UNIT - I

INTRODUCTION

Properties of steel - structural steel sections - Limit state design concept - Loads on structures - connections using rivets, welding and bolting - design of bolted and welded joints - eccentric connections - efficiency of joints.

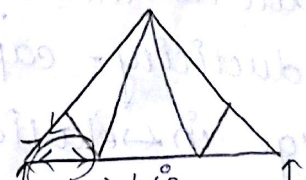
4.1.2017 Introduction:-

* A steel structure is an assemblage of group of elements expected to sustain their share of applied forces and to transfer them safely to the ground.

* The applied loads may be axial, bending, torsion or combination of these.

* The axial load may be tensile or compressive accordingly members are called tension or compression members.

* The example for tension member is tie, and compression member is strut or column or post



* Tension members are subjected to tensile force

* compression members are subjected to compressive forces.

* Flexural member are subjected to bending

Eg:- beam & slab.

* The elements of a structure connected by rivets or bolt or welds.

Uses of steels :- in buildings (industrial building)

Transmission towers

Railway bridges

Overhead tank

chimneys

Bunkers and silos

The points should be taken care before designing steel structures :-

* A section selected should be available in market.
* In steel buildings various elements should be compactable at the joints.
* Building It should have frequent maintenance.
* Transportation facilities for builtup sections should be explored before designing them.

Advantages of structural steel materials :-

* Steel members have high strength to unit weight.
* Steel should be ductile material, it should not fail suddenly. (ductility - capacity of a member undergo large inelastic deformations without loss of strength (or) ability to deform beyond elastic limit)
* Structural steel are tough because steel members are subjected to large deformations during fabrication and erection (toughness - It is withstand sudden load (impact load) the capacity of absorbed energy or ability of steel to resist fracture under impact loading)
* It should be light for angling and transportation.

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* Properly maintained structures will have long life.
* Additions or alterations is easily made in steel structures.
* It can be erected at faster rate.
* It has highest scrap value.
* It is a recyclable material.

Disadvantages (or) Limitations of steel structures:

* Steel structures exposed to atmosphere subjected to corrosion, therefore it requires frequent painting and maintenance.
* Steel structures need fire proof treatment, it may increases the cost of construction.
* Fatigue of steel is a major drawback. Fatigue is the reduction in the strength when subjected to large number of stress reversals and variation of tensile stresses.

Properties of steel structures:

* Unit mass of steel, $\rho = 7.85 \times 10^3 \ Kg/m^3$
* Modulus of elasticity, $E = \frac{\text{Linear (or) Longitudinal stress}}{\text{Linear (or) Longitudinal strain}}$

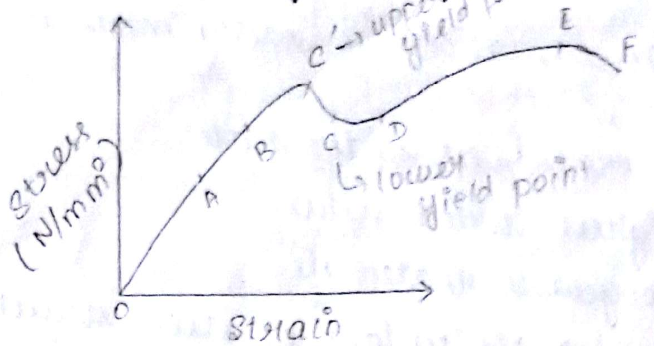
Shear force ↓ tangent to the surface

$= 2 \times 10^5 \ N/mm^2$

$= 2 \times 10^5 \ MPa$

* Poisson's ratio, $\mu = \frac{\text{Lateral strain}}{\text{Longitudinal strain}} = 0.3$
* Modulus of rigidity, $G = \frac{\text{Shear stress}}{\text{Shear strain}} = 0.769 \times 10^5 \ N/mm^2$
* Coefficient of thermal expansion, $\alpha_t = 12 \times 10^{-6} / ^\circ C$
* It is an isotropic material

Stress-strain diagram for mild steel:



Portion OAB - straight line where stress is proportional to strain, therefore, it obeys Hooks law.

Point A - Limit of proportionality

Point B - Elastic limit representing where the maximum stress upto which a specimen begans original length on removal of load.

Portion C'C - where definite increase in strain without any further increase in stress.

Portion CD - representing the plastic yielding. It is the strain at which at occurs after yield point with no increase in stress.

Portion DE - represents strain hardening. It is the range where additional stress produces additional strain and strain increases fast with stress till ultimate load reached.

Point E - It is the ultimate stress corrosponding to the ultimate load.

Point F - Breaking stress corrosponding to breaking load.

Types of structural steel:

① carbon steel:

* carbon and magnesium are the main strengthening element.
* The ultimate strength of the steel is 380-450 MPa

* The yield strength is 230 - 300MPa.

② High strength carbon steel:-

* It has high carbon content.
* The ultimate strength is
* The yield strength is 350 - 400MPa.
* It is used in transmission towers.

③ Medium and high strength micro alloy steel:-

* It has low carbon content, but achieves high strength due to addition of alloys such as vanadium, titanium and boron.
* The ultimate strength of steel is 440 - 590 MPa.
* The yield strength is 300 - 450MPa.

④ High strength quenched and tempered steel:- (molecular attraction)

* These steels are heat treated to develop high strength. It is tough and weldable.
* The ultimate strength is 750 - 950 MPa
* The yield strength is 550 - 700 MPa.

⑤ weathering steel:-

* It is a low alloy corrosion resistant steel.
* The ultimate strength is 450MPa.
* The yield strength is 350MPa.

⑥ Stainless steel:-

* It is a low carbon steel with 10.5 to 20% chromium and 0.5% nickel.

⑦ Fire resistant steel:-

* It is a thermo mechanically treated steel (TMT

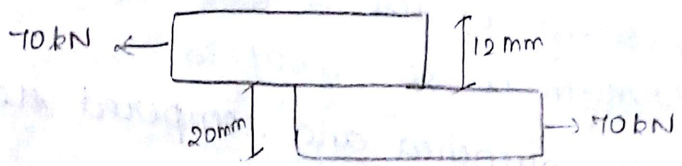
18.1.17 IS 800 : 2007

2017) Terminology pg:- 1 to 5

2) loads on steel structures pg:- 15,16 cl: 3.2.1 (dead load) cl: 3.2.1.2 (Imposed load), cl: 3.5.1

3) Pg. no. (19, 20) (Table 3), (32 (6.2 design of tension members), 33, 34, 35, 36, 37), (45, 46 [(7.3.4) splices], 47, 48, 49) (51) — Problems

25.1.17 1. Design a lap joint between two plates to transmit a factor load of 70KN using M_{16} size of bolt and grade of 4.6



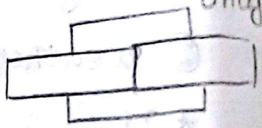
Given:-

(d) Nominal dia of bolt = 16mm (if not given assume)

Dia. of hole (d_0) = 16 + (2) → clearance

= 18mm

For grade 4.6 bold, f_{ub} = 400Mpa n_s is applicable in this case only



For Fe_{410}, f_u = 410Mpa

(i) Nominal shear strength

IS 800, 10.3.3 (Pg:- 75)

$$V_{dsb} = V_{nsb}/\gamma_{mb}$$

$$V_{nb} = \frac{f_{ub}}{\sqrt{3}}(n_n A_{nb} + n_s A_{sb})$$

$$A_{nb} = 0.78 \times \frac{\pi}{4} \times d^2 = 0.78 \times \pi/4 \times 16^2$$

n_n = (1) (one plate)

n_s = 0.

