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Subject Steel Structure

Mid term Summer exam

Q1) What is the general statement of design philosophies? Write notes on ASD and LRFD

Ans Design Philosophies:-

A general statement assuming safety in engineering design.

Resistance (of materials and 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 reffered to as limit state and 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."

To facilitate the analysis of load effects and strength of the materials the two distinct procedures employed by designers are
Allowable Stress Design (ASD)
Load & Resistance Factor Design (LRFD)

1) Allowable Stress Design (ASD)

- Safety in the design by specifying 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 / 0.5fy
= 2

Mathematically :-

$$\frac{\phi R_n}{\gamma} \geq \sum Q_i$$

R_n = Resistance or strength of the component being designed
ϕ = Resistance factor or strength reduction factor
γ = Overload or Load factors
$\frac{\gamma}{\phi}$ = Factor of Safety FS
Q_i = Effect of Applied loads.

Advantages of ASD :-

Following are the advantages of ASD :-

1) Elastic analysis for loads become compatible for design.
2) Old famous books are according to this method.
3) Experienced engineers are used to this method
4) In past it was the only method for design purposes.
5) This method is included in AISC-05 specifications an an alternate method

Drawbacks :-

- Implied in the ASD method is the assumption that the stress in the number is zero before any loads are applied i-e, no residual stresses exist from forming the members.
- ASD does not give reasonable measure of strength, which is more fundamental measure of resistance than the allowable stress.
- Another drawback in ASD is that safety is applied only too stress level. Loads are considered to be determine (without variation)

LRFD :-

=> To overcome the difficiencies of ASD, the LRFD method is based on : Strength of materials.

=> It considers the variability not only in resistance but also in the effects of load.

=> It provides measure of safety related to probability of failure.

- Safety in the design is obtained by specifying that the reduced Nominal strength of a designed structure is less than the effect of factored load acting on the structure

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

R_n = Resistance or Strength of the component being designed

Q_i = Effect of Applied Loads

n = Takes into account ductility, redundancy and operational imp.

ϕ = Resistance Factor or Strength Reduction Factor.

γ = Overload or load factors

$\frac{\gamma}{\phi}$ = Factor of safety

Advantages:-

- LRFD accounts for both variability in resistance and load.
- It achieves fairly uniform levels of safety for different limit-states.

Disadvantages:-

- Its disadvantage is change in design philosophy from previous method.
- It requires an understanding of the basic concepts of probability and statistics.

Q2) Write brief note on types of bolted connections in Steel Structures? Also explain failures in bolted connections with figures.

Ans Types of Bolted Connections:-

These are three types of basic joints that we will consider

1) Snug tight
2) Pretensioned
3) Slip Critical

The differences among these joints 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

1) Snug-Tight Connection:-

- A snug-tight connection 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.
- A snug-tight joint can be specified for most simple shear connections as well as tension only-only connections.
- Snug-tight joints are not permitted for connections supporting non-static loads nor are they permitted with A490 bolts loaded in tension.

2) Pretensioned Connection:-

- A pretensioned joint has a greater amount of clamping force than the ~~snug~~ snug-tight condition and therefore provides a greater degree of slip-resistance in the joint.
- Pretensioned joints are used for joints that are subject to ~~cyclic~~ 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

3) Slip-Critical connection:-

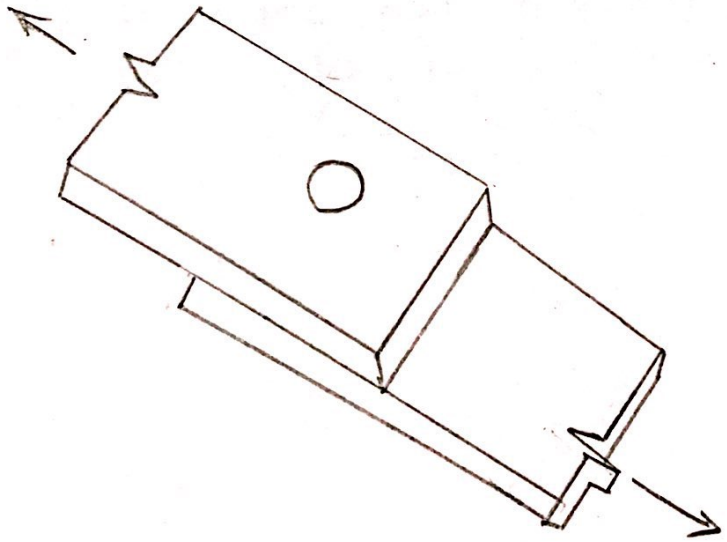
- This type of joint is similar to pretensioned joint except that failure is assumed to occur when the applied load is greater than the friction force and thus slip does not occur between the faying surfaces.
- As with pretensioned joints. slip critical joints are used for joints subjected to cyclical loads.
- They are 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 Pretensioned or clamping force for a slip-critical bolt is the same that was used for pretensioned joints.

