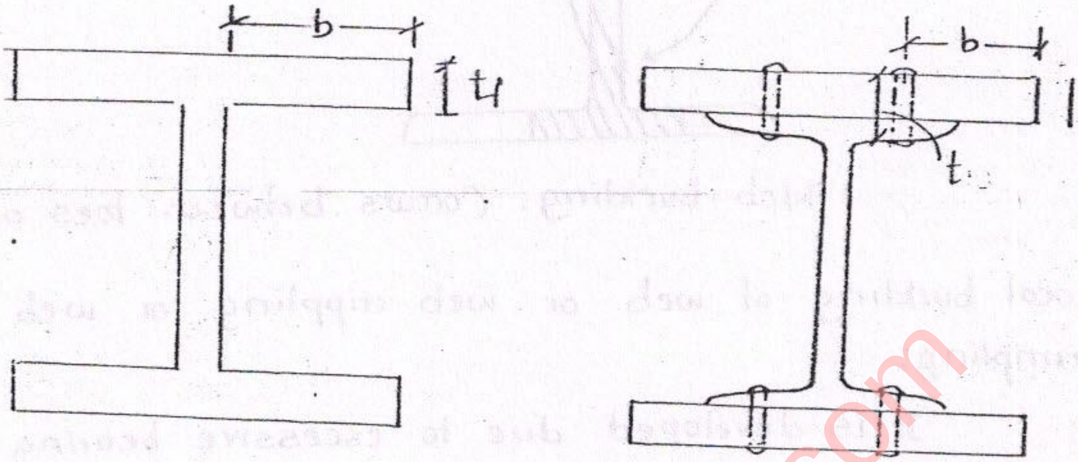
Secondary criteria in beam design (Buckling criteria)

① Local flange buckling :

It is developed due to bending compressive stress



To prevent local flange buckling.

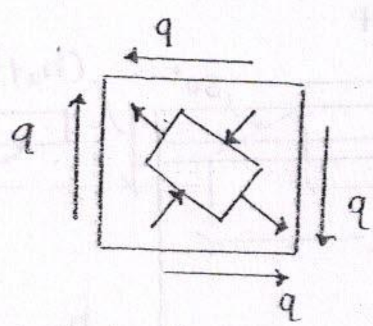
$$\frac{b}{t_f} \ngtr 16$$

$$\frac{b'}{t_f} \ngtr 50$$

b'- distance between the rivet lines (in WSM)

② Web buckling :

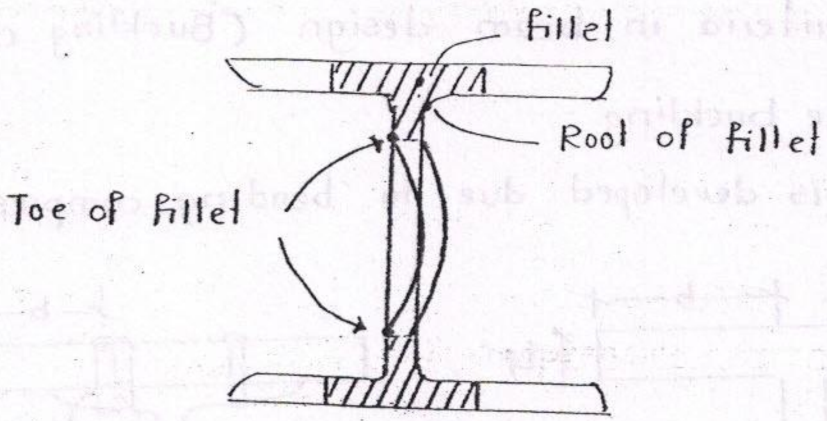
It occurs due to diagonal compression in web, which is produced due to shear force in web.



Element subjected to pure shear.

Diagonals are subjected to compression and tension, called diagonal compression stress and diagonal tensile stress. Web may buckle due to diagonal compression.

