USN										

Sub:	Design of steel structures					Sub Code:	15CV62
Date:	12/03/2018	Duration:	90 min's	Max Marks:	50	Sem / Sec:	

Answer any TWO FULL Questions

Note: Use of IS 800:2007 is permitted and Assume missing data.

1 (a) What are the advantages and disadvantage of using steel structures?

→ Advantages of Steel Structure:

1. High strength resulting in reduction of dead wgt.
2. Gas & water tightness due to high density.
3. Assured, Quality, reliability & durability.
4. Ease of fabrication and erection.
5. Ease of strengthening the existing structure.
6. Ease of dismantling and reuse of materials.
7. Easy inspection of maintanance.

→ Disadvantage of Steel Structures:

1. Steel structure have relatively higher coast of construction in compared to RCC structure.
2. Steel is susceptible to corrosion & hence requires painting @ Regular interval.
3. It losses its strength @ High temperature.

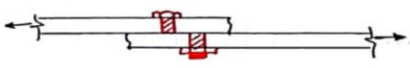
2 (a) Explain the various modes of failure of bolted connection with neat sketch.

Behaviour of Bolted joints.

Loads are transferred from one member to another by means of connection between them.

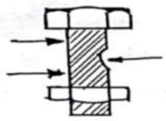
The possible 'limit states' or failure modes that may control the strength of bolted connection in Fig. Thus any joint may fail in any one of the following.

- Shear failure of bolt.
- Shear failure of plate.
- Bearing failure of bolt.
- Bearing failure of plate
- Tensile failure of bolt.
- Tensile failure of plate.

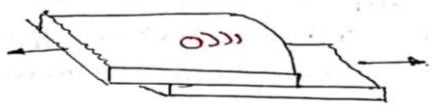


Shear failure of bolt

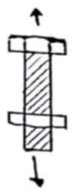
Shear failure of plates.



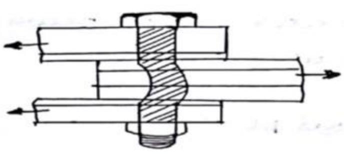
Bearing failure of bolt.



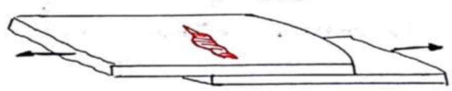
Bearing failure of plate



Tensile failure of bolt.

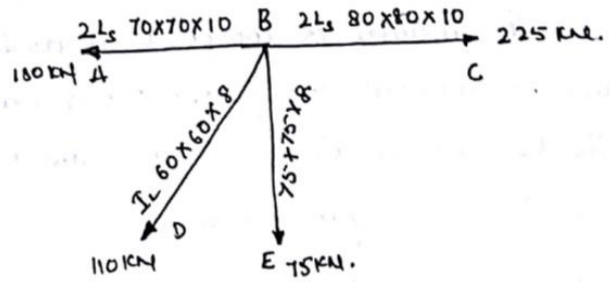


Bending failure of bolts.



Tensile failure of plate

(b) Design joint B of a roof truss as shown in Fig. the members are connected with 16mm dia, bolt of grade 4.6 to the gusset plate of 12mm thick.



$f_u = 410$ Mpa.

$f_{ub} = 400$ Mpa.

$A_{nb} = 0.78 \times \pi/4 \times 16^2 = 157\ mm^2$

$d_o = 16+2 = 18mm$

$\gamma_{mb} = 1.25$

* Strength of bolt in single shear.

$$V_{dsb} = \frac{\frac{f_{ub}}{\sqrt{3}}(n_n A_{nb} + n_s A_{ns})}{\gamma_{mb}} = \frac{\frac{400}{\sqrt{3}}(1 \times 157)}{1.25} = 29.0\ KN.$$

$\therefore$ Strength of bolt in double shear = $29.0 \times 2 = 58.0$ KN.

