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Subject # Steel Structure

Q1:

Ans: Design Philosophies:

A general statement assuming safety in engineering design.

"Resistance (of materials & 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 mode, 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".

" ——— "

Allowable Stress Design (ASD):

Safety in the design is obtained by specifying, that the effect of the loads should produce stresses that is a fraction of the yield Stress 'f_y', say one half.

This is equivalent to:

$$FOS = \text{Resistance, } R \,/\, \text{Effect of load, } Q$$

$$FOS = R/Q$$

$$= f_y / 0.5 f_y$$

$$= 2$$

Mathematical Description of ASD:

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

R = 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.

Drawbacks:

- 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 members.

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

- Another drawback in ASD is that safety is applied only to stress level, Loads are considered to be deterministic.

LRFD:

* To overcome the deficiencies of ASD, the LRFD method is based on: Strength of Materials.
* It consider the variability not only in resistance but also in the effect 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 Loads acting on the Structure

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

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

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.

Q no 2:

Ans: **Bolts:**

Bolted connections are used when it is necessary to fasten two elements tightly together, especially to resist shear and bending, as in column and beam connections.

Types of Bolted Connections:

1) **Slip-Critical connections:** Connection transmits the force by friction produced between the faying surfaces by the clamping action of the bolts.

(2) Slip-critical connections are recommended for joints subjected to stress reversal severe stress fluctuation, impact, vibration or where slip is objectionable.

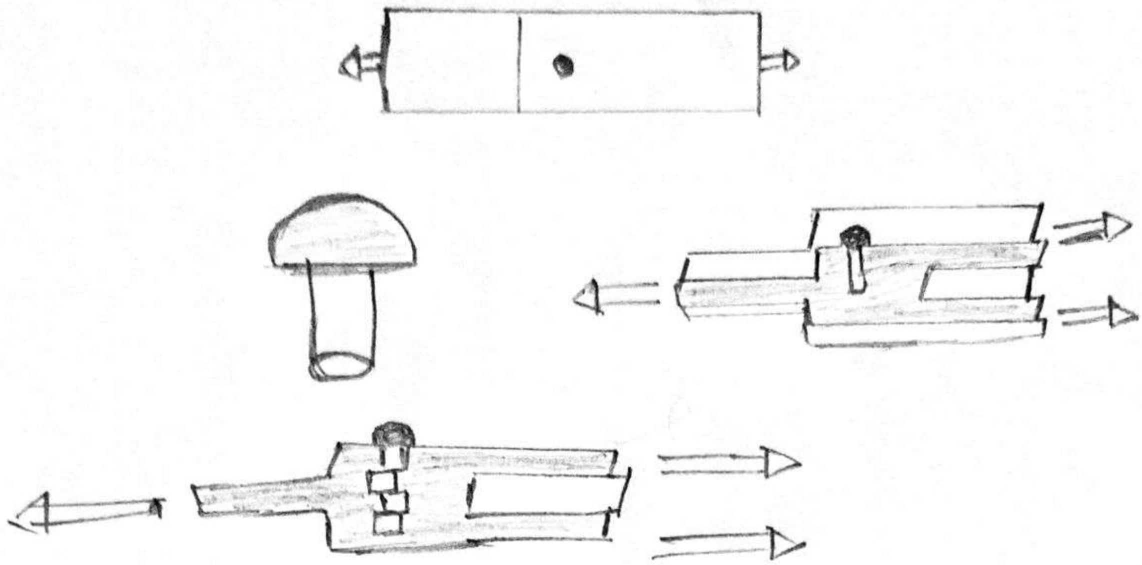
② **Bearing type connections:**
Load is transferred by shearing and bearing on the bolt.

③ Capacity in shear depends on whether shear plane intersects the body of bolt or threaded portion.

