UNIT- I- METHODS OF DESIGN OF CONCRETE STRUCTURES

(2 MARKS)

1. List out the advantages of reinforced cement concrete when compared with other building materials. (Apr/May 2007)

The advantages of reinforced cement concrete are (Any four)

- Concrete is workable when green and strong when hardens
- It can be moulded into any required shape and size
- The raw materials required are easily available
- Skill is not required for casting concrete elements
- Concrete is durable, fire resisting and rigid
- Concrete requires less maintenance.

2. List out the disadvantages of reinforced cement concrete when compared with other building materials. (Apr/May 2004)

The disadvantages of reinforced cement concrete are (Any four)

- The self-weight of the structural elements will be more while concrete is used
- Concrete has a very low tensile strength. Hence cracks will form in the tension zone if reinforcement is not provide properly.
- Cracks develop in concrete, also due to shrinkage, creep, temperature etc. which permit seepage of water into the concrete. This causes corrosion of steel reinforcement and thereby peeling of concrete
- Concrete has poor insulating property
- Dismantling and reusing of concrete elements are mostly not possible
- Concrete is brittle in nature and hence has low impact resisting capacity.

3. What is the necessity of providing reinforcements in concrete? Why steel is used as reinforcement? (May/June 2012)

The necessities of providing reinforcements in concrete are

- The reinforcement in concrete should have a high tensile strength, high modulus of elasticity and almost the same coefficient of linear expansion as that of concrete.
- lt also develops a good bond with concrete.
- Steel satisfies all the above requirements. Hence steel is used as the reinforcing

material in Reinforced cement concrete.

4. State the important factors to be considered while designing structural elements.

The important factors to be considered while designing structural elements are Strength, Serviceability, durability and fire resistance.

5. Define Design Mix Concrete.

When concrete mix is graded and specified in terms of compressive strength, it is known as design mix concrete.

6. Define Nominal Mix Concrete.

Concrete is specified as proportion of cement, fine aggregate and coarse aggregate by volume. It is known as Nominal mix concrete.

7. How can strength of concrete be enhanced?

Strength of concrete can be enhanced by decreasing the water-cement ratio, increasing the fineness of cement, by age of concrete, by increasing the size of aggregate and by proper grading and shape of concrete.

8. Define durability of concrete. (Apr/May 2005)

Durability of concrete is defined and interpreted as its resistance to deteriorating influences which may be negligently present inside the concrete itself.

9. What are the precautions taken to ensure the durability of concrete?

Taking the following precautions with respect to its exposure ensures the durability of reinforced concrete.

- Providing proper cover to the reinforcement
- Minimum cement content and the maximum water content ratio that can be used for the given

  conditions of exposure to permeability of concrete

  Minimum grade of concrete – Mild steel –M20

  Sea water – M30
- Using proper type of cement and water cement ratio to withstand special conditions like sulphateaction.
- Using suitable fine and coarse aggregates, which will not produce any alkali aggregate action.

10. What are the factors affecting the durability of concrete? (May/June 2013)

The following factors are affecting the durability of concrete.

- Corrosion of Steel
- Deterioration of concrete
- Permeability
- Method of Compaction
- Curing
- Quality of aggregate and water

11. What are the factors influencing the durability of concrete? (May/June 2007)

The following factors are influencing the durability of concrete.

- Quality of cement
- Quality of water
- Quality of aggregates
- Water cement ratio
- Temperature

12. What do you understand by modulus of rupture?

The maximum tensile stress called modulus of rupture. Fr = My/I (Or) As per IS 456:2000, cl6.2.2. fr = 0.7 $\sqrt{fck}$

13. What are the different grades of concrete recommended for plain cement concrete?

M10, M15 and M20 are the different grades of concrete recommended for plain cement concrete.

14. What are the different grades of concrete recommended for reinforced cement concrete?

M15, M20 and M25 are the different grades of concrete recommended for reinforced cement

concrete.

15. What are the different grades of steels recommended for reinforced cement concrete?

Fe250, Fe415, Fe500 and Fe550 are the different grades of steel recommended for reinforced

cement concrete.

