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Section : B

Subject : Steel structure

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Q No 1.

Design philosophies:-

A general statement assuming safety in engineering design.

Resistance (of materials & X-section) ≥ Effects 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. than it should be compared with bearing capacity of soil.

→ When particular loading reaches it's limit, failure is the assume result, i.e the loading conditions become failure modes. such a condition is refferred to as limit state and it can be defined as

"A limit state is a condition beyond which a structural component ceases to ful fill the function for which it is designed.

~~Example~~

1) Allowable stress design (ASD):-

In this method structural design the safety in design is obtained by specifying the condition that the effects of loads should produce stresses that works a friction of yield stress

"fy" (for example 1/2 of yield stress).
Numerically this condition is equivalent to the expression that the

$$F.O.S = \frac{Resistance}{Applied\ load}$$

OR

$$F.O.S = R/p = \frac{Fy}{0.5Fy} \quad —① $$

OR

$$F.O.S = 2.0$$

In this method the specifications set the limits on stresses therefore it known as Allowable stress design.
This method is reasonably applicable where stresses are uniformly distributed over ~~the~~ the cross section.

~~Mathematical expressions~~

Mathematical Description of ASD.

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

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

Q_i = Effect of applid load

2). Load and Resistance factor design (LRFD):-

To overcome the defficiencies in ASD the LRFD method is used. This method is used based on the following parameters.

1) In this method the strength of material is properly measured and then multiply with a reduction factor to obtain the safe value for design.

2) In this method the change in considered not only in resistance but also in the effect of loads.

3) This method provides a measure of safety based on the criteria

resistance should be ≥ to applied load.

$\phi R_n \geq (\text{Applied}) P_n$ — (1)

The LRFD therefore accounts both variability in load and resistance. It therefore achieves a uniform level of safety for different limit states.

Mathematically:

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

R_n = Resistance or strength of the component being designed.

Q_i = Effect of Applied load.

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

ϕ = Resistance factor.

γ = Load factors.

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

Advantages of Allowable stress design method:

i) Elastic analysis of loads become compatible for design.

ii) Old famous books are according to this method.

iii) Experienced engineers are used to this method.

iv) In past it was the only method for design purposes.

v). This method is included in AISC-05 specifications as an alternate method.

Disadvantages of ASD.

1) 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.

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

3). Another drawback in ASD is that safety is applied only to stress level. Loads are considered to be deterministic (without variation).

Advantages of LRFD.

1). LRFD account for both variability in resistance and load.

2). It achieves fairly uniform levels of safety for different limit states.

Disadvantages of LRFD

1) Its disadvantage is change in design philosophy from previous method.

Q NO 2.

Structural Bolts:-

→ Two commonly used types of bolts are:

- Unfinished (A 307)
- High strength bolt (A 325, A 449, A 490)

→ A307 is known by names unfinished, rough common, ordinary and machine.

→ They are made of low carbon steel having tensile strength of 60ksi.

→ A 325 is made of medium carbon steel whose tensile strength decreases with increase in dia

→ High strengths bolts ~~are~~ can be tightened to large tensions.

Types of Connections :-

→ Slip critical connections:

→ Connection tramits the force by friction produced between the faying surface by the clamping action of bolts

→ Slip Critical connection are recomended for joints subjected to stress reversal, severe stress fluctuation, impact, vibration or where slip is is objectionable.

→ Slip critical connection becomes bearing type connection after the slip occurs so every slip critical connection is essentially a bearing type connection also.

→ Bearing type connections:

→ Load is transferred by shearing and bearing on the bolt.

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

→ Bearing type connection is the most widely used general type connection in which the load is resisted by the bolt body without any friction between faying surfaces.

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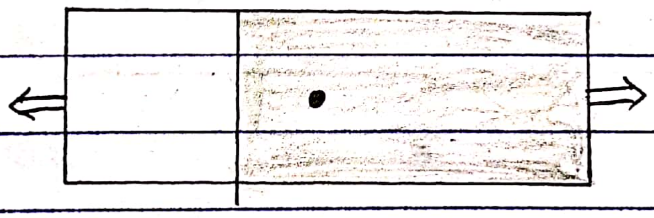
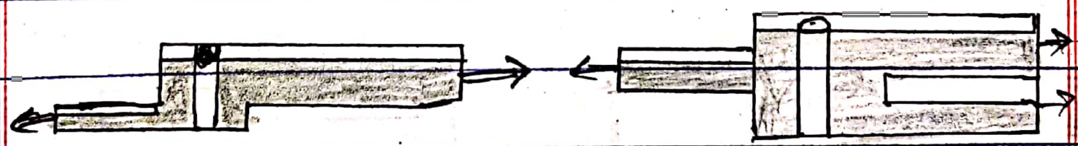
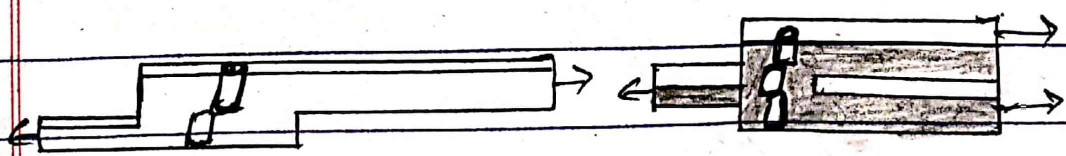
Types of Failure:

Shearing failure of bolts:

The shear stress in the bolts ~~are~~ may exceed the working shear stress in the bolt. shear stresses are generated because the plates slip due to applied forces.

