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Plate Girder

It is a built up beam subjected to heavy loading and long span. It has following component:-

1. Flange :- It is made of steel plates and flange angle. Standard size of flange angle is ISA 150x150x15
2. Web plate :- Size of web plate depend upon shear force. Thickness of web plate shall not be less than 6 mm.
3. Vertical intermediate stiffness :- These are provided in the form of angle section on both sides of web plate. The stiffness provide lateral strength to the web plate. So that buckling of web can be control. Standard size of stiffness is ISA 100x100x10.
4. Bearing stiffness :- These are provided at support, end support in the form of of double angle on both sides of web plate. Standard size of Bearing stiffness ISA 130x130x10 mm
5. Horizontal stiffness :- This is provided in middle of web plate if the ration of depth of web to thickness of web is more than 200.
6. Splices :- If plates G are not available to the required length then 2 plates G are joined in the form of double cover butt joint. The plates on both sides of web plates for double cover butt joint is known as splices.
7. Angles are also provided with splices if necessary.

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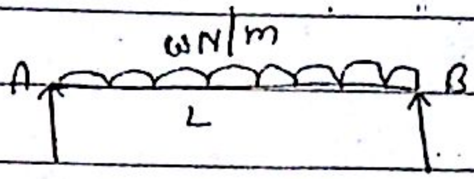
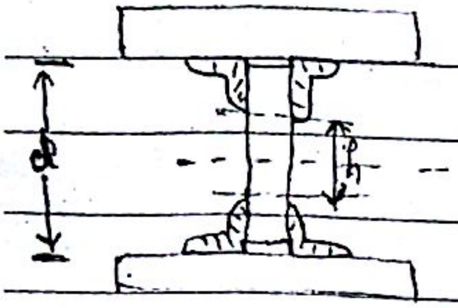
Steps for design the plate Girder :-

Step-1. Assume self weight of girder = $\frac{W_{s.g.} \times L}{300}$ N/m

So. $W = W_{s.g} + W_{self}$





Design of web :- It is designed for shear force

$S.F = \frac{wl}{2}$ N.

Depth of the web.

Area of the web $(A_w) = \frac{S.F}{\sigma_s}$ mm²

Maximum permissible shear stress = 100 N/mm²

Depth of web = $5.5 \sqrt[3]{\frac{M}{f_b}}$

where M = bending moment. = $\frac{wL^2}{8} \times 1000$ = N mm

∴ f_b = Max. permissible bending stress = 165 N/mm²

The clear hight of web (h) = d − connected leg of angles

$A_w = h t_w$

Web thickness (t_w) = ? It shall not be less than 6 mm.

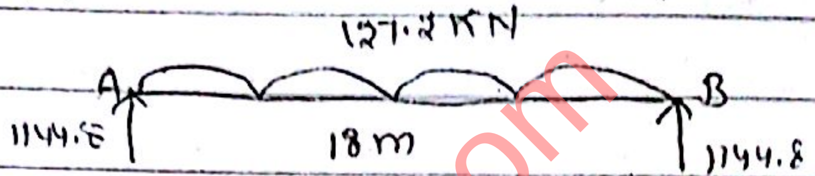
Q. A plate girder have span 18 m. It carries a UDL of 120 kN/m. use 20 dia. rivets and assume suitable stresses. Design the plate girder.

Sol: Step-1 Assume self weight of girder.

$$= \frac{W_{dig} \times L}{300} = \frac{120 \times 18}{300} = 7.2 \text{ kN}$$

$\omega = 120 + 7.2$

$\omega = 127.2$ kN/m



$$R_A = \frac{127.2 \times 18^{9}}{2} = 1144.8 \text{ kN}$$

S.F = Maximum Reaction = 1144.8

Step-2. Max. bending moment $= \frac{\omega L^2}{8} = \frac{127.2 \times 18^2}{8}$

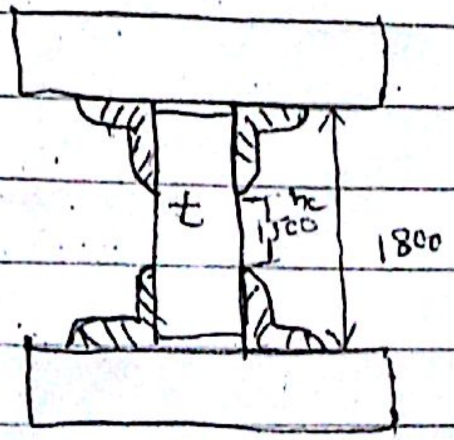
$= 5151.6$ kNm

Step-3 Economical depth of plate girder

$$= 5.5 \sqrt[3]{\frac{M}{\sigma_b}} = 5.5 \sqrt[3]{\frac{5151.6 \times 10^6}{165}}$$