γ_{mb} = 1.25, Pg:- 30, Table 5

$$V_{dsb} = \frac{\frac{400\times10^{-3}}{\sqrt{3}}(1\times(0.78\times\pi/4\times(16)^2)) + 0}{1.25}$$

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$V_{dsb} = 28.974\ KN$

(ii) Bearing capacity:

IS 800 Pg: 75 (10.3.4)

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

$$V_{npb} = 2.5 K_b d t f_u$$

t → minimum thickness

p → pitch distance

e → end distance

K_b smaller of

$d_0 = 18$.

(a) $\frac{e}{3d_0} = \frac{1.5d_0}{3d_0} = \frac{1.5}{3} = 0.5$

(b) $\frac{p}{3d_0} - 0.25 = \frac{2.5d}{3 \times d_0} - 0.25 = \frac{2.5 \times 16}{3 \times 18} - 0.25 = 0.49$

(c) $\frac{f_{ub}}{f_u} = \frac{400}{410} = 0.975$

(d) 1.0

∴ $K_b = 0.49$ (i.e) lesser value of a, b, c, d

$$V_{dpb} = \frac{2.5 \times 0.49 \times 16 \times 12 \times 410 \times 10^{-3}}{1.25}$$

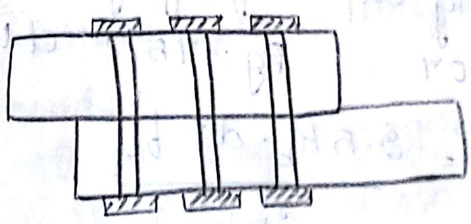
$V_{dpb} = 77.316\ KN$

Strength of bolt = 28.974 KN (least strength)

(iii)

No. of bolts.

$= \frac{Load}{strength} = \frac{70}{28.974} = 2.4 \simeq 3$ No.s



2. The member of truss consists of two angle of ISA 75X75X6 placed back to back which carries an ultimate tensile load of 150KN and is connected to an Gusset plate of 8mm thick placed between the two connected legs. Determine the no. of nominal dia 16mm dia bolt 4.6 grade ordinary bolt for the joint Design

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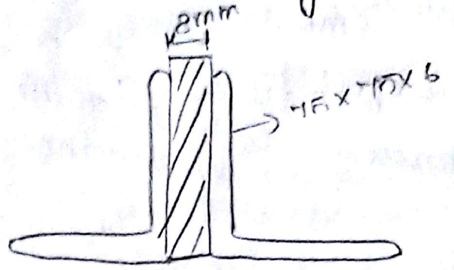
shear capacity and bearing capacity of gusset plate.

(Gusset plate → It is a plate provided to make the connections at the place where more than one member is to be joined.



Sol:

Given:

Nominal dia of bolt (d) = 16mm

Dia of hole (d_o) = 16+2 = 18mm

For grade 4.6 . f_{ub} = 400 Mpa

Fe 410 , f_u = 410 Mpa

(i) Nominal shear strength:-

IS 800 : 2007 Pg:- 75 cl 10.3.3

$$V_{dsb} = \frac{V_{nsb}}{\gamma_{mb}} = \frac{\frac{f_{ub}}{\sqrt{3}}(n_n A_{nb} + n_s A_{sb})}{\gamma_{mb}}$$

$$= \frac{\frac{400\times10^{-3}}{\sqrt{3}}\left(1\times0.78\times\pi/4\times16^2 + 1\times\pi/4\times16^2\right)}{1.25}$$

$$\boxed{V_{dsb} = 66.12\,KN}$$

The gusset plate and two angle sections controls the bearing capacity.

(ii) Nominal bearing capacity of gusset plate.

IS 800 : 2007 Pg:- 75 cl 10.3.4

$$V_{dpb} = \frac{V_{npb}}{\gamma_{mb}} = \frac{2.5 K_b \cdot d t f_u}{\gamma_{mb}}$$

(i) $\frac{e}{3d_o} = \frac{1.5d_o}{3d_o} = 0.5$

(ii) $\frac{p}{3d_o} - 0.25 = \frac{2.5d}{3d_o} - 0.25 = \frac{2.5\times16}{3\times18} - 0.25 = 0.49$

(iii) $\frac{f_{ub}}{f_u} = \frac{400}{410} = 0.95$

(iv) 1.

$k_b = 0.49$ — thickness of gusset plate

$$V_{dpb} = \frac{2.5 \times 0.49 \times 16 \times 8 \times 410}{1.25}$$

$V_{dpb} = 51.43\ KN$

(iii) Nominal bearing capacity of 2 angle sections :- (no. of angle 2, thickness of angle sections)

$$V_{dpb} = \frac{2.5 \times 0.49 \times 16 \times (2 \times 6) \times 410 \times 10^{-3}}{1.25}$$

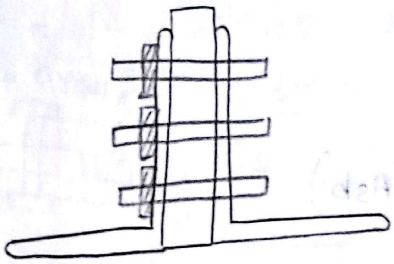
$V_{dpb} = 77.146\ KN$

∴ The strength of bolt = 51.43 KN (lesser of 3 strength values)

(iv) No. of bolts :

$$= \frac{\text{load}}{\text{strength}}$$

$$= \frac{150}{51.43} = 2.9 \simeq 3 \text{ bolts}$$



(Refer IS800:2007 cl (6.2, 6.3))

Tensile strength of plate : Pg :- 32

If the tensile load on the plate is more than tensile strength of the plate, the plate fails in tension through rupture.

The pattern of bolts may be ~~changed~~ chain or zig-zag or diamond.

In this zig-zag (staggered) pattern is better than chain pattern chain pattern but diamond pattern is more efficient and economic.

Strength and efficiency of joint :

Strength of a bolted joint is minimum strength of bolt ~~with~~ in shear or bearing.

Efficiency of a bolted joint $\eta = \dfrac{\text{strength of bolted joint/pitch length}}{\text{Strength of solid plate/pitch length}} \times 100$

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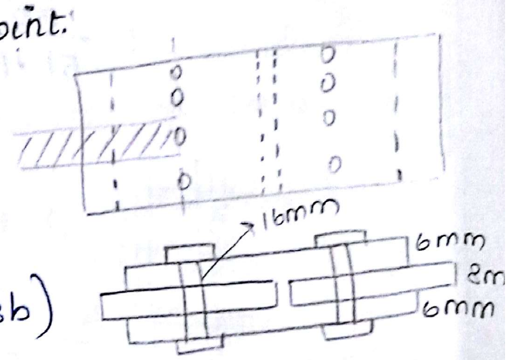
27.1.17

1. A single bolted double cover butt joint is used to connect two plates which are 8mm thick. use 16mm ϕ, 4.6 grade bolt, cover plate of 6mm thick. calculate (i) strength and efficiency of joint if 4 bolts are provided in the bolt line at a pitch of 45mm. Find (ii) efficiency of joint if two lines of bolts with two bolts in each line arranged to result in a double bolted double cover butt joint.