PART –B

1. **Explain the concept of elastic method and ultimate load method and write the advantages of limit state method over other methods. (May/June 2013)**
2. **What are the methods involved in the design of reinforced concrete structures? Briefly explain the design procedure of the methods. (AU April/May 2015)**
3. **Explain the working stress and limit state methods of design of RC structures. (Nov/Dec 2012)**
4. **A singly reinforced concrete beam 250mm wide and 400mm deep to the centre of the tensile reinforcement has a span of 5m and carry a total udl of 900N/m including its weight. The stresses in concrete and steel are not to exceed 7N/mm2 and 230N/mm2 respectively. Find the steel reinforcement necessary. (Nov/Dec 2008)**
5. **A singly reinforced concrete beam 300 mm wide has an effective depth of 500 mm, the effective span being 5m. It is reinforced with 804mm2 of steel. If the beam carries a total load of 16 kN/m on the whole span. Determine the stresses produced in concrete and steel. Take m = 13.33**
6. **A reinforced concrete beam of rectangular section is required to resist a serve moment of 120kNm. Design suitable dimensions for the balanced section of the beam. Assume width of the beam is half the depth. Adopt the M20 grade concrete and Fe415 HYSD bars. (Apr/May 2005)**
7. **A singly reinforced beam has a span of 5m and carries udl of 25kN/m. The width of the beam is chosen to be 300mm. Find the depth and steel area required for a balanced section. Use M_{20} concrete and Fe_{415} steel. (May/June 2007)**
8. **Find the moment of resistance of a singly reinforced beam section 225mm wide and 350mm deep to the centre of the tensile reinforcement if the permissible stresses in concrete and steel are $230N/mm^2$ and $7N/mm^2$. The reinforcement consists of 4 bars of 20**

mm diameter bars. What is the maximum udl of this beam can safely carry on a span of 8m? Take m=13.33.

9. A doubly-reinforced concrete beam is 250mm wide and 500mm deep to the centre of tension reinforcement. The centre of the compression reinforcement is 50mm from the compression edge. The area of the compression and tension steel are $1016mm^2$ and $1256mm^2$. If m=13.33 and the bending moment of the section is 70kNm. Calculate the stresses in concrete and steel.(Apr/May 2010)

10. A beam of reinforced concrete 250mm wide and 450mm deep to the centre of the tensile reinforcement is provided with 4 bars of 16mm □ as compressive steel at an effective cover of 40mm and 4 bars of 20mm □ as tensile steel. If the permissible stresses in concrete and steel are $5N/mm^2$ and 140 N/mm^2, find the M.R of the beam. Take m=18.67

UNIT- II - LIMIT STATE DESIGN FOR FLEXURE

(2MARKS)

1) Write the formula for the effective flange width of isolated l-beam? (Dec 2009)

For isolated beams, the effective flange width shall be obtained as below but in no case greater than the actual width,

T-beam, bf = [$\frac{lo}{\frac{lo}{6}+4} + bw$]

L-beam, bf = [$\frac{lo}{\frac{lo}{6}+4} + bw$]

Where bf = effective width of flange

Lo = distance between points of zero moment in the beam

L = effective span

B_W = breadth of web

Df = flange thickness

B = actual width of the flange

2) Differentiate between one way slab and two way slab.

One way slab	Two way slab
Reinforced concrete slabs supported on two opposite sides	In the case of a multistory building with column and beam construction the floor and roof slabs are supported on all the four sides.
The span/depth ratio specified in IS 456-2000 for beam is also applicable slab	The flexural moments are maximum at the center of the slab with a larger magnitude of moment developing along shorter span.
The percentage of reinforcement in the slab is generally low ranges of 0.3-0.5%	The positive moment reinforcement uniformly distributed our the middle strip extending over 75%

3) Disadvantages of providing large clear cover to slab

- At each end of reinforcing bar not less than 25mm, nor less than twice the diameter of such bar.

- The increased cover thickness may be provided when the surface of concrete members is exposed to the action of harmful chemicals (as in the case of concrete in contact with earth faces contaminated with such chemical) acid, vapour, saline atmosphere, sulphrous smoke as in the care of stream operated railways) etc. and such increase may be between the cover should not exceed 75mm.

4) **Purpose of providing distribution reinforcements in RC slab**

- One-way slabs are supported on opposite sides and the loads are transmitted in one direction.

- The verandah slab is a typical example of one way slab with main reinforcements in the transverse direction.

5) Purpose of providing lintel beam in buildings

Beams provided over door, windows or any other opening in the wall, to transit load of wall above there openings to the sides are called lintels. It is because of this natural arch formation that only a triangular portion of the masonry loads the lintel beam.

6) Types of reinforcement to resist shear

In the shear of steel is placed in reinforced concrete to contract the cracking and shear failure.

- A system of vertical stirrups
- A system of inclined stirrups placed at right angle to the diagonal tension cracks

- Main tension steel bent up and placed as declined in point 2

7) Codal provision for minimum reinforcement to the provided main & secondary reinforcement in slab.

The amount of reinforcement should be provided in the middle strip in x & y direction. As per codal provision the minimum reinforcement of edge strip is equal to 0.12% of cross sections.

8) List the advantages of limit state design. (Nov/Dec 2012)

Limit state method of designing structures based on a statistical concept of safety and associated statistical probability of failure structural design to satisfy all the limit states such as safety & sensibility.

