**DEPARTMENT: CIVIL** **SEMESTER: 05**
**SUBJECT CODE /NAME: CE8501 – DESIGN OF REINFORCED CEMENT**

**QUESTION BANK WITH ANSWER**

**CONCRETE ELEMENTS**
**YEAR: III**

## UNIT I

## INTRODECTION

1. **What is a composite structure?**
   A structural member made by two or more different components constructing together is called as composite structure. Eg. Reinforced concrete structures
2. **Define reinforced concrete.**
   Reinforced concrete is a composite material, which is concrete with steel bars embedded in it.
3. **What are the ingredients of plain cement concrete (PCC)?**
   Ingredients of PCC are cement, fine aggregate (sand), course aggregate and water.
4. **What are Imposed loads on building?**
   Examples of imposed loads on building are; the weight of its occupants, furniture, machinery, wind pressure, weight of snow, retained earth or water and the forces caused by thermal or shrinkage of concrete.
5. **Define elastic method of design.**
   It is otherwise known as working stress design. Elastic behaviours of materials are used in elastic method of design. Factor of safety is taken into account only on stress in materials, not on loads.
6. **What are the assumptions made in the working stress method? (NOV-DEC 2012)**
   a) At any cross-section, plane sections before bending remain plain after bending.
   b) All tensile stresses are taken up by reinforcement and none by concrete, except as otherwise specifically permitted.
   c) The stress-strain relationship of steel and concrete, under working loads, is a straight line.
   d) The modular ratio m has the value -280/3σbc.
7. **Define factor of safety.**
   It is the ratio between ultimate load and working load.
8. **Define ultimate load design method.**
   This method is based on the ultimate strength, when the design member would fail. It is otherwise called load method or ultimate strength method. This method gives more economical design of beam & column by comparing with elastic method.

**9. What are the advantages in limit state method?**

Limit state method is the combination of working stress method and ultimate load method. In this method, partial factor of safety is considered on both loads and material stresses. This method has advantages over the other methods, since safety and serviceability are considered.

**10. Define partial safety factor?**

It is the ratio between design load and characteristic load.

**11. Write the value of partial safety factor for (a) concrete (b) steel (NOV 2007)**

Partial safety factor for concrete ($\gamma_c$) = 1.5

Partial safety factor for steel ($\gamma_s$) = 1.15

**12. What are the factors considers for limit state of collapse?**

Flexure, compression, shear, torsion

**13. What are the factors considers for limit state of collapse?**

Deflection, cracking, durability, vibration, fatigue, fire resistance

**14. Draw the stress strain curve for concrete in limit state design for flexure. (NOV 2007)**

Refer code IS456-200

**15. What is SP-34? (MAY 2008)**

SP-34-1987 – 'handbook on concrete reinforcement and detailing'

**16. What is SP-24?**

SP-24- Explanary handbook on IS 456-2000

**17. What is SP-16?**

SP-16-1980, Design aids for reinforced concrete to IS 456-1978

**18. Draw stress-strain curve for mild steel bars.**

Refer IS 456-2000

**19. Differentiate between design mix and nominal mix. (MAY 2007)**

Design mix

In designed concrete mixes, proportions of ingredients of concrete are determined to achieve desired strength and workability in a most economical way.

Nominal mix

Nominal concrete mix may be used for concrete of grade M5, M7.5, M10, M15 and M20. The proportions of ingredients are specified in terms of fixed ratios of cement, sand and course aggregate by volume.

**20. Give approximate nominal mix proportions of M5 to M20 grades concrete**

| | |
|---|---|
| M5 | 1:5:10 |
| M7.5 | 1:4:8 |
| M10 | 1:3:6 |
| M15 | 1:2:4 |
| M20 | 1:1.5:3 |

21. What are the factors governing concrete mix design?

(i) Grade of concrete

(ii) Type of cement

(iii) Cement content

(iv) Size, shape, grading of aggregate

**22. Differentiate WSD and LSD? (MAY 2007)**

**Working Stress Method**

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

(ii) The method follows linear stress-strain behaviour of both the materials.

