Model Set Questions with Answers

MODEL – 1

[CET - 501]

Full Marks – 70 **Time – 3 Hours**

*Answer any **five** questions.*

Figures in the right-hand margin indicate marks.

1. (a) Mention any two advantages of doubly reinforced beam. [2

(b) Establish the comparision between working stress method and limit state method. [5

(c) Find the depth of neutral axis of a singly reinfored RC beam of 230 mm width and 450 mm effective depth. It is reinforced with 4 bars of 16mm diameter. Use M-20 concrete and Fe-415 bars. Use WSM and state type of beam is it. [7

2. (a) What do you know by M-15 grade of concrete ?[2

(b) Explain the assumption in LSM of design. [5

(c) A singly reinforced concrete beam 250 mm width is reinforced 4 bars of 25 mm diameter at an effective depth of 400 mm. If M-20 grade concrete and Fe-415 bars are used, compute ultimate moment of resistance of the section in LSM. [7

3. (a) Define moment of Resistance. [2

(b) State the assumptions made in limit state of collapse : Flexure. [5

(c) Ashort RCC column of size 400 mm × 400 mm has to carry an axial factored load of 2000 KN. Assuming $l_{min} < 0.05$ D, design the column using M20 grade of concrete and HYSD grade of steel Fe 415. [7

4. (a) State reasons why overreinforced section is not allowed in limit state method of design. [2

(b) A simply supported rectangular beam (250 mm × 450 mm) reinforced with 4 nos of 16 mm dia bars as tension reinforcement is subjected to an all inclusive load of 20 KN / m over a span of 3.5 m. Design suitable shear reinforcement. The materials are M20 and Fe 415. [5

(c) A RCC column of diamensions 250 mm × 500 mm is reinforced with (4 – 16 + – 12) bars equally distrubuted on all sides. Calculate and show the details of transverse reinforcement with the help of a sketch. [7

5. (a) What are the codal provisions of stripping time for removal of props to beams ? [2

(b) A doubly reinforced beam section 250 mm wide and 450 mm deep to the centre of the tensile reinforcement. It is reinforced with 2 bars of 16 mm diameter as compressions reinforcement at an effective cover of 50 mm and 4 bars of 25 mm diameter as tensile steel. Assume M 20 concrete and Fe 415 steel. Calculate moment of resistance of the beam section. [5

(c) Design a RCC column of the following specification using LSM.

(i) Axial factored load = 1800 kN

(ii) Effective length = 2.25 m

(iii) Grade of steel = Fe 415

(iv) Grade of concrete = M 25. [7

6. (a) Write the purpose of providing distribution steel in RCC slabs. [2

(b) A short RCC column 450 mm × 450 mm is provided with 8 bars of 16 mm diameter. If the effective length of the column is 2.5 m, find ultimate load for the column. Use M 20 concrete and Fe 415 steel. Solve by LSM method. [5

(c) ARCC beam of overall dimensions 250 mm × 400 mm is subjected to a bending moment of 50 KN - m. Using M20 and Fe 415, design the section by working stress method and show details of reinforcement by a neat sketch. Assume suitable cover for mild exposure condition. [7

7. (a) Give reasons why over reinforced section is not allowed in limit state method of design. [2

(b) A simply supported rectangular beam (250 mm × 400 mm) reinforced with 5 nos. of 16 mm dia bars as tension reinforcement is subjected to an all inclusive load of 16 kN/m over a span of 5 m. Design for the shear reinforcement by using a

ing stress method of design and show the
of main reinforcement by a neat sketch.
suitable cover for moderate exposure
ı. [7

VERS TO MODEL – 1

n any two advantages of doubly ed beam.

higher value of factor of safety for en adopted than steel because there are of variation of strength of concrete due mpaction, inadequate curing, improper ning and variations in the properties of

the comparision between working ethod and limit state method.

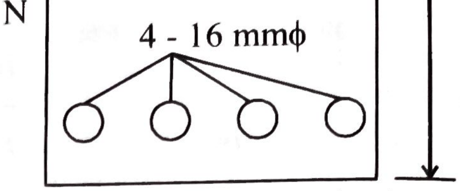
lesigning the structural elements in such tresses in the materials are not greater stresses. Here the material are assumed the design method is known as working elastic theory of design.

eptable limit for the safety and quirements before failures occurs is state. In this method of design, the ned to withstand safely all loads liable ghout its life. The structure also has to ne serviceability requirements such as lection and cracking.

depth of neutral axis of a singly RC beam of 230 mm width and 450 tive depth. It is reinforced with 4 16mm diameter. Use M-20 and Fe-415 bars. Use WSM and e of beam is it.

M_{20} mix, m = 13.33

$\frac{\pi}{4}(16)^2 = 804\ mm^2$



Let x be the depth of neutral axis.

Taking moment of transformed are about neutral axis.

$$b.x.\frac{x}{2} = m.\ A_{st}(d-x)$$

$$\Rightarrow \frac{230}{2}x^2 = 13.33 \times 804(450-x)$$

$$\Rightarrow 115\ x^2 = 4822794 - 10717\ x$$

$$\Rightarrow x^2 + 93x - 41937 = 0$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$= \frac{-93 \pm \sqrt{8649 + 167748}}{2}$$

$$= 163\ mm$$

Depth of critical neutral axis

kd = 0.29 × 450 = 130.5 mm

$x_{act} > x_{crit}$

∴ The beam is over-reinforced.

2.(a) What do you know by M-15 grade of concrete ?

Ans. M_{20} means

M → Mix.

20 → Characteristic strength of 150 mm cube at 28 days.

(b) Explain the assumption in LSM of design.

Ans. Assumption for Designing Flexure

⇒ Plane sections normal to the axis remain plane after bending.

⇒ The maximum strain in concrete at the outermost compression fibre is taken as 0.0035 in bending.

⇒ The relationship bet^n the compressive stress distribution in concrete & the strain in concrete may be assumed to be rectangle, traplzoid, parabola or any other shape.

⇒ The tensile strength of the concrete is ingnored.

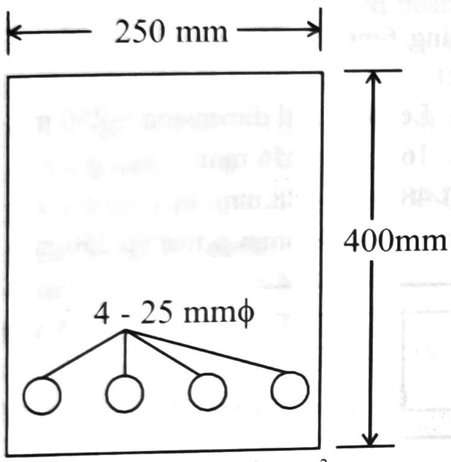
⇒ The stresses in the reinforcement are derived from representative stress-strain curve for the type of steel used.

⇒ The maximum strain in the tension reinforcement in the section at failure shall not be less than.

$$\frac{f_y}{1.15Es} + 0.002$$

(c) A singly reinforced concrete beam 250 mm width is reinforced 4 bars of 25 mm diameter at an effective depth of 400 mm. If M-20 grade concrete and Fe-415 bars are used, compute ultimate moment of resistance of the section in LSM.

Ans.



$A_{st} = 4 \times 490.87 = 1963\ mm^2$

Total compression $= 0.36\ f_{ck}\ b\ x_u$

$= 0.36 \times 20 \times 250\ x_u = 1800\ x_u$.

Total tension $= 0.87\ f_y\ A_{st}$

$= 0.87 \times 415 \times 1963 = 708741$ N.

Total compression = Total tension

$\Rightarrow 1800\ x_u = 708741$

$\Rightarrow x_u = 393.7$ mm

$x_{umax} = 0.48\ d = 0.48 \times 400 = 192$ mm

$x_u > x_{umax}$

The section is over-reinforced and $x_u = 192$ mm.

Lever arm $= z = d - 0.42\ x_u = 400 - 0.42 \times 192$

$= 319.36$ mm

$\Rightarrow M_u = 0.36\ f_{ck}\ b\ x_u\ z$

$= 0.36 \times 20 \times 250 \times 192 \times 319.36 \times 10^{-6}$KNm.

$= 110.37$ KNm.

3.(a) Define moment of Resistance.

Ans. Moment of resistance means couple produce when a beam subject to bending under the action of loads. It is found from the moment of inertia I and the distance from the outside of the object concerned to its major axise W = I/elt is used in structural.

(b) State the assumptions made in limit state of collapse : Flexure.

Ans. Refer to 2018(W), Q. No. 3.(b)

(c) Ashort RCC column of size 400 mm × 400 mm has to carry an axial factored load of 2000 KN. Assuming l_{min} < 0. 05 D, design the column using M20 grade of concrete and HYSD grade of steel Fe 415.

Ans. $A_C = 400 \times 400 - A_{SC}$

$2000 \times 10^3 = 0.4 \times 20\ (400 \times 400 - A_{SC}) + 0.67 \times 415\ A_{SC}$.

$= 286.05\ A_{SC}$.

$\Rightarrow 720000 = 270.05\ A_{SC}$.

$\therefore\ A_{SC} = 2666.17\ mm^2$

Provide 8 nos of 20mm diameter bars with

$$A_{SC} = 8 \times \frac{\pi}{4}(20)^2 = 2670\ mm^2$$

Area of concrete required for direct load

$$= \frac{2000 \times 10^3}{0.4 \times 20} = 25000 mm^2$$

Minimum steel required

$$= \frac{0.8}{100} \times 25000 = 2000 mm^2$$

Lateral ties

$$\phi_{rt} = \frac{\phi}{4} = \frac{20}{4} = 5mm < 6mm$$

Use 6mmϕ MS ties

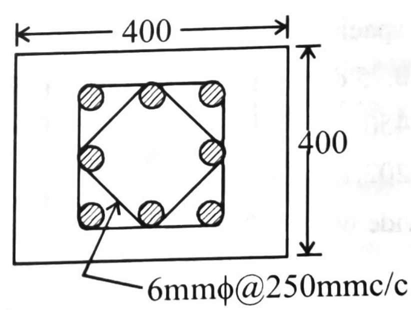
Spacing should not exceed

(i) 400 mm

(ii) 16 × 20 = 3.20 mm

(iii) 300 mm

Use 6mm ϕ @ 250 mm C/C.



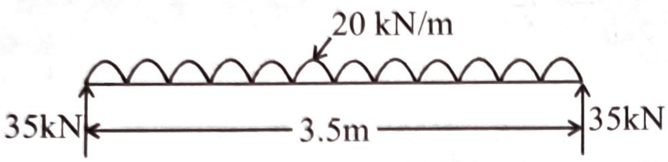
4.(a) State reasons why overreinforced section is not allowed in limit state method of design.

Ans. In case of over reinforced s/c, the steel are provided is more than that required for a balanced section. Hence, the full capacity of steel isn't utilised at same value of loads, the stresses in concrete will reach it's permissible value and fails, while stress in steel is less than it's permissible value. As concrete is a brittle material and therefore the failure is brittle and sudden. Hence over reinforced s/c isn't allowed in limit state method of design.

(b) A simply supported rectangular beam (250 mm × 450 mm) reinforced with 4 nos of 16 mm dia bars as tension reinforcement is subjected to an all inclusive load of 20 KN / m over a span of 3.5 m. Design suitable shear reinforcement. The materials are M20 and Fe 415.

Ans. Size3 of beam, b = 250mm

d = 450 mm



$$\tau_v = \frac{V_u}{bd} = \frac{35 \times 10^3}{250 \times 450} = 6.3\ N/mm^2$$

$$A_{st} = 4 \times \frac{\pi}{4}(16)^2 = 804.24 mm^2$$

$$P_t = \frac{A_{st}}{bd} \times 100 = \frac{100 \times 804.24}{250 \times 450} = 0.71$$

$\therefore\ Z_i$

$Z > Z_v < Z_{mm}$, hence safe.

Using 6mm ϕ mild steel bars for stirrups.

$A_{sv} = 2 \times 28 = 56\ mm^2$ for 2 legged vertical stirrups. Minimum spacing of stirrups.

$$S_v \le \frac{A_{cv} f_y \times 0.87}{0.46} = \frac{56 \times 415 \times 0.87}{0.4 \times 250} = 202.18mm$$

The spacing can be least of

(i) 0.75 d = 0.75 × 450 = 337.5 mm

(ii) 450 mm

(iii) 202.18 mm

Provide 6mm ϕ 2 legged vertical stirrup @ 200 mm C/C.

(c) A RCC column of diamensions 250 mm × 500 mm is reinforced with (4 – 16 + – 12) bars equally distrubuted on all sides. Calculate and show the details of transverse reinforcement with the help of a sketch.

Ans. For column size = 250mm × 500mm

D = 250mm

0.05 D = 0.05 × 250 = 12.5mm ≤ 20mm

hence provide minimum eccentricity = 20mm

$A = 250 \times 250 = 125000\ mm^2$

$$A_{SC} = 4 \times \frac{\pi}{4}(16)^2 + 4 \times \frac{\pi}{4}(12)^2$$

$= 1256.63\ mm^2.$

$A_C = A - A_{SC} = 125000 - 1256.63 = 123743.36\ mm^2.$

$P_u = 0.4\, f_{ck}\, A_C + 0.67\, f_y\, A_{SC}$

$= (0.4 \times 15 \times 123743.36) + (0.67 \times 250 \times 1256.63)$

$= 952.94$ KN.

allowable service load $= \frac{P_u}{1.5} = 635.3KN$

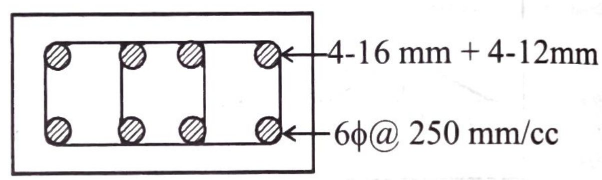
Using 6mm ϕ ties, spacing is the least of the following :

(i) Least lateral dimension = 250 mm

(ii) 16 × 16 = 256 mm

(iii) 48 × 6 = 288 mm

hence provide 6mm ϕ ties @ 250 mm C/C.



5.(a) What are the codal provisions of stripping time for removal of props to beams ?

Ans. Stripping time for removal of prop to beams

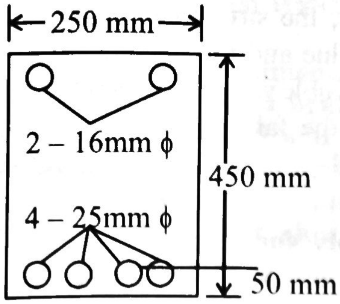
→ Spanning upto 6m = 14 days

→ Spanning over 6m = 21 days

(b) A doubly reinforced beam section 250 mm wide and 450 mm deep to the centre of the tensile reinforcement. It is reinforced with 2 bars of 16 mm diameter as compressions reinforcement at an effective cover of 50 mm and 4 bars of 25 mm diameter as tensile steel. Assume M 20 concrete and Fe 415 steel. Calculate moment of resistance of the beam section.