Sol:

45



Step (i) ① strength of bolt in shear/pitch length:-

$$V_{dsb} = \frac{f_{ub}}{\sqrt{3}\,\gamma_{mb}}(n_n A_{nb} + n_s A_{sb})$$

$$= \frac{f_u}{\sqrt{3}\,\gamma_{mb}}(2 n_n A_{nb})$$

$$= \frac{400 \times 10^{-3}}{\sqrt{3} \times 1.25}(2 \times 0.78 \times \pi/4 \times 16^2)$$

$$= 58\ KN$$

(ii) strength of bolt in bearing/pitch length:

~~$V_{nsb} = \frac{f_{ub}}{\sqrt{3}}$~~ $V_{dpb} = V_{npb}/\gamma_{mb} = \dfrac{2.5 k_b d t f_u}{\gamma_{mb}}$

k_b

(i) $\dfrac{e}{3d_0} = \dfrac{1.5d_0}{3d_0} = 0.5$

(ii) $\dfrac{p}{3d_0} - 0.25 = \dfrac{45}{3 \times 18} - 0.25 = 0.58$

(iii) $\frac{f_u}{f_{ub}} = 0.975$

(iv) 1

$K_b = 0.5$

$$V_{dpb} = \frac{2.5 \times 0.5 \times 16 \times 80 \times 410 \times 10^{-3}}{1.25}$$

$= 52.48 KN$

∴ strength of bolted joint/pitch length = 52.48 KN.

(iii) Net tensile strength of plate / pitch length.

IS 800: 2007 pg: 32 cl: 6.3.1

$T_{dn} = 0.9 A_n f_u / \gamma_{m1}$

$$A_n = \left[b - nd_n + \sum_i \frac{P_{si}^2}{4g_i} \right] t$$

For chain bolting (p → pitch, d_n → dia of hole, n → no. of bolt holes)

$A_n = (p - nd_n) t$

$= (45 - 1 \times 18) 8$

$A_n = 216 mm^2$

$$\therefore T_{dn} = \frac{0.9 \times 216 \times 410 \times 10^{-3}}{1.25}$$

$T_{dn} = 63.76 KN$

(iv) strength of solid plate / pitch length

$$= \frac{0.9 A_g f_u}{\gamma_{m1}}$$ (not in code book.)

$A_g = p \times t$

$$= \frac{0.9 \times 45 \times 8 \times 410 \times 10^{-3}}{1.25}$$

$= 106.27 KN.$

(v) Efficiency of plate;

$$\eta = \frac{\text{strength of bolt p/ pitch length}}{\text{strength of plate/ pitch length}} \times 100.$$

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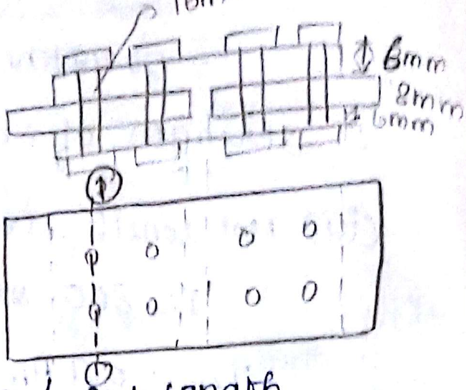
$$= \frac{52.48}{106.27} \times 100$$

$$\boxed{\eta = 49.38\%}$$

(ii) when the bolts are arranged in two rows then the strength of the joint/pitch length will be



In shear

(a) Bolt = 2 × 58 = 116 KN

(b) In bending:

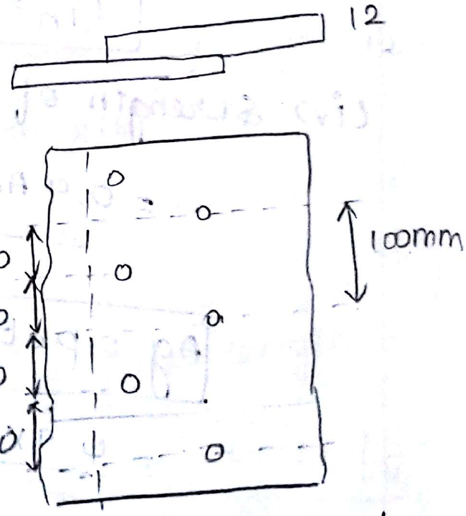
$= 2 \times 52.48 = 104.96$ KN

(c) Net tensile strength of plate/ pitch length = 63.76 KN

(only one bolt fall in critical section ①-①)

$\therefore$ Efficiency $= \frac{63.76}{106.27} \times 100 = 59.99\%$.

Determine strength and efficiency of lap joint as shown in figure. The bolts are 20mm φ and 4.6 grade. The two plates to be joined are 10mm and 12mm thickness.



Sol:

(i) strength of bolt in single shear:

$$= \frac{f_{ub}}{\sqrt{3}\,\gamma_{mb}} (n_n A_{nb} + n_s A_{sb})$$

$$= \frac{400 \times 10^{-3}}{\sqrt{3} \times 1.25} (1 \times 0.78 \times \frac{\pi}{4} \times 20^2)$$

= 45.26 KN

(ii) Strength of bolted joint/pitch length in shear

(2 bolts are falls/pitch length.)

$= 2 \times 45.26$

= 90.52 KN.

(ii) Strength of bolt in bearing:-

$$V_{dpb} = \frac{2.5 K_b d t f_u}{\gamma_{mb}}$$

K_b:-

(i) $\frac{e}{3d_0} = \frac{1.5d_0}{3d_0} = 0.5$

(ii) $\frac{P}{3d_0} - 0.25 = \frac{50}{3 \times 22} - 0.25 = 0.5$

(iii) $\frac{f_{ub}}{f_{up}} = 0.976$

(iv) 1

$\therefore K_b = 0.5$

$$V_{dpb} = \frac{2.5 \times 0.5 \times 20 \times 10 \times 410 \times 10^{-3}}{1.25}$$

$= 82 KN$

$\therefore$ Strength of bolt / pitch length in bearing $= 2 \times 82 = 164 KN$

(2 bolts / pitch length)

(iii) Net tensile strength of plate / pitch length.

