SUBJECT- STEEL STRUCTURES DESIGN
DEPARTMENT- CIVIL ENGG.

LEARNING OUTCOMES

- Explain structural properties of steel and its designation as per Indian Standards
- Select different types of bolted and welded joints
- Analyze and design single and double angle section struts and I section compression members
- Explain different types of trusses, their different components and usability
- Analyze and design of simply supported steel beams
- Select various types of plate girders
- Supervise fabrication and erection of steel structure like trusses, columns and girders

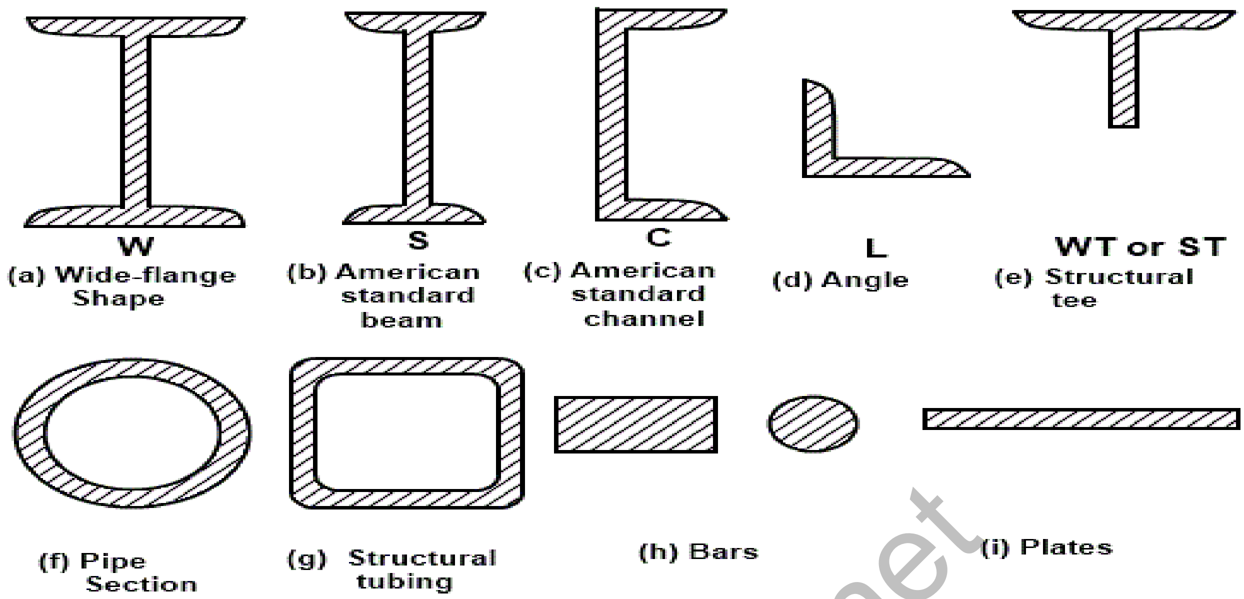
UNIT-1.
Structural Steel and Sections:

1.1 Properties of structural steel as per IS Code

Following properties of structural steel are considered before using them for a construction.