9) IS code provision for maximum spacing of vertical stirrups in RC beams

- The maximum spacing of main steel in slab has been limited to 300mm.
- The maximum spacing for vertical stirrups for shear reinforcement has been limited to o.75d or 300mm instead of 450 of old code.

10)Partial safety factors for material strength γ_m

The grade strength of concrete is the characteristic strength of concrete, and the guaranteed yield strength of steel is the characteristic strength of steel.

Design strength = $\left(\frac{\text{Characteristic strength}}{\text{partial safety factors for strength } \gamma m}\right)$

This simply means that the strength to be used for design should be the reduced value of the characteristic strength of the factors denoted by the partial safety factor for the material. The recommended values for their partial safety factors are given.

11) Define Balanced section (or)Enumerate balanced section? (n_a=n_c)(Nov/Dec 2015)

The dimension of the section can be proportioned such that limiting stresses/ strains in concrete and steel, are induced simultaneously. Such a section known as **balanced section**, though efficient in the use of material is not necessarily the most economical section.

12) Define a Over reinforced section. (^{n}a > ^{n}c)

When the % of steel in a section is more that required for balanced section. The section is called off over reinforced section

$M_R = 1/2\sigma_{cbc}\, x_{ab}[d - x_a/3]$

13) What is it necessary to be providing transverse reinforcement in one way slab?

- The transverse reinforcement also called distribution reinforcement is also provided in a direction at right angles to the span of the slab.
- The transverse reinforcement is provided to serve the following purposes.
- It distributes the effects of point load on the slab more evenly &uniformly.
- It distributes shrinkage and temperature cracks more evenly.
- It keeps the reinforcement position.

14) What are the rules to be followed in the design of slabs as per IS456-2000? (Nov/Dec 2011)

- As per IS456-2000, continuous solid slabs are designed for maximum bending moment due to design loads based on bending moment coefficients given in table - 12.
- After thickness and area of steel calculation, the slabs are checked for shear based on shear force due to design loads (Table-13) and design shear strength of concrete (Table-19)
- Finally slab has to be checked for deflection based on basic values (clause 23.2.1) and modification factor (fig.4)

15) Enumerate corner reinforcement for two way slab. (Nov/Dec 2012)

Torsional reinforcements is required for the situation, "Two way slab corners are held down" or "Corners are not free to lift up."

<u>Design parameters for torsional reinforcements in two way slab</u>

- Torsional reinforcements consists of top and bottom mesh.
- Covering area of each mesh

$$\frac{\textit{short}\ \text{span}\ (l_x)}{5} \times \frac{\textit{long}\ \text{span}\ (l_y)}{5}$$

❖ Area of torsional reinforcement per meter width

$= \frac{3}{4} \times$ *short* span area of steel, A_{st}

(16 MARKS)

1. A doubly reinforced beam section is 300mm X 500mm and is provided with 2 bars of 12mm diameter as compression shear and 4 bars of 25mm diameter as tensile shear. These reinforcements are provided at an effective cover 40mm. Determine the ultimate moment of resistance of the beam section use M_{20} concrete and Fe_{415} shear.

2. A doubly reinforced beam section is 250 mm wide and 500 mm deep to the centre of tensile reinforcement it is reinforced with 2 bars of 16mm diameter as compression reinforcement at an effective cover of 50mm and 4 bars of 20mm diameter as tensile shear using M_{20} concrete and Fe_{415} shear. Calculate the moment of resistance of the beam section.

3. A doubly reinforced beam section is 250mm wide and 500mm deep to the centre of the tensile reinforcement. It is reinforced with 2 bars of 18 mm diameter as compression reinforcement an effective cover of 40mm and 4 bars of 25mm diameter as tensile shear using M_{20} concrete and Fe_{415} shear. Evaluate the moment of resistance of the beam.

4. What are the different steps involved in the design of flanged beam. [May / June 2013]

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5. A T-beam an effective flange width of 2500mm is required to resists an ultimate moment of 1200 KNM, the thickness of the flange is 150mm, the width of the side is 300 mm and the effective depth is 900mm using m20 concrete and Fe250 shear determine the area of reinforcement required. (Nov/Dec 2011)

6. A T-beam of flange width 1400mm, flange thickness 100mm, rib width 250mm bars as effective depth of 500mm the beam is reinforced with 4 bars of 20mm diameter. Find the ultimate moment of resistance use M_{20} concrete and Fe_{415} shear. (May/June 2012)

7. **Find the reinforcement required if the beam section is subjected to an ultimate moment of 500kNm use M_{20} concrete Fe_{415} steel. (Nov/Dec 2013)**

8. A T-beam of flange width 1000mm, flange thickness 100mm effective depth 550mm and rib width 275mm has to be designed as a balanced section determine the area of shear required and the limiting moment of resistance use M_{20} concrete and Fe_{415} shear.

