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7758

Section B

Steel structure

Mid Summer Exam

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Question No 1

1 Design Philosophies:-

A general statment assuming safety in engineering design:

Resistance (of materials & X-Section) ≥ Effects of applied loads ---(i)

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

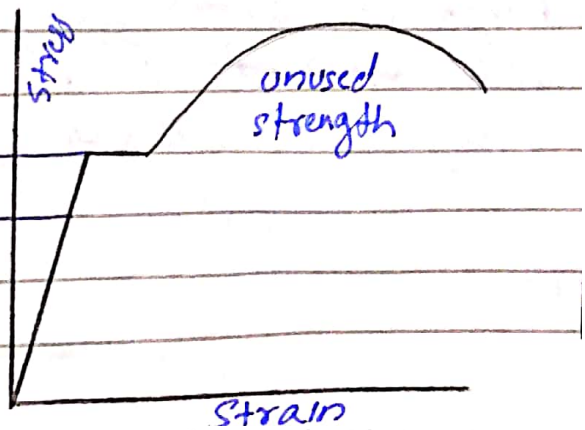
Allowable Stress Design (ASD)

Safetly 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:

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

$$= F_y / 0.5 f_y$$

$$= 2$$



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.

γ/ϕ = Factor of safety FS

Q_i = Effect of applied loads.

* Advantages of Using Allowable Stress design method.

Following are some advantages of (ASD).

→ Elastic analysis for loads become compatible for design.
→ Old famous books are according to this method.
→ Experienced engineers are used to this method.
→ In past, it was the only method for design Purposes.
→ This method is included in AISC-05 Specification as an alternate method.

Drawbacks of ASD.

-> Implied in ASD method is assumption that the stress in 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 Material

- It consider 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

the effect of factored load acting on the structure.

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

R_n = Strength of the component being designed.
Q_i = Effects of applied loads.
n = Takes into account ductility, redundancy.
ϕ = Resistance factor.
γ = Overload.

γ/ϕ = 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.

- It's disadvantage is change in design philosophy from previous method.

Question No 2

Types of Connections:-

→ **Slip-Critical Connections:-**

Connection transmits the force by friction produced between the faying surfaces by the clamping actions of bolts-

- Slip-critical connections are recommended for joints subjected to stress reversal, severe stress fluctuation, impact, vibration or where slip 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:-**

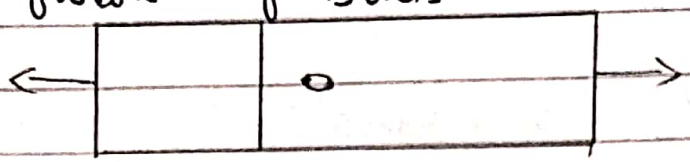
→ Load is transfered by shearing & bearing on the bolt.

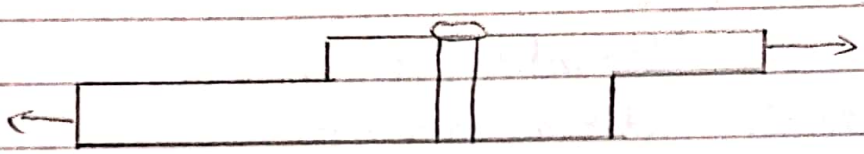
→ Capacity in shear depends on whether shear plane intersects the body of bolt or threaded portion.

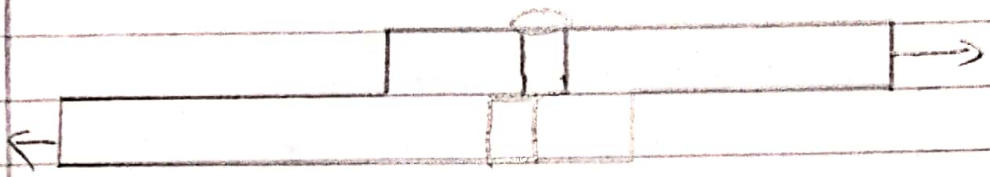
→ Bearing type connection is the most widely used general type connection in which the load is resisted by the bolt body without any friction btw faying surfaces.

Types of failure.

Shearing failure of bolts.