$= 1730 \simeq 1800$

* Web plate shall not touch Flange plate there is a clearance of 5mm b/w Flange plate and web plate.
Flange plate and web plate are joined by ISA 150 x 150 x 15 on both side of web.



(h) The clear height of web = 1800 − 300 = 1500

let t_w = web thickness.

Assume max. permissible shear stress 100 N/mm²

web is design for shear force

$$A_w = \frac{S.F}{\sigma_s} = \frac{1444.8 \times 1000}{100} = 11448 \text{ mm}^2$$

$$A_w = h_c t_w$$

$$11448 = 1500\, t_w$$

$$t_w = 7.632 \text{ mm}$$

let $t_w = 8$ mm

$$\frac{h_c}{t_w} = \frac{1500}{8} = 187.5 < 200 \quad \therefore$$

Geometry of section is ok

Design of flange :- (A_f) Area of flange $= \frac{M}{\sigma_b \cdot h} - \frac{A_w}{8}$

$$A_f = \frac{5151.6 \times 10^6}{165 \times 1800} - \frac{1790 \times 8}{8} = 15555 \text{ mm}^2$$

flange area is provided by flange plate & flange angle.

Size of flange angle 150×150×15 from steel tables is = 42.78 cm² for 1 angle

For 2 angle = 2×42.78 = 8556 mm²

There are four rivet hole in 2 angle

So Area of four rivet hole is = $d \times t \times 4$ = 21.5×15×4

= 1290 mm²

∴ Net area provided by angle

$= 8556 - 1290 = 7266\ mm^2$

Net Area to be provided by the cover plate

$15555 - 7266 = 8289.6\ mm^2$

Width of flange plate (B) = 2 out-stand + 50 mm

$= 2 \times 150 + 50 = 350\ mm$

there are 2 rivet hole in flange plate

therefor net width $= 350 - 21.5 \times 2 = 307$

Let T is thickness of cover plate

$(307) t = 8289$

$t = 30$

provide 2 cover plate each 15 mm thick

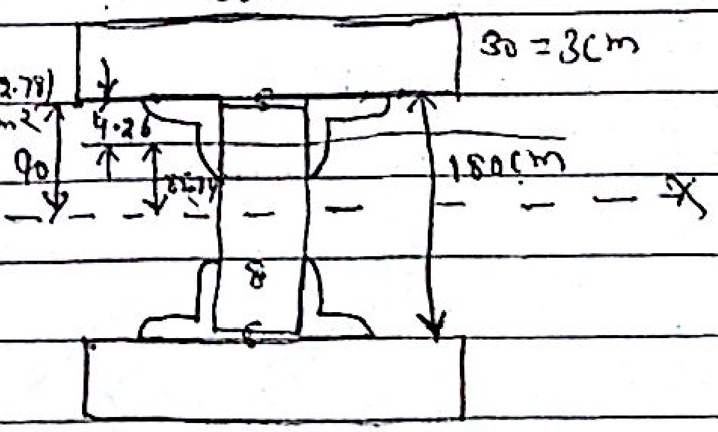
Top cover plate can be curtailed towards support of girder on basic of bending moment.

Check for Bending stress in the section of the plate girder.

Acc. to I.S.A 150 x 150 x 15 of A = (42.78) cm^2

$I_{xx} = 896.8\ cm^4$

$C_{xx} = 4.26\ cm$



$$I_{xx} = \frac{bd^3}{12} + A\bar{x}^2$$

$$I_{xx} = 2\left[\frac{35 \times 3^3}{12} + (91.5)^2 35 \times 3\right] + \frac{8 \times 1790^3}{12} + 4\left(896.8 + 42.78 \times 85\right)$$

$I_{xx} = 3.4 \times 10^6 \ cm^4 = 3.4 \times 10^{10} \ mm^4$

$\frac{M}{I_{xx}} = \frac{\sigma}{Y} \Rightarrow \frac{5151.6 \times 10^6}{3.4 \times 10^{10}} = \frac{\sigma_b}{930}$

