

Sol<sup>n</sup>

$$t = 20 \text{ mm}$$

Bolt

Date → 25/07/2019

Grade 4.6 or  $f_{ub} = 400 \text{ N/mm}^2$

$$0.9 \times f_y = 250 \text{ N/mm}^2$$

$$F_{euro}, f_y = 410 \text{ N/mm}^2$$

$$f_y = 250 \text{ N/mm}^2$$

Strength of the plate @ the point of yielding

$$T_{dn} = \frac{0.9 A n f_y}{\gamma_m 1}$$

$$d_o = 20 + 2 = 22 \text{ mm}$$

$$A_n = (b - n d_o) t$$

$$= (180 - 3 \times 22) \times 20$$

$$= 2280 \text{ mm}^2$$

$$\gamma_m = 1.25 \quad (\text{Table-5, IS 800 2007})$$

$$T_{dn} = \frac{0.9 \times 2280 \times 410}{1.25} = 6730.48 \text{ Nmm} = 673.048 \text{ kN}$$

~~Strength of bolt~~ = ~~6730.48 Nmm~~

~~= 673.048 kN~~

~~= 673.056 kN~~ ~~For the first left flange~~

$$\underline{\text{Strength of the bolt}} = \frac{0.8}{\gamma_m \times \gamma_0} = \frac{0.8}{0.9 \times 1.25} = 0.64 \text{ (d)}$$

(i) ~~Strength of bolt in shear~~ ~~for 2d + 0.8p = 2(20) + 0.8(8) = 56.4 mm~~ ~~is 9.8 kN~~ (d)

$$V_{deb} = V_{nsb} / \gamma_m = \frac{0.8P}{\gamma_m} = \frac{0.8P}{0.9} = \frac{0.8P}{0.9} = 0.8889P \text{ (d)}$$

$$V_{nsb} = \frac{f_{ub}}{B} (n_n A_{nb} + n_s A_{sb}) \text{ (d)}$$

$$n_n = 1, n_s = 0 \text{ for cap joint} = 0.8889P$$

$$n_s = 1, \text{ double cover butt joint} = 0.8889P$$

$$A_{nb} = \frac{0.78 \times \frac{\pi}{4} \times d^2}{1.2 + 0.8P} = \frac{0.08181}{1.2 + 0.8P} = \frac{0.08181}{1.2 + 0.8 \times 20} = \frac{0.08181}{20.16} = 0.00405 \text{ mm}^2$$

$$V_{deb} = \frac{f_{ub}}{B} (8 \times 245 + 0) = \frac{400}{1.25} (8 \times 245) = 271585.56 \text{ N}$$

$$= \frac{(400 \times (8 \times 245))}{1.25} = 271585.56 \text{ N} = 271.58 \text{ kN}$$

$$271.58 \text{ kN} = 4$$

(ii) Strength of bolt in shear  $\rightarrow 26.1 = 100$

$$V_{dpb} = V_{npb} / \gamma_{mb} = \frac{0.84 \times 0.336 \times R \cdot 0}{26.1} = 0.67$$

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

$k_b$  is the smaller of  $2.20, 8F_d$

$$(a) \frac{l}{3d_0} = \frac{30}{3 \times 22} = 0.4545 \xrightarrow{\text{less than } 2.20} \text{Ansatz}$$

$$(b) \frac{P}{3d_0} = \frac{60 - 0.25}{3 \times 22} = 0.9090 \xrightarrow{\text{less than } 2.20} 0.6579$$

$$(c) \frac{f_{ub}}{f_{ue}} = \frac{400}{410} = 0.9756 \xrightarrow{\text{less than } 0.8F_d} 0.26V$$

$$(d) \frac{1}{(A_f + A_m)} \frac{d.f.t.}{\delta F} = 0.26V$$

$$V_{npb} = 2.5 \times 0.4545 \times 20 \times 20 \times 490$$

$$\text{Ansatz} = \frac{181800 \text{ N}}{1.25} = 149040 \text{ N} \\ = 186.89 \text{ kN}$$

$$V_{dpb} = \frac{181800}{1.25} = \frac{149040}{1.25} = 119076 \text{ N} \\ = 149 \text{ kN} \times 6 = 894 \text{ kN}$$

The design strength of the joint is the least of the  $(0.72 \times 8F_d)$   $\frac{d.f.t.}{\delta F_d} = 0.26V$   $\frac{(0.72 \times 8F_d) \times 0.26}{\delta F_d} = 0.26V$

$$0.26 \times 282 \text{ kN} = 200 \left( \frac{(0.72 \times 8F_d) \times 0.26}{\delta F_d} \right) =$$

$$0.26 \times 282 \text{ kN} = 200 \times 26.1$$

~~P = 415.4 N/mm²~~

$$\text{Strength of the solid plate} = \frac{A_g f_y}{\gamma_m} = \frac{(180 \times 20) \times 250}{1.25} = 720000 \text{ N/mm}^2 = 720 \text{ kN}$$

Efficiency of the joint,

$$\eta = \frac{\text{Strength of joint}}{\text{Strength of the solid plate}} \times 100$$

$$= \frac{271.58}{720} \times 100 = 37.71\%$$

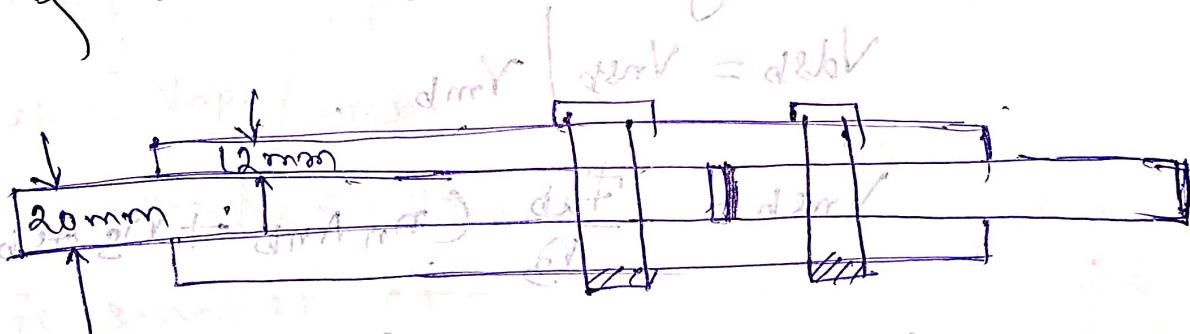
$$= \frac{271.58}{720} \times 100 = 37.71\% = 37.71$$

Date = 26/07/2019

Date = 08/08/2019

Q: Find the efficiency of the joint, if in the above example instead of lap butt joint is made using two cover plates each of size 12 mm & 6 nos. of bolts on each side (i).