(iii) Modular ratio can be used to determine allowable stresses.

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

(v) Ultimate load carrying capacity cannot be predicted accurately.

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

**Limit state Method**

(i) The stress are obtained from design and compared with design strength.

(ii) This method follows linear strain relationship but not linear stress relationship.

(iii) The ultimate stresses of materials itself are used as allowable stresses.

(iv) 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.

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

**23. 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√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√fck. (From Cl No. 6.2.3.1, IS 456-2000)

Where, E, is the short term static modulus of elasticity in N/mm$^2$

**24. Write the formula for the neutral axis depth factor 'k' in working stress design. (MAY 2009)**

Neutral axis depth factor, $k = 1/(\sigma_{st}/m\sigma_{cbc})+1$

Where $\sigma_{st}$ = Permissible stress in steel in tension

Where $\sigma_{cbc}$ = Permissible stress in concrete in bending compresion

**25. Write the formula for the lever arm depth factor 'j' in working stress design.**

Lever arm factor, k =1-k/3 where k= neutral axis depth factor

**26. What is under reinforced section?**

Steel reaches maximum permissible stress earlier than concrete, due to external loads, is called under reinforced section.

**27. What is over reinforced section?**

Concrete reaches maximum permissible stress earlier than steel, due to external loads, is called over reinforced section.

**28. What is meant by balanced section? [N/D12]**

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

**29. 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.

**30. 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 balanced moment is smaller than the Actual moment

Doubly reinforcement is provided for the following circumstances.

(i) To increase the moment of resistances of a beam section of limited dimensions,

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

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

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

**31. Write down the basic values of span to effective depth ratios for different types of beam.**

Refer IS 456-2000 Cl 23.3.1

**32. Give the codal specification for the limiting neutral axis depth in limit state method.**

Refer IS 456-2000 Cl 38.1

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

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

**34. 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.

**35. 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

**36. What are the assumptions made in the working stress method? [N/D-12], [M/J11]**

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

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

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

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

**37. 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

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

**Advantages of limit state method over the other methods**

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. 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.

**39. 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.

**40. 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.

**41. Write any two assumptions are made in elastic theory methods. [M/J16]**

The following are the assumptions made in working stress method:

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

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

c) The stress-strain relationship of steel and concrete, under working loads, is a straight line

d) The modular ratio m has the value -280/3

**42. 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

**43. 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.

**44. What are the basic assumptions in limit state of flexure? (Refer IS456-2000)**

(i) Plain section normal to the axis remain plane after bending

(ii) The maximum strain in concrete at the outermost compression fibre is taken as 0.0035 in bending

(iii) For design purpose, the compressive strength of concrete in the structure shall be assumed to be 0.67times the characteristic strength. The partial safety factor =1.5 shall be applied in addition to this.

(iv) Tensile strength of concrete is ignored, since concrete is weak in tension.

**45. What are the minimum and maximum areas of tension reinforcement for beams?**

**Minimum reinforcement (Refer IS456-2000)**

The minimum area of tension reinforcement shall be less than that given by the following

As/bd = 0.85/fy

As = minimum ares of tension reinforcement

b = breath of beam or breath of the web of T beam

d = effective depth

fy = characteristic strength of reinforcement in $N/mm^2$

**Maximum reinforcement**

The maximum area of tension reinforcement shall not exceed 0.04bD

D=Overall depth of beam

## UNIT II
## DESIGN OF BEAM

1. **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.

2. **Enumerate balanced section? [N/D-15], [N/D12]**

   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.

3. **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

   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.

4. **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.

5. **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.

6. **What is doubly reinforced beam? [M/J-13], [M/J11]**

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

7. **When the flexural members are designed as T-beam and L-beam?**

   T-beam and L-beam may form apart of concrete beam and slab floor. When the beams are resisting sagging moment, part of the slab acts as a compression flange and the members may be designed as a T or L-beam.