* Strength of bolt in bearing

$$V_{dpb} = \frac{2.5 k_b d t f_u}{\gamma_{mb}} = \qquad \therefore K_b = 0.67$$

i.e K_b is least of $\frac{e}{3d_o}$, $\frac{p}{3d_o} - 0.25$, $\frac{f_{ub}}{f_u}$, 1

$\therefore$ Assuming $e = 40mm$, $p = 50mm$

$\therefore$ $\frac{40}{3 \times 18}$, $\frac{50}{3 \times 18} - 0.25$, $\frac{400}{410}$, 1

Strength of 16mm dia bolt in bearing

(i) $t = 6mm$; $V_{dpb} = \frac{2.5 \times 0.67 \times 16 \times 6 \times 410}{1.25} = 52.74$ KN.

(ii) $t = 8mm$, $V_{dpb} = \frac{2.5 \times 0.67 \times 16 \times 8 \times 410}{1.25} = 70.32$ KN

(iii) $t = 12mm$, $V_{dpb} = \frac{2.5 \times 0.67 \times 16 \times 12 \times 410}{1.25} = 105.48$ KN.

Member AB: Factored force = 180 KN.

The member is composed of double angle section JSA 70 X 70 X 10mm and is connected to opposite sides of a 12mm thick gusset plate.
The bolt will be double shear and bear against 12mm thick (least of 12mm & 2x10mm) gusset plate.

∴ Strength of bolt will be least of 58.0 KN & 105.48 KN.

i.e 58.0 KN.

∴ No. of ~~plate~~ bolt $= \frac{180}{58.0} = 3.10 \simeq 4$ no.

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Member. BC (2-legged - 80x80x10) connected to 12mm thick gusset plate

∴ t = least of (12mm & 2X10) = 12mm.

Strength in bolt = least of 58.0 KN & 105.48 KN.

i.e [illegible]

No. bolt $= \frac{225}{58.0} = 3.86 \simeq 4$ no.

Illy **Member BD** (I_L 60X60X6) — Connected with 12mm thick plate.

The bolts will be bearing against 6mm thick plate (angle leg).

(least of 6mm and 12mm) i.e 6mm

∴ t = 6mm &

Strength of bolt will be least of [illegible] 29 KN (Since single shear)

& 57.74 KN. i.e 29 KN

No. of bolt $= \frac{110}{29} = 3.79 \simeq 4$ no.

Member BE (I_L 75 X 75 X 8) — connected with 12mm thick gusset plate.

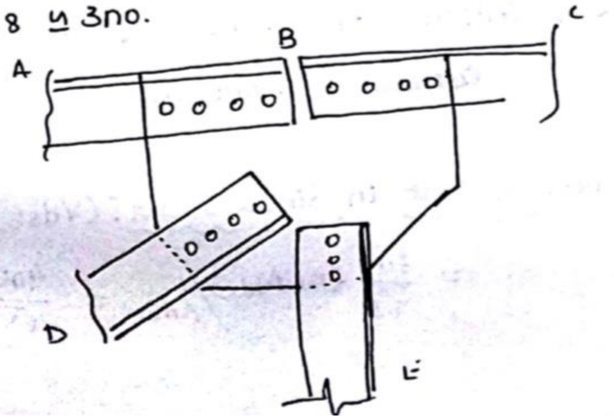
The bolt is in bearing against 8mm thick plate (angle leg)

t will be least of (8mm & 12mm) i,e. t = 8mm.

& strength of bolt = least of 29KN & 70.32

i,e 29KN.

∴ No. of bolt = $\frac{75}{29}$ = 2.58 ≅ 3no.



3 Explain the Design basis of limit state design.
(a)

Design philosophy:

There are three design philosophies for the design of steel structures. Elastic or working stress method
Plastic or ultimate load method
Limit state method

The basic design difference between the three design philosophies is the manner in which safety is considered in the design and the confidence level enjoyed by the designer.

In working stress method of design, the factors of safety used are purely based on engineering judgment.

In ultimate load method of design, load factor is used by which a set of loads acting on the structure must be multiplied so just cause structural or component failure, no safety factor is applied to ~~both load and strength~~ materials.

Limit state design approach makes use of partial safety factor applied to both loads and strength. usually these are specified by codes.

