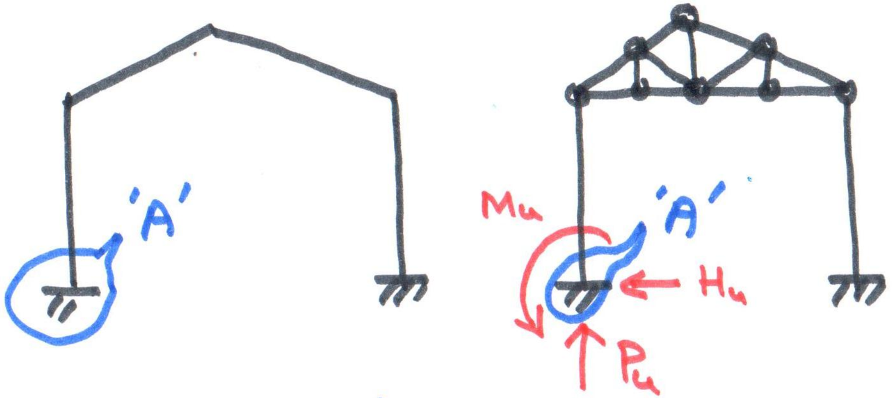
COLUMN BASE CONNECTION



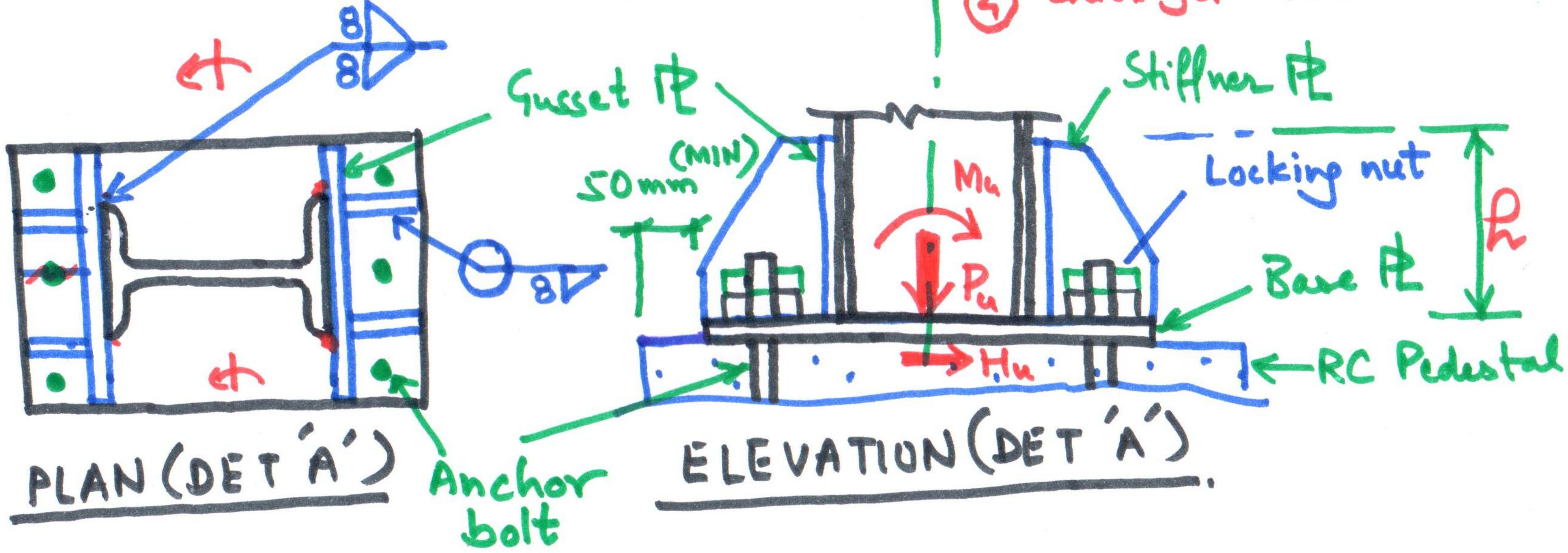
Elements of Design

✓ ① Thickness & height of gusset PL, welds, stiffners.

