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Q1 General Statement of design philosophies

A general statement assuming safety in Engineering design is

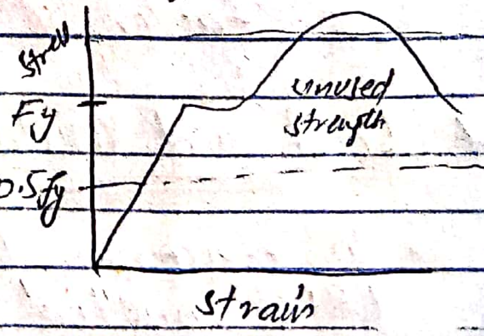
Resistance ≥ Effect of applied loads —(1)

- In eq (1) it is essential that both sides are evaluated for same conditions & units e.g. compressive stress on soil should be compared with bearing capacity of soil.

- Resistance of structure is composed of its members which comes from material X-section
- Terms like Demand, stresses and load are used to express Effect of applied loads.

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



- Since the specifications set limits on the stresses, it became allowable stress design (ASD)

- It is mostly reasonable where stresses are uniformly distributed over X-section (such as determinate trusses, arches, cable etc)

Mathematical Description of ASD

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

R_n = Resistance or strength of the component being design

ϕ = Resistance factor or strength Reduction factor.

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

γ = overload or load Factors

Q_i = Effect of applied loads

In ASD we check a design in terms of stresses Therefore design checks are cast in terms of stresses.

$$\frac{M_n}{F_s} \geq M$$

M = Moment resulting from applied unfactored loads

M_n = Nominal Flexural strength of a Beam

~~[illegible]~~

F_s = Factor of safety

* Load and Resistance Factor design (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 provide measure of safety related to probability of failure.

Mathematical Description of LRFD

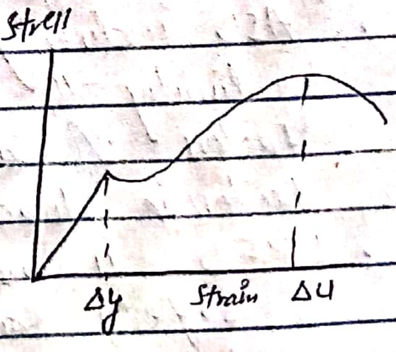
$$\phi R_n \geq \eta \Sigma \gamma Q_i$$

R_n = Resistance or strength of the component being designed.
Q_i = Effect of Applied loads
η = Takes into account ductility & redundancy
ϕ = Resistance Factor or strength Reduction Factor
γ = overload or load Factors

γ/ϕ = Factor of safety

The role of "η"

Ductility: it implies a large capacity for inelastic deformation without rupture



$u = \Delta u / \Delta y$

Redundancy: ① A simply supported beam is a determinate structure so it has no redundant actions.
② A Fixed beam is indeterminate by 2 degree so it has two redundant action.

merits & Demerits

- ASD combines Dead & live load & treats them in the same way.
- In LRFD different load Factors are assigned to Dead load & live loads which is appealing.
- Changes in the load Factors & resistance Factors are much easier to make in LRFD compared to changing the allowable stress in ASD
- LRFD is intrinsically appealing as it requires better understanding of behavior of the structure in its limit states
- Design approach similar to LRFD is being followed in Design of Concrete structures in Form of ultimate strength Design why not use similar approach design of steel structures.
- ASD indirectly incorporates the Factors of safety by limiting the stress whereas LRFD aims to specify Factors of safety directly by specifying Resistance Factors & load Factors.
- LRFD is more rational as different Factors of safety can be assigned to different loads such as Dead load, live loads, Earthquake & impact loads

Q02 Types of Bolted Connections

① **Slip-Critical Connection** :- The clamping Force applied to the bolt bring the two member close enough so that applicable Friction is produce b/w them which is responsible to resisting the load. The more the clamping Force more is to Friction and strong is the connection but the clamping Force should not exceed to the tensile Strength of the bolt.

② **Bearing type connection** : load is transferred by shearing and bearing on the bolt.

- Bearing type Connection is most widly used general type of Connection in which the load is resisted by the bolt body with out any friction b/w Faying Surface.

