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***Subject*** ***Steel structure***

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Q No 1

A general statement assuming safety in engineering design.

Resistance (of material & x-section) ≥ effect of Applied Loads → (1)

In eq (1) it is essential that both sides are evaluated for same conditions e.g. if effect of load is to produce compressive stress on soil, then it should be compared with bearing capacity of soil.

→ when particular loading reaches its limit failure is the assumed result i-e the loading condition become failure modes, such a condition is referred to as limit state and it can be defined as.

" A limit state is a condition beyond which a structural system or a structural component ceases to fulfill the function for which it is designed"

## A.S.D

Saftey in the design is obtain by specifyig that the effect of the loads should produce stresses that is a fraction of the yield stress fy, say one half

→ This is equivalent to

FOS = Resistance, R/effect of Load, Q

= fy/0.5 fy

= 2

Mathematically: ⇒ $\frac{\phi R_n}{\gamma} \geq Q_i$

$R_n$ = Resistance or strength of Component being designed.

$\phi$ = Resistance factor or strength reduction factor.

$\gamma$ = over load or load factors.

$\gamma/\phi$ = Factor of Safety Fs.

$Q_i$ = Effect of applied loads.

## Draw backs:

Implied in the ASD method is the assumption that the stress in the member is zero before any loads are applied i-e no residual stresses exist from forming the member.

-> ASD ~~Design~~ does not give reasonable measure of strength which is more fundamental measure of resistance than is allowable stress.

## L.R.F.D:

To over come the deficiencies of ASD, the LRFD method is based on : strength material.

-> it consider the variability not only in resistance but also in the effects of load.

-> it provide measure of safety realated to probability of failure.

Mathematically.

$$\phi R_n \geq n \Sigma \gamma Q_i$$

$R_n$ = Resistance.

$Q_i$ = Effect of Applied Load.

$n$ = Take into account ductility.

$\phi$ = Resistance factor.

$\gamma$ = over Load.

$\gamma/\phi$ = Factor of Safety.

⇒ Advantages:

→ LRFD accounts for both variability in resistance and Load.

→ it achieves fairly Uniform Levels of Safety for different Limit state.

(5)

Dis advantages.

its dis advantage is change in design philosophy from previous Method.

———— x ————

*Q = 2*

Write brief note on types of bolted connections in Steel structures? Also explain failures in bolted connections, with the help of figures.

*ANS :*

# Types of Bolted Connections

There are three basic joint types that we will consider:

1. Snug tight
2. Pretensioned
3. Slip critical.

• The differences among these joint types are essentially the amount of clamping force that is achieved when tightening the bolts and the degree to which the connected parts can move while in service.

• The contact area between the connected parts is called the faying surface.

• In any project, the engineer must indicate the joint type and the faying surface that are to be used for any given connection.

# 1: Snug-Tight Connection

- A snug-tight condition occurs when the bolts are in direct bearing and the
plies of a connection are in firm contact.
- This can be accomplished by the full effort of a worker using a spud wrench,
which is an open-ended wrench approximately 16 in. long.
- A snug-tight joint can be specified for most simple shear connections, as well
as tension-only connections.
- Snug-tight joints are not permitted for connections supporting non static
loads, nor are they permitted with A490 bolts loaded in tension.
- There is generally no need to limit the actual level of pretension in snugtightened joints, per RCSC specification section 9.1.
- RCSC specification section 4.1

## 2: Pretensioned Connection

• A pretensioned joint has a greater amount of clamping force than the snugtight condition and therefore provides a greater degree of slip-resistance in the joint.

• Pretensioned joints are used for joints that are subject to cyclical loads or fatigue loads.

• They are also required for joints with A490 bolts in tension.

• Some specific examples of connections where pretensioned joints should be specified are

• Column splices in buildings with high height-to-width ratios,

• Connections within the load path of the lateral force resisting system, and

• Connections supporting impact or cyclical loads such as cranes or machinery.

It is important to note that the design strength of a pretensioned joint is equal to that of a snug tightened joint.

- In a pretensioned joint, slip is prevented until the friction force is exceeded.
- Once the friction force is exceeded, the bolts slip into direct bearing and the pretension or clamping force is essentially zero (i.e., equivalent to a snugtight condition).
- For both snug tight and pretensioned bolts, the faying surface is permitted
to be uncoated, painted, or galvanized, but must be free of dirt and other
foreign material.
- The AISC specification stipulates that the minimum required clamping force
should be at least 70% of the nominal tensile strength, Rn, of the fastener.
- RCSC specification section 4.2

## 3: Slip-Critical Connection

• This type of joint is similar to a pretensioned joint except that failure is assumed to occur when the applied load is greater than the friction force and thus slip does not occur between the faying surfaces.