IS 800 : 2007 pg:- 32 cl : 6.3.1

$A_n = [P - nd_n] t$

$= (100 - 1 \times 22) \times 10$ (2X50)

$$T_{dn} = \frac{0.9 \times (100 - 22) 10 \times 410 \times 10^{-3}}{1.25}$$

$T_{dn} = 230.256 KN$

$\therefore$ Strength of joint / pitch length $= 90.52 KN$

(iv) Strength of solid plate:-

$$= \frac{0.9 A_g f_u}{\gamma_{ml}} \qquad A_g = P \times t$$

$$= \frac{0.9 \times 100 \times 10 \times 410 \times 10^{-3}}{1.25}$$

$= 295.2 KN$

$$\eta = \frac{90.52}{295.2} \times 100 = 30.66\%$$

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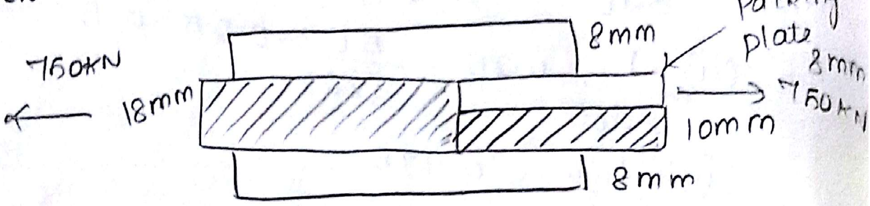
08.1.19: Two plates 10mm and 18mm thick are to be joined by double cover butt joint and it is subjected to tensile load of 750KN. Use 20mm dia bolt grade of steel Fe410 and grade of bolt 4.6 and two no.s of cover plates each 8mm thick



Here packing plate of 8mm is used because two plates of 18 mm and 10mm are jointed (18-10) = 8

IS 800:2007 pg: 75 10.3.3.3

According to IS800:2007 cls 10.3.3.3 thickness of packing plate, if greater than 6mm, shear strength will be reduced by factor β_{PK}.

$$\beta_{PK} = (1-0.0125\, t_{PK})$$

$$= (1-0.0125 \times 8) = 0.9$$

(i) strength of bolt in double shear / pitch length.

$$V_{dsb} = \frac{f_{ub}}{\sqrt{3}\,\gamma_{mb}} (n_n A_{nb} + n_s A_{sb}) \times \beta_{pkg}$$

$$= \frac{400 \times 10^{-3}}{\sqrt{3} \times 1.25} (2 \times 0.78 \times \pi/4 \times 20^2) \times 0.9$$

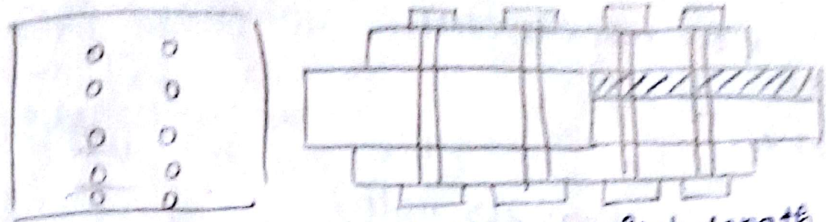
$$= 81.5\text{KN}$$

Assume strength of bolt in bearing / pitch to be more than that ensure.

∴ The no. of bolts that required = $\frac{\text{Load}}{\text{strength}}$

$$= \frac{750}{81.5} = 9.2 \simeq 10 \text{ Nos.}$$

Provide bolts in two rows (chain pattern) as shown in figure.



∴ There will be two bolts per pitch length. Therefore shear strength of bolt per pitch length

$= 2 \times 81.5 kN$

$= 162.94 kN$

To calculate pitch distance equate net tensile strength of plate/pitch length = shear strength/pitch length.

$T_{dn} = 0.9 A_n f_u / \gamma_{m1}$

$A_n = \left[p - n d_n + \sum_i \frac{P_{si}^2}{4 g_i} \right] t$

$A_n = (p - n d_n) t$

$0.9 \frac{f_u}{\gamma_{m1}} (p - n d_n) \times t = 162.94$

$0.9 \frac{\times 400 \times 10^{-3}}{1.25} (p - 1 \times 22) \times 10 = 162.94$

$p = 77.19 mm$

Pg: 73. cl: 10.2.2, 10.2.3

According to cl: 10.2.2.

$p \nless 2.5d = (2.5 \times 20)$

$= 50mm$

$p = 77.19mm > 2.5d$

Hence OK.

$p \approx 80mm$.

$V_{dpb} = \frac{2.5}{\gamma_{mb}} k_b d t f_u$

$k_b = 0.5$

k_b

$\frac{e}{3d_0} = \frac{1.5 d_0}{3 d_0} = 0.5$

$\frac{p}{3d_0} - 0.25 = 0.962$

$\frac{f_{ub}}{f_u} = \frac{400}{410} = 0.975$

1

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$= \frac{2.5}{1.25} \times 0.5 \times 20 \times 10 \times 410$

$V_{dpb} = 82KN$

82 > 81.5 (shear strength)

Hence design is safe.

20.1.17 1. Two flats each 210 mm x 8mm are to be joined using 20mm dia 4.6 grade bolt to form a lap joint. The joint is supposed to transfer a factored load of 250KN, design the joint and determine suitable pitch for the bolt. Assume Fe410 grade steel.

Sol:

Assume Bearing strength of bolt is more than the shear strength.

① Shear capacity: (∵ ~~ship~~ single shear)

Pg: 75 cl 10.3.3

$V_{dsb} = \frac{f_{ub}}{\sqrt{3} \times \gamma_{mb}} (n_n A_{nb} + A_{sb} n_s)$

$= \frac{400 \times 10^{-3}}{\sqrt{3} \times 1.25} (1 \times 0.78 \times \pi/4 \times 20^2)$

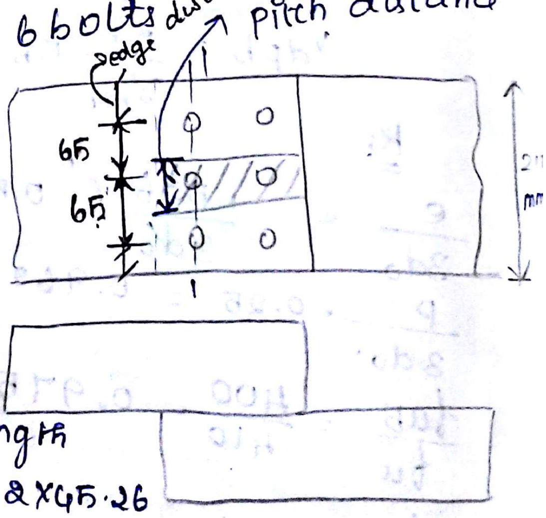
= 45.26 KN

② No. of bolts:

$= \frac{Load}{Strength}$

$= \frac{250}{45.27}$

= 5.52 ≃ 6 bolts



Arrange the bolts in three lines as shown in figure.

∴ Strength of the joint / pitch length
(Two bolts/pitch length)
~~(strength of the bolt/pi~~ = 2 × 45.26

= 90.52 KN

To calculate the pitch distance

Strength of bolt / pitch length = Net tensile strength.

$A_n = (P - n d_n) t$. critical section always (1).

$90.52 = \frac{0.9 A_n f_u}{\gamma_{m1}}$

$90.52 = \frac{0.9 \times 410 \times 10^{-3} (P - 1 \times 22) \times 8}{1.25}$

$P = 60.32 \simeq 65mm$

$P \nless 2.5d$

$\nless 2.5 \times 20$

$P \nless 50$.

Hence OK.

Edge distance (e) $= \frac{210 - (65+65)}{2} = 40mm$

<u>Bearing strength</u> :-

$V_{dpb} = \frac{2.5}{\gamma_{mb}} K_b d t f_u$

(K_b)

$\frac{e}{3d_0} = \frac{40}{3 \times 22} = 0.6$

$\frac{P}{3d_0} - 0.25 = \frac{65}{3 \times 22} - 0.25 = 0.734$

$\frac{f_{ub}}{f_{u}} = \frac{400}{410} = 0.975$

(1)

$K_b = 0.6$

$V_{dpb} = \frac{2.5}{1.25} \times 0.6 \times 20 \times 8 \times 410 \times 10^{-3}$

$V_{dpb} = 78.72 KN$

$78.72 > 45.26$ (shear strength)

Hence design is safe.

