Model Set Questions with Answers

MODEL - 1

(CET - 602)

Full Marks : 70 **Time : 3 Hours**

Answer any **five** questions.

The figures in the right-hand margin indicate marks.

1. (a) State the basic difference between slab base and gusseted base. [2
   (b) A timber column 200 × 200 mm section having an unsupported length of 3.5 m. Find the safe axial load for the column assuming it to be sal wood. [5
   (c) A RCC column 500 × 500 mm in section, carries an axial load of 600 kN. Design an isolated footing of uniform thickness for the column. The safe beariing capacity of soil is 120 kN/m². Use M15 concrete and mild steel. [7
2. (a) What is the recommended throrat thickness for incomplete penertration butt welds welded from one side only ? [2
   (b) Calculate the maximum tensile load that can be taken by an ISA 125 mm × 75 mm × 10 mm connected through longer leg by fillet welding. [5
   (c) Design a slab base for a column consisting of ISHB 300 @ 0.577 kN/m and carrying at axial load of 1400 kN. The column is to be supported on a concrete footing with permissible bearing pressure of 4.0 N/mm². The safe bearing capacity of soil is 250 kN/m². [7
3. (a) What is the objective of providing tack rivets in steel structural members ? [2
   (b) A double angle discontinuous struct consist of two angles ISA 80 × 80 × 6 mm and connected by both sides of gusset plate 10 mm thick by two rivets. The length of the strut between centre to centre intersections is 2.8 m and is track rivetted. Calculate the compressive load carrying capacity of the strut for steel of grade f_y = 250 N/mm². [5
   (c) A timber beam having a clear span of 6.0 m carries a uniformly distributed load of 15 kN/m including the self weight of beam. Assuming the beam to be made of Deodar wood, design the beam. [7
4. (a) Define and state the significance of slenderness ratio. [2
   (b) Calculate the pitch for a double rivetted double cover butt joint. The pitch of rivet of inner row is half the pitch of rivet in the outer row and the thickness of the plates is 12 mm. Thickness of each cover plate is 8 mm. [5
   (c) Design an unequal angle section to act as a tie member 1.60 m long in a roof truss if it is to carry an axial load of 130kN. Use hand driven rivets at joints. [7
5. (a) Why tubular steel section is preferred as compression member in place of rolled steel section ? [2
   (b) Design an unequal angle section to act as a tie member 1.6 m long in a roof truss if it is to carry an axial load of 120 kN. Use power driven shop rivet at joints. Show detail diagram of the joint. [5
   (c) A straight stair in a residential building is supported on wall on one side and stringer beam on the other side. The risers are 150 mm and treads are 250 mm and the horizontal span of the stair may be taken as 1.2 m. Design the steps. Use M20 concrete and HYSD bar. Also show reinforcement detailing. Use LSM. [7
6. (a) What is the minimum edge distance for rivetted joint and why it is provided ? [2
   (b) Design a lap joint for connecting two flats of size 150 × 8 mm and 150 × 12 mm. [5
   (c) A strut of roof truss carries an axial compression load of 180 kN> Design a suitable double angle section for the compression member. The length of strut between centre to centre of intersection is 2.35 m and the yield stress of steel is 250 MPa. [7
7. (a) Enumerate the four type of rivets. [2
   (b) Briefly discuss different ways of failure of rivetted joint with diagram. [5
   (c) Design a lap joint for two plates of size 100mm × 8 mm and 100mm × 12mm. the permissible stresses for plates in tension and weld are 160 MPa and 110 MPa respectively. [7

MODEL - 1 (ANSWER)

1.(a) State the basic difference between slab base and gusseted base.

Ans. Incase of slab base the column end is machined to rest are a steel base plate. Sufficient fastenings are provided to retain the column securely on the base plate and resist all moments and forces arising during tranist, unloading and erection.

Gusseted base consists of a base plate connected to the column through gusset plates. The thickness of the base plate in this case will be less than the thickness of the slab base for the same axial load as the bearing area of the column on base plate increases by the gusset plates.

(b) A timber column 200 × 200 mm section having an unsupported length of 3.5 m. Find the safe axial load for the column assuming it to be sal wood.

Ans. Unsupported length of the column = 3.5 m.

d = (least lateral dimension) = 200 mm.

$$\frac{L}{d} = \frac{3500}{200} = 17.5$$

$$k = 0.702\sqrt{\frac{E}{f_c}}$$

$E = 12.7 \times 10^3$ N/mm² (for sal wood)

$f_c = 9.4$ N/mm².

$$k = 0.702\sqrt{\frac{12.7\times10^3}{9.4}} = 25.8$$

$$\frac{\rho}{d} < k$$

So this is a long column.

Safe stress

$$= \frac{0.329E}{(L/d)^2} = \frac{0.329\times12.7\times10^3}{(17.5)^2} = 13.64$$

∴ Safe load carrying capacity = safe stress × area

= 13.64 × 200 × 200

= 545737.14 N = 545.73 kN.

(c) A RCC column 500 × 500 mm in section, carries an axial load of 600 kN. Design an isolated footing of uniform thickness for the column. The safe beariing capacity of soil is 120 kN/m². Use M15 concrete and mild steel.

Ans. Column side = 500 mm × 500 mm

Load = 600 kN.

Foundation load = (10% of column load) = 60 kN.

Total load = 600 + 60 = 660 kN.

S.B.C = 120 kN/m²

f_{ck} = 15 N/ mm²

f_y = 250 N/mm²

Ultimate load = 1.5 × 660 = 990 kN.

$$A_{required} = \frac{\text{ultimate load}}{\text{S.B.C}} = \frac{990}{120} = 8.25\ m^2$$

Let B = 3m, L = 3m

$A_{Provided}$ = 3 × 3 = 9m²

Upward pressure =

$$\frac{\text{Column load}}{\text{Area provided}} = \frac{1.5\times600}{9} = 100\ kN/m^2 < SBC$$

Bending moment Calculation

$$M_{xx} = M_{yy} = q\times B\times\frac{(B-b)^2}{8}$$

$$= 100\times3\times\frac{(3-0.5)^2}{8} = 234.375\ kNm.$$

Depth Calculation

$$M_{lim} = 0.36\ f_{ck}\frac{x_{man}}{d}\left[1-0.42\frac{x_{um}}{d}\right]bd^2$$

⇒ 234.375 × 10⁶ = 0.36 × 15 × 0.46 [1 – (0.42 × 0.46)] × 3000 d².

⇒ d = 197.44 m = 300 mm.

D = d + clear cover = 300 + 50 = 350 mm.

Steel Calculation

$A_{stx} = A_{sty}$

$$\frac{M_u}{bd^2} = \frac{237.375\times10^6}{3000\times(300)^2} = 0.86$$

Pt = 0.450

$$A_{st} = \frac{0.450}{100}\times3000\times300 = 4050\ mm^2$$

Provide 20 mm of 13 nos.

So $A_{Provide}$ = 4084 mm²

Check for one-way shear.

Critical section 'd' from the face of the column

$$i_v \le ki_c$$

$$iv = \frac{V_u}{bd}$$

$$V_u = q \times L \times \left(\frac{L-l}{2} - d\right)$$

$$= 100 \times 3 \times \left(\frac{3-0.5}{2} - 0.3\right) = 285 \text{ kN.}$$

$$i_v = \frac{V_u}{bd} = \frac{285 \times 10^3}{3000 \times 300} = 0.31$$

here k = 1.

$P_t = 0.450$

$i_c = 0.36$ N/mm²

$ki_c = 1 \times 0.36 = 0.36$ N/mm²

$i_v < ki_c$, It is satisfy

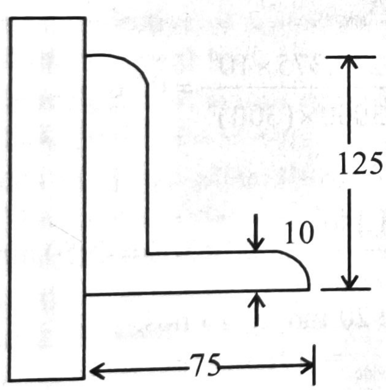
2.(a) What is the recommended throrat thickness for incomplete penertration butt welds welded from one side only ?

Ans. The perctration of the weld metal is generally incomplete and the effective throat thickness is taken as $\left(\frac{5}{8}\right)$ × thickness of thinner part connected. The change in thickness while joining unequally thick plates should be gradual. A tapper not exceeding 1 in 5 is provided when the difference in thickness of parts exceeds 25% of the thickness of the thinnerpart or 3 mm, whichever is greater.

(b) Calculate the maximum tensile load that can be taken by an ISA 125 mm × 75 mm × 10 mm connected through longer leg by fillet welding.

Ans. ISA mm × 75 mm × 10 mm connected through longer by

S = size of weld = 6 mm



$$A_1 = \left(L_2 - \frac{t}{2}\right) \times t$$

$$= \left(125 - \frac{6}{2}\right) \times 6 = 732 \text{ mm}^2$$

$$A_2 = \left(L_1 - \frac{t}{2}\right) \times t = \left(75 - \frac{6}{2}\right) \times 6 = 432 \text{ mm}^2$$

$$k = \frac{3A_1}{3A_1 + A_2} = \frac{3 \times 732}{3 \times 732 + 432} = 0.83$$

$A_{eff} = A_1 + A_2k = 732 + (432 \times 0.83) = 1090.56$ mm².

Assume $f_y = 250$ N/mm²

$\delta_{at} = 0.6 \times f_y = 0.6 \times 250 = 150$ N/mm².

Tensile load $= \delta_{at} \times A_{eff} = 150 \times 1090.56 = 163.58$ kN.

(c) Design a slab base for a column consisting of ISHB 300 @ 0.577 kN/m and carrying at axial load of 1400 kN. The column is to be supported on a concrete footing with permissible bearing pressure of 4.0 N/mm². The safe bearing capacity of soil is 250 kN/m².

Ans. Column section = ISHB 300 @ 577 kN/m.

Axial load = 1400 kN.

Allowable pressure in concrete (δ_e) = 4 N/mm²

Bending stress (δ_b) = 185 kN/m².

$$A_{req} = \frac{\text{Load}}{\delta_c} = \frac{1400 \times 10^3}{4} = 35 \times 10^4 \text{ mm}^2$$

Let $L_B = 700$ mm

$B_B = 550$ mm

$A_{Pro} = 700 \times 550 = 385 \times 10^3$ mm²

$$\text{Upward pressure} = \frac{\text{Load}}{\text{Aprovided}}$$

$$= \frac{1400 \times 10^3}{700 \times 550} = 3.6 \text{ N/mm}^2 < 4 \text{ N/mm}^2$$

Thickness of base plate

$$T_B = \sqrt{\frac{3w}{\delta_{bs}}\left(a^2 - \frac{b^2}{4}\right)}$$

$$a = \frac{L_B - Df}{2} = \frac{700 - 300}{2} = 200 \text{ mm}$$

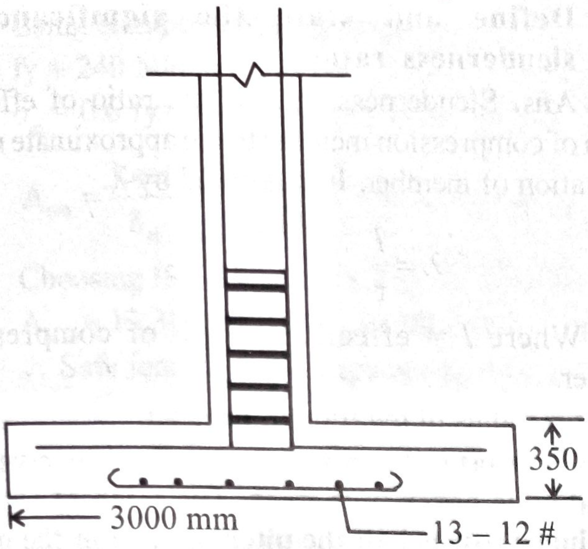
$$b = \frac{B_B - Df}{2} = \frac{550 - 300}{2} = 125 \text{ mm}$$

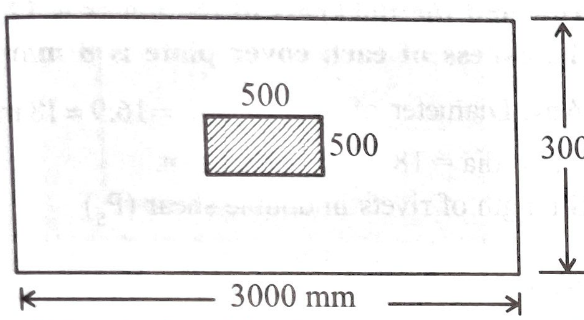
$$\therefore T_B = \sqrt{\frac{3\times3.6}{185}\times\left(200^2 - \frac{125^2}{4}\right)} = 45.9 \text{ mm}$$

∴ Size of base plate = 700 mm × 550 mm

Thickness of the base plate = 46 mm ≃ 50 mm.

Use 150 × 150 × 8 mm cleat angle.





3.(a) What is the objective of providing tack rivets in steel structural members ?

Ans. A compression member composed of two angles channels or tees back to back in contact or separate by a small distance should be connected together by riveting. Thus type rivet is called tack rivets.

(b) A double angle discontinuous struct consist of two angles ISA 80 × 80 × 6 mm and connected by both sides of gusset plate 10 mm thick by two rivets. The length of the strut between centre to centre intersections is 2.8 m and is track rivetted. Calculate the compressive load carrying capacity of the strut for steel of grade f_y = 250 N/mm².

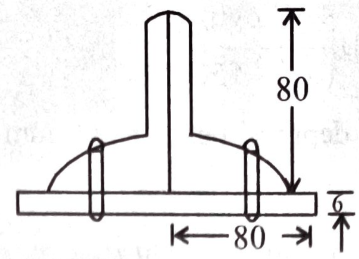
Ans. ISA = 80 × 80 × 6 section used.

The unsupported length of strut = 2.8 m.

Leff = L = 2.8 m.

A_{avail} = 8.66 × 10²mm²

$$r_{min} = \sqrt{\frac{I_{min}}{A}}$$



$$I_{xx} = 2 \times (I_0) = 2 \times 45.7 = 91.4$$

$$I_{yy} = 2\,[I_{xx} + A \times h^2]$$

$$= 2 \times [45.7 + (8.68 \times 2.06^2)] = 165.06 \text{ cm}^4.$$

$$r_{xx} = \sqrt{\frac{I_{xy}}{A}} = \sqrt{\frac{91.4}{8.66}} = 3.240 \text{ cm.}$$

$$r_{yy} = \sqrt{\frac{I_{yy}}{A}} = \sqrt{\frac{165.06}{8.66}} = 4.36 \text{ cm.}$$

$$r_{min} = r_{xy} = 3.24 \text{ cm.}$$

$$\lambda = \frac{L_{eff}}{r_{min}} = \frac{2.8\times10^3}{3.24\times10} = 86.4$$

$f_y \rightarrow$ 250 N/mm²

$\lambda \downarrow$ 70 → 112

80 → 101

$$\delta_{ac} = \left\{112 - \left(\frac{112-101}{80-70}\right)\times(86.4-70)\right\}$$

= 93.96 N/mm²

∴ δ_{ac} = 93.96 N/mm².

∴ $(P_{safe}) = \delta_{ac} \times A = 93.96 \times 8.66 \times 10^2 \times 10^{-3}$

= 81.37 kN.

(c) A timber beam having a clear span of 6.0 m carries a uniformly distributed load of 15 kN/m including the self weight of beam. Assuming the beam to be made of Deodar wood, design the beam.

Ans. Clear span = 6m.