$\sigma_b = 140.9 \ N/mm^2$

gross area of the Section

(1) Area of cover plate = $350 \times 30 = 10500 \ mm^2$

(2) Area of two angle = $8556 \ mm^2$

(3) Area of web b/w angles = $145 \times 8 = 1160 \ mm^2$

Total gross area = $20216 \ mm^2$

Deduction for rivet hole

(1) flange plate = $2 \times 21.5 \times 30 = 1290 \ mm^2$

(2) rivet hole in flange angle . $4 \times 21.5 \times 15 = 1270 \ mm^2$

(3) one rivet hole in web = $21.5 \times 8 = 172 \ mm^2$

Total area for rivet hole = $2752 \ mm^2$

(A_n) Net area of section = $20216 - 2752 = 17464 \ mm^2$

$A_g = 20216 \ mm^2$

$A_n \sigma_n = A_g \sigma_b$

$17464 \ \sigma_n = 20216 \times 140$

$\sigma_n = 162 \ N/mm^2 < 165$

$\therefore$ Section is safe against bending.

Q How will you design intermediate stiffner for a riveted plate girder.

Step-1 Calculate actual shear stress in web of plate girder

$$= \frac{S.F}{h.t_w}$$ where h = clear height of P.G. and t_w = web thickness

Step-2 Find the ratio of $\frac{h}{t_w}$

S-3 Corresponding to S-1 and S-2 find out centre to centre spacing of stiffners from the tables of I.S. code considering f_y=250 then calculate clear spacing b/w stiffners. Standered size of stiffner is 100 x 100 x 10 mm both side of web plate may be consider.

S-4 Determine moment of interia about Horizontal axis passes through the centroid of web plate.

S-5 Moment of interia required for the stiffners acc. to measure score

$$= \frac{1.5 (t_w)^3 h^3}{spacing^2}$$

S-6 :- Moment of interia calculated shall be more than moment of interia required. other wise choose another section

Design of bearing Stifness

1) This stifnes is provided at the support & under the point, It consist of 4 angle, 2 angle on either side of web plate. Standarised size of bearing stifnes is ISA 130 X 130 X 10 mm.

This Stiffnes is designed for bearing Stress which is equal to = $\frac{S.F}{\text{bearing Area}}$

Bearing Stress shall be less than 187.5 N/mm^2

2. Bearing Stiffnes is also design as a compression member. Effective length of the B.S = 0.7 time of given length.

given length is the clear distance b/w flange angle

3) Slenderness ratio is calculated & than Strength of compression member is formed out. This shall be more than Shear force for the plate girder.

Stiffners :- These are member provided to Strengthen or stiffen the thin web plate against any possible buckling action caused by compressive stresses in the web.

In a plate girder Stiffner are neccesary to prevent failure by diagonal compression in the web plate.

Stiffners may be classified into
(i) Bearing stiffners (ii) Intermidiate stiffnere

Bearing stiffners :- A bearing stiffners is meant to transmit concentrated load to the web. These stiffners are, therefor, provided at the supports and at a points where concentrated load are applied. Usually a bearing stiffner consist of (i) Bearing stiffnere are not joggled
(2) A pair of angle with one angle on each side of web
(3) Two such pair of angles.
(4) These are fastened over the flange angles and tightly against the horizontal legs of flange angl
(5) The gap b/w Stiffner angle and web is filled with packing plates.
(6) The bearing stiffners provided at the end is known as End bearing stiffners
(7) 130 X 130 X 10 mm Standard size