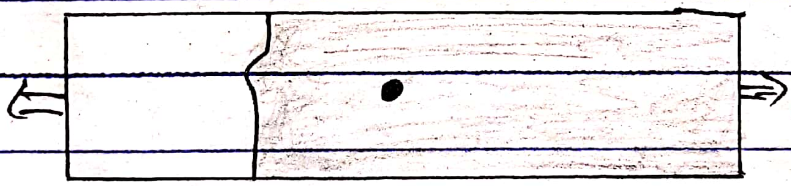


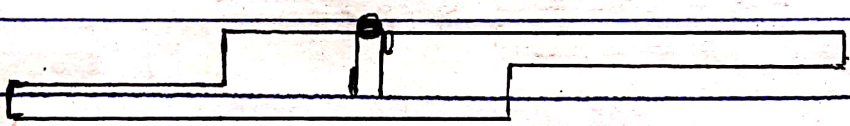


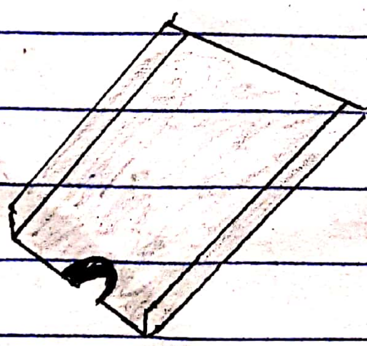


2) Bearing Failure :

The plate may be crushed when the bearing stress in the plate exceeds the working bearing stress.







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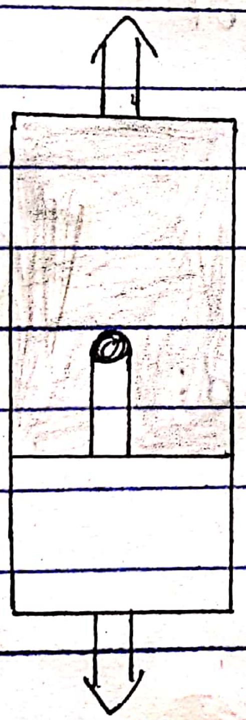
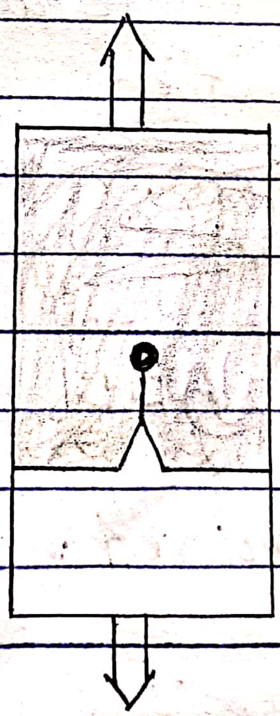
3) Tension or tearing failure of plates:

The tensile stress in the plate at the net cross-section may exceed the working tensile stress. Tearing failure occurs when bolts are stronger than the plates.



shearing failure edge of plate



Traverse Tension Failure.

QNo(3).

Given data.

Dead load = 130K
Live load = 265K
Two plates ξ 10 x 30

1" guset plate

All material is A36 steel
Bolts are A325 with 3/4 in dia Bearing type connection.
Threads excluded from shear plane use three lines of bolts.

ASD Method:

Required:-
Number of bolts required = ?
Appropriate layout.

Sol:-

Design force = D.L + L.L
⇒ 130 + 265
⇒ **395K**

Bolt Design:-

For 3/4" dia bolt

Area = $\pi/4 (D^2) \Rightarrow \pi/4 (3/4)^2$

Area = $0.4418 \, in^2$.

Shear design:-

Shear strength of bolts when threads are excluded from shear plane, from table

$F_V = 30 \, ksi$

$R_V = Area \times F_V$

$\Rightarrow 0.4418 \times 30$

$\Rightarrow$ 13.25K per shear surface

→ As there are two shear surfaces per bolt

⇒ Number of bolts = $\dfrac{\text{Design force}}{2 \times R_V}$

$$\Rightarrow \frac{395}{2 \times 13.25}$$

$\Rightarrow 14.90$

So bolt 15 bolts.

Bearing:

Bearing strength, $F_p = 1.2 F_u$

$F_u = 58$

$F_p = 1.2 \times 58$

$F_p = 69.6$ Ksi

$\Rightarrow$ For Channel, $R_p = d \cdot t \, F_p$

$t_w = 0.673$

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

$R_p = 35.13$ K

for single bearing surface.

As there are 15 bolts so 30 surfaces.

Capacity:-

30 × 35.13

⇒ 1053.9 K > 395 K

OK

⇒ For gusset plate.

$R_p = d\,t\,F_p$

⇒ $3/4 \times 1 \times 69.6$

$R_p = 52.2$.

capacity.

$15 \times 52.2 = 783\,K > 395\,K$

OK

Spacing:

For 3/4" dia bolts min edge distance from table 2.8

$= 1\frac{1}{4}''$ (1.25")

Also

End distance $= 1\,1/2\,d$

⇒ $1\frac{1}{2}(3/4)$

⇒ 1.13 in < 1.25

So

Edge distance, L_e = 1 1/4" or 1.25"

Centre to centre distance:

$L = 3d$

⇒ $3(3/4)$

⇒ $L = 2.25''$

Channel:

$$L_e = \frac{2P}{F_u t}$$

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

$P = 24.4K$

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

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

$\Rightarrow \quad P = 31.7K.$

As the bolts are arranged in three rows and five bolts per row.

Capacity:

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

$$\Rightarrow 907.2K > 395K$$

OK

Gusset plate:

$$Le = \frac{2P}{Fut}$$

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

$$P = 36.25K$$

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

$$2 = \frac{2P}{58 \times 1} + \frac{3/4}{2}$$

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$\Rightarrow$ $P = 47.134$

Capacity:

$3 \times 36.25 + 12 \times 47.134$

$674.358\ K > 395\ K$

OK

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