Assume width of the bearing at eachend = 300 mm.

$$\text{Effective span of beam} = 6 + \frac{0.3}{2} + \frac{0.3}{2} = 6.3 \text{ m}$$

Bending moment

$$M = \frac{wl^2}{8}, \; w = 15 \text{ kN/m}$$

$$= \frac{15\times(6.3)^2}{8} = 74.42 \text{ kNm.}$$

$\left(400^2 + 55000\right)$

n allowable bending stress

$\times 10.2 = 9.587$ N/mm².

$$\frac{.42\times10^6}{5.584} = 1332.73\times10^4 \text{ mm}^3$$

$$\text{beam} = b = \frac{1}{50}\times 6.3\times10^3 = 126 \text{ mm}$$

$b = 250$ mm

$d = 400$ mm.

or shear

$$\left(\frac{}{2} - D\right) = 15\times\left(\frac{6.3}{2} - 0.4\right) = 41.25 \text{ kN}$$

$$\frac{5V}{bd} = \frac{1.5\times41.25\times10^3}{250\times400} = 0.62 \text{ N/mm}^2$$

ble shear stress = 0.9 N/mm²

rmissible shear stress.

or deflection

$$\frac{5}{384}\frac{wl^4}{EL}$$

$\times\ 10^3$ N/mm²

$$= \frac{250\times400^3}{12} = 1333\times10^6 \text{ mm}$$

$$\frac{5}{384}\times\left\{\frac{15\times(6300)^4}{9.5\times10^3\times1333\times10^6}\right\} = 24.3 \text{ mm}$$

$$\text{e deflection} = \frac{6300}{250} = 25.2 \text{ mm}$$

owable defelction hence ok.

or bearing

$$\text{at support} = \frac{wl}{2} = \frac{15\times6.3}{2} = 47.25 \text{ kN.}$$

ress at support

$$\frac{10^3}{400} = 0.47 \text{ N/mm}^2$$

4.(a) Define and state the significance of slenderness ratio.

Ans. Slenderness ratio is the ratio of effective length of compression member to the approximate radius of gyration of member. It is denoted by λ.

$$\lambda = \frac{l}{r}$$

Where l = effective length of compression member.

r = radius of gyration of member.

(b) Calculate the pitch for a double rivetted double cover butt joint. The pitch of rivet of inner row is half the pitch of rivet in the outer row and the thickness of the plates is 12 mm. Thickness of each cover plate is 8 mm.

Ans. Diameter of rivet = $6\sqrt{8} = 16.9 \simeq 18$ mm

Gross dia = 18 + 1.5 = 19.5 mm.

Strength of rivets in double shear (P_s)

$$= 2\times\frac{\pi}{4}\times(19.5)^2\times\frac{100}{1000} = 59.73 \text{ kN.}$$

Strength of rivet in bearing (P_b)

$$= 19.5\times8\times\frac{300}{1000} = 46.8 \text{ kN}$$

Strength of plate in tension (P_t) = 0.6 × 260 = 156 N/mm².

$\therefore$ rivet value = 46.8 kN.

Gauge distance of rivet

Let g be the gauge of rivets

Strength of plate per gauge lengths

$$Pl = (g - 19.5)\times 8\times\frac{156}{1000}$$

= 1.248 (g – 19.5) kN.

Keeping strength of plate $P_t = P_s$ or P_b which is less.

$\Rightarrow$ 1.248 (g – 19.5) = 46.8

$$g = \frac{46.8}{1.248} + 19.5 = 57 \text{ mm}$$

$\therefore$ Adopt gauge = 60 mm.

(c) Design an unequal angle section to act as a tie member 1.60 m long in a roof truss if it is to carry an axial load of 130kN. Use hand driven rivets at joints.

Ans. Given :

Axial load = 130 kN

Using Hand driven shop rivet

$f_y = 240$ N/mm²

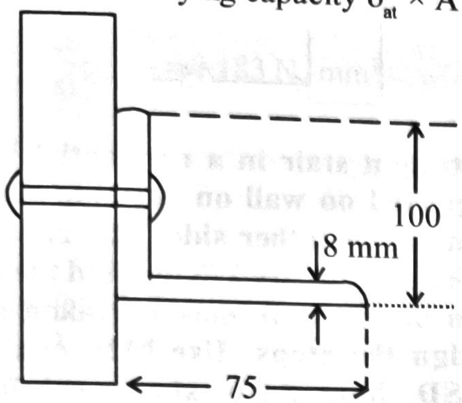
$\delta_{at} = 0.6\, f_y = 0.6 \times 240 = 144$ N/mm²

$$A_{req} = \frac{Load}{\delta_{at}} = \frac{130 \times 10^3}{144} = 902.77 mm^2$$

Choosing ISA 100 × 75 × 8 @ 10.5 kg/m

$A_{avail} = 13.36$ cm² $\geq A_{req}$ i,e 90.2 cm²

∴ Safe load carrying capacity $\delta_{at} \times A_{eff}$



$A_{eff} = A_1 + A_2 k$

$$A_1 = \left(L_2 - \frac{t}{2}\right) \times t - dt$$

$$A_2 = \left(L_1 - \frac{t}{2}\right) \times t$$

∴ Q = 20 mm

d = 20 + 1.5 = 21.2 mm

$$K = \frac{3A_1}{3A_1 + A_2}$$ Take gusset plate thickness = 8 mm

$L_1 = 75$ mm

$L_2 = 100$ mm

$$A_1 = \left\{\left(100 - \frac{8}{2}\right) \times 8\right\} - (215 \times 8) = 596 mm^2$$

$$A_2 = \left(75 - \frac{8}{2}\right) \times 8 = 568 mm^2$$

$$K = \frac{3 \times 596}{(3 \times 596) + 568} = 0.76$$

$A_{eff} = 596 + (568 \times 0.76) = 1027.68$ mm²

$P_{safe} = \delta_{at} \times A_{eff} = 144 \times 1027.68 \times 10^{-3} = 148$ kN

$P_{safe} > P_{given}$ (This section is satisfy).

Connection Design.

$$\text{No. of rivet} = \frac{Load}{\text{Strength of each rivet}}$$

Hand driven shop rivet

$\tau_{vf} = 80$ N/mm², $\delta_{pf} = 250$ N/mm²

Assume single rivet subjected to single shear.

Shearing stength of rivet sub to single shear

$$(F_s) = \tau_{vf} \times \left(\pi/4 \times d^2\right) \times n' \times n =$$

$$80 \times \left(\pi/4 \times 215^2\right) \times 1 \times 1 = 29.04 \times 10^3 N$$

Bearing strength of each rivet $(F_b) = \delta_{pf} \times d \times t \times n$

$= 250 \times 21.5 \times 8 \times 1 = 43 \times 10^3$ N

Strength of each rivet = Minimum of F_s or $F_b = 29.04 \times 10^3$N

$$\text{No. of rivet} = \frac{Load}{\text{Strength of each rivet}}$$

$$= \frac{130 \times 10^3}{29.04 \times 10^3}$$

5.(a) Why tubular steel section is preferred as compression member in place of rolled steel section ?

Ans. The round tabular section have as much as 40% less surface area than that of an equivalent rolled steel shape. Therefore, the cost of maintenance, cost of painting, fire proofing and other protective coatings reduce considerably. The moisture and dirt don't collect on the smooth external surface of the tubes. Therefore, the possibility of corrosion also reduces. The end of tubes are sealed as a result of this, the interior surface isn't subjected to corrosion. The interior surfaces don't need any protective treatment. The tabular sections have motorline resistance. The tube sections have a higher frequency vibrations under dynamic loading.

(b) Design an unequal angle section to act as a tie member 1.6 m long in a roof truss if it is to carry an axial load of 120 kN. Use power driven shop rivet at joints. Show detail diagram of the joint.

Ans. Axial load = 120 kN.

Using power driven shop rivet $f_y = 240$ N/mm².

$f_{at} = 0.6\, f_y = 0.6 \times 240 = 144$ N/mm².

$$A_{req} = \frac{\text{Load}}{\delta_{at}} = \frac{120\times10^3}{144} = 833.33\ \text{mm}^2$$

Choosing ISA 100 × 75 × 8 @ 10.5 kg/m.

$A_{avail} = 13.36\ \text{cm}^2 \geq A_{req}$ i.e. 83.3 cm²

∴ Safe load carrying capacity $\delta_{at} \times A_{eff}$

$$A_{eff} = A_1 + A_2 k$$

$$A_1 = \left(L_2 - \frac{t}{2}\right)\times t - dt$$

$$A_2 = \left(L_1 - \frac{t}{2}\right)\times t$$

d = 20 + 1.5 = 21.5 mm.

$k = \frac{3A_1}{3A_1 + A_2}$, Take gusset plate thickness = 8 mm.

$L_1 = 75$ mm

$L_2 = 100$ mm

$$A_1 = \left\{\left(100 - \frac{8}{2}\right)\times 8\right\} - (21.5\times 8) = 596\ \text{mm}^2$$

$$A_2 = \left(75 - \frac{8}{2}\right)\times 8 = 568\ \text{mm}^2$$

$$k = \frac{3\times 596}{(3\times 596)+568} = 0.76$$

$A_{eff} = 596 + (568 \times 0.76) = 1027.68\ \text{mm}^2$

$P_{safe} = \delta_{at} \times A_{eff} = 144 \times 1027.68 \times 10^{-3} = 148$ kW.

$P_{safe} > P_{given}$ (This section is satisfy)

Connection design

$$\text{No. of rivet} = \frac{\text{Load}}{\text{Strength of each rivet}}$$

Power driven shop rivet

$\delta_{vf} = 100\ \text{N/mm}^2,\ \delta_{pf} = 300\ \text{N/mm}^2$

Assuming single rivet subjected to single shear.

Shearing strength of rivet sub to single shear

$$(F_s) = \delta_{vf} \times \frac{\pi}{4} d^2 \times n' \times n$$

$$= 100 \times \frac{\pi}{4} \times (21.5)^2 \times 1 \times 1 = 36.3\times 10^3\ \text{N}$$

Bearing strength of each rivet $(F_b) = d_{Pf} \times d \times t \times$

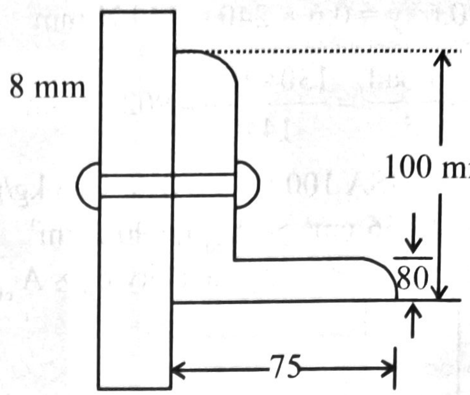
= 300 × 21.5 × 8 × 1 = 51.6 × 10³ N.

Strength of each rivet = minimumof F_s or F_b

= 36.3 × 10³ N.

$$\text{No. of rivet} = \frac{\text{Load}}{\text{strength of each rivet}} = \frac{120\times10^3}{36.3\times10^3}$$

= 3.3 ≃ 4 nos.



(c) A straight stair in a residential building is supported on wall on one side and stringer beam on the other side. The risers are 150 mm and treads are 250 mm and the horizontal span of the stair may be taken as 1.2 m. Design the steps. Use M20 concrete and HYSD bar. Also show reinforcement detailing. Use LSM.

Ans. Assume

Height of building = 3.5 m.

Width of each flight = 1.5 m.

Rise = 150 mm

Trade = 250 mm

Assume weight slab thichkness = 100 mm.

$$\text{No. of rise} = \frac{3500}{150} = 23.3 \simeq 24\ \text{nos.}$$

No. of trade = 24 – 1 = 23 nos.

Load Calculation

Self load = 0.1 × 25 = 2.5 kN/m²

Floor finish = 1 kN/m²

Live load = 4 kN/m².

Total load = 7.5 kN/m².

Ultimate load = 1.5 × 7.5 = 11.25 kN/m²

Effective span = 3150 + 100 = 3250 mm.

Consider 1 m length of slab

$$M = \frac{wl^2}{8} = \frac{11.25\times(3.25)^2}{8} = 14.86\ \text{kNm}.$$

Steel Calculation

$$\frac{M_u}{bd^2} = \frac{14.86\times10^6}{1000\times(100)^2} = 1.49$$

$P_t = 0.4736$

$$A_{st} = \frac{0.4736}{100}\times1000\times100 = 473.6\ mm^2$$

$$\text{Minimum steel} = \frac{0.12}{100}\times1000\times100 = 120\ mm^2$$

Provided 10 # 150 mm c/c = 524 mm².

Check for Shear

$$V_u = \frac{wl}{2} = \frac{11.25\times3.25}{2} = 18.28\ kN$$

$$i_v = \frac{18.28\times10^3}{1000\times100} = 0.183\ N/mm^2$$

$k = 1.3$

$P_t = 0.4736$

$i_c = 0.47\ N/mm^2$

$ki_c = 1.8 \times 0.47 = 0.61\ N/mm^2 > i_v$ hence ok.

Check for deflection

$P_t = 0.23$

$$\frac{Span}{d} = 20$$

Modification factor = 1.28

$$\text{Allowable } \frac{Span}{d} = 20\times1.28 = 25.6$$

$$\text{Actual } \frac{Span}{d} = \frac{3250}{150} = 21.67 < \text{Allowable} \frac{Span}{d}$$

hence ok.

Design of flight

Inclined lengthof waist slab (B)

$$= \sqrt{(250)^2+(150)^2} = 291.54\ mm$$

Wadst slab thickness = 170 mm.

$$\text{Load in plan} = \frac{291.54}{250}\times0.17\times.25 = 5.05\ kN/m^2$$

Floor finish = 1 kN/m²

$$\text{Weight of step} = \frac{150}{2000}\times25 = 2\ kN/m^2$$

Liv load = 4 kN/m².

Total load = 12.05 kN/m².

Ultimate load = 1.5 × 12.05 = 18.075 kN/m²

$R_A = R_B = 28.5$ kN.

$$M_u = (28.5\times1.775) - 11.25\times\frac{(11.775)^2}{2} = 32.86\ kNm$$

$$d_{req} = \sqrt{\frac{32.86\times10^6}{1000\times2.76}} = 109.4\ mm$$

$d_{pro} = 170$mm.

$$\frac{M_u}{bd^2} = \frac{32.86\times10^6}{1000\times(170)^2} = 1.15$$

$P_t = 0.343.$

$A_{st} = 583.1\ mm^2$

Provided 8 mm # 100 mm c/c

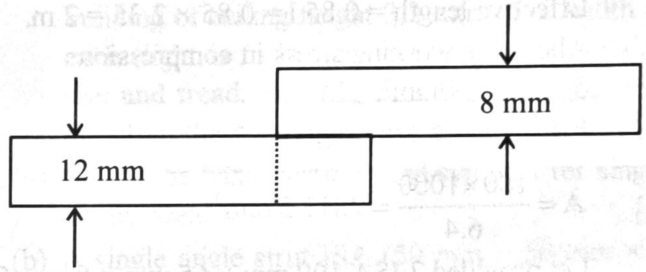
6.(a) What is the minimum edge distance for rivetted joint and why it is provided ?

Ans. Minimum edge distance is provided in rivet connection against failure of edge cracking.

Nominal dia of rivet (mm)	12	14	16	18	20	22	24
Min^m edge distance (mm)							
→ For rough edge	19	25	29	32	32	38	44
→ For planed edge	17	22	25	29	29	32	38

(b) Design a lap joint for connecting two flats of size 150 × 8 mm and 150 × 12 mm.

Ans. Assume site of the weld = 8 mm.



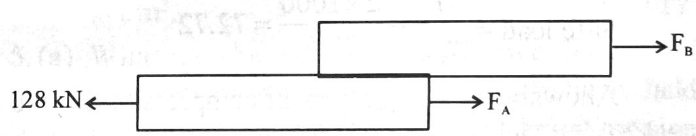
Let permissible stress in tension = 160 N/mm².

Permissible stress in weld = 110 N/mm²

Strength of the member = $\delta_{at} \times b \times t$

= 160 × 150 × 8 = 192 kN.

Strength of the weld = Stress in held × leff × throat thickness.



Lap length = 5 × thickness of thinner plate

= 5 × 8 = 40 mm.

$F_A + F_B = 128$

$\Rightarrow F_B = 128 - F_A$ .... (1)

$$\frac{F_A \times L}{AE} = \frac{F_B L}{AE}$$

$$\Rightarrow \frac{F_A \times 20}{150 \times 12} = \frac{F_B \times 40}{8 \times 150} = 0.03F_B$$

$\Rightarrow F_A = 2.7\ F_B$ .... (2)

$\Rightarrow F_A = 2.7\ (128 - F_A) = 345.6 - 2.7F_A$

$$\therefore F_A = \frac{345.6}{3.7} = 93.40 \text{ kN.}$$

$F_B = 2.7 \times 93.40 = 252.19$ kN.

For S_A : Strength of the weld = ...

$\Rightarrow 110 \times 150 \times 0.707S_A = 93.40 \times 10^3$

$S_A = 80.86$ mm $\simeq$ 81 mm.