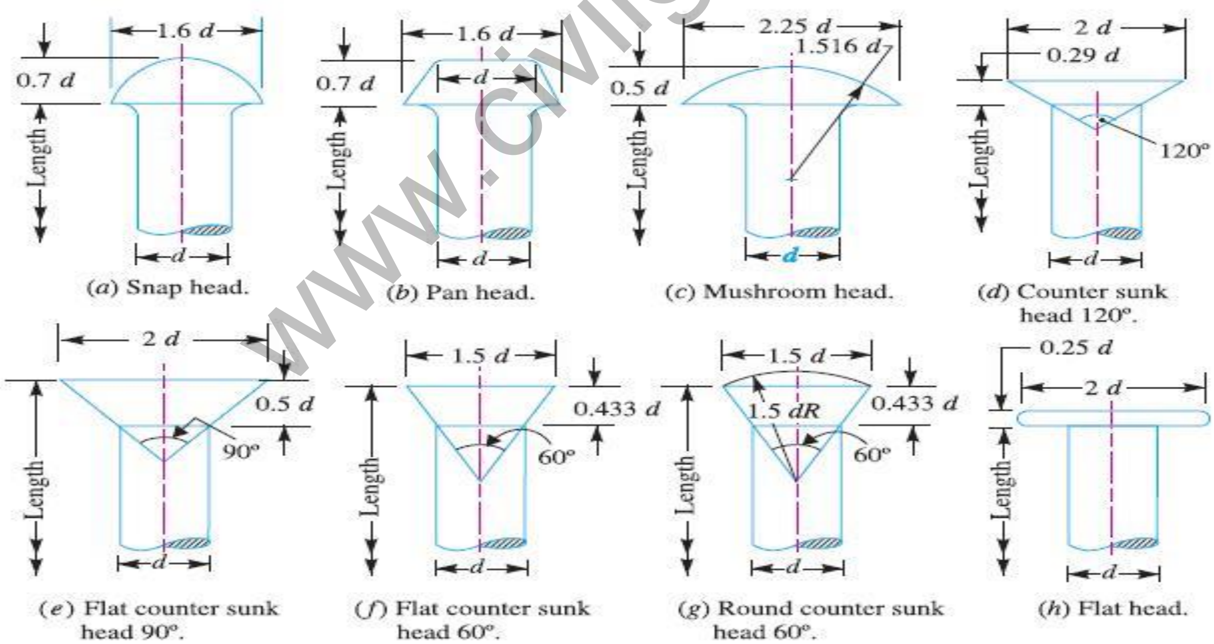
1. Density
Density of a material is defined as mass per unit volume. Structural steel has density of 7.75 to 8.1 g/cm3.
2. Elastic Modulus
Elastic modulus or modulus of elasticity is the measurement of tendency of an object to be deformed when force or stress is applied to it. Typical values for structural steel range from 190-210 gigapascals.
3. Poisson's Ratio
It is the ratio between contraction and elongation of the material. Lower the value, lesser the object will shrink in thickness when stretched. Acceptable values for structural steel are 0.27 to 0.3.
4. Tensile Strength
Tensile strength of an object is the determination of limit up to which an object can be stretched without breaking. Fracture point is the point at which an object breaks after application of stress. Structural steel has high tensile strength so is preferred over other materials for construction.
5. Yield Strength
Yield strength or yield point is the stress at which an object deforms permanently. It cannot return to its original shape when stress is removed. Structural steel made of carbon has yield strengths of 187 to 758 megapascals. Structural steel made of alloys has values from 366 to 1793 megapascals.
6. Melting Point
There is no defined value for melting point due to the wide variations in types of structural steel. Melting point is the temperature at which object starts to melt when heated.
7. Specific Heat
Specific heat or heat capacity is the amount of heat which needs to be applied to the object to raise its temperature by a given amount. A higher value of specific heat denotes greater insulation ability of the object. Values are measured in Joules per Kilogram Kelvin. Structural steel made of carbon has values from 450 to 2081 and that made from alloys has values ranging from 452 to 1499.
8. Hardness
Hardness is the resistance of an object to shape change when force is applied. There are 3 types of hardness measurements. Scratch, indentation and rebound. Structural steel made by using alloys has hardness value between 149-627 Kg. Structural steels made of carbon has value of 86 to 388 Kg.