Ans. $f_{ck} = 20\ N/mm^2$

$f_y = 415\ N/mm^2$



Force of tension = $0.87\sigma_y$ Ast

$= 0.87 \times 415 \times 4 \times 490 = 708$ kN.

Force of compression $C = C_1 + C_2$

$C_1 = 0.36\ f_{ck}\ bx$

$= 0.36 \times 20 \times 250 \times (0.53 \times 400)$

$= 381.6$ kN.

$C_2 = (\sigma_{sc} - \sigma_{cc})A_{sc}$

$= (0.87 \times 415 - 0.446 \times 20) \times 2 \times \pi/4(16)^2$

$= 352.13 \times 402.18 = 142$ kN.

$\therefore C = C_1 + C_2 = 523$ kN.

Hence this is an under reinforced beam.

M.O.R $= 0.36\ f_{ck}\ bx\ (d - 0.42x) + (\sigma_{SA}A_{SC} - \sigma_{CC}A_{SC})\ (d - d')$

$= 0.36 \times 20 \times 250 \times 166\ (400 - 0.42 \times 166) + (0.87 \times 415 - 0.446 \times 20)\ (450 - 50)$

$= (298 \times 330) + (352 \times 400) = 239$ kN mm.

(c) Design a RCC column of the following specification using LSM.

(i) Axial factored load = 1800 kN

(ii) Effective length = 2.25 m

(iii) Grade of steel = Fe 415

(iv) Grade of concrete = M 25.

Ans. Given, Axial factored load = $P_u = 1800$ kN.

Effective length = 2.25 m

Grade of steel $f_y = 415\ N/mm^2$

Grade of concrete $f_x = 25\ N/mm^2$

$P_u = 0.4 f_{ck} A_c + 0.67\ f_y A_{SC}$.

$\Rightarrow 1800 \times 10^3 = 0.4 \times 25 \times a^2(1 - 0.008) + 0.67 \times 415 \times 0.008a^2$

$= 9.92a^2 + 2.24a^2$

$\therefore a = 385$ mm.

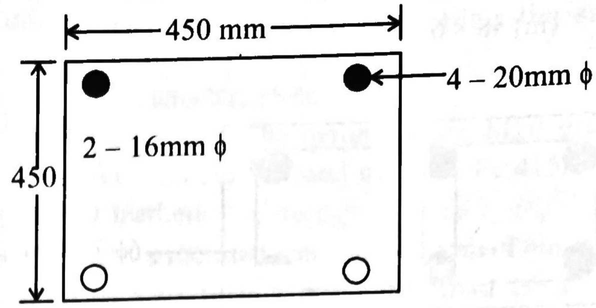
Adopt 450 mm × 450 mm square section.

A_g provided = 450 × 450 = 202500 mm^2

Area of conc. required = 148225 mm^2

Longitudinal area of steel = 0.008 × 148225 = 1185.8 mm^2.

Use 4 – 200 ϕ.



adopt 6 mm ties.

Pitch P ≤ 450 mm

≤ 16 × 20 = 320 mm

≤ 300 mm

Adopt a pitch of 280 mm c/c.

6.(a) Write the purpose of providing distribution steel in RCC slabs.

Ans. The functions of distribution bars slabs are

→ To keep the main reinforcement in position.

→ To resist the stresses due to shrinkages and temperature.

→ To attribute uniformally the concentrated load on the slab.

(b) A short RCC column 450 mm × 450 mm is provided with 8 bars of 16 mm diameter. If the effective length of the column is 2.5 m, find ultimate load for the column. Use M 20 concrete and Fe 415 steel. Solve by LSM method.

Ans. For column size = 450 mm × 450 mm.

D = 450 mm

0.05 D = 0.05 × 450 = 22.5mm > 20mm

hence provide minimum eccentriedfy = 20mm.

A = 450 × 450 = 202500 mm^2

$$A_{sc} = 8 \times \frac{\lambda}{4}(16)^2 = 1608.49 mm^2$$

$A_c = A - A_{SC} = 202500 - 1608.49 = 200891.5\ mm^2$

$P_u = 0.4$ fck $A_c + 0.67$ fy A_{sc}

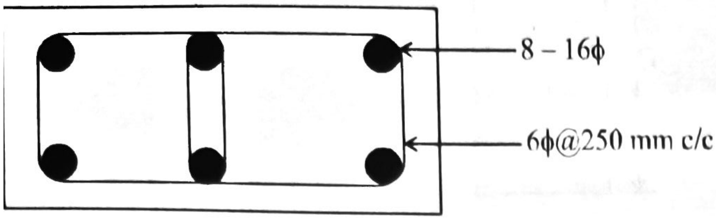
$= 0.4 \times 20 \times 200891.5 + 0.67 \times 415 \times 1608.49$

$= 1607132 + 447215.62 = 2054$ kN.

allowable service load $= \frac{P_u}{1.5} = 1369.5$ KN

Using 6mm ϕ ties, spacing is the least of the following

(i) Least lateral dimension = 450mm.
(ii) 16 × 16 = 256mm
(iii) 48 × 6 = 288mm
hence provide 6mm ϕ ties @ 250mm c/c



(c) ARCC beam of overall dimensions 250 mm × 400 mm is subjected to a bending moment of 50 KN - m. Using M20 and Fe 415, design the section by working stress method and show details of reinforcement by a neat sketch. Assume suitable cover for mild exposure condition.

Ans. Overall size of beam (b × d) = 250mm × 450mm.

For M_{20} concrete, $\sigma_{cbc} = 7\ N/mm^2$
For Fe_{415} steel, $\sigma_{st} = 230\ N/mm^2$
m = 13
For balanced section

$$K = \frac{m\sigma_{cbc}}{m\sigma_{cbc} + \sigma_{st}} = \frac{13 \times 7}{13 \times 7 + 230} = 0.283$$

$$j = 1 - \frac{k}{3} = 1 - \frac{0.283}{3} = 0.906$$

$$R = \frac{1}{2} c.j.k = \frac{1}{2} \times 7 \times 0.906 \times 0.283 = 0.898$$

M.O.R. = R.b.d² = 0.898 × 250 × d²
$\Rightarrow$ 50 × 10⁶ = 224.5 D\D²

$$d = \sqrt{\frac{50 \times 10^6}{224.5}} = 370\text{ mm} \approx 395\text{mm}$$

Area of steel

$$\therefore A_{st} = \frac{M}{\sigma_{st}.j.d} = \frac{50 \times 10^6}{250 \times 0.906 \times 375} = 588\text{mm}^2$$

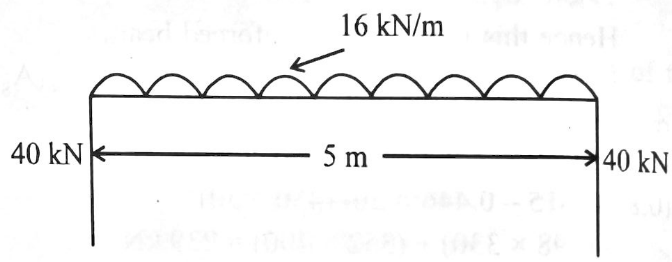
Thus provide a beam of 250mm width and 400mm effective depth with area of tensile reinforcement equal to 588 mm².

7.(a) Give reasons why over reinforced section is not allowed in limit state method of design.

Ans. In case of over reinforced s/c, the steel are provided is more than that required for a balanced section. Hence, the full capacity of steel isn't utilised at same value of loads, the stresses in concrete will reach it's permissible value and fails, while stress in steel is less than it's permissible value. As concrete is a brittle material and therefore the failure is brittle and sudden. Hence over reinforced s/c isn't allowed in limit state method of design.

(b) A simply supported rectangular beam (250 mm × 400 mm) reinforced with 5 nos. of 16 mm dia bars as tension reinforcement is subjected to an all inclusive load of 16 kN/m over a span of 5 m. Design for the shear reinforcement by using a combination of bent up bars and vertical stirrups assumming the ends of reinforcement are confined with compressive reaction. The materials are M20 and Fe415.

Ans. Size of beam, b = 250mm
d = 400mm



$$\upsilon_V = \frac{V_u}{bd} = \frac{40 \times 10^3}{250 \times 400} = 0.4\,N/mm^2$$

$$Ast = 5 \times \frac{\lambda}{4}(16)^2 = 1005\text{mm}^2$$

$$P_t = \frac{Ast}{bd} \times 100 = \frac{100 \times 1005}{250 \times 400} = 1.0$$

$\therefore \iota = 0.60$
$\therefore \iota > \iota_v < \iota_{max}$, hence safe.
$\iota_{c\ max} = 2.5\ N/mm^2$ for $M_{\iota 0}$ concrete
Using 6mm ϕ mild steel bars for stirrups
Asv = 2 × 28 = 56mm² for 2 legged vertical stirrups.

Minimum spacing of stirrups

$$S_v \leq \frac{Asv\,fy \times 0.87}{0.4b} = \frac{56 \times 415 \times 0.87}{0.4 \times 250} = 202.18\text{mm}$$

The spacing can be least of
(i) 0.75d = 0.75 × 400 = 300mm

(ii) 450mm

(iii) 202.18mm

Provide 6mm ϕ two legged vertical stirrups @ 200mm c/c

(c) A RCC beam of overall dimensions 250 mm × 450 mm is subjected to a bending moment of 50 kNm. Using Fe 415 and M20 design the section by working stress method of design and show the details of main reinforcement by a neat sketch. Assume suitable cover for moderate exposure condition.

Ans. Overall size of beam (b × D) = 250 mm × 450 mm

For m_{20} concrete, $c = \sigma_{cbc} = 7\ N/mm^2$

For fe_{415} steel, $\sigma_{st} = 230\ N/mm^2$

$m = 13$

For a balanced section

$$K = \frac{m\sigma_{cbc}}{m\sigma_{cbc} + \sigma_{st}} = \frac{13 \times 7}{13 \times 7 + 230} = 0.283$$

$$j = 1 - k/3 = 1 - \frac{0.283}{3} = 0.906$$

$$R = \frac{1}{2}.C.j.k = \frac{1}{2} \times 7 \times 0.906 \times 0.283 = 0.898$$

$M.O.R = R.b.d^2 = 0.898 \times 250 \times d^2$

$\Rightarrow 50 \times 10^6 = 224.5\ d^2$

$$d = \sqrt{\frac{50 \times 10^2}{224.5}} = 470mm \simeq 415mm$$

Area of steel

$$Ast = \frac{M}{\sigma_{stjd}} = \frac{50 \times 10^6}{250 \times 0.906 \times 415} = 532\,mm^2$$

This provide a beam of 250mm width and 415mm effective depth with area of tensile reinforcement equal to 532mm².

MODEL – 2

[CET - 501]

Full Marks – 70 **Time – 3 Hours**

Answer any five questions.

Figures in the right-hand margin indicate marks.

1. (a) Calculate the flexural strength of which grade of concrete. [2

(b) A rectangular R.C.C. beam of size 350 mm width × 450 mm effective depth is reinforced with 4 nos. 16 mm diameter bars. Find the safe concentrated central point load on a simple span of 3.6 m, which the beam can carry in additionj to its self-weight. The materials are M20 grade concrete and HYSD steel of grade Fe 415. Use WSD method. [5

(c) A simply supported rectangular beam of 5m span carries a uniformly disributed load 16 kN/m inclusive of its self weight. It also carries a central point load of 16 kN. The width of beam is 230 mm and the materials are M_{20} and mild steel reinforcement (WSM)

(i) Fnd the depth.

(ii) Find the steel area. [7

2. (a) Name the grades of fconcrete which are used as lean concrete. [2

(b) A short column of size (230 × 300) mm is reinforced with 6nos. of 16 mm dia bars. Determine the safe factored load on column. If the materials are M_{20} conc and HYSD reinforcement of grade Fe415. [5

(c) A rectangular beam is reinforced with 2 nos of 16 mm dia at top and 3 nos of 20 mm dia at bottom. The beam is 250 mm wide and 460 mm effective depth is subjected to a moment of 60 kN.m. Findout maximum stress developed in materials if M_{20} conc and m.s bar is used. [7

3. (a) What is the role of concrete cover over the reinforcement ? [2

(b) A simply supported rectanuglar beam over a span of 3.6 m is reinforced in tension only. The beam is 230 mm wide and had an effective depth of 510 mm. It is reinforced with 4 no. 16 mm diameter bars. Calculate the stresses in both materials at the centre span when the beam carries a uniformly distributed load of 36 kN/m inclusive of self wt. The materials are M20 grade concrete and mild steel reinforcement use WSD method. [5

(c) A simply supported rectangular beam of 8 m span carries a uniformly distributed load of 23 kN/m, inclusive of its self weight. Determine the reinforcement for flexure. The materials are M 30 grade concrete and TMT bars of grade Fe 415, Use LSM. [7

4. (a) Mention the cases in which you would recommend a double reinforced beam. [2

(b) A tee-beam section having 230 mm width of web and 460 mm effective depth is reinforced, with 5 nos. of 16 mm dia bars as tension reinforcement which continue for a distance greater than effective depth, past the section. The section is subjected to a factored shear of 90 kN. Check the shear stresses and design the shear reinforcement. The materials used are M20 grade concrete and HYSD reinforcement of grade Fe 415. Use mild steel bars ofr stirrups. [5

(c) A doubly reinforced rectangular beam of overall size 230 mm width × 550 mm depth is reinforced with 2 nos 20 mm diameter bars at top and 4 nos 20 mm diameter bars at bottom. If this beam is subjected to a momment of 72 kN-m, consider d = 500 m, d' = 50 mm. Use M_{20} and Fe_{415} Adopt working stress method.

(i) Find the stress in concrete.

(ii) Find the stress in comp steel.

(iii) Find the stress in tension steel. [7

5. (a) Where would be the critical section for which shear reinforcement is to be designed if the applied loads introduce tension in the end regions of a beam ? [2

(b) A simply supported tee-beam of 8m clear span carries a total characteristic load of 30 kN/m. The section of the beam is 230 mm wide × 500 mm effective depth. It is reinforced with 6 no. of 20 mm diameter bars. design the shear reinforcemetn using vertical strirrups only. The ends of the beam are confined by compressive reaction. The materials are M20 grade concrete and HYSD steeel of grade Fe 415. Use mild steel bar of 6 mm diameter for minimum shear reinforcement. Show different section on the beam by line diagram. Use LSM. [5

(c) A simply supported rectangular beam of 6 m span carries a uniformly istributed characteristic load of 24 kN/m inclusive of its self-weight. The beam section is 230 × 600 mm overall. The materials are M20 grade concrete and HYSD reinforcement of grade Fe 415. Design the beam for flexure and check for development length and deflection. Use LSM. [7

6. (a) Calculate the effective width fo flange for a continuous T beam. $l_{off} = 4.5$ m, $b_w = 300$ mm D_f = 130 mm. [2

(b) Show that the value of neutral axis factor for flexural members by working stress method for balanced section depends only on σ_{st} (permissible stress in steel in tension). [5

(c) A tee beam of effective flange width of 1800 mm, thickness of slab 100 mm, width of rib 230 mm and effective detpth of 500 mm is reinforced with 7 (seven) nos 28 mm diameter bars. The materials are M_{20} and Fe_{415} (Use LSM). [7

(i) Find actual neutral axis

(ii) Find factored moment of resistance

(iii) Find factored udl inclusive of its own weight assuming simply supported at both ends having effective span 4.5 m.