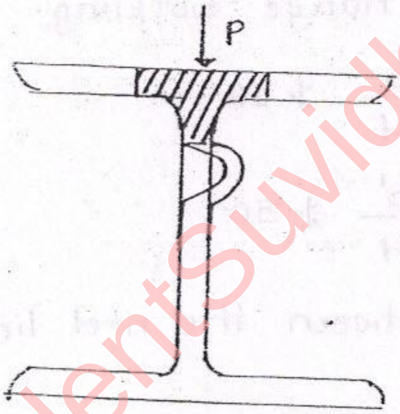
download all btech stuff from StudentSuvidha.com



Web buckling. (Occurs between toes of fillet)

③ Local buckling of web or web crippling or web crimpling:

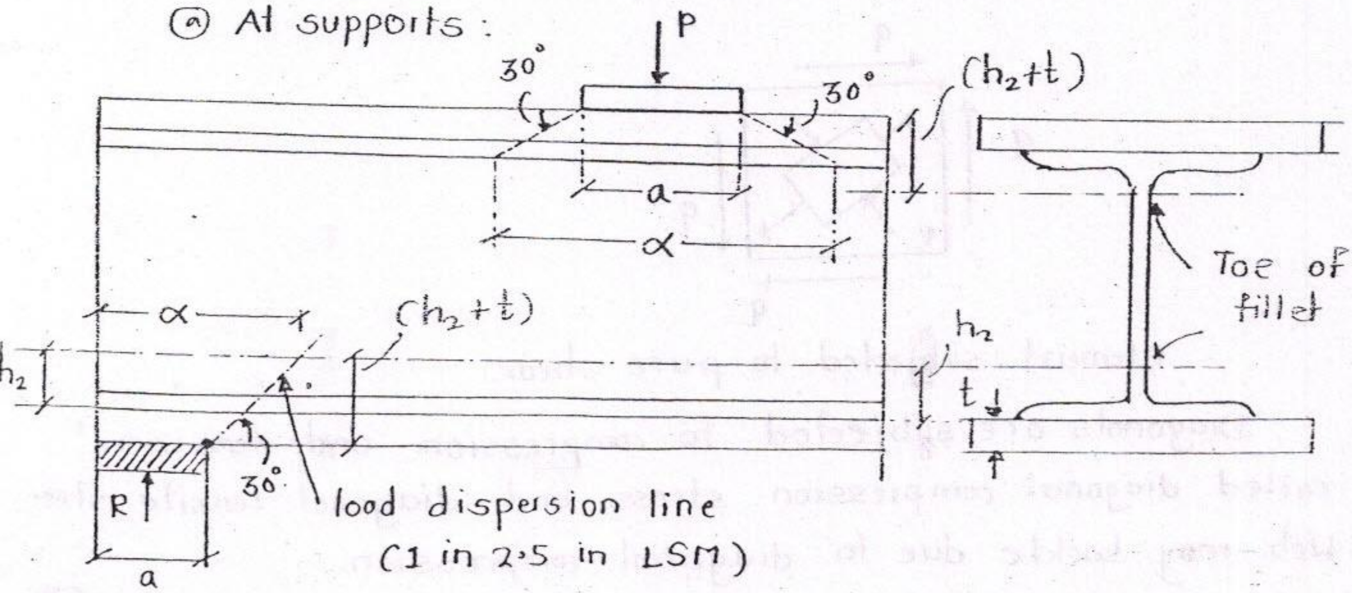
It is developed due to excessive bearing stress at junction of fillet and web i.e. at toe of fillet.



Local buckling of web (occurs at toe of fillet in web)

④ To prevent web crippling or crimpling:

ⓐ At supports:



download all btech stuff from StudentSuvidha.com

To prevent web crippling.

$\sigma_{p.cal}$ - calculated bearing stress at toe of fillet

$$= \frac{R}{\text{Bearing area at toe of fillet}}$$

$$= \frac{R}{\alpha \times t_w}$$

$\sigma_{p.cal} \leq \sigma_p$ - permissible bearing stress $(0.75 f_y)$

If above condition is satisfied, web crippling will not happen.

$$\alpha = a + x$$

$$= a + \sqrt{3}\,(h_2 + t)$$

$$\tan 30^\circ = \frac{h_2 + t}{x}$$

$$x = \sqrt{3}\,(h_2 + t)$$

where, t - thickness of flange plate

t_w - thickness of web.

(b) To prevent web crippling under point load in supported span.

