MOHAMED SATHAK AJ COLLEGE OF ENGINEERING

DEPARTMENT OF CIVIL ENGINEERING

CE8501-DESIGN OF REINFORCED CEMENT CONCRETE ELEMENTS

EXAM PREPARATION CLASS IMPORTANT QUESTIONS

UNIT 1

INTRODUCTION

PART A

1.What are the assumption made in working stress method?

At any cross-section, plane sections before bending remain plain after bending.

All tensile stresses are taken up by reinforcement and none by concrete, except as otherwise specifically permitted.

The stress-strain relationship of steel and concrete, under working loads, is a Straight line.

The modular ratio m has the value -280/3σbc.

2.Differentiate WSD and LSD? (MAY 2007)

Working Stress Method

The stresses in an element is obtained from the working loads and compared with permissible stresses.

The method follows linear stress-strain behavior of both the materials.

Modular ratio can be used to determine allowable stresses.

Material capabilities are under estimated to great extent extent. Factor of safety is used (on materials strength only) in working stress method.

Ultimate load carrying capacity cannot be predicted accurately.

The main drawback of this method is uneconomical, since need to provide huge quantity of steel and concrete.

Limit state Method

The stress are obtained from design and compared with design strength.

This method follows linear strain relationship but not linear stress relationship.

The ultimate stresses of materials itself are used as allowable stresses.

The material capabilities are not under estimated as much as they are in working stress method. Partial safety factors are used in limit state method.

It shall also satisfy the serviceability requirements, such as limitation on deflection and cracking.

3.What are the expressions recommended by the IS 456-2000 for Modulus of Elasticity and Flexural Strength? (MAY JUNE 2009)

Flexural strength $f_{cr}=0.7\sqrt{fck}$ N/mm^2

Where 'fck' is the characteristic cube compressive strength of concrete in N/mm^2. (From Cl No. 6.2.2, IS 456-2000) Modulus of elasticity of concrete Ec = $500\sqrt{fck}$. (From Cl No. 6.2.3.1, IS 456-2000) Where, E, is the short term static modulus of elasticity in N/mm^2

4.What is meant by balanced section?

When the maximum stress in steel and concrete simultaneously reach their allowable values, the section is said to be balanced section. In this section the actual neutral axis depth is equal to the critical neutral axis

5.When do you do for doubly reinforced beams? (NOV-DEC 2012) (NOVDEC2010) (APRIL MAY 2012)

The section reinforced in both tension and compression zone is known as doubly reinforced section. The doubly reinforced beams are adopted when the balancedmoment is smaller than the Actual moment

Doubly reinforcement is provided for the following circumstances.

To increase the moment of resistances of abeam section of limiteddimensions,

The external live load may be changed. That is, load may be acting on either face of the member.

The loading may be eccentric and eccentricity of the load may change from one side of the axis to another side.

The member may be subjected to a shock or impact or accidental lateral force.

6.Define characteristic strength in limit state method.[M/J-12]

The term 'characteristic strength' means that value of the strength of the materialbelow which not more than 5 present of the test results are expected to fall.

7.Define: Limit state.[M/J-12]

The acceptable limit for the safety and serviceability requirements before failure occurs is ca**l** ed a 'limit state'. The aim of design is to achieve acceptable probabilities that the structure will not become unfit for the use for which it is intended, that is, that it will not reach a limit state

8.What is the formula used to find the actual neural axis in working stress methods. [N/D-16]

$0.5\ b\ na^2 = m\ Ast\ (d - na)$ where, b = width of beam d = effective depth of beam na = actual Neutral axis

9.Write any two advantages of limit state over other methods. [N/D-15], [N/D11]

The advantages of limit state method over the other methods are the following

a) In the limit state method of analysis, the principles of both elastic as well as plastic theories used and hence suitable for concrete structures

b) The structure designed by limit state method is safe and serviceable under design loads and at the same time it is ensured that the structure does not collapse even under the worst possible loading conditions

c) The process of stress redistribution, moment redistribution etc., are considered in the analysis and more realistic factor of safety values are used in the design

d) Hence the design by limit state method is found to be more economical

e) The overall sizes of flexural members (depth requirements) arrived by limit state method are less and hence they provide better appearance to the structure

10.Difference between Elastic method and limit state method. (NOV-DEC 2010)

Advantages of limit state method over the other methods

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b. The structure designed by limit state method is safe and serviceable under design loads and at the same time it is ensured that the structure does not collapse even under the worst possible loading conditions.

c. The process of stress redistribution, moment redistribution etc., are considered in the analysis and more realistic factor of safety values are used in the design. Hence the design by limit state method is found to be more economical.

d. The overall sizes of flexural members (depth requirements) arrived by limit state method are less and hence they provide better appearance to the structure

e. Because of the modified assumptions regarding the maximum compressive strains in concrete and steel, the design of compressive reinforcement for double reinforced beams and eccentrically loaded columns by limit state method gives realistic valued which is not so in other methods.