Sol)



Given data,  $\sigma_{bol} = \frac{P}{A} = 410 \text{ N/mm}^2$

$$t = 12 \text{ mm}$$

$$d = 20 \text{ mm}$$

$$f_{ub} = 400 \text{ N/mm}^2$$

$$f_{th} = 410 \text{ N/mm}^2$$

$$b = 180 \text{ mm}$$

$$d_h = 20 + 2 = 22 \text{ mm}$$

$f_y = 250 \text{ N/mm}^2$  for grade 40

### Strength of the Joint:-

$$0.75 \times T_{dn} \geq \frac{0.9 A_n f_u}{Y_m}$$

Joint area =

$$A_n = [b - n d_n] t$$

$$= [(80 - 3 \times 22) \times 22] \times 20$$

$$= 2280 \text{ mm}^2$$

$$T_{dn} = \frac{0.9 \times 2280 \times 410}{1.25} \quad \text{(Page - 32)}$$

$$\text{Prob 10/28} = 673.056 \text{ N}$$

$$\text{Prob 20/28} = 673.056 \text{ kN}$$

est no. of trial cut to splices with first

### Strength of bolt :-

$$V_{dsb} = V_{nsb} / Y_{mb}$$

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

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

$$= 0.78 \times \frac{\pi}{4} \times 20^2 \text{ mm}^2 = 7$$

$$= 245.04 \text{ mm}^2$$

$$\rightarrow \text{mm}^2/\text{loop} = 1.7$$

$$\rightarrow \text{mm}^2/\text{loop} = 1.7$$

$$\text{mm}^2 = 4$$

$$A_{sb} = \frac{\pi}{4} d^2 \\ = 314 \cdot 15 \text{ mm}^2$$

$$V_{nsb} = \frac{400}{\sqrt{3}} (1 \times 245.04 + 1 \times 314.15) \\ = 339.537 \text{ kN}$$

$\mu_s \cdot d_s \times 2 = 1.0$  and not  $d_s V / f_t$

$$\text{Total } V_{nsb} = \frac{339.537}{1.0}$$

Total  $V_{nsb}$  for 6 no. of bolt.

$$= 6 \times 129.13$$

$$= 774.78 \text{ kN}$$

Design shear strength,

$$V_{deb} = \frac{V_{nsb}}{\gamma_{mb}} = \frac{774.78}{1.25}$$

$$= 619.82 \text{ kN}$$

(Front corner 25% lesser  $\mu_s = 0.8 \times 0.8 = 0.64$ )

Appoint 2 extra bolt of the bolt.

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

$$V_{npb} = 2.5 R_b d_t f_u \text{ for Appoint 2 bolts}$$

$R_b$  is smaller of

$$(a) \frac{(0.8 \times 0.8)}{3d_o} = \frac{0.64}{3 \times 22} = 0.0545$$

$$(b) \frac{1.8 \times 0.8}{3d_o} = \frac{1.44}{3 \times 22} = 0.25 = 0.6590$$

$$(c) \frac{f_{ub}}{f_u} = \frac{400}{410} = 0.9756$$

$$(d) 1.00$$

$$\text{So, } k_b = 0.4545$$

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

$$(2.5 \times 0.4545 \times 20 \times 20 \times 40) \frac{0.01}{0.8} = 186.345 \text{ N}$$

$$= 186.345 \text{ KN} \quad \text{not F.S. pass}$$

$$\text{Total } V_{npb} \text{ for 6 no. of bolt} = 6 \times 186.34$$

$$= 1118.04 \text{ KN.}$$

Q. Design bearing strength,

$$V_{dpb} = \frac{1118.04}{1.25} = 894.43 \text{ KN.}$$

$$\text{Design Strength of bolt} = 619.82 \text{ KN} \text{ less than.}$$

Since total thickness of cover plates

$$= 2 \times 12 = 24 \text{ mm which is more than}$$

thickness of the plates, strength of the plates is the strength of main plate is the strength of the only.

Design Strength of solid plate =  $A_g f_y$

$$= 250 \times 180 \times 20 = 81818 \text{ KN}$$

$$OP22.0 = 22.0 - \frac{2.0}{0.86} = 81818 \text{ KN (d)}$$

$$dTFP-0 = \frac{0.01}{0.01} = \frac{1.0}{0.01} = 100.0 \text{ (d)}$$

$$= 00.1 \text{ (d)}$$

Efficiency of the joint  $\frac{\text{Strength of joint}}{\text{Strength of solid plate}} \times 100$   
 width of web is  $\sqrt{\frac{\text{Strength of joint}}{\text{Strength of solid plate}} \times 100}$   
 width is  $\sqrt{\frac{619.82}{818.18} \times 100} = 75.75 \text{ mm}$   
 deformation at yield  $= 2.47 \text{ mm}$

## Design Philosophy

The aim of design is "to decide shape, size & connection details of the members so that the structure being designed will perform satisfactorily during its intended life. It is appropriate degree of safety the structure should be".