Indian standard flats → plates

2. Two ISF section 200 × 10mm each and 1.5m long are to be joined to make a member length of 3m. Design a butt joint with the bolts arranged in the

diamond pattern. The flats are supposed to carry a factored tensile force of 450KN. steel of grade Fe410, 20mm dia bolt of grade 4.6 used to make the connection. Determine the net tensile strength of main plate and cover plates.

Sol:

(Assume as a double cover butt joint.)

& Let us provide double cover butt joint:

① Shear strength: (double shear)

IS 800 : 2007 Pg: 75 Cl: 10.3.3

$$V_{dsb} = \frac{f_{ub}}{\sqrt{3}\,\gamma_{mb}} (n_n A_{nb} + n_s A_{sb})$$

$$= \frac{400 \times 10^{-3}}{\sqrt{3} \times 1.25} \left(1 \times 0.78\, \pi/4\, (20)^2 + \pi/4\, (20)^2\right)$$

$$\boxed{V_{dsb} = 90.52\ KN}$$

② strength of bolt in bearing:

$$V_{dpb} = \frac{2.5 K_b\, d t\, f_u}{\gamma_{mb}}$$

(K_b)

a) $\frac{e}{3d_0} = \frac{1.5d_0}{3d_0} = 0.5$

b) $\frac{p}{3d_0} - 0.25 = \frac{2.5d}{3d_0} - 0.25 = \frac{2.5 \times 20}{3 \times 22} - 0.25 = 0.5$

c) $\frac{f_{ub}}{f_u} = 0.975$

d) 1.

$$V_{dpb} = \frac{2.5 \times 0.5 \times 20 \times 10 \times 410 \times 10^{-3}}{1.25}$$

$= 82\ KN$

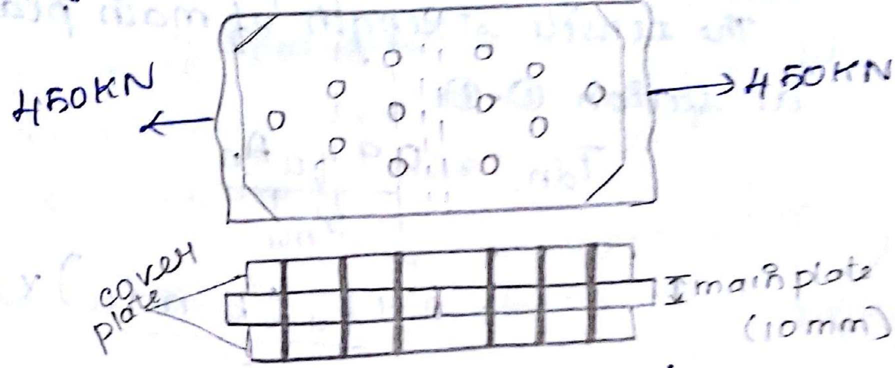
∴ Strength of bolt = 82 KN.

$= \frac{\text{Load}}{\text{Strength of bolt}}$

$= \frac{450}{82}$

$= 5.48 \approx 6$ bolts.

Arrange the six no. of bolts in diamond pattern as shown in figure.



Thickness of cover plate ≮ $5/8 \times t$

$t_{cp} = \frac{5}{8} \times 10 = 6.2 \approx 8mm.$

∴ Provide 8mm thick cover plate to make double cover butt joint.

Not for exam:

The force of main plate transfered to the cover plate through bolts.

∴ There will be Maximum load in the main plate before section ①-① and equal to applied load.

∴ Main plate will be critical @ section ①-①

when it crosses section ①-① bolts absorb force equal to their strength and transfer it to the cover plates.

The coverplates after section ①-① will carry forward this transfered force from the main plate.

Thus in the main plate, the force reduces as it successive sections such as ②-②, ③-③ etc... and in the cover plates, the transfered force increases.

In the present case, the entire force from the main plate will be transfered by the bolts to the cover plates after crossing section ③-③.]

Therefore; section ③-③ will be critical for main plate.

The tensile strength of main plate will be critical at section ①-①

$$T_{dn_1} = \frac{0.9 f_u A_n}{\gamma_{m_1}}$$

$$= \frac{0.9 f_u (b - n d_n) \times t}{\gamma_{m_1}}$$

$$= \frac{0.9 \times 410 \times 10^{-3}}{1.25} (200 - (1 \times 22)) \times 10$$

$$\boxed{T_{dn_1} = 525.47 \text{ KN}}$$

The tensile strength of the cover plate will be critical at section ③-③

$$T_{dn_2} = \frac{0.9 f_u}{\gamma_{m_1}} (b - n d_n) \times t$$

$$= \frac{0.9 \times 410 \times 10^{-3}}{1.25} (200 - 3 \times 22) \times 16$$

$$\boxed{T_{dn_2} = 632.90 \text{ KN}}$$

Scanned by CamScanner

6.2.17 **Welding:** (Theory refer PPT)

Advantages — 2m

Lap joint — 1m

1) Two plates of 16mm and 14mm thickness are to be joined by ~~group~~ groove weld. The joint is subjected to a factored tensile force of 430KN. Due to some reasons, the effective length of the weld that could be provided was 145mm only. Check the safety of the joint if (a) single V groove weld is provided (b) double V groove weld is provided. Assume the plates are to be shop welded.

Sol:

Case(i):- Single V- groove weld:-

For Fe410 $f_y = 250 N/mm^2$ → Pg-14 (yield stress)

Strength of the weld

$$T_{dw} = \frac{l_w t_e f_y}{\gamma_{mw}}$$

where l_w = effective length of weld. (145mm)

t_e = throat thickness

t_e (for single V butt joint) $= \frac{5}{8} \times t$

$= \frac{5}{8} \times 14$

$= 8.75mm$

Refer Pg: 30 Table 5

γ_{mw} = Partial safety factor of the material.

Refer IS800:2007 pg: 30 cl:- 5.4.1,

Table ⑤: $\boxed{\gamma_{mw} = 1.25}$ (shop fabrication)

$\therefore T_{dw} = \frac{145 \times 8.75 \times 250 \times 10^{-3}}{1.25}$

$= 806.25KN < 430KN$ (given)

∴ It is not safe.

Case (ii):- Double V- groove weld:-

$$T_{dw} = \frac{l_w t_e f_y}{\gamma_{mw}}$$

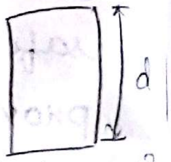
t_e for double goove joint = thickness of thinner plate = 14mm

$= \frac{175 \times 14 \times 250 \times 10^{-3}}{1.25}$

$= 490 \text{ KN} > 430 \text{ KN}$

$\therefore$ Safe.

2. A groove weld (butt joint) is to connect two plates 180 x 18 mm each determine the designed bending strength of the joint if it is subjected to a moment of 13 KNm. Also determine the adequacy of the joint if the shear force at the joint is 200KN. Assume the welds to be double U shop welded.