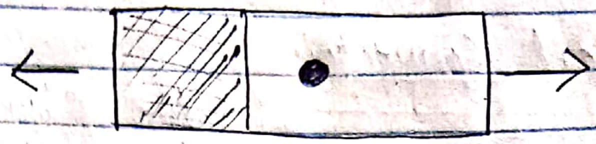
Type of connection Failures

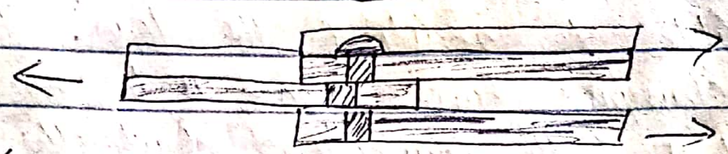
① Shearing Failure of Bolts.

② Bearing Failure of plate

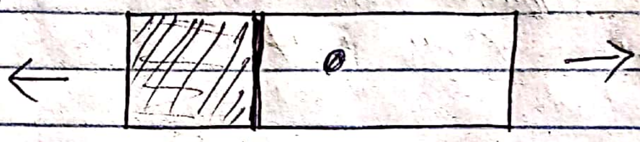
③ Tearing Failure at edge of plate

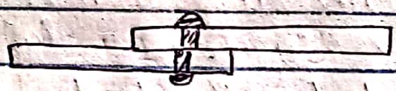
① Shearing Failure of Bolts.

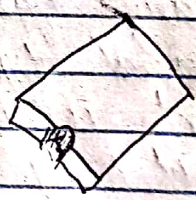




② Bearing Failure of plate







③ Tearing Failure

Bolt are stronger than plate.

Shearing Failure edge of plate

Transverse Tension Failure.

Q3

Given Data

Live load = 265 K
Dead load = 130 K
gussete plate = 1 inch
Standard of gp = $C_{10\times30}$
Bolts = A 325
dia of Bolts = 3/4"
no. of line of Bolts = 3

~~Required~~ Required: No of Bolt = ? , capacity using ASD = ?

Sol

Using ASD Method

① Design Force = 130 + 265 ∵ (live + Dead load)
= 395 K (Total servic load)

② Bolt Design = For 3/4" dia of bolt.

Nominal Area = A = $0.4418 in^2$
$f_v = 30 ksi$

$R_v = 0.4418 \times 30$

= 13.25 Kips / shear surface.

③ No. of Bolts

we know that there are two shear surface. so

$$\text{No. bolts} = \frac{395}{2 \times 13.25}$$

| No. of bolts = 11.25 ≅ (12) |

(4) Bearing

$$F_p = 1.2 f_u$$

From Table 2.9
A-325 = f_u = 58

$$F_p = 1.2 \times 58$$

$$\boxed{F_p = 69.6 \text{ ksi}}$$

Channel

$$R_p = d \times t \times F_p$$

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

$$\boxed{R_p = 35.13 \text{ Kips}}$$ For single surface of channel

For Bolts there are 24 bearing surface so

Capacity = 2×12 ×35.13
= 845 > 395 (OK)

Gusset plate

$$R_p = d \times t \times F_p$$

$$= \frac{3}{4} \times 1 \times 69.5$$

$$= 52.125$$ For single bearing surface

Capacity

= 1×12×52.125
= 625.5 Kips > 395 Kips (OK)

Spacing

end ~~space~~ distance sheared edge = $1\frac{1}{4}$ ~~d~~ (min in)

End distance = $1\frac{1}{2}d = 1\frac{1}{2}\left(\frac{3}{4}\right)$

$= 1.13 \leq 1\frac{1}{4}$ in (OK)

center to center space

$3d = 3(0.75)$

$= 2.25in \leq 1\frac{1}{4}$ (Ok)

Shearing

$Le = 1\frac{1}{4}$

$L = 2$

Channel

$$Le = \frac{2P}{f_u T}$$

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

$$\boxed{P = 24.4 \text{ Kips}}$$

$$L = \frac{2P}{f_u T} + \frac{d}{2}$$

$$2 = \frac{2P}{58 \times 0.673} + \frac{0.75}{2}$$

$$\boxed{P = 31.7 \text{ Kips}}$$

Capacity

$= 2((3 \times 24.4) + (9 \times 31.71))$

$= 717.18K > 395$ (OK)

gusset plate

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

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

$P = 36.25$ Kips

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

$2 = \frac{2P}{58 \times 1} + \frac{0.75}{2}$

$P = 47.13$ Kips

capacity

~~$= (3 \times 36.25) + \ldots$~~

$= (3 \times 36.25) + (9 \times 47.13)$

$= 532.92$ Kips > 395 Kips

X ———— X