- (i) Sustain all loads extracted expected on width.
- (ii) Sustain deformations during and after construction.
- (iii) Should have adequate durability.
- (iv) Should have adequate resistance against misuse of forces to need.
- (v) The structure should be safe to each member of joint.
- (vi) Design must be simple.
- (vii) Strength must be equal to the strength of load.
- (viii) Yield stress must be greater than yield stress of material.

Date - 05/08/2019

## Welded connection:

### Assumptions of welded connection:-

1. Welds connecting various joints are homogeneous, isotropic & elastic elements.
2. Parts connected by weld are rigid & the deformation is neglected.
3. Only stresses due to external load are considered.

There are 3 types of welded connection :-

1. Butt weld

2. Fillet weld

3. Slot weld & Plug weld.

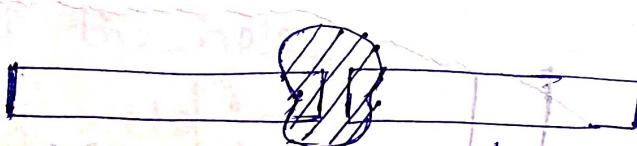
### 1. Butt weld:-

According to the shape of welding there are various kind of butt weld.

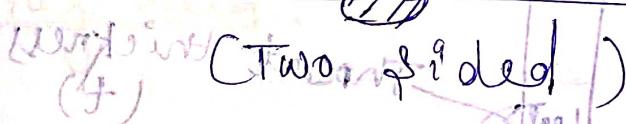
(i) Square butt weld.



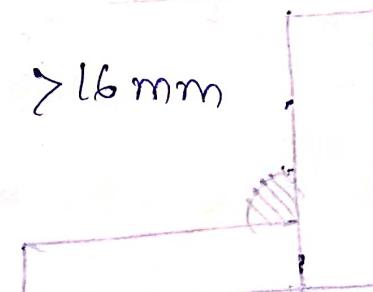
(One side)



> 16 mm

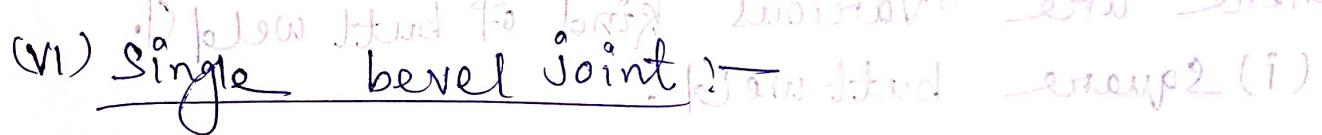
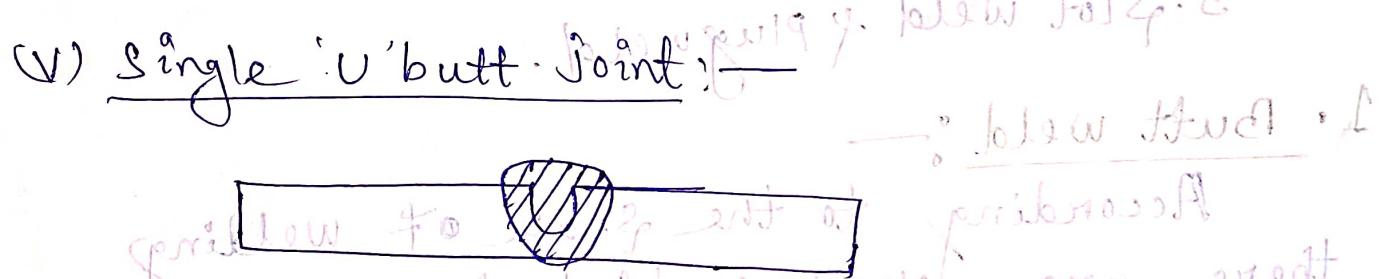
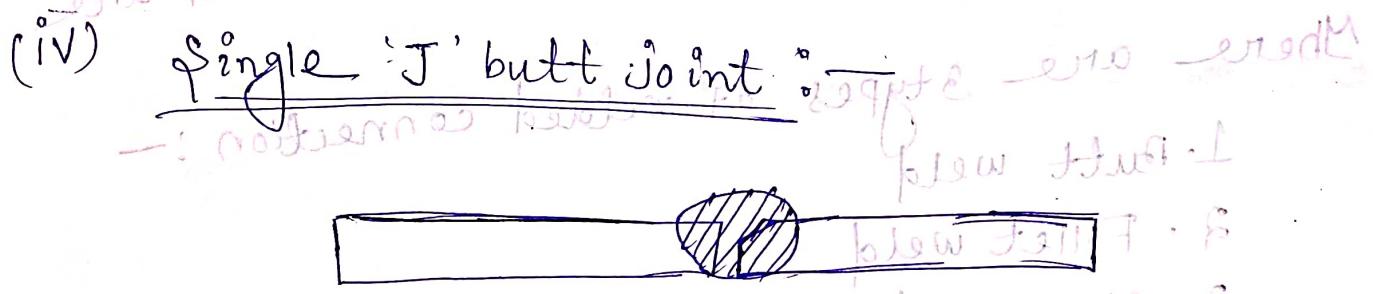
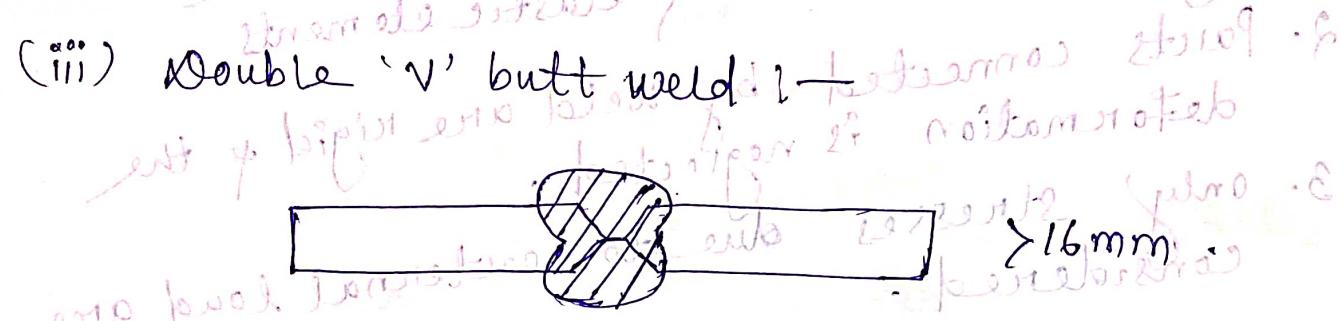
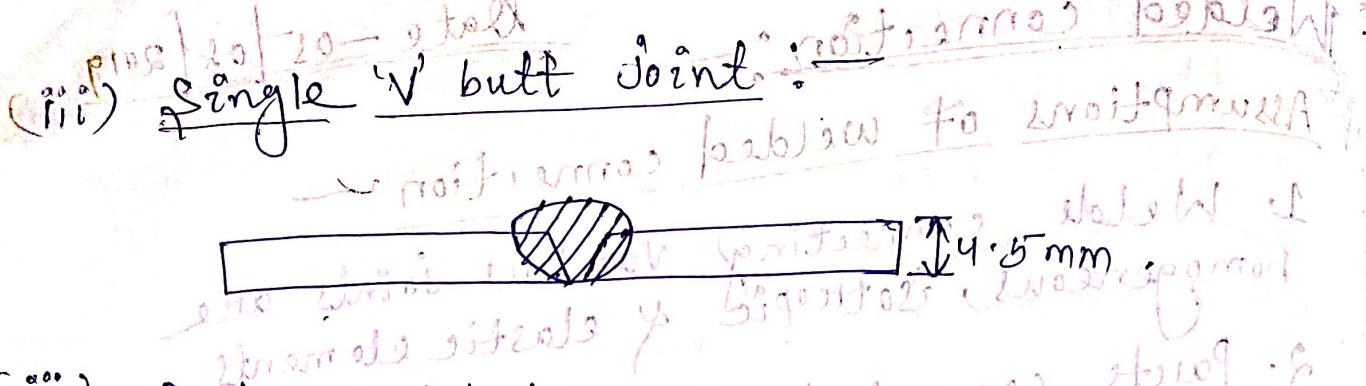