✓ ② No. & diameter of anchor bolts

③ Thickness of base PL.

④ Check for welds.



PLAN (DET 'A')

ELEVATION (DET 'A')

Approach ②, ③, ① & ④

DESIGN STEPS

A) Choose grade of bolts IS 1367(III)

4.6

4.8

5.6

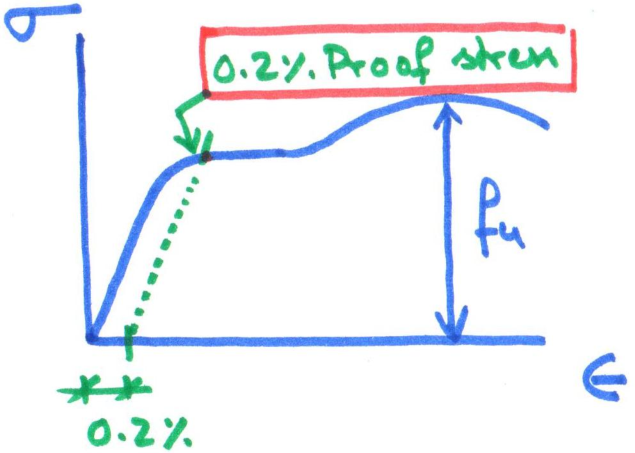
⋮

12.9

4 – Nominal tensile strength $f_u = 400$ MPa.

6 – Yield strength $f_y = 60\%$ of f_u

$= 240$ MPa

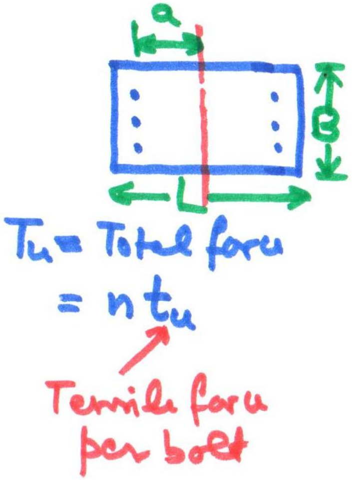


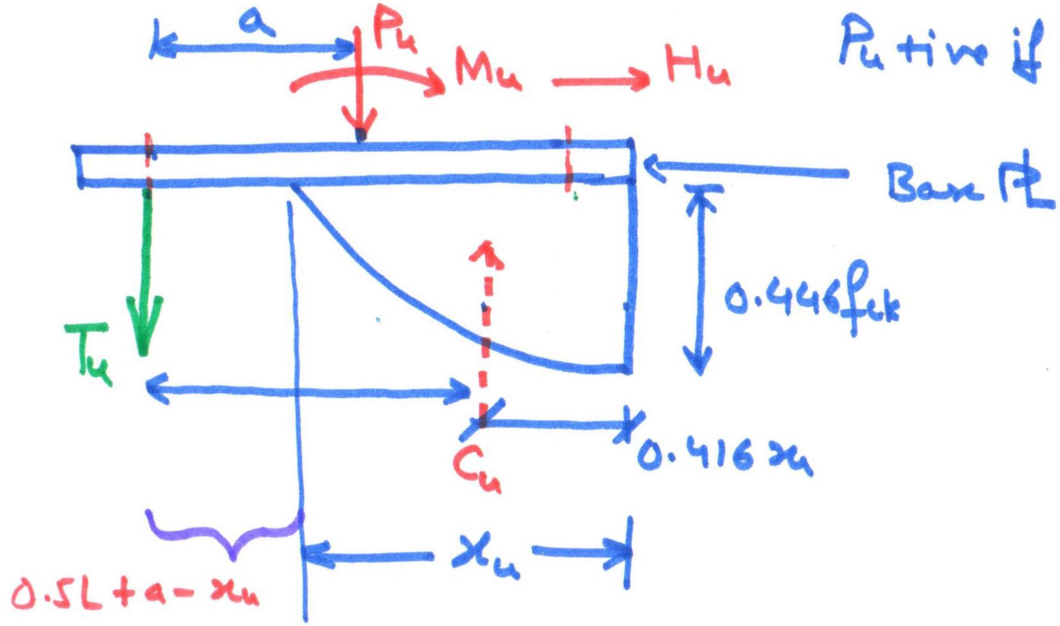
Diameter of bolts may also be decided at this stage.