For S_B : $110 \times 150 \times 0.707\ S_B = 252.19 \times 10^3$

$S_B = 21.61$ mm.

(c) A strut of roof truss carries an axial compression load of 180 kN> Design a suitable double angle section for the compression member. The length of strut between centre to centre of intersection is 2.35 m and the yield stress of steel is 250 MPa.

Ans. Assuming the strut is connected to both sides of gusset 10 mm thick by two or more than 2 rivets.

Length of strut = 2.35 m.

Effective length = 0.85 l = 0.85 × 2.35 = 2 m.

Allowable working stress in compression

$\delta_{ac} = 6.4$ N/mm².

Effective s/e area required

$$A = \frac{180 \times 1000}{6.4} = 2812.5 \text{ mm}^2$$

Let provided 2 ISA 100 mm × 65 mm × 8 mm @ 0.099 kN/m.

Sectionl area (A) = 2514 mm².

Radius of gyration $R_{yy} = 31.6$ mm.

$r_{gy} = 27.5$ mm.

Slenderness ratio $r_{min} = 27.5$ mm

$$\text{Safe load} = \frac{l}{r_{min}} = \frac{2 \times 1000}{27.5} = 72.72$$

Allowable working stress in compression for the steel having yield stress as 250 N/mm²

$\delta_{ac} = 61.48$ N/mm².

Safe load carrying capacity of the strut

$$P = \frac{61.48 \times 2514}{1000} = 154.50 \text{ kN.}$$

Hence design is ok.

Provide 2 ISA 100 mm × 65 mm × 8 mm for the strut.

7. (a) Enumerate the four type of rivets.

Ans. Types of rivets

→ Flat head rivet

→ Countersunk rivet

→ Snap head rivet

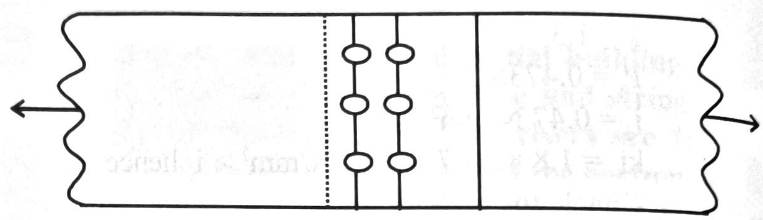
→ Pan head rivet

→ Mushroom head rivet

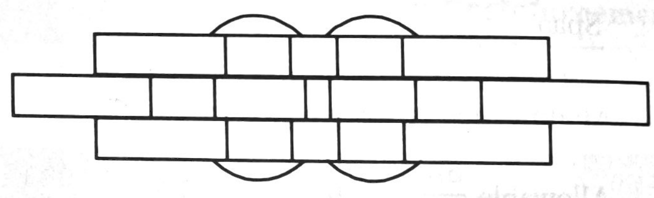
(b) Briefly discuss different ways of failure of rivetted joint with diagram.

Ans. Figure of rivetted joint

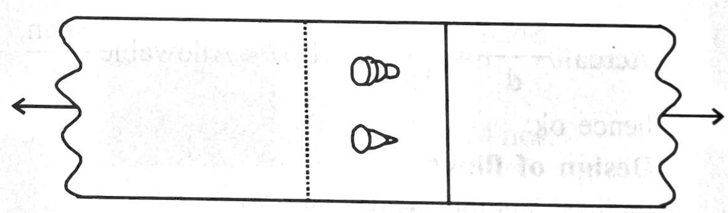
→ Tearing of the plate between rivet holes.



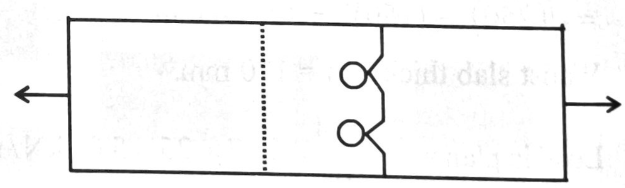
→ Shearing of rivet.



→ Bearing of plate or rivet.

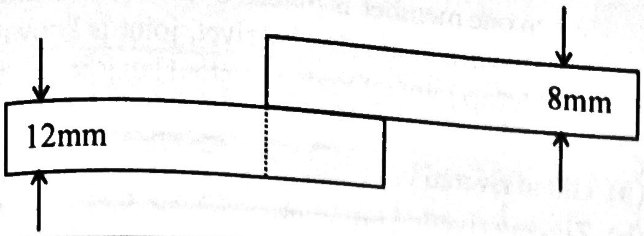


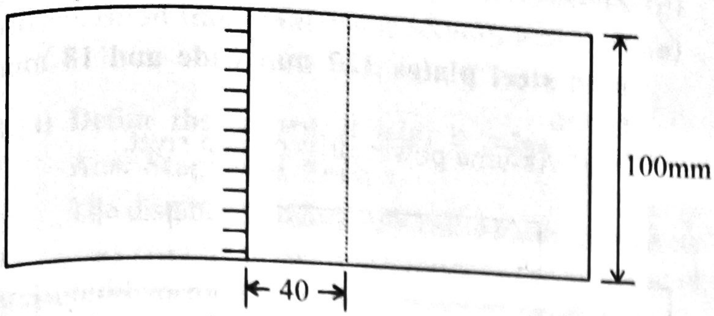
→ Edge cracking



(c) Design a lap joint for two plates of size 100mm × 8 mm and 100mm × 12mm. the permissible stresses for plates in tension and weld are 160 MPa and 110 MPa respectively.

Ans.





Assume size of the weld = 8 mm

Permissble stress in tension = 160 MPa = 160 N/mm²

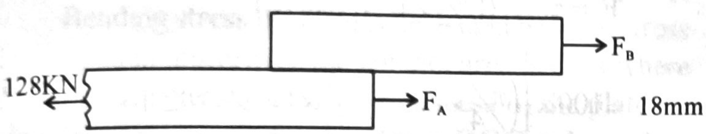
Permissble stress in weld = 110 MPa = 110N/mm²

Strength of the member

$= \delta_{at} \times b \times t = 160 \times 100 \times 8$

$= 128 \times 10^3$ N = 128 kN.

Strength of the weld = Stress in held × L_{eff} × throat thickness = 622.16 L_{eff}



Lap length = 5 × thickness of thinner plate

= 5 × 8 = 40 mm

$F_A + F_B = 128 \Rightarrow F_B = 128 - F_A$ ....(1)

$$\left(\frac{F_A \times L}{AE}\right)_A = \frac{F_b L}{AE}$$

$$\Rightarrow \frac{F_A \times 20}{12 \times 100} = \frac{F_B \times 40}{8 \times 100} = 0.05 F_B$$

$$\Rightarrow F_A = \frac{0.05}{0.034} F_B = 1.5 F_B \quad ....(2)$$

$\Rightarrow F_A = 1.5\,(128 - F_A) = 192 - 1.5\,F_A$

$\Rightarrow F_A = 76.8$kN

$F_B = 128 - 76.8 = 51.2$ kN

For S_A : Strength of the weld = Load

$\Rightarrow 110 \times 100 \times 0.707\, S_A = 76.8 \times 10^3$

$\Rightarrow S_A = 9.8$ mm $\simeq 10$ mm

For S_B : $110 \times 100 \times 0.707\, S_B = 51.2 \times 10^3$

$\Rightarrow S_B = 6.5$ mm $\simeq 7$ mm

MODEL - 2

(CET - 602)

Full Marks : 70 **Time : 3 Hours**

Answer any **five** questions.

The figures in the right-hand margin indicate marks.

1. (a) State the types of bolts used in strucutre. [2
   (b) State and sketch double lap joint. [5
   (c) Design a double cover butt joint between two mild steel plates 320 mm wide and 18 mm thick. [7
2. (a) Define the failure of joint in adge cracking. [2
   (b) State the assumptions in the theory of riveted joints. [5
   (c) Design square footing for a RCC column 250 mm × 250 mm carrying a load of 250 kN founded on a soil of SBC 160 kN/m² in LSM. Use M_{25} and FE_{415} and give a neat sketch of the detailing. [7
3. (a) Sketch the basic sections and symbols for single V-butt weld. [2
   (b) State and sketch the common sections of tension members. [5
   (c) Design a dog legged staircase by LSM for a public building of ceiling height 3.3 mtrs. The width of each flight is to be kept 1.5m. Choose suitable rise and tread. Use M_{20} and Fe_{415}. Give a neat sketch of the detailing. [7
4. (a) Sketch the basic sections and symbols for single V-butt weld. [2
   (b) A single angle strut ISA (50 mm × 50 mm × 6 mm) of a room struss is 1.10 m long. It is connected by one rivet at each end. Determine the safe load that strut can carry. [5
   (c) Design uniform depth RCC footing for a masonary wall 25cm thick subjected to a load of 100 kN/m inclusive of self weight. The SBC of soil is 120 kN/m². [7
5. (a) What is the value of effective length of compression member in case of effectively held in position at both ends restrained against rotation at one end. [2
   (b) Find the safe axial load on a circular sal column of diameter 15 cm and length 3.5 m. [5

(c) In a roof truss, a diagonal consists of an ISA 150mm × 75mm × 10mm and is connected to a gusset plate by one leg only by 18 mm diameter rivets in one chain line along the length of member. Determine the tensile strength of the member.[7

6. (a) What is the value of maximum slenderness ratio for a member carrying compressive loads resulting from dead load and superimposed loads ? [2

(b) A single angle strut ISA (50 mm × 50 mm × 6 mm) of a room struss is 1.10 m long. It is connected by one rivet at each end. Determine the safe load that strut can carry. [5

(c) Design the RCC footing for a masonary wall 300 cm thick subjected to a load of 80 kN/m including self weight. The SBC of soil is 150kN/m². [7

7. (a) What are the types of column bases usually used ? [2

(b) Compare riveted joints with welded joints. [5

(c) 2 ISA 90 mm × 90 mm × 8 mm transmitting tensile force are connected to the gusset on either side by fillet welding. Design the joint for maximum efficiency. [7

MODEL - 2 (ANSWER)

1.(a) State the types of bolts used in strucutre.

Ans. Types of Bolts :

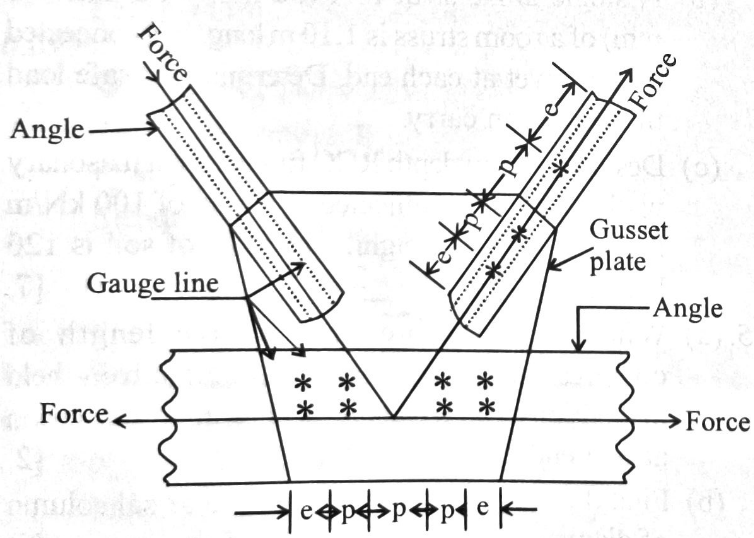
Black bolts

Precission & Semi precision bolts.

High strength friction grip bolts.

(b) State and sketch double lap joint.

Ans.



Double LAP Joint

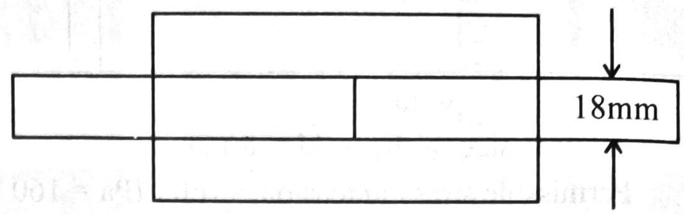
When one member is placed over another member and two are connected by rivet, joint is known as double lap joints. Double rivetted lap joint are two type.

(a) Chain riveted lap joint.

(b) Zig-zag rivetted lap joint.

(c) Design a double cover butt joint between two mild steel plates 320 mm wide and 18 mm thick.

Ans. Assume power driven shop rivet.



τ_{Vf}=100 N/.mm²

δ_{Pf}=300 N/mm²

t = 18 mm, $Q = 6\sqrt{t} = 6\sqrt{18} = 23.2 \simeq 24$mm

d = 24 + 1.5 = 25.5 mm

F_i= (Shearing strength of each rivet sub. to double shear)

$$F_s = \tau_{Vf} \times \left\{\left(\pi/_4 \times d^2\right)\right\} \times n' \times n$$

$$=100 \times \left\{\left(\pi/_4 \times (25.5)^2\right)\right\} \times 1 \times 2 = 102.141 \times 10^3 n$$

F_b= (Bearing strength of rivet) = $\delta_{pf} \times d \times t \times n$.

= 300 × 25.5 × 18 × 1137.7 × 10³ N

F_t= (Tearing strength of riveting member)

= δ_{at} (b–n″d) × t

= 150 {320 – (1 × 25.5)} × 15 = 662.625 × 10³N

Rivet strength = Minimum of F_s, F_b & F_t i.e.

F_i= 102.141 × 10³N

Solid member strength = $\delta_{at} \times b \times t$

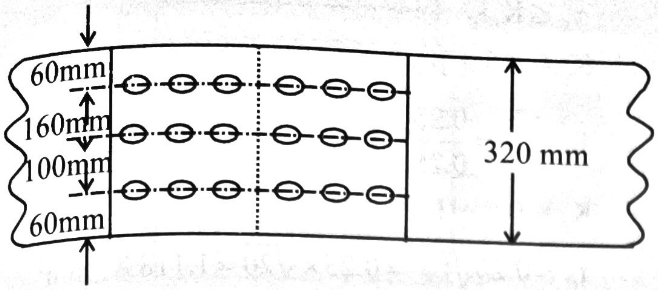
= 150 × 320 × 18 = 864.00 × 10³ N

No. of rivet

$$= \frac{\text{Load}}{\text{Strength of rivet}} = \frac{864.00 \times 10^3}{102.141 \times 10^3} = 8.4\text{nos} \simeq 12\text{nos}$$

P_{Min} = 2.5 ϕ = 2.5 × 24 = 60 mm

P_{Max}= 32t ot 300 which ever is less = 32 × 18 = 576 mm edge distance = 60mm.



2.(a) Define the failure of joint in adge cracking.

Ans. Staggered Pitch :

The distance between any two consecutive rivets in a zig-zag riveting, measured parallel to the direction of stress in the member is called staggered pitch.

(b) State the assumptions in the theory of riveted joints.

Ans. Assumption in the theory of riveted joints.

The tensile stress is uniformly distributed on the portion of the plate between the rivets.

The friction between the plates is neglected.

The shearing stress is uniformly distributed on the cross-section of the rivets.

The rivets fill the holes completely.

The rivets in a group share the direct load equally.

Bending stress in rivets is nelgected bending stress distribution is uniform & the contact area is d × t where 'd' is the diameter & 't' is the thickness of the plate.

(c) Design square footing for a RCC column 250 mm × 250 mm carrying a load of 250 kN founded on a soil of SBC 160 kN/m² in LSM. Use M_{25} and FE_{415} and give a neat sketch of the detailing.