(Two sides)

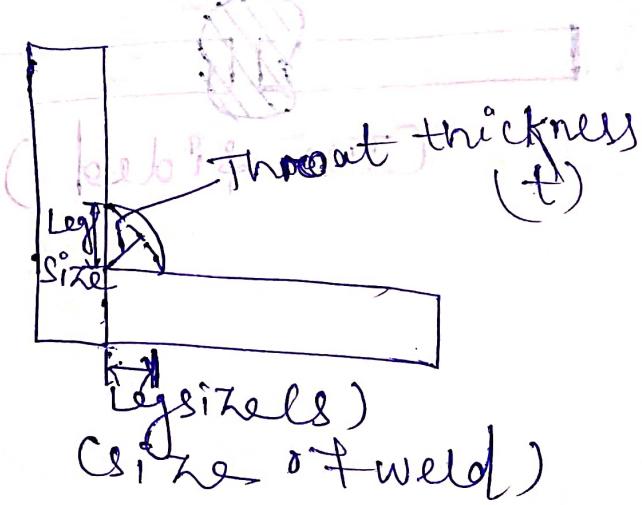
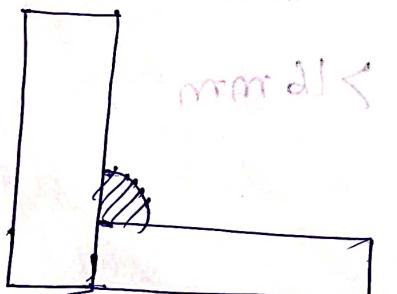


(Electrode)

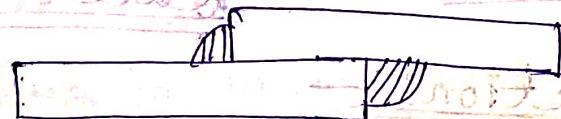
(Jewel to set)



## 2. Fillet weld:



प्राप्त सूची को देखें : जिसके लिए यह अपडेट है



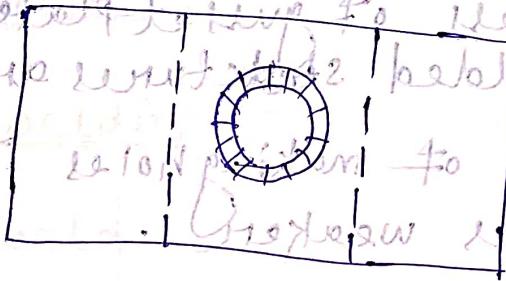
### (Standardised fillet weld)

→ Fillet weld is a weld of approximately triangular cross section joining two surfaces at right angle. If the cross section of fillet weld form is not triangle, then it is known as standardised fillet weld.

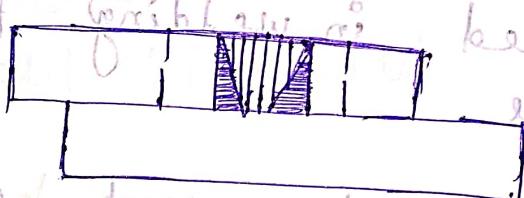
### Q. Slot weld & Plug weld :-

#### Slot weld :-

In which a slot is made in one of the plates to be joined & the weld is made in the slot.

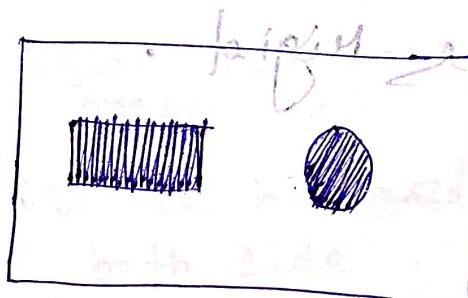


If the slot is very long, then the joint will be in tension & will have greater strength.