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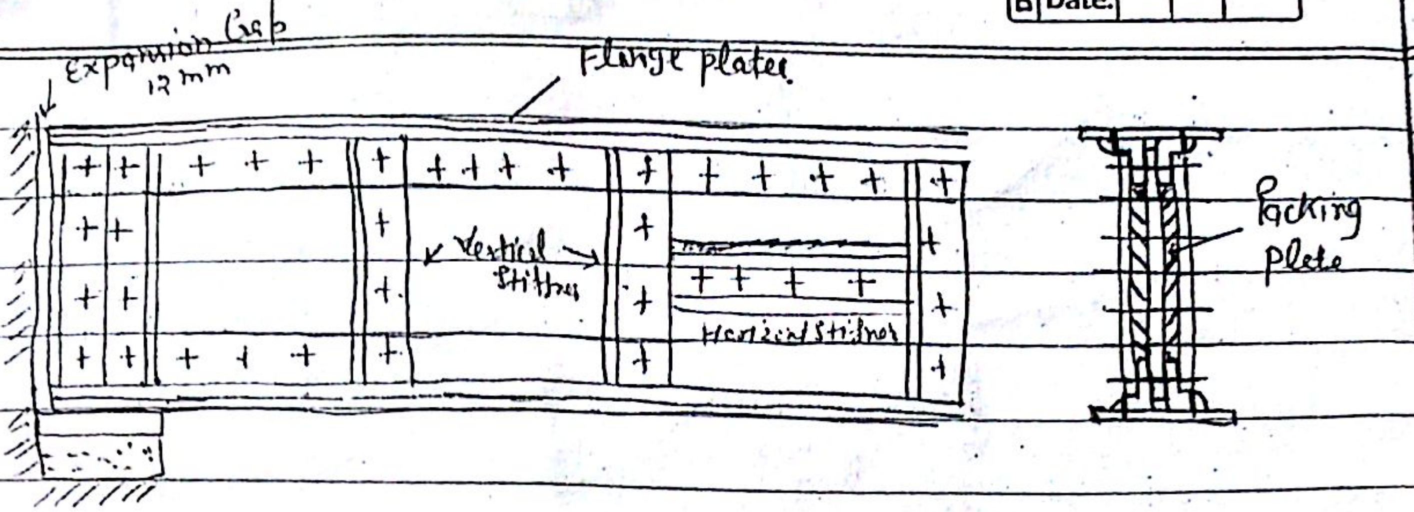


Front elevation. Vertical Section along X-X.

2. Intermediate Stiffner :- has two types
(i) Vertical Stiffners (ii) Horizontal Stiffners.

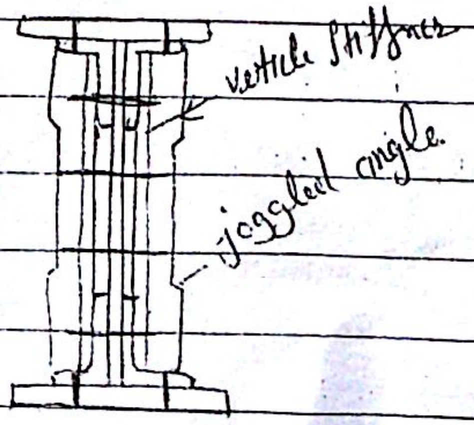
Vertical Stiffners :- Vertical stiffners are vertical angles placed b/w Horizontal flange angle. Vertical Stiffner may consists single or double angle.

(i) Vertical Stiffners are required when the ratio of the clear depth of web to web thickness exceeds 85 i.e $\frac{d}{t} > 85$.
If the ratio is b/w 85 and 200, vertical Stiffners are sufficient.

ii) The spacing of vertical stiffners shall be kept 0.33d to 1.5d

iii) If single Stiffners are used, they will be arranged alternately on both the sides of the web.

iv) joggled vertical Stiffners are very commonly used in P.G.

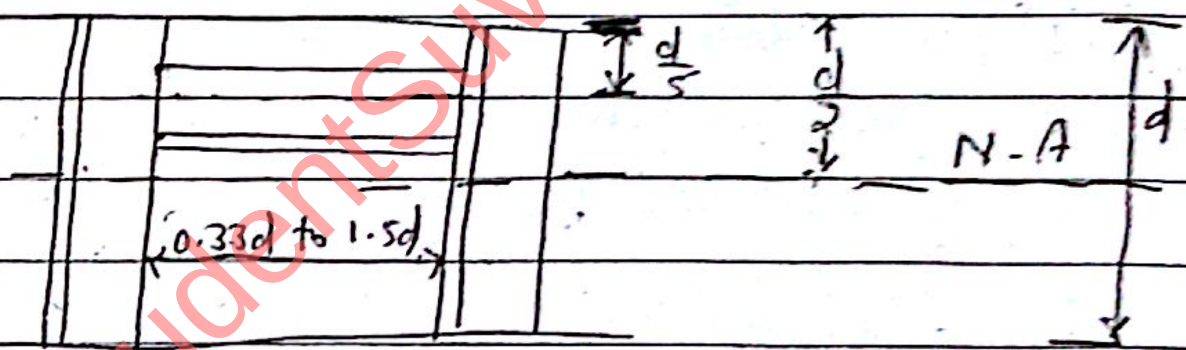


Horizontal stiffners :- (i) These are required when the ratio of the clear depth of web to web thickness exceeds 200 i.e $\frac{d}{t} > 200$.

