⇒ Design strength of Tension member ;

1. For gross section yielding ;

$$\boxed{T_{dg} = \frac{f_y}{\gamma_{mo}} . A_g}$$

where ; $\gamma_{mo} = 1.1$

$A_g \rightarrow$ gross area

Note :-

→ When a Tension member is subjected to Tensile force although the Net cross-section yields first, the deformation within the length of the connection will be smaller than the deformation in the remainder of the tension member, It is because the Net section exist within the small length of member, most of the length of member will have an unreduced cross-section, So attainment of yield stress on gross area will result in larger total elongation.

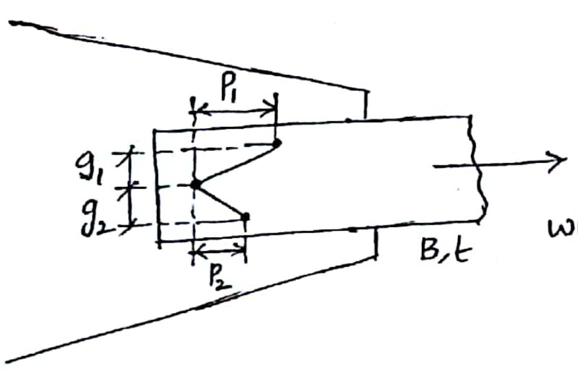
• For Net section rupture (fracture) ;

(a) In plates & Flats ;

$$\boxed{T_{dn} = \frac{0.9 f_u}{\gamma_{m_1}} . A_n}$$

Where ; $\gamma_{m_1} \rightarrow 1.25$

A_n = net area



$$A_n = \left(B - n d_o + \sum_{i=1}^{m} \frac{P^2}{4g}\right) t$$

$$A_n = \left(B - 3d_o + \frac{P_1^2}{4g_1} + \frac{P_2^2}{4g_2}\right) t$$

where ; $n \rightarrow$ no. of bolts along failure line

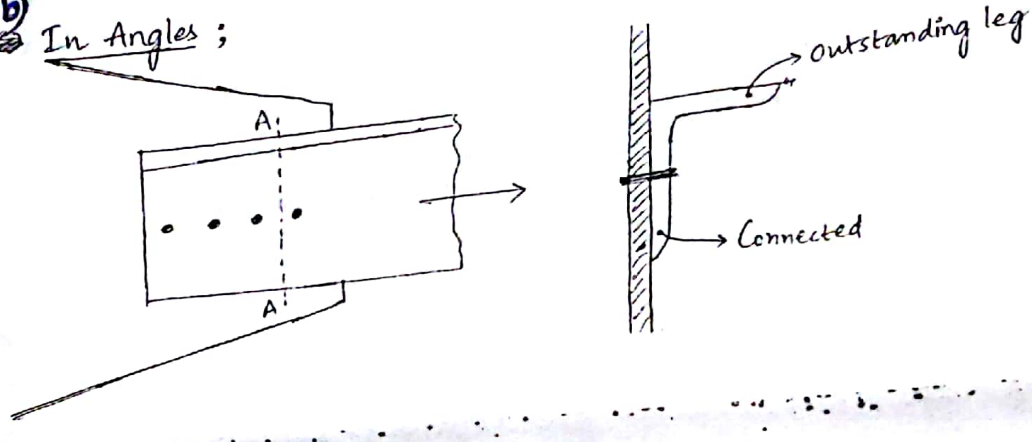
$d_o \rightarrow$ dia of bolt line

$m \rightarrow$ no. of inclined lines

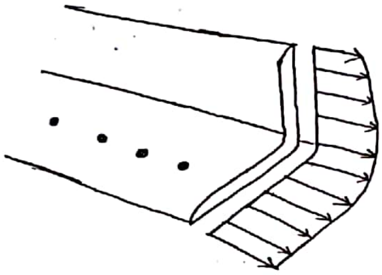
→ for each inclined line we add a term $\frac{P^2}{4g}$

→ At the critical section ; A_n is minimum

(b) In Angles ;



- Force transferred to one leg by end connection locally gets transferred as Tensile stress over the entire Cross-section by shear. The connected leg will have higher stresses than the outstanding leg thus as one part of the angle lags behind the other in stress, the phenomenon is called "Shear Lag"



→ Since, shear lag reduces the effectiveness of outstanding leg unequal angles are connected through the longer legs.