1.2 Designation of structural steel sections as per IS handbook and IS:800

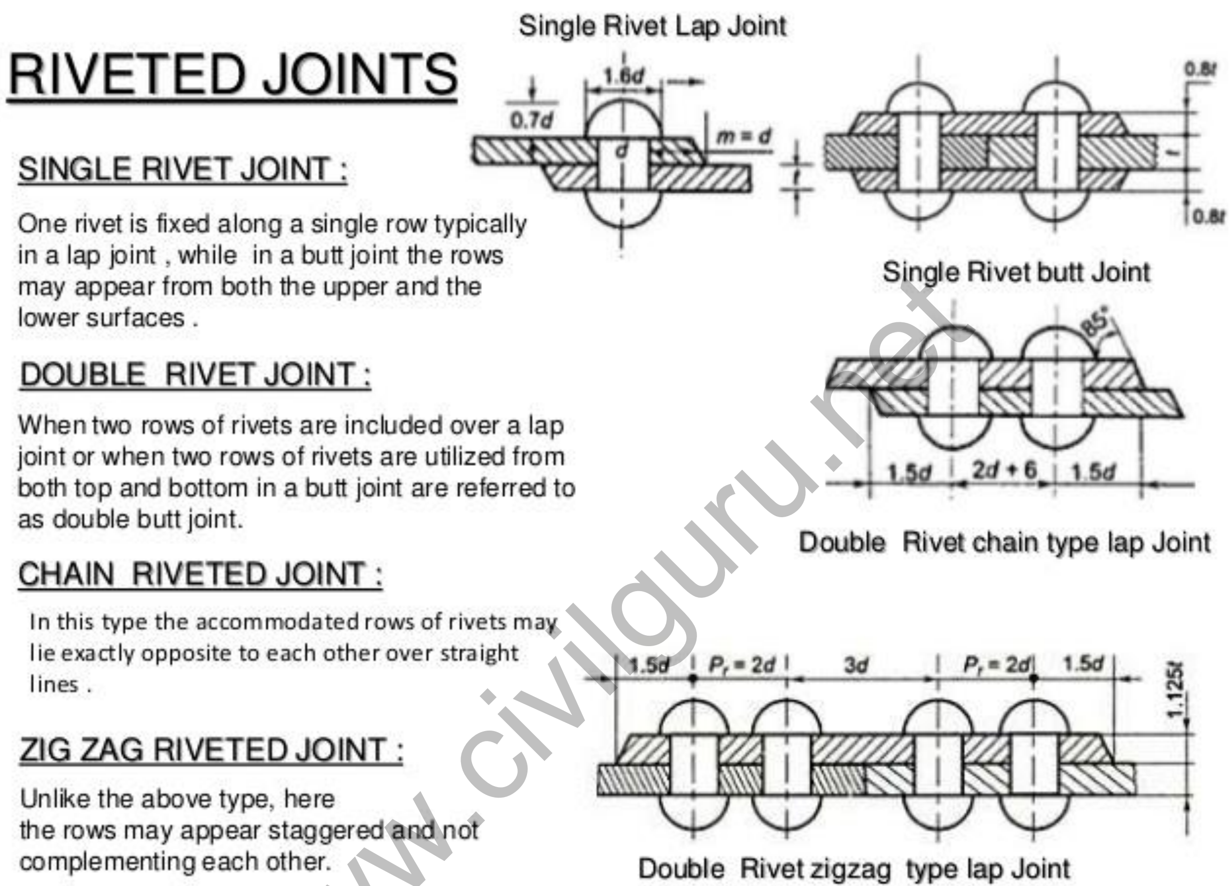


UNIT-2. Riveted Connections

Types of Rivet



types of riveted joints



ASSUMPTIONS FOR THE DESIGN OF RIVETED JOINT

Procedure for design of a riveted joint is simplified by making the following assumptions and by keeping in view the safety of the joint.

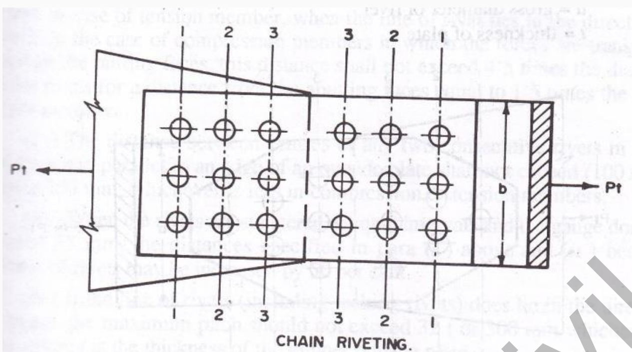
1. Load is assumed to be uniformly distributed among all the rivets
2. Stress in plate is assumed to be uniform
3. Shear stress is assumed to be uniformly distributed over the gross area of rivets

4. Bearing stress is assumed to be uniform between the contact surfaces of plate and rivet
5. Bending stress in rivet is neglected
6. Rivet hole is assumed to be completely filled by the rivet
7. Friction between plates is neglected

6.3 ARRANGEMENT OF RIVETS

Rivets in a riveted joint are arranged in two forms, namely, 1. Chain riveting, 2. Diamond riveting.

6.3.1 Chain Riveting: In chain riveting the rivets are arranged as shown in Fig. 6.1 and in the figure 1-1, 2-2 and 3-3 shows sections on either side of the joint. Section 1-1 is the critical section as compared to the other section. At section 2-2 is equal to the strength of plate in tearing at 2-2 plus strength of three rivets in bearing or shearing whichever is less at 1-1. At section 3-3 is equal to the strength of plate in tearing at 3-3 plus strength of rivets in bearing or shearing whichever is less (6 nos.).



Therefore,

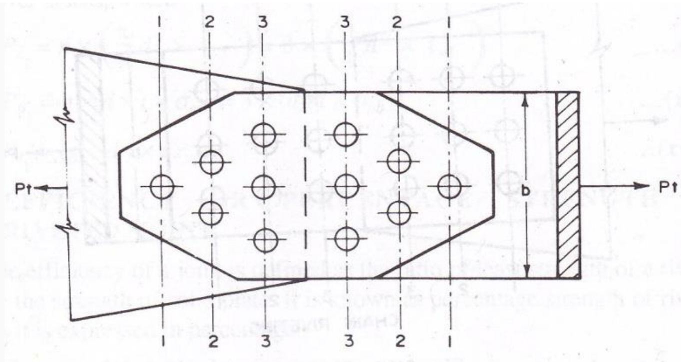
Strength of plate in tearing at 1-1 = (b-3D).t.p_t

Where b= width of the plate; D=Gross diameter of the rivet and t=Thickness of the plate.