In which a plate with circular hole is kept with another plate to be joined & the fillet welding is made along the periphery of the hole.

#### Plug weld :-



In which small holes are made in one plate & it is kept over another plate to be connected & then the entire hole is filled with filler material.

## Design of fillet weld:

Date → 9/08/2014

### Welded connections

#### Assumptions

• Strength of base metal is 80% below yield.

• Design of fillet welds are based on equivalent to

•  $F_u$  of 0.72 times of  $F_y$ . approx. equal to

• Intermittent fillet welds most likely fail at

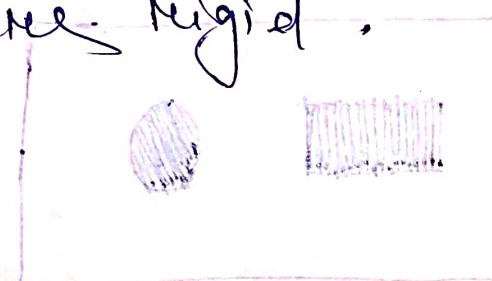
• Plug & slot welds are considered to be strong

→ below yield & below  $F_y$ .

→ below  $F_y$

#### Advantages

1. Due to the excess of gusset plate, connecting angle etc, welded structures are lighter.
2. The absence of making holes for fasteners (not welding process weaker).
3. Noise produced in welding process is relatively less.
4. Welded connections have good aesthetic appearance of joints in terms of joints.
5. It is possible to achieve 100% efficiency in the joint whereas in bolted connection it can reach a maximum of  $F_u = 80\%$  only.
6. Welded joints are rigid.



ets 19 and 20 have been used between end of eto 19 and start of eto 20 to restore main load carrying capacity.

## Disadvantages:

1. Due to uneven heating & cooling, members are likely to distort in the process of welding.
2. There is a greater possibility of brittle fracture in welding.
3. Highly skilled person is required for welding.
4. Proper welding in the field condition is difficult.
5. The inspection of welded joint is difficult & expensive.

## Types of welding

1. Butt weld
2. Fillet weld
3. Slot weld & Plug weld

### 1. Butt weld :-

It is also known as groove weld.  
Depending upon the shape of the groove welding butt welds are classified:

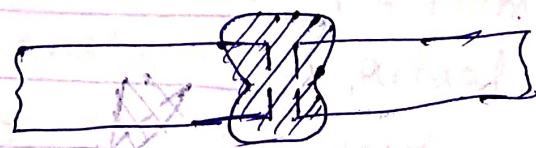
SL. NO.

Type of butt weld, sketch

1. Square butt weld, one on side



2. Square butt weld, both sides



3. Single V butt joint

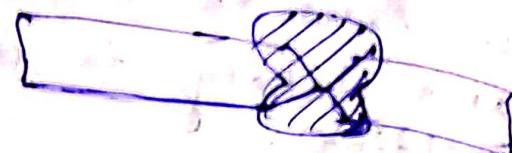


SL.  
No.

Types of  
butt-weld

Sketch

4. Double V butt joint



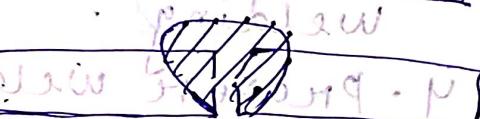
5. Single V butt joint



6. Single J butt joint



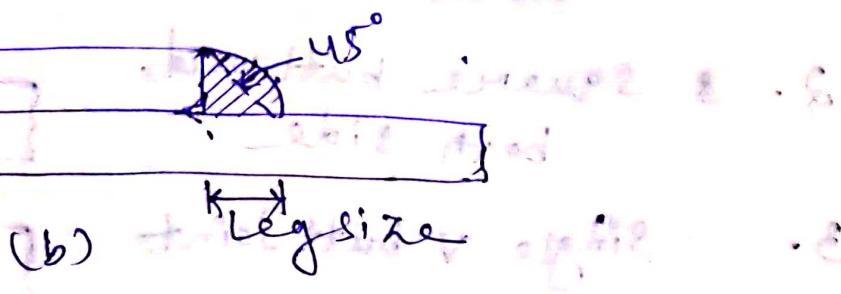
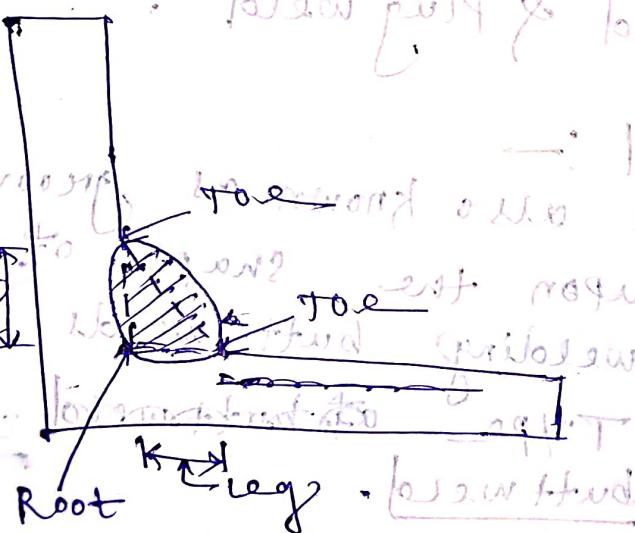
7. Single bevel butt joint