7. (a) Find the required cross-sectional area of column when (i) MU = 4000 kN (ii) Grade = M_{20} Fe_{415} (iii) 1.0% reinforcement. [2

(b) A L-beam has a flange of effective width 90 cm and depth 10 cm. Determine th areas of compression and tension steels needed for the cross-section if it is to carry a factored bending moment of 600 kN-m. Asssume M_{20} and Fe_{500} and use limit state method.

(i) For determination of tension steel.

(ii) For determination of compression steel. [5

(c) A short column 400 mm × 400 mm is reinforced with 4 nos. of 25 mm diameter bars. Find the ultimate load carrying capacity of the column if the minimum eccentricity is less than .05 times the lateral dimensions. The materials are M 20 grade of concrete and Fe 415 grade of steel. Adopt limit state method. [7

ANSWER TO MODEL - 2

1.(a) Calculate the flexural strength of which grade of concrete.

Ans. Flexural strength for $f_{cr} = 0.7\sqrt{f_{ck}}$

For M_{20} grade of concrete

$$f_{ck} = .7\sqrt{20} = 3.1305\ N/mm^2$$

(b) A rectangular R.C.C. beam of size 350 mm width × 450 mm effective depth is reinforced

with 4 nos. 16 mm diameter bars. Find the safe concentrated central point load on a simple span of 3.6 m, which the beam can carry in additionj to its self-weight. The materials are M20 grade concrete and HYSD steel of grade Fe 415. Use WSD method.

Ans. For M20 grade concrete, $\sqrt{cbc} = 7N/mm^2$

$$m = \frac{280}{3\sqrt{cbc}}$$

$$\Rightarrow m = \frac{280}{3 \times 7} = 13.3$$

$$A_{st} = 4 \times \frac{\pi}{4} \times 16^2 = 804\ mm^2$$

Let x be the depth of neutral axis. Taking moment of transformed areas about NA.

$$350 \times \frac{\pi^2}{2} = 13.33 \times 804(450 - x)$$

$\Rightarrow x^2 = 27558.82 - 61.24$

or, $x^2 + 61.24 \times - 27558.82 = 0$

Which gives x = 138.19 mm

Depth of critical NA = 0.29 × 450 = 130.5 mm.

$x_{actual} > x_{critical}$

∴ Section is over reinforced and concrete will fail first.

$$MR = \frac{1}{2}.\sigma_{cbc}.bx\left(d - \frac{x}{3}\right)$$

$$= \frac{1}{2} \times 7 \times 350 \times 138.19\left(450 - \frac{138.19}{3}\right)$$

= 68.40 kNm.

Self wt of beam = 0.35 × 0.500 × 25 × 3.6

= 15.75 kN.

If load on beam is WKN.

$$M = \frac{w\ell}{2} = 68.40$$

W = 38 kN.

∴ Additional safe concentrated load on beam

= 38 − 15.75 = 22.25 kN.

(c) A simply supported rectangular beam of 5m span carries a uniformly disributed load 16 kN/m inclusive of its self weight. It also carries a central point load of 16 kN. The width of beam is 230 mm and the materials are M_{20} and mild steel reinforcement (WSM)

(i)Fnd the depth.

(ii)Find the steel area.

Ans. $M = \frac{\omega l^2}{8} + \frac{Wl}{4}$

$$= \frac{16 \times 5^2}{8} + \frac{16 \times 5}{4}$$

= 70kNM.

$$m = \frac{280}{3 \times \delta cbc} = \frac{280}{3 \times 7} = 13.33$$

Q bal = 1.21

$$\text{Effective depth required} = \sqrt{\frac{M}{Qbal \times b}}$$

$$= \sqrt{\frac{70 \times 10^6}{1.21 \times 230}}$$

= 501.5 MM >

$$A_st_{bal} = \frac{M}{\delta st\ jd}$$

$$= \frac{70 \times 10^7}{140 \times 0.87 \times 501.5}$$

$= 1146MM^2$

2.(a) Name the grades of fconcrete which are used as lean concrete.

Ans. The grade of concrete below M_{10} is used as lean concrete.

(b) A short column of size (230 × 300) mm is reinforced with 6nos. of 16 mm dia bars. Determine the safe factored load on column. If the materials are M_{20} conc and HYSD reinforcement of grade Fe415.

Ans. Size of column = 230 × 300

using 6 nos. 16 mm # bar

$Asc = 1206\ mm^2$

Ac = gross area − Asc

= (230 × 300) − 1206

$= 67794\ mm^2$

using M_{20} conc.s Fc_{415} steel

$fck = 20\ N/mm^2$

fy = 415 N/mm²

Assume minimum eccentricity city is less than 0.5D, I_{min} = 20 mm.

Pu = 0.4 fck Ac + 0.67 fy Asc

= (0.4 × 415 × 67794) + (0.67 × 415 × 1206) × 10^{-6}

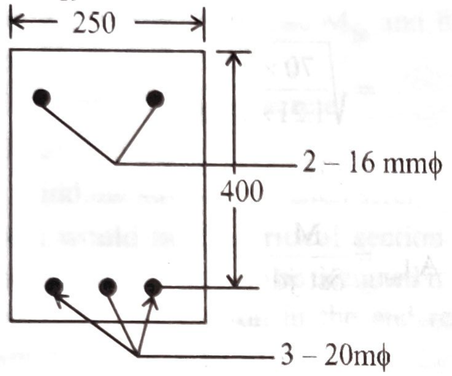
= 11.59 KN.

(c) A rectangular beam is reinforced with 2 nos of 16 mm dia at top and 3 nos of 20 mm dia at bottom. The beam is 250 mm wide and 460 mm effective depth is subjected to a moment of 60 kN.m. Findout maximum stress developed in materials if M_{20} conc and m.s bar is used.

Ans. b = 250 mm

d = 460 mm

use M_{20} conc and M.S bar



fck = 20 N/mm²

fy = 250 N/mm²

Bending moment = 60 kN. m

Factor Moment = 1.5 × 60 = 90 KN m.

2 nos. of 16 mm ϕ at top

So, Asc = 402 mm².

3 nos of 20 m ϕ at bottom.

Ast = 942 mm².

Mu = 90 KN m.

$$M_{ucim} = 0.36\,fck\,bd^2\frac{X_{umax}}{d}\left(1-0.42\frac{X_{umax}}{d}\right)$$

= 0.36 × 20 × 250 × (460)² × 0.53 (1 – 0.42 × 0.53) × 10^{-6}

= 156.93 KNm.

3.(a) What is the role of concrete cover over the reinforcement ?

Ans. A concrete cover is provided to the reinforcement for the following reasons

(1) To protect the reinforcement from weather and fire, so that it does not corrode or melt.

(2) To ensure the grip of concrete over reinforcement so that they act as one and resist the loads.

(b) A simply supported rectanuglar beam over a span of 3.6 m is reinforced in tension only. The beam is 230 mm wide and had an effective depth of 510 mm. It is reinforced with 4 no. 16 mm diameter bars. Calculate the stresses in both materials at the centre span when the beam carries a uniformly distributed load of 36 kN/m inclusive of self wt. The materials are M20 grade concrete and mild steel reinforcement use WSD method.

Ans. For M20 mix, m = 13.3

A_{st} = 4 × 201 = 804 mm²

Transformed area of steel = mA_{st}

= 13.33 × 804 = 10717 mm²

To find neutral axis, taking moments of transformed areas about neutral axis.

$$230\frac{x^2}{2} = 10717(510 - x)$$

$\Rightarrow x^2 = 47527.56 - 53.19x$

$\Rightarrow x^2 = 53.19 \times - 47527.56 = 0$

x = 193.02 mm

For the beam,

$$\text{Maximum moment at centre} = \frac{wl^2}{8}$$

$$= \frac{36\times3.6^2}{8} = 58.72 \text{ KNM.}$$

$$\text{Lever arm} = 510 - \frac{193.02}{3} = 445.66 \text{ mm.}$$

$$\text{Steel stress fst} = \frac{58.72\times10^6}{804\times445.66} = 163.88 \text{ N/mm}^2$$

$$\text{Concrete stress } f_{cb} = \frac{f_{st}}{m}\times\frac{x}{d-x}$$

$$= \frac{163.88}{13.33}\times\frac{193.02}{510-193.02} = 5.48 \text{ N/mm}^2$$

(c) A simply supported rectangular beam of 8 m span carries a uniformly distributed load of 23 kN/m, inclusive of its self weight.

Determine the reinforcement for flexure. The materials are M 30 grade concrete and TMT bars of grade Fe 415, Use LSM.

Ans. For Fe 415 grade reinforcement

$$\frac{M_{u\,lim}}{f_{ck}bd^2}=0.138$$

and $$\frac{P_{t\,lim}f_y}{f_{ck}}=19.68$$

For M30 grade concrete

Q lim = 0.138 × 30 = 4.14

$$P_{t\,lim}=\frac{19.86\times30}{415}=1.44$$

Maximum bending moment

$$M=23\times\frac{8^2}{8}=184\text{ KNM}$$

Ultimate bending moments

Mu = 1.5 × 184 = 276 KNM.

Adopt b = 250 mm.

Balanced depth, $Q_{lim}=\frac{Mu}{bd^2}$

$$\Rightarrow d=\sqrt{\frac{276\times10^6}{4.14\times250}}=516.4\text{ mm}$$

Assume 10% larger depth and 60 mm effective cover.

D = 1.1 × 516.4 + 60 = 628 mm.

Use D = 650 mm d = 650 – 60 = 590 mm

$$\frac{Mu}{bd^2}=\frac{276\times10^6}{250\times590^2}=3.17$$

$$P_f=50\left[\frac{1-\sqrt{1-\frac{4.6}{30}\times3.17}}{\frac{415}{30}}\right]=1.02$$

$$A_{st}=\frac{1.02}{100}\times250\times590=1505\text{ mm}^2$$

$$A_{st\,lim}=\frac{1.44}{100}\times250\times590=2124\text{ mm}^2$$

Provide 5 – 20# = 5 × 314 = 1570 mm²

$A_{st\ required} < A_{st\ provide} < A_{st}$ lim .... (ok)

4.(a) Mention the cases in which you would recommend a double reinforced beam.

Ans. For a design moment M, if the size of the rectangular section is fined and the moment of resistance of a singly reinforced section is less than M, a double reinforced beam is recommended.

(b) A tee-beam section having 230 mm width of web and 460 mm effective depth is reinforced, with 5 nos. of 16 mm dia bars as tension reinforcement which continue for a distance greater than effective depth, past the section. The section is subjected to a factored shear of 90 kN. Check the shear stresses and design the shear reinforcement. The materials used are M20 grade concrete and HYSD reinforcement of grade Fe 415. Use mild steel bars ofr stirrups.

Ans. V_u = 90 KN, b = 230 MM d = 460 MM

Nominal shear stress, $\tau_v=\frac{V_u}{b\times d}$

$$\tau_v=\frac{90\times10^3}{230\times460}=0.85\text{ N/MM}^2<2.8\text{ N/MM}^2$$

Where 2.8 N/MM² is the maximum nominal shear stress for M20 Mix.

$$\frac{100A_s}{bd}=\frac{100\times1005}{230\times460}=0.95$$

For $\frac{100A_s}{bd}=0.95$, τ_c shall be calculated by interpolation.

For $\frac{100A_s}{bd}=0.75,\ \tau_c=0.56\text{ N/MM}^2$

For $\frac{100A_s}{bd}=1.00,\ \tau_c=0.62\text{ N/MM}^2$

∴ For $\frac{100A_s}{bd}=0.95$

$$\tau_c=0.56+\frac{0.62-0.56}{1-0.75}(0.95-0.75)$$

= 0.608 N/MM²

Now $\tau_v > \tau_c$, therefore shear reinforcement shall be designed.

Shear resistance of conrete

$V_{uc}=\tau_c bd$ = 0.608 × 203 × 460 × 10⁻³ = 64.3kN

Shear to be resisted by stirrups

$V_{us}=V_u-V_{uc}$ = 90 – 64.3 = 25.7 KN

Using 6MM diameter two-legged stirrups

$A_{sv} = 56\ MM^2$

$$S_V = \frac{0.87 f_y A_{sv} d}{V_{us}} = \frac{0.87 \times 250 \times 56 \times 460}{25.7 \times 10^3} = 218\ MM$$

or by using equation.

$$S_V = \frac{0.87 \times f_y \times A_{sv}}{b(\tau_v - \tau_c)}$$

$$= \frac{0.87 \times 2.50 \times 56}{230(0.85 - 0.608)} = 218\ MM$$

The spacing shall not exceed

(i) 0.75 d = 0.75 × 460 = 345 MM

(ii) 300 MM

(iii) due to minimum shear reinforcement required i.e 132.4 MM

(iv) required spacing = 218 MM

∴ Provide 6 MM ϕ two-legged stirrups about 130 MM c/c.

(c) A doubly reinforced rectangular beam of overall size 230 mm width × 550 mm depth is reinforced with 2 nos 20 mm diameter bars at top and 4 nos 20 mm diameter bars at bottom. If this beam is subjected to a momment of 72 kN-m, consider d = 500 m, d' = 50 mm. Use M_{20} and Fe_{415} Adopt working stress method.

(i) Find the stress in concrete.

(ii) Find the stress in comp steel.

(iii) Find the stress in tension steel.

Ans. For M 20 grade concrete m + 13.33

Compression steel $A_{sc} = 2 \times \frac{\pi}{4} \times 20^2$

$= 628\ MM^2$

Transformed area= (105 × 13.33 × – 1) × 628

$= 11938 MM^2$

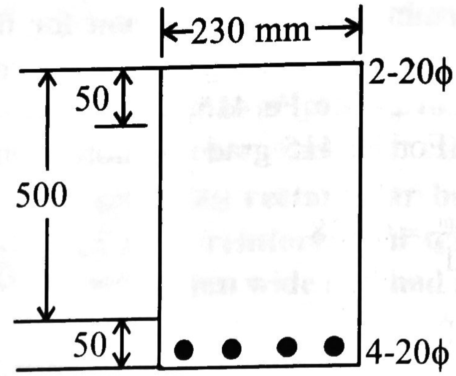
Tension steel $= 4 \times \frac{\pi}{4} \times 20^2$

$= 1256\ MM^2$

Transformed area = 13.33 × 1256

$= 16750 MM^2$

To find the position of neutral axies taking moments of transformed areas about NA



$$\frac{1}{2} \times 230\,x^2 + 11938(x - 50) = 16750(500 - x)$$

$$\Rightarrow 115x^2 + 28688x - 8971900 = 0$$

$$\Rightarrow x^2 + 249.5x - 78016.5 = 0$$

which gives x =181.2 MM.