When safe load carried by the joint (P) is known, width of the plate can be found as follows;

$$b = \left(\frac{P}{t \times p_t} + 3D\right)$$

6.3.2 Diamond Riveting: In diamond riveting, rivets are arranged as shown in Fig.6.2. All the rivets are arranged symmetrically about the centre line of the plate. Section 1-1 is the critical section. Strength of the plate in tearing in diamond riveting section 1-1 can be computed as follows



DIAMOND RIVETING.

$$P_t = (b - D).t.p_t$$

When the safe load carried by the joint (P) is known, width of the plate can be found as follows

$$b = (\frac{P}{t \times p_t} + D)$$

Where b=width of the plate, D=gross diameter of the rivet and t=thickness of the plate.

At section 2-2: All the rivets are stressed uniformly, hence strength of the plate at section 2-2 is

$$P_t = (b - 2D).t.p_t + strength\ of\ one\ rivet\ in\ shearing\ \&\ bearing\ whichever\ is\ less$$

At section 3-3,

$$P_t = (b - 3D).t.p_t + strength\ of\ three\ rivet\ in\ shearing\ \&\ bearing\ whichever\ is\ less$$

In diamond riveting there is saving of material and efficiency is more. Diamond riveting is used in bridge trusses generally.

6.4 SPECIFICATION FOR DESIGN OF RIVETED JOINT

6.4.1 Members meeting at Joint: The centroidal axes of the members meeting at a joint should intersect at one point, and if there is any eccentricity, adequate resistance should be provided in the connection.

6.4.2 Centre of Gravity: The centre of gravity of group of rivets should be on the line of action of load whenever practicable.

6.4.3 Pitch:

a. Minimum pitch: The distance between centres of adjacent rivets should not be less than 2.5 times the gross diameter of the rivet.

b. Maximum pitch: Maximum pitch should not exceed 12t or 200 mm whichever is less in compression member and 16t or 200 mm whichever is less in case of tension members, when the line of rivets lies along the line of action of force. If the line of rivets does not lie along the line of action of force, its maximum pitch should not exceed 32t or 300 mm whichever is less, where t is the thickness of the outside plate.

6.4.4 Edge Distance: A minimum edge distance of approximately 1.5 times the gross diameter of the rivet measured from the centre of the rivet hole is provided in the rivet joint. Table 6.1 gives the minimum edge distance as per recommendations of BIS in IS : 800-1984.

TABLE 6.1 EDGE DISTANCE OF HOLES

Gross diameter of rivet (mm)	Edge distance of Hole	
	Distance to sheared or Hand flame cut edge (mm)	Distance to rolled machine flame cut or planed edge (mm)
13.5 and below	19	17
15.5	25	22
17.5	29	25
19.5	32	29
21.5	32	29
23.5	38	32
25.5	44	38
29.0	51	44
32.0	57	51
35.0	57	51

6.5 DESIGN PROCEDURE FOR RIVETED JOINT

For the design of a lap joint or butt joint, the thickness of plates to be joined is known and the joints are designed for the full strength of the plate. For the design of a structural steel work, force (pull or push) to be transmitted by the joint is known and riveted joints can be designed. Following are the usual steps for the design of the riveted joint:

Step 1:

The size of the rivet is determined by the Unwin's formula

$$d = 6.04\sqrt{t}$$

Where d= nominal diameter of rivet in mm and t= thickness of plate in mm.

The diameter of the rivet computed is rounded off to available size of rivets. Rivets are manufactured in nominal diameters of 12, 14, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 42 and 48 mm

Step 2:

The strength of rivets in shearing and bearing are computed. Working stresses in rivets and plates are adopted as per ISI. Rivet value R is found. For designing lap joint or butt joint tearing strength of plate is determined as follows

$$P_t=(p-D).t.p_t$$

Where p=pitch of rivets adopted, t=thickness of plate and p_t = working stress in direct tension for plate. Tearing strength of plate should not exceed the rivet value R (P_s or P_b whichever is less) or

$$(p-D).t.p_t \leq R$$

From this relation pitch of the rivets is determined.

Step 3:

In structural steel work, force to be transmitted by the riveted joint and the rivet value are known. Hence number of rivets required can be computed as follows

$$Number\ of\ rivets\ required\ in\ the\ joint = \frac{Force}{Rivet\ value}$$

The number of rivets thus obtained is provided on one side of the joint and an equal number of rivets is provided on the other side of joint also.

Step 4:

For the design of joint in a tie member consisting of a flat, width/thickness of the flat is known. The section is assumed to be reduced by rivet holes depending upon the arrangements of the rivets to be provided, strength of flat at the weakest section is equated to the pull transmitted by the joint. For example, assuming the section to be weakened by one rivet and also assuming that the thickness of the flat is known we have

$$(b-D).t.p_t = P$$

Where b= width of flat, t=thickness of flat, pt=working stress in tension in plate and P=pull to be transmitted by the joint. From this equation, width of the flat can be determined.