Limit State Method:

This is developed to take account of all condition that can make the structure unfit for use, considering actual behaviour of material and structures. The design values, both for materials strength and for loads, are derived from characteristic values through the use of partial safety factor.

The section designed should also satisfy the serviceability requirements, such as limitation of deflection and vibration. and should not collapse under accidental load such as from explosions or impact load to an extent not expected to occur.

(b) Design a bracket connection to transfer an end reaction of 225kN due to factored load as shown in fig 3.b. The end reaction from the girder acts at an eccentricity of 300mm from the face of column flange. Design bolted joint connecting the Tee- flange with column flange steel of grade Fe 410 and bolt of grade 4.6

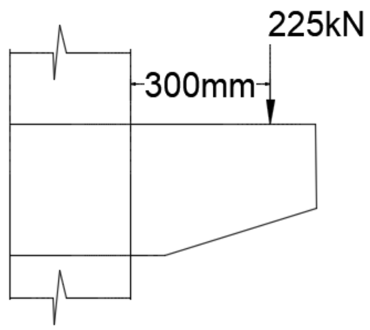


Fig. 3.b

Sol^n: For Fe 410 grade of steel : $f_u = 410$ Mpa.
For bolt of grade 4.6 $f_{ub} = 400$ Mpa.
$\gamma_{mb} = 1.25$

(i) Shear due to load, P = 225 KN. passing through C.G of joint.

(ii) Tension due to bending Moment = $M = P \times e = 225 \times 300 = 67,500$ kN-mm

Assume bolt of dia 24mm.

$\therefore A_{nb} = 0.78 \times \pi/4 \times 24^2 = 353\ mm^2$

$p = 65mm$.

$e = 40mm$.

(i) Shear Strength

$$V_{dsb} = \frac{\frac{f_u}{\sqrt{3}}(n_n A_{nb})}{1.25} = \frac{\frac{400}{\sqrt{3}}(1 \times 353)}{1.25}$$

$V_{dsb} = 65.22$ KN

• Strength of bolt in tension.

$T_{nb} = 0.9 f_{ub} A_{nb}/\gamma_{mo} \ngtr f_{yb} \frac{\gamma_{mb}}{\gamma_{mo}} A_{sb}/\gamma_{mb}$

$= 0.9 \times 400 \times 353 \ngtr 240 \times \frac{1.25}{1.10} \times \pi/4 \times 24^2$

$= 127$ KN. $\ngtr 123.27$.

Hence Consider $\frac{123.27}{1.25} = 98.61$ KN.

$\therefore$ No. of bolts in one vertical row $= \sqrt{\frac{6M}{n p R}} = \sqrt{\frac{6 \times 67,500}{2 \times 65 \times 65.22}} \simeq 6.91 \simeq 7$ no.

∴ Total ht of bracket plate = h = (6×65) + 2×40
= 470mm.

When h = 470-40
= 430mm

N-A. is @ h/7 from bottom of bracket. i.e $\frac{430}{7}$ = 61.42 mm.

$\Sigma y_i = 2[(65+40-61.42) + (130+40-61.42) + (195+40-61.42) + (260+40-61.42) + (325+40-61.42) + (390+40-61.42)]$

Σy_i = 2472.96mm

lly Σy_i^2 = 657,502.6 mm²

moment resisted by bolt.

$M' = \frac{M}{1 + \frac{2h}{21} \cdot \frac{\Sigma y_i}{\Sigma y_i^2}} = \frac{67.5 \times 10^3}{1 + \frac{2\times430}{21} \times \frac{2472.96}{657,502.6}} = 58.496 \times 10^{3} \text{ KN-m}.$

Tensile force in critical bolt. (y_n = 368.58mm)

$T_b = \frac{M' y_n}{\Sigma y_i^2} = \frac{58.496\times10^3 \times 368.58}{657502} = 32.79 \text{ KN}.$

Shear force in critical bolt.