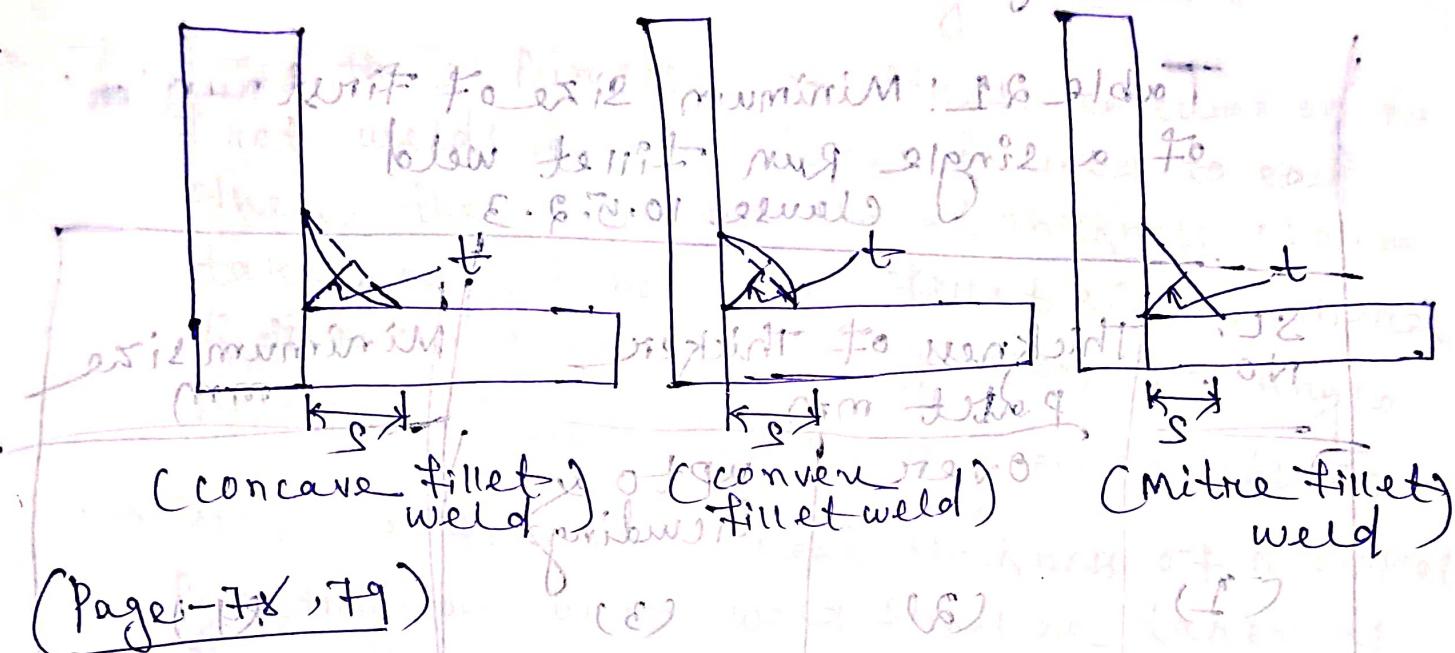
8. Fillet weld

It is a weld of approximately triangular cross section joining two surfaces approximately ~~at~~ at right angles to each other in lap joint, T joint corner joint.

It is a weld of approximately triangular cross section joining two surfaces approximately ~~at~~ at right angles to each other in lap joint, T joint corner joint.



The figure shows typical fillet welds. When the cross section of fillet weld is isosceles triangle with face had  $45^\circ$ , it is known as standard fillet weld. In special circumstances  $60^\circ \times 30^\circ$  angles are also used.



(Page-78, 79)

### Size of weld:

The size of normal fillets shall be taken as the minimum weld leg size. For deep penetration welds, where the depth of penetration beyond the root run is a minimum of 2.4 mm, the size of the fillet should be taken as the minimum leg size plus 2.4 mm.

For fillet welds made by semi-automatic or automatic processes, where the depth of penetration is considerably in excess of 2.4 mm, the size shall be taken considering actual depth of penetration subject to agreement between the Purchaser & the contractor.

The size of fillet welds shall not be less than 3 mm. The minimum size of the first run hole of a single-run fillet weld shall be as given in Table 21, to avoid the risk of cracking in the absence of preheating.

Table 21: Minimum size of first run of a single run fillet weld  
clause 10.5.2.3

SL. No.	Thickness of thicker part mm	Minimum size mm
(1)	(2)	(3)
(i)	—	10
(ii)	10 & up to 10 mm	20
(iii)	10 & below 10 mm	15
(iv)	10 & above 10 mm	32
		6
		80 ft from end of weld
		10 ft from minimum size of weld

The size of butt weld shall be specified by the effective throat thickness. The effective throat thickness is the sum of the thicknesses of the parts being joined at the joint. It is equal to the thickness of the thinner part plus twice the thickness of the thicker part.

## Effective Throat Thickness

- The effective throat thickness of a fillet weld shall not be less than 3mm, & shall generally not exceed  $0.7 t$  or  $1.0t$  under special circumstances, where  $t$  is the thickness of the thinner plate of elements being welded.
- For the purpose of stress calculation in fillet welds joining faces inclined to each other, the effective throat thickness shall be taken as  $k$  times the fillet size, where  $k$  is a constant, depending upon the angle between fusion faces, as given in Table 22.
- The effective throat thickness of a complete penetration butt weld shall be taken as the thickness of the thinner part joined, and that of an incomplete penetration butt weld shall be taken as the minimum thickness of the weld metal common to the parts joined, excluding reinforcements.

Table 22 Values of  $k$  for different Angles between Fusion Faces (Clause 10.25.3.2)

Angle between fusion faces	60°-90°	91°-100°	101°-106°	107°-113°	114°-120°
constant, $k$	0.70	0.65	0.60	0.55	0.50

## Effective Length or Area of weld:

→ The effective length of fillet weld shall be taken as only that length which is of the specified size & required throat thickness.

In practice the actual length of weld of the effective length shown in drawing plus two times the weld size, but not less than four times the size of the weld.

→ The effective length of butt weld shall be taken as the length of the continuous profiled weld, but not less than four times the size of the weld.

→ The effective area of a plug weld shall be considered as the nominal area of the hole in the plane of the flange surface. These welds shall not be designed to carry eccentric stresses.