Example 6.1: A single riveted lap joint is used to connect plate 10 mm thick. If 20 mm diameter rivets are used at 55 mm pitch, determine the strength of joint and its efficiency. Working stress in shear in rivets=80 N/mm^2 (MPa). Working stress in bearing in rivets=250 N/mm^2 (MPa). Working stress in axial tension in plates=156 N/mm^2.

Solution

Assume that power driven field rivets are used. Nominal diameter of rivet (D) is 20 mm and gross diameter of rivet is 21.5 mm.

Strength of rivet in single shear = $(\pi/4) \times 21.5^2 \times 80/1000$

P_s = 29.044 kN

Strength of rivet in bearing = 21.5 x 10 x 250/1000

P_b = 53.750 kN

Strength of plate in tension per gauge length = P_t=(p-D).t.p_t

P_t = (55-21.5) x 10 x 156/1000

= 52.260 kN

Strength of joint is minimum of P_s, P_b or P_t

Therefore, the strength of joint is = 29.044 kN

Efficiency of joint

$$\eta = \frac{Strength\ of\ joint\ per\ pitch\ length}{Strength\ of\ solid\ plate} \times 100$$

$$\eta = \frac{29.044 \times 10^3}{55 \times 10 \times 156} \times 100 = 33.85\ \%$$

Example 6.2: A double riveted double cover butt joint is used to connect plates 12 mm thick. Using Unwin's formula, determine the diameter of rivet, rivet value, pitch and efficiency of joint. Adopt the following stresses;

Working stress in shear in power driven rivets=100 N/mm^2 (MPa).

Working stress in bearing in power driven rivets=300 N/mm^2 (MPa).

For plates working stress in axial tension =156 N/mm^2.

Solution

Nominal diameter of rivet from Unwin's formula

$$d = 6.04\sqrt{t} = 6.04\sqrt{12} = 20.923\ mm$$

Adopt nominal diameter of rivet = 22 mm; Gross diameter of rivet = 23.5 mm

Strength of rivet in double shear = $2 \times \frac{\pi}{4} \times 23.5^2 \times \frac{100}{1000} = 86.75\ kN$

Strength of rivet in bearing = D x t x p_b = 23.5 x 12 x 300/1000 = 84.6 kN

The strength of a rivet in shearing and in bearing is computed and the lesser is called the rivet value (R). Hence the Rivet value is 84.6 kN.

Let p be the pitch of the rivets. P_t = (p-D) x t x p_t = ((p-23.5) x 12 x 156/100) =1.872 (p-23.5) kN

In double riveted joint,

Strength of 2 rivets in shear P_s = 2 x 86.75 = 173.5 kN

Strength of 2 rivets in bearing P_b = 2 x 84.6 = 169.2 kN

The pitch of the rivets can be computed by keeping $P_t = P_s$ or P_b whichever is less

Therefore 1.872 (p-23.5) = 169.2

p-23.5 = (169.2/1.872) = 90.385

p= 90.385 + 23.5 = 113.885 mm

Adopt pitch, p= 100 mm

Efficiency of joint $\eta = \frac{(p-D)}{p} \times 100$

$$= \frac{(100 - 23.5)}{100} \times 100 = 76.5\,\%$$

Example 6.3: A double cover butt joint is used to connect plates 16 mm thick. Design the riveted joint and determine its efficiency.

Solution

Nominal diameter of rivet from Unwin's formula

$$d = 6.04\sqrt{t} = 6.04\sqrt{16} = 24.16\,mm$$

The hot driven rivets of 16 mm, 18 mm, 20 mm and 22 mm diameter are used for the structural steel works. Unwin's formula gives higher values. Hence, adopt nominal diameter of rivet = 22 mm; Gross diameter of rivet = 22 +1.5 = 23.5 mm

In double cover butt joint, rivets are in double shear. As per IS : 800-84,

Shear stress for power driven rivets=100 N/mm^2 (MPa).

Bearing stress for power driven rivets=300 N/mm^2 (MPa).

Strength of plate in tension =156 N/mm^2.

Strength of rivet in double shear = $2 \times \frac{\pi}{4} \times 23.5^2 \times \frac{100}{1000} = 86.75\,kN$

Strength of rivet in bearing = D x t x p_b = 23.5 x 16 x 300/1000 = 112.8 kN

The strength of a rivet in shearing and in bearing is computed and the lesser is called the rivet value (R). Hence the Rivet value is 86.75 kN.