Ans. Given Data :

Column size = 250 mm × 250 mm

Load = 250 kN

S_{BC} = 160 kN/m²

Using M_{25} & Fe_{415}

F_{ck}=25 N/mm²

fy = 415 N/mm²

Step -1 :

Column load = 250 kN

Total load = column Load + Foundation load

= 250 + (10% of the column load)

$$= 250+\left(\frac{10}{100}\times 250\right)=275\text{kN}$$

ultimate load = 1.5 × 275 = 412.5kN

Step -2 :

$$A_{req}=\frac{\text{ultimate load}}{S_{BC}}=\frac{412.5}{160}=2.57\text{m}^2$$

B = 1.6 m

B = L = 1.7 m (For square footing)

A_{avail} = 1.7 × 1.7 = 2.89 m²

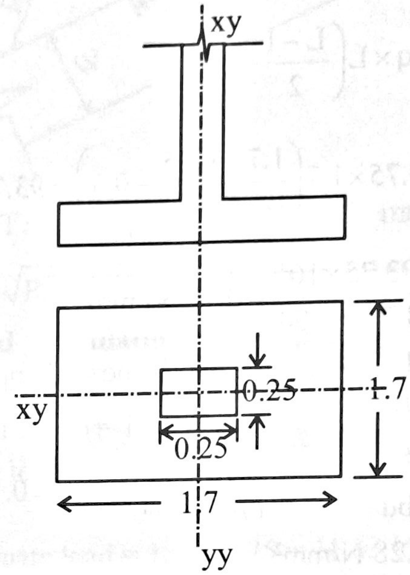
Step-3 :

$$\text{Upward Pressure (q)}=\frac{\text{column load}}{A_{Provided}}=\frac{1.5\times 250}{289}$$

= 129.75 kN/m² < S_{BC}, i.e. 160 kN/m² (OK)

Step-4 : Bending momet calculation :

$$M_{xx}=M_{yy}=q\times B\frac{(B-b)^2}{8}=129.75\times 1.7\times\frac{(1.7-0.25)^2}{8}$$



Step - 5 Depth Calculation

$$M_{u\,lim}=0.36\,f_{Ck}\frac{X_{u\,max}}{d}\left[1-0.42\frac{X_{u\,max}}{d}\right]bd^2$$

⇒ 57.97 × 10⁶ = 0.36 × 20 × 0.48 [1 – (0.42 × 0.48)] × 1.7 × 10³ × d²

d = 111.16 mm ≃ 300 mm

∴ D = d + clear over = 300 + 50 = 350 mm

Step - 6 - Steel Calculation

$(A_{St})_x = (A_{St})_y$

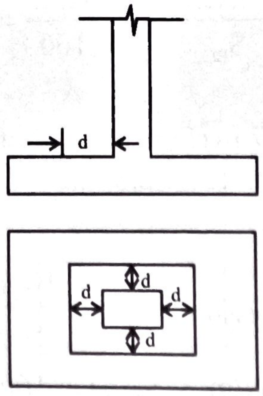
$$\frac{M_u}{bd^2}=\frac{57.97\times 10^6}{1700\times(300)^2}=0.38$$

P_t = 0.105

$$A_{St}=\frac{0.105\times 1700\times 300}{100}=535.5\text{ mm}^2$$

Step - 7 - Check for one-way shear

Critical section 'd' from the face of the column.



$\tau_v \le K i_C$

$$\tau_v = \frac{V_u}{bd}$$

$$V_u = q \times L\left(\frac{L-1}{2} - d\right)$$

$$= 129.75 \times 1.7\left(\frac{1.7 - 0.25}{2} - 0.3\right) = 93.75 \text{ kN}$$

$$\tau_v = \frac{93.75 \times 10^3}{1700 \times 300} = 0.18 \text{ N/mm}^2$$

K = 1 (For overal depth more than 300. Here D = 350 mm)

$$P_t = \frac{A_{St}}{bd} \times 100 = \frac{5355}{1700 \times 300} \times 100 = 0.105$$

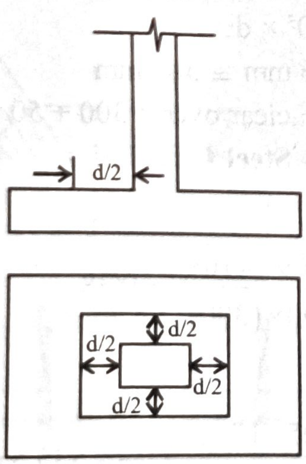
$i_C = 0.28$ N/mm²

$Ki_C = 1 \times 0.28 = 0.28$ N/mm²

$\tau_V < Ki_C$

Step - 8 - Check for two-way shear

Critical section from d/2 from the face of the column.



$\tau_V \le K_S i_C$

$K_s = 0.5 + \beta_C$.

$$\beta_C = \frac{b}{I} = \frac{0.25}{0.25} = 1$$

$K_S = 0.5 + 1 = 1.5 \simeq 1$

$i_C = 0.25\sqrt{f_{Ck}} = 0.25 \times \sqrt{20} = 1.118 \text{ N/mm}^2$

$k_C i_C = 1 \times 1.118 = 1.118$ N/mm²

$$\tau_V^l = \frac{V_u^l}{b'd'}$$

$L'' = L' + d = 0.25 + 0.3 = 0.55$ m

$b'' = 0.55$ m

$b' = 2(b'' + c'') = 2(0.55 + 0.55) = 2.2$ m

$L' = 2.2$ m

$V_u' = q \times [(L \times b) - (0.55 \times 0.55)]$

$= 129.75\ [(1.7 \times 1.7) - (0.55 \times 0.55)]$

$= 335.73$ kN.

$$\tau_V^l = \frac{V_u^l}{b'd'} = \frac{335.75 \times 10^3}{2200 \times 300} = 0.5 \text{ N/mm}^2 < K_S i_C$$

It is satisfy.

Step - 9 - Check for development length

$$(L_d)_{Provided} = \frac{L-1}{2} - \text{side cover} = \frac{1700 - 250}{2} - 50 = 675 \text{ mm}$$

$$(L_d)_{required} = \frac{\phi 0.87 fy}{4 i_{bd}}$$ (i_{bd} = 1.4 N/mm² for M_{20} grade conc. ϕ of = 16 mm)

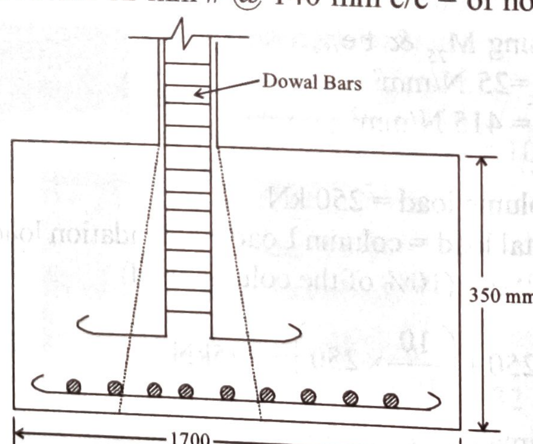
$$(L_d)_{required} = \frac{16 \times 0.87 \times 415}{4 \times 14} = 1031.57 \text{ mm}$$

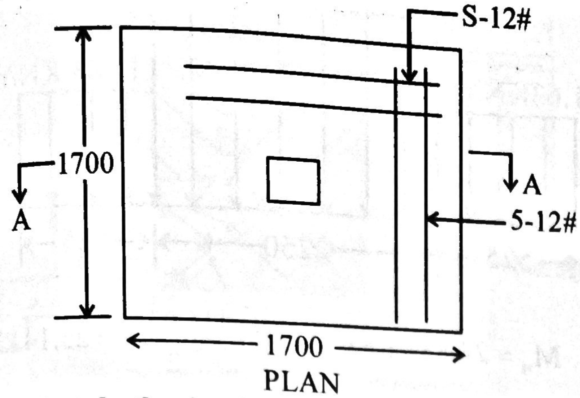
So $(L_d)_{Provided}$ = 1032 mm

Steel calculation

A_{St} = 535.5 mm²

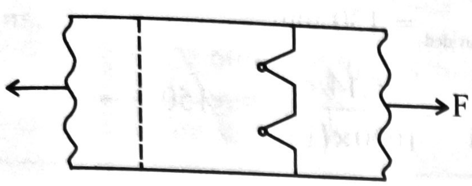
Provide 12 mm # @ 140 mm c/c = of nos.





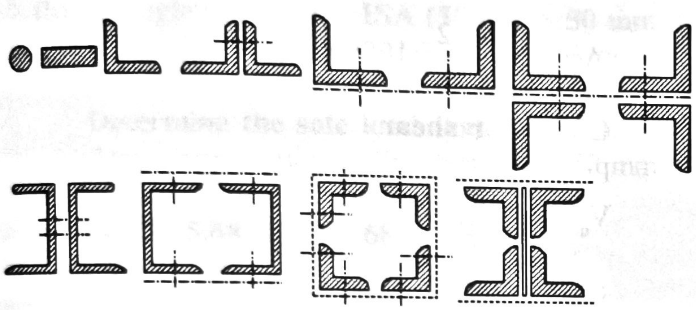
3.(a) Sketch the basic sections and symbols for single V-butt weld.

Ans. Edge Cracking :



(b) State and sketch the common sections of tension members.

Ans.



- A tension member or a tie carries a direct axial tension in a foat truss or bridge truss.
- Wire cables, circular & flat bars are the simplest from of tension member in use for light bridge & roof truss.
- Steel section such as angle I-channel & tee-section, provide more regiadity towards buckling in compression when several of load takes place under wind load.
- A single-angle section develops bending stress due to the ecentricity between the end connection & the Cg of the angle section.
- Double angle section & channel section develop relatively less eccentricity.
- Built up section are used for heavy loads.
- The arrangements of built up sections are made with angle or channel-section & cover plates or leaving to provide sufficient cross-sectional area & to suit the joints with adjoining members.

(c) Design a dog legged staircase by LSM for a public building of ceiling height 3.3 mtrs. The width of each flight is to be kept 1.5m. Choose suitable rise and tread. Use M_{20} and Fe_{415}. Give a neat sketch of the detailing.

Ans. Ceiling height = 3.3 m

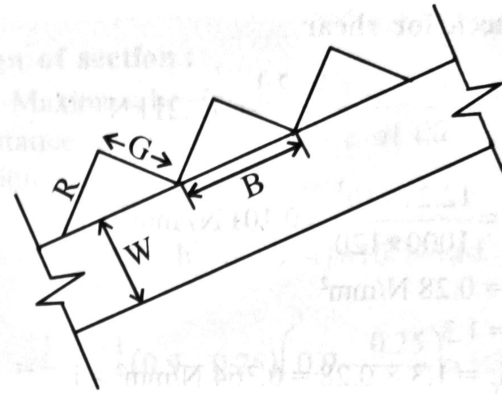
Width of each flight = 1.5 m

Assume Rise (R) = 150 mm

Trade (T) = 225 mm

Noising = 25 mm

Thickness of waist slab (W) = 100 mm



G = T + noising = 225 + 25 = 250 mm

$$B = \sqrt{R^2 + T^2} = \sqrt{150^2 + 250^2} = 291.54 \text{ mm}$$

Load Calculation

Self load = 0.15 × 25 = 3.75 kN/m²

Floor finish = 1.00 kN/m²

Live load = 3.00 kN/m²

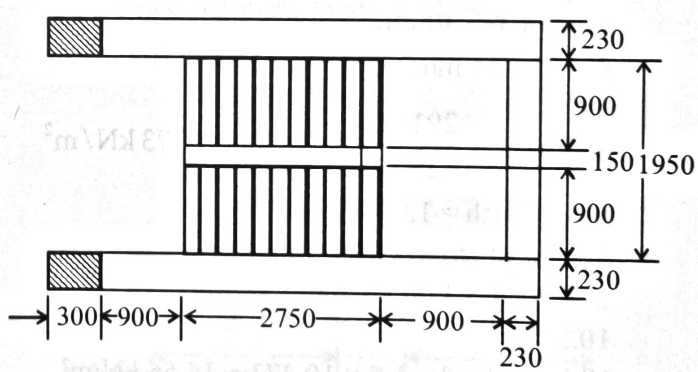
7.7 kN/m²

Ultimate load = 1.5 × 7.75 = 11.63 kN/m²

Assume waist slab thickness = 150 mm (W)

Effective span = 1950 + 150 = 2100 mm

d = 150 – 25 – 5 = 120 mm



Step - 2

Steel Calculation

$$M_u = \frac{Wl^2}{8} = \frac{11.63\times(21)^2}{8} = 6.41\,\text{kNm}$$

$$\frac{M_u}{bd^2} = \frac{6.41\times10^6}{1000\times(120)^2} = 0.445$$

$P_1 = 0.127$

$$A_{St} = \frac{0.127}{100}\times100\times200 = 152\ \text{mm}^2$$

Provide 8 mm # 270 mm c/c = 185 mm²

Step - 3

Check for shear

$$V_u = \frac{wl}{2} = \frac{11.63\times2.1}{2} = 12.21\,\text{kN}$$

$$i_v = \frac{12.21\times10^3}{1000\times120} = 0.101\,\text{N/mm}^2$$

$i_C = 0.28$ N/mm²

k = 1.3

$Ki_C = 1.3 \times 0.28 = 0.364$ N/mm² $> i_v$

Step - 4

Check for deflection

$$\text{Basic}\ \frac{\text{Span}}{d} = 20$$

$P_t = 0.154$

Modification factor = 1.8 (From sp. 16)

$$\text{Allowable}\ \frac{\text{Span}}{d} = 20\times1.8 = 36$$

$$\text{Actual}\ \frac{\text{Span}}{d} = \frac{2100}{120} = 17.5 < 36$$

Step - 5

Design for Flight

B = 291.54 mm

$$\text{Self load} = \frac{29154}{250}\times0.15\times25 = 4.373\,\text{kN/m}^2$$

Floor finish = 1.00 kN/m²

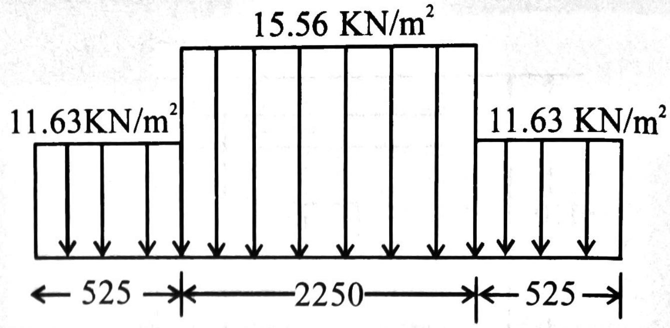
Weight of stq = 2.00 kN/mm²

Live load = 3.00 kN/m²

10.373 kN/m²

Ultimate load = 1.5 × 10.373 = 15.56 kN/m²

$$R_A = R_B = 0.525 \times 11.63 + 16.64 \times \frac{2.25}{2} = 24.83\,\text{kN}$$



$$M_u = 24.83\times1.65 - 11.63\times\frac{(11.65)^2}{2} = 25.14\,\text{kN/m}$$

$$d_{req} = \sqrt{\frac{25.14\times10^6}{1000\times2.76}} = 95.44\ \text{mm}$$

$d_{Provided}$ = 130 mm

$$\frac{M_u}{bd^2} = \frac{25.14\times10^6}{1000\times(130)^2} = 150$$

$P_t = 0.460$

A_{St} = 598 mm²

Provide 10 mm # 130 mm c/c = 604 mm²

$$Ast_{min} = \frac{0.12}{100}\times1000\times150 = 156$$

Check for shear

Provide 8 # @ 270 mm c/c = 277 mm²

V_u = 24.83 kN

$$i_V = \frac{24.83\times10^3}{1000\times130} = 0.191\,\text{N/mm}^2$$

$P_t = 0.46$

$i_C = 0.46$ N/mm²

K = 1.3

$Ki_C = 1.3 \times 0.46 = 0.6$ N/mm² $> i_V$

Check for deflection

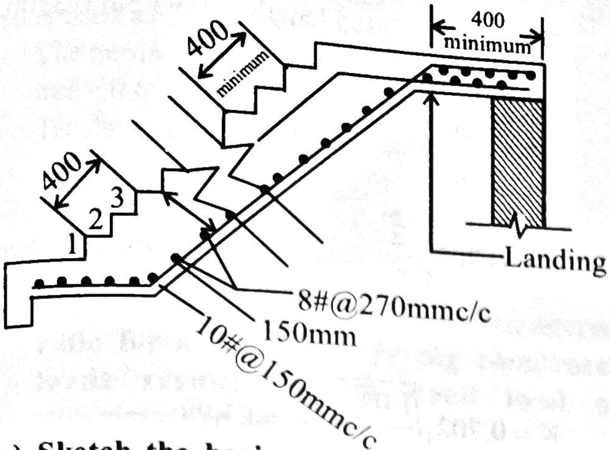
$$\text{Basic}\ \frac{\text{Span}}{2} = 20$$

$P_t = 0.46$

Modification factor = 1.36

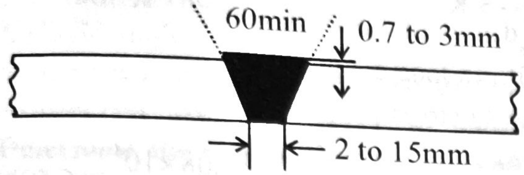
$$\text{Allowable}\ \frac{\text{Span}}{2} = 1.36\times20 = 27.2$$

$$\text{Actual}\ \frac{\text{Span}}{2} = \frac{3300}{130} = 25.38 < \text{Allowable}\frac{\text{Span}}{d}$$



4.(a) Sketch the basic sections and symbols for single V-butt weld.

