

CEH 501 Design of RCC Structures (Limit State Method)

PART-A

UNIT I INTRODUCTION TO REINFORCED CEMENT CONCRETE STRUCTURES

1. In the Limit State Method, the principal reason for considering both ultimate and serviceability limit states is to ensure that a reinforced concrete structure:

- a) Remains elastic under all possible loads
- b) Is safe against collapse and performs satisfactorily under working conditions
- c) Has minimum reinforcement in all structural members
- d) Has maximum possible load-carrying capacity

Answer: b) Is safe against collapse and performs satisfactorily under working conditions

2. According to IS 456:2000, the characteristic strength of concrete is defined as the strength below which not more than:

- a) 2% of the test results are expected to fall
- b) 5% of the test results are expected to fall
- c) 10% of the test results are expected to fall
- d) 15% of the test results are expected to fall

Answer: b) 5% of the test results are expected to fall

3. A concrete mix is designated as M30. The designation primarily indicates that:

- a) The characteristic compressive strength at 7 days is 30 N/mm²
- b) The characteristic tensile strength at 28 days is 30 N/mm²
- c) The characteristic compressive strength at 28 days is 30 N/mm²
- d) The design compressive strength at 28 days is 30 N/mm²

Answer: c) The characteristic compressive strength at 28 days is 30 N/mm²

4. The primary structural purpose of providing tensile reinforcement in a reinforced concrete beam is to:

- a) Increase the compressive strength of concrete
- b) Resist tensile stresses that concrete is relatively weak in resisting
- c) Prevent concrete from undergoing any strain
- d) Eliminate the need for shear reinforcement

Answer: b) Resist tensile stresses that concrete is relatively weak in resisting

5. Under the Limit State of Collapse in Flexure, which assumption regarding the tensile strength of concrete is generally made in the flexural design of RCC sections?

- a) Tensile strength of concrete is fully considered
- b) Tensile strength of concrete is considered equal to compressive strength
- c) Tensile strength of concrete is neglected
- d) Tensile strength of concrete is taken as 50% of compressive strength

Answer: c) Tensile strength of concrete is neglected

6. According to the assumptions of IS 456:2000 for the Limit State of Collapse in Flexure, the maximum strain in concrete at the extreme compression fibre is taken as:

- a) 0.002
- b) 0.003
- c) 0.0035
- d) 0.0045

Answer: c) 0.0035

7. In the design of an RCC beam at the Limit State of Collapse in Flexure, the design load is generally obtained from characteristic loads by:

- a) Applying partial safety factors less than unity
- b) Applying appropriate load factors greater than unity
- c) Dividing all loads by the material safety factor
- d) Using only dead load

Answer: b) Applying appropriate load factors greater than unity

8. The partial safety factor for the strength of concrete under the Limit State of Collapse, as adopted in IS 456:2000, is:

- a) 1.00
- b) 1.15
- c) 1.50
- d) 1.75

Answer: c) 1.50

9. A doubly reinforced rectangular beam is particularly advantageous when:

- a) The beam is subjected only to negligible bending moment
- b) The required moment of resistance exceeds the capacity of a singly reinforced section of given dimensions
- c) No tensile stresses develop in the beam
- d) Concrete is completely removed from the compression zone

Answer: b) The required moment of resistance exceeds the capacity of a singly reinforced section of given dimensions

10. Which statement about a doubly reinforced RCC beam is **most appropriate**?

- a) Compression reinforcement contributes nothing to flexural resistance
- b) Compression reinforcement can increase moment capacity when the section dimensions are restricted
- c) Compression reinforcement is provided only to resist shear
- d) Compression reinforcement makes tensile reinforcement unnecessary

Answer: b) Compression reinforcement can increase moment capacity when the section dimensions are restricted

11. For a cantilever beam, the effective span is generally taken as:

- a) Clear span between support and free end
- b) Distance from the face of support to the free end
- c) Distance from the face of support to the free end plus half the effective depth
- d) Centre-to-centre distance between supports

Answer: c) Distance from the face of support to the free end plus half the effective depth

12. A simply supported RCC beam has a clear span of 5.0 m and effective depth of 450 mm. The distance between the centres of supports is 5.2 m. According to IS 456, its effective span is approximately:

- a) 5.00 m
- b) 5.20 m
- c) 5.45 m
- d) 5.65 m

Answer: b) 5.20 m

13. The primary purpose of specifying a minimum concrete cover to reinforcement in an RCC beam is to:

- a) Increase the dead load of the beam
- b) Increase the effective depth
- c) Ensure adequate durability and protection against fire and environmental effects
- d) Eliminate the requirement for development length

Answer: c) Ensure adequate durability and protection against fire and environmental effects

14. For a beam exposed to moderate environmental conditions, the nominal cover prescribed by IS 456:2000 is intended primarily to satisfy:

- a) Only flexural strength requirements
- b) Durability requirements
- c) Only shear strength requirements
- d) Only deflection requirements

Answer: b) Durability requirements

15. The minimum tension reinforcement in a reinforced concrete beam is specified primarily to:

- a) Prevent sudden failure immediately after cracking and control cracking
- b) Increase concrete compressive strength
- c) Eliminate shear stresses
- d) Reduce the effective depth of the beam

Answer: a) Prevent sudden failure immediately after cracking and control cracking

16. The maximum tension reinforcement in a reinforced concrete beam, according to IS 456:2000, shall not exceed:

- a) 2% of the gross cross-sectional area
- b) 3% of the gross cross-sectional area
- c) 4% of the gross cross-sectional area
- d) 5% of the gross cross-sectional area

Answer: c) 4% of the gross cross-sectional area

17. Side-face reinforcement is generally required in a beam when the overall depth of the web exceeds:

- a) 500 mm
- b) 600 mm

- c) 750 mm
- d) 900 mm

Answer: c) 750 mm

18. Development length of a reinforcing bar is provided primarily to:

- a) Increase the concrete cover
- b) Develop the required stress in the reinforcement through adequate bond with concrete
- c) Reduce the diameter of the reinforcing bar
- d) Reduce the dead load of the structure

Answer: b) Develop the required stress in the reinforcement through adequate bond with concrete

19. When a reinforcing bar is provided with a standard hook or bend, its anchorage value is considered because:

- a) It reduces the concrete strength
- b) It provides additional anchorage beyond the straight development length
- c) It eliminates the need for reinforcement
- d) It increases the characteristic strength of concrete

Answer: b) It provides additional anchorage beyond the straight development length

20. In a simply supported beam carrying a uniformly distributed load, the maximum design bending moment occurs:

- a) At the supports
- b) At one-quarter of the span
- c) At the centre of the span
- d) At the point of contraflexure

Answer: c) At the centre of the span

21. A beam has a calculated required tensile reinforcement area smaller than the minimum reinforcement specified by IS 456:2000. The designer should:

- a) Provide the calculated area only
- b) Omit tensile reinforcement because the area is small
- c) Provide at least the code-specified minimum reinforcement
- d) Increase the concrete cover instead

Answer: c) Provide at least the code-specified minimum reinforcement

22. Assertion (A): M20 concrete has a characteristic compressive strength of 20 N/mm².

Reason (R): M20 concrete is generally used for structural concrete work.

- A)** Both Assertion (A) and Reason (R) are true, and R is the correct explanation of A.
- B)** Both A and R are true, but R is not the correct explanation of A.
- C)** A is true, but R is false.
- D)** A is false, but R is true.

Answer: B

23. Assertion (A): The limit state of serviceability deals with the collapse of a structure.

Reason (R): Serviceability mainly concerns deflection, cracking and vibration under normal use.

- A) Both Assertion (A) and Reason (R) are true, and R is the correct explanation of A.
- B) Both A and R are true, but R is not the correct explanation of A.
- C) A is true, but R is false.
- D) A is false, but R is true.

Answer: D

24. Assertion (A): Characteristic load is a load value that has a small probability of being exceeded during the life of the structure.

Reason (R): Loads are subject to variations during the life of a structure.

- A) Both Assertion (A) and Reason (R) are true, and R is the correct explanation of A.
- B) Both A and R are true, but R is not the correct explanation of A.
- C) A is true, but R is false.
- D) A is false, but R is true.

Answer: A

25. Assertion (A): The design strength of Fe415 steel is approximately 360.87 N/mm².

Reason (R): The characteristic strength of Fe415 steel is divided by 1.15.

- A) Both Assertion (A) and Reason (R) are true, and R is the correct explanation of A.
- B) Both A and R are true, but R is not the correct explanation of A.
- C) A is true, but R is false.
- D) A is false, but R is true.