Now $x_{critical} = 0.29 \times 500$

$= 145\ MM.$

$x_{actual} > x_{critical}$

∴ Section is overreinforced and concrete will fail first.

Taking moments of compressive forces about tensile steel and equating to the external BM

$$M = (1.5m - 1)A_{sc} \times \frac{x - d'}{x} f_{cb}(d - d')$$

$$+ bx\frac{f_{cb}}{2}\left(d - \frac{x}{3}\right)$$

$$\Rightarrow 70 \times 10^6 = (1.5 \times 13.33 - 1) \times 628$$

$$\times\left(\frac{181.2 - 50}{181.2}\right) \times f_{cb}(500 - 50) + 230$$

$$\times 181.2 \times \frac{f_{cb}}{2}\left(500 - \frac{181.2}{3}\right)$$

$$= 13048162.28 f_{cb}$$

$$\Rightarrow f_{cb} = 5.36 N / MM^2$$

0 Stress in compression steel

$$F_{sc} = 1.5m\left(\frac{x - d}{x}\right)f_{cb}$$

$$= 1.5 \times 13.33\left(\frac{181.2 - 50}{181.2}\right) \times 5.36$$

$$= 77.6 N / MM^2$$

N / MM^2

...uld be the critical section for which ...forcement is to be designed if the ...ads introduce tension in the end ... a beam ?

... applied loads introduce tension in the ...beam the shears computed at the face ...ll be used in the design of the member.

...upported tee-beam of 8m clear span ...otal characteristic load of 30 kN/ ...ction of the beam is 230 mm wide ... effective depth. It is reinforced ... of 20 mm diameter bars. design ... reinforcemetn using vertical ... only. The ends of the beam are ... by compressive reaction. The ...are M20 grade concrete and HYSD ...rade Fe 415. Use mild steel bar of ...diameter for minimum shear ...ment. Show different section on the ...ine diagram. Use LSM.

...load = 30 kN/m

...ad = 1.5 × 30 = 45 kN/m

... shear force,

$$\frac{1}{2} \times 45 \times 8 = 180 \text{ kN.}$$

...s,

$$\frac{180 \times 10^3}{230 \times 500} = 1.56 \text{ N/mm}^2$$

...m^2.

...irrups

$$(20)^2 = 1884\text{mm}^2$$

$$\frac{...00 \times 1884}{230 \times 500} = 1.64$$

... N/mm^2

$$S_v = \frac{...}{0.4b} = \frac{...}{0.4 \times 230} = 392 \text{ mm}$$

$S_v > 300$ mm

$> 0.75 \times 500 = 375$ mm, which ever is smaller.

i.e. $S_v = 300$ mm

Provide 8 mm # 2 legged stirrups @ 300 mm c/c

Shear resistance,

$$V_{us\,min} = \frac{0.87 f_y A_{sv} d}{S_v} = \frac{0.87 \times 415 \times 100 \times 500 \times 10^{-3}}{300}$$

= 60.2 kN.

Total shear resistance = 84.7 + 60.2 = 144.9 kN.

At the face of the support is considered.

$V_u = 180$ kN, $\tau_v = 1.56$ N/mm^2, $\tau_c = 0.737$ N/mm^2

$\tau_v > \tau_c$

Thus shear design is necessary

$V_{uc} = 84.7$ kN, $V_{us} = 180 - 84.7 = 95.3$ kN.

Using 8 mm # 2 legged vertical stirrup.

$$S_v = \frac{0.87 f_y A_{sv} d}{V_{us}} = \frac{0.87 \times 415 \times 100 \times 500}{95.3 \times 10^3} = 189 \text{ mm}$$

The spacing should not exceed.

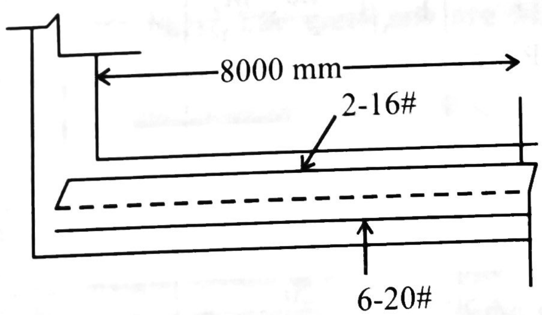
(i) 392 mm

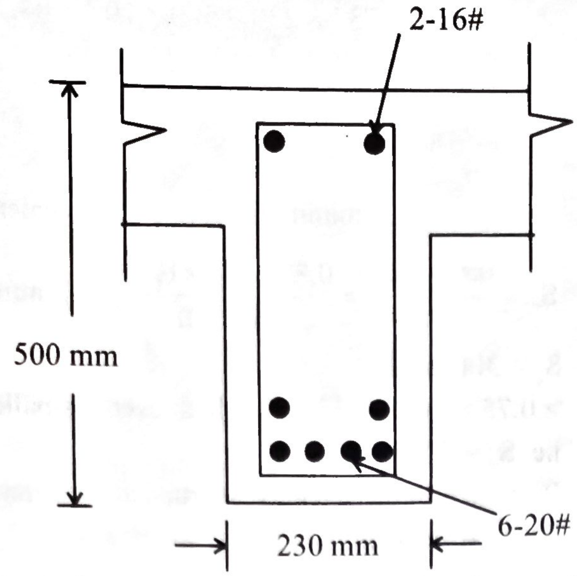
(ii) $0.75d = 0.75 \times 500 = 375$ mm

(iii) 300 mm.

Provide 8 mm # @ 180 mm c/c stirrups at support continue the same spacing upto 780 mm.

$$\text{No. of stirrups} = \frac{780}{180} + 1 = 6 \text{ nos.}$$





(c) A simply supported rectangular beam of 6 m span carries a uniformly istributed characteristic load of 24 kN/m inclusive of its self-weight. The beam section is 230 × 600 mm overall. The materials are M20 grade concrete and HYSD reinforcement of grade Fe 415. Design the beam for flexure and check for development length and deflection. Use LSM.

Ans. Factored load = 1.5 × 24 = 36 kN/m.

$$M_u = \frac{36\times 6^2}{8} = 162\text{ kN/m}$$

$$V_u = \frac{36\times 6}{8} = 108\text{ kN.}$$

(a) Moment steel

Assuming 20 mm diameter bars in one layer

d = 600 – 30 – 10 = 560 mm.

$$\frac{M_u}{bd^2} = \frac{162\times 10^6}{230\times 560^2} = 2.25 < 2.76$$

∴ The section is singly reinforced.

$$P_t = 50\left[\frac{1-\sqrt{1-\frac{4.6}{f_{ck}}\times\frac{M_u}{bd^2}}}{f_y/f_{ck}}\right]$$

$$= 50\left[\frac{1-\sqrt{1-\frac{4.6}{20}\times 2.25}}{415/20}\right] = 0.74$$

$$A_{st} = \frac{0.74}{100}\times 230\times 560 = 953\text{ mm}^2$$

$$A_{st\,lim} = \frac{0.96}{100}\times 230\times 560 = 1236\text{ mm}^2$$

Provide 2.20 # 2.16 # = 2(314 + 201) = 1030 mm².

Let 2.16 # bars are bent a 1.25 D = 1.25 × 600 = 750 mm, from the face of the support.

The remaining bars should extend within the support for a distance of

$$\frac{L_d}{3} = \frac{1}{3}\times 47\times 20 = 313\text{ mm}$$

(b) Check for development length

(1) A bar can be bent up at a distance greater than L_d = 47 # from the centre of the support, i.e. 47 × 16 = 752 mm.

In this case this distance (3000 – 750) = 2250 mm.

(2) For the remaining bars A_{st} = 2 × 314 = 628 MM².

$$M_{ulin} = 0.87 f_y A_{st} d\left(1-\frac{f_y A_{st}}{f_{ck} bd}\right)$$

= 0.87 × 415 × 628 × 560

$$\left(1-\frac{415\times 628}{20\times 230\times 560}\right)\times 10^{-6}$$

= 114.12 kNm

V_u = 108 kN, L_0 = 12# (assume)

As the reinforcement is confined by compressive reaction

$$1.3\frac{M_{ul}}{V_u} + L_0 \geq L_d$$

$$\therefore 1.3\times\frac{114.12\times 10^6}{108\times 10^3} + 12\# \geq 47\# 39.2 \geq \#$$

provided = 20 MM .... (Safe)

The remaining bars should extend within the support for a distance of $\frac{L_d}{3} = \frac{1}{3}\times 47\times 20 = 313$ MM.

If support width is 300 mm, the bars extends for 150 + L_0 = 150 + 12 × 20 = 390 mm within the support.

(c) Check for deflection

Basic

$\frac{\text{span}}{d}$ ratio = 20 (for simply supported beam)

Service stress = $0.58 \times f_y \times \frac{A_{st\ required}}{A_{st\ pro}}$

$$= 0.58 \times 4.15 \times \frac{936}{1030}$$

$$= 219\ \text{N/mm}^2$$

$$\frac{100A_{st}}{bd} = \frac{100 \times 1030}{230 \times 560} = 0.8$$

Modification factor = 1.15

$\frac{\text{Span}}{d}$ permissible = 20 × 1.15 = 23

Actual $\frac{\text{Span}}{d} = \frac{6000}{565} = 10.62$ .... (safe)

6.(a) Calculate the effective width fo flange for a continuous T beam. l_{off} = 4.5 m, b_w = 300 mm D_f = 130 mm.

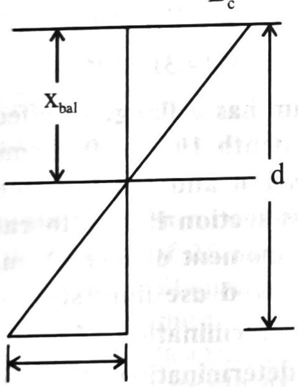
Ans. $b_f = \frac{l_0}{6} + 6D_f + bw$

$$= \frac{4.5 \times 10^3}{6} + 6 \times 130 + 300 = 1830\text{MM}.$$

(b) Show that the value of neutral axis factor for flexural members by working stress method for balanced section depends only on σ_{st} (permissible stress in steel in tension).

Ans. $\frac{X_{bal}}{d - X_{bal}} = \frac{\varepsilon_c}{\varepsilon_{st}}$

$$E_c = \frac{\delta abc}{E_c}$$



$$\varepsilon st = \frac{\delta st}{E_s}$$

$$= \frac{\frac{\delta cbc}{Ec}}{\frac{\sqrt{st}}{Es}} = \frac{M\delta\ cbc}{\delta st}$$

Solving for X_{bal}

$$X_{bal} = \left(\frac{M\delta cbc}{M\delta cbc + \delta st}\right)d.$$

$$= \left[\frac{1}{1 + \frac{\delta st}{M\delta cbc}}\right]d.$$

Substituting $M = \frac{280}{3\delta cbc}$

$$X_{bal} = \left[\frac{1}{1 + \frac{\delta st}{\frac{280}{3\delta cbc \times \delta cbc}}}\right]d. = k\,d$$

Where k is known as neutral axis constant.

$$k = \frac{1}{1 + \frac{\delta st}{\frac{280}{3}}} = \frac{1}{1 + 0.0107\ \delta st}$$

This shows that the value of constant k does not depend on grade of concrete but on the permissible stress in steel.

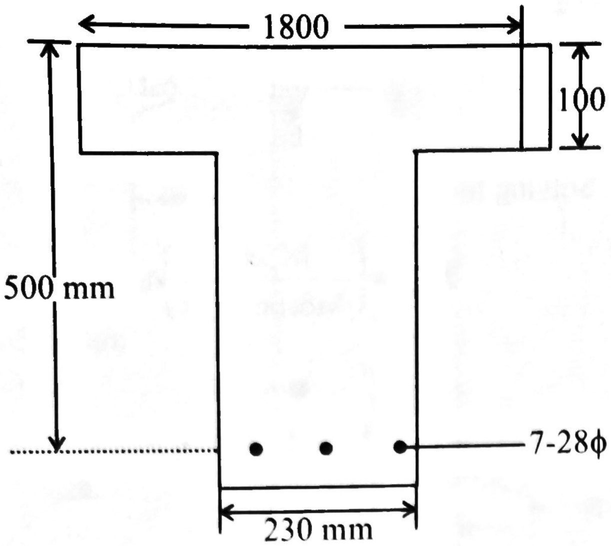
(c) A tee beam of effective flange width of 1800 mm, thickness of slab 100 mm, width of rib 230 mm and effective detpth of 500 mm is reinforced with 7 (seven) nos 28 mm diameter bars. The materials are M_{20} and Fe_{415} (Use LSM).

(i) Find actua! neutral axis

(ii) Find factored moment of resistance

(iii) Find factored udl inclusive of its own weight assuming simply supported at both ends having effective span 4.5 m.

Ans.



$$A_{st} = 7 \times \frac{\pi}{4} \times 28^2 = 4310\ MM^2$$

Assuming NA to fall in flange, we have

$$\frac{X_u}{d} = \frac{0.87\ f_y\ A_{st}}{36 f_{ck}\ b_{fd}} = 0.240$$

$$x_u = 0.24 \times 500 = 120MM > D_f$$

Hence NA falls outside flange

To obtain a new value of X_u equate compressive force to tensile force

$$T_u = 0.87\ f_y A_{st} = 1556125.5N$$

$$y_t = 0.15\ x_u + 0.65\ D_t = 83 > D_t$$

$$C_u = 0.36\ f_{ck} x_u bw + 0.446\ f_{ck}(b_f - b_w)y_f$$

$$= 0.36 \times 20 \times x_u \times 230 + 0.446 \times 20(1800 - 230)(0.15\ x_u + 0.65\ D_t)$$

$$= 1656\ x_u + 14004.4(0.15\ x_u + 65)$$

$$= 3756.66\ x_u + 910586$$

Equating, T_u and C_u

$$1556125.5 = 3756.66\ x_u + 910286$$

$$\Rightarrow X_u = 171.92\ MM.$$

$$X_{u\,max} = 0.48 \times d = 240MM > x_u$$

Now $\frac{3}{7} x_u = 73.68 < D_f$

$$y_f = 0.15\ x_c + 0.65\ D_f$$

$$= 0.15 \times 171.92 + 65$$

$$= 90.8\ MM.$$

$$M_u = 0.36\ fck\ bw\ x_u(d - 0.42\ x_u)$$

$$+0.446\ fck(b_f - b_w)y_f \times \left(D_f - \frac{y_f}{2}\right)$$

$$= 0.36 \times 20 \times 230 \times 171.92\ (500 - 0.42 \times 171.92) + 0.446 \times 20(1800 - 230) \times 90.8\left(100 - \frac{90.8}{2}\right)$$

$$= 191.22\ kNM.$$

Let W_u = Factored udl inclusive of its own weight

$$\Rightarrow M_u = \frac{\omega_u l^2}{8}$$

$$\Rightarrow 191.22 = \frac{\omega_u \times 4.5^2}{8}$$

$$\Rightarrow \omega_u = 75.6\ kN/M$$

7.(a) Find the required cross-sectional area of column when (i) MU = 4000 kN (ii) Grade = M_{20} Fe_{415} (iii) 1.0% reinforcement.