→ If the maximum length  $L_p$  of the side welds transferring shear along its length exceeds 180 times the throat size of the weld, the reduction in weld strength

(as per the long joint (See 10.5.7.3) should be considered. For flange to web connection,

Where the welds are loaded over the full length, the above limitation would not apply.

## Intermittent Welds:

- Unless otherwise specified, the intermittent fillet welding shall have an effective length of not less than four times the weld size, with a minimum of 100 mm.
- The clear spacing between the effective lengths of intermittent fillet weld shall not exceed 12 & 16 times the thickness of thinner plate joined, for compression & tension joint respectively & in no case be more than 200 mm.
- Unless otherwise specified, the intermittent butt weld shall have an effective length of not less than four times the weld size & the longitudinal space between the effective length of welds shall not be more than 16 times the thickness of the thinner part joined. The intermittent welds shall not be used in positions subject to dynamic, repetitive & alternating stresses.

## Weld Types & Quality:

For the purpose of this code, weld shall be fillet, butt, slot or plug or compound welds.

Welding electrodes shall conform to IS:814.

## Design stresses in welds

\* Shop welds

\* Fillet welds:

Design strength of a fillet weld,  $f_w$

Shall be based on its throat area &

Shall be given by:  $f_w = f_u / \gamma_{mw}$

Where,  $f_u$  = ultimate tensile stress at yield point

$f_w = f_u / \gamma_{mw}$  (where  $\gamma_{mw}$  is partial safety factor)

$$f_w = f_u / \gamma_{mw}$$

$f_u$  = smaller of the ultimate stress for parent metal or of the weld metal.

$\gamma_{mw}$  = partial safety factor, assumed for the weld metal.

## Butt welds

Butt welds shall be treated as parent metal with a thickness equal to the throat thickness, & the stresses shall not exceed those permitted in the parent metal.

\* Slot one plug weld

The design shear stress on slot or plug welds shall be,

$$f_w = f_w / \gamma_{mw}$$

## Site welds:

The design strength in shear & tension for site welds made during erection of structural members shall be calculated according to 10.5.7.1 but using a partial safety factor  $\gamma_{Mw}$  of 1.5.

## Long joints:

When the length of the welded joint is off a splice or end connection in a compression or tension element is greater than 150 t<sub>f</sub>, the design capacity of weld weld shall be reduced by the factor

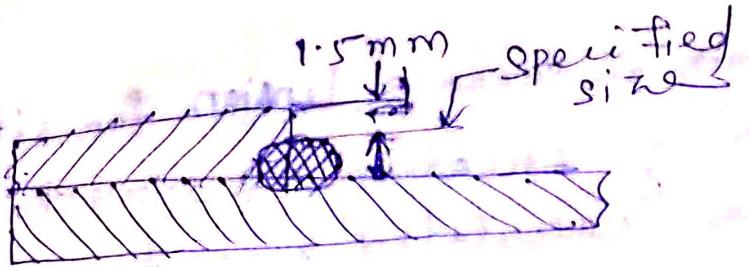
$$P_{lw} = 1.2 - \frac{0.21 l_f}{150 t_f} \leq 1.0$$

Where

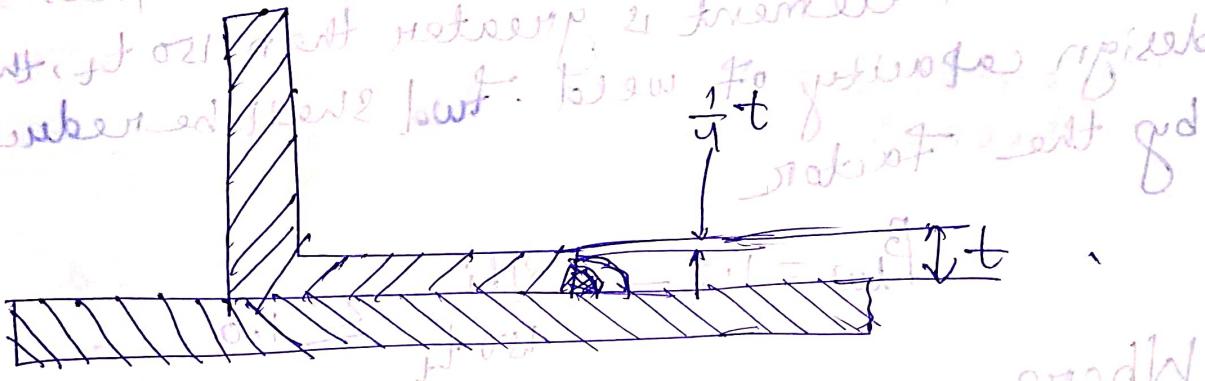
$l_f$  = length of the joint in the direction for transfer of force, below the throat size of the weld.

→ Fillet weld applied to the edge of a plate or section.

→ Where a fillet weld is applied to the square edge of a part, the specified size of the weld should generally be at least 1.5 mm less than the edge thickness in order to avoid washing down of the thickness of the section composed areas.



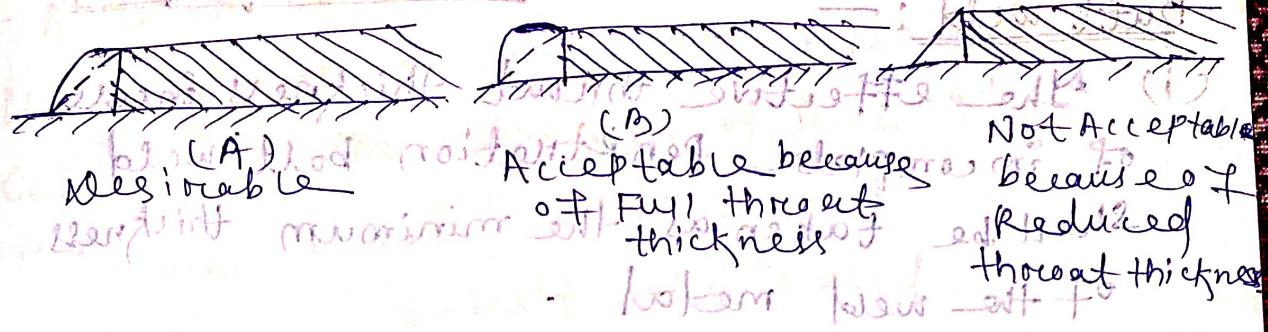
→ Where the fillet weld is applied to the rounded toe of a rolled section, the specified size of the weld should generally not exceed  $\frac{3}{4}$  of the thickness of the section at the toe.