• As with pretensioned joints, slip-critical joints are used for joints subjected to cyclical loads or fatigue loads.

• They should also be used in connections that have slotted holes parallel to the direction of the load or in connections that use a combination of welds and bolts along the same faying surface.

• The amount of pretension or clamping force for a slip-critical bolt is the same that was used for pretensioned joints.

• The design strength of a slip-critical joint is generally lower than that of a bearingtype connection since the friction resistance is usually lower than any other failure mode for a bolt (such as direct shear or bearing).

• RCSC specification section 4.3

Shearing Failure of Bolts.

## Explain failures in bolted connections, with the help of figures.

# Types of Connection failures.

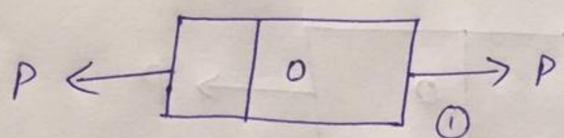
There are

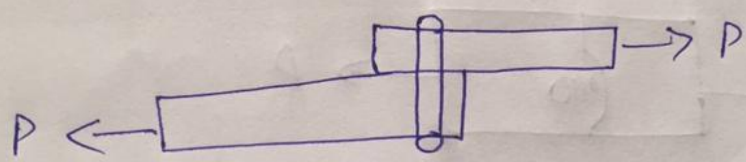
① shearing failure of bolt.

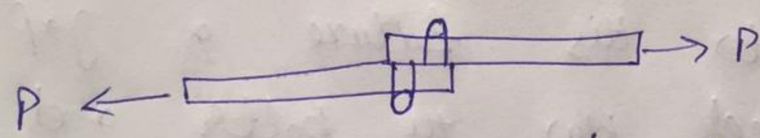
② Bearing failure of plate.

③ Tearing failure at edge of plate.

## ①⇒ shearing failure of bolts:-



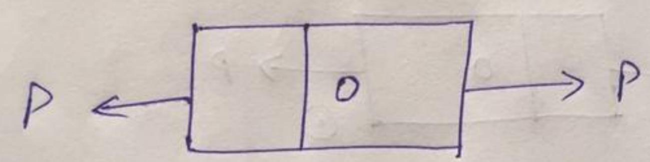



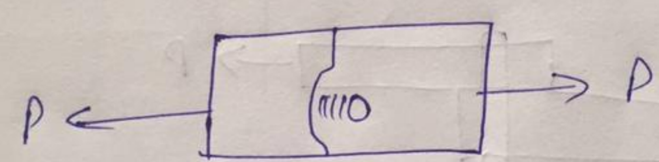




Here the Load is transfer by the shearing of bolts and here shearing stress exceed the shear strength of bolts, thats why the bolts fails in shear. It may be Single or double shear.

② Bearing failure of plate.

This is a failure of plate and the bearing stresses induced on the plate exceeds the bearing strength of the plate and hence failure of the connection occur and known as bearing failure of plate as shown.

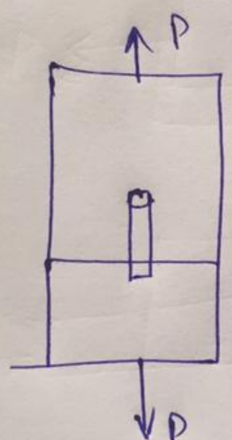


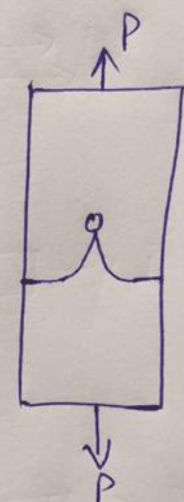

Due to this failure a gap is produced b/w the bolts and the surface of plate (In bearing).

(3) Tearing of plate at the Edges.

This failure may be due to shear or tranverse tension failure of the plate. Here the stresses exceeds the shear strength of the plates and hence the plate are sheared at the edge as shown