Let p be the pitch of the rivets. P_t = (p-D) x t x p_t = ((p-23.5) x 16 x 156/100) =2.496 (p-23.5) kN

The pitch of the rivets can be computed by keeping $P_t = P_s$ or P_b whichever is less

Therefore 2.496 (p-23.5) = 86.75

$$(p-23.5) = (86.75/2.496) = 34.756$$

$$p = 34.756 + 23.5 = 58.256 \text{ mm}$$

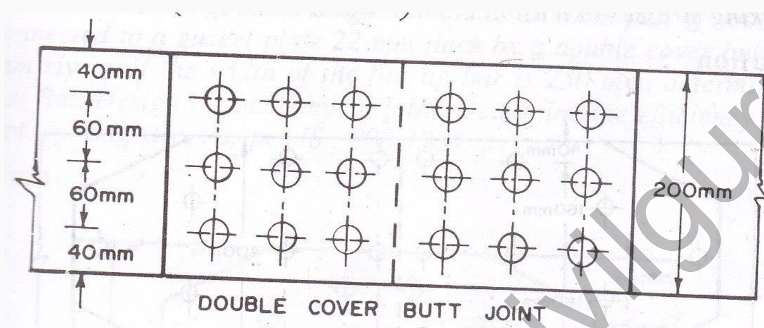
Adopt pitch, $p = 55$ mm

Adopt thickness of each cover plate $t \approx 5/8 \times 16 \approx 10$ mm

Efficiency of joint $\eta = \frac{(p-D)}{p} \times 100$

$$= \frac{(55-23.5)}{55} \times 100 = 55.27\ \%$$

Example 6.4: Determine the strength of a double cover butt joint used to connect two flats 200 F 12. The thickness of each cover plate is 8 mm. Flats have been joined by 9 rivets in chain riveting at a gauge of 60 mm as shown in Fig. 6.3. What is the efficiency of the joint? Adopt working stresses in rivets and flats as per IS : 800-84.



Solution

Size of flat used = 200 F 12

Width of flat = 200 mm

Thickness of flat = 12 mm

Use power driven rivets

Nominal diameter of rivet from Unwin's formula

$$d = 6.04\sqrt{t} = 6.04\sqrt{12} = 20.923\ mm$$

Adopt nominal diameter of rivet = 22 mm; Gross diameter of rivet D = 23.5 mm

Strength of rivet in double shear = $2 \times \frac{\pi}{4} \times 23.5^2 \times \frac{100}{1000} = 86.75\ kN$

Strength of rivet in bearing = D x t x p_b = 23.5 x 12 x 300/1000 = 84.6 kN

Strength of joint in shear, P_s = 9 x 86.75 = 780.75 kN

Strength of joint in bearing P_b = 9 x 84.6 = 761.40 kN

Strength of plate in tearing P_t = (b-3D) x t x p_t

= ((200-3x23.5) x 12 x 156/1000)

= 242.42 kN

Strength of joint is minimum of P_s, P_b or P_t

Therefore, the strength of joint is = 242.42 kN

Efficiency of joint

$$\eta = \frac{Least\ of\ P_s, P_b\ or\ P_t}{Strength\ of\ solid\ plate} \times 100$$

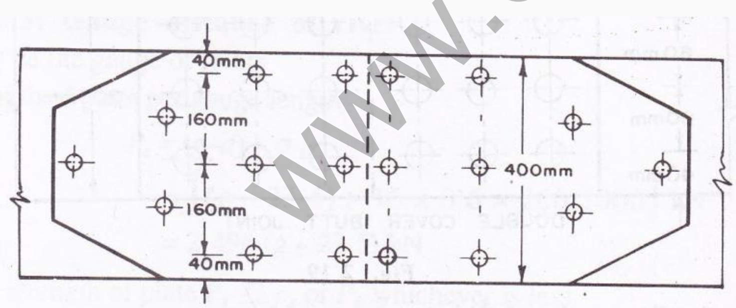
$$\eta = \frac{242.42 \times 10^3}{200 \times 12 \times 156} \times 100 = 64.75\ \%$$

Example 6.5: In a truss girder of a bridge, a diagonal consists of a 16 mm thick flat and carries a pull of 750 kN and is connected to a gusset plate by a double cover butt joint. The thickness of each cover plate is 8 mm. Determine the number of rivets necessary and the width of the flat required. What is the efficiency of the joint? Sketch the joint. Take

Working stress in shear in power driven rivets=100 N/mm^2 (MPa).

Working stress in bearing in power driven rivets=300 N/mm^2 (MPa).

For plates working stress in axial tension =156 N/mm^2.



DOUBLE COVER BUTT JOINT

Solution

Nominal diameter of rivet from Unwin's formula

$$d = 6.04\sqrt{t} = 6.04\sqrt{16} = 24.16\ mm$$

The hot driven rivets of 16 mm, 18 mm, 20 mm and 22 mm diameter are used for the structural steel works. Unwin's formula gives higher values. Hence, adopt nominal diameter of rivet = 22 mm; Gross diameter of rivet = 22 +1.5 = 23.5 mm

Strength of rivet in double shear = $2 \times \frac{\pi}{4} \times 23.5^2 \times \frac{100}{1000} = 86.75\ kN$

Strength of rivet in bearing = D x t x p_b = 23.5 x 16 x 300/1000 = 112.8 kN

The strength of a rivet in shearing and in bearing is computed and the lesser is called the rivet value (R). Hence the Rivet value is 86.75 kN.