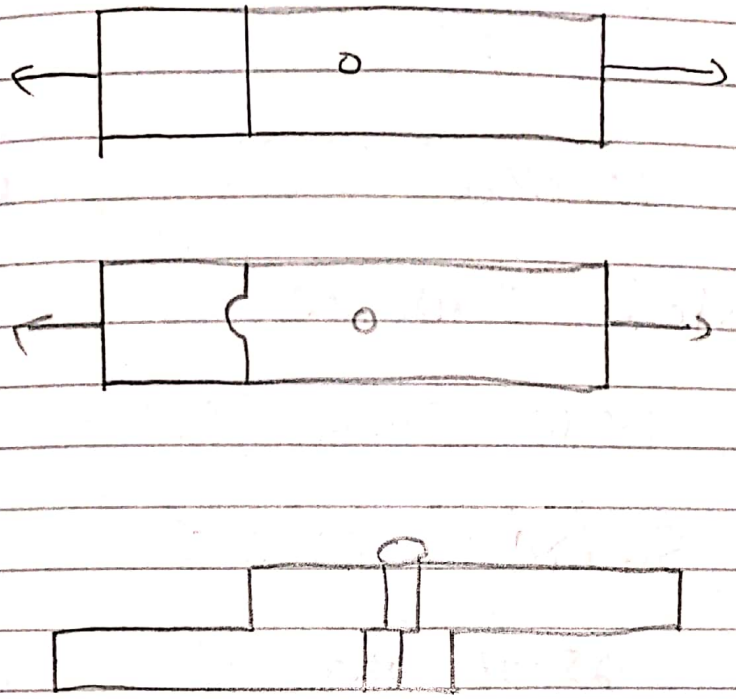






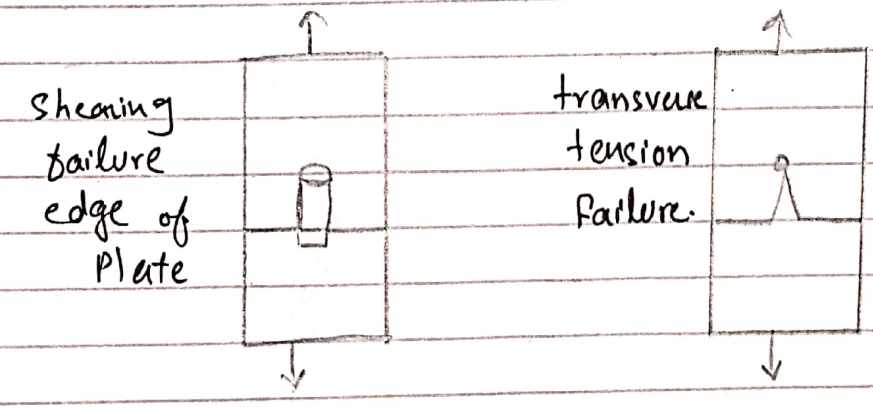
The shear stress in the bolts may exceed the working shear stress in the bolt. shear stresses are generated because the plate slip due to applied forces.

② Bearing failure of plates :-



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

③ Tearing failure at the edge of plate.



The tensile stress in plate at the net cross-section may exceed the working tensile stress.

Question No 3

Given Data:-

Dead load = 130k
Live load = 265k
Section = C10x30
Gusset plate = 1 in
Bolts dia = 3/4 in
A325, A36
three lines bolts-

Required:-

No. of bolts = ?
Capacity using ASD = ?

Sol:-

① Finding total Service Load:-

= D.L + Live load.
= 130 + 265
= 395 kips.

2) Bolts Design:-

For dia 3/4

Area = 0.4418 in^2 (Nominal area)
Fv = 30 ksi (table 2.11)

Rv = 0.4418 x 30
= 13.25 kips./shear surface.
↳ resistance offered by a single in shear

As there are two shear surfaces per bolt

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

③ Bearing:-

$F_p = 1.2 F_u$ (specification allowable stress)

$F_p = 1.2 \times 58$

$F_p = 69.6$ ksi

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

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

Channel:-

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

$R_p = 35.13$ kips. (Single bearing surface of channel)

For bolts there are 30 bearing surfaces.

Capacity $= 30 \times 35.13$

$= 1053.9 > 395$ kips ok✓

Gusset plate:-

$R_p = d + F_p$

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

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

For gussed plate there are 15 bearing surfaces So;

Capacity = 15 x 52.2
= 783 > 395 k

ok ✓

4) Spacing :-

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

End distance = $2\frac{1}{2}$ d = 1.13 in $\leq 1\frac{1}{4}$ in } table 2-8 & 2-9

Centre to centre = 3d = $2\frac{1}{4}$ in

$$L_e = \frac{2P}{F_{ut}} - 1.25 \quad \left(t = 0.673 \text{ from table 1-5 AISC Manual.}\right)$$

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

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

$$L = \frac{2P}{F_{ut}} + \frac{d}{2}$$

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

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

Capacity = 2(3 x (24.4) + 12(31.7))

= 907.2 > 395 k

ok ✓

Gusset plate:-

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

$$P = 36.25\ K.$$

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

$$P = 47.13\ K$$

$$Capacity = (3 \times (36.25) + 12(47.13))$$

$$= 674.31 > 395\ k \quad \text{OK}$$

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