Ans.



Single V - Butt weld

Symbol = ▽

(b) A single angle strut ISA (50 mm × 50 mm × 6 mm) of a room struss is 1.10 m long. It is connected by one rivet at each end. Determine the safe load that strut can carry.

Ans. Given section = ISA (50 mm × 50 mm × 6 mm)

$A_{avail} = 5.68\ cm^2 = 5.68 \times 10^2\ mm^2$

For 'δ_{ac}' we required λ & fy.

$$\lambda = \frac{L_{eff}}{R_{Min}}$$

$L_{eff} = L = 1.10$ m ($\because$ One riveted each and so $L_{eff} = L$).

$r_{min} = 0.96\ cm^3$ (i,e r_w)

$$\lambda = \frac{1.1\times10^3}{0.96\times10} = 114.58$$

fy = 250

$110 \rightarrow 72$

$120 \rightarrow 64$

$$\delta_{ac} = 72 - \left(\frac{72-60}{120-110}\right)\times(114.58-110) = 68.332 N/mm^2$$

$$(\delta_{ac})_{all} = 0.8\delta_{ac} = 0.8\times68.332 = 54.668 N/mm^2$$

$$(P_{safe}) = (\delta_{ac})_{all}\times A = 54.668\times5.68\times10^2$$

$= 31.05 \times 10^3$ N = 31.05 kN

(c) Design uniform depth RCC footing for a masonary wall 25cm thick subjected to a load of 100 kN/m inclusive of self weight. The SBC of soil is 120 kN/m².

Ans. Assuming M20 concrete andFe415 Steel.

Design constants :

R_c=0.289, J_c = 0.904 and Q_c= 0.914

$$\text{Width B of footing} = \frac{100}{120} = 0.833M$$

Adopt B = 0.9M

Net upward pressure

$$P_o = \frac{100}{0.9} = 111.11 KNM^2/m$$

Design of section :

Maximum bending moment occurs at saection X-X distance b/4 from the centre of the wall and its magnitude is giveen by

$$M = \frac{P_o}{8}(B-b)(B-b/4)\times10^6 NMM$$

$$= \frac{111.11}{8}(0.9-0.25)\left(0.9-\frac{0.25}{4}\right)\times10^6$$

$= 7.56 \times 10^6$ NMM

$$d = \sqrt{\frac{7.56\times10^6}{1000\times0.914}} = 90.95MM$$

Provide a total depth of 160 mm and a cover to the centre of the steel equal to 60mm. So that available d = 160 – 60 = 100mm.

Check for shear :

For balanced section

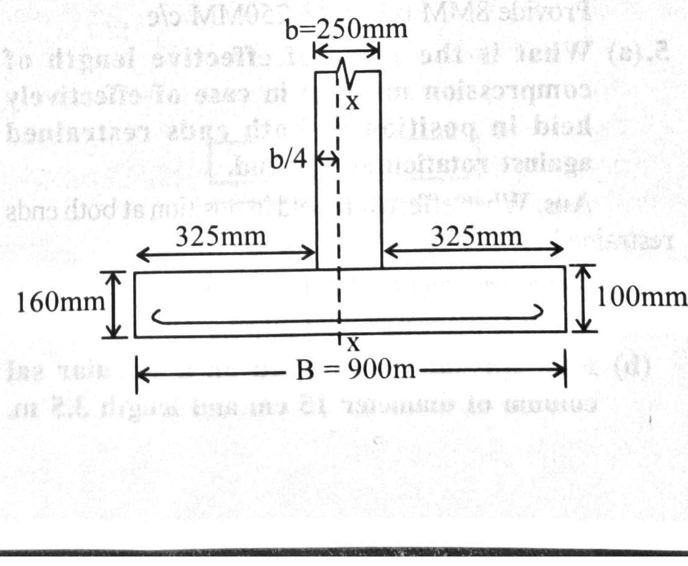
P = 0.44% for M20 Conerete and Fe4 15 steel.

Z = 0.28 N/mm²

K= 0.30

Hence permissible shear stress

$= K\mu_c = 1.3 \times 0.28 = 0.364$ N/m



The critical section lies at a distance of d (=100 mm) from the face of the wall. Hence distance of critical section from edge of footing.

$$=\frac{1}{2}(B-d)-d=\frac{1}{2}(0.9-0.25)-0.100$$

= 0.225 M.

V = 106000 × 0.225 = 23850 N/M

$$\mu_v=\frac{V}{bd}=\frac{23850}{1000\times100}=0.2385N/mm^2$$

This is less than the permissible shear stress. Hence safe.

Design of reinforcement :

$$A_{st}=\frac{M}{6_s+jd}$$

$$=\frac{7.56\times10^6}{230\times0.904\times100}=363.6N/mm^2$$

Using 12 MM ϕ bars,

$$A\phi=\frac{\pi}{4}\times12^2=113MM^2$$

$$\text{Spacing } S=\frac{1000\times A\phi}{AS}=\frac{1000\times113}{364}$$

= 310 mm.

Provide 12mm f bars @ 300 MM C/C

Area of longitudinal reinforcement

= 0.12% area of cross - section

$$=\frac{0.12}{100}\times100\times160=192MM^2$$

= 50.26 MM²

$$\text{Spacing}=\frac{1000\times50.26}{192}=261mm$$

Provide 8MM ϕ bars @ 250MM c/c

5.(a) What is the value of effective length of compression member in case of effectively held in position at both ends restrained against rotation at one end.

Ans. When effectively held in position at both ends restrained against rotation at one end.

Efffective length = 0.8 L

where L→ unsupported length.

(b) Find the safe axial load on a circular sal column of diameter 15 cm and length 3.5 m.

Ans. Unsupported length (S) = 3.5m = 3500 mm

d = 150 m = 150 mm

$$\frac{S}{d}=\frac{3500}{150}=23.33$$

$$K=0.702\sqrt{\frac{E}{f_c}}\qquad E = 1.08\times10^4\ N/mm^2$$

f_c = 11 N/mm²

$$K=0.702\sqrt{\frac{1.08\times10^4}{11}}=21.99$$

$$\frac{S}{d}>K$$

It is a long column.

Safe stress =

$$\frac{0.329E}{(S/d)^2}=\frac{0.329\times1.08\times10^4}{(23.33)^2}=6.52N/mm^2$$

Safe load carrying capacity = Safe stress × Area

$$=6.25\times\left\{\pi/_4\times(150)^2\right\}=115.22\times10^3=115.22kN$$

(c) In a roof truss, a diagonal consists of an ISA 150mm × 75mm × 10mm and is connected to a gusset plate by one leg only by 18 mm diameter rivets in one chain line along the length of member. Determine the tensile strength of the member.

Ans. Net area of section : ISA 150mm × 75mm × 10mm is used as a tension member.

Diameter for rivet hole = 18 + 1.5 = 19.5mm

The rivets are used in one chain line along the length of the member.

Net sectional area of connected leg.

A_1 = (150 – 19.5 – 5) × 10 = 1255

Area of outstanding leg,

$$A_2=\left(75-\frac{1}{2}\times10\right)\times10=700mm^2$$

$$K=\frac{3A_1}{3A_1+A_2}=\frac{3\times1255}{3\times1255-700}=0.8432$$

Net effective area of the angle.

An $A_1 + A_2K$ = 1255 +700 × 0.8432

= 1845.26 mm²

It is assumed that have the value of yield stress for steel used as 260N/mm²

The permissible stress in axial tension.

$\sigma at = 0.6 \times 260 = 156\ N/mm^2$

Tensile strength of the member

$$P_1 = \frac{1845.26 \times 156}{1000}$$

$= 287.860$ KN

6.(a) What is the value of maximum slenderness ratio for a member carrying compressive loads resulting from dead load and superimposed loads ?

Ans. A member carrying compressive loads resulting from dead load & superimposed load. Maximum slenderness ratio is 180.

(b) A single angle strut ISA (50 mm × 50 mm × 6 mm) of a room struss is 1.10 m long. It is connected by one rivet at each end. Determine the safe load that strut can carry.

Ans. Given section = ISA (50 mm × 50 mm × 6 mm)

$A_{avail} = 5.68\ cm^2 = 5.68 \times 10^2\ mm^2$

For 'δ_{ac}' we required λ & fy.

$$\lambda = \frac{L_{eff}}{R_{Min}}$$

$L_{eff} = L = 1.10$ m ($\because$ One riveted each and so $L_{eff} = L$).

$r_{min} = 0.96\ cm^3$ (i,e r_w)

$$\lambda = \frac{1.1 \times 10^3}{0.96 \times 10} = 114.58$$

fy = 250

$110 \rightarrow 72$

$120 \rightarrow 64$

$$\delta_{ac} = 72 - \left(\frac{72-60}{120-110}\right) \times (114.58 - 110) = 68.332 N/mm^2$$

$$(\delta_{ac})_{all} = 0.8\delta_{ac} = 0.8 \times 68.332 = 54.668 N/mm^2$$

$$(P_{safe}) = (\delta_{ac})_{all} \times A = 54.668 \times 5.68 \times 10^2$$

$= 31.05 \times 10^3$ N = 31.05 kN

(c) Design the RCC footing for a masonary wall 300 cm thick subjected to a load of 80 kN/m including self weight. The SBC of soil is 150kN/m².

Ans. Wall load = 80kN/m (Including Self weight)

$S_{BC} = 150 kN/m^2$

Wall thickness = 300 mm

Step- I :

Assume in length of footing.

$$(Area)_{req} = \frac{Load}{S_{BC}} = \frac{1.5 \times 80}{150} = 0.8 m.i.e.width$$

Step - II : Upward Pressure :

$$q = \frac{Load}{A_{Provide}} = \frac{80}{1 \times 0.8} = 100 kN/m^2 < S_{BC}$$

Step-III : Bending Moment $= q \times \frac{B-b}{2} \times \frac{B-b}{4}$

$$= 100 \times \left(\frac{0.8-0.3}{2}\right) \times \left(\frac{0.8-0.3}{4}\right) = 3.125 kN.m$$

Step-IV : Depth Calculation :

$$M_{u\,Lim} = 0.36 f_{CK} \frac{X_{u\,Max}}{d}\left[1 - 0.42\frac{X_{u\,Max}}{d}\right] bd^2$$

$\Rightarrow 3.125 \times 10^6 = 0.36 \times 20 \times 0.48\ [1-(0.42 \times 0.48)] \times 1000 \times d^2$

$\Rightarrow d = 33.65\ mm \simeq 100$ mm

Step - V : Steel Calculation :

$$\frac{M_u}{bd^2} - \frac{3.125 \times 10^6}{1000 \times (100)^2} = 0.33$$

$P_t = 0.0934$

$A_{st} = 93.4\ mm^2$

Spacing =

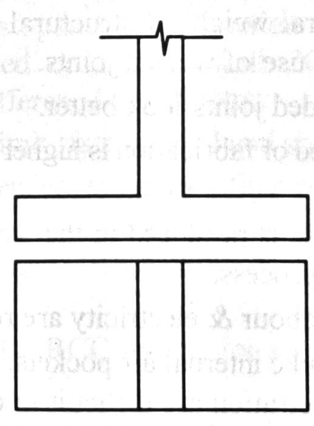
$$\frac{\pi/4 \times 10^2}{A_{St}} \times 1000 = 840.1 mm = 845 mm$$

$(S_d)_{Max} = 3d$ or $300 = 3 \times 100 = 300$

Provide 10mm # @ 300 mm c/c as main reinforcement.

Step-VI : Check for one-way shear :

$i_v \le k i_c$



$$i_V = \frac{V}{bd}$$

$$V = q \times 1 \times \left(\frac{B-b}{2}\right) - d = 100 \times 1 \times \left(\frac{0.8-0.3}{2}\right) - 0.1$$

= 24.9 kN

$$i_V = \frac{24.9 \times 10^3}{1000 \times 100} = 0.249 N/mm^2$$

K=1.30 (For D= 150 mm)

$i_c = ?$

$P_t = 0.934$

i_c= 0.28 N/mm²

Ki_c= 1.3 ×0.28 = 0.364 N/mm² > i_V (It is satisfy)

7.(a) What are the types of column bases usually used ?

Ans. Type of Column Base :

Slab base

Gusseted base

Grillage foundation.

(b) Compare riveted joints with welded joints.

Ans. Riveting Joint :

As holes are required for riveting. So strength may be reduced.

When the riveting is done the rivet head is prepared by hammering. The hammering causes noise.

The are usually bucky in shape.

Unskilled labours are no used electricity is required.

The riveting is done in cold as well as hot. While hammering.

Welded Joint

As no holes are required for welding the strucutral member are more effective in taking loads.

The overal weight of structural steel required is reduced by the use of welded joints.

The welded joints look better.

The speed of fabrication is higher with the welding process.

No. Noise is produced in the welding process as in the riveting process.

Skilled labour & electricity are required.

Defects like internal air pockets, slag inclusion & incomplete penetration are difficult to detect.

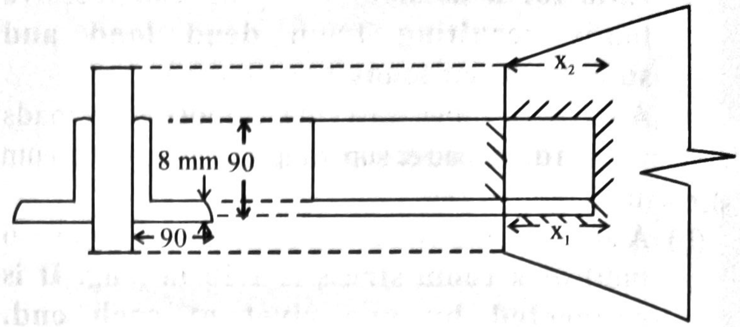
(c) 2 ISA 90 mm × 90 mm × 8 mm transmitting tensile force are connected to the gusset on either side by fillet welding. Design the joint for maximum efficiency.

Ans. 2ISA → 90 mm × 90 mm × 8 mm

$(Area)_{avail}$ = 2 × 13.79 = 27.58 cm²

Assume the stress for the weld = 110 N/mm²

δ_{at} = 150 N/mm²



Assume gusset plate thickness = 10 mm

Size of the weld = 6 mm

∴ Strength of the weld = Strength of the member

⇒ Stress × L_{eff} × 0.707 S = δ_{at} × Area

⇒ 110 × L_{eff} × 0.707 × 6 = 150 × 27.58 × 10²

⇒ L_{eff} = 887 mm

But $L_{eff} = 2x_1 + 2x_2 + (2 \times 90) = 2(x_1 + x_2) + 180$

⇒ $2(x + x_2) + 180 = 887$

⇒ $x_1 + x_2 = 353.7$ .....(1)

Taking moment about C.h.

$$\frac{x_1}{x_2} = \frac{e_{xx}}{c_{xx}} = \frac{649}{251} = 2.58$$

⇒ $x_1 = 2.58\ x_2$ .....(2)

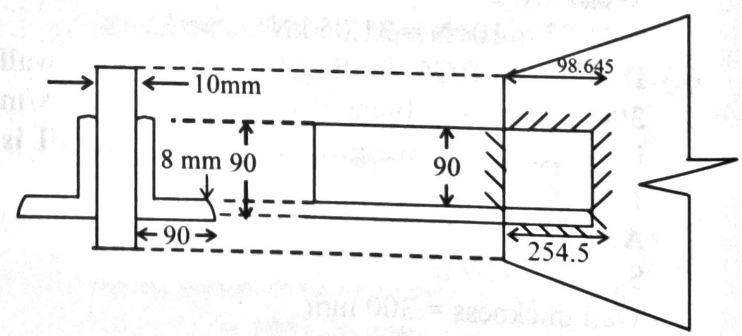
From equation (1) $x_1 + x_2 = 353.7$

⇒ $x_2 = 353.7 - 2.58\ x_2$

⇒ x_2 = 98.643 mm

∴ $x_1 = 2.58\ x_2$

= 2.58 × 98.643 = 254.5 mm



MODEL - 3

(CET - 602)

Full Marks : 70 **Time : 3 Hours**

Answer any **five** questions.