Number of rivets required to transmit pull of 750 kN   n= (750/86.75) = 8.67 ≈ 9 rivets.

Using diamond group of riveting, flat is weakened by one rivet hole. Strength of plate at section 1-1 in teaing

P_t = (b-d) x t x p_t = ((b-23.5) x 16 x 156/100) = 2.496 (b-23.5) kN

Since P = 750 kN,   2.496 (b-23.5) = 750

b=(750/2.496)+23.5 = 323.98 mm

Hence provide 400 mm width of diagonal member. The design of joint is shown in Fig. 6.4.

Efficiency of the joint

$$\eta = \frac{(b-D) \times t \times p_t}{b \times t \times p_t} \times 100 = \frac{400-23.5}{400} \times 100 = 94.125\ \%$$

Example 6.6: A bridge truss diagonal carries an axial pull of 500 kN. It is to be connected to a gusset plate 22 mm thick by a double cover butt joint with 22 mm rivets. If the width of the tie bar is 250 mm, determine the thickness of flat. Design the economical joint. Determine the efficiency of the joint. Adopt working stresses in rivets and flats as per IS : 800-84.

Solution

Nominal diameter of rivet = 22 mm; Gross diameter of rivet = 23.5 mm

Strength of power driven rivet in double shear = $2 \times \frac{\pi}{4} \times 23.5^2 \times \frac{100}{1000} = 86.75\ kN$

Strength of power driven rivet in bearing = D x t x p_b = 23.5 x 22 x 300/1000 = 155.1 kN

The strength of a rivet in shearing and in bearing is computed and the lesser is called the rivet value (R). Hence the Rivet value is 86.75 kN.

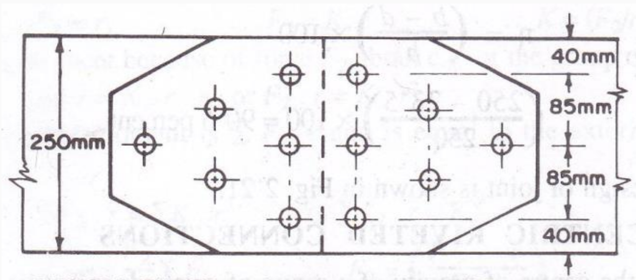
Number of rivets required to transmit pull of 500 kN   n= (500/86.75) = 5.76 ≈ 6 rivets.

Provide six rivets in diamond group of riveting for efficient joint.

Let the thickness of flat be t mm

Strength of plate at weakest section P_t = (b-d) x t x p_t = ((250-23.5) x t x 156/100) = 500 kN

Therefore t = 14.151 mm; Adopt 16 mm thickness of flat. Keep 40 mm edge distance from centre of rivet and 85 mm distance between centre to centre of rivet lines as shown in the Fig. 6.5.



DIAMOND RIVETED DOUBLE COVER BUTT JOINT

Efficiency of joint

$$\eta = \frac{(b-D) \times t \times p_t}{b \times t \times p_t} \times 100 = \frac{250 - 23.5}{250} \times 100 = 90.6\ \%$$

Bolt Connections

Also known as a "coach" bolt, has a domed or countersunk head. The square section under the head grips into the part being fastened p
turning when the nut is tightened.
Shop Carriage Bolts
Hex Head Bolts

Hex tap bolts, hex cap screws, trim head hex cap screws, and hex serrated flange bolts fall under this category. They share a hexagonal
a wrench. Referred to as both bolts and screws.
Shop Hex Head Bolts
Machine Screws

A machine screw is a screw or bolt with a flat point. Available in a variety of drive types and heads, they fit a wide variety of applicatio
tapped holes. Used with nuts and washers, also known as "stove bolts" or "stovers".
Shop our Machine Screws
Shoulder Bolts

Shoulder bolts (also known as shoulder screws or stripper bolts) are machine screws with a shoulder between the thread of the screw ar
Once installed, the non-threaded portion extends out of the surface of the application site, allowing the bolts to act as dowels or shafts f
can be installed by hand or with a socket (Allen) driver.
Shop Shoulder Bolts

Socket Cap Screws

Socket cap screws are available in button socket, button flange socket head, flat socket, and socket cap. Driven with a socket wrench or a hex Allen key. The term socket head cap screw typically refers to a type of threaded fastener whose head diameter is nominally 1.5 times or more than that of the screw shank diameter. Shop our Socket Cap Screws

TERMINOLOGY

The following terms used in bolted connection should be clearly understood [Ref. Fig. 2.1(a)]:

1. Pitch of the Bolts (p): It is the centre-to-centre spacing of the bolts in a row, measured along the direction of load.