$\frac{bd^2}{12}$

7.2.17 Sol:

(i) Design bending strength, $F_{dw} = 1.2 Z_e \frac{f_y}{\gamma_{mo}}$

where Z_e → elastic section modulus $\frac{bd^2}{6}$

$= \frac{18 \times (180)^2}{6}$ → depth

$= 97.2 \times 10^3 \text{ mm}^3$

γ_{mo} => partial safety factor against yielding $= 1.1$

$F_{dw} = \frac{1.2 \times 97.2 \times 10^3 \times 250 \times 10^{-3}}{1.1}$

$= 26,509.09$ KNmm

Factored moment $= 1.5 \times M$ (moment) (1.5 → F.O.S)

$= 1.5 \times 13 \times 10^3$

$= 19500$ KNmm.

$F_{dw} = 26,509.09 \text{ KNmm} > 19500 \text{ KNmm}$

Hence safe.

(ii) Factored shear force $= 1.5 \times S.F.$

S.F = 200 KN (given) $= 1.5 \times 200$

$= 300$ KN

Design shear strength $= \frac{l_w t_e f_{yw}}{\sqrt{3}\, \gamma_{mw}}$

$f_y = f_{yw} = 250$ mpa

(for double U-weld, t_e = thickness of smaller plate = 18mm)

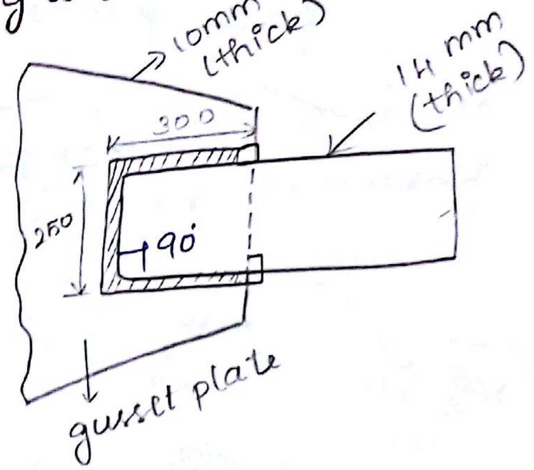
$$300\times10^3 = \frac{l_w \times 18 \times 250}{\sqrt{3}\times 1.25}$$

~~$l_w = 144.33mm$~~ < 180mm.

$l_w = 144.33mm$ < 180mm

Hence safe

3. A tie member in a truss girder is 250×14mm size. It is welded to a 10mm thick gusset plate by fillet weld. The overlap of the member is 300mm and the weld size is 6mm. Determine the design strength of the joint if the welding is shown in figure. what is the increase in strength of the joint if the welding is done all around. Assume shop welding.



Sol:

Design strength of the fillet weld (10.5.7.1.1) Pg:79

$$P_{wd} = \frac{l_w t_t f_u}{\sqrt{3}\,\gamma_{mw}}$$

l_w: effective length of weld
$= (2\times300) + 250$
$= 850mm$

t_t (or) t_e = effective throat thickness
Pg:78 (10.5.3.2)

$= KS$ → Table : 22 Pg:78

$= 0.7\times6 = 4.2mm$

$$P_{wd} = \frac{850\times4.2\times410\times10^{-3}}{\sqrt{3}\times1.25}$$

$P_{wd} = 676.05KN$

(i) when welding is done all around

$$P_{dw} = \frac{l_w \times t_t \times f_u}{\sqrt{3}\times\gamma_{mw}}$$

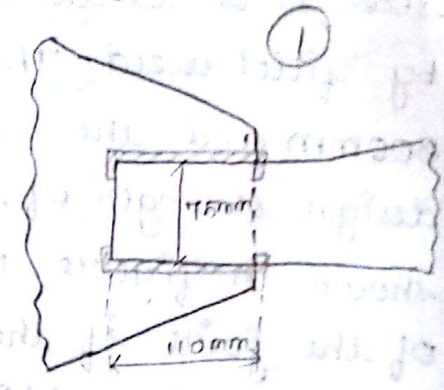
$$= \frac{((2\times250)+(2\times300))\times4.2\times410\times10^{-3}}{\sqrt{3}\times1.25}$$

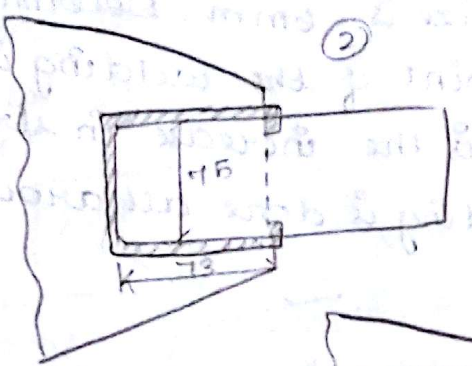
$= 874.89$ KN

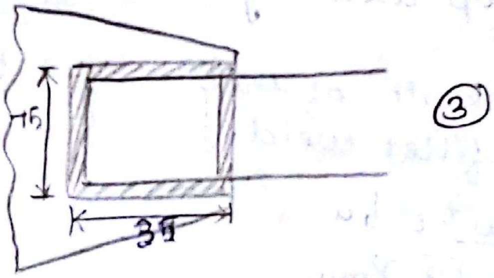
∴ Increase in strength = 874.89 − 676.05

= 198.84 kN

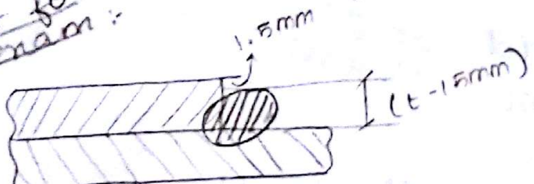
4. A 75×8mm tie member is to transmit a factored load of 145kN. Design the fillet weld and necessary overlap for cases shown in figure. Use Fe 410 grade steel. assume gusset plate thickness 12mm.



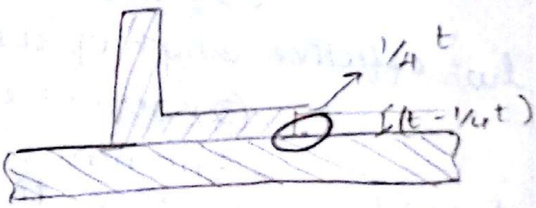


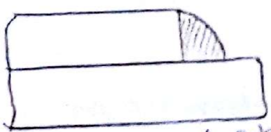


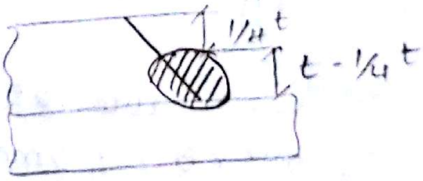
Not for exam :