(ii) If the ratio $\frac{d}{t} > 200$ and < 250, provide Horizontal stiffner in addition to the vertical stiffners at a distance from the compression flange equal to $\frac{2}{5}$ times the distance b/w compression flange and neutral axis.

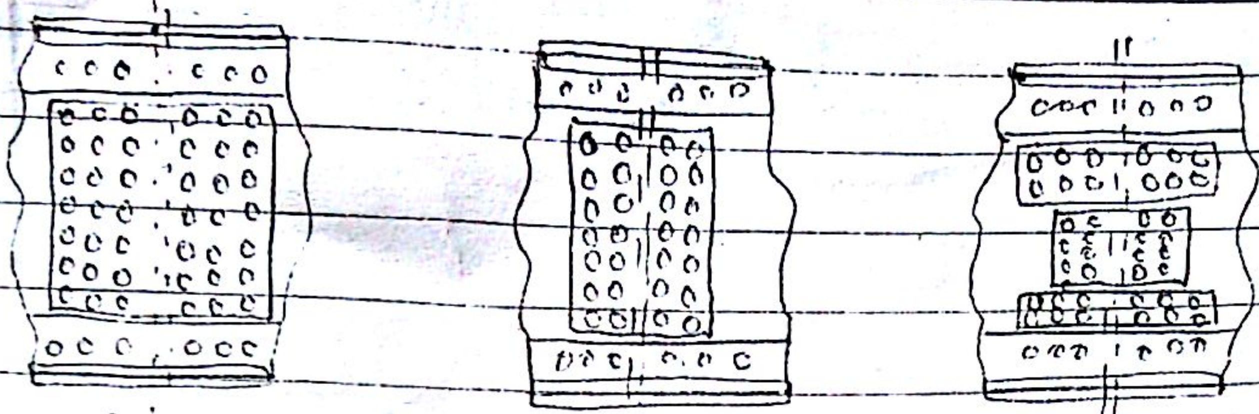
(iii) If the ratio $\frac{d}{t} > 250$ provide second horizontal stiffners at the N.A of the girder.

(iv) Horizontal stiffners may be in pairs arranged on each side of the web or single.



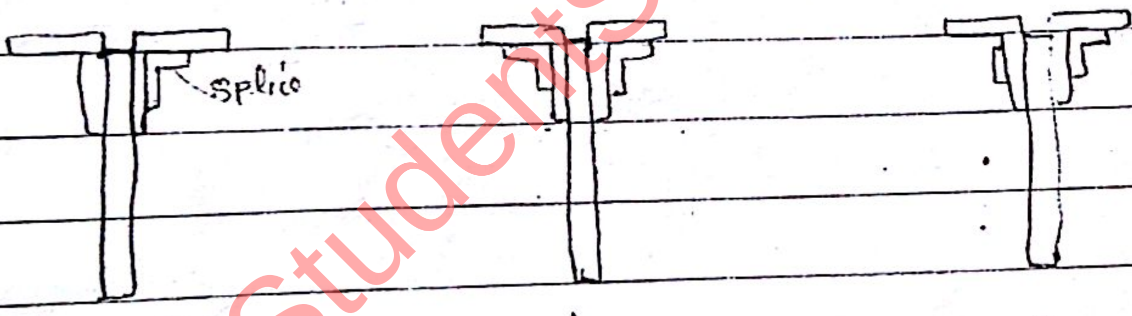
Web Splices :- These are connecting plates to connect two web plates.

The splice must be able to resist shear force at the section and also provide moment of resistance of the web. Usally three type of splices are used.

