

CONNECTIONS

Advantages of Bolted Connections

1. The erection of the structure can be speeded up.
2. Less skilled workers are required
3. Cheaper compared to riveted connections due to reduced labour and equipments required.

Disadvantages of Bolted Connections

1. Cost of material is high, double the cost of rivets
2. The tensile strength is reduced because of area reduction at the root of the thread and due to stress concentration.
3. Normally, these are of a loose fit excepting turned bolts and hence their strength is reduced.
4. When subjected to vibration or shock, bolts may get loose.

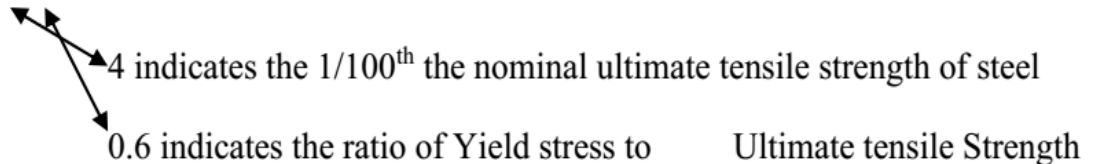
Types of Bolts

- i. Unfinished Bolts
- ii. High Strength Bolts

Unfinished bolts: The bolts are available in 5 mm to 36 mm diameter designated as M5 to M36. The ratio of net area to nominal plain shank area of bolt is 0.78.

The bolts are available in Grade 4.6 and 8.8

Here in Grade 4.6



Thus Ultimate Tensile Strength of Class 4.6 bolt is 400 N/mm² and yield strength is 240 N/mm² (0.6 x 400).

These bolts are called as Bearing- Type Joints as the force is transferred by bearing and interlocking of bolts.

High Strength Bolts: These Bolts are also called as friction type bolts

DESIGN OF STEEL STRUCTURES

Advantages of High Strength Bolts (or) High Strength Friction Bolts (HSFG)

- i. HSFG bolt can provide a rigid joint. There is no slip between the elements connected.
- ii. Large tensile forces are developed in bolts, which provide large clamping force to the connected elements.
- iii. Bolts are not subjected to shear or bearing
- iv. The possibility of failure at net section is minimized
- v. No stress concentration in holes therefore the fatigue strength is more.
- vi. Few person are required to make connections, thus the cost is minimized
- vii. Alterations are easy to make.
- viii. For same, Strength lesser bolts are required as compared to rivets/ ordinary bolts which bring overall economy.

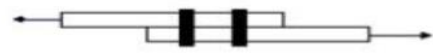
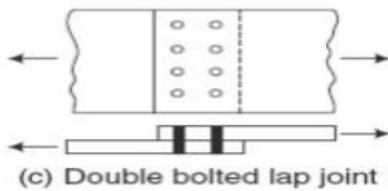
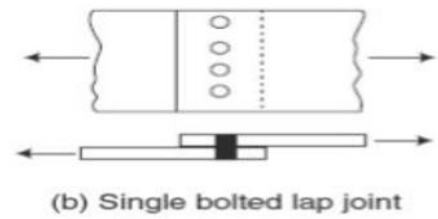
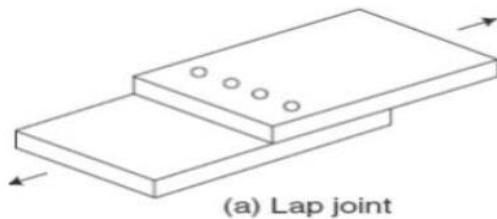
Types of Bolted Joints

i. Lap Joint

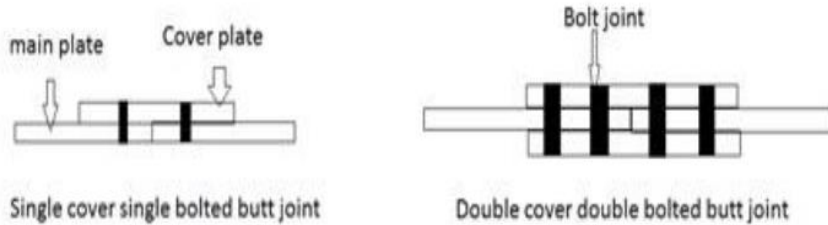
- Single Bolted Lap Joint
 - Double Bolted Lap Joint
 - Eccentricity in Lap Joint
- } Lap Joints in Single Shear

ii. Butt Joint

- Single Cover Single Bolted Butt Joint
 - Single Cover Double Bolted Butt Joint
 - Double Cover Single Bolted Butt Joint
 - Double Cover Double Bolted Butt Joint
- } Butt Joints in Double Shear.