$$\sigma_{p.cal} = \frac{P}{\alpha \times t_w} \leq \sigma_p = 0.75 f_y$$

where,

$\alpha = a + 2\sqrt{3}\,(h_2 + t)$

= width of web at toe of fillet

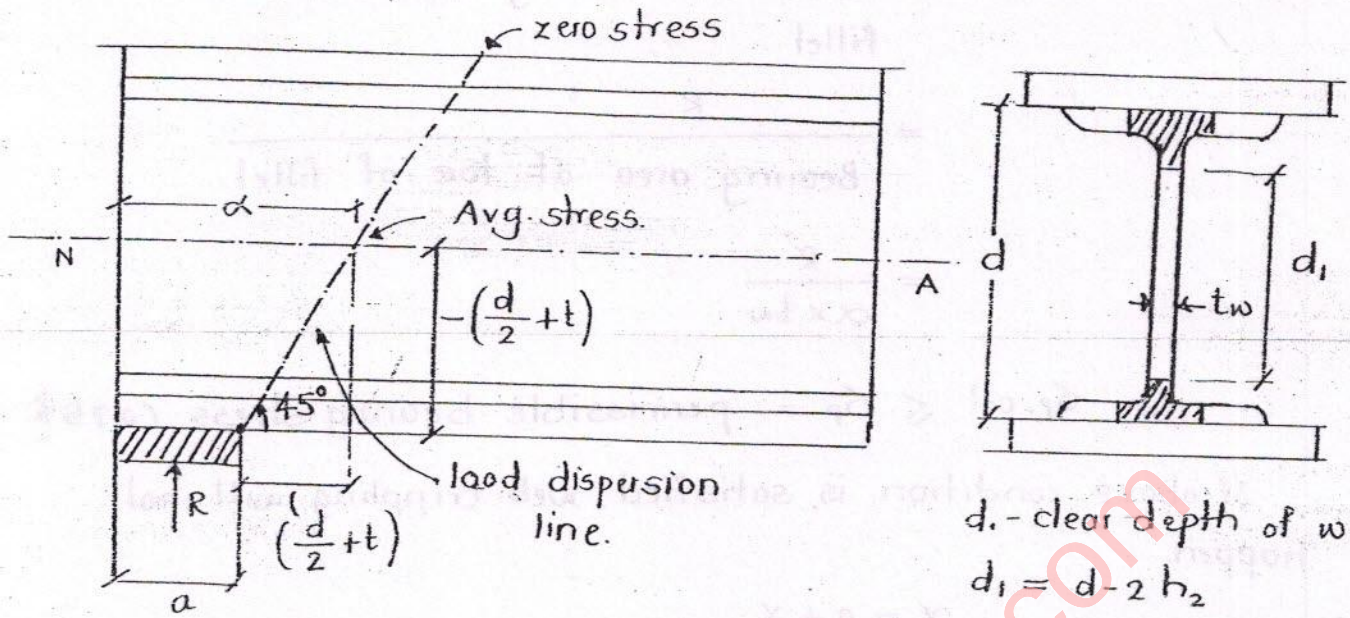
t_w - thickness of web.

If the above condition is not satisfied, we have to increase the thickness of web. to reduce the bearing stress at the toe of fillet or we can use bearing stiffner to reduce bearing stress at toe of fillet.

download all btech stuff from StudentSuvidha.com

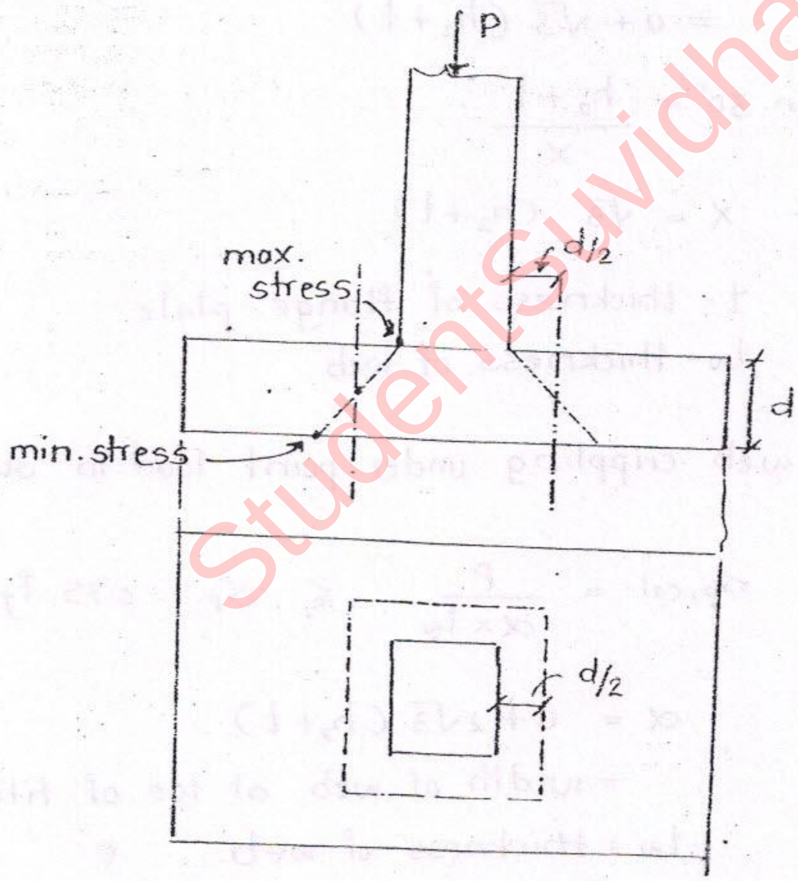
⑤ To prevent web buckling :