Ans. $$\frac{Pu}{Ag} = 0.4\ fck + \frac{p}{100}(0.67 fy - 0.4 fck)$$

$$\Rightarrow \frac{4000 \times 10^3}{Ag} = 0.4 \times 20 + \frac{1}{100}(0.67 \times 415 - 0.4 \times 20)$$

$$= 10.7005$$

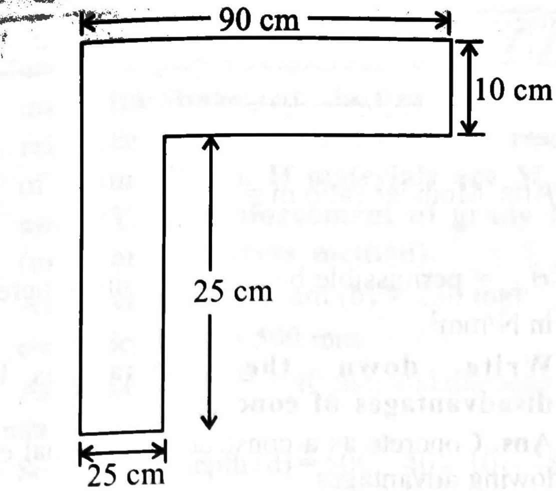
$$\Rightarrow Ag = 373814.31 MM^2.$$

(b) A L-beam has a flange of effective width 90 cm and depth 10 cm. Determine th areas of compression and tension steels needed for the cross-section if it is to carry a factored bending moment of 600 kN-m. Asssume M_{20} and Fe_{500} and use limit state method.

(i) For determination of tension steel. [4

(ii) For determination of compression steel.[3

Ans. $$\frac{b_f}{b\omega} = \frac{900}{250} = 3.6$$



$$\frac{D_f}{d} = \frac{\omega\, 0}{(350-40)} = 0.32$$

Assuming effective tension cover = 40 MM.

$$\frac{Mu\lim}{f_{ck} b_w d^2} = 0.417$$

$$\Rightarrow Mu\lim = 0.417 \times 20 \times 250 \times 310^2$$

$$= 200.4 \text{ kNM}.$$

$$Ast_1 = \frac{Mu\lim}{0.87 \times f_y\left(d - \frac{Df}{2}\right)}$$

$$= \frac{200.4 \times 10^6}{0.87 + 500\left(310 - \frac{100}{2}\right)}$$

$$= 1771.9 \text{ MM}^2$$

$$M_2 = 600 - 200.4$$

$$= 399.6 \text{ kNM}$$

$$Ast_2 = \frac{399.6 \times 10^6}{0.87 \times 500 + (310 - 40)}$$

$$= 3402.3 \text{ MM}^2$$

$$Ast = Ast_1 + Ast_2$$

$$= 5174.2$$

(c) A short column 400 mm × 400 mm is reinforced with 4 nos. of 25 mm diameter bars. Find the ultimate load carrying capacity of the column if the minimum eccentricity is less than .05 times the lateral dimensions. The materials are M 20 grade of concrete and Fe 415 grade of steel. Adopt limit state method.

Ans. Size of column = 400 mm × 400 mm

$$A_{st} = 4 \times \frac{\pi}{4} \times 25^2 - 1962 \text{ mm}^2$$

Area of concrete = 160000 – 1962.5 = 158037.5 mm^2.

e_{min} does not exceed 0.5 × b

$P_u = 0.4\, f_{ck} \cdot A_c + 0.67\, f_y \times A_{st}$

$= 0.4 \times 20 \times 158037.5 + .67 \times 415 \times 1962.5$

$= 1809973.125$ N $= 1809.97$ KN.

MODEL – 3

[CET - 501]

Full Marks – 70 **Time – 3 Hours**

Answer any five questions.

Figures in the right-hand margin indicate marks.

1.(a) What is modular ratio ? [2

(b) Write down the advnatages and disadvantages of concrete. [5

(c) A singly reinforced beam (230 × 500) mm overall depth is reinforced with 3 nos. of 20 mm dia bars at bottom as tension reinforcement. Find out moment of resistance of beam section. If materials are M_{20} conc and HYSD reinforcement of grade FE415 (use working stress method). [7

2. (a) Define the characteristic strength of material. [2

(b) A simply supported beam (250 × 500) mm overall depth is reinforced with 4 nos. of 20 mm dia as tension reinforcement. The beam is subjected to factored shear of 100kN at support. Check the shear stress and design the 6mm dia vertical stirrups at support. The materials are M_{20} conc. and m.a. reinforcement. [5

(c) Design a simple supported singly reinforced beam of 230 mm wide which carries a factored load of 30 kN/m including its self weight. The span of beam is 6m. Design the beam for flexture and shear by limit state method if mateials are M_{15} conc and HYSD bars of Fe415. [7

3. (a) What do you mean by M_{20} mix ? [2

(b) A rectangular beam is reinforced with 2 nos of 16 mm dia at top and 3 nos of 20 mm dia at bottom. The beam is 250 mm wide and 460 mm effective depth is subjected to a moment of 60 kN.m. Findout maximum stress developed in materials if M_{20} conc and m.s bar is used. [5

(c) Design a simply supported Tee beam of spam 6m and spaced at 3m centres. The thickness of slab is 120 mm and total factored load including self weight of beam is 45 kN/m. Design the beam for flexure and shear it materials are M_{20} conc. and HYSD bars of grade Fe415. [7

4.(a) What do you mean by balanced design ? [2

(b) A singly reinforced beam (230 × 500) mm overall depth is reinforced with 3 nos. of 20 mm dia bars at bottom as tension reinforcement. Find out moment of resistance of beam section. If materials are M_{20} conc and HYSD reinforcement of grade FE415 (use working stress method). [5

(c) A short RCC column has to carry an axial factored load of 2000 kN. Design the column by using M_{15} grade conc and m.s. reinforcement. [7

5. (a) What do you mean by diagonal tension and diagonal compression. [2

(b) A rectangular beam of size (250 × 560) mm effective depth is subjected to a factored moment of 220kN.m. Find the reinforcement for flexture if the materials are M_{20} conc and HYSD reinforcement of grade Fe415. [5

(c) Design a two-way restrained slab for an office floor carring a live load of 2.5 kN/m². The slab is 4.5 m × 5.5 m from centre to centre of beam and two adjacent edges are discontinuous. Use M_{15} conc and mild steel bars. [7

6. (a) What are the advantages of two way slab over one way slab. [2

(b) A.R.C. beam has an effective depth of 500 mm and a breadth of 350 mm. It contains 4-25 mm bars. Calculate the shear reinforcement heeded for a factored shear force of 350 kN. Adopt limit state method and design and assume M 15 grade of concrete and Fe 415 grade of steel. [5

(c) Design a slab for a room measuring 5.5 × 4 m assuming superimposed load of 3 kN/m². The slab is supported on 300 mm thick walls on all four sides and is simply supported at edges with no provision to resist torsion at corners.
HYSD reinforcement of grade Fe 415 L.S.M. of design. [7

7. (a) Mention the value of partial safety factor for concrete and steel. [2

(b) What are the assumptions made in the design for flexure in working stress method ? [5

(c) A short RCC column has to carry an axial factored load of 2000 kN. Design the column by using M_{15} grade conc and m.s. reinforcement. [7

ANSWER TO MODEL - 3

1.(a) What is modular ratio ?

Ans. Modular ratio $m = \dfrac{280}{3\sigma_{cbc}}$

σ_{cbc} = permissible bending stressin compression in N/mm²

(b) Write down the advnatages and disadvantages of concrete.

Ans. Concrete as a construction material entails the following advantages.

Advantage

1. It has high compressive strength and corrossive and wealthering effects are minimal. It strength equal that of a hard material stone when properly prepared.
2. As compared to other material concrete is economical in the logn run.
3. It is durable and ffire resistant and require very little maintainance.
4. The green concrete can be easily handled and moulded into any shape or size according to specification.
5. The concrete can be pumped and hence it can be laid in difficult position.
6. Concrete can even be sprayed on and filled into the cracks for repair by griding process.
7. It has unlimited application in combination with steel reinforcement.

Disadvance

Following are the disadvantage

1. Concrete is rainforced with steel bars since it has low tensile strength and hence cracks easily.
2. Provision of construction joints has to be made to avoid development of cracks due to drying shrikage an moisture movement in fresh concrete.
3. In order to avoid the formation of crack due to thermal movement concrete expands and contracts with the change of temperature expansion joint have to be provided.
4. Concrete as a materials lacks in ductility and this factor provides disadvantageous with respect earthquack resistance design ?
5. Concrete is liable to disintegrate by alkaline and sulphate attack.
6. Concrete undergo creep under sustained loading resulting in reduction of prestress in the pretressed concrete construction.

(c) A singly reinforced beam (230 × 500) mm overall depth is reinforced with 3 nos. of 20 mm dia bars at bottom as tension reinforcement. Find out moment of resistance of beam section. If materials are M_{20} conc and HYSD reinforcement of grade FE415 (use working stress method).

Ans. breath of the beam (b) = 230 mm

overal depth (c) = 500 mm.

Assume clearcover = 40 mm and diameter of bar = 20 mm

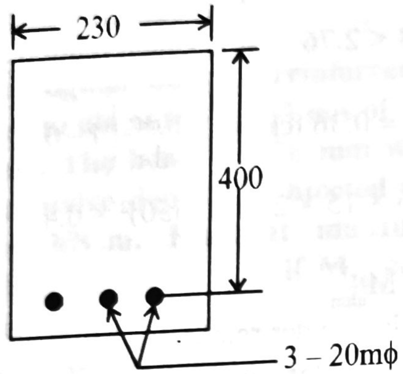
So, effective depth (d) = 500 – 40 – 10 = 450 mm.

M_{20} φ Fe_{415} materials used.

σ_{cbc} = 7 N/mm².

$$\text{So, Fck} = 20 \text{ N/mm}^2 M = \frac{280}{3 \times \sigma cbc}$$

$$= \frac{280}{3 \times 7} = 13.3$$



σcbc = 7 N/mm²

σst = 230 N/mm²

3 nos 20 mm dia bars are used Ast = 942 mm²

By transformed area method

$$b \times x \times \frac{x}{2} = M.Ast(d - x)$$

$$\Rightarrow 230 \times \frac{x^2}{2} = 13.33 \times 942(450 - x)$$

$$\Rightarrow 115x^2 = 5650587 - 12556.86x$$

$$\Rightarrow x^2 - 491355.5 - 12556.86x$$

$$\Rightarrow x^2 + 109.49x - 49135.5 = 0$$

$$\Rightarrow x = 173.67 \text{ mm.}$$

$$\text{But } X_{cr} = \frac{1}{1 + \frac{1\sigma st}{m\sigma cbc}} \times d$$

$$K = \frac{1}{1 + \frac{\sigma st}{m\sigma cbc}} = \frac{1}{1 + \frac{230}{13.33 \times 7}} = 0.29$$

x_{cr} = 0.29 × 450 = 130.5 mm

$X_{actual} > X_{critical}$

So, this is a over-reinforced Beam.

$$M.R = \frac{1}{2}\sigma_{cbc} \times x\left(d - \frac{x}{3}\right) \times b$$

$$= \frac{1}{2} \times 7 \times 173.7\left(450 - \frac{173.7}{3}\right) \times 230 \times 10^{-6}$$

= 54.82 kN.m.

2.(a) Define the characteristic strength of material.

Ans. Characterstic Compressive Strength

It means that value of the strength of the materials below which not more than 5% of the test result are expected to fail.

M_{15} grade of conc and Fe_{250} is used

So, σcbc = 5 M/mm²

$$m = \frac{280}{3 \times 5} = 18.67$$

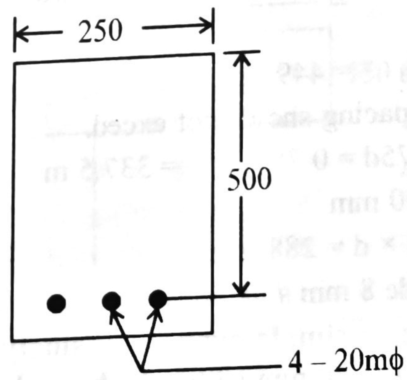
(b) A simply supported beam (250 × 500) mm overall depth is reinforced with 4 nos. of 20 mm dia as tension reinforcement. The beam is subjected to factored shear of 100kN at support. Check the shear stress and design support. Design the 6mm dia vertical stirrups at support. The materials are M_{20} conc. and m.a. reinforcement.

Ans. Data given

b = 250 mm.

D = 500 mm

Using 4 – 20 mm φ bar.



Ast = 1257 mm^2

Assume clear cover = 40 mm.

Effective depth (d) = 500 – 40 – 10 = 450 mm.

Factor shear force = 100 kN = V_u

Using M_{15} and M.S Bar

So, fck = 15 N/mm^2

fy = 250 N/mm

$$\frac{100As}{bd} = \frac{100\times1257}{250\times450} = 1.11$$

τ_c = 0.67 N/mm^2 (15456 T – 19)

$$\tau_u = \frac{V_u}{bd} = \frac{100\times10^3}{250\times450} = 0.89 N/mm^2$$

$\tau_u > \tau_c$.

Shear design is necessary

$V_u = \tau_{cbd}$ = 0.67 × 250 × 450 = 75375 = 75.375 KN.

$V_{us} = V_u - V_{ue}$

= 100 – 75.375 = 24.625 kN.

Using 6 mm 4 legged stirrups with Asv = 113 mm^2.

$$Sv = \frac{0.87 fy.A_{svo}}{Vus}$$

$$= \frac{0.87\times250\times113\times450}{24.625\times10^3}$$

= 449 mm

Spacing is least of following

(i) 449 mm

(ii) 0.75 × 450 = 337.5 mm i.e. 300 mm

Provide 6 mm 4 legged stirrup @ 300 mm C/C

$$V_{us}\min = \frac{0.87fyAsvd}{Sv}$$

$$= \frac{0.87\times250\times113\times450}{300}$$

= 449 mm.

