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Subject: Steel Structures

Mid-Term Examination 2020

Q1: What is the general statement of design philosphies? Write brief note on ASD and LRFD. Write merits and demerits.

Ans: A general statement assuming safety in engineering design.

Resistance (of materials & X-section) $\geq$ Effect of applied loads ..... (1)

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

Allowable stress design (ASD)

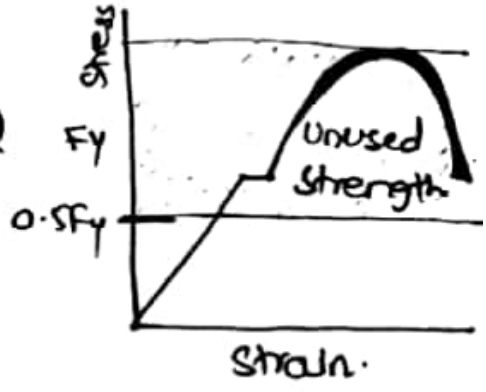
Safety in the design is obtained by specifying, that the effect of the loads should produce stresses that is a fraction of the yield stress f_y. say one half.

This is equivalent to:

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

$$= f_y / 0.5 f_y$$

$$= 2$$



Mathematical description of ASD.

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

R_n = Resistance or strength of the componed being used.
ϕ = Resistance factor or strength Reduction factor
γ = overload or load factors

γ/ϕ = factor of Safety FS.

Q_i = Effect of Applied loads.

LRFD: To overcome the deficiencies of ASD. The LRFD method is based on "Strength of Materials"

⇒ It is consider the variability not only in resistance but also in the effects of load.

⇒ It provides measures of safety related to probability of failure.

⇒ In LRFD, safety in design is obtained by specifying the reduced nominal strength of a designed structure is less than the effect of factored loads acting on the structure.

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

R_n = Resistance or strength of the component being designed

Q_i = Effect of applied loads.

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

ϕ = Resistance factor or strength Reductor factor.

γ = Overload or load factors.

γ/ϕ = factor of safety.

Advantages of Using Allowable stress design method:

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 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 on ASD is that safety is applied only to stress level. loads are considered to be deterministic (without variation).

Advantages of LRFD:

1. LRFD accounts for both variability in resistance and load.
2. It acheives fairly uniform levels of safety for different limits states.

Disadvantages.

1. It's disadvantage is change in design philosophy from previous method.
2. Validity of previous designs is still to be checked according to ASD.

Q2:- Write brief note on types of bolted connections in steel structures ? Also explain failures in bolted connections with help of figures.

Ans: Slip. Critical Connections:

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

- slip-critical connections are recommended for joints subjected to stress reversal, severse stress fluctuation, impact, vibration or where slip is objectionable.

Types of bolted connections:

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:-

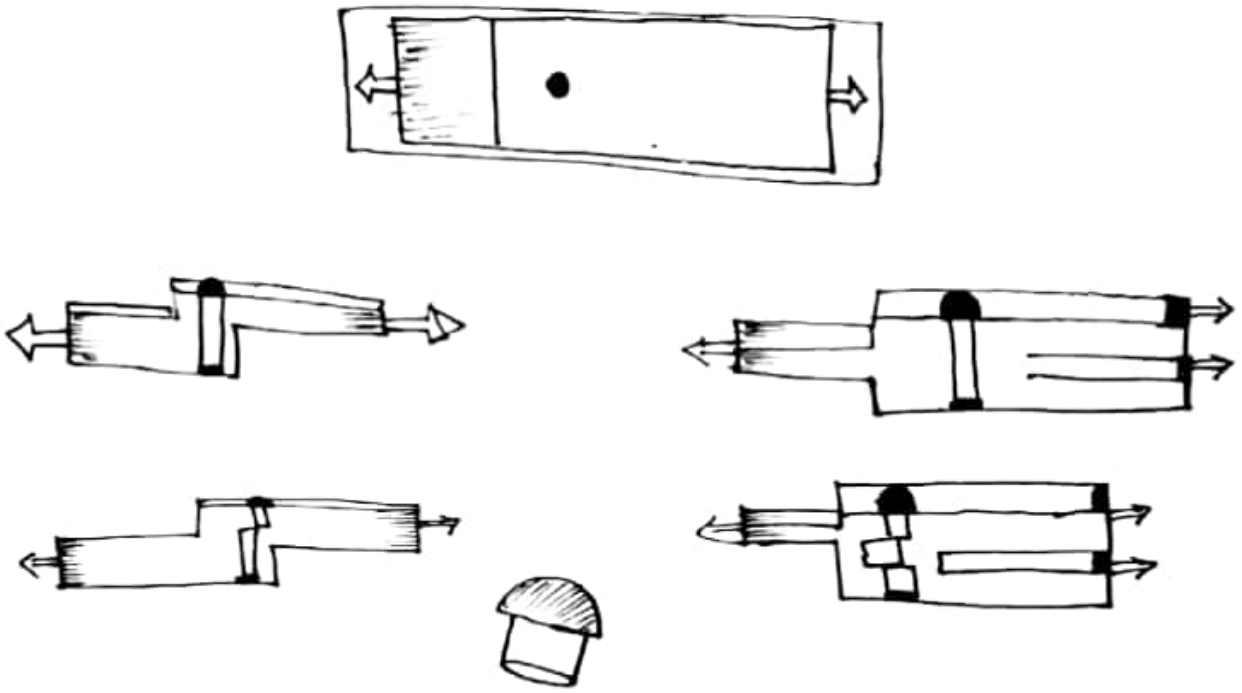
- load is transferred by shearing and bearing on the bolt.
- capacity in shear depends on wether shear plane intersects the body of bolt or threaded portion.
- Bearing type connection is the most widely used general type connection in which the load is resisted by the bolt body without any friction btw faying surfaces.