TYPES OF LAP JOINTS

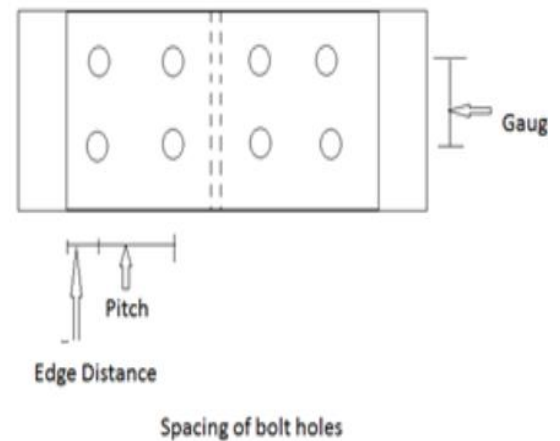


TYPES OF BUTT JOINT

Terminology for Bolted Joints

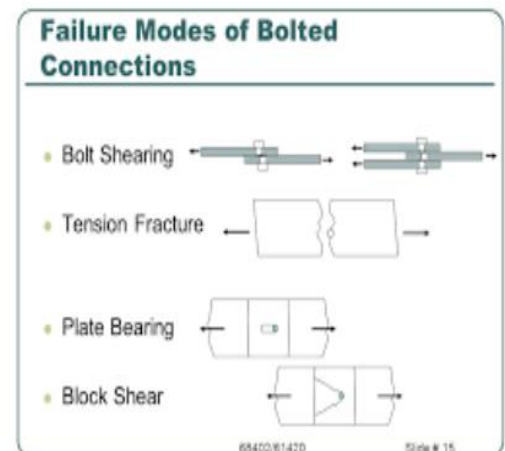
Pitch: It is the distance between the centers of two consecutive bolts along a row

Gauge Length: It is the distance between adjacent bolt lines or distance between the back of the rolled section and the bolt line, or centre to centre distance between two consecutive bolts measured along the width of the member or connection.



Failure of Bolts

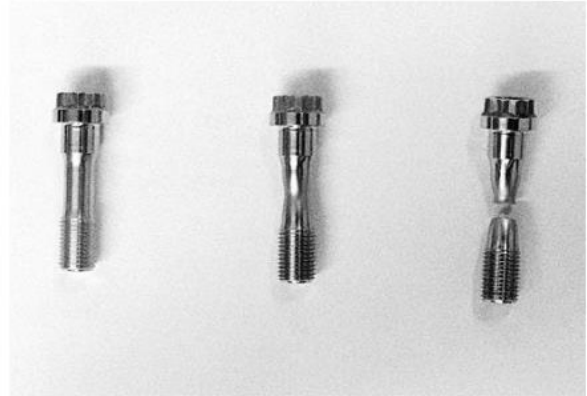
- i. Shear Failure of Bolts
- ii. Bearing Failure of Bolts
- iii. Bearing Failure of Plates
- iv. Tension Failure of Bolts
- v. Tension or Shear Failure of Plates
- vi. Block Shear Failure.



DESIGN OF STEEL STRUCTURES



FAILURE OF BOLT IN DOUBLE SHEAR



FAILURE OF BOLTS DUE TO TENSION

Advantages of Welded Connections.

- i. Welded Designs offer the opportunity to achieve a more efficient use of materials. Welding is the only process that produces one piece construction.
- ii. The speed of fabrication and erection helps compress production schedules
- iii. Welding saves weight and reduces cost.
- iv. No deductions are there for holes; thus the gross area is effective in carrying loads
- v. Welded Joints are better in fatigue, impact and vibration loads

Welding Defects

1. Incomplete Fusion
2. Incomplete Penetration
3. Porosity
4. Slag Inclusion
5. Under Cutting

Assumptions in Analysis of Welded Joints

1. The welds connecting the various parts are homogenous, isotropic and elastic elements
2. The parts connected by the weld are rigid and therefore deformations are neglected.
3. Only stresses due to external loads are considered. The Effects of residual stresses, stress concentrations and shape of the welds are neglected.

Fillet Vs Butt Weld

Fillet Weld is preferred in comparison to butt weld for the following reasons.

1. A fillet weld saves the operation of veeing and finishing the ends of the members
2. In Case of butt weld, members are fabricated slightly long and cut exactly to have a close fit in field. This is uneconomical.
3. Fillet Welds have lower residual stress.

Welded Joints vs Bolted vs Riveted Joints

1. Welded Joints are economical because the need for splice plates and bolts/ rivets is eliminated.
2. Welded Joints are more rigid (due to continuity of section at joints)
3. Strength of welded Joint is same as the parent metal.
4. It's possible to connect tubular sections with welded joints, which are economical
5. Due to the fusion of two metals joined, a continuous structure is formed
6. Process of Welding is faster compared to bolting and riveting
7. More Skilled labour is required as compared to bolting or riveting
8. Inspection of welding is difficult and expensive, whereas bolted and riveted can be inspected by tapping with hammer.
9. Efficiency of Welding is higher than bolted or riveted. Its even possible to achieve 100 % efficiency by proper welding.
10. Possibility of brittle failure is higher in case of welding than compared to bolted or riveted

Solved Problems

Question 1

Calculate the strength of a 20 mm diameter bolt of grade 4.6 for the following cases. The main plates to be joined are 12mm thick.