The figures in the right-hand margin indicate marks.

1. (a) What is limit of slenderness ratio for a short and solid rectangular columns ? [2

(b) Compare and contrast a rivet joint and welded joint. [5

(c) Design a simply supported beam to carry a uniformly distributed load of 50kN/m. The effective span of beam is 9m. The compression flange of the beam would be prevented from lateral deflection. [7

2. (a) What type of shape of the footing adopted if the width of the foundation for two equal column is restricted. [2

(b) Find Suitable Pitch for double rivetting cover butt joint for a plate 12 mm thick. If the thickness of the cover plate 12 mm thick. If the thickness of the cover plate are 8 mm each and the pitch for the inner row of rivets is half the pitch for the outer row, find the efficiency of the joint assuming power driven shop rivets. [5

(c) An R.C.C column of size 300mm × 300mm carries a characteristic load of 700kN. The allowable bearing pressure on soil is 180kN/m^2. Design an isolated sloped footing. The materials are grade M20 concrete and HYSD reinforcement of grade Fe415 for both column and footing. [7

3. (a) State the shape of the footing adopted if the width of the foundation for two equal column is restricted. [2

(b) A double cover butt joint is used to connect two plates 24mm thick. Design the joint. [5

(c) Design a gusseted base of a column consisting of ISHB 400 × 82.2 kg/m with flange plate 300 mm × 16 mm on each flange. The column carries a load of 2000 kN and is supported on concrete pedestal with a bearing capacity of 40MPa. [7

4. (a) What is the minimum and maximum value of pitch of rivet in a rivet line for a tension member ? [2

(b) A column 1450mm × 150 mm is made of babul wood. The unsupported length is 3.7 m. Determine the safe axial load on the column. [5

(c) A column section ISHB 300 @ 0.630 kN/m with one cover plate 500mm × 20mm on each side is carrying an axial load of 3000 kN inclusive of self weight of base and column. Design a gussetted base. The allowable bearing pressure in bending in concrete is 4N/mm^2. The allowable bending stress in base plate is 185 N/mm^2. [7

5. (a) What is the effective length of compression flange for a simple supported beam with ends of compression flange partially resumed against [2

(b) A tie member of a roof truss consists of 2 ISA 90mm × 60mm × 10mm. The tie member is subjected to apull of 200kN. The angles are connected either side of a gusset plate 12 mm thick. Design the welded connection. [5

(c) A diagonal consists of 14mm thick flat and carries a pull of 600 kN and is connected to a gusset plate by a double cover butt joint. The thickness of each cover plate is 8mm. Determine the member of rivet necessary and the width of the flat required. Arrange the rivets in diamond rivetting. What is the efficiency of joint ? Sketch the joint. [7

6. (a) What is the minimum depth of foundation for a soil with s.b.c. of 150 kN/m^2, unit weight of 20 kN/m^3 and $\phi = 30°$? [2

(b) A column 120mm in diameter is made of deodar wood. The effective length of column is 1.20m. Determine the safe axial load of the round column. The column is situated in outside location. Take safe working stress in axial compression parallel to the grains for outside location $f_{cp} = 7N/mm^2$.[5

(c) Design single flight of dog legged staircase for an intermediate floor with following data : Tread = 250mm, Rise = 150 mm,. Width of flight as well as landing = 1.2 mtr, Use M20 & Fe415. The landings span in the direction of flight and are supported on masonry walls 300 mm thick with level difference of 1.5 mtrs.

Adopt limit state method and show detailing. [7

7. (a) How slenderness ratio influences design of steel structural compression members. [2

(b) State the assumptions in the theory of riveted joints. [5

(c) Design the RCC footing for a masonary wall 300 cm thick subjected to a load of 80 kN/m including self weight. The SBC of soil is 150kN/m^2. [7

MODEL - 3 (ANSWER)

1.(a) What is limit of slenderness ratio for a short and solid rectangular columns ?

Ans. Splenderness ratio= 180 for carrying come. load from dead load & superimposed load.

(b) Compare and contrast a rivet joint and welded joint.

Ans. Rivetted Joint :

1. Rivetted is prepared by hammering. The hammering causes noise in the process of riveting.
2. The riveting is done cold as well as hot. While hammering rivets may fly away & injure the person. When the hot rivetting is done, the rivets are made red hot & handled oveer to place them in position.
3. Rivetting taken for long time.
4. Riveting is very costly.
5. Riveting is stronger than welding & bolted joint.
6. Unskilled labour is required & no electricity is required.

Welded Joint :

1. There is silence in the process of welding.
2. There is safety of welding operator in the welding.
3. The welding may be done quickly in comparison to the riveting.
4. The welding is economical in comparison to the riveting.
5. Skilled labour & electricity are required for welding.

(c) Design a simply supported beam to carry a uniformly distributed load of 50kN/m. The effective span of beam is 9m. The compression flange of the beam would be prevented from lateral deflection.

Ans. Effective span of beam = 9 m.

Load calculation = $w_D + w_L$

w_L = 50 kN/m.

$$w_D = \frac{W \times L}{300} = \frac{500 \times 9}{300} = 1.5\ kN/m.$$

Total load = 50 + 1.5 = 51.5 kN/m.

Bending moment

$$= \frac{wl^2}{8} = \frac{51.5 \times (9)^2}{8} = 521.44\ kNm.$$

Section modulus $(z_{req}) = \frac{M}{\sigma bc}$

Maximum permissible stress = 0.66 fy

Assume, fy = 250 N/mm²

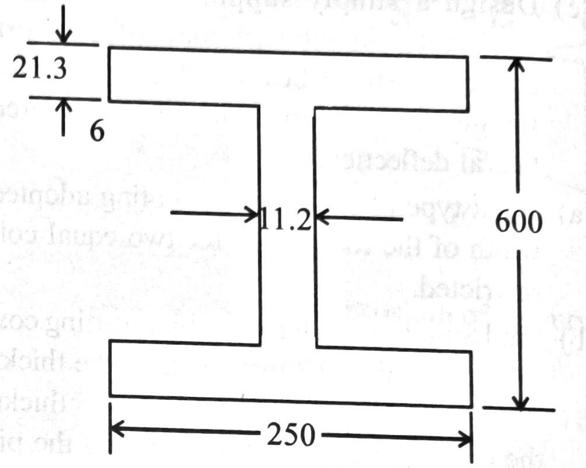
$$(\sigma_{at})_{max} = 0.66 \times fy = 0.66 \times 250 = 165\ N/mm^2$$

$$z_{req} = \frac{521.44 \times 10^6}{165} = 3160.24 \times 10^3\ mm^3$$

$= 3160.24\ cm^3$.

Choosing ISWB 300@, 133.7 kg/m

$z_{avl} = 3540\ cm^3$.



Check for bending

Moment of resistance = $\sigma_{bc} \times z_{avl}$

For σ_{bc} : fy = 250 N/mm²

$$\frac{T}{t} = \frac{21.3}{11.2} = 1.9 < 2$$

$d_1 = 600 - (2 \times 21.3) = 557.4$

$$\frac{d_1}{t} = \frac{557.4}{11.2} = 46.45 < 85$$

$$\frac{D}{T} = \frac{600}{21.3} = 28.16$$

L = 9000 mm

r_{min} = 5.25 cm = 52.5 mm

$$\frac{L}{ry} = \frac{9000}{52.5} = 171.43$$

$$x = 98 - \left\{\left(\frac{98-92}{30-25}\right)(28.16-25)\right\} = 34.25\ N/mm^2$$

$$y = 93 - \left\{\left(\frac{93-87}{30-25}\right)(28.16-25)\right\} = 89.20\ N/mm^2$$

$$z = 94.29 - \left\{ \left(\frac{94.2 - 89.2}{160 - 150} \right) - (152.38 - 150) \right\} = 93.1\ N/mm^2$$

M.O.R. = 93.1 × 3540 × 10^3 = 329.57 kN < B : M

M.O.R < B.M.

So this is not satisfy.

Taking ISWB 600@ 145.1 kg/m

z_{avl} = 3854.2 cm^3.

Check for bending

M.O.R. = $\sigma_{bc} \times z_{avl}$

$$\frac{T}{t} = \frac{23.6}{11.8} = 2$$

From code IS 800 – 1984

d_1 = 600 – (2 × 23.6) = 552.6 mm

$$\frac{d_1}{t} = \frac{552.6}{11.8} = 46.84 < 85$$

$$\frac{D}{T} = \frac{600}{23.6} = 25.42$$

L = 9000 mm.

r_{min} = 53.5 mm.

$$\frac{L}{ry} = \frac{9000}{53.5} = 168.22$$

$$x = 103 - \left\{ \left(\frac{103 - 97}{30 - 25} \right) \times (25.42 - 25) \right\} = 102.49\ N/mm^2$$

$$y = 98 - \left\{ \left(\frac{98 - 92}{30 - 25} \right) \times (25.42 - 25) \right\} = 97.45\ N/mm^2$$

$$z = 102.49 - \left\{ \left(\frac{102 - 97.45}{150 - 140} \right) \times (149.53 - 140) \right\} = 898.19\ N/mm^2$$

M.O.R = 98.19 × 3854.2 × 10^3 = 378.44 kNm > B.M.

So, this is satisfied.

Check for Shear

$$\tau_v = \frac{\text{Shear force}}{\text{Area of web}}$$

$$\text{Shear force} = \frac{WL}{2} = \frac{51.25 \times 9}{2} = 230.63\ kN.$$

Area of web = D × t_w = 600 × 11.8 = 7080 mm^2

$$\tau_{veal} = \frac{230.63 \times 10^3}{7080} = 27.4\ N/mm^2$$

τ_{vt} = 0.4fy = 0.4 × 250 = 100 N/mm^2.

$(\tau_{vcal}) < \tau_{vt}$

Check for deflection

$\sigma_{cal} = \sigma_{max}$

$$\sigma_{max} = \frac{L}{325} = \frac{9000}{32.5} = 27.7\ mm$$

$$\sigma_{cal} = \frac{5}{325} = \left(\frac{WL^4}{EI} \right)$$

$$= \frac{5}{384} \left(\frac{450 \times 9^3}{2 \times 10^4 \times 115626.4} \right) = 0.84\ mm$$

$\sigma_{cal} < \sigma_{va}$

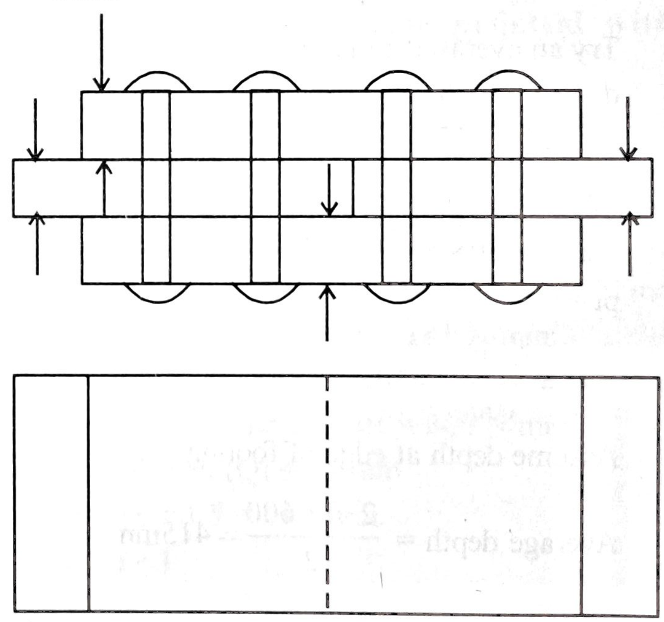
Hence ok.

2.(a) What type of shape of the footing adopted if the width of the foundation for two equal column is restricted.

Ans. Combined type of foundation is provided for a humber of columns constructed in a row.

(b) Find Suitable Pitch for double rivetting cover butt joint for a plate 12 mm thick. If the thickness of the cover plate 12 mm thick. If the thickness of the cover plate are 8 mm each and the pitch for the inner row of rivets is half the pitch for the outer row, find the efficiency of the joint assuming power driven shop rivets.

Ans.



(c) An R.C.C column of size 300mm × 300mm carries a characteristic load of 700kN. The

allowable bearing pressure on soil is 180kN/ m^2. Design an isolated sloped footing. The materials are grade M20 concrete and HYSD reinforcement of grade Fe415 for both column and footing.

Ans. Size of footing :

Load on column = 700kN

Assume dead load of footing = 70kN

Total load on soil = 770kN.

$$\text{Area of footing required} = \frac{770}{180} = 4.3\text{m}^2$$

Adopt 2.1M × 2.1 M footing

Area = 4.41 m^2

Net upward pressure :

Net factored upward pressure

$$= \frac{1.5 \times 700}{2.1 \times 2.1} = 2.38.1\text{kN/m}^2$$

Moment steel :

$$\text{Net contilever} = \frac{2100 - 300}{2} = 900\text{mm}$$

$$M_{UX} = M_{UY} = \frac{0.9^2}{2} \times 238.1 \times 2.1 = 202.5\text{kNm}$$

The resisting section has a width = 300mm + 150 mm = 450 mm

$$\text{Depth required} = \sqrt{\frac{202.5 \times 10^6}{450 \times 2.76}} = 403.8\text{mm}$$

Try an overall depth of 600mm.

d_x = 600 – 50 – 6 = 544 mm.

d_y = 544 – 12 = 532 mm (second layer)

$$\frac{Mu}{bd^2} = \frac{202.5 \times 10^6}{450 \times 532^2} = 1.59$$

pt = 0.491

$$Ast = \frac{0.491}{100} \times 450 \times 532 = 1175.45\text{mm}^2$$

Assume depth at edge of footing = 230mm

$$\text{Average depth} = \frac{230 + 600}{2} = 415\text{mm}$$

$$\text{Minimum steel} = \frac{0.12}{100} \times 2100 \times 415 = 1046\text{mm}^2$$

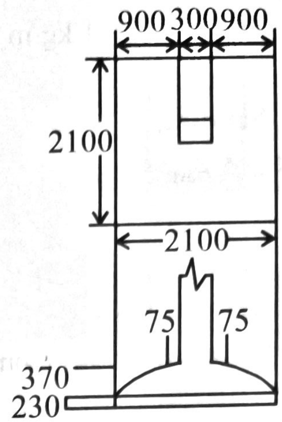
Provide 11 nos 12 diameter bars

Ast = 1244 mm^2 > 1176 mm^2 ....(ok)

Development length = 47 × 12 = 564 mm

Available anchorage = 900 – 50 (cover)

= 850 mm > 564 mm ....(ok)



One-way shear :

Shear force at 532 mm from face of the column

V_u = 00.368 × 2.1 × 238.1 = 184 kN

b = 300 + 2 × 532 = 1364 mm

$$d = 165 + \frac{368}{900} \times 370 = 316.3\text{mm}$$

$$Mu = \frac{0.368^2}{2} \times 238.1 \times 2.1 = 33.86\text{kNm}$$

$$\tau_V = \frac{V_u - \frac{m_u}{d}\tan\beta}{bd}$$

$$\tan\beta = \frac{370}{900} = 0.411$$

$$\mu_V = \frac{184 = \frac{33.86}{0.316} \times 0.411}{1364 \times 310} \times 10^3$$

= 0.33 N/mm^2

The bars have all bend at the end

$$\frac{100As}{bd} = \frac{100 \times 1176}{1364 \times 310} = 0.278$$

τ_c = 0.374 N/mm^2

$\tau_v < \tau_c$ .... ok

Two-way shear :

Avg. depth = 0.5 (544 + 532) = 538 mm

Two-way shear is checked at

$$= \frac{d_{avg}}{2} = \frac{538}{2} = 269\,mm$$

From face of column

shear force = $(2.1^2 - 838^2) \times 238.1$

= 883.35 kN

d= 4 × 838 = 3352 mm

$$d = 165 + \frac{631}{900} \times 370 = 424.4mm$$

Actual shear stress

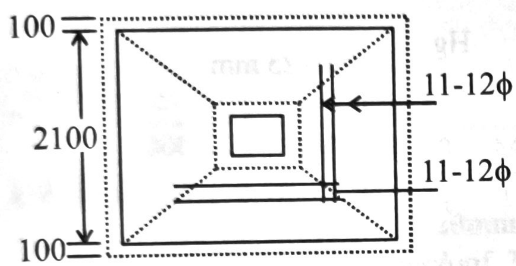
$$\mu_v = \frac{883.35 \times 10^3}{3352 \times 424.4} = 0.621 N/mm^2$$

design shear strength

$k\tau_c = 0.968 N/mm^2\ \tau_v$ ....ok

$$\text{Spacing of bars} = \frac{2100 - 100 - 12}{11} \text{ ....ok}$$

= 180.7 mm < 3 ×165 or 300 mm ....ok



3.(a) State the shape of the footing adopted if the width of the foundation for two equal column is restricted.