Answer: A

26. Assertion (A): In flexural design, the neutral axis separates the compression and tension zones of a beam section.

Reason (R): The longitudinal strain at the neutral axis is zero.

- A) Both Assertion (A) and Reason (R) are true, and R is the correct explanation of A.
- B) Both A and R are true, but R is not the correct explanation of A.
- C) A is true, but R is false.
- D) A is false, but R is true.

Answer: A

27. Assertion (A): A beam can always be designed with a very small depth if sufficient reinforcement is provided.

Reason (R): Beam depth also influences stiffness and deflection control.

- A) Both Assertion (A) and Reason (R) are true, and R is the correct explanation of A.
- B) Both A and R are true, but R is not the correct explanation of A.
- C) A is true, but R is false.
- D) A is false, but R is true.

Answer: D

28. Assertion (A): Side face reinforcement is provided in deep beams to control cracking on the side faces.

Reason (R): Side face reinforcement is required when the overall depth of the beam exceeds the limit specified in IS 456.

- A) Both Assertion (A) and Reason (R) are true, and R is the correct explanation of A.
- B) Both A and R are true, but R is not the correct explanation of A.
- C) A is true, but R is false.
- D) A is false, but R is true.

Answer: B

29. Assertion (A): A doubly reinforced beam contains reinforcement in both the tension and compression zones.

Reason (R): Compression reinforcement may be required when the required moment exceeds the limiting moment capacity of a singly reinforced section.

- A) Both Assertion (A) and Reason (R) are true, and R is the correct explanation of A.
- B) Both A and R are true, but R is not the correct explanation of A.
- C) A is true, but R is false.
- D) A is false, but R is true.

Answer: B

30. Assertion (A): Increasing nominal cover while keeping overall beam depth constant reduces the effective depth.

Reason (R): Effective depth is measured from the compression face to the centroid of tension reinforcement.

- A) Both Assertion (A) and Reason (R) are true, and R is the correct explanation of A.
- B) Both A and R are true, but R is not the correct explanation of A.
- C) A is true, but R is false.
- D) A is false, but R is true.

Answer: A

UNIT II DESIGN OF RECTANGULAR BEAMS FOR FLEXURE AND SHEAR

1. In the Limit State Design of an RCC beam, shear failure is generally considered more critical than flexural failure because:

- a) Shear failure is always preceded by large visible deflection
- b) Shear failure can be sudden and brittle, with limited warning
- c) Shear strength is independent of concrete grade
- d) Shear reinforcement is not effective after cracking

Answer: b) Shear failure can be sudden and brittle, with limited warning

2. In the expression $\tau_v = V_u/(bd)$, the effective depth (d) is used instead of the overall depth (D) because:

- a) (d) represents the approximate lever arm associated with internal resistance
- b) (D) is always equal to zero at the support
- c) (d) is always greater than (D)
- d) Shear stress is independent of beam depth

Answer: a) (d) represents the approximate lever arm associated with internal resistance

3. According to IS 456:2000, the design shear strength of concrete, τ_c primarily depends upon:

- a) Only the width of the beam
- b) Concrete grade and percentage of longitudinal tension reinforcement
- c) Only the diameter of stirrups
- d) Only the effective span

Answer: b) Concrete grade and percentage of longitudinal tension reinforcement

4. If the nominal shear stress τ_v exceeds the design shear strength of concrete τ_c , but does not exceed the maximum permissible shear stress $\tau_{c,max}$, the beam should generally be designed by:

- a) Ignoring shear reinforcement
- b) Providing appropriate shear reinforcement
- c) Reducing the longitudinal reinforcement to zero
- d) Increasing only the concrete cover

Answer: b) Providing appropriate shear reinforcement

5. The maximum permissible shear stress $\tau_{c,max}$ is specified primarily to:

- a) Prevent excessive diagonal compression failure of concrete
- b) Control flexural cracking only
- c) Determine the minimum longitudinal reinforcement
- d) Eliminate the need for stirrups

Answer: a) Prevent excessive diagonal compression failure of concrete

6. The design shear strength provided by inclined stirrups is influenced by:

- a) Only the beam width
- b) The inclination of the stirrups to the beam axis
- c) Only the concrete cover
- d) Only the span-to-depth ratio

Answer: b) The inclination of the stirrups to the beam axis

7. The minimum shear reinforcement in a beam is primarily provided to:

- a) Resist all shear force independently of concrete
- b) Control diagonal cracking and provide a minimum level of shear resistance
- c) Increase the flexural tensile strength of concrete
- d) Eliminate the need for longitudinal reinforcement