Types of failures:-

1) Shearing Failure of Bolts
2) Bearing Failure of plate
3) Tearing failure of plate

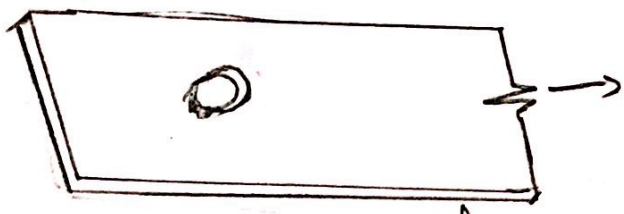
1) Shear Failure:-

Shear failure consists of chainline vertical cracks in the masonary substrate close to the supports, which developed at a slope of approx 45 degrees.



2) Bearing failure of plate:-

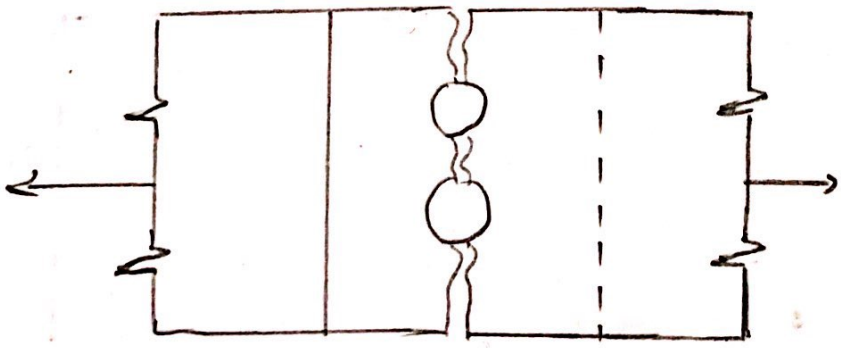
Bearing failure reduce a plants operating efficiency, increase downtime, drive cost of operations up and in the worst cases may injure workers.



Bearing failure

3) Tearing failure of plate:-

Tearing failure occurs when bolts are stronger than the plates. Bolts may have been placed at a lesser edge distance than required causing the plates to split or shear out. The plate may be crushed when the bearing stress in the plate exceeds the working bearing stress.



Tearing Failure of plates.

(Q3)

Determine the number ---

Given Data :-

Dead load = 130K

Live load = 265K

Section = C10 x 30

Gusset plate = 1"

Bolts diameter = $\frac{3}{4}$"

A325 , A36

three bolt lines

Required :-

No of bolts = ?

Capacity using ASD = ?

Solution :-

1) Finding total service load

= 130 + 265 = 395 kips

2) Bolt Design :-

For 3/4 dia

Area = 0.4418 in^2 (Normal Area)

FV = 30ksi (shear ~~strength~~ of bolt in single shear table 2.11)

RV = 0.4418 x 30

R_V = 13.25 kips / shear surface
↳ Resistance offered by a single in shear

As there are two shear surfaces per bolt

No of bolts $\frac{395}{2 \times 13.25} = 14.9 \approx 15$ bolts

3) Bearing

$F_p = 1.2\ F_u$ (specification allowable stresses)

$F_p = 1.2 \times 58$

$F_p = 69.6$ ksi

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

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

Channel

$R_p = d + F_p = \frac{3}{4} \times 0.673 \times 69.6$

$R_p = 35.13$ kips (single bearing surface of Channel)

For bolts there are 30 bearing surface so;

Capacity = 30×35.13

$= 1053.9 > 395$ kips $\Rightarrow$ ok

Gusset plate :-

$R_p = d + F_p$

$R_p = \frac{3}{4} \times 1 \times 69.6$

$R_p = 52.2$ kips (single bearing surface of gusset plate)

For gusset plate there are 15 bearing surfaces so;

Capacity = 15 x 52.2

= 783 > 395 kips ⇒ OK

(4) Spacing:-

End distance sheared Edge = 1¼ (minimum)

End distance = $1\frac{1}{2}d$ = 1.15 in ≤ $1\frac{1}{4}$ in

C/C = 3d = $2\frac{1}{4}$ in

} Table 2-8 and 2-9

⇒ As we can see that Rp for both channel & 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

$$Le = \frac{2P}{Fut} = 1.25 \quad \left[\begin{array}{l} t = 0.673 \\ \text{From table 1-5} \\ \text{AISC manual} \end{array}\right]$$

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

$$P = 24.4 \text{ kips.}$$

$$L = \frac{2P}{Fut} + \frac{d}{2}$$

$$2 = \frac{2P}{58.0.673} + \frac{3/4}{2}$$

$$P = 31.7 \text{ kips}$$

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

Capacity = $907.2 > 395$ kips $\Rightarrow$ OK

Gusset :-

$$Le = \frac{2P}{Fut} \Rightarrow 1.25 = \frac{2P}{58 \times 1}$$

$$P = 36.25 \text{ kips}$$

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

$$P = 47.13 \text{ kips}.$$