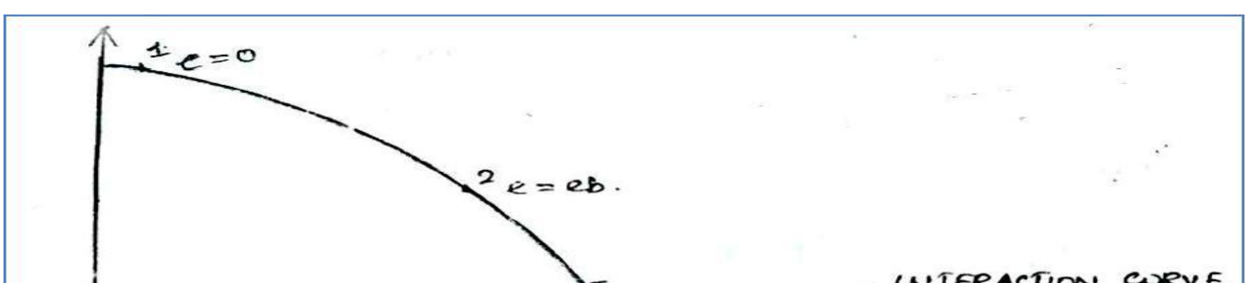
9. A T-beam of flange width 120mm, flange thickness 80mm, effective depth 500mm and rib width 250mm has to bed designed as a balanced section. Determine the area of the shear required and the limiting moment of resistance use M_{20} concrete and Fe_{415} shear.

10.A T- beam of flange width 900mm, flange thickness 100mm, rib width 250mm has an effective depth of 525mm is reinforced width shear of area 4909mm^2. Find the ultimate moment of resistance use M_{20} concrete and Fe_{415} shear.[May/June 2012]

UNIT – 3 - LIMIT STATE DESIGN FOR BOND, ANCHORAGE SHEAR & TORSION

PART-A

1) Draw a typical column interaction diagram showing the salient points? (Nov/Dec 2008)



The saline points of interaction points are given below.

5. The point „1" and the load axis correspond to the axial loading write zero

$M_u = 0$, e=0

ii) The eccentricity increases, are moment increases with the neutral axis „x_u" moving from outside towards extreme failure. Point „2" corresponding to this condition.

- The point „3" on the surface interaction diagram represents the balanced failure stage. (e=eb, $x_u = x_{umax}$)

Define development length? (May/June 2009)(April/May 2015)

The bond is provided by anchoring extending the boss beyond the points of maximum shear to a length which would be able to resist the shear at that section in the case of all flexural members. This length is called as „Development length" of bars.

$$L_d = \frac{(0.87fy)\phi}{4tbd} \text{ for tension}$$

$$L_d = \frac{(0.87fy)\phi}{4tbd(1.25)} \text{ for compression}$$

5. Name the locations in beam where the developments lengths of tension bars should be checked? (Nov/Dec 2008)

The development length of bars which are in tension due to bending should be checked at the following places.

- Section of maximum bending moment

- Supports
- Points of inflection, and at
- Points of cut-off of reinforcement.

6. What are specifications of pitch of lateral ties in column? (Nov/Dec 2008)

The pitch of transverse reinforcement shall be not more than the least of the following distances

- The least lateral dimension of the compression member
- 16 times the smallest diameter of the longitudinal reinforcement bar to tied.
- 48 times the diameter of the transverse reinforcement.

5) Equilibrium Torsion (or) Primary torsion? (Nov/Dec 2008)(May/June 2014)

In general, one may say that torsion in statically determinate structure is of the equilibrium type and torsion in statically indeterminate structure may be either of the equilibrium or the compatibility type.

6) Effective length? (Nov/Dec 2009)

In the absence of more exact analysis, the effective length of columns in framed structure may be obtained from the ratio of the effective length to sun supported length lef/l. when relative lateral displacement of ends is noy prevented in the later case. It recommended that the effective length l_{eff}/l may not be taken to be less than 1.2.

7) Define bond and anchorage? (Nov/Dec 2009)(May/June 2013)

The term „bond‟ in reinforced concrete design refers to the adhesion or the shear stress that occurs between concrete and steel in a loaded member. it is the bond b/w steel and concrete that enables the two materials to act together without slip.

8) State the minimum required of shear reinforcement (or) equation for nominal shear? (Nov/dec 2009)

$\left(\frac{Asv}{sv}\right)_{min} = \frac{0.4b}{0.87fy}$

Where,

A_{SV} = Total c/s area of legs of one stirrups.

S_V = Spacing of stirrups along the length of member

B = Breadth of beam

Fy = characteristics strength of stirrup reinforcement (not exceeds 415 N/mm^2)

- **State maximum permitted spacing of stirrups in a beam as per IS specification? (April/May 2008)**

The max. Spacing of shear reinforcement in a beam shall not be greater than.