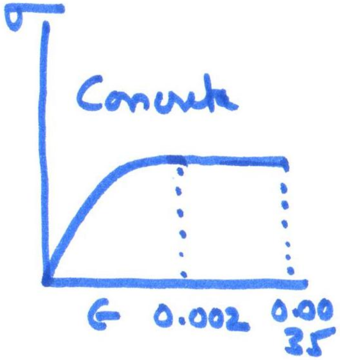
M30 bolt of 4.6 grade

M30 – Nominal diameter

P_u +ive if compressive.







$x_u < x_{ul}$ to ensure under-reinforced section.

Equilibrium equations —

Force :

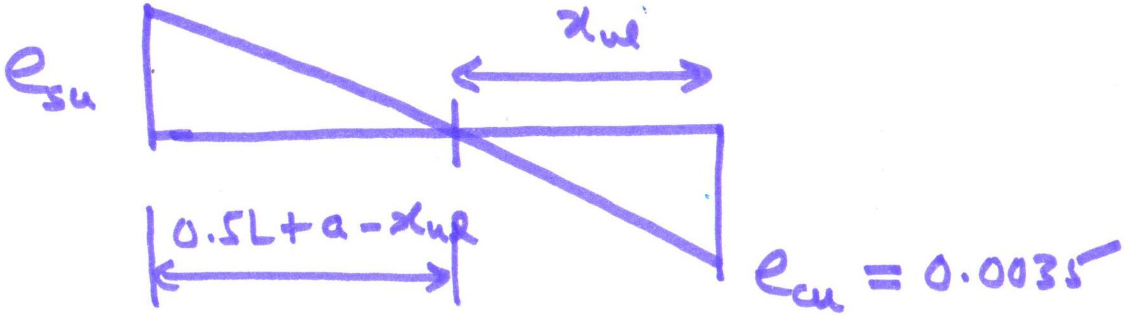
$$P_u + \underset{?}{\boxed{T_u}} = C_u = 0.36 f_{ck}\, b \overset{\text{decide}}{\underset{?}{\boxed{x_u}}} \qquad ①$$

Moment (about line of action of tensile force)

$$M_u + P_u \underset{\text{decide}}{a} = \underset{0.36 f_{ck} b x_u}{C_u}\left(0.5L + a - 0.416 x_u\right) \qquad ②$$

So ② ⟹ x_u ⟹ input in ⟹ T_u

Compare $x_u \Longleftrightarrow x_{ul}$.



$$e_{su} = \frac{f_y}{E_s \, \overset{\uparrow}{\gamma_{mo}}} \quad \text{1.1} \qquad \frac{e_{cu}}{x_{ul}} = \frac{e_{su}}{0.5L + a - x_{ul}}.$$

Solve for x_{ul}

If $x_u < x_{ul} \Rightarrow$ we can proceed.

Else → increase 'L' & 'b'

T_u : We have determined.

T_b = Ultimate force (tension) on bolt

$$= \frac{T_u}{n}$$

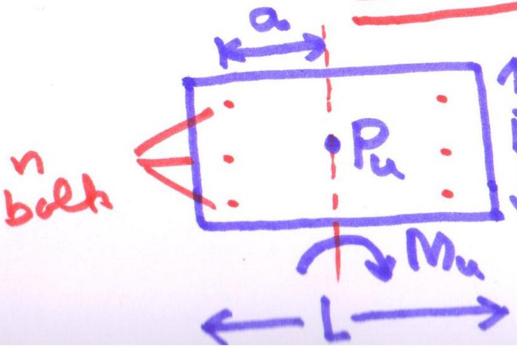
↖ No. of bolts in row

$$T_b \le T_{db}$$

↖ Design strength of bolt in tension.