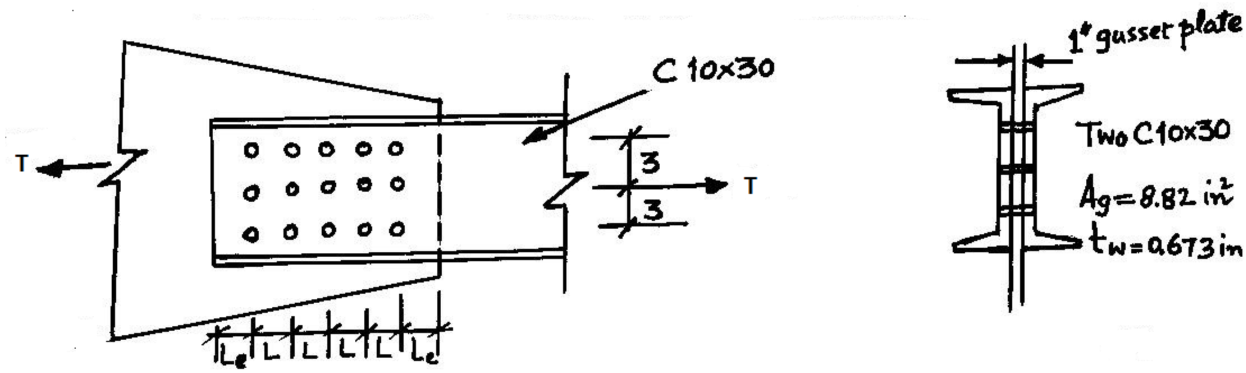

Shear failure




Transverse tension failure.

Q = 3

Determine the number of bolts required, and an appropriate lay out, to transmit a dead-load force of 130 k and a live-load of 265 k through two C10 x 30 to a 1-in gusset plate as shown in figure. All material is A-36. Bolts are A325 with ¾ -in diameter (standard holes) in a bearing-type connection with threads excluded from the shear plane. Use three lines of bolts across the web of the channel. Check the capacities for Channels only. Use ASD method.




***ANS:***

Q3

Given Data.

Dead Load = 130K

Live Load = 265K

Section = C10×30

Gusset plate = 1 in

Bolts diameter = 3/4 in

A325 , A36

three bolts lines.

Required:

No of bolts = ?

Capacity using ASD = ?

Diagram:

Solution:-

(1) Finding total Service Load

= 130 + 265 = 395 Kips.

(2) Bolts Design;

For 3/4 dia.

Area = 0.4418 $in^2$ ( Nominal Area)

Fv = 30 ksi ( shear strength of bolt in single shear table 2-11)

Rv = 0.4418 x 30

Rv = 13.25 kips/shear surface

↳ Resistance offered by a single in shear.

As there are two shear surfaces per bolt.

$$\text{No of bolts} = \frac{395}{2 \times 13.25} = 14.90 \approx 15 \text{ bolts.}$$

(3) Bearing:-

$F_P = 1.2 F_V$ (specification allowable stresses)

$F_P = 1.2 \times 58$

$F_P = 69.6 \text{ ksi}$

$\Rightarrow$ $l_e = 1\frac{1}{2} d$

$L = 3d$ (Table 2-9)

Channel

$R_P = d\,t\,F_P = \frac{3}{4} \times 0.673 \times 69.6$

$R_P = 35.13 \text{ Kips}$ (single bearing surface of channel)

For bolts there are 30 bearing Surfaces so;

Capacity = $30 \times 35.13$

$= 1053.9 > 395$ kips OK ✓

Gusset plate:

$R_P = d t F_P$

$R_P = 3/4 \times 1 \times 69.6$

$R_P = 52.2$ kips (Single bearing surface of gusset plate)

For gusset plate there are 15 bearing surfaces so;

Capacity = $15 \times 52.2$

$= 783 > 395$ kips (OK) ✓

Spacing

END distance sheared Edge = $1\frac{1}{4}$ (minimum)

END distance = $1\frac{1}{2}$ d = 1.13 in ≤ $1\frac{1}{4}$ in
Center to Center = 3d = $2\frac{1}{4}$ in
} Table 2-8 and 2-9

→ As we can see that Rp for both channel and gusset plate is considerably greater than required.
Consider minimum end distance of $1\frac{1}{4}$ in and the minimum b/w connection spacing of 2 in.

$$l_e = \frac{2P}{F_u t} = 1.25$$

[ t = 0.673
From table 1-5
AISC Manual

$$\frac{2P}{58 \times 0.673} = 1.25$$

$$P = 24.4 \text{ Kips}$$

⑥

$$L = \frac{2P}{F_u t} + \frac{d}{2}$$

$$2 = \frac{2P}{58 \times 0.673} + \frac{3/4}{2}$$

$P = 31.7$ Kips

Capacity = $2(3 \times (24.4) + 12(31.7))$

Capacity = $907.2 > 395$ kips (OK) ✓

Gusset plate

$$L_e = \frac{2P}{F_u t} \Rightarrow 1.25 = \frac{2P}{58 \times 1}$$

$P = 36.25$ kips

$$L = \frac{2P}{F_u t} + \frac{d}{2} \Rightarrow 2 = \frac{2P}{58 \times 1} + \frac{3/4}{2}$$

$P = 47.13$ kips

Capacity = (3 x (36.25) + 12 (47.13))

Capacity = 674.31 > 395 kips (OK) ✓

So Use 15 bolts in 3 rows of five with end distance 1.25 in and center to center spacing of 2 in.

———————— x ————————