   All intermediate beams with a part of the slab acts as a compression flange are designed to be T-beam.

All edge beams with a part of the slab acts as a compression flange are designed to be L-beam.

8. **Write down the formula for calculating effective width of flange in flanged beams.**

**For T-beams** Refer Code book (IS 456-2000)

$b_f = \frac{lo}{6} + b_w + 6D_f$

**For L-Beam**

$b_f = \frac{lo}{12} + b_w + 3D_f$

$b_f$ = effective width of flange

$l_o$ = distance between points of zero moments in a beam

$b_w$ = breath of the web

$D_f$ = thickness of flange

b = actual width of the flange

9. **What do you understand by 'development length' of a bar? (MAY 2009)**

The reinforcement bar must be extended in the anchorage zone concrete sufficiently to develop the required stress. The extended length of the bar inside the face of supported is known as development length. It is denoted by the symbol $L_d$.

Development length $L_d = \frac{\phi\sigma s}{4\tau bd}$

10. **Define anchorage length.**

Anchorage length is embedded portion of the bar in concrete, which is not subjected to any flexural bond.

11. **Define anchorage bond.**

All types of reinforcement must be anchorage within the concrete section, in order that the anchorage bound should be sufficient to develop the stress in the bar. The anchorage depends on the area of contact, the bond between the bar and the concrete.

12. **How are beam designs for shear?**

RC beam are designed to resist the shear force resulting from external loads after determination of bending reinforcement. Steel stirrups are to be provided to resist shear force where ever the nominal shear capacity of concrete is inadequate.

13. **Define curtailment of bars.**

In flexural member, design of reinforcement is done based on the bending moment along the span. As the magnitude of the bending moment on a beam decreases along its length, the area of bending reinforcement may be reduced by curtailing bars, as they are no longer required.

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

a) **<u>Vertical stirrups</u>**

Spacing between stirrups can be calculated using the following expressions.

$S_v$ from the formula, $\frac{Asv}{b\,Sv} \geq \frac{0.4}{0.87fy}$ or $S_v = \frac{0.87\,fy\,Asv\,d}{Vus}$, whichever is smaller

b) **<u>Inclined stirrups and bent up bars</u>**

i) For inclined stirrups or a series of bars bent – up at different cross-section

$S_v = \frac{0.87\ fy\ d\ (sine\propto + cos\propto)}{Vus}$

ii) For single bar or single group of parallel bars, all bent-up at the same cross-section

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

Where

Strength of shear reinforcement, $V_{us} = Vu - \tau_c\ bd$

$\alpha$ = angle between inclined stirrups or bent up bars and axis of member not less than $45^0$

$A_{sv}$ = cross section area of one stirrup

b= width of beam

d=effective depth of beam

$S_v$ = stirrups spacing

$f_y$ = characteristic strength of stirrups.

**15. Compute the development length of 28 mm diameter steel rods in tension zone. (NOV 2007)**

Development length $L_d = \frac{\phi\sigma s}{4\tau bd}$

Nominal diameter of bar, $\phi$=28mm

Stress in bar at the section considered at design load = 0.87fy, from clause No.26.2.1.1, IS 456-2000,

For M20 grade concrete, design bond stress, $\tau_c$ =1.2 N/mm$^2$

For Fe 415 steel $\tau_{bd}$ increased by 60%,

Development length $L_d = \frac{\phi\sigma s}{4\tau bd} = \frac{28\ x\ 361.05}{4\ x\ 1.2\ x\ 1.6}$ = 1316.33 mm ≈1320 mm

**16. What do you mean by equilibrium torsion?**

Torsion induced by eccentric loading and equilibrium condition alone is sufficient to determine twisting moment is known as equilibrium torsion.

**17. What is compatibility torsion?**

Torsion induced by application of an angle twist and the result moment which depends on the torsional stiffness of the member is known as compatibility torsion.