The spacing shows not exced.

(1) 0.75d = 0.75 × 450 = 337.5 mm

(2) 300 mm

(3) 48 × d = 288 mm.

Provide 8 mm # @ 280 C/C stirrup at support

(c) Design a simple supported singly reinforced beam of 230 mm wide which carries a factored load of 30 kN/m including its self weight. The span of beam is 6m. Design the beam for flexture and shear by limit state method if mateials are M_{15} conc and HYSD bars of Fe415.

Ans. Width of the beam (b) = 230 mm fck = 15 KN/mm.

(∵ M15con)

factor load = 30 KN/m

Span of the beam = 6m.

$$\text{Factor Moment} = \frac{ML^2}{8} = \frac{30\times(6)^2}{8}$$

= 138 KN/m.

$$\text{Assume } D = \frac{\text{Span}}{10} = 600 \text{ mm}$$

$$\frac{Mu}{bd^2} = \frac{138\times10^2}{230\times(550)^2} \quad d = 600 - 50 = 550 \text{ mm}$$

= 1.98 < 2.76 – It is single reinforced beam.

$$M_{ucim} = 0.36 \text{ fck } bd^2 \frac{X_{u\max}}{d}\left(1 - 0.42\frac{X_{u\max}}{d}\right)$$

= 0.36 × 15 × 230 × $(550)^2$ × 0.48 × (1 – 0.42 × 0.48) × 10^{-6}

Mu < M_{ulim}

So, it is a under reinforced beam

Steel calculation

$$Mu = 0.87 \text{ fy Ast d}\left(1 - \frac{fyAst}{bdffck}\right)$$

$$\Rightarrow 138\times10^6 = 0.87415\times Ast\times550\left(1 - \frac{415Ast}{230\times550\times15}\right)$$

⇒ 138 × 10^6 = 198577.5 Ast – 43.43 Ast^2

⇒ Ast^2 – 45722.28 Ast + 3177527 = 0

⇒ Ast = 3717 mm^2

Provide 25 mm 8 nos

Ast provided = 3927 mm^2.

Design for shear

$$\text{Maximum shear} = \frac{wL}{2}$$

$$= \frac{138\times6}{2} = 414 \text{ KN}$$

$$\tau_v = \frac{V_u}{bd} = \frac{414\times10^3}{230\times550} = 3.2\ N/mm^2$$

$$\frac{100As}{bd} = \frac{100\times3922}{230\times550} = 3.1$$

$\tau_c = 0.71\ N/mm^2 (15456 - T - 19)$

$\tau_v = \tau_c$.

Minimum Stirrup

Use 6 mm 2 lengged stirrup Ast = 56 mm²

$$Sv = \frac{0.87 fyAsv}{0.4b} = 219\ mm$$

· Spacing is minimum of the following (1) 219 mm, (ii) 1.75d = 412.5 mm (iii) 300 mm (iv) 48 × 6 = 288 mm

Sv 6 mm 2 legged stirrup @ 280 mm C/C

3.(a) What do you mean by M_{20} mix ?

Ans. M_{20} means

M → Mix.

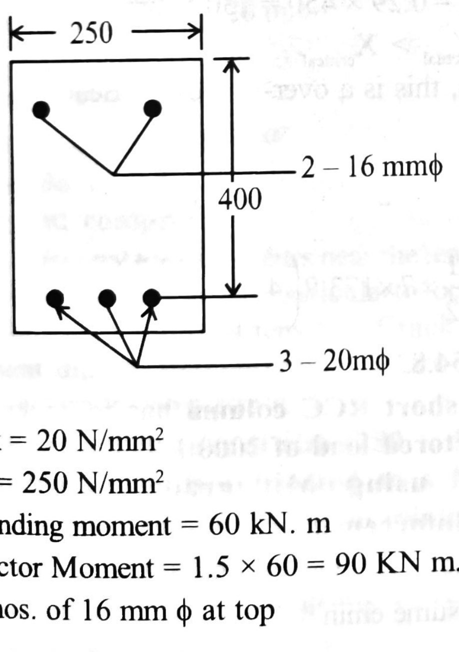
20 → Characteristic strength of 150 mm cube at 28 days.

(b) A rectangular beam is reinforced with 2 nos of 16 mm dia at top and 3 nos of 20 mm dia at bottom. The beam is 250 mm wide and 460 mm effective depth is subjected to a moment of 60 kN.m. Findout maximum stress developed in materials if M_{20} conc and m.s bar is used.

Ans. b = 250 mm

d = 460 mm

use M_{20} conc and M.S bar



fck = 20 N/mm²

fy = 250 N/mm²

Bending moment = 60 kN. m

Factor Moment = 1.5 × 60 = 90 KN m.

2 nos. of 16 mm ϕ at top

So, Asc = 402 mm².

3 nos of 20 m ϕ at bottom.

Ast = 942 mm².

Mu = 90 KN m.

$$M_{ucim} = 0.36\ fck\ bd^2 \frac{X_{u\,max}}{d}\left(1 - 0.42\frac{X_{u\,max}}{d}\right)$$

= 0.36 × 20 × 250 × (460)² × 0.53 (1 – 0.42 × 0.53) × 10⁻⁶

= 156.93 KNm.

(c) Design a simply supported Tee beam of spam 6m and spaced at 3m centres. The thickness of slab is 120 mm and total factored load including self weight of beam is 45 kN/m. Design the beam for flexure and shear it materials are M_{20} conc. and HYSD bars of grade Fe415.

Ans. t = 15 cm

br = 30 cm

Span of slab = 3.5 m

left of beam = 6m

super imposed load of slab = 5 KN/m²

Overall depth of beam $= \frac{1}{12}$ to $\frac{1}{20}$ of the span.

Provide over all depth = 450 mm

Provide 20 mm bar at clear cover of 25 mm

Effective cover to reinforcement = 35 mm

Effective depth = 450 mm – 35 mm = 415 mm

Load from slab = 5000 × 3.5 = 17500 N/m

D.L. of the rib = 25000 × .3 × .3 = 2250 N/m

Total load 19750 N/m

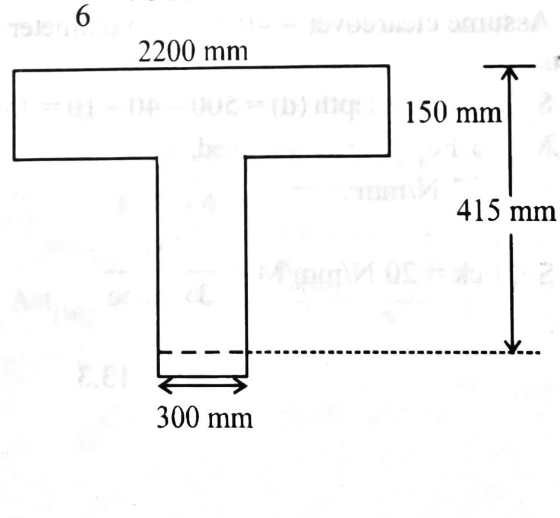
Factored load = 1.5 × 19750 = 29625 N/m

$$M_u = \frac{29625\times62}{8} = 133312.5\ N/m$$

Width of flange

$$B = \frac{L}{6} + br + 6t$$

$$= \frac{6000}{6} + 300 + 6\times150 = 2200\ mm$$



$$\frac{M_u}{Bd^2} = \frac{133312.5 \times 1000}{2200 \times 415^2}$$

$$\frac{133312500}{78895000} = .352$$

Percentage of steel

$$P = 50\left(\frac{\left(1-\sqrt{1-\frac{4.6}{20}\times .352}\right)}{250/15}\right)$$

$$= \frac{50 \times .0413}{16.67} = 0124\%$$

$$P = 100\frac{A_{st}}{Bd}$$

$$A_{st} = \frac{0.124 \times 2200 \times 415}{100} = 1132\,mm^2$$

Provide 4 bar of 20 mm (1256 mm^2)

4.(a) What do you mean by balanced design ?

Ans. Balanced section.

The section is so proportioned that the steel and conrete both reach their maximum permisible values of stresses at the same time.

(b) A singly reinforced beam (230 × 500) mm overall depth is reinforced with 3 nos. of 20 mm dia bars at bottom as tension reinforcement. Find out moment of resistance of beam section. If materials are M_{20} conc and HYSD reinforcement of grade FE415 (use working stress method).

Ans. breath of the beam (b) = 230 mm

overal depth (c) = 500 mm.

Assume clearcover = 40 mm and diameter of bar = 20 mm

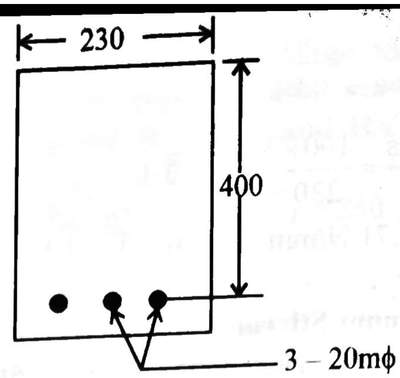
So, effective depth (d) = 500 – 40 – 10 = 450 mm.

M_{20} φ Fe_{415} materials used.

σ_{cbc} = 7 N/mm².

$$\text{So, Fck} = 20\ N/mm^2 M = \frac{280}{3 \times \sigma cbc}$$

$$= \frac{280}{3 \times 7} = 13.3$$



$\sigma cbc = 7\ N/mm^2$

$\sigma st = 230\ N/mm^2$

3 nos 20 mm dia bars are used Ast = 942 mm²

By transformed area method

$$b \times x \times \frac{x}{2} = M.Ast(d-x)$$

$$\Rightarrow 230 \times \frac{x^2}{2} = 13.33 \times 942(450-x)$$

$\Rightarrow 115x^2 = 5650587 - 12556.86x$

$\Rightarrow x^2 - 491355.5 - 12556.86x$

$\Rightarrow x^2 + 109.49x - 49135.5 = 0$

$\Rightarrow x = 173.67$ mm.

$$\text{But } X_{cr} = \frac{1}{1+\frac{1\sigma st}{m\sigma cbc}} \times d$$

$$K = \frac{1}{1+\frac{\sigma st}{m\sigma cbc}} = \frac{1}{1+\frac{230}{13.33 \times 7}} = 0.29$$

$x_{cr} = 0.29 \times 450 = 130.5$ mm

$X_{actual} > X_{critical}$

So, this is a over-reinforced Beam.

$$M.R = \frac{1}{2}\sigma_{cbc} \times x\left(d - \frac{x}{3}\right) \times b$$

$$= \frac{1}{2} \times 7 \times 173.7\left(450 - \frac{173.7}{3}\right) \times 230 \times 10^{-6}$$

= 54.82 kN.m.

(c) A short RCC column has to carry an axial factored load of 2000 kN. Design the column by using M_{15} grade conc and m.s. reinforcement.

Ans. Axias load = 2000 KN.

Assume emin < 05 × D

But emin = 20 mm

Therefore the min side of the col^n

$= \frac{20}{0.50} = 400$ mm

col^n size = 400 × 400

Assume 0.8% steel.

Asc = 0.008 Ag

Ac = Ag. Asc = 0.992 Ag

Pu = 0.4 fck Ac + 0.67 fy Asc.

⇒ 2000 × 10 = (0.4 × 15 × 0.992Ag) + (0.67 × 250 × 008Ag)

= 5.952 Ag + 1.34 Ag

= 7.292 Ag

⇒ Ag = 274273 mm^2

So one side of the column = 530 mm.

i.e. size of the col^n = 530 × 530

Pu = 0.4 fck Ac + 0.67 fy Asc.

⇒ 2000 × 10^3 = {0.4 × 15}

(530 × 530 – Asc) + (0.67 × 250 × Asc)

= 1685400 – 6 Asc + 167.5 Asc

⇒ Asc = 1948 mm^2

Ac = (530 × 530) – 1948

= 278952 mm^2

Asc = 1948 mm^2.

Provid = 8 – 20ϕ Asc provid = 2513 mm^2

Lateral ties.

Use 6mm ϕ latures ties

Spacing should not exceed

(i) 530 mm

(ii) 16ϕ = 16 × 20 = 320 mm

(iii) 300 mm

(iv) 48 × 6 = 288 mm

So 6 mm ϕ ties at 280 C/C.

5.(a) What do you mean by diagonal tension and diagonal compression.

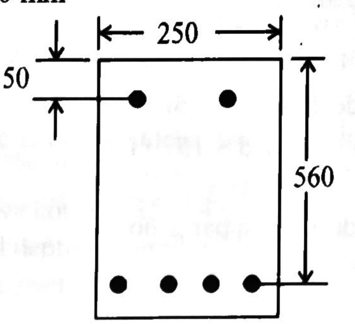
Ans. Diagonal tension occurs near the tension face tensile crack in the direction perpendicularto local tensile stress are known as diagonal tension. Crack occur in high moment diagonal compression failure occur in column. It is perp to comp stress.

(b) A rectangular beam of size (250 × 560) mm effective depth is subjected to a factored moment of 220kN.m. Find the reinforcement for flexture if the materials are M_{20} conc and HYSD reinforcement of grade Fe415.

Ans. Data given

b = 250 mm

d = 560 mm



Factore Bending Moment = 220 KN.M

Using M_{20} conc. H_{YSD} Bar

So, fck = 20 N/mm^2.

fy = 415 N/mm^2

Mu_1 = 220 KN.m.

$$M_{ucm} = 0.36 fck\, bd^2 \frac{X_{u\,max}}{d}\left(1 - 0.42\frac{X_{u\,max}}{d}\right)$$

= 0.36 × 20 × 250 × $(560)^2$ × 0.48 (1 – 0.42 × 0.48) × 10^{-6}

= 216.32 KN.M

$M_u > M_{ucim}$

So this is a doubly reinforced beam.

Assume d^1 = 50 mm

$$\frac{d^1}{d} = \frac{50}{560} = 0.08 = 0.1$$

So fsc = 353 N/mm^2

M_{u1} = 220 KN.m

M_{ucim} = 216.32 KN.m

M_{u2} = 220 – 216.32 = 3.68 KNm.

$$Asc = \frac{M_{u2}}{fsc(d - d^1)} = \frac{3.68 \times 10^6}{353(560 - 50)} \times 20.40\ mm^2$$

$$Ast_2 = \frac{Asc fsc}{0.87fy}$$

$$= \frac{20.40 \times 353}{0.87 \times 415} = 20\ mm^2$$

$$Ast_{(lim)} = \frac{M_{u(lim)}}{0.87fyd\left(1 - 0.42 \times \frac{X_{u\,max}}{d}\right)}$$

$$= \frac{216.32 \times 10^6}{0.87 \times 415 \times 560(-0.42 \times 0.48)}$$

= 1340 mm²

Ast = 1340 + 20 = 1360 mm²

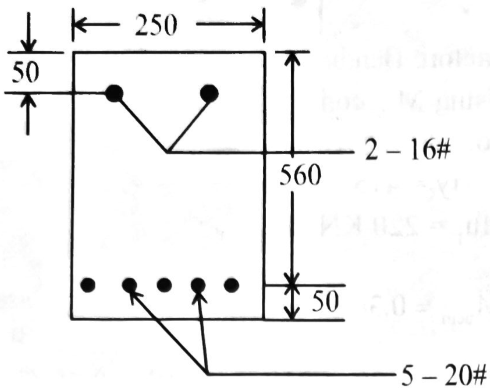
provide 20 mm bar 5nos.