0.75d for vertical stirrups and “d” for incline stirrups.

300mm

- **What is compatibility torsion? Give an example. (May/June 2007)**

Compatibility torsion is the torsion induced in the member due to compatibility of rotations at the joint of interconnected members.

Example: Spandrel beam rigidly connected to cross beam, interconnected bridge girder and grids in horizontal plane.

11) Define Equivalent shear?

Effect of torsion is combined with shear and an increased value of shear is called equivalent shear or fictitious shear.

12) Two types of torsion?

1) Primary torsion (or) equilibrium torsion
2) Secondary (or) compatibility torsion

13) Define bond stress?

Bond stress can be defined as the longitudinal shear stress at the interface between concrete and reinforcement. (Or)

Bond stress is defined as the intensity of adhesive force per unit of surface area.

14) What are factors affecting the bond resistance?

1) Grade of concrete
2) Diameter of bars
3) Bare profile condition
4) Nature of force in the bars
5) Stress level in the reinforcement
6) Bends and hooks
7) Groups of bars bundled
8) Curtailment of bars in tension

15) How do you calculate the development length requirement at the supports as per BIS code? (May/June 2009)

L_d = $\frac{\varphi\sigma st}{4\tau bd}$

Where, $\varphi - Dia\ in\ "mm"$

$\frac{bn2a}{2}$ = Permissible stress in steel in N/mm^2

<u>PART - B</u>

1. A reinforced concrete beam of cross section 250 x 600 mm is reinforced with 4 bars of 22mm dia out of 2 bars of bent up near the support section at an angle of 45° where a factored shear force of 350kN is acting. Use M20 grade concrete and Fe415 grade steel. Design suitable shear reinforcement at the support section. (May/June 2012)(May/June2016

2. A reinforced beam of rectangular section 300mm wide is reinforced with 4 bars of 25mm dia. At an effective depth of 600mm. The beam has to resist a factored shear force of 400kN at support section. Use M25 grade concrete and Fe415 grade steel. Design vertical stirrups for the section. (Nov/Dec 2013).

3. A reinforced concrete beam of rectangular section with a width of 350mm and overall depth of 500mm is subjected to a factored bending moment of 215kNm.

Ultimate torsional moment of 1.5kNm and ultimate shear force of 150kN. Use M20 grade concrete and Fe415 grade steel with a cover of 50mm. Design suitable reinforcement in the section.(Nov/Dec 2012)(Nov/Dec 2014)

4. Design the reinforcement required for a rectangular beam section with the following data:

Size of the beam section = 300mm x 600mm Factored shear force = 95kN

Factored torsion = 45kNm

Factored Bending moment = 115kNm

Materials = M20 concrete and Fe415 steel. Adopt limit state design method. (Nov/Dec 2012)(April/May 2015)

5. A rectangular reinforced concrete beam of size 250mm x 500mm is reinforced with 4 bars of 20mm diameter distributed at the corners with a cover of 50mm depth wise and 25mm widthwise. Further 8mm diameter 2 legged stirrups are provided at 100mm centers. Find the torsional strength of the section. Fe415 HYSD bars are used and the transverse shear is 80kN. (May/June 2012)

6. The T-beam and slab system of a structure are made of beams spaced at 2.4m with clear span of 7.5m between masonry walls of 300mm thick. For the T-beam D_f = 120mm; b_w = 300mm; D = 600mm. If f_{ck} = 20N/mm^2 and f_y = 415N/mm^2. Design the shear steel. Assume that 2 no's of 28mm dia. Bars of tension steel are continued to support and live load = 8kN/m^2(Nov/Dec 2011)

7. A reinforced concrete beam of 300mm wide and 600mm depth is build into a column of 500mm wide. The cantilever beam is subjected into a hogging moment of 200kNm at the function of beam and column. Design the suitable reinforcement in the beam. Check for the required anchorage length. Use M20 grade concrete and Fe415 steel. (May/June 2013

8. A cantilever beam having a width of 250mm and effective depth of 300mm

supports a uniformly distributed load and it is reinforced with 4 bars of 16mm dia.. If the factored load is 80kN. Calculate the maximum local bond stress and anchorage length required.

9. A reinforced concrete beam of 6m span is uniformly loaded and it is reinforced with 5 bars of 20mm dia. On the tension side at an effective depth of 400mm. Find the distance from the center of the beam where one of the bar can be curtailed. Use M20 grade concrete and Fe415 grade steel.

10. A reinforced concrete beam 300mm x 750mm is reinforced 4 bars of 25mm dia. , effective cover = 50mm, Bending moment = 250kNm; f_{ck} = 25N/mm^2; f_y = 500N/mm^2. Find the value of T_u.