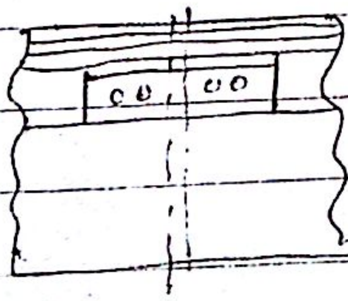


Type-A Type-B Type-C

Flange splice: These are connecting components to connect two flange angles on one side of the web. It apply mainly in three manner.



a b c



Section – D

PLATE GIRDER

Ques: A plate girder have span 18m. It carries a udl of 120kN/m. Use 20mm dia rivets and assume suitable stresses. Design the plate girder.

Sol^n:

Step – I

Given load = 120 kN/m.

Assuming self weight =

$$\frac{\text{Given Load} \times L}{300} = \frac{120 \times 18}{300}$$

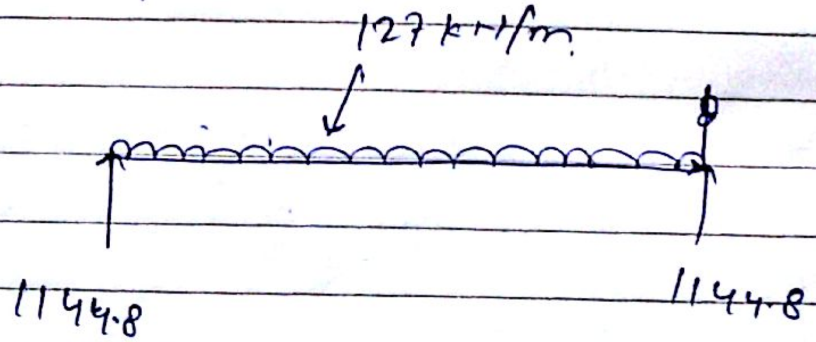
$$= 7.2 \text{ kN.}$$

Total load = $120 + 7.2 = 127.2$ kN/m

Shear force = ~~127.2 × 18~~

$$\frac{wL}{2} = \frac{127.2 \times 18}{2}$$

$$= 1144.8 \text{ kN.}$$



Step - II

max. Bending moment -

$$\frac{wL^2}{8} = \frac{127.2 \times (18)^2}{8}$$

$$= 5151.6 \text{ KN-m}$$

Step - III

Economical depth of plate Girder

$$d = 5.5 \sqrt[3]{\frac{M}{\sigma_b}}$$

{ $f_y = 250$.
$\sigma_b = 0.66 \times f_y = 165$ (bending stress)
$\tau_s = 0.44 \times f_y = 110$ (Average shear stress)

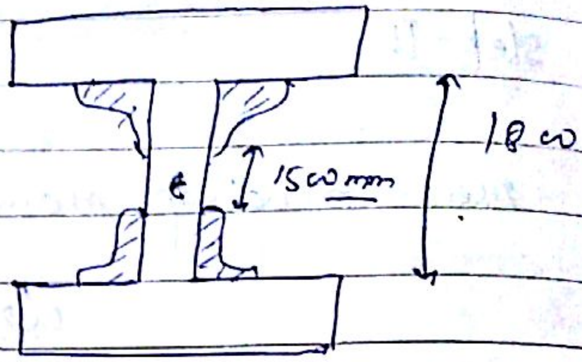
$$= 5.5 \sqrt[3]{\frac{5151.6 \times 10^6}{165}}$$

$d = 1730 \sim \underline{1800}$

web plate shall not touch flange plate. and there is clearence of 5mm b/w web plate and flange plate

∴

web plate and flange plate are joined by ISA 150 × 150 × 15 on both side of the web.



The clear height of the web (h_c) is

$$1800 - 300 = 1500 \text{ mm}$$

Step - IV

Design of Web

Let t_w = web thickness = ~~8mm~~

Assume max. permissible shear stress = 100 N/mm²

web is design for shear force.

$$A_w = \frac{S.F}{\tau_s} = \frac{1144.8 \times 1000}{100} \text{ mm}^2$$

$$= 11448 \text{ mm}^2$$

$A_w = t_w \cdot h_c$

$= 11448 = t_w \times 1500$

$\therefore t_w = 7.632$ mm

Let t_w = 8 mm

$$\frac{h_c}{t_w} = \frac{1500}{8} = 187.5 < 200$$

So, Geometry of section is o/c.

Step - V

Design of flange

Area of Flanges (A_f) =

$$\frac{M}{\sigma_b \cdot h} - \frac{A_w}{8}$$

$$= \frac{517.6 \times 10^6}{165 \times 1800} -$$