ⓐ At support :



d_1 - clear depth of web

$d_1 = d - 2h_2$



To take avg. effect critical section is taken as mid-point i.e. at $d/2$ from face of column.

download all btech stuff from StudentSuvidha.com

To prevent web buckling, web is treated as an imaginary column of length d_1 with both ends fixed and subjected to compression force at one end and zero at other end.

The c/s area of imaginary column is taken at N.A. level To take care of the avg. effect of compressive force.

A_g of imaginary column at N.A. level $= \alpha \times t_w$.

where, $\alpha = a + \left(\frac{d}{2} + t\right)$

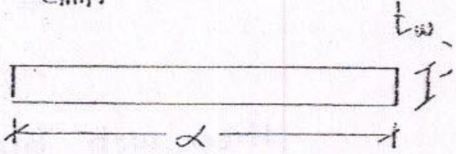
a - width of support.

Length of imaginary column $= d_1 = (d - 2h_2)$

Effective length $(L) = \frac{d_1}{2}$ (both ends fixed)

λ of imaginary column $= \frac{L}{r_{min}} = \frac{(d_1/2)}{r_{min}}$

$$r_{min} = \sqrt{\frac{I_{min}}{A_g}}$$



c/s are of column.

$$= \sqrt{\frac{\frac{\alpha \cdot t_w^3}{12}}{(\alpha \times t_w)}}$$

$$= \frac{t_w}{\sqrt{12}} = \frac{t_w}{2\sqrt{3}}$$

$$\therefore \lambda = \frac{(d_1/2)}{\left(t_w/2\sqrt{3}\right)} = \frac{\sqrt{3} \cdot d_1}{t_w}$$

Find σ_{ac} corresponding to λ.

P_{safe} = safe load carrying capacity of imaginary column.

$= \sigma_{ac} \times A_g$

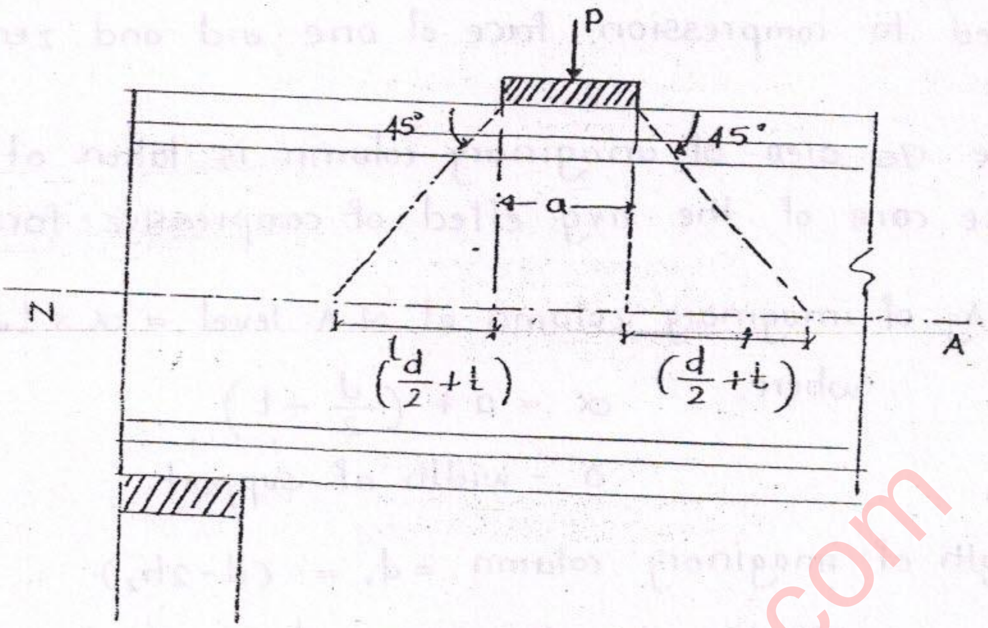
$= \sigma_{ac} \times (\alpha \times t_w)$

Then, web buckling will not happen.