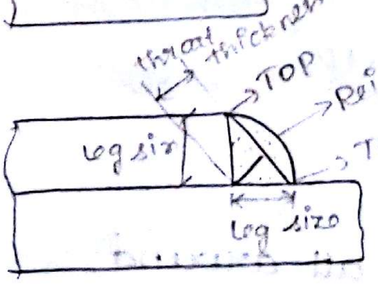
fillet weld on square edge

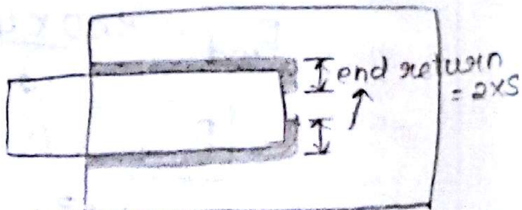






Pg→80
Fig: 17





Take table 21, pg: 78

The minimum size of weld for 12 mm thickness of gusset plate } = 5mm

The maximum size of weld for 8mm thick plate (Refer fig: 17 pg: 80) } = t − 1.5

= 8 − 1.5

= 6.5mm

Let us provide 5mm thick weld

Case (a): Figure①

Design strength of weld, $P_{dw} = \frac{l_w t_t f_u}{\sqrt{3}\gamma_{mw}}$ → given in code book just multiply with area $(l \times t)$

$t_t = KS = 0.7 \times 5 = 3.5mm$

$$145 \times 10^3 = \frac{l_w \times 3.5 \times 410 \times 10^3}{\sqrt{3} \times 1.25}$$

$\boxed{l_w = 218.77mm}$ ≃ 220mm

∴ Length of weld on each side $= \frac{220}{2} = 110mm. < 75mm$ Hence OK.

End return $= 2 \times S = 2 \times 5 = 10mm$

∴ The overlap required = 110mm.

∴ Total length of weld = $(2 \times 110) + (4 \times 10)$

$= 260mm.$

Case (b) :- Figure②

Total length required as found above is 220mm.

The weld length accomodate on the transverse side = 75mm

∴ The required overlap is found from

$$\frac{220 - 75}{2} = 73mm$$

∴ The overlap = 73mm.

The total length of weld = $2(73) + 2(10) + 75$ (End return)

$= 241mm$

Case (c) :- Figure③

Total lcng over lap required $= \frac{220 - (2 \times 75)}{2}$

$= 35$

Total length of the weld $= (2 \times 35) + (2 \times 75)$

$= 220mm.$

5. The circular plate 150mm ϕ is welded with another plate by means of 6mm fillet weld. Calculate the ultimate twisting moment that can be resisted by the weld. Use Fe410 steel and shop welding

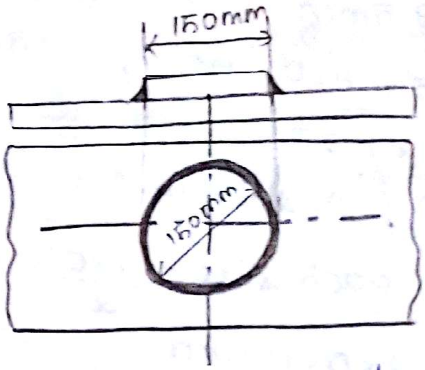
$t_t = KS = 0.7 \times 6 = 4.2$

Strength of weld/mm length

$= \frac{l_w \times t_t \times f_u}{\sqrt{3}\ \gamma_{mw}}$

$= \frac{1 \times 4.2 \times 410 \times 10^{-3}}{\sqrt{3} \times 1.25}$

$= 795.36$ KN/mm

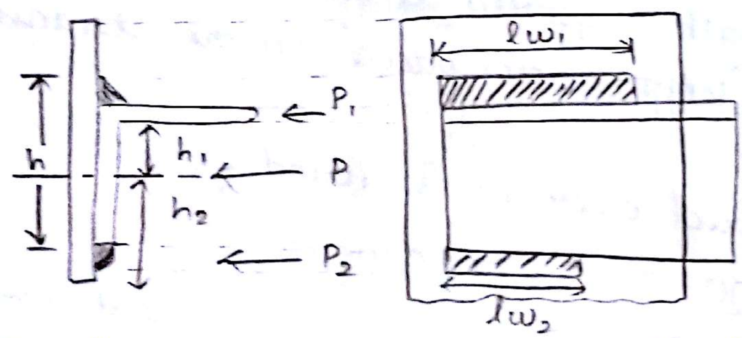


Total length of weld $= \pi d = \pi \times 150 = 471.24$mm

$\therefore$ Twisting moment $= \frac{795.36 \times 471.24 \times 150}{2}$

$= 28.11 \times 10^{6}$ KNmm

8.8.17. Fillet weld for truss member :-



l_{w_1} & l_{w_2} → length of longitudinal fillet weld on 2 sides.

P_1, P_2 → Factored design loads along length l_1 & l_2 respectively.

P → Factored design load acting on centroid of the section.

Taking moment about the line passing through the length lw_2

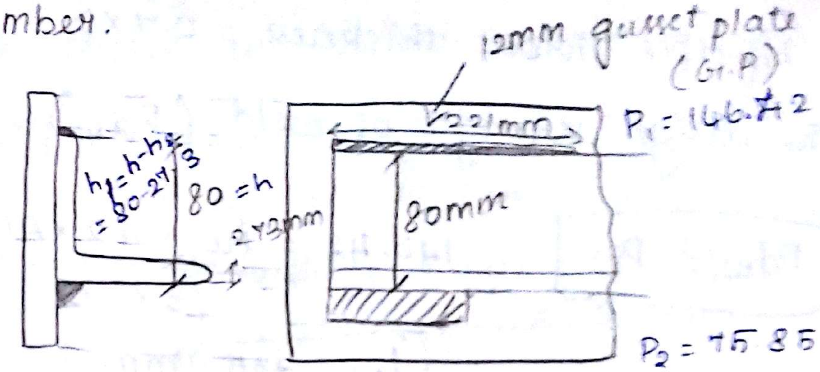
moment @ lw_1

$P_1 h - P h_2 = 0$

$P_1 = \frac{P h_2}{h}$

$P_2 = \frac{P h_1}{h}$

Q) A tie member consists of an ISA 80×50×8mm is welded to 12mm gusset plate at ~~sig~~ site. Design welds to transmit load equal to the design strength of the member.



Sol:

The given weld is site weld

Partial safety factor for site weld $\gamma_{mw} = 1.5$

$\gamma_{mo} = 1.1$

Refer steel handbook for ISA 80x50x8

$A_g = 978 \, mm^2$

$C_{zz} = 27.3$

To find:

Design strength of the member governed by yielding of gross section

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

$$= \frac{978 \times 250 \times 10^{-3}}{1.1}$$

$$P = \boxed{T_{dg} = 222.27 \text{ KN}}$$

∴ The weld will be designed to transmit a force equal to 222.27 KN

The force resisted by weld at ~~lower~~ upper side of the angle $P_1 = \frac{P h_2}{h}$

$$= \frac{222.27 \times (80 - 27.3)}{80}$$

$$\boxed{P_1 = 146.42 \text{ KN}}$$

The force resisted by weld at ~~upper~~ lower side of the angle $P_2 = \frac{P h_1}{h} = \frac{222.27 \times 27.3}{80}$

$$\boxed{P_2 = 75.85 \text{ KN}}$$

Assume size of the weld, S = 6mm (> 3mm)

∴ Effective throat thickness = 0.7 × 6 = 4.2mm

The design strength of weld $(P_{dw})_1 = \frac{l_w t_t f_u}{\sqrt{3}\gamma_{mw}}$

$P_{dw_1} = P_1$

$$146.42 = \frac{l_{w_1} \times 4.2 \times 410 \times 10^{-3}}{\sqrt{3} \times 1.5}$$