11.Write a short note on limit state of durability. [N/D15]

The acceptable limit for safety and serviceability requirements before failure occurs is called a limit state. The aim of design is to achieve acceptable probabilities that the structure will not become unfit for the use for which it is intended, that is, that it will not reach a limit state.

12.What is partial safety factor? [N/D-15]

Factors of safety (FoS), also known as (and used interchangeably with) safety factor (SF), is a term describing the load carrying capacity of a system beyond the expected or actual loads. Essentially, the factor of safety is how much stronger the system is than it usually needs to be for an intended load.

13.Distinguish between under reinforced and over reinforced sections. (MAY JUNE 2009)

A beam reaches its permissible stress in steel under the working moment before

Concrete reaches its stress is called as under reinforced section. A beam reaches its permissible stress in concrete under the working moment before steel reaches its stress is called as over reinforced section.

14.When do you do for doubly reinforced beams? (NOV-DEC 2012) (NOVDEC2010) (APRIL MAY 2012)

The section reinforced in both tension and compression zone is known as doubly

Reinforced section. The doubly reinforced beams are adopted when the balancedmoment is smaller than the Actual moment

Doubly reinforcement is provided for the following circumstances.

1. To increase the moment of resistancesof a beam section of limiteddimensions,
2. The external live load may be changed. That is, load may be acting on either

Face of the member.

3. The loading may be eccentric and eccentricity of the load may change fromone side of the axis to another side.
4. The member may be subjected to a shock or impact or accidental lateral force.

15.Define: Limit state. [M/J-12]

The acceptable limit for the safety and serviceability requirements before failure occurs is called a 'limit state'. The aim of design is to achieve acceptable probabilities that the structure will not become unfit for the use for which it is intended, that is, that it will not reach a limit state.

16.**What is the formula used to find the actual neural axis in working stress methods. [N/D-16]**

$0.5\ b\ na^2 = m\ Ast\ (d - na)$ where, b = width of beam d = effective depth of beam na = actual Neutral axis

PART B

1. Design a simply supported reinforced concrete beam to carry a bending moment of 50kNm as doubly reinforced section by working stress method. Keep the width is equal to half the effective depth.

2. A reinforced concrete beam of span 5m has a rectangular section of 250mm x 500mm. the beam is reinforced with 3 bars of 16mm diameter on the tension side at an effective depth of 450mm and 2 bars of 16mm diameter on the compression side at a cover of 50mm from the compression face. Estimate the maximum permissible live load on the beam. Use M-15 grade concrete and Fe-250 grade steel.

3. What are the methods involved in the design of reinforced concrete structures? Briefly explain the design procedure of the methods.

4. A rectangular beam of breadth 300mm and effective depth 800mm with cover of 40mm to centre of steel is to be designed for M20 concrete and Fe 415 grade steel. Use working stress method. Determine the area of steel required if the moment due to characteristic load is 160KN.

5. A simply supported RC slab having an overall thickness of 150mm is reinforced with 12mm diameter bars at an effective depth of 130mm. the spacing of the bars is 100mm. effective span of the slab is 4m. if the self weight of the slab and finishes is 4.2KN/m^2. Estimate the maximum permissible live load on the slab. Adopt M-15 grade concrete and MS grade I steel. Use working stress method.

6. A RC beam having a rectangular cross section 300mm wide is reinforced with 2 bars of 12mm diameter at an effective depth of 550mm. the section is subjected to a service load moment of 40 KN.m. Estimate the stresses in concrete and steel. Adopt M20 grade concrete and Fe 415 HYSD Bars. Adopt working stress method.

UNIT II

DESIGN OF BEAMS

PART A

1.Define collapse load. [M/J-13]

The load that causes the (n +1) th hinge to form a mechanism is called collapse load where n is the degree of statically indeterminacy. Once the structure becomes a mechanism

2.Enlist different factors that are influencing the durability of concrete as per BIS? [M/J-13]

Factors affecting durability of concrete, Concrete durability has been defined by the American concrete institute as its resistance to weathering action, chemical attack, abrasion and other degradation processes. Durability is the ability to last a long time without significant deterioration.