StudentSuvidha.com

download all btech stuff from StudentSuvidha.com

(b) To prevent web buckling under point load in supported span:



P_{safe} - safe load carrying capacity of imaginary column.

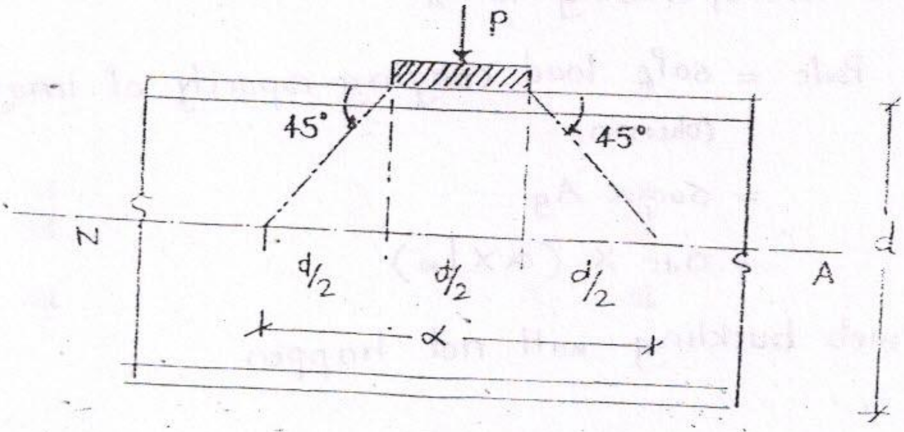
$= \sigma_{ac} \times A_g$

$= \sigma_{ac} \times (\alpha \times t_w) \geq P_{applied}$

then web buckling will not happen.

$$\alpha = a + 2\left(\frac{d}{2}+t\right)$$

Q. 1. The beam is subjected to transfer load P as shown in fig. If f is permissible axial compressive stress in the imaginary column and t is thickness of web, the load carrying capacity of imaginary column.



StudentSuvidha.com

download all btech stuff from StudentSuvidha.com

$$P_{safe} = \sigma_{ac} \times A_g$$
$$= \sigma_{ac} \times (\alpha \times t_w) \qquad \alpha = \frac{d}{2} + \frac{d}{2} + \frac{d}{2}$$
$$= f \times 1.5 d \times t \qquad = 1.5\,d.$$
$$= 1.5\, f d \cdot t_f$$

Design of built up beams
(Plated beams)

(i) If a single beam section is not capable of withstanding applied loads, then built up beams are used. (If built-up beams cannot withstand applied loads then plate girders are used.) If plate girders cannot withstand applied load then truss girders are used.

In a truss girders B.M. is taken by top and bottom members shear force is taken by vertical and diagonal members.

(ii)
$$Z_{reqd} = \frac{M}{\sigma_{bc}}$$

(iii) If cover plates are used in built up beams.

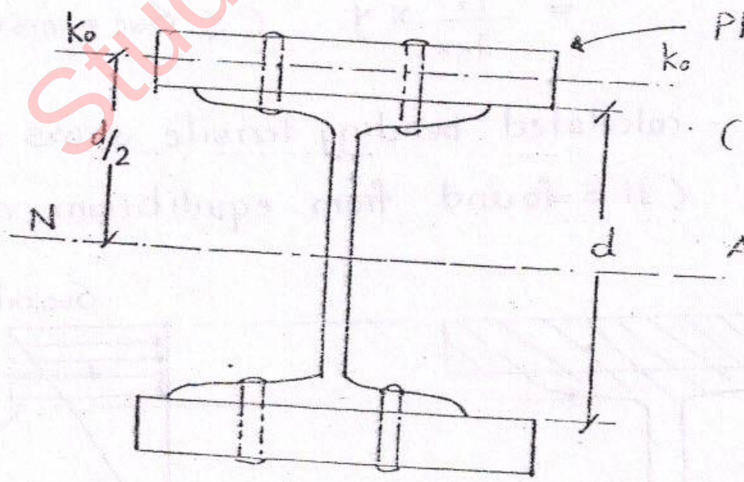


Plate area (A_p) taken as line are (t^2, t^3 - neglected in calculations)

$$I_{k_o k_o} \simeq 0$$

For plates,

$$I_{xx} = I_{k_o k_o} + A \cdot h^2$$
$$= \left[0 + A_p\left(\frac{d}{2}\right)^2\right] \times 2 \quad \leftarrow \text{2 plates, (at top \& bottom)}$$

StudentSuvidha.com

download all btech stuff from StudentSuvidha.com