ mm^2}$$

Flange width (B)

$$= \frac{L}{40} \text{ to } \frac{L}{45}$$

$$= \frac{30000}{40} \text{ to } \frac{30000}{45}$$

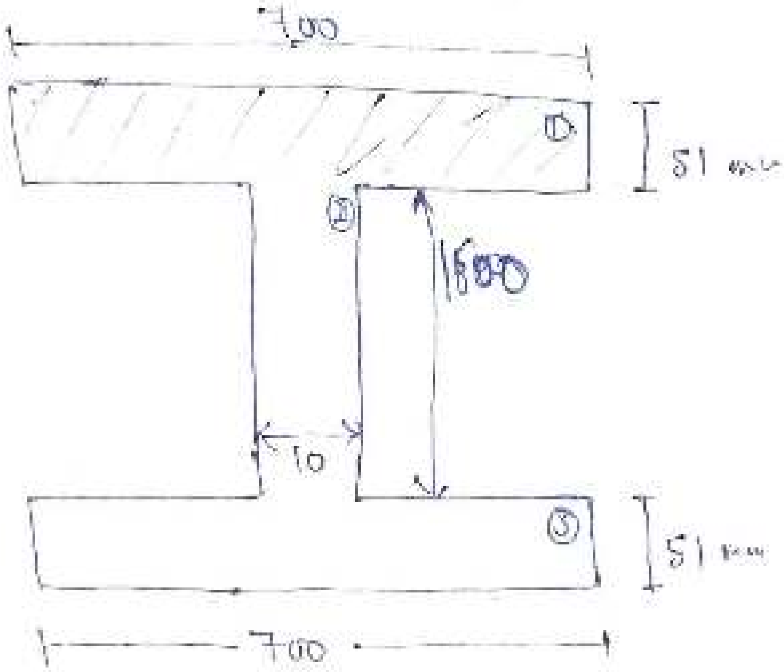
$$= 750 \text{ to } 670\ mm$$

We take Value = $\underline{\underline{700}}$ Assume

$B \times t_f = \text{Area}$

$700 \times t_f = 35654$

$t_f = \frac{35654}{700} = 50.93 \approx \underline{51}\ mm$

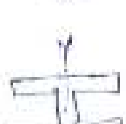


$I_{xx} = I_{xx_1} + I_{xx_2} + I_{xx_3}$

$= \frac{bd^3}{12} + 2\left[\frac{bd^3}{12} + A r_1^2\right]$

$= \frac{10 \times 1600^3}{12} + 2\left[\frac{700 \times 51^3}{12} + 700 \times 51 \times \left(800 + \frac{51}{2}\right)^2\right]$

$= \underline{5208 \times 10^7\ mm^4}$



$I_{yy} = 2\left(\frac{db^3}{12}\right) + \frac{db^3}{12}$

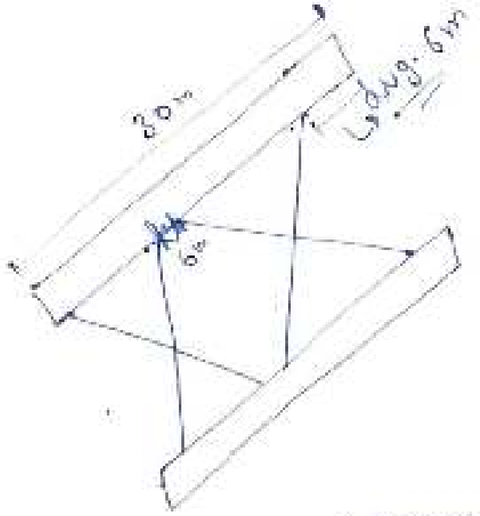
$= 2\left(\frac{(700)^3 \times 51}{12}\right) + \frac{10^3 \times 1600}{12} = 291.5 \times 10^7\ mm^4$

$$r_{yy} = \sqrt{\frac{I_{YY}}{A}}$$

$A = 2 \times 50 \times 700 + 1600 \times 16$

$= 86000\ mm^2$

$$= \sqrt{\frac{291 \times 10^7}{86000}} = 185$$



Let it braced laterally at every 6 m.

$$C_s = \frac{26771300}{(l/r_y)^2} \sqrt{1 + 0.05\left(\frac{L}{r_y} \cdot \frac{t_e}{D}\right)^2}$$

$$= \frac{2677300}{(6000/185)^2} \sqrt{1 + 0.05\left(\frac{6000}{185} \cdot \frac{51}{1702}\right)^2}$$

$= 2604.6\ N/mm^2$

[If $C_s > 2150$ than value of $\sigma_{bc} = 158$]

If less than 2150 than we take value of σ_{bc} from table (Pg-172)

Now $\sigma_{bc} = 158$

Step - Check for Bending stress

$$\frac{M}{I} = \frac{\sigma}{y} \Rightarrow \frac{MY}{I_{xx}} = \sigma_{bc}$$

$$= \frac{8645.2 \times 10^6 \times 851}{5208 \times 10^7} = 141.26\ N/mm^2$$

< 158

Hence Safe.

Step- Check for shear stress ÷

Calculate ⇒ $\frac{d}{t} = \frac{1600}{10} = 160$ mm

Assume spacing of stiffner

$= 0.6 - 0.9d$

Let $= 0.9d$

$= 0.9 \times 1600 = 1500$ mm

From table 8W
Pg - No - 173
→ $\tau_v = 87$ N/mm²

τ_v actual $= \frac{V}{t_w \times h}$

$= \frac{1221.5 \times 10^3}{10 \times 1600} = 76.3$ N/mm²

If τ_v actual is less than 87 N/mm², than it is safe.

Truss Bridge :-

It is economical is span 100 to 200 m. A bridge truss drives its economy from its two major structural advantage.

i) Primary forces on its member are axial forces.

2) Greater over depth, permissible with its open web construction leads to reduce self weight when compared with solid web system.

Most Common form in Warren truss. The pratt truss is consider to be advantageous in that the longer diagonal are in tension while shorter vertical are in compression.

Arch Bridge :-

Arch form is best suited to deep gorges with steep rocky bank which furnish efficient natural abutment to receive heavy thrust exerted by the rib.

Disadvantage :-

- Costly during construction of abutment when there is no rock for arch bridge.
- Time consuming.

⇒ It economical span is 100 to 250 m

Ex: Rainbow bridge across niagra river at Niagra fall.

Cantilever Bridge :-

A cantilever bridge with a single main span consist of an anchor arm at either end b/w abutment and the pier.

A cantilever arm from either pier to end of the suspended span such an arrangement permit a longer clear span for navigation. The firth of Forth bridge with two main span of 521 m each became a milestone in the bridge construction on its completion in 1889.

Cable stayed Bridge :-