**18. Name the locations in beam where the development lengths of tension bars should be checked?**

At beam, the development length should be checked at the section where,

- Maximum bending moment occurs
- Point of curtailment
- Point of inflation

**19. What is the IS code provision for maximum spacing of vertical stirrups in RC beams? (MAY 2008)**

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

Where

Strength of shear reinforcement, $V_{us} = Vu - \tau_c bd$

$A_{sv}$ = cross section area of stirrups.

b= width of beam

d=effective depth of beam

$S_v$ = stirrups spacing

$f_y$ = characteristic strength of stirrups.

**20. Distinguish between flexural bond and development bond. (MAY 2008)**

**Flexural bond**

It arises in flexural member on account of shear or a vertical bending moment, which in turn causes a variation in axial tension along the length of a reinforcing bar.

**Anchorage or development bond**

It arises over the length of anchorage provided for a bar or near the end of reinforcing bar,

**21. What are the types of reinforcement used to resist shear force? (MAY2009)**

i. Vertical stirrups
ii. Inclined stirrups
iii. Bent-up bars

**22. Write down the formulae for equivalent shear and bending moment on a RC beam subjected to flexural shear and torsional shear.**

Equivalent shear, $V_e = Vu + (1.6\frac{Tu}{b})$

Equivalent bending moment, $M_e = M_{ut} \pm M_u$

Bending moment due to torsional moment, $M_{ut} = T_u (1+\frac{D}{B})/1.7$

Where Tu = ultimate shear force

Mu= ultimate bending moment

Tu= torsional moment

D= overall depth of Beam

b=width of beam

**23. What are the purposes of providing shear reinforcement in the beam?**

The shear reinforcement provides to the strength of the beam in the following ways.

i. Shear reinforcement carries a part of the shear due to the truss action
ii. It limit the diagonal tension crack
iii. It provides support to the longitudinal bars which crossed by shear crack
iv. It increases the strength of the concrete.

**24. Under what situation the closed stirrups become compulsory?**

Closed beam must be provided for the following two cases.

i. Beam subject torsion
ii. Doubly reinforced beams

**25. Why the shear strength of concrete (τc) in a beam related to the percentage of tension steel?**

Formation of inclined cracks in beam occurs when the principal tensile stress reaches the tensile stress of the concrete. It is also influenced by other parameters such as the 'a/d' ration and percentage of tension steel. Hence the shear stress of concrete $\tau_c$ is taken based on the percentage of tension steel.

Where a- distance between point of action of load and centre of support

d- Effective depth of beam

**26. Which is the critical section for shear in a RC beam? Explain in details.**

As per the code, critical section located at a distance'd' (effective depth of the support and it progressively reduces with increasing distance from the support. Inclined crack do not develop near the face of the supports even though shear force value is maximu. Generally inclined crack appears at a distance'd' (effective depth) from the face of the support.

**27. What are the functions of longitudinal reinforcement with respect torsion? [N/D15]**

 To assist concrete, in resting compression, so as to reduce the overall size, of the column.

 To resist any tension that might develop due to bending caused by transverse load, eccentric load or the moments.

 To reduce the effect of creep and shrinkage due to sustained loading.  To prevent or delay sudden brittle collapse.

 To impart necessary ductility to the column.

 To hold the transverse reinforcement.

**28. 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.

**29. 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.

**30. 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.

**31. 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.

However, loads away from the plane of bending will induce torsional moment along with bending moment and shear.

**32. 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.

**33. 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 value of a standard U-type hook shall be equal to 16 times the diameter of the bar

**34. 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

**35. 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.

## UNIT III

## DESIGN OF SLAB AND STAIRCASE

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. **Sketch the edge and middle strip of one way slab?**

   Refer code book IS 456-2000

6. **What is RC slab? How can it be classified?**

   Reinforcement concrete slabs are used in roofs of building. Slab is a flexural member that transmits imposed and dead load to the supports. A support may be a wall, beam or column. It can be broadly classified into two types

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

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

   **<u>Minimum reinforcement</u>**

   <u>For Mild steel</u>

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

   <u>For HYSD bars</u>

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

   **<u>Spacing</u>**

   For main reinforcement

   Spacing = 3d or 300 mm whichever is smaller

   For secondary reinforcement

   Spacing = 5d or 450 mm whichever is smaller

   Where d=effective depth of slab

8. **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

9. **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 otherwise called distribution or temperature reinforcements.