3.Differentiate between under reinforced and over reinforce section [N/D-15], [M/J-12] A beam reaches its permissible stress in steel under the working moment before concrete reaches its stress is called as Under reinforced section. A beam reaches its permissible stress in concrete under the working moment before steel reaches its stress is called over reinforced section

4.Write any two guidelines to select the cross sectional dimensions of reinforced concrete beams. [M/J-16]

The deflection of a structure or part there of shall not adversely affect the appearance or efficiency of the structure or finishes or partitions. The deflection shall generally be limited to the following:

a) The final deflection due to all loads including the effects of temperature, creep and shrinkage and measured from the as-cast level of the, supports of floors, roofs and all other horizontal members, should not normally exceed span/250

The deflection including the effects of temperature, creep and shrinkage occurring after erection of partitions and the application of finishes should not normally exceed span/350 or 20 mm, whichever is less.

5.Enumerate the advantages of flanged beams. [M/J16]

- Since the beam is casted monolithically with the slab, the flange also takes up the compressive stresses which mean it will be more effective in resisting the sagging moment acting on the beam.
- Better head room, this is direct outcome of the first point since the depth of the beam can be considerably reduced.
- For larger spans, t beams are usually preferred rather than rectangular beam as the deflection is reduced to a good extent.

6.On what circumstances doubly reinforced beams are to be adopted? [N/D-16], [M/J-12]

Situations in which doubly reinforced sections preferred are: a) when the members are subjected to alternate external loads and the bending moment in the section reverses

b) When the members are subjected to loading eccentric on either side of axis

c) When overall size of beam section is limited d) when beam section is continuous over several supports.

7.What is the importance of anchorage value of bends? [M/J16]

The bond between steel and concrete is very important and essential so that they can act together without any slip in a loaded structure. With the perfect bond between them, the plane section of a beam remains plane even after bending.

8.Define shear friction. [M/J16]

The shear friction analogy is a design. It is a valuable and simple tool which can be used to estimate the maximum shear force transmitted across a cracked plane in a reinforced concrete member.

9.What is the important mechanism of shear resistance in beams with web reinforcement? [N/D-16]

In reinforced concrete building construction, stirrups are most commonly used as shear reinforcement, for their simplicity in fabrication and installation. Stirrups are spaced closely at the high shear region. Congestion near the support of the reinforced concrete beams due to the presence of the closely spaced stirrups increase the cost and time required for installation.

10.Write down the effect of torsion in RC beams? [M/J-13]

Generally beams are provided with main reinforcement on the tension side for flexure and transverse reinforcement for shear and torsion. On several situations beams and slabs are subjected to torsion in addition to bending moment and shear force. Loads acting normal to the plane of bending will cause bending moment and shear force.

11.Write about local bond and anchorage length? [M/J-13]

Local bond length is provided for overlapping two rebars in order to safely transfer the load from one bar to another bar. Anchorage Length is provided to transfer the load from steel to concrete. Development Length is also known as anchorage length. Development length is the length of the bar required to transfer stress from steel to concrete.

12.Write about anchorage bars in tension. [M/J12]

Deformed bars may be used without end anchorages provided the development length required is satisfied. Hook should normally be provided for plain bars in tension. The anchorage value of a band shall be taken as 4times the diameter of the bar for each 450 bend subjected to a maximum of 16 times the diameter of the bar. The anchorage valueof a standard U-type hook shall be equal to 16 times the diameter of the bar

13.What are the types of shear failure in reinforced concrete beam? [N/D13]

A) Shear tension b) Flexure shear c) Shear compression d) Shear bond

14.Define bond stress. [N/D-12], [M/J-13]

The tangential or shear stress developed along the contact surface of the reinforcing bar and the surrounding concrete if generally termed as bond stress and is expressed in terms of the tangential force per unit nominal surface of the reinforcing bar.

15.What are the types of reinforcements used to resist shear and write down the expression for shear resistance offered by each type? (NOV – 2007)

Spacing between stirrups in RC beams is the minimum of following 4 cases.

$$S_v = \frac{0.87\ fy\ Asv\ d}{Vus}$$

$$S_v = \frac{2.175\ fy\ Asv}{b}$$

$S_v = 0.75\ d$

$S_v = 400mm$

PART B

1. A T-Beam has the following width b=350mm : breadth of the beam=250mm. effective depth = 500mm: thickness of flange=90mm: applied moment=130mm. design beam using M20 grade concrete and Fe 415 grade steel.

and d=350mm has a factored shear of 400KN at the critical section near the support. The steel at the tension side of the section consist of four 32mm dia bars which are continued to support. Assuming F_{ck} =25 N/mm^2 and F_y = 415 N/mm^2.