UNIT – 4 - LIMIT STATE DESIGN OF COLUMNS
(2MARKS)

1. How do you classify column as short column (May/June2007)

IS 456 clarifies rectangular column as short when the ratio of effective length (le) to the least dimension is less than 12 the ratio is called slenderness ratio of column if the column is of dimension b x d

Slenderness ratio about major axis =l_{ex}/d

Slenderness ratio about major axis =l_{ey}/d

If any of these two ratio is equal to or move than 12, it is called a slender column if both sides are less than 12, it is a short column

2. Write short on braced column (may/june2009)(Nov/Dec2015)

In tall buildings lateral supports like shear wall can be provided so that the lateral loads are taken by them such column are called braced column

3. Define uni-axial bending (nov/dec2009)

column such as the external column of framed buildings or column carrying crane load through cables of a column are not only to direct load (p),but also the moments (m0 due to the eccentricity in application of the load in the above column the eccentricity in with respect to one axis only and these column are said to be under uniaxial bending

5. Define Short column and long column (May/June 2007)

Short column the permissible load for column with helical reinforcement shall be 1.05 times the permissible load for similar member with lateral or the ratio of volume of helical reinforcement to the volume of the core shall not be less than d.36(ag/ac -1 fck/fy) Long column the maximum permissible stress in a reinforced concrete column or part there of having a ratio of effective column length to least lateral dimension above 12 shall not exceed the ratio of effective column length to least lateral radius of gyration above to shall not exceed

6. What is column?

When a member carrying axial load is vertical and having an effective length exceeding three times the least lateral dimension is called as column

6. Classify the column based on type of loading and transverse reinforcement?

Column can be classified into three types based on loading

- column with axial loading
- column with uniaxial eccentric loading
- column with biaxial eccentric loading

7. What is axially loaded column? (or) write short notes on axially loaded column.

An axial loaded column transmits the compressive force without an explicit design requirement to carry lateral loads or end moments

(or)

When the line action of load passes through from centre of gravity of column it is called as axially loaded

9. What is eccentrically loaded column? (Or) write short notes on eccentrically loaded column?

An eccentrically loaded column transmits the compressive force with an explicit design requirement to carry lateral loads or end moments

(Or)

When the line of action of load passes away from centre of gravity of column, it is called as eccentrically loaded

10. What is unbraced column? (or) write short notes on unbraced column?

When relative transverse displacement between the upper and lower ends of a column is not prevented the frame is said to be unbraced column

11. What is uniaxial bending? (or) write short notes on uniaxial bending (Nov/Dec 2009)

A column is subjected to eccentric load along one axis only such a column is said to be under uniaxial bending. (or)

The moment due to load transferred from one direction of column is called as uniaxial bending

12. What is biaxial bending? (or) write short notes on biaxial bending?

A column is subjected to eccentric load along both x and y axes such a column is said to be under biaxial bending (or)

The moment due to load transferred from bath direction of column is called as biaxial bending

4. Under which condition a column is designed with axial load and biaxial bending?

 column with axial load and biaxial bending is commonly found in structures because of two major reasons

axial load may have natural eccentricities through small with respect to both the axis

II.corner column of a building may be subjected to bending moments in both the direction along with axial load

14. State the codal recommendation for slenderness limits for column?

I The unsupported length between the end restraints shall not exceed 60 times the least lateral dimension of a column

II If in any place one end of a column is unrestrained its unsupported length should not exceed 100 b^2/d where b and d are width and depth of cross section measured in place under consideration

15. State the minimum eccentricity to considered for column design?

(OR) Write down the expression for minimum eccentricity. (May/June 2013)

Minimum eccentricity (e_{min}) = l0/500 + d/30 but less than

20mm Where, $l_o \rightarrow$ unsupported length

$d \rightarrow$ lateral dimension in bending

16. What are the reinforcements used to resist shear force in column? (Nov/Dec 2012)

- Longitudinal reinforcement
- Transverse reinforcement

PART -B

1. Design the reinforcements in a circular column of diameter 300mm to support a service axial load of 800kN. The column has an unsupported length of 3m and is braced against side away. The column is reinforced with helical ties. Adopt M20 grade concrete and Fe415 HYSD bars. (May/June 2014, 2016) (Nov/Dec 2014)(May/June 2016)

2. Design the reinforcements in a short column 400 x 400 mm at the corner of a multi-storied building to support an axial factored load of 1500kN, together with biaxial moments of 50kNm acting in perpendicular planes. Adopt M20 grade and Fe415 HYSD bars. (May/June 2014, 2016) (Nov/Dec 2014) (May/June2016)

3. Design a short R.C.C column to carry an axial load of 1600kN. It is 4m long, effectively held in position and restrained against rotation at both ends. Use M20 concrete and Fe415 steel. (May/June 2013)

4. Design a reinforced concrete square column of 500mm side to carry an ultimate load of 2000kN at an eccentricity of 180mm. Use M20 concrete and Fe415 steel. (Nov/Dec 2013, 2015).