So Astprovided = 1570 mm²

Asc = 20 mm²

Provide 16 mm bar 2 nos.

Asc = 402 mm²



(c) Design a two-way restrained slab for an office floor carring a live load of 2.5 kN/m². The slab is 4.5 m × 5.5 m from centre to centre of beam and two adjacent edges are discontinuous. Use M_{15} cone and mild steel bars.

Ans. Room size = 4.5 m × 5.5m

Lx = 4.5 m

Ly = 5.5m

Load calculation

Assume thinkness of the slab = 150 mm

effective depth of slab = 150 – 20 = 150 mm.

Dead load = 0.13 × 25 = 3.25 KN/m²

Live load = 2.5 KN/m²

Flwr finish = 1.0 KN/m²

Total load = 6.75 KN/m²

Factor load = 1.5 × 6.75 = 10.125 KN/m².

Moment Calculation

$Mx = \alpha x\, wl_x^2$

$My = \alpha y wl_y^2$

$$\frac{Ly}{Lx} = \frac{5.5}{4.5} = 1.2 < 2$$

Cond. - two adajacent edges are discontinious

αx = –0.053 = +0.040

αy = 0.047 = + 0.035

Short direction

Mx = (–Ve) = 0.053 × 10.125 × (4.5)² = 10.80 KN.m

= (+Ve) = 0.004 × 10.125 × (4.5)² = 8.20 KN.m

Long direction

My = (–Ve) = 0.047 × 10.125 × (4.5)² = 9.63 kNm.

= (+Ve) = 0.035 × 10.125 × (4.5)² = 7.17 KN.m

Steel Calculation

$$\frac{Mx}{bd^2} = \frac{10.86 \times 10^6}{1000 \times (130)^2} = 0.8$$

Pt = 0.29

Ast = 377 mm². Use 8 mm at 120 mm c/c

Long direction

$$\frac{My}{bd^2} = \frac{9.63 \times 10^6}{1000 \times (130)^2} = 0.55$$

Pt = 0.265

Ast = 344.5 mm²

$$\text{Spacing} = \frac{\text{Area of 1 bar} \times 1000}{344.5} = 145.13$$

use 8 mm @ 140 mm C/C.

Check For Delfection

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

$$\frac{\text{Span}}{d} = \frac{4.5}{130} = 34 < \text{Basic}$$

There fore the assumed depth ratio is enough.

6.(a) What are the advantages of two way slab over one way slab.

Ans. One way slab

1. The slab supported in two opposite supports is a one way slab.

2. If $\frac{I_y}{I_x} \geq 2$ is a one way slab.

I_y = Long or length.

I_x = Shorter length.

3. Bending moments deflection are more two way slab.

Two way slab

1. The slab supported on all four edges.

2. $\frac{I_y}{I_x} < 2$ is two way slab.

3. Bending moment and deflection are considerable reduced.

(b) A.R.C. beam has an effective depth of 500 mm and a breadth of 350 mm. It contains 4-25 mm bars. Calculate the shear reinforcement heeded for a factored shear force of 350 kN. Adopt limit state method and design and assume M 15 grade of concrete and Fe 415 grade of steel.

Ans. deff = 500 m, b = 350 mm

$$A_{st} = 4 \times \frac{\pi}{4} \times 25^2 = 1962.5 \text{ mm}^2$$

S_u = 350 KN, M_{15} and Fe_{415}

$$\iota_v = \frac{S_u}{bd} = \frac{350 \times 10^3}{350 \times 500} = 2 \text{N/mm}^2$$

Percentage of steel

$$= \frac{A_{st}}{bd} \times 100 = \frac{1962.5}{350 \times 500} = 112\%$$

For 1.12% $\iota_C = 0.64$

$\iota_v > \iota_c$

Shear resisted by concrete = ι_v bd = 0.64 × 350 × 500 = 112000 N = 112 KN.

Shear to be resisted by stirrup = S − ι_c.bd = 350 − 112 = 238 KN.

Provide 2 legged 6 mm diameter stirrup

$$S_V = \frac{.87 f_y \times A_w \times d}{V_{as}} = \frac{.87 \times 415 \times 500 \times A_w}{238 \times 10^3}$$

$$= \frac{.87 \times 415 \times 500 \times 2 \times 28}{238 \times 10^3} = 42.5 \text{ mm}$$

Spcing of stirrup at least of the following.

(i) 42.5 mm (ii) 75 × d = 75 × 500 = 375 mm

(iii) 300 mm

(iv) $\frac{A\omega fy}{0.4} = \frac{(2 \times 28) \times 415}{0.4 \times 350} = 166 \text{ mm}$

use 2 legged 8 mm stirrup at 40 mm c/c.

(c) Design a slab for a room measuring 5.5 × 4 m assuming superimposed load of 3 kN/m². The slab is supported on 300 mm thick walls on all four sides and is simply supported at edges with no provision to resist torsion at corners.

HYSD reinforcement of grade Fe 415 L.S.M. of design.

Ans. Short span between centre of bearing = 5.5 + .3 = 5.8 m.

Long span between centre of bearing = 4 + 0.3 = 4.3 m.

Assuming 0.3% of steel, modification factor = 1.43

$$\text{Effective depth required} = \frac{\text{short span}}{20 \times \text{mod factor}}$$

$$\frac{4.3 \times 1000 \text{ mm}}{20 \times 143} = 150.3 \text{ mm}$$

Provide 8 mm diameter bar at a clear cover off 15 mm.

Effective cover = 15 + 4 = 19 mm

Overall depth required = 150.3 + 19 = 169.3 mm

Provide overall depth = 170 − 19 = 151 mm

Actual effective depth for short span = 151 − 8 = 143 mm

Effective length should be provided for short span

(i) 4.3 m

(ii) clear span + effective depth = 4 + 0.151 = 4.151 m.

use L_x = 4.151 m

$$r = \frac{L_y}{L_x} = \frac{5.643}{4.151} = 1.36$$

Refering is – 456 – 2000

$\propto_x = 997$, $\propto_y = .053$

Loads

Dead load = 25 × 170 = 4250 N/m²

20 mm floor finish = 24 × 20 = 480 N/m²

Live load = 3000 N/m²

Total load = 7730 N/m²

Factored load = 1.5 × 7730 = 11595

Maximum short span B.M for metre width

$M_{ux} = \alpha_x w_u . l_x^2$ = .09997 × 11595 × 4.151² = 19919.2 N.

M_{uy} = 0.053 × 11895 × 4.151² = 10589 Nm

Check for depth

$$d = \sqrt{\frac{M_{ax} \text{B.M}}{0.138 b \times f_{ck}}}$$

$$= \sqrt{\frac{19919.2 \times 10^3}{138 \times 1000 \times 20}} = 84.95 \text{ mm} < 151 \text{ mm}$$

Percentage of steel

$$\frac{M_x}{bd^2} = \frac{19019.2 \times 10^3}{1000 \times 151^2} = 0.874$$

Percentage of steel from S.P – 16

Page 47 = 26

$$26 = 100 \frac{A_{st}}{bd}$$

$$A_{st} = \frac{26}{100} \times 1000 \times .151 - 3926\ mm^2$$

use 8 mm bar

$$\text{spacing} = \frac{\text{Area of bar} \times 1000}{\text{Total area}}$$

$$= \frac{50 + 1000}{392.6} = 127.3m$$

use 8 mm bar at 125 mm C/C.

$$\frac{M_{uy}}{bd^2} = \frac{10589 \times 10^3}{1000 \times 43^2} = 52\%$$

Percentage of steel from sp. 16, page 47 = 146.

$$P = 100 \frac{A_{st}}{bd}$$

$$A_{st} = \frac{146 \times 1000 \times 143}{100} = 208.78\ mm^2$$

use 8 mm bar

$$\text{spacing} = \frac{\text{Area of 1 bar} \times 100}{\text{Total area}}$$

$$= \frac{50 \times 1000}{208.78} = 239.48\ mm$$

use 8 mm bar at spacing of 200 mm.

Check for shear

$$V_u = \frac{w \times l_x}{2} = \frac{11595 \times 4.151}{2} = 24065.4\ N$$

$$\tau_v = \frac{V_u}{bd} = \frac{24065.4}{100 \times 151} = .159\ N/mm^2$$

K = 1.3 (I.S 456 – 2000 calcuse 40.2%)

$$\frac{100A_{st}}{bd} = \frac{100 \times 208.78}{1000 \times 151} = 0.138$$

$\tau_c = 28$

$K \times \tau_c = 1.3 \times 28 = 364\ N/mm^2$

$\tau_v < \tau_c$ (so safe)

Check for deflection

$$\frac{\text{Span}}{d} = 20 \quad (\text{Is } 456(23.2.1))$$

Percnetage along $I_x = 26$

Allowable I/d ratio = 20 × 2.85 = 57(sp – 16)

$$\frac{\text{Actual span}}{\text{Depth}} = \frac{4000}{170} = 23.5$$

Allowable 7 actual ok.

7.(a) Mention the value of partial safety factor for concrete and steel.

Ans. The partial safety factor for concrete is 1.5 and for steel is 1.15.

(b) What are the assumptions made in the design for flexure in working stress method ?

Ans. Assumption in working stress methods are

1. Plane section traverse to the centre of line of a member before bending remain plane section after bending.
2. Elastic modules of concrete has the same value within the limits of deformation of the member.
3. Elastic modulus of steel has same value withing the limit σ f the deformation σ f member.
4. The reinforcement does not slip from concrete sorrounding.
5. Steel is free from intial stresses.
6. There is no resultant thrust on any transverse section of the member.

(c) A short RCC column has to carry an axial factored load of 2000 kN. Design the column by using M_{15} grade conc and m.s. reinforcement.

Ans. Axias load = 2000 KN.

Assume emin < 05 × D

But emin = 20 mm

Therefore the min side of the col^n

$$= \frac{20}{0.50} = 400\ mm$$

col^n size = 400 × 400

Assume 0.8% steel.

Asc = 0.008 Ag

Ac = Ag. Asc = 0.992 Ag

Pu = 0.4 fck Ac + 0.67 fy Asc.

⇒ 2000 × 10 = (0.4 × 15 × 0.992Ag) + (0.67 × 250 × 008Ag)

= 5.952 Ag + 1.34 Ag

= 7.292 Ag

⇒ Ag = 274273 mm²

So one side of the column = 530 mm.

i.e. size of the col^n = 530 × 530

$Pu = 0.4\ fck\ Ac + 0.67\ fy\ Asc.$

$\Rightarrow 2000 \times 10^3 = \{0.4 \times 15\}$

$(530 \times 530 - Asc) + (0.67 \times 250 \times Asc)$

$= 1685400 - 6\ Asc + 167.5\ Asc$

$\Rightarrow Asc = 1948\ mm^2$

$Ac = (530 \times 530) - 1948$

$= 278952\ mm^2$

$Asc = 1948\ mm^2$.

Provid = 8 – 20ϕ Asc provid = 2513 mm^2

Lateral ties.

Use 6mm ϕ latures ties

Spacing should not exceed

(i) 530 mm

(ii) $16\phi = 16 \times 20 = 320$ mm

(iii) 300 mm

(iv) $48 \times 6 = 288$ mm

So 6 mm ϕ ties at 280 C/C.

PRACTICE SETS

SET – 1

[CET - 501]

Full Marks – 70 **Time – 3 Hours**

*Answer any **five** questions.*

Figures in the right-hand margin indicate marks.

1. (a) What is the minimum shear stress that can be taken care of by the provision of minimum shear reinforcement provided as per IS 456 ? [2

(b) Bond and Achorage [5

(c) A singly reinforced beam has to carry a maximum beilding miment of kN-m. It has a width of 230 mm. Obtain the depth of the beam and area of reinforcement required in tension side. Use M_{20} and mild steel. Adopt working stress method. [7

2. (a) Write down the functions of stirrups in beams.[2

(b) Shear reinforcement [5

(c) A beam of size 250 mm × 500 mm in section, is reinforced with two 12 mm Φ bars on compression side and four 20 mm Φ bars on tension side. The bars are at 50 mm centres respectively from bottom and top edge of the beams. Calculate the moment of resistance of the beam, if Q_{bc} = 7N/ mm² Q_{st}= 140 N/mm².

Q_{sc} = 230 N/mm² and m = 13.33 [7

3. (a) Find out the anchorage length in tension in a single mild steel bar of dia ϕ in concrete of grade M 20. [2

(b) Torsion reinforcement in two-way slab

The moment accompanied by torsion $T = \frac{E14\delta}{1_x^{\ 2}}$. [5

(c) A simply supported one way slab for an office building of a clear span 3m is supported over beams of 240 mm width. Design the slab for a live load of 4 kN/m. The materials used are M20 concrete and HYSD Fe 415 steel. [7

4. (a) What is the minimum strain in the concrete at the outermost compression fibre in bending as per LSM ? [2

(b) A rectangular beam 200 mm × 400 mm effective depth is reinforced with three nos. 16 mm bars at bottom and two nos. 10 mm bars at top. The materials are M 20 grade concrete and HYSD grade Fe 415 steel. Cover to compression reinforcement at top is 40 mm and the section is subjected to a moment of 40 kNm. Using WSM, findout the maximum stress in concrete and steel. [5

(c) A simply supported rectangular beam section 230 mm wide × 440 mm effective depth is reinforced with 6 × 16 bars at bottom. It is subjected to a factore shear of 200 kN at support. Design the shear reinforcement at support it.

(i) all the bars are carried into support.