2. Gauge Distance (g): It is the distance between the two consecutive bolts of adjacent rows and is measured at right angles to the direction of load.

3. Edge Distance (e): It is the distance of bolt hole from the adjacent edge of the plate.

Apex: The highest point on a truss.

Barge: Trim along the edge of roofing at a gable end. Slopes at roof pitch. It is fixed to ends of battens, purlins or verge rafters.

Batten: Roofing battens or ceiling battens. Usually timber members fixed at right angles to the truss chords to support roof tiles or ceiling material. Also provides lateral restraint to the truss. Bearing/Support point: Point at which the truss is supported. A truss must have two or more supports located at truss panel points.

Bottom chord: Truss member forming bottom edge of truss. Butt joint

Splice: End-to-end joint between two pieces of timber.

Camber: Vertical displacement built into a truss to compensate for the downward movement expected when truss is fully loaded.

Cantilever: That part of a truss that projects beyond an external main support, not including top chord extensions or overhangs.

Chord: The truss members forming the top and bottom edges of the truss. Clear span: Horizontal distance between inner edges of supports.

Concentrated load: A load applied at a specific position. e.g. load applied by an intersecting truss.

Connector: Light gauge steel plates with teeth projecting from one face. When pressed into intersecting timber members the plate connects the members in a rigid joint.

Creep: Movement resulting from long-term application of load to a timber member.

Cut-off: Description of a truss based on standard shape but which is cut-off short of its full span.

Dead Load: Permanent loads due to the weight of materials and truss self-weight.

Deflection: Vertical and horizontal movement in a truss due to the applied load. Design Loads: The various loads that a truss is designed to support.

Distributed Load: Loads spread evenly along truss member. Fascia: Trim along the edge of the eaves.

Gable Truss: Standard triangular shaped truss. Girder Truss: Truss designed to support one or more trusses.

Heel Joint: The joint on a truss where the top and bottom chords meet.

Heel Point: The position on a truss where the bottom edge of the bottom chord meets the top chord. Used for setting up production jigs.

Hip: Intersection of two roof surfaces over an external corner of a building.

Hip Roof: Roof constructed with rafters or trusses pitched over all perimeter walls.

Joint Strength Group: Classification of timber according to its ability to perform with fasteners such as bolts, nails and Gang-Nail connectors. The grouping depends on timber species and moisture content.

King Post: Vertical web at the centre of a gable truss, or the vertical web at the end of a half gable truss

Lateral Brace: Bracing restraint applied at right angles to web or chord to prevent buckling.

Longitudinal Tie: Bracing restraint applied at right angles to web or chord to prevent buckling.

Live Load: Temporary load due to traffic, construction, maintenance etc. Overall Length: Length of truss excluding overhangs.

Overhang: Extension of top chord beyond support. Provision of eaves on gable trusses.

Nominal Span: The horizontal distance between supports of a truss.

Panel-point: The point where several truss members meet to form a joint.

Panel-point Splice: Splice joint in a chord coinciding with web intersection.

Pitch: Angular slope of truss chord measured in degrees.

Purlin: Roofing purlins. Usually timber members fixed at right angles to the truss chords to support roof sheeting. Also provides lateral restraint to truss. Similar to battens except more widely spaced.

Rafter: A roof member supporting roofing battens or roofing purlins in conventional construction. Rafters employ only the bending strength of the timber. A roof truss may also be called a trussed rafter.

Ridge: The highest point on a gable roof.

Span: The horizontal distance between the outer edges of the truss supports.

Span Carried: The span of standard trusses that are supported by a girder truss.

Stress Grade: Strength classification of timber. Based on species, seasoning and frequency of defects such as knots and sloping grain. Alternatively based on actual mechanical testing of each piece.

Station: The position of a truss measured from the outside face of the end wall. Usually used to describe the position of truncated Girder and Standard trusses in a Hip End.

Strut: Structural member subject to axial compression. In the context of truss, this term is used for compression webs.

Symmetrical Truss: Truss with symmetrical configuration and design loading. Top Chord: Truss member forming top edge of truss.

Truss: Trussed rafter. Triangulated, self-supporting framework of chords and webs that supports applied loads by a combination of the bending strength of the chords and the axial compressive and tensile strength of the chords and webs.

Valley: Intersection of two roof surfaces over an internal corner of a building.

Verge: Roof overhang at a gable-end.

Verge Rafter: Rafter projecting from gable end to support verge.

Waling Plate: Timber member bolted to the face of a truss to support intersecting rafters or trusses. May also be used to support intersecting battens or purlins.

Web: The internal members of a truss. Usually only subject to axial loads due to truss action.

Wind Load: Load applied to the roof by the wind.