5. Design the reinforcement to be provided for a short column 400mm x 500mm subjected to the following forces:

P_u = 1600kN ; M_{ux} = 200kNm ; M_{uy} = 150kNm. Use M25 and Fe415. (Nov/Dec 2013), (May/June 2012), (Nov/Dec 2011)

6. Determine the reinforcement required for a column with the given data and which is restrained against sway.

Size of the column = 500mm x 400mm

Concrete grade = M30 ;f_y = 415N/mm^2 ; l_{ex} = 7.0m ; l_{ey} = 6.0m Unsupported length = 7.0.m

Factored load (P_u) =1600kN

Factored moment is 40kNm at top, 25 kNm at bottom, in the direction of larger dimension.

Factored moment in direction of shorter dimension = 30kNm at top and 20kNm at bottom.

The column is bend in double curvature with reinforcement equally distributed on all four sides. (May/June 2013) (Nov/Dec 2011)

7. Design the reinforcement in a circular column of diameter 400mm with helical reinforcement of 8mm diameter to support a factored load of 1200kN. The column has an unsupported length of 3m and is braced against side sway. Adopt M20 grade of concrete and Fe415 steel. (May/June 2012)

8. A short R.C.C column 450mm x 450mm is reinforced with 8 bars of 20mm diameter. The effective length of the column is 2.75m. Find the ultimate load for the column. Use M20 concrete and Fe250 steel. (Nov/Dec 2012)

9. A rectangular column of effective height 4m is subjected to a characteristic load of 800kN and bending moment of 100kNm about major axis of the column. Design the suitable section for the column so that the width should not exceed 400mm. Consider M25 grade concrete and Fe415 grade steel. (Nov/Dec 2012) (April/May 2015)

10. Design a square subjected to an ultimate axial load of 1000kN. Consider concrete grade M20 and steel of grade Fe415. (May/June 2008)

UNIT- V- LIMIT STATE DESIGN OF FOOTING

(2 marks)

1. **What is meant by proportioning of footing? [N/D-15**]
   The pressure on the soil from each square foot of the footings should be the same, where the soil is uniform, and at no place must the bearing power of the soil be exceeded. To secure the most satisfactory results, therefore, the footings must be proportioned to properly distribute the weight they are to carry over sufficient areas of ground, to secure uniform settlement in each case. If these conditions were always properly considered, there would be few cracks in the mason work, as such cracks are caused usually by unequal settlement. A uniform settlement even of an inch or more would in most buildings pass unnoticed.

2. **On which circumstances combined rectangular footings are suitable? [N/D-15]**
   Combined footings are provided when two or more columns are located close to each other or they are heavily loaded or rest on soil with low safe bearing capacity, resulting in an overlap of areas.

3. **Why the dowel bars are provided in footing? [M/J-16]**
   When complete column bars are not erected at the beggining then you can place dowel bars and tie column rods after footing

4. **What is the necessity of providing combined footings? [M/J-16]**
   Combined footings are used when:
   1) there are two isolated footings overlapping (when columns are too close to each other, like within 2m)
   2) soil bearing capacity is inconsistent and low within an area
   3) the footing is extending beyond your property.

5. **Enumerate proportioning of footings. [N/D-16]**
   The shear failure of column footing occurs either similar to that of footing for wall due to formation of diagonal tension cracks on an approximate 45˚ plane known as one way shear. The shear failure of column footing occurs either similar to that of footing for wall due to punching of column through the slab known as two way shear.

6. **Define punching shear. [N/D-16]**
   The shear failure of column footing occurs either similar to that of footing for wall due to punching of column through the slab known as Punching shear. It occurs at a distance of half the effective depth of footing from the face of column.

7. **When is the combined footing provided? [M/J-13]**
   Combined footings are provided only when it is absolutely necessary, as
    When two columns are close together, causing overlap of adjacent isolated footings
    Where soil bearing capacity is low, causing overlap of adjacent isolated footings
    Proximity of building line or existing building or sewer, adjacent to a building column.

8. **What are the advantages of providing a pedestal?**
   The advantages of providing pedestal are:
   (i) For providing pedestal, the cantilevering projection of footing is reduced, thus reducing bending

moment and shear for the footing
(ii) Width for resisting the bending moment is reduced
(iii) Larger perimeter is provided to resist two way shear

9. **What are the causes for failure of footing? [N/D-12**]
The common causes for failure of footing are:
(i) Unequal settlement of sub soil
(ii) Shrinkage of soil below the foundation due to withdrawal of moisture
(iii) Lateral pressure causing over turning of structure
(iv) Lateral movement of soil close to the structure

10. **Why transverse reinforcement is necessary in a column? [M/J-13**]
Transverse reinforcement is provided to impart effective lateral support against buckling to every longitudinal bar. It is either in the form of circular rings or polygonal link(lateral ties) with internal angles not exceeding 135˚.