Ans. Trapezoidal shape of the footing adopted if the width of the foundation for two equal column is restricted.

(b) A double cover butt joint is used to connect two plates 24mm thick. Design the joint.

Ans. Step : 1 : Diameter of rivet :

Size of rivet, suing Unwins formula

$$d = 6\sqrt{t}$$

$$d = 6\sqrt{24} = 29.59 \text{ mm} \approx 30\text{mm}$$

adopt nominal diameter of rivet = 30mm

Gross diameter of rivet = 30 + 2 = 32mm.

Step - 2 : Rivet value. In double cover bult joint, rivets are in double shear as per IS : 800 - 1984.

Shear stress for power driven rivet = 100 N/mm²

Bearing stress for power driven rivet = 300N/mm²

Strength of plate in tension

= 0.6 × 260 n/mm² = 156 N

Strength of rivet in double shear

$$P_s = \frac{2\pi}{4} \times (32)^2 \times \frac{100}{1000} = 160.84kN$$

Strength of rivet in bearing,

$$P_b = \frac{32 \times 24 \times 300}{1000} = 230kN$$

Step -3 : Gauge distance of rivet Let g be the guage of rivets.

Strength of plate per guage length

Pt= (g–d) + 6t

$$= \frac{(g - 32) \times 24 \times 0.6 \times 260}{1000} kN$$

= 3.744 (g–32)kN

Keep strength of plate Pt = Ps or Pb whichever is less or 3.744 (g–32) = 160.84

or g = 7490mm

Adopt guage g = 75mm

Adopt thickness of each cover plate

$$= \frac{5}{8} \times 24 = 15mm$$

(c) Design a gusseted base of a column consisting of ISHB 400 × 82.2 kg/m with flange plate 300 mm × 16 mm on each flange. The column carries a load of 2000 kN and is supported on concrete pedestal with a bearing capacity of 40MPa.

Ans. Dtat given

Column section : ISHB 400 @ 82.2 kg/m

Cover plate = 300 mm × 16 mm

Load = 2000 kN

Bearing strength of conc. = 4 MPa = 4 N/mm²

Assume bending stress = 185 N/mm²

Shearing strength of rivet = 100 N/mm²

Bearing strength of rivet = 300 N/mm²

Dia of rivet (Q) = 18 mm

d = 18 + 1.5 = 19.5 mm.

Step - 1

Load = 200 kN

$$A_{req} = \frac{\text{Load}}{\delta_{Ce}} = \frac{2000 \times 10^3}{4} = 50 \times 40^4\,mm^2$$

$L_B = 850$ mm, $B_B = 650$ mm.

$(\text{Area})_{\text{Provided}} = 850 \times 650 = 552500\ \text{mm}^2$.

Step - 2

Upward Pressure

$$\frac{\text{Load}}{\Delta_{\text{Provided}}} = \frac{2000 \times 10^3}{552500} = 3.6\ \text{N/mm}^2 < \delta_{Ce}$$

Step - 3

No. of rivet required to correct the gusset plate

$$\text{with flange of the column} = \frac{\text{Load}}{\text{Strength of each rivet}}$$

$$\text{Load} = \text{up} \times 2 \times \left\{\frac{L_B}{2} \times \frac{B_B - B_f}{2}\right\}$$

$$= 3.6 \times 2 \times \left\{\frac{850}{2} \times \frac{650 - 400}{2}\right\}$$

$= 382.5 \times 10^3$ N

F_s = (Shearing strength of each rivet sub.single shear)

$$= \tau_{Vf} \times \frac{\pi}{4} \times d^2 \times n \times n'$$

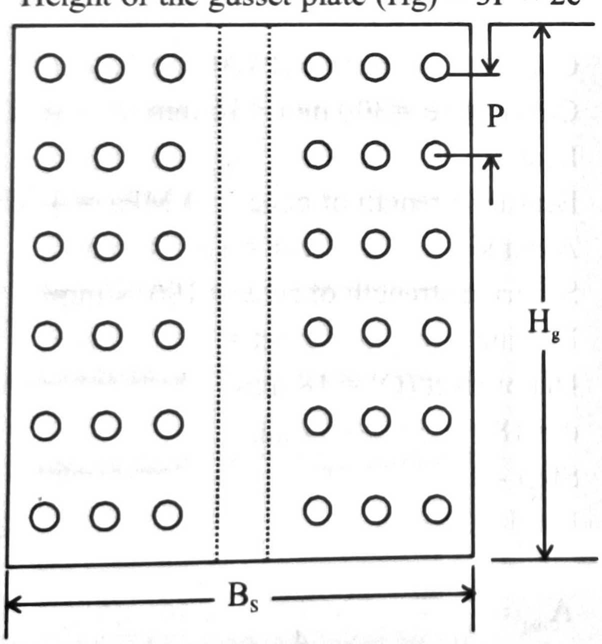
$$= 100 \times \frac{\pi}{4} \times (19.5)^2 \times 1 \times 1$$

$= 29.865 \times 10^3$ N.

$$\text{No. of rivet} = \frac{382.5 \times 10^5}{29.865 \times 10^3} = 13$$

The arrangement is 4 × 4

Height of the gusset plate (Hg) = 3P × 2e



$P = P_{min} = 2.5\phi = 2.5 \times 18 = 45$ mm

e = edge distance = 32 mm

$Hg = 3P + 2e = (3 \times 45) + (2 \times 32)$

$= 199 \simeq 250$ mm

Step - 4

Thickness of the gusset plate

$$\frac{M}{I} = \frac{f}{y}$$

$f = 185\ \text{N/mm}^2$

$$M = \text{up} \times \frac{L_B}{2} \times \left(\frac{B_B - B_f}{2}\right) \times \left(\frac{B_B - B_f}{4}\right)$$

$$= 3.6 \times \frac{850}{2} \times \left(\frac{650 - 400}{2}\right) \times \left(\frac{650 - 400}{4}\right)$$

$= 119.53 \times 10^5$ N.mm.

$$I = \frac{t_g (Hg)^3}{12} = \frac{t_g \times (250)^3}{12} = 1302083.3\, t_g \text{mm}^4$$

$$y = \frac{Hg}{2} = \frac{250}{2} = 125\ \text{mm}$$

$$\frac{M}{I} = \frac{f}{y}$$

$$\Rightarrow \frac{119.53 \times 10^5}{1302083.3 t_g} = \frac{185}{125}$$

$\Rightarrow t_g = 6.2\ \text{mm} \simeq 20\ \text{mm}$

4.(a) What is the minimum and maximum value of pitch of rivet in a rivet line for a tension member ?

Ans. $P_{min} = 2.5\ \phi$

Where $\phi \rightarrow$ Nominar dia of rivet.

P_{max} (For tension member) = 16 t or 200 mm which is less where t → Minimum thick ness of connecting member.

(b) A column 1450mm × 150 mm is made of babul wood. The unsupported length is 3.7 m. Determine the safe axial load on the column.

Ans. Slenderness ratio : Effective length of column, L = 3.7M = 3700mm

Least dimension of column d= 150MM

Maximum slenderness ratio, $\frac{L}{s} = \frac{3.7 \times 1000}{150}$

$= 24.67 > 11$

For babul wood, safe working stress in axial compression parallel to the grains feb = 11.2N/mm² and E = 10800 N/mm².

$$K_8 = 0.582\left[\frac{E}{f_{cp}}\right]^{1/2}$$

$$= 0.582\left[\frac{10800}{11.2}\right]^{1/2} = 18.074$$

The slenderness ratio of the column is greater than K_8

The column is treated as a long column

Permissible stress on the column :

$$F_c = \frac{0.329E}{\left(L/d\right)^2} = \frac{0.329 \times 10800}{(24.67)^2} = 5.84\ N/mm^2$$

Safe axial load on the column :

$$P = \frac{5.84 \times 150 \times 150}{1000} = 131.36kN$$

(c) A column section ISHB 300 @ 0.630 kN/m with one cover plate 500mm × 20mm on each side is carrying an axial load of 3000 kN inclusive of self weight of base and column. Design a gussetted base. The allowable bearing pressure in bending in concrete is 4N/mm². The allowable bending stress in base plate is 185 N/mm².

Ans. Area of the base plate regd.

$$= \frac{3000 \times 1000}{4} = 750000\ mm^2$$

Let is provide 12mm thick guser plates and ISA 150 × 15 angles for connection.

Minimum width of the base plate regd to accommodate these components

= 300 + 2(20) + 2 × 12 + 2 × 150

= 300 + 40 + 24 + 300 + 664 mm.

Length of the base plate regd =

$$\frac{750000}{664} = 1129.51 = 1150mm$$

Use base plate 1150 × 664

Actual bearing pressure intensity on the base plare.

$$= \frac{3000 \times 10^3}{1150 \times 664} = 3.93N/mm^2$$

Cantilever proj = 150 – 12 = 138 mm.

Consider a cantilever strep of base plate 1 mm wide and 138 mm long.

Two critical sections :

Section. 1–1:N/Mat 1–1

$$= \frac{3.93 \times 138^2}{2} = 37421.46mm$$

$$\frac{M}{Z} = \delta_{bc} \qquad \left(Z = \frac{bt^2}{6}\right)$$

(b = 1)

$$= \frac{37421.46 \times 6}{1 \times t^2} = 185 \Rightarrow t^2 = 1213.669$$

t = 34.84 mm

Thickness of base plate = 34.84 – 12 = 22.84 mm ≃ 25mm

Section. 2 – 2 : Bending Moment at 2.2

$$= \frac{3.93 \times 364^2}{8} - \frac{3.93 \times 150^2}{2}$$

= 65088.66 – 44212.5 = 20876.16 Nmm.

Hence the thickness calculated.

Hence use 1150 × 664 × 30 mm base plate.

Assuming **Column end machined for** complete bearing. Load transmitted by fastenings through gusset plates.

= 50% of column load = 0.5 × 3000 = 1500 kN.

$$\text{Strength of rivet in single shear} = \frac{100}{1000} \times \frac{\pi}{4}(19.5)$$

(using 18 mm ϕ rivets)

= 29.86 kN

$$\text{Strength in bearing} = \frac{300}{1000} \times 19.5 \times 12 = 70.2kN$$

Rivet Value = 29.86 kN

No. of rivets regd to transmit 1500 mN load to the gusser plants.

$$= \frac{1500}{29.86} = 50.23\ \text{rivets}$$

pression flange partially resumed

imple supported beam with ends of nge partially restrained against lateral = 0.855 L.

→ unsupported length of the column.

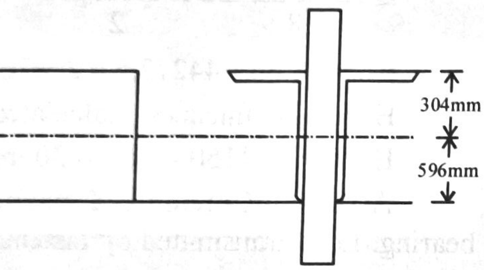
mber of a roof truss consists of 2 n × 60mm × 10mm. The tie member ted to apull of 200kN. The angles ected either side of a gusset plate ick. Design the welded connection.

of weld : The size of weld should not kness of the rolled steel section at the

= 9mm.

s :

veld of 6mm size is provided on both ngle section carries a pull of 100 kN.



e

$$\frac{P.b\times1000}{)\times0.7\times6\times100}\Big]$$

$$\frac{\times1000}{6\times100}=157.67mm$$

$$\frac{30.4\times100}{7\times6\times100}$$

e effective lengths of welds.

consists of 14mm thick flat and ll of 600 kN and is connected to a by a double cover butt joint. The

Working Stresses in bearing in rivet = 300N/mm²

Working stresses in tension in plate = 0.6× 260N/mm²

Step-1 : Rivet value

Use 22 mm diameter of rivets

Strength of power driven shop rivets in double shear

D = 22 + 1.5 = 23.5 mm

$$= 2\times\left((23.5)^2\times\frac{\pi}{4}\times\frac{100}{1000}\right)=86.70kN$$

Strength of power driven shop rivets in bearing

$$= 23.5\times14\times\frac{300}{1000}=98.7kN$$

Rivet value = 86.7 kN

Step - 2 : Number of rivets

Number of rivets required to transmit pull of 600kN

$$N=\frac{600}{86.7}=6.9=7\text{rivets}$$

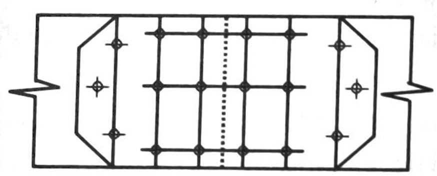
Using diamond group of riveting, flat is weakened by one rivet hole.

Step -2 : Strength of plate

Strength of plate at sec 1–1 in tearing

Pt = (b –23.5) × kN

$$\left(\frac{14\times0.6\times260}{1000}\right)=2.184(b-23.5)kN$$



P = 600 KN, Z = 184 (b – 23.5) = 600

$$b=\frac{600}{2.184}+2.184\times23.5$$

= 236.049 MM

Provide 350 MM width of diagonal member

Step - 4 : Efficiency of joint

$$n = \frac{(b-d)t.pt}{b.t.pt} = \frac{(350-23.5)}{350} \times 100$$

$= 93.286\ \%$

6.(a) What is the minimum depth of foundation for a soil with s.b.c. of 150 kN/m², unit weight of 20 kN/m³ and ϕ = 30° ?

Ans. $$D = \frac{9}{r}\left(\frac{1-\sin\phi}{1+\sin\phi}\right)^2 = \frac{150}{20}\left(\frac{1-\sin 30^{\circ}}{1+\sin 30}\right)^2$$

$$= 7.5 \times \left(\frac{1}{2} \times \frac{2}{3}\right)^2 = 0.833\text{m}$$

(b) A column 120mm in diameter is made of deodar wood. The effective length of column is 1.20m. Determine the safe axial load of the round column. The column is situated in outside location. Take safe working stress in axial compression parallel to the grains for outside location f_{cp} = 7N/mm².

Ans. Slendernes ratio :

Sectional area of round column = $\frac{\pi}{4}D^2$

$$= \frac{\pi}{4} \times 120^2 = 113\,10\text{mm}^2$$

Let d be the dimension of a square column of equivalent cross-sectional area to that of round column.

Sectional area od square column = d² mm²

d² = 11310

ord = 106.35mm

The effective length of columns is 1.2m and least dimension is 106.35mm.

Maximum slenderness ratio, $\frac{S}{d} = \frac{1.20 \times 1000}{106.35}$

$= 11.28 > 11.$

Safe working stress :

For deodel wood, safe working stress in axial compression parallel to grain, fep = 7N/mm² & E = 10800N/mm².

$$K_8 = 0.584\left[\frac{E}{Fep}\right]^{1/2}$$

$$= 0.584\left[\frac{10800}{7}\right]^{1/2} = 22.94$$

The slenderness ratio of the column is greater than 11 and it is less than K_8.

$$f_c = 7\left[1 - \frac{1}{3}\left(\frac{1.2 \times 1000}{22.94 \times 106.35}\right)^4\right]$$

= 7 [1 – 0.0195]

= 6.86 N/mm²

Safe axial load on the column :

$$P = \frac{6.86 \times 106.35 \times 106.35}{1000}$$

= 77.6kN

(c) Design single flight of dog legged staircase for an intermediate floor with following data : Tread = 250mm, Rise = 150 mm,. Width of flight as well as landing = 1.2 mtr, Use M20 & Fe415. The landings span in the direction of flight and are supported on masonry walls 300 mm thick with level difference of 1.5 mtrs.

Adopt limit state method and show detailing.