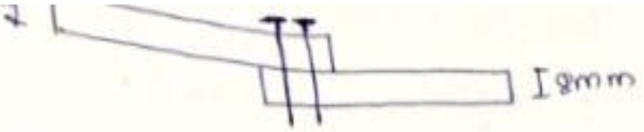
$V_{sb} = \frac{P}{\text{no. of bolt}} = \frac{225}{2\times7} = 16.07 \text{ KN}.$

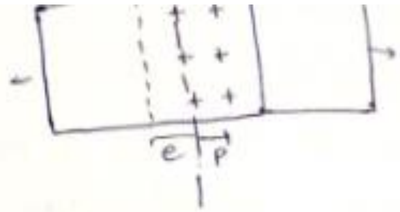
Check $\left(\frac{V_{sb}}{V_{dsb}}\right)^2 + \left(\frac{T_b}{T_{db}}\right)^2 \le 1.0$

$\left(\frac{16.07}{65.22}\right)^2 + \left(\frac{32.79}{98.61}\right)^2$.

$0.1712 \le 1.0.$

1 (b) Two flats (Fe 410 grade steel), each 210mm8mm, are to be jointed using 20mm dia, 4.6 grade bolts, to form a lap joint is supposed to transfer a factored load of 250kN. Design the joint and determine suitable pitch for bolts.





Given :

$d = 20mm$

$d_0 = 20+2 = 22mm.$

$f_{ub} = 400MPa$

$f_u = 410 MPa$ (assumed).

load $= 250 kN$

$p = ?$

$t = 8mm.$

i) Design shear strength of bolt.

$$V_{dsb} = \frac{V_{nsb}}{\gamma_{mb}} \quad (\text{Pg. 75, Cl 10.3.3, IS 800:2007})$$

$$V_{nsb} = \frac{f_{ub}}{\sqrt{3}}\left(n_n A_{nb} + n_s A_{sb}\right)$$

$n_s = 0$

$n_n = 1$ ($\because$ single shear)

$$= \frac{400}{\sqrt{3}}\left(1 \times 0.78 \times \frac{\pi}{4} \times 20^2\right)$$

$$= 56590.54 \text{ N.}$$

$$V_{dsb} = \frac{56590.54}{1.25} = 45.272 \text{ kN}$$

) Design bearing strength of bolt @ joint

$= \frac{0.9 f_{ub} A_n}{\gamma_{mb}}$

$= 0.9/(\ldots$

$V_{dpb} = \frac{V_{npb}}{\gamma_{mb}} = \frac{2.5 K_b d t f_u}{1.25}$ (Pg. 75, Cl. 10.3.4, IS 800:2007)

$K_b = \frac{e}{3d_0}, \frac{P}{3d_0} - 0.25, \frac{f_{ub}}{f_u}, 1.0.$

$= \frac{1.7 d_0}{3d_0}, \frac{2.5d}{3d_0} - 0.25, \frac{f_{ub}}{f_u}, 1.0$

$= \frac{1.7 \times 22}{3 \times 22}, \frac{2.5 \times 20}{3 \times 22} - 0.25, \frac{400}{410}, 1$

$0.56, 0.5, 0.97, 1$

$\therefore K_b = 0.5$

$\therefore V_{dpb} = \frac{2.5 \times 0.5 \times 20 \times 8 \times 410}{1.25} = 65.600$ kN

$\therefore$ No. of bolts $= \frac{\text{load}}{\text{design strength}} = \frac{250}{45.272} = 5.5 \approx$ 6 no.s

No. of bolts = 6 no.s

iii) Design strength of bolt @ joint.

$$T_b = \frac{0.9 f_{ub} A_n}{\gamma_{mb}}$$ (Pg. 76, cl 10.3.5, IS 800:2007)

$$= \frac{0.9 (p - 3d_0) \times \frac{\pi}{4} \times 20^2 \times 0.78 \times t}{1.25}$$ ($d_0 \to 22$)

$$250 = \frac{0.9 (p - 3 \times 22) \times \pi/4 \times 20^2 \times 0.78 \times 8}{1.25}$$

$$p = 66.17 \approx 70 mm$$

∴ Pitch for bolts is 70 mm.