10. **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,

11. **What is a stair case?**

    A staircase consists of a number of steps arranged in a series, with landings at appropriate locations, for the purposes of giving access to different floors of a building.

12. **Define tread**
    The horizontal portion of a step was the foot rests is referred to, as tread.250 to 300 mm is the typical dimensions of a tread. Riser is the vertical distance between the adjacent treads or the vertical projection of the step with value of 150 to 190 mm depending upon the type of building.
13. **Define Going**
    Going is the horizontal projection of an inclined flight of steps between the first and last riser.
14. **What is a flight?**
    A flight is the length of the staircase situated between two landings. The number of steps in a flight may vary between 3 to 12.
15. **What is the minimum rise and tread in residential buildings?**
    In residential buildings, the rise may vary between 150mm to 180mm tread between200mm to 250mm.
16. **What is the minimum rise and tread in public buildings?**
    In public buildings, the rise may vary between 120mm to 150mm tread between200mm to 300mm.

## UNIT IV
## DESIGN OF COLUMNS

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:
   i. The maximum compressive strain in concrete in axial compression is 0.002
   ii. Plane sections remain plane in compression
   iii. The design stress strain curve for steel in compression is taken to be the same as 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 unsupported length, 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:
   i. The maximum compressive strain in concrete in axial compression is 0.002
   ii. Plane sections remain plane in compression
   iii. The design stress strain curve for steel in compression is taken to be the same as 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 column

k = 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.

**13. Difference between Uniaxial and Biaxial Bending?**

(i) <u>Uniaxial eccentrically loaded column</u>

Axial load and bending moment along one direction (either $M_x$ or $M_y$) that are acting simultaneously on the column is known as uniaxial eccentrically loaded column.

(ii) <u>Biaxial eccentrically loaded column</u>

Axial load and bending moment along two direction (both $M_x$ or $M_y$) that are acting simultaneously on the column is known as biaxial eccentrically loaded column

**14. According to IS code"All column should be designed for minimum eccentricity"- Justify the statement.**

IS 456-2000, clause no.25.4 specifies that all columns should be designed for minimum eccentricity, $e_{min}$ due to the following reasons.

i. Lateral loads such as wind and seismic loads are not considered in design
ii. Misalignments in construction
iii. Slenderness effects are not considered in design
iv. Accidental lateral or eccentric loads

**15. Write down the formula for calculating minimum eccentricity.**

Minimum eccentricity $e_{min} = \frac{L}{500} + \frac{D}{30} \leq 20mm$

Where l= unsupported length of column
D = lateral dimension

**16. What are the specifications for the pitch of lateral ties in column? (NOV-2008)**

As per IS 456-2000, Clauses no 26.5.3.2

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

i. The lateral dimension of the compression members
ii. Sixteen times the smallest diameter of the longitudinal reinforcement bar to be tied
iii. 300mm

**17. Write any two functions of lateral ties in an RC column? (MAY 2008)**

i. Lateral ties hold the main or longitudinal steel bars in position.
ii. It provides lateral support to main reinforcements, so that the main bars cannot buckle outwards

**18. Distinguish braced and un braced column.**

Based on side sway

i) Braced column

A column prevented from side is called braced column. Lateral loads are resisted by walls or some other form of bracing.

ii) Unbraced Column

A column subjected to lateral deflection is called Unbraced column. Lateral loads are resisted by bending actions of the columns.

**19. What are braced columns?**

Columns prevented from side sway are called braced columns. As per ACI (American Concrete Institute) code, stability index 'Q' of a column in frames can be used to classify whether the column is braced or unbraced. Stability Index 'Q' <0.04: braced column in frames.