Ans. Data given

Trade (T) = 250 mm

Rise (R) = 150 mm

Width of flight = 1.2 m

Thickness of masonary wall = 300 mm

Effective span = 1.5 m

Assume thickness of waist slab (W) = 150 mm

Step - 1

Load Calculation

Self weight = 0.15 × 25 = 3.75 kN/m²

Assume floor finish = 1.00 kN/m²

Live load = 3.00 kN/m²

7.75 kN/m²

Ultimate load = 1.5 × 7.75 = 11.63 kN/m²

Step - 2

Bending moment Calculation

$$\text{B.M.} = \frac{WL^2}{8} = \frac{11.63 \times (15)^2}{8} = 3.3\text{ kNm}$$

Step - 3

Depth Calculation

$$M_{4\lim} = 0.36 f_{Ck} \frac{X_{4\max}}{d}\left[1 - 0.42\frac{X_{4\max}}{d}\right] bd^2$$

⇒ 3.3 × 10⁶ = 0.36 × 20 × 0.48 [1 – (0.42 × 0.48)] 1000 × d²

⇒ d = 34.58 mm ≃ 75 mm

But w = 150 mm

d = 150 – 15 – 6 = 129 mm

Step - 9

Steel Calculation

$$\frac{M_4}{bd^2}=\frac{33\times10^6}{1000\times(75)^2}=0.6$$

$P_1 = 0.172$

$$A_{st}=\frac{0.172}{100}\times1000\times75=130\ mm^2$$

$$(A_{St})_{min}=\frac{0.12}{100}\times1000$$

7.(a) How slenderness ratio influences design of steel structural compression members.

Ans. The slenderness ratio of a compression member is defined as ratio of effective length of compression member to appropriate radius of a compression member should be as small as possible so that the material may be stressed to its greatest possible limit.

(b) State the assumptions in the theory of riveted joints.

Ans. Assumption in the theory of riveted joints.

The tensile stress is uniformly distributed on the portion of the plate between the rivets.

The friction between the plates is neglected.

The shearing stress is uniformly distributed on the cross-section of the rivets.

The rivets fill the holes completely.

The rivets in a group share the direct load equally.

Bending stress in rivets is nelgected bending stress distribution is uniform & the contact area is d × t where 'd' is the diameter & 't' is the thickness of the plate.

(c) Design the RCC footing for a masonary wall 300 cm thick subjected to a load of 80 kN/m including self weight. The SBC of soil is 150kN/m².

Ans. Wall load = 80kN/m (Including Self weight)

S_{BC} = 150kN/m²

Wall thickness = 300 mm

Step- I :

Assume in length of footing.

$$(Area)_{req}=\frac{Load}{S.B.C.}=\frac{1.5\times80}{150}=0.8m\ i.e.\ width$$

Step - II : Upward Pressure :

$$q=\frac{Load}{A_{Provide}}=\frac{80}{1\times0.8}=100kN/m^2<S_{BC}$$

Step-III : Bending Moment $= q\times\frac{B-b}{2}\times\frac{B-b}{4}$

$$=100\times\left(\frac{0.8-0.3}{2}\right)\times\left(\frac{0.8-0.3}{4}\right)=3.125kN.m$$

Step-IV : Depth Calculation :

$$M_{u\,Lim}=0.36f_{CK}\frac{X_{u\,Max}}{d}\left[1-0.42\frac{X_{u\,Max}}{d}\right]bd^2$$

$\Rightarrow 3.125 \times 10^6 = 0.36 \times 20 \times 0.48$ $[1-(0.42 \times 0.48)] \times 1000 \times d^2$

$\Rightarrow$ d = 33.65 mm ≃ 100 mm

Step - V : Steel Calculation :

$$\frac{M_u}{bd^2}-\frac{3.125\times10^6}{1000\times(100)^2}=0.33$$

P_t = 0.0934

A_{st} = 93.4 mm²

Spacing =

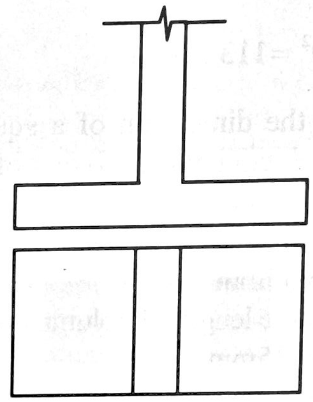
$$\frac{\pi/4\times10^2}{A_{St}}\times1000=840.1mm=845mm$$

$(S_d)_{Max}$ = 3d or 300 = 3 × 100 = 300

Provide 10mm # @ 300 mm c/c as main reinforcement.

Step-VI : Check for one-way shear :

$i_v \le ki_c$



$$i_v=\frac{V}{bd}$$

$$V=q\times1\times\left(\frac{B-b}{2}\right)-d=100\times1\times\left(\frac{0.8-0.3}{2}\right)-0.1$$

= 24.9 kN

$$i_v=\frac{24.9\times10^3}{1000\times100}=0.249N/mm^2$$

K=1.30 (For D= 150 mm)

i_c = ?

P_t = 0.934

i_c = 0.28 N/mm²

Ki_c = 1.3 × 0.28 = 0.364 N/mm² > i_v (It is satisfy)

PRACTICE SETS

SET – 1

(CET - 602)

Full Marks : 70 **Time : 3 hours**

Answer any **five** questions

The figures in the right-hand margin indicate marks.

1. (a) State the types of bolts used in strucutre. [2
(b) State and sketch double lap joint. [5
(c) Design a double cover butt joint between two mild steel plates 320 mm wide and 18 mm thick. [7

2. (a) Define the failure of joint in adge cracking. [2
(b) State the assumptions in the theory of riveted joints. [5
(c) Design square footing for a RCC column 250 mm × 250 mm carrying a load of 250 kN founded on a soil of SBC 160 kN/m² in LSM. Use M_{25} and FE_{415} and give a neat sketch of the detailing. [7

3. (a) Sketch the basic sections and symbols for single V-butt weld. [2
(b) State and sketch the common sections of tension members. [5
(c) Design a dog legged staircase by LSM for a public building of ceiling height 3.3 mtrs. The width of each flight is to be kept 1.5m. Choose suitable rise and tread. Use M_{20} and Fe_{415}. Give a neat sketch of the detailing. [7

4. (a) Sketch the basic sections and symbols for single V-butt weld. [2
(b) A single angle strut ISA (50 mm × 50 mm × 6 mm) of a room struss is 1.10 m long. It is connected by one rivet at each end. Determine the safe load that strut can carry. [5
(c) Design uniform depth RCC footing for a masonary wall 25cm thick subjected to a load of 100 kN/m inclusive of self weight. The SBC of soil is 120 kN/m². [7

5. (a) What is the value of effective length of compression member in case of effectively held in position at both ends restrained against rotation at one end. [2
(b) Find the safe axial load on a circular sal column of diameter 15 cm and length 3.5 m. [5
(c) In a roof truss, a diagonal consists of an ISA 150mm × 75mm × 10mm and is connected to a gusset plate by one leg only by 18 mm diameter rivets in one chain line along the length of member. Determine the tensile strength of the member. [7

6. (a) What is the value of maximum slenderness ratio for a member carrying compressive loads resulting from dead load and superimposed loads ? [2
(b) A single angle strut ISA (50 mm × 50 mm × 6 mm) of a room struss is 1.10 m long. It is connected by one rivet at each end. Determine the safe load that strut can carry. [5
(c) Design the RCC footing for a masonary wall 300 cm thick subjected to a load of 80 kN/m including self weight. The SBC of soil is 150kN/m². [7

7. (a) What are the types of column bases usually used ? [2
(b) Compare riveted joints with welded joints. [5
(c) 2 ISA 90 mm × 90 mm × 8 mm transmitting tensile force are connected to the gusset on either side by fillet welding. Design the joint for maximum efficiency. [7

SET – 2

(CET - 602)

Full Marks : 70 **Time : 3 hours**

Answer any **five** questions

The figures in the right-hand margin indicate marks.

1. (a) Enumerate the four type of rivets. [2
(b) Briefly discuss different ways of failure of rivetted joint with diagram. [5
(c) Design a lap joint for two plates of size 100mm × 8 mm and 100mm × 12mm. the permissible stresses for plates in tension and weld are 160 MPa and 110 MPa respectively. [7

2. (a) What is the recommended throrat thickness for incomplete penertration butt welds welded from one side only ? [2
(b) Calculate the maximum tensile load that can be taken by an ISA 125 mm × 75 mm × 10 mm connected through longer leg by fillet welding. [5

(c) Design a slab base for a column consisting of ISHB 300 @ 0.577 kN/m and carrying at axial load of 1400 kN. The column is to be supported on a concrete footing with permissible bearing pressure of 4.0 N/mm². The safe bearing capacity of soil is 250 kN/m². [7

3. (a) Define and state the significance of slenderness ratio. [2

(b) Calculate the pitch for a double rivetted double cover butt joint. The pitch of rivet of inner row is half the pitch of rivet in the outer row and the thickness of the plates is 12 mm. Thickness of each cover plate is 8 mm. [5

(c) Design an unequal angle section to act as a tie member 1.60 m long in a roof truss if it is to carry an axial load of 130kN. Use hand driven rivets at joints. [7

4. (a) Why tubular steel section is preferred as compression member in place of rolled steel section ? [2

(b) Design an unequal angle section to act as a tie member 1.6 m long in a roof truss if it is to carry an axial load of 120 kN. Use power driven shop rivet at joints. Show detail diagram of the joint.[5

(c) A straight stair in a residential building is supported on wall on one side and stringer beam on the other side. The risers are 150 mm and treads are 250 mm and the horizontal span of the stair may be taken as 1.2 m. Design the steps. Use M20 concrete and HYSD bar. Also show reinforcement detailing. Use LSM. [7

5. (a) What is the objective of providing tack rivets in steel structural members ? [2

(b) A double angle discontinuous struct consist of two angles ISA 80 × 80 × 6 mm and connected by both sides of gusset plate 10 mm thick by two rivets. The length of the strut between centre to centre intersections is 2.8 m and is track rivetted. Calculate the compressive load carrying capacity of the strut for steel of grade f_y = 250 N/mm².[5

(c) A timber beam having a clear span of 6.0 m carries a uniformly distributed load of 15 kN/m including the self weight of beam. Assuming the beam to be made of Deodar wood, design the beam. [7

6. (a) What is the minimum edge distance for rivetted joint and why it is provided ? [2

(b) Design a lap joint for connecting two flats of size 150 × 8 mm and 150 × 12 mm. [5

(c) A strut of roof truss carries an axial compression load of 180 kN> Design a suitable double angle section for the compression member. The length of strut between centre to centre of intersection is 2.35 m and the yield stress of steel is 250 MPa.[7

7. (a) State the basic difference between slab base and gusseted base. [2

(b) A timber column 200 × 200 mm section having an unsupported length of 3.5 m. Find the safe axial load for the column assuming it to be sal wood.[5

(c) A RCC column 500 × 500 mm in section, carries an axial load of 600 kN. Design an isolated footing of uniform thickness for the column. The safe beariing capacity of soil is 120 kN/m². Use M15 concrete and mild steel. [7

SET – 3

(CET - 602)

Full Marks : 70 **Time : 3 hours**

Answer any **five** questions

The figures in the right-hand margin indicate marks.

1. (a) Mention the types of buckling in a compression member. [2

(b) Explain buckling class of cross-sections in compression member. [5

(c) Calculate the design compressive load for an ISHB 250 @ 536.6 N/m, 4 m high. The column is restrained in erection only at both the ends. It is to be used as an uncased column in a single storey building. [7

2. (a) Where do you recommended base plate ? [2

(b) Explain special considerations in steel design.[5

(c) Design a slab base for a column ISHB 350 @ 710.2 N/m subjected to a factored load of 15000 kN/ M25 concrete is used for the foundation. Provide welded connection between column and base plate. [7

3. (a) Two plates of 8 mm and 18 mm thickness are to be jointed using longitudinal fillet weld. Suggest a suitable size of weld. [2

(b) Write down the advantages of welded connections over bolted connections. [5

(c) Calculate the strength of a 20 mm diameter bolt of grade 4.6 for double cover butt joint each of the cover plate being 8 mm thick and main plates to be jointed are 12 mm thick. [7

4. (a) Define net section area of a tension member.[2

(b) Write down the advantages of steel structures.[5

(c) A tension member 0.8 m long to resist a service load of 20 kN and a service like load of 50 kN. Design a rectangular bar of standard structural steel of grade Fe-410. Assume that the member is connected by one line of 16 mm diameter bolts of grade 4.6. [7

5. (a) Define web buckling. [2

(b) State the assumptions in the theory of riveted joints. [5

(c) Design a simply supported beam of effective span 2.5 m carrying a factored concentrated load of 300 kN at mid-span point. Assuming it to be laterally supported. [7

6. (a) What will be the effective span of a staircase supported at top and bottom risers by beam spanning parallel with the riser ? [2

(b) If four planks 160 mm × 40 mm are to be formed in the shape of a box, find the maximum load for the mango timber with unsupported length of 3.5 m and inside location. [5

(c) Design a square footing for a RCC column of 400 mm × 400 mm carrying a load of 1000 kN. The SBC of the soil is 100 kN/M2. Use M20 grade concrete and Fe 415 grade steel for both column and footing. Use LSM. [7

7. (a) Where will be the location of critical section of bending moment for RC wall ? [2

(b) Draw the reinforcement detailing of a Tread-riser staircase showing various components of the staircase. [5

(c) Design a dog-legged staircase by LSM for residential building of ceiling height 3m and width of each flight is to be kept 1.5 m. The rise and tread of 140 mm and 300 mm. Use M25 and Fe 415 grade of steel. [7

SET – 4

(CET - 602)

Full Marks : 70 **Time : 3 hours**

Answer any **five** questions

The figures in the right-hand margin indicate marks.

1. (a) State the location of critical section for bending for footings under masonry walls and concrete walls. [2

(b) Show the typical reinforcement detailing of a tread-riser staricase. [5

(c) Design a square footing for a RCC column 300 × 300 mm carrying a load of 400 kN founded on a soil of SBC 100 kN/m^2 in LSM. Use M-20 an d Fe-415 and give a neat sketch of detailing. [7

2. (a) State and magnitude of live load (uniformly distributed as well as concentrated) to be considered in the design of a staircase for one office building likelty to be over crowded. [2

(b) State and sketch the different types of footings.[5

(c) Design the single flight of a dog-legged staircase for an intemediate floor with the following data: Tread = 250 mm, Rise = 150 mm, Width of flight = 1.0 mm. The leadings span in the direction of flight and are supported on masonry walls of 250 mm thick with level difference of 1.6 metres. Use M-20 and Fe-415. Assume residential building and adopt LSM. [7

3. (a) What do you mean by action in the limit state method of design ? [2

(b) List the assumptions made in the design of bearing bolts along with their limitations. [5

(c) A sal. wood (M.P.) column is 150 mm × 200 mm. Determine the safe axial load on the column if the unsupported length of the column is (i) 1.6 m and (ii) 2.8 m assuming inside location and timber of standard grade (Grade-I). [7

4. (a) List two important advantages of welding over bolting. [2

(b) What is block shear failure ? Explain with sketches for the cases of bolted and welded connections ? [5

(c) A laterally supported beam ISMB 600 @ 1202.71 N/m is placed between two supports. Determine the safe uniformly distributed load per meter length which can be placed over the beam for an effective span of 10 m. Take f_y = 250 N/mm². Neglect web buckling and web crippling. [7

5. (a) Determine the buckling class of IS HB 225 @ 459 N/m. [2

(b) What do you mean by slip critical connections ? Explain the principle of high strength friction grip bolts. [5

(c) Design a welded lap joint for two plates of size 200 mm × 8 mm and 200 mm × 12 mm for maximum efficiency. Assume shop welding and Fe-410 grade of steel. [7

6. (a) Distinguish between slab base and gusseted base. [2

(b) Determine the plastic section modulus of a T-section having flangle width 150 mm, flange thickness 16 mm, depth of web 150 mm and width of web 12 mm. [5

(c) Find the maximum force that can be transmitted through a double bolted chain lap joint consisting of 6 bolts in 2 rows connecting two plates of thickness 12 mm and 10 mm. Given that M-16 bolts of grade 4.6 and plates of Fe-410 are to be used. [7

5. (a) What do you mean by grading of timber ? [2

(b) Explain the special considerations that are to be taken care of in steel design. [5

(c) Design a steel column using channel section only to carry a factored axial load of 350 kN. The column is 3.5 m long and is effecetively held in position and restrained against rotation at both the ends. Take f_y = 250 MPa and assume wind/earthquake actions. [7

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