- a) Lap Joint
- b) Single Cover Butt Joint; the cover plate being 10 mm thick
- c) Double Cover Butt Joint; each of the cover plate being 8 mm thick.

For Fe 410 grade of steel $f_u = 410 \text{ Mpa} = 410 \text{ N/mm}^2$

For bolts of grade 4.6: $f_{ub} = 400 \text{ Mpa} = 400 \text{ N/mm}^2$

γ_{mb} = partial safety factor for the material of bolts = 1.25

A_{nb} = Net tensile stress area of 20 mm diameter bolt = $0.78 \times \frac{\pi D^2}{4} = 245 \text{ mm}^2$

- (a) The bolts will be in single shear and bearing

Diameter of bolts $d = 20 \text{ mm}$

The strength of bolt in single shear

$$V_{sb} = A_{nb} \frac{f_{ub}}{\sqrt{3} \gamma_b} = 245 \times \frac{400}{\sqrt{3} \times 1.25} \times 10^{-3} = 45.26 \text{ kN}$$

The Strength of bolt in bearing,

$$V_{pb} = 2.5 k_b b t \frac{f_u}{\gamma_{mb}}$$

DESIGN OF STEEL STRUCTURES

For bolt of diameter 20 mm , diameter of opening $d_o = 22$ mm and $e = 33$ mm. Assume pitch = 50 mm (2.5 x 20 mm)

K_B is the least of

$$\frac{e}{3d_o} = \frac{33}{3 \times 22} = 0.5$$

$$\frac{p}{3d_o} - 0.25 = \frac{50}{3 \times 22} - 0.25 = 0.5$$

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

And 1

Hence $k_b = 0.5$

$$V_{pb} = 2.5 \times 0.5 \times 12 \times \frac{400}{1.25} \times 10^{-3} = 96 \text{ kN.}$$

The strength of bolt will be the minimum of the bolt in shear and bearing will be 45.26 kN.

b) The thickness of plate $t = 10$ mm.

The strength of bolt in bearing

$$V_{pb} = 2.5 k_b b t \frac{f_u}{\gamma_{mb}} = 2.5 \times 0.5 \times 20 \times 10 \times \frac{400}{1.25} \times 10^{-3} = 80 \text{ kN.}$$

The minimum strength of bolt in bearing and shear is 45.26 kN.

c) The bolt will be in single shear and bearing

The strength of bolt in double shear.

$$V_{sb} = 2 \times A_{nb} \frac{f_{ub}}{\sqrt{3} \gamma_b} = 2 \times 245 \times \frac{400}{\sqrt{3} \times 1.25} \times 10^{-3} = 90.52 \text{ kN}$$

The bolt strength in bearing.

$$V_{pb} = 2.5 k_b b t \frac{f_u}{\gamma_{mb}} = 2.5 \times 0.5 \times 12 \times \frac{400}{1.25} \times 10^{-3} = 96 \text{ kN}$$

The Minimum strength of bolt in shear and bearing is 90.52 kN.

DESIGN OF STEEL STRUCTURES

Question 2

Two plates of 16 mm and 14 mm thickness are joined together by a groove weld. The joint is subjected to a factored load tensile load of 430 kN. Due to some reasons the effective length of weld that was provided was 175 mm, Check the safety of the joint if

- Single V groove joint is provided
- Double V Groove Joint is provided

- a) Assume the plates are to be shop welded. ($\gamma_{mw} = 1.25$)

For the 410 grade of steel, $f_y = 250$ Mpa

Throat thickness, $t_e = (5/8)t = (5/8) \times 14 = 8.75$ mm

For Shop weld partial safety factor for material

Effective length of weld $L_w = 175$ mm

$$T_{dw} = L_w t_e \frac{f_y}{\gamma_{mw}} = 175 \times 8.75 \times \frac{250}{1.25} \times 10^{-3} = 306.25 \text{ kN} < 430 \text{ kN}$$

Which is inadequate.

- b) In case of double groove V weld complete penetration of the weld takes place. Therefore as per specification,

Throat Thickness = $t_e = 14$ mm.

$$T_{dw} = L_w t_e \frac{f_y}{\gamma_{mw}} = 175 \times 14 \times \frac{250}{1.25} \times 10^{-3} = 490 \text{ kN} > 430 \text{ kN}$$

The provided Section is adequate.