(ii) two nos. 16 mm bars are curtailed at 500 mm from support and

(iii) two nos, 16 mm bars are bent at 625 mm from face of support. The ends are confined by compression. M20 concrete and Fe 415 HYSD steel used. [7

5. (a) Define effective depth and depth of neutral axis.[2

(b) Design a simple supported singly reinforced beam of 230 mm wide which carries a factored load of 30 kN/m including its self weight. The flexture and shear by limit state method if mateials are M_{15} conc and HYSD bars of Fe415. [5

(c) A singly reinforced rectangular concrete beam has to resist an ultimate moment of 90 kN-m. Design gthe section if forsome reasons (a) depth of neutral axis is to be restricted to 0.3 d or (b) M_u = 1.785 bd² . Assume b = 300 mm,

F_{ck}= 15 N/mn² and f_y = 415 N/mm² . [7

6. (a) Calculate development length of Fe415 steel and M_{25} conc. [2

(b) Design the sections, for an axially loaded RCcolumnin the method of Limit State Design. Given date P_u= 2100 kN, M_{20} Fe 415. [5

(c) A single room measures 4.25 m × 6.5 m. It is supported on 350 mm thick walls on all four sides. The slab is simply supported at edges. Design the slab using grade M20 concrete and HYSD reinforcement of grade Fe 415. [7

7. (a) What is the role of concrete cover over the reinforcement ? [2

(b) Ashort RCC column of size 400 mm × 400 mm has to carry an axial factored load of 2000 KN. Assuming l_{min} < 0. 05 D, design the column using M20 grade of concrete and HYSD grade of steel Fe 415. [5

(c) Design a simply supported slab for a span 3.5 m to carry live load of 2. kN/M² nad floor finish of 0.75 kN/m² Widthof supporting walls is 250 mm. Concrete and steel grades used are M_{20} and Fe_{415} respectively. Adopt Limit State Design Method.[7

SET – 2

[CET - 501]

Full Marks – 70 **Time – 3 Hours**

Answer any five questions.

Figures in the right-hand margin indicate marks.

1. (a) Calculate the modular ratio for concrete of fgrade M_{25}. [2

(b) Design a short circular column to carry an axial load working load of 1400 kN by using Lateral ties. Assume minimum eccentricity as less than 0.05D. The materials used are M20 grade concrete and HYSD reinforcement of grade Fe 415. Use 8 mm mild steel bars for lateral ties. [5

(c) Design a short column rectangular in section, to carry an axial load of 2200 kN using Fe_{415} and M_{20}. Adopt LSM design . Assume the unsupported length as 3.00 mt.

(i) Longitudinal Reinforcement.

(ii) Transverse REinforcement

(iii) Reinforcement details. [7

2. (a) What is the codal provision of striping time for removal of props to slabs ? [2

(b) A simply supported slab of clear span 2.6 mt is uspported on 350 mm thick brick wall at one end and on 230 mm thick brick wall at the other. Loads on the slab are 1 kN/m² floor finish and 2 kN/m² live load. The materials are M_{20} and Fe_{415} . Adopt LSM of design.

(i) Design for flexure and distribution steel.

(ii) Check for shear, development length and deflection.

(iii) Reinforcing details as per SP 34. [5

(c) Design a rectangular beam simply supported over a clear span of 6m, if superimposed load is 25 kN/m and support width is 30 cm each. Use M_{15} and Fe_{415}. Adopt LSM of design :

(i) Design for flexure

(ii) Design for shear

(iii) Check for development length and deflection.

(iv) Reinforcing details as per SP 34. [7

3. (a) Why over reinforced design section is not preferred. [2

(b) A T-beam floor consists of 15 cm thick R.C slab monolithic with 30 cm wide beams. The beams are spaced at 3.5 m centre to centre and their effective span is 6 m. If the superimposed load on the slab is 5 kN/m², design and intermediate beam (Reinforcement area only). Adopt L.S.M. of design. [5

(c) A single room measures 4.25 m × 6.5 m. It is supported on 350 mm thick walls on all four sides. The slab is simply supported at edges. Design the slab using grade M20 concrete and HYSD reinforcement of grade Fe 415. [7

4. (a) Write down the minimum eccentricity mentioned in code practice for axially loaded column. [2

(b) Draw the idealized stress-strain prove for mild steel bar and HYSD bars, used in limit state method and design. [5

(c) A 5 m long simply supported beam carries a superimposed load of 20 kN/k. Design the midspan section if its effective depth is kept constant at 500 mm using.

(i) Working stress method.

(ii) Limit state method.

and compare the results.

Neglect self weight of the beam

Adopt M20 grade of concrete and Fe 4/5 grade of steel. [7

5. (a) Write at least two least two conditions for termination of tension reinforcement in flexural members. [2

(b) Show that the limiting depth of neutral axis for a rectangular cross-section reinforced with Fe 500 grade steel is 46 d. [5

(c) A simply supported rectangular beam of 4 m span carries a.u.d. 1 of 18 kN/m. The width of the beam is 220 mm. Find out the depth and area of steel required for balanced design by working stress method.

Use – M20 grade of concrete an Fe 415 graded steel. [7

6. (a) Define the characteristic strength of material. [2

(b) Calculate the development length for Fe 500 grade of steel and M_{20} of concrete used as a compression member. [5

(c) Design short column, square in section to carry an axial load of 2000 kN. Adopt L.S method of design and assume Fe 415 grade of steel and M20 mix. [7

7. (a) What is the maximum premissible dia meter of the reinforcing bar for a 130 mm thick R.C.C. slab ? [2

(b) A T-bea of effective flange width 1200 mm, thickness of slab 100 mm, width of rib 300 mm and effective depth of 560 mm is reinforced with 5 no. 25 mm diameter bars. Calculate the factored moment of resistance. The materials are M20 grade concrete and HYSD reinforcement of grade Fe 415. [5

(c) A rectanular beam of size 230 mm wide × 565 mm effective depth is subjected to a factored moment 250 kNm. Find the reinforcement for flexure. The material are M20 grade concrete and HYSD reinforcement of grade Fe 415. In case the beamis double reinforced use d′ = 40 mm. Use LSM. [7

SET – 3

[CET - 501]

Full Marks – 70 **Time – 3 Hours**

*Answer any **five** questions.*

Figures in the right-hand margin indicate marks.

1. (a) Calculate the effective width fo flange for a continuous T beam. $l_{eff} = 4.5$ m, $b_w = 300$ mm $D_f = 130$ mm. [2

(b) Show that the value of neutral axis factor for flexural members by working stress method for balanced section depends only on σ_{st} (permissible stress in steel in tension). [5

(c) A tee beam of effective flange width of 1800 mm, thickness of slab 100 mm, width of rib 230 mm and effective detpth of 500 mm is reinforced with 7 (seven) nos 28 mm diameter bars. The materials are M_{20} and Fe_{415} (Use LSM). [7

(i) Find actual neutral axis

(ii) Find factored moment of resistance

(iii) Find factored udl inclusive of its own weight assuming simply supported at both ends having effective span 4.5 m.

2. (a) Name the grades of fconcrete which are used as lean concrete. [2

(b) A short column of size (230 × 300) mm is reinforced with 6nos. of 16 mm dia bars. Determine the safe factored load on column. If the materials are M_{20} conc and HYSD reinforcement of grade Fe415. [5

(c) A rectangular beam is reinforced with 2 nos of 16 mm dia at top and 3 nos of 20 mm dia at bottom. The beam is 250 mm wide and 460 mm effective depth is subjected to a moment of 60 kN.m. Findout maximum stress developed in materials if M_{20} conc and m.s bar is used. [7

3. (a) What is the role of concrete cover over the reinforcement ? [2

(b) A simply supported rectanuglar beam over a span of 3.6 m is reinforced in tension only. The beam is 230 mm wide and had an effective depth of 510 mm. It is reinforced with 4 no. 16 mm diameter bars. Calculate the stresses in both materials at the centre span when the beam carries a uniformly distributed load of 36 kN/m inclusive of self wt. The materials are M20 grade concrete and mild steel reinforcement use WSD method. [5

(c) A simply supported rectangular beam of 8 m span carries a uniformly distributed load of 23 kN/m, inclusive of its self weight. Determine the reinforcement for flexure. The materials are M 30 grade concrete and TMT bars of grade Fe 415, Use LSM. [7

4. (a) Calculate the flexural strength of which grade of concrete. [2

(b) A rectangular R.C.C. beam of size 350 mm width × 450 mm effective depth is reinforced with 4 nos. 16 mm diameter bars. Find the safe concentrated central point load on a simple span of 3.6 m, which the beam can carry in additionj to its self-weight. The materials are M20 grade concrete and HYSD steel of grade Fe 415. Use WSD method. [5

(c) A simply supported rectangular beam of 5m span carries a uniformly disributed load 16 kN/m inclusive of its self weight. It also carries a central point load of 16 kN. The width of beam is 230 mm and the materials are M_{20} and mild steel reinforcement (WSM)

(i) Fnd the depth.

(ii) Find the steel area. [7

5. (a) Where would be the critical section for which shear reinforcement is to be designed if the applied loads introduce tension in the end regions of a beam ? [2

(b) A simply supported tee-beam of 8m clear span carries a total characteristic load of 30 kN/m. The section of the beam is 230 mm wide × 500 mm effective depth. It is reinforced with 6 no. of 20 mm diameter bars. design the shear reinforcemetn using vertical strirrups only. The ends of the beam are confined by compressive reaction. The materials are M20 grade concrete and HYSD steeel of grade Fe 415. Use mild steel bar of 6 mm diameter for minimum shear reinforcement. Show different section on the beam by line diagram. Use LSM. [5

(c) A simply supported rectangular beam of 6 m span carries a uniformly istributed characteristic load of 24 kN/m inclusive of its self-weight. The beam section is 230 × 600 mm overall. The materials are M20 grade concrete and HYSD reinforcement of grade Fe 415. Design the beam for flexure and check for development length and deflection. Use LSM. [7

6. (a) Mention the cases in which you would recommend a double reinforced beam. [2

(b) A tee-beam section having 230 mm width of web and 460 mm effective depth is reinforced, with 5 nos. of 16 mm dia bars as tension reinforcement which continue for a distance greater than effective depth, past the section. The section is subjected to a factored shear of 90 kN. Check the shear stresses and design the shear reinforcement. The materials used are M20 grade concrete and HYSD reinforcement of grade Fe 415. Use mild steel bars ofr stirrups. [5

(c) A doubly reinforced rectangular beam of overall size 230 mm width × 550 mm depth is reinforced with 2 nos 20 mm diameter bars at top and 4 nos 20 mm diameter bars at bottom. If this beam is subjected to a mommment of 72 kN-m, consider d = 500 m, d' = 50 mm. Use M_{20} and Fe_{415} Adopt working stress method.

(i) Find the stress in concrete.

(ii) Find the stress in comp steel.

(iii) Find the stress in tension steel. [7

7. (a) Find the required cross-sectional area of column when (i) MU = 4000 kN (ii) Grade = M_{20} Fe_{415} (iii) 1.0% reinforcement. [2

(b) A L-beam has a flange of effective width 90 cm and depth 10 cm. Determine th areas of compression and tension steels needed for the cross-section if it is to carry a factored bending moment of 600 kN-m. Asssume M_{20} and Fe_{500} and use limit state method.

(i) For determination of tension steel.

(ii) For determination of compression steel. [5

(c) A short column 400 mm × 400 mm is reinforced with 4 nos. of 25 mm diameter bars. Find the ultimate load carrying capacity of the column if the minimum eccentricity is less than .05 times the lateral dimensions. The materials are M 20 grade of concrete and Fe 415 grade of steel. Adopt limit state method. [7

SET – 4

[CET - 501]

Full Marks – 70 **Time – 3 Hours**

*Answer any **five** questions.*

Figures in the right-hand margin indicate marks.

1. (a) Define moment of Resistance. [2

(b) Discuss the detailing requirements for reinforcement in a two - way slab with corners held down. [5

(c) Ashort RCC column of size 400 mm × 400 mm has to carry an axial factored load of 2000 KN. Assuming $l_{min} < 0.05$ D, design the column using M20 grade of concrete and HYSD grade of steel Fe 415. [7

2. (a) State reasons why overreinforced section is not allowed in limit state method of design. [2

(b) A simply supported rectangular beam (250 mm × 450 mm) reinforced with 4 nos of 16 mm dia bars as tension reinforcement is subjected to an all inclusive load of 20 KN / m over a span of 3.5 m. Design suitable shear reinforcement. The materials are M20 and Fe 415. [5

(c) A RCC column of diamensions 250 mm × 500 mm is reinforced with (4 – 16 + – 12) bars equally distrubuted on all sides. Calculate and show the details of transverse reinforcement with the help of a sketch. [7

3. (a) Mention any two advantages of doubly reinforced beam. [2

(b) Establish the comparision between working stress method and limit state method. [5

(c) Find the depth of neutral axis of a singly reinfored RC beam of 230 mm width and 450 mm effective depth. It is reinforced with 4 bars of 16mm diameter. Use M-20 concrete and Fe-415 bars. Use WSM and state type of beam is it. [7

4. (a) What do you know by M-15 grade of concrete ?[2

(b) Explain the assumption in LSM of design. [5

(c) A singly reinforced concrete beam 250 mm width is reinforced 4 bars of 25 mm diameter at an effective depth of 400 mm. If M-20 grade concrete and Fe-415 bars are used, compute ultimate moment of resistance of the section in LSM. [7

5. (a) Write the purpose of providing distribution steel in RCC slabs. [2

(b) A short RCC column 450 mm × 450 mm is provided with 8 bars of 16 mm diameter. If the effective length of the column is 2.5 m, find ultimate load for the column. Use M 20 concrete and Fe 415 steel. Solve by LSM method. [5

(c) ARCC beam of overall dimensions 250 mm × 400 mm is subjected to a bending moment of 50 KN - m. Using M20 and Fe 415, design the section by working stress method and show details of reinforcement by a neat sketch. Assume suitable cover for mild exposure condition. [7

6. (a) Give reasons why over reinforced section is not allowed in limit state method of design. [2

(b) A simply supported rectangular beam (250 mm × 400 mm) reinforced with 5 nos. of 16 mm dia bars as tension reinforcement is subjected to an all inclusive load of 16 kN/m over a span of 5 m. Design for the shear reinforcement by using a combination of bent up bars and vertical stirrups assumming the ends of reinforcement are confined with compressive reaction. The materials are M20 and Fe415. [5

(c) A RCC beam of overall dimensions 250 mm × 450 mm is subjected to a bending moment of 50 kNm. Using Fe 415 and M20 design the section by working stress method of design and show the details of main reinforcement by a neat sketch. Assume suitable cover for moderate exposure condition. [7

5. (a) What are the codal provisions of stripping time for removal of props to beams ? [2

(b) A doubly reinforced beam section 250 mm wide and 450 mm deep to the centre of the tensile reinforcement. It is reinforced with 2 bars of 16 mm diameter as compressions reinforcement at an effective cover of 50 mm and 4 bars of 25 mm diameter as tensile steel. Assume M 20 concrete and Fe 415 steel. Calculate moment of resistance of the beam section. [5

(c) Design a RCC column of the following specification using LSM.

(i) Axial factored load = 1800 kN

(ii) Effective length = 2.25 m

(iii) Grade of steel = Fe 415

(iv) Grade of concrete = M 25. [7