11. What is meant by uniaxially and biaxially eccentrically loaded columns? [N/D-12]
Uniaxially eccentrically loaded columns: If the moments act about only one axis, they are called as uniaxially eccentrically loaded columns.

Biaxially eccentrically loaded columns: If the moments act about both the axis, they are called as biaxially eccentrically loaded columns.

12. List out the specifications for spacing of transverse links. [M/J-12]
Spacing of transverse links shall not exceed the least of the following:

(a) The least lateral dimensions of the column

(b) Sixteen times the diameter of smallest longitudinal reinforcing rod in column

(c) Forty-times the diameter of transverse reinforcement

13. List out the IS recommendations regarding longitudinal reinforcements. [M/J-12]
The following are the IS recommendations regarding longitudinal reinforcements:
a) The minimum number of longitudinal bars provided in a column shall be four in rectangular columns
and six in circular column
b) The bars shall be not be less than 12 mm in diameter
c) Spacing of longitudinal bars measured along the periphery of column shall not exceed 300 mm

14. What are the specifications for diameter of transverse links? [N/D-11]

Specifications for diameter of transverse links are the following:
The diameter of the transverse links shall not be less than
(i) One-fourth diameter of the largest longitudinal bar
(ii) 5 mm

15. **Why transverse reinforcement is necessary in a column? [M/J-13]**
Transverse reinforcement is provided to impart effective lateral support against buckling to every longitudinal bar. It is either in the form of circular rings or polygonal link(lateral ties) with internal angles not exceeding 135˚.

(16 MARKS)

1. **A 230mm thick masonry wall is to provided with a reinforced concrete footing on a site having soil with SBC,**
unit weight and angle of repose of 125 kN/m2, 17.5 kN/m3 and 300 respectively. The M20 grade of concrete and HYSD steel bars of grade Fe 415. Design the footing when the wall supports at service state: a load of 150 kN/m length. (16) [N/D-15], [M/J-12]
2. **A Rectangular column 600x400 mm carries a load of 800kN. Design a rectangular footing to support the**
column. The safe bearing capacity of the soil is 200 kN/m2. Use M20 grade concrete. (16) [N/D-15]
3. **Design a reinforced concrete footing for a rectangular column of section 300mm x500mm supporting an azial factored load 1500 kN. The safe bearing capacity of the soil at site is 185 kN/m2. Adopt M 20 grade of**
concrete and HYSD steel bars of grade Fe 415.
4. **Design a combined column footing with a strap beam for two reinforced concrete 300mm x300mm size spaced 4m apart and each supporting a factored axial load of 750kN. Assume the ultimate bearing capacity of soil at site as 225 kN/m2. Adopt M20 grade of concrete and steel grade Fe415 HYSD bars.**
5. **A 230mm thick masonry wall is to provided with a reinforced concrete footing on a site having soil with SBC, unit weight and angle of repose of 130 kN/m2, 17.5 kN/m3 and 300 respectively. The M20 grade of concrete and HYSD steel bars of grade Fe 415. Design the footing when the wall supports at service state: a load of**
150 /m length.
6. **A Rectangular column 550x350 mm carries a load of 775kN. Design a rectangular footing to support the**
column. The safe bearing capacity of the soil is 210 kN/m2. Use M15 grade concrete.

7. **Design a reinforced concrete footing an azial factored load 2000 kN. The safe bearing capacity of the soil at site is 150 kN/m2. Adopt M 20 grade of concrete and HYSD steel bars of grade Fe 415.**
8. **Design a combined column footing with a strap beam for two reinforced concrete 300mm x300mm size spaced 4m apart and each supporting a factored axial load of 750kN. Assume the ultimate bearing capacity of soil at site as 225 kN/m2. Adopt M20 grade of concrete and steel grade Fe415 HYSD bars.**
9. **A 230mm thick masonry wall is to provided with a reinforced concrete footing on a site having soil with SBC,**
   unit weight and angle of repose of 125 kN/m2, 17.5 kN/m3 and 300 respectively. The M20 grade of concrete and HYSD steel bars of grade Fe 415. Design the footing when the wall supports at service state: a load of 150 kN/m length. (16) [N/D-15], [M/J-12]
10. **A Rectangular column 600x400 mm carries a load of 800kN. Design a rectangular footing to support the**
    column. The safe bearing capacity of the soil is 200 kN/m2. Use M20 grade concrete. (16) [N/D-15]