Must keep margin to account for shear.

Initial Preliminary design →

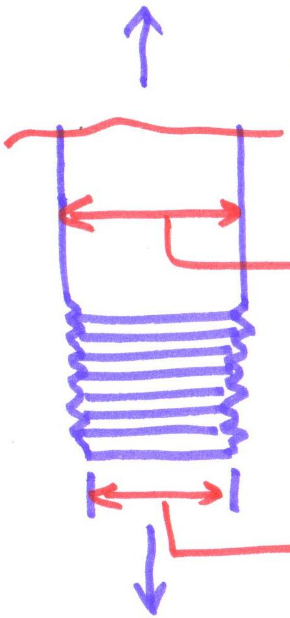


$$T_u \approx -\frac{P_u}{2} \pm \frac{M_u}{2a}$$

↑ Total tensile force carried by row of bolts

Force per bolt $= \frac{T_u}{n}$

DESIGN OF BOLTS



Shank

$A_{sb} = \frac{\pi d^2}{4}$ ← Nominal diameter M30

Net area A_n or Nominal stress area IS 1367 (III) Table 7

Design of bolts
- Tension T_{db}
- Shear/Bearing V_{db}
- Combined (tension + shear)

DESIGN FOR TENSION

IS 800 (2007) 10.3.5

① Ultimate failure of net area (threads)

② Yielding of gross area (shank)

T_{db}

Design tensile strength of bolt

$$T_{db} = \text{Lesser of} = \begin{cases} \dfrac{0.9 f_{ub} A_n}{\gamma_{mb}} \\[2ex] \dfrac{f_{yb} A_{sb}}{\gamma_{m0}} \end{cases}$$

Ultimate tensile strength of bolt

Yield stress of bolt.

$\gamma_{m0} = 1.1$

$\gamma_{mb} = 1.25$

Partial Safety Factors for bolt. (Table 5 IS 800)

$T_b \le T_{db}$ (Must take margin for shear)

Factored tensile force

SHEAR

IS 800 10.3.2

Design factored shear force = $V_{sb} = \dfrac{H_u}{2n}$

To be checked against V_{dsb} & V_{dpb}

Design

Shear

Bolt

Bearing

V_{db} = Lower of (V_{dsb}, V_{dpb})

Shank area

Net area

$$V_{dsb} = \frac{f_u}{\sqrt{3}} \frac{1}{\gamma_{mb}} \left(n_n A_{nb} + n_s A_{sb} \right)$$

No. of shear planes passing thru. shank.

Table 5 IS 800

No. of shear planes passing thru. threads

$$\approx \frac{f_u \, n \, A_{nb}}{\sqrt{3} \, \gamma_{mb}}$$

BOLT CAPACITY IN BEARING

$$V_{dpb} = \frac{V_{npb}}{\gamma_{mb}}$$

Nominal bearing strength.

plate thk.

$$V_{npb} = 2.5\, k_b\, d\, t\, f_u$$

Bolt ~~Hole~~

$k_b \rightarrow$ Depends on configuration & materials

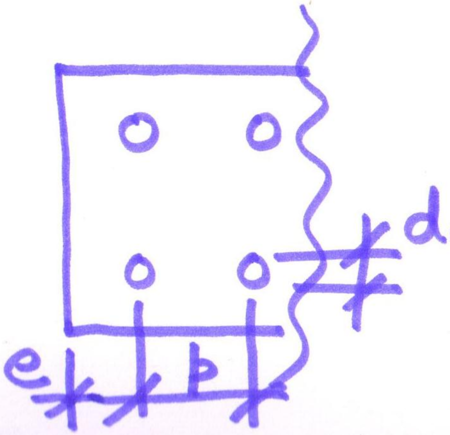
k_b = Smaller of

① $\frac{e}{3d_0}$

② $\left(\frac{p}{3d_0} - 0.25\right)$

③ $\frac{f_{ub}}{f_u}$ ← Ultimate tensile str. of plate

④ 1



d_0 = ~~Bolt~~ Hole dia.