2. Check for the development length at support of a doubly reinforced beam 400mm x 750mm (effective) the clear span of the beam is 5.25m. the beam carries UDL of 46KN/m(including self-weight). The beam is reinforced with 8 bars of 20mm diameter (4 are bent up near support) on tension side and 4 bars of 16mm diameter on compression side. Adopt M20 grade concrete and Fe415 HYSD bars.

3. Design a shear of rectangular reinforced concrete beam section to carry a factored bending moment of 220KNm, factored shear force of 140KN, and factored torsional moment of 80KNM. Use M20 grade concrete and Fe 415 steel.

4. A Simply supported RC beam of size 300x500mm effective is reinforced with 4 bars of 16mm diameter HYSD steel of grade Fe415, determine the anchorage length of the bars at the simply supported end if it is subjected to a factored force of 350KN at the center of 300mm wide masonry wall. The concrete mix of grade M20 is to be used. Draw the reinforcement detail.

5. A Simply supported beam is 5m in span and carries a load of 75KN/m. if 6 No's of 20mm M-20 grade concrete and Fe415 grade steel.

6. Determine the reinforcement required for a rectangular beam section with following data.

Size of the beam= 300mm x 500mm

Factored bending moment – 80KNm

Factored torsional moment=40KNm

Factored shear force=70KN

Use M-15 grade concrete and Fe-415 HYSD Bars.

UNIT III

DESIGN OF SLABS AND STAIRCASE

PART A

1. **Write any two general features of two way slab? [N/D16]**

   Two way slabs is supported by beams in all four sides. The ratio of longer span panel (L) to shorter span panel (B) is less than 2. Thus, L/B < 2. Main reinforcement is provided in both the directions for two way slabs.

2. **Explain the check for deflection control in the design of slabs? (NOV-DEC 2012)**

   The deflection of a structure or part thereof shall not adversely affect the appearance or efficiency of the structure or finishes or partitions. The deflection shall generally be limited to the following:

   a) The final deflection due to all loads including the effects of temperature, creep and shrinkage and measured from the as-cast level of the , supports of floors, roofs and all other horizontal members, should not normally exceed span/250.

   b) The deflection including the effects of temperature, creep and shrinkage occurring after erection of partitions and the application of finishes should not normally exceed span/350 or 20 mm whichever is less.

3. **What type of slabs are usually used in practice, under reinforced or over reinforced? (NOV-DEC 2009)**

   The depth of slab chosen from deflection requirements will be usually greater than the depth required for balanced design. Hence the area of steel required will be less than the balanced amount. So, the slab is designed as under reinforced section.

4. **Why is necessary to provide transverse reinforcement in one way slab? (APRIL MAY 2012)**

   Since the one way slab bends in one direction and also in shorter direction, so it is necessary to provide transvers reinforcement in one way slabs. These slabs adopted when availability of two supports in one direction.

5. **What are the codal provision for minimum reinforcement to be provided as main and secondary reinforcement in slab and their maximum spacing? (NOV 2007) Minimum reinforcement**

   For Mild steel

   A_{st} min = 0.15% of total cross sectional area = $\frac{0.15}{100} bD$

   For HYSD bars

   A_{st} min = 0.12% of total cross sectional area = $\frac{0.12}{100} bD$

   Spacing

   For main reinforcement

   Spacing = 3d or 300 mm whichever is smallerFor secondary reinforcement

   Spacing = 5d or 450 mm whichever is smallerWhere d=effective depth of slab

6. **What is the different between one way slab and two way slabs? (NOV 2008)**

   One way slab $\frac{Ly}{Lx} > 2$

   Two way slab $\frac{Ly}{Lx} < 2$

   L_y = Effective span of slab in long span direction L_x = Effective span of slab in short span direction

7. **Why is secondary reinforcement provided in one way RC slab?(MAY-2008)**
   Secondary reinforcement is provided running at perpendicular to the main reinforcement, in order to take the temperature and shrinkage stresses. It is otherwisecalled distribution or temperature reinforcements.
8. **What are the types of staircases? (AUC May/Jun-2012) (AUC Nov/Dec-2012) (AUC Nov/Dec-2011)**
   They are broadly classified as Quarter turn stair Half turn stair Dog legged stair Open newer stair with quarter space landing Geometrical stairs such as circular stair, spiral stair.