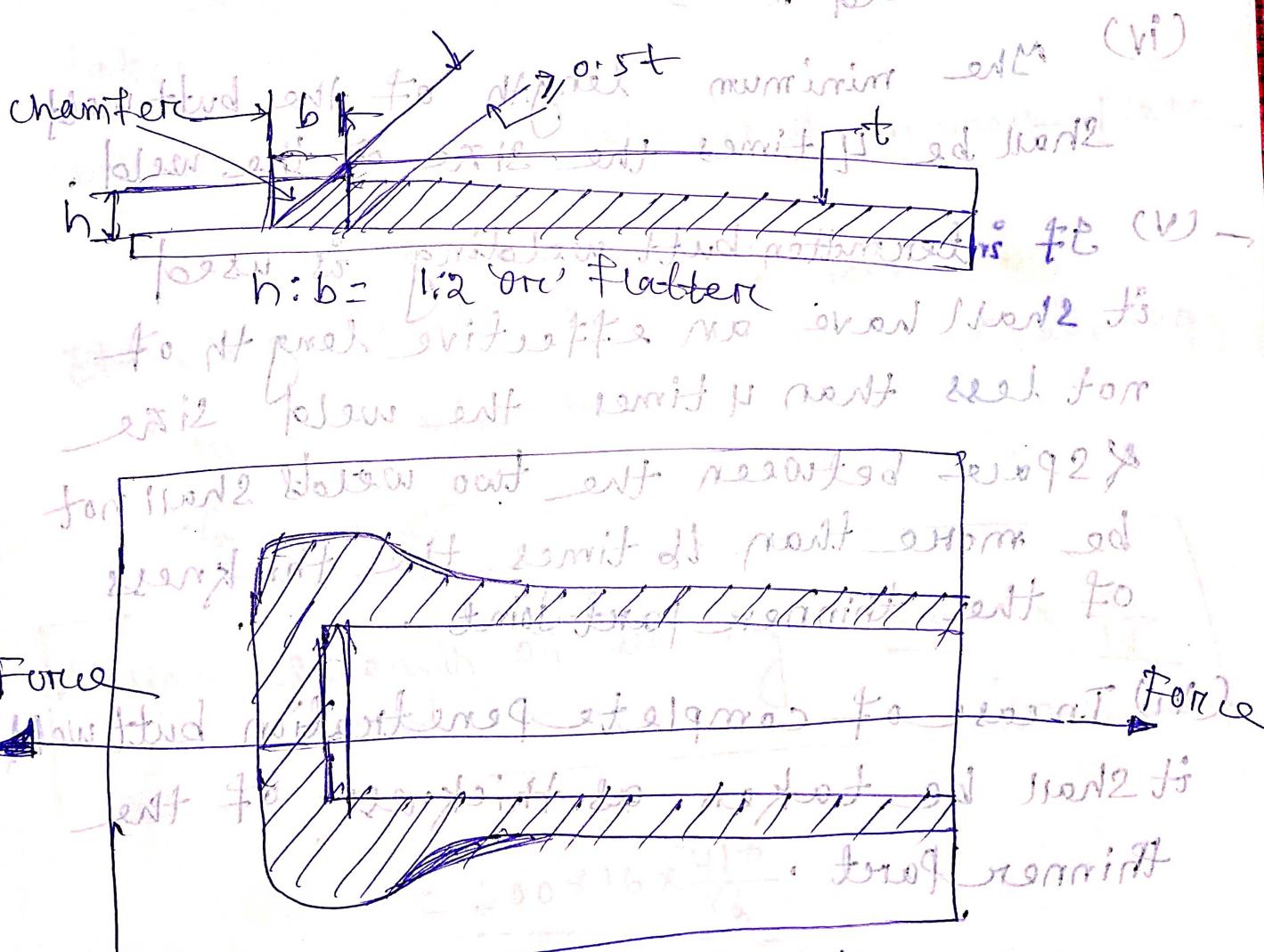
→ Where the size specified for a fillet weld is such that the parent metal will not project beyond the weld, no melting of the outer cover or covers shall be allowed to occur to such an extent as to reduce the throat thickness.

When fillet welds are applied to the edges of a plate or section in members subject to dynamic loading, the fillet weld shall be full size with its leg length equal to the thickness of the plate or section, with the limitations specified in 10-5-8-3.

100.180 (P1 - 200)



→ End fillet welds normal to the direction of force shall be of unequal size with a throat thickness not less than  $0.5t$ , where  $t$  is the thickness of the part, as shown in figure. The difference in thickness of the welds shall be negotiated at an uniform slope.



End fillet weld normal to direction of force.

Date - 19/08/2019

### Butt weld :-

- (i) The effective throat thickness increase of incomplete penetration butt weld shall be taken as the minimum thickness of the weld metal.
- (ii) If the absence of actual data it may be taken as  $\frac{5}{8}$  th of thickness of thinner material.
- (iii) The effective length of butt weld shall be taken as the length of full size weld.
- (iv) The minimum length of the butt weld shall be 4 times the size of the weld.
- (v) If intermittent butt welding is used it shall have an effective length of not less than 4 times the weld size & space between the two welds shall not be more than 16 times the thickness of the thinner part joint.
- (vi) In case of complete penetration butt weld it shall be taken as thickness of the thinner part.