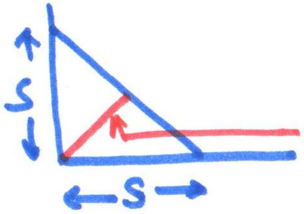
IS 800 10.3.4

Check for combined stress.

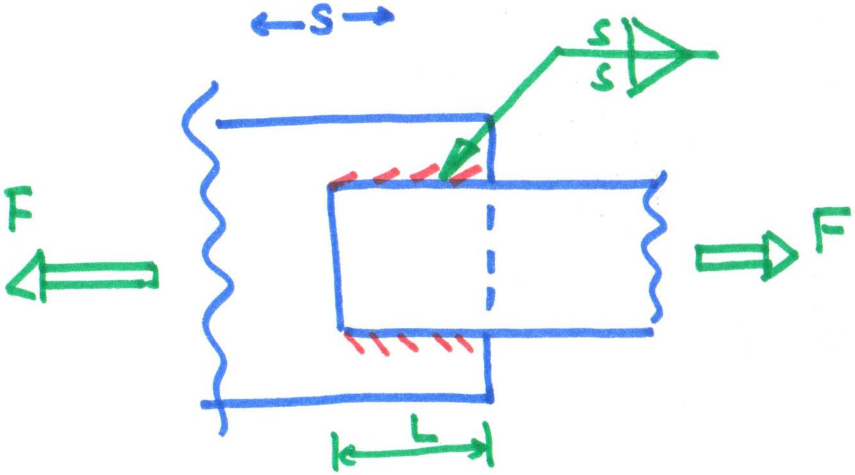
$$\left(\frac{V_{sb}}{\underset{\text{Lower of } V_{dsb} \text{ \& } V_{dpb}}{\underbrace{V_{db}}}}\right)^2 + \left(\frac{T_b}{T_{db}}\right)^2 \leq 1.0$$

DESIGN OF WELDING (FILLET WELDING)

Failure of weld → By shear
- → Longitudinal ✓
- → Transverse ✓
- → Equivalent shear (Bending/normal stress) + shear stress



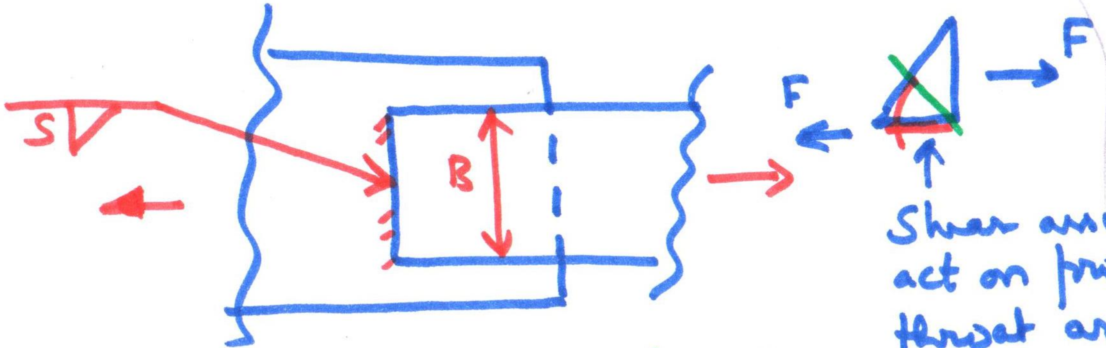
T= Throat thk. = 0.7S



q_L = Longitudinal shear stress

$$q_L = \frac{F}{2LT} \le f_{dw}$$

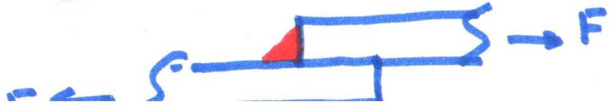
↑ Design strength of weld.