- The Code has recommended the following relation for computation of design rupture strength, T_{dn}.

$$\boxed{T_{dn} = \frac{0.9 f_u}{\gamma_{m1}} \cdot A_{nc} + \beta \cdot \frac{f_y}{\gamma_{m0}} \cdot A_{go}}$$

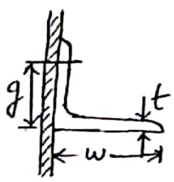
where ; $\beta = 1.4 - 0.076 \frac{w}{t} \times \frac{f_y}{f_u} \times \frac{b_s}{l_c}$

$$\leq \frac{0.9 f_u/\gamma_{m1}}{f_y/\gamma_{m0}}$$

$$\geq 0.7$$

A_{nc} → Net area of connected leg

A_{go} → Gross area of outstanding leg



w → width of outstanding leg

t → thickness of angle

b_s → Shear lag width. It is the distance from the farthest point on the outstanding leg to the nearest bolt or weld line

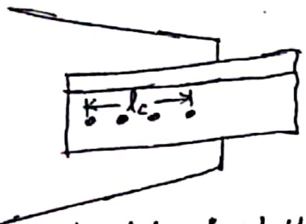
$b_s = w + g - t$ .... (for bolted connection)

$b_s = w$ .... (for welded connection)

→ Infact b_s is the distance of the farthest point on the outstanding leg from the nearest bolt (or) weld line

l_c → length of connection in the direction of load transfer.

i.e, c/c distance between the extreme bolts.



→ As the above equation has t & l_c terms which cannot be determined unless design is complete hence for preliminary sizing the rupture strength of net section may be approximated as;

$$\boxed{T_{dn} = \alpha \frac{f_u A_n}{\gamma_{m_1}}}$$

$\alpha = 0.6$ → for one (or) two bolts

$\alpha = 0.7$ → for three bolts

$\alpha = 0.8$ → for four or more bolts

$\alpha = 0.8$ → for welded connection.

→ where 'α' is the reduction factor considering shear lag & depends upon the length of the connection, i.e, the no. of bolts per line in the direction of applied load.

Note :-

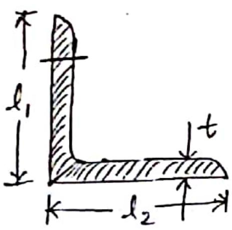
→ from the above expression it is evident that the shear lag effect can be reduced by increasing length of the end connection.