Types of failure:

→ Shearing failure of Bolts.
→ Bearing failure of plates.
→ Tension or tearing failure of plates

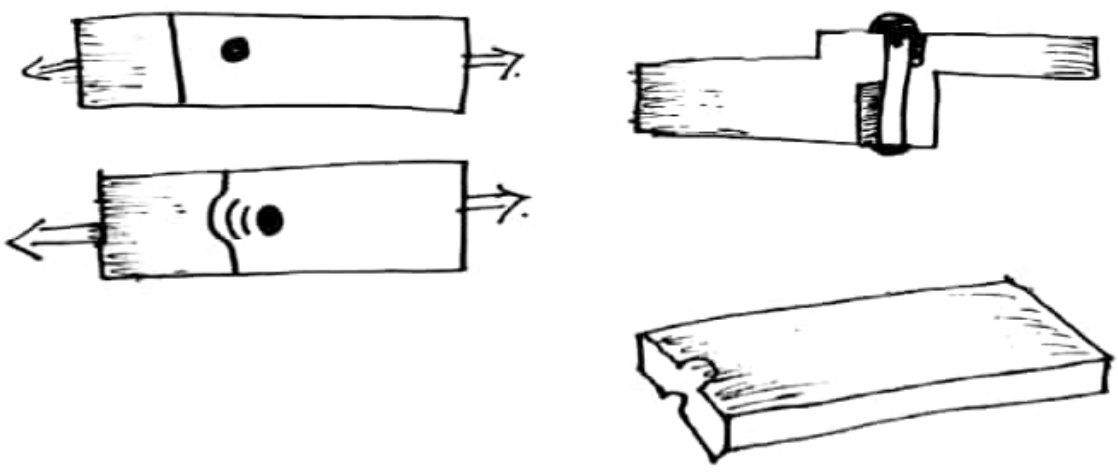
1- Shearing failure of bolts.-

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



2- Bearing failure of plates:-

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



3. Tearing failure at edge of plate:

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

shearing failure at edge of plate

Transverse Tension failure.

Q3: Determine the number of bolts required, and appropriate layout .....

--- Channels only, Use ASD method.

Given Data:

Dead load = 130k
Live load = 265k

Two plates C10x30
1' gusset plate

All material is A 36 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

Solⁿ

Design force = $D_{iL} + L_{iL}$
= 130 + 265
= 395 k

⇒ Bolt design: for $\frac{3}{4}$" dia bolts

Area = $\frac{\pi}{4}(D^2) \Rightarrow \frac{\pi}{4}(3/4)^2$ Area = 0.4418 in².

Shear Design: shear strength of bolts when threads are excluded from shear plane. from table. Fv = 30ksi.

R_v = Area x Fv = 0.4418 x 30
= 13.25k per shear surface.

As There are two shear surface per bolt

Number of bolts = $\frac{\text{Design surface}}{2 \times R_v}$

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

$= 14.90$

So 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

For Channel: $R_p = d t F_p$

$t_w = 0.673$

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

$R_p = 35.13$ k

for single bearing surface.

As there are 15 bolts so 30 surfaces.

Capacity: 30×35.13

$= 1053.9$ k > 395 k

ok.

$\Rightarrow$ for Gusset plate: $R_p = d + F_p$

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

$R_p = 52.2$.

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

$= 1\frac{1}{2} (3/4)$

$= 1.13$ in $< 1.25"$

So,

Edge distance, $le = 1\frac{1}{4}''$ or $1.25''$

Centre to Centre distance

$$L = 3d$$
$$= 3(3/4) = \underline{2.25''}$$

Channel :- $Le = \frac{2P}{Fut}$

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

$$P = 24.4k.$$

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

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

$$P = \underline{31.7k}$$

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

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

$907.2k > 39k$
ok

Gusset plate

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

$$1.25 = \frac{2P}{58 \times 1} \qquad P = 36.25k.$$

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

$$2 = \frac{2P}{58 \times 1} + 3/4/2 \qquad P = 47.134.$$

Capacity :

$3 \times 36.25 + 12 \times 47.134$

$674.358\,k > 395\,k$

ok.