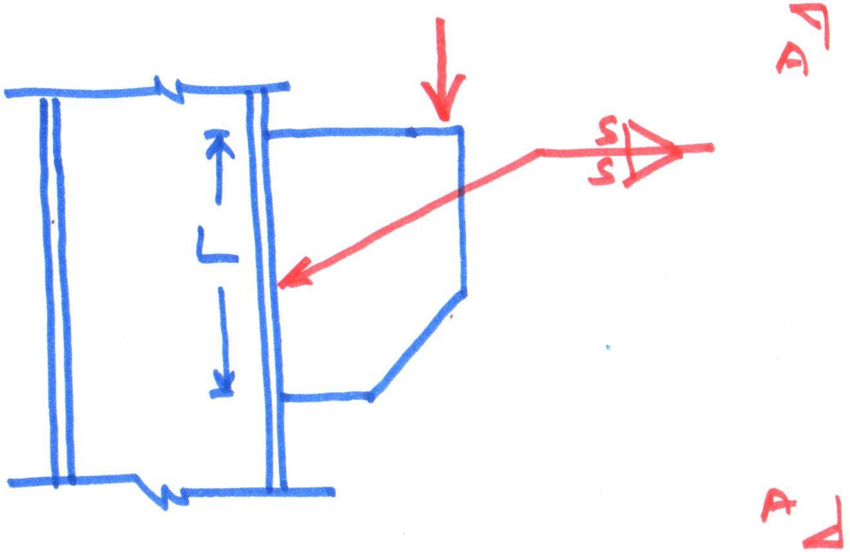


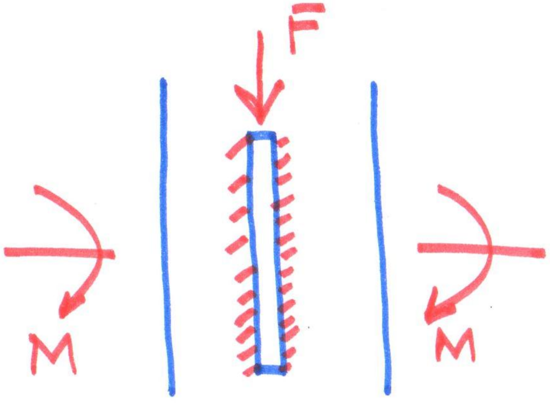
Shear assumed to act on projected throat area

q_T = Transverse shear stress

$$= \frac{F}{B\,T} \le f_{dw}$$







VIEW A-A

✓

$$q_L = \frac{F}{2LT}$$

$$q_T = 0$$

✓

$$f_a = \frac{M}{Z_{weld}}$$

↑
Normal stress

$$Z_{weld} = (2T)\frac{L^2}{6}$$

Equivalent shear stress

$$f_e = \sqrt{f_a^2 + 3q_L^2} \le f_{dw}$$

if $q_T \neq 0$ $q = \sqrt{q_L^2 + q_T^2}$

$$f_e = \sqrt{f_a^2 + 3q^2}$$

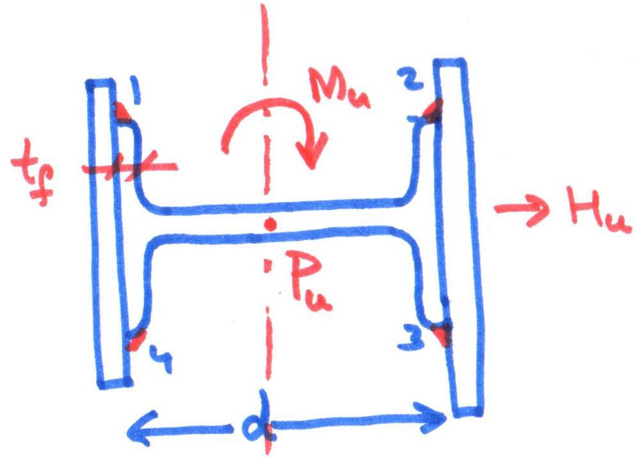
WELDING CODES :