PART B

1. Design one way reinforced concrete beam simply supported at the edges for a public building with clear span of 4m supported on 200mm solid concrete masonry walls. Live load on slab is 5KN/m^2. Adopt M20 grade concrete and Fe415 HYSD Bars.

2. A Tee beam slab of an office comprise of a slab 150mm thick spanning between ribs spaced at 3m centres. The effective span of the beam is 8m. Live load on floor is 4KN/m^2. Design one of the intermediate beam using M20 Grade concrete and Fe 415 HYSD Bars.

3. Design a two way slab of an office floor size 3.5m x 4.5m with discontinuous and simply supported edges on all the sides with the corners prevented from lifting and supporting a service live load of 4.4KN/m^2. Adopt M20 grade concrete and Fe415 HYSD bars.

4. Design a simply supported rectangular slab for a hall of size 4m x 5m to carry a UDL of 5KN/m^2. Use working stress method.

5. Design a dog legged stair for building in which vertical distance between floor is 3.6m. the stair hall measures 25m x 5m. the live load may be taken as 2500N/m^2. Use M20 grade concrete and Fe 415 HYAD bars.

6. Design a RC Slab for a room measuring 5m x6m size. The slab is simply supported on all four edges, with corners held down and carries a superimposed load of 30 N/m^2, inclusive of floor finishes etc. use M20 grade concrete and Fe 415 HYSD bars.

UNIT IV
DESIGN OF COLUMNS
PART A

1. **What is meant by braced column? [N/D15]**
   A column may be considered braced in a given plane if lateral stability to the structure as a whole is provided by walls or bracing or buttressing designed to resist all lateral forces in that plane.
2. **How the compression failures occur in columns? [N/D15]**
   The following assumptions are made for column failing under pure compression:
   The maximum compressive strain in concrete in axial compression is 0.002
   Plane sections remain plane in compression
   The design stress strain curve for steel in compression is taken to be the sameas in tension
3. **What is the salient condition for minimum eccentricity of column?[N/D-16]**
   All axially loaded columns should be designed considering the minimum eccentricity ex min ≥ greater of)l/500 + D/30) or 20 mm
   ey min ≥ greater of)l/500 + b/30) or 20 mm where l, D and b are the unsupportedlength, larger lateral dimension and least lateral dimension, respectively.
4. **Write any two salient assumptions are made in the limit state design of columns.[M/J16]**
   The following assumptions are made for column failing under pure compression:
   The maximum compressive strain in concrete in axial compression is 0.002
   Plane sections remain plane in compression
   The design stress strain curve for steel in compression is taken to be the sameas in tension
5. **What are the important limitations of slender columns? [M/J16]**
   A short concrete column is one having a ratio of unsupported length to least dimension of the cross section equal to or less than 10. If the ratio is greater than 10, it is considered a long column (sometimes referred to as a slender column).
6. **Write any two reinforcement provision in columns. [N/D16]**
   As per IS 456-2000 a reinforced concrete column shall have longitudinal steel reinforcement and cross sectional area of such reinforcement shall not be less than 0.8% nor more than 6% of cross sectional area of column required to transmit all the loading.
   The effective length of a column depends upon unsupported length and boundary conditions at end of columns. The effective length Lef can be expressed in the form:
   L_{ef} = kL where L = Unsupported length or clear height of columnk = Effective length ratio
7. **What is pedestal? [M/J13]**
   A concrete pedestal is a compression element provided to carry the loads from supported elements like columns, statues etc. to footing below the ground. It is generally provided below the metal columns.
8. **What are the modes of failure of a column? [N/D-16], [M/J-13]**
   □ Compression failure □ Tension failure
9. **Write about percentage of reinforcement for columns [M/J-12] [N/D-13]**
   As per is 456 a reinforced concrete column shall have longitudinal steel reinforcement and the cross-sectional area of such reinforcement shall be not be less than 0.8% nor more than 6% of the cross sectional area of the column required to transmit all the loading.
10. **What is the loading the condition for short column? [M/J-13]**
    Short axially loaded members in axial compression Short axially loaded column with minimum eccentricity

11. Define column.

Column transmits load coming from the beam or slab and distributes it to the foundation. Usually the columns are square, rectangle, circular or L-shaped in cross section. It is reinforced with longitudinal and laterals ties. Load carry capacity of the column depends upon longitudinal steel and cross sectional size of the column. Lateral ties are given lateral support to the longitudinal steel. The columns are analyses for axial forces and moment.