**20. Define slenderness ratio.**

Slenderness ratio, λ=Effective length/Least lateral dimensions

**21. What is spiral column?**

For a circular column, longitudinal reinforcement tied with closely spaced helix are called spiral columns.

**22. What are the specifications for pitch of lateral ties in spiral columns?**

As per clauses 26.5.3.2, IS 456-2000, pitch of helical reinforcement shall not be more than the least of the following values.

i. Spacing or pitch not greater than 75mm
ii. Spacing or pitch not greater than diameter of core/6
iii. Spacing not less than 25mm
iv. Spacing not less than 3 x diameter of helical reinforcement

v. $P_s = \frac{Volume\ of\ helical\ reingorcement}{Volume\ of\ core}$ *not less than are equal* $0.36(A_g/A_{core}-1)$ fck/fy

Where $A_g$ = Gross area of the section

**23. What is the minimum and maximum percentage of reinforcement that can be provided for a column?**

The cross sectional area of longitudinal reinforcement, shall not be less than 0.8% and not more than 6% of cross sectional area of the column.

**24. What are the specifications for diameter of lateral ties in column?**

From clauses 26.5.3.2, IS 456-2000,

$\Phi$ of ties > $\frac{1}{4}$x $\phi$ of largest main bar

Or

5mm

**25. What is slender column?**

If the slenderness ratio of column about either axis is greater than 12, it is classified as long column. Long columns should be designed as slender columns.

$\frac{lex}{Dx}$ or $\frac{ley}{Dy}$ > 12 ; long or slender column

**26. Mention the function of the Travers reinforcement in a RC column.**

**As per IS 456-2000, clause no 26.5.3.2,**

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

i. The least lateral dimension of the compression members
ii. Sixteen times the smallest diameter of the longitudinal reinforcement bar to be tied
iii. 300 mm

**27. Difference single and double curvature in a column.**

According to the clause no. 38.7.1, SP 24 -1983, braced column can be classified in to two type single and double curvature.

Moment in braced slender column

Case (1) column bent in one direction (single curvature)

Initial moment, $M_{ui} = (0.6\ M_{u2} + 0.4\ M_{u1})$ not less than $M_{u2}$

Case (2) column bent in both directions (Double curvature)

Initial moment, $M_{ui} = (0.6\ M_{u2} - 0.4\ M_{u1})$ not less than $M_{u2}$

$M_{u1}$ = smaller end moment

$M_{u2}$ = larger end moment

Total moment, Mu = Initial moment, Mui + Additional moment, Ma < Mu2

**28. Write down the formula for ultimate load carrying capacity of the short axially loaded column.**

From clause 39.3, IS 456-2000

Pu = 0.4fck Ac + 0.67fyAsc

Pu- Factored axial load

Ac-Area of concrete

Asc-Area of steel

## UNIT V
## DESIGN OF FOOTINGS

**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:
   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. **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 $D_{min} = \frac{q}{\gamma}(1\text{-}\sin\phi/1\text{-}\sin\phi)^2$
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. **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 shears
10. **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

11. **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˚.
12. **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.
13. **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
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. **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
16. **Wall footing.**
Wide base slab provided continuously under load bearing masonry walls of the building is called wall or strip footing. It is also called as continuous footing
17. **What is the necessity to provide combined rectangular footing?**
A combined footing is usually provided to support two or more columns of unequal loads.
Combined footing is preferred in the following three case:
1, column are spaced too closely
2, Foundation on boundary or property line
3, Differential settlement under two columns
18. **What is the major role of foundation?**
Foundation is a very important component of a structure, which is located below the ground level. The foundation transfers and spreads the load from the column or wall into the ground soil evenly. It is otherwise called sub structures.
19. **What are the purposes of providing foundations?**
The functions of foundations are as follows.
    i. Foundation transfers live load and dead loads of the structure to thr ground soil over a large area uniformly.
    ii. It resists lateral forces such as wind, seismic etc.,

iii. It resists uplift force due to ground water.
iv. It provides good support for walls and columns
v. It provides stability against sliding and overturning particularly for retaining wall
vi. It should not settle in the downward direction due to loads and soil condition
vii. It prevents differential settlement of building
viii. It provides a plane surface for the convenience of construction.