IS : 814 (2004)
IS : 1278 (1972)

$$f_{dw} = \frac{f_u}{\sqrt{3}\,\gamma_{mw}}$$

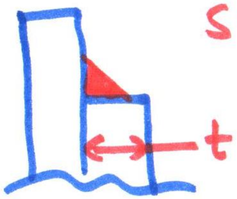
Partial FOS weld $\left\{\begin{array}{ll} 1.25 & \text{Shop welding} \\ 1.5 & \text{Field welds} \end{array}\right.$

f_u = Smaller of the ultimate tensile strength of weld or the parent metal.



$S \ngtr \frac{3}{4} t_f$

$S \leq t - 1.5$



$M_u + P_u \longrightarrow$ Longitudinal shear on welds 1, 2, 3, 4

$H_u \longrightarrow$ Transverse shear

Design steps :

① Decide weld size

② Design shear strength of weld $f_{dw} = \dfrac{f_u}{\sqrt{3}\,\gamma_{mw}}$

③ Longitudinal/transverse shear stresses

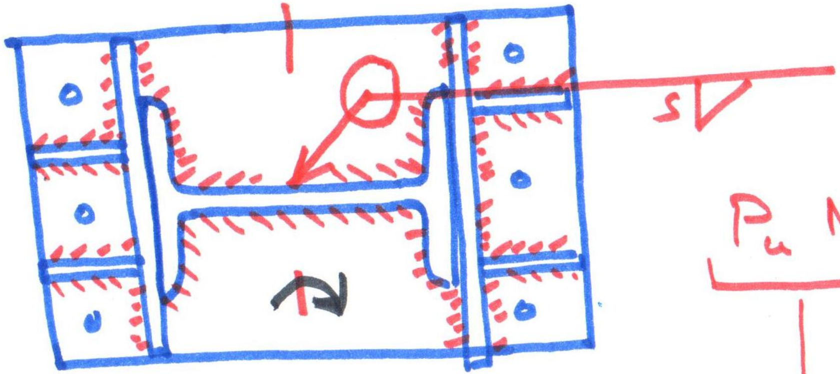
$$q_L = \frac{P_u}{4HT} \pm \frac{M_u}{2dHT}$$

Weld height/Gusset PL height

$$q_T = \frac{H_u}{4HT}$$

$$q_{res} = q = \sqrt{q_L^2 + q_T^2} \le f_{dw}$$

Solve for 'H'



$$\underbrace{P_u \quad M_u} \quad H_u$$

P_u, M_u → f_a = Normal stress

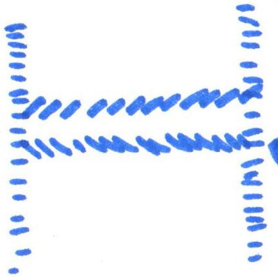
H_u → Shear (Transverse or longitudinal) = q

Shear stress $= q = \dfrac{H_u}{T(\text{Total length of weld})}$

$$f_a = \text{Normal stress} = \left(\pm \frac{M_u}{Z_{weld}} + \frac{P_u}{A_{weld}}\right)$$