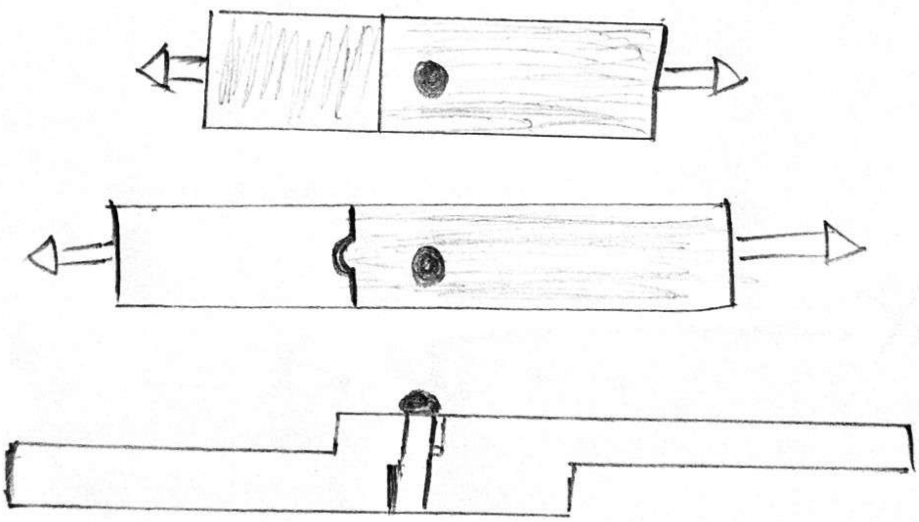
Types of failures:

① Shearing Failure of Bolts.
② Bearing Failure of plate.
③ Tearing failure at edge of plate.

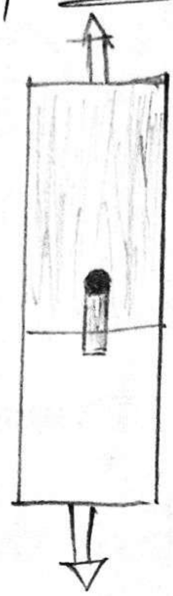
(1) Shearing Failure of Bolts:



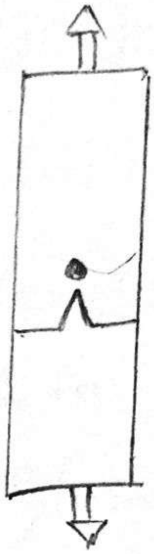
(2) Bearing Failure of Plate:



Tearing Failure at the edge of plate :



Shearing Failure edge of plate



Transverse Tension Failure

* ———————— *

Q3:

Given DATA:

Dead Load = 130 k

Live Load = 265 k

Section = C 10 x 30

Gusset plate = 1 in

Bolts diameter = 3/4 in

A 325 , A36

three bolts lines

Required:

No of bolts = ?

Capacity using ASD = ?

Solution :

① Finding total service load

$= 130 + 265 = 395$ kips

② Bolts Design :

For 3/4 dia

Area $= 0.4418 \, in^2$

$F_v = 30$ ksi

$R_v = 0.4418 \times 30$

$R_v = 13.25$ kips/shear surface

As there are two shear surface per bolt.

No of bolts $= \frac{395}{2 \times 13.5} = 14.9 \approx 15$ bolts

③ Bearing :-

$F_p = 1.2\ F_v$ (specifiction allowable stress)

$F_p = 1.2 \times 58$

$F_p = 69.6$ ksi

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

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

④ Channel :-

$R_p = d + F_p = 3/4 \times 0.673 \times 69.6$

$R_p = 35.13$ Kips (Single bearing surface of channel)

For bolts these are 30 bearing surface so ;

Capacity $= 30 \times 35.13$

$= 1053.9 > 395$ kips

Gusset Plate:

$R_p = dt\,F_p$

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

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

For gusset plate these are 15 bearing surfaces so;

Capacity $= 15 \times 52.2$

$= 783 > 395$ kips

(4) **Spacing:** End distance sheared Edge $= 1\frac{1}{4}$

End distance $= 1\frac{1}{2} d = 1.13 \text{ in} \leq 1\frac{1}{4}$ in

Center to center $= 3d = 2\frac{1}{4}$ in

} Table 2-8, 2.9

As we can see that R_p for both channel and gusset plate as considerably greater than required consider minimum end distance of $1\frac{1}{4}$ in

$$L_e = \frac{2P}{F_u t} = 1.25$$ ($t = 0.673$ from table 1-5 AISC Manual)

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

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

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

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

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

$$\text{Capacity} = 2(3 \times (24.4) + 12(3.17))$$

$$\text{Capacity} = 907.2 > 395 \text{ kips}$$

Gusset

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

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

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

$$\boxed{P = 47.13 \text{ Kips}}$$

Capacity $= (3 \times (36 \times 25) + 12\,(47.13))$

Capacity $= 674.31 > 395$ kips

✓ ok

So use 15 bolts in 3 rows of five with end distance $1\frac{1}{4}$ in and center to center spacing of 2 in.