$l_{w_1} = 220.91mm$

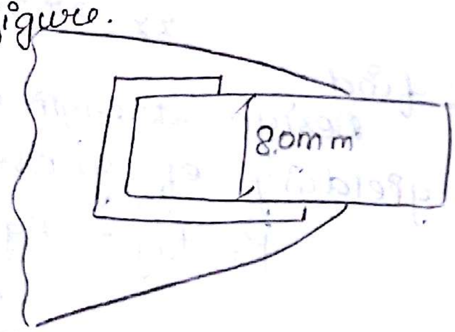
$\simeq 221mm$

$P_{dw_2} = P_2$

$$75.85 = \frac{l_{w_2} \times 4.2 \times 410 \times 10^{-3}}{\sqrt{3} \times 1.5}$$

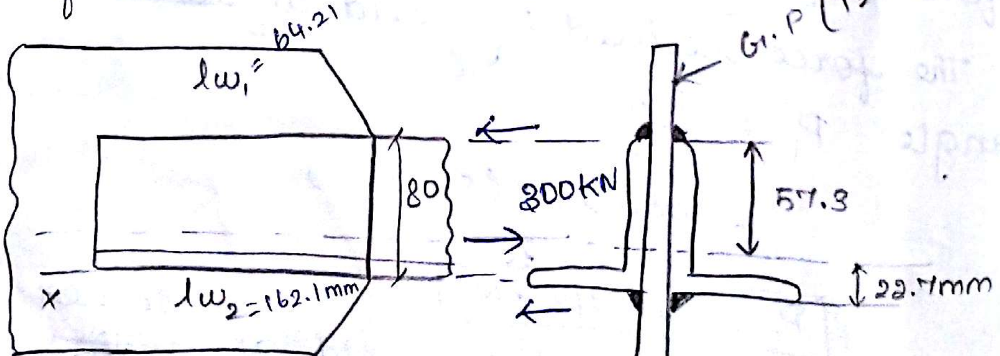
114.4mm ≃ 115mm.

8 2. Design a fillet weld for the previous problem, the weld is done as shown in figure.



3. A tie member of a truss consists of double angle section each 80 × 80mm × 8 mm welded on opposite side of 12mm thick gusset plate. Design a fillet weld for making the connection in the workshop. The factored tensile force in the member is 300KN.

T.A.



l_{w_1} & l_{w_2}

Let the length of the weld at the top and bottom of the angle section be l_{w1} and l_{w2}.

Total length of the weld is $l_{w1} + l_{w2}$

$$T.L.W = 2(l_{w1} + l_{w2})$$

Minimum size of weld = 5mm (for 12 G.P)

Maximum size of weld = 8 - 1.5 = 6.5mm

∴ size of weld = 5mm

$t_t = KS = 0.7 \times 5 = 3.5mm$

W.K.T

Design strength of weld, P_{dw}

$$= \frac{l_w t_t f_y}{\sqrt{3} \times \gamma_{mw}}$$

Design strength of weld/mm length = $\frac{1 \times 3.5 \times 410}{\sqrt{3} \times 1.25}$

$= 662.79$ N/mm

Design strength of weld = Factored tensile force.

$$662.79 \times 2(l_{w1} + l_{w2}) = 300 \times 10^3$$

$l_{w1} + l_{w2} = 226.31mm$

Taking moment to find out l_{w1} & l_{w2}.

Take the moment about the line XX.

$$662.79 \times 2 l_{w1} \times 80 = 300 \times 10^3 \times 22.7$$

$l_{w1} = 64.21mm$

$l_{w2} = 226.51 - 64.21$

$l_{w2} = 162.1mm$

Indian Standard Light channel

An ISLC 300 at 324.7 N/m is to carry a factored tensile force of 900KN. The channel section is to be welded at the site to a gusset plate 12mm thick. Design a fillet weld if the overlap is limited to / restricted to 150mm

Sol: Refer IS steel book

If the words are given we should provide slot welding

For ISLC 300 pg-6 → Steel table
334.4 N/m
$A_g = 4211 mm^2$
$t_f = 11.6 mm$
$t_w = 6.7 mm$

Minimum size of the weld (for 13mm thick gusset plate) } = 5mm.

Pg: 78, Table (12). IS 800: 2007

Maximum size of the weld = $t_w - 1.5$
= 6.7 - 1.5
S = 5.2 mm

∴ Provide 5mm size weld.

Effective throat thickness → Pg: 78, table 22
= KS
= 0.7 × 5
= 3.5mm

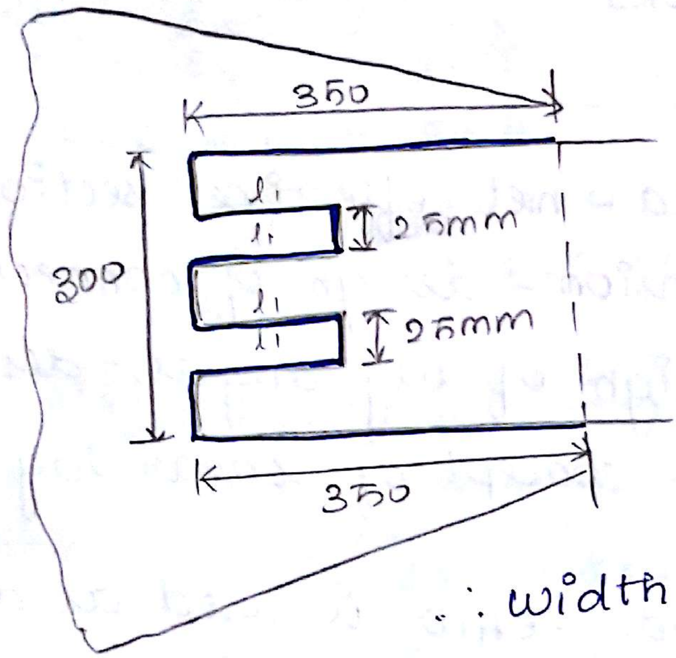
Design strength of the weld/mm length
$= \frac{l_w \times t_t \times f_u}{\sqrt{3}\,\gamma_{mw}}$
$= \frac{1 \times 3.5 \times 410}{\sqrt{3} \times 1.5}$
= 552.33 N/mm

Design strength of weld } = Factored load.
$\frac{l_w \times t_t \times f_u}{\sqrt{3} \times \gamma_{mw}}$
$\frac{l_w \times 3.5 \times 410}{\sqrt{3} \times 1.5} = 900 \times 10^3$
$l_w = 1629.46 mm$

$l_w \simeq 1630 mm$

Because of restriction given the length of the weld as 350mm. The overlap length of the weld that can be provided

$= 2 \times 350 + 300 = 1000mm < 1630mm$.



Provide slot welding as shown in figure.

Provide width of the slot either $3t_w$ (or) 25mm which ever is greater.

$3t$
$= 3 \times 6.7 = 20.1$ (or) 25mm

$\therefore$ width of slot $= 25mm$

Provide length of the slot l_1 :-

$1630 = (2 \times 350) + 300 + 4l_1$

$l_1 = 157.5mm \simeq 158mm$.

Provide $(150 \times 25)mm$ 2no. of slots.