12. Differentiate between long and short column.(MAY 2007)

Based on slenderness ratio (λ) column can be classified into long and short. Slenderness ratio, λ = Effective length /least lateral dimension.

i. Short column $\lambda \leq 12$
ii. Long column $\lambda \geq 12$

Short column fail by crushing or compression and long column fails by buckling.

PART B

1. Design a rectangular column of 4.5m unsupported length, restrained in position and direction at both ends, to carry an axial load of 1200 KN. Use M20 grade concrete and Fe415

2. Design a circular column of dia 400mm with helical reinforcement subjected to a working load of 1200KN. Use M25 grade and Fe415 HYSD bars. The column has unsupported length of 3m. it is effectively held in position at both the ends but not restrained against trotation.

3. Determine the reinforcement for a short column for the following data

Column size= 300mm x 500mm

P_u =2200KN

M_{ux}=140KNm

M_{uy}=90KNm

Use M20 grade concrete and Fe415 HYSD bars. Use limit state method.

4. Design a reinforced concrete column 400mm square to carry an ultimate load of 1200KN at an eccentricity of 170mm. Use M20 grade concrete and Fe415 HYSD bars.

5. Design a column 10m long to carry an axial load of 600KN. The column is restrained at ends. Use M25 grade concrete and Fe415 HYSD bars.

6. Design the reinforcement in a short column 400mm x 400mm at the corner of a multistory building to support an a axial factored load of 1500KN together with Biaxial moment of 50KNm acting in perpendicular planes. Adopt M2O and Fe 415 HYSD bars.

UNIT V

DESIGN OF FOOTING

PART B

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 beginning 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:

   There are two isolated footings overlapping (when columns are too close to each other, like within 2m)

   Soil bearing capacity is inconsistent and low within an area

   The footing is extending beyond your property.

5. **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.

6. **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.

7. **State the Rankin's equation to determine the minimum depth of foundation? [M/J-13]**

   Minimum depth of foundation is calculated from the Rankin's formula

   $D_{min} = (1-\sin\phi/1-\sin\phi)^2$

8. **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.

9. **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˚.

10.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.

11.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

12.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

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.Under what circumstances combined footing is necessary.(NOV 2008)

Combine footing are provided due to any one of the following responses

a) *The columns are spaced too closely:-* when two columns are very close, causing overlap of adjacent isolated footings
b) *Foundation on boundary or property line:-* If isolated footing is provided in boundary or property line, the footing has to be extended beyond the property line. In such case, two or more columns can be supported on a single rectangular or trapezoidal foundation.
c) *Differential settlement under two columns*

15.Define the safe bearing capacity of soil (MAY 2007)

It is the maximum intensity of load or pressure developed under the foundation without causing failure of soil. Unit for safe bearing capacity of soil is kN/m2. Safe bearing capacity of soil is determined by plate load test at the site.

16.What is punching shear in RCC footing? (MAY 2009)

Punching shear is a type of shear failure occurs in reinforcement concrete footing due to axial load from the column and upward soil thrust from the ground.

PART B

1. Design a reinforced concrete circular footing for a circular column of 300mm diameter supporting a factored axial load of 750KN. Adopt the safe bearing capacity of the soil as 200KN/m^2 and use M20 grade concrete and Fe415 HYSD bars.

2. Design a combined column footing with strap beam for two reinforced concrete columns 300 x 300mm size spaced 4m apart and each supporting a factored axial load of 750 KN. Assume the ultimate bearing capacity of soil at site as 225KN/m^2. Adopt M20 grade concrete and Fe415 HYSD bars.

3. A 230mm thick masonry wall is to be provided with a reinforced concrete footing on a site having soil with SBC, unit weight and angle of repose of 125KN/m^2, 17.5KN/m^2 and 30^o respectively. Use M20 grade of concrete and HYSD steel bars of grade Fe415. Design the footing when the wall supports at service state, a load of 150KN/m length.

4. A rectangular column 600 x 400 mm carries a load of 800 KN. Design a rectangular footing to support the column. The safe bearing capacity of the soil is 200KN/m^2. Use M20 grade concrete.

5. Explain in detail about the different types of foundations based on soil investigation.

6. Design a combined rectangular footing for two columns A and B, carrying in size and column B is 400mm x 400mm in size. The center to center spacing of the column is 3.4m. The SBC of soil is 150 N/m^2. Use M20 concrete and Fe 415 steel.