**20. What is pad foundation?**

Isolated or pad foundation are provided under a single column. Shape of isolated footing may be square, rectangular or circle in plan depending upon the shape of the column and loads.

**21. Sketch one way and two shear on footing (NOV-2007))**

**22. 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*

**23. 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.

**24. 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.

**25. Sketch the reinforcement detailing for a cantilever slab? (MAY 2009)**

**26. What are the advantages of providing pedestals to column?**

Pedestals are provided to connect column and footing for the following purposes.

i. Where pedestals are provided, and full force is transferred to the footing without additional reinforcements
ii. Pedestal provides a plan surface for the convenience of column construction.

**27. What is the situation in which trapezoidal shape is preferred to a rectangular shape for a two column combined footing?**

If one of the columns is carrying much larger load than the other one, trapezoidal combined footing is provided.

**28. What is spread foundation?**

Wide base slab that is provide continuously under load bearing masonry walls of the building is called spread or strip footing.

**29. What is meant by eccentric loading on a footing, and under what situation does this occur?**

In eccentric loading, resultant of the acting forces does not coincide with the centroid of footing which creates non uniform bearing pressure.

Eccentricity may be caused by a moment at the column base or by an unsymmetrical footing base

**30. Define strap footing.**

The strap footing is used instead of a rectangular or trapezoidal combined footing, if the distance between the columns is large.

All so it is used to connect an eccentricity loaded column footing to an interior column footing by a strap or beam. The strap is used to transmit the moment caused froman eccentricity to the interior column footing so that a uniform soil pressure is generated under both footings.

**31. What is mat foundation? Under what circumstances mat footing is required.**

A common footing that is provided to connect all columns in a structure is called mat or raft foundation. This type of foundation is more expensive than the other types.

Raft foundation is provided under following circumferences.

i. Structures like chimneys, silos, cooling towers, building with basements where continuous water proofing is needed.
ii. For foundation where differential settlement can be a major problem
iii. Construction site contain soft or weak soils strata such as silt, back cotton soil, shrinkable or expansible clay etc.
iv. In situation where individual footings may touch or overlap each other.

**32. What is foundation? How are foundation classified?**

The foundation is a very important part of a structure, which is located below the ground level. The foundation transfer and spread the loads from column or wall into the ground soil evenly. It is otherwise called sub structures.

Depending on the dimensions such as depth, width of the footing and load transfer, foundation can be broadly classified into two types.

a) Shallow foundation
b) Deep foundation

**33. What is shallow foundation?**

Depth of the foundation which is less than or equal to the width of footing is called shallow foundation.

**34. List out the types of shallow foundation?**

Types of shallow foundation are,

i. Isolated footing
ii. Spread or strip footing
iii. Combined footing
iv. Strap footing
v. Mat or raft footing

**35. What is deep foundation? List out the types of deep foundation?**

Depth of the foundation when is more than the width of the footing is called deep foundation.

Types of deep foundation are,

a) Pile foundation
b) Well foundation

**36. Write down the formula for calculating maximum and minimum soil pressure for a rectangular footing that carries eccentric point load?**

The maximum and minimum value of soil pressure at extreme edge of base are,

Soil pressure, $p = \frac{P}{A} \pm \frac{M}{Z}$ in kN/m$^2$

$P_{max} = \frac{P}{A} \pm \frac{M}{Z}$ in kN/m$^2$

$P_{min} = \frac{P}{A} \pm \frac{M}{Z}$ in kN/m$^2$

P = Axial load from the column including self-weight of footing and overburden soil in kN

Moment, M=P x e in kNM
e = eccentricity of axial load from the centroid of the footing in m
A = Base area of footing in $m^2$
Z= Section modulus of the footing in $m^3$