A_{weld} = $L_{Total} \times T$

Z_{weld} = $\dfrac{I_{weld}}{y_{max}}$ — Can make simplification

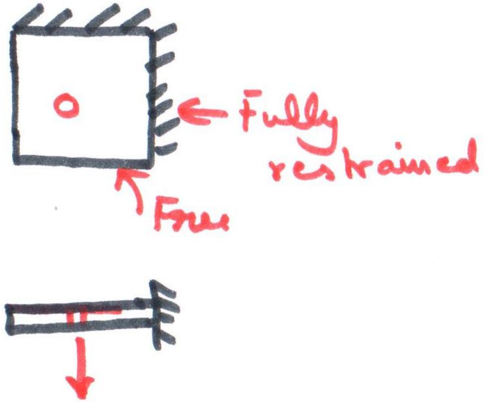


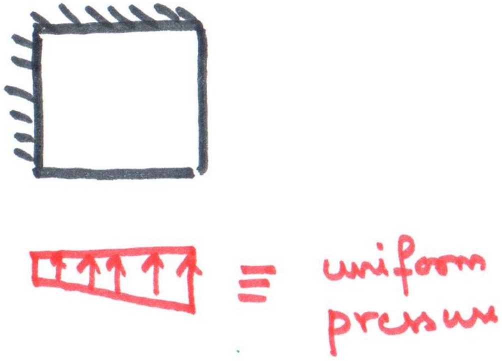
$$f_e = \sqrt{fa^2 + 3q^2} \le f_{dw}$$

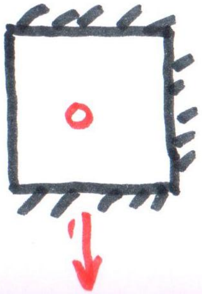
THICKNESS & WIDTH OF GUSSET ⅊

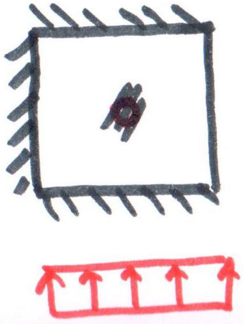
A & $I_{⅊}$ of gusset $>$ A & I of col.

BASE PLATE THICKNESS







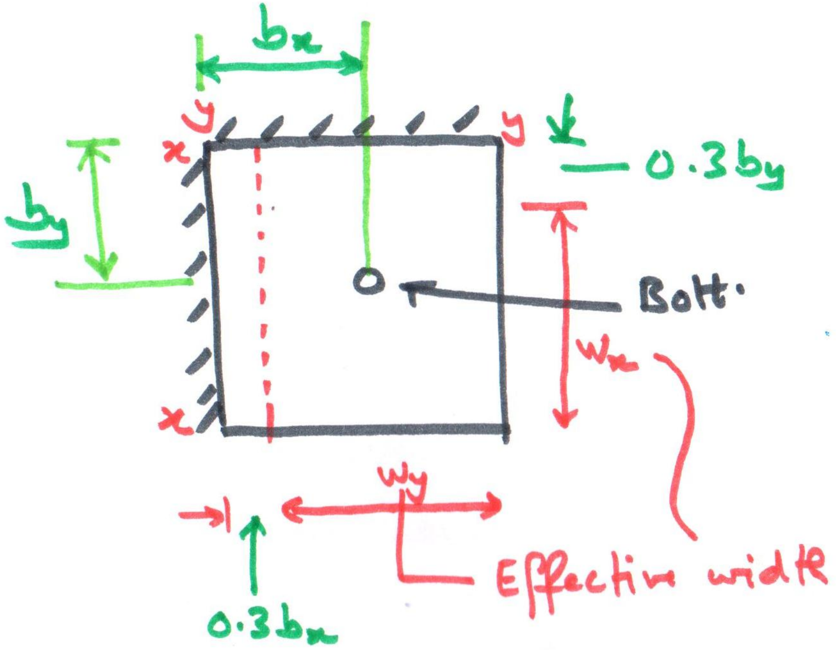


Ref: Formulas for stress & strain
Roark, R.J & Young W.C.
593.4 (083) ROA

Uniform pressure
Book provides σ_b ↔ Compare with design bending stress.

Ref: Plate with bolt forces.

Structural steelwork connections by
Owens & Cheal



F = Total bolt force (computed analytically)

Force $F = F_x + F_y$ — Force .... 'yy'

F_x — Force producing moment on 'xx'

M_x = Moment acting on xx

$= F_x \, b_x$

$M_y = F_y \, b_y$

Compare with design bending

$$F_x = \left[\frac{(w_x/b_x)}{(w_x/b_x) + (w_y/b_y)} \right] F$$

$$F_y = \left[\frac{(w_y/b_y)}{(w_x/b_x) + (w_y/b_y)} \right] F$$