→ $A_{go} = l_2 t - \frac{1}{2}t^2$

$A_{go} = (l_2 - \frac{t}{2})t$

$A_{nc} = (l_1 - d_o - \frac{t}{2})t$

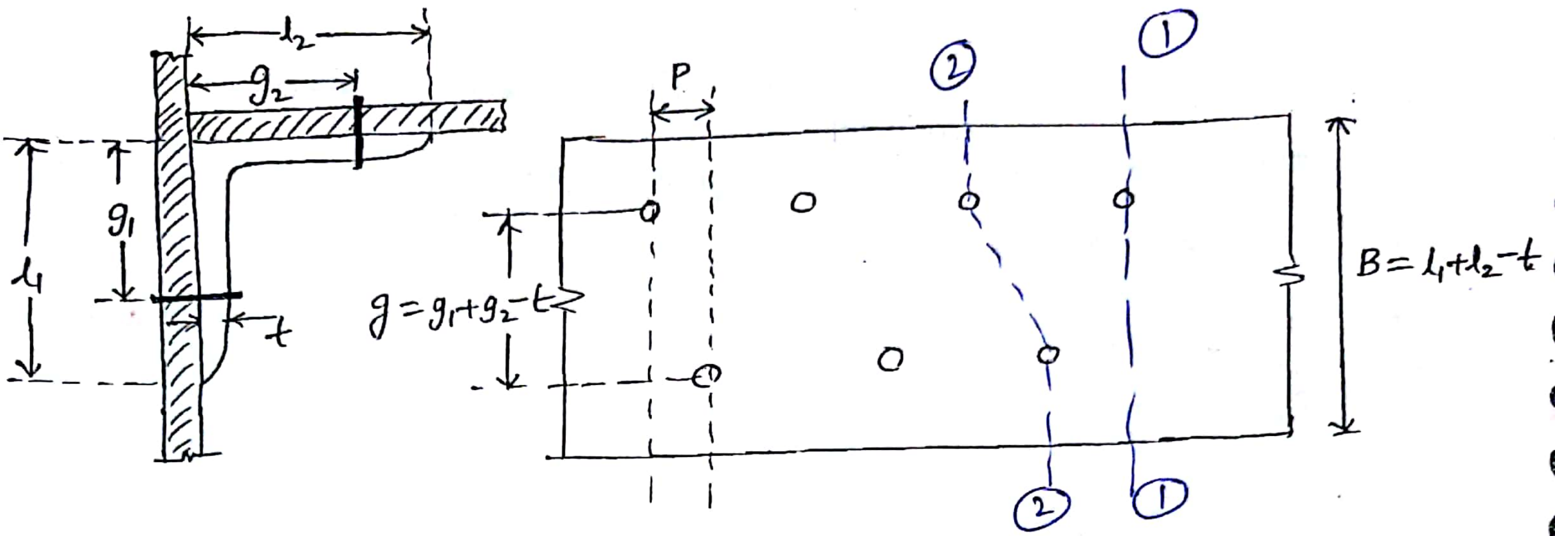
$A_g = (l_1 + l_2 - t)t$



→ In the new Code we do not have a difference in the net area whether angles are connected on both side of gusset plate (or) on same side of gusset plate (or) if there is tacking (or) No tacking.

→ The T_{dn} has been calculated under the assumption that when the connected leg reaches the ultimate state, outstanding leg reaches the yield state.

c) When both the legs of the angle is connected to gusset plate



When both the legs of the angles are connected, the angle can be opened and can be treated as a plate.

$$A_n = \left(B - n d_0 + \sum_{i=1}^{m} \frac{p_i^2}{4 g_i}\right) t$$

$$A_{n_1} = (B - d_0)t$$

$$A_{n_2} = \left(B - 2d_0 + \frac{p^2}{4g}\right)t$$

$$A_n = \min.\{A_{n_1}, A_{n_2}\}$$

$$T_{dn} = \frac{0.9 f_u A_n}{\gamma_{m_1}} \quad ; \quad \gamma_{m_1} = 1.25$$

For Block shear failure ;

$T_{db} \rightarrow$ Block shear strength

$$T_{db} = \min. \begin{cases} \dfrac{f_y A_{vg}}{\sqrt{3}\,\gamma_{m0}} + \dfrac{0.9 f_u A_{tn}}{\gamma_{m_1}} & \rightarrow \text{Shear yielding \& Tension rupture} \\[2ex] \dfrac{0.9 f_u A_{vn}}{\sqrt{3}\,\gamma_{m_1}} + \dfrac{f_y A_{tg}}{\gamma_{m0}} & \rightarrow \text{Shear rupture \& Tension yielding} \end{cases}$$

Note :-

→ In case of welded angle tension member, A_{tn} & A_{vn} should be replaced by A_{tg} & A_{vg} respectively.

→ $\boxed{\text{Design Tensile strength } (T_d) = \min.\{T_{dg}, T_{dn}, T_{db}\}}$

→ Slenderness ratio (λ) ;

$$\boxed{\lambda = \frac{l_{eff}}{r_{min}}}$$

→ Although there is no stability problem in Tension member yet maximum Slenderness ratio (λ_{max}) is ~~defined~~ limited to safeguard against buckling due to load reversals during transportation, erection etc

→ Maximum slenderness ratio for Tension member ###

This case is more critical case

Description	λ_{max}
1. A tension member in which reversal of direct stress is due to loads other than wind (or) earthquake (i.e, DL & LL)	180
2. A member normally acting as a tension member but in which stress reversal is due to wind (or) earthquake	350
3. A member always under tension except pretensioned member	400