Answer: b) Control diagonal cracking and provide a minimum level of shear resistance

8. The critical section for shear in a simply supported RCC beam is generally considered:

- a) At the centre of the span
- b) At the face of the support
- c) At the free end only
- d) At the point of maximum bending moment only

Answer: b) At the face of the support

9. In a beam carrying a uniformly distributed load, the shear force generally:

- a) Is maximum at the centre and zero at supports
- b) Is maximum near the supports and decreases toward the centre
- c) Remains constant throughout the span
- d) Is always zero at the support

Answer: b) Is maximum near the supports and decreases toward the centre

10. For a beam subjected to uniformly distributed loading, the design shear force at a section located at a distance (d) from the face of support is generally lower than that at the face of support because:

- a) The bending moment becomes zero
- b) A portion of the external load between the support face and the section is excluded from the shear force calculation
- c) Concrete has no shear strength beyond the support
- d) The effective depth becomes zero

Answer: b) A portion of the external load between the support face and the section is excluded from the shear force calculation

11. A staircase in a building is primarily designed to:

- a) Transfer only lateral loads to the foundation
- b) Provide safe and convenient vertical circulation between different floor levels
- c) Reduce the dead load of the building
- d) Replace the need for lift facilities

Answer: b) Provide safe and convenient vertical circulation between different floor levels

12. The characteristic feature of a dog-legged staircase is that:

- a) The two flights are parallel and rise in opposite directions
- b) The flights are perpendicular to each other
- c) It contains only one flight
- d) It has no intermediate landing

Answer: a) The two flights are parallel and rise in opposite directions

13. A staircase in which successive flights change direction by 180° with an intermediate landing is classified as:

- a) Quarter-turn staircase
- b) Half-turn staircase
- c) Three-quarter-turn staircase
- d) Circular staircase

Answer: b) Half-turn staircase

14. The horizontal distance measured along the direction of movement between the faces of two consecutive risers is called:

- a) Rise
- b) Tread
- c) Going
- d) Nosing

Answer: c) Going

15. For a staircase, the effective span should be determined primarily based on:

- a) Architectural appearance only
- b) Structural system and the manner in which the staircase is supported
- c) Number of windows in the building
- d) Thickness of plaster finish

Answer: b) Structural system and the manner in which the staircase is supported

16. For a simply supported stair slab spanning longitudinally between supports, the effective span is generally determined in accordance with the principles applicable to:

- a) Columns
- b) Beams/slabs
- c) Footings only
- d) Retaining walls only

Answer: b) Beams/slabs

17. A staircase spanning longitudinally between landings is structurally different from a staircase spanning transversely between side walls primarily because:

- a) The direction of bending and load transfer is different
- b) The concrete grade automatically changes
- c) The stair geometry becomes irrelevant
- d) No reinforcement is required in either case

Answer: a) The direction of bending and load transfer is different

18. In a dog-legged staircase supported longitudinally at the landings, the main reinforcement in each flight is generally placed:

- a) Perpendicular to the direction of span
- b) Along the direction of span
- c) Only at the centre of the landing
- d) Vertically through the risers

Answer: b) Along the direction of span

19. A dog-legged staircase is often preferred in buildings because:

- a) It requires no structural support
- b) It provides a compact arrangement and efficiently utilizes the available floor area
- c) It eliminates the need for landings
- d) It always has zero bending moment

Answer: b) It provides a compact arrangement and efficiently utilizes the available floor area

20. In planning a staircase, excessive riser height and insufficient tread width are undesirable primarily because they:

- a) Increase the characteristic strength of concrete
- b) Reduce walking comfort and stair safety
- c) Reduce the self-weight of the staircase
- d) Eliminate the need for handrails

Answer: b) Reduce walking comfort and stair safety

21. During the planning of a dog-legged staircase, which combination of parameters must be considered simultaneously to obtain a safe and functional design?

- a) Rise, tread, width, landing dimensions, headroom and structural support conditions
- b) Only rise and concrete grade
- c) Only tread and reinforcement diameter
- d) Only stair width and floor finish

Answer: a) Rise, tread, width, landing dimensions, headroom and structural support conditions

22. Assertion (A): Shear failure in a reinforced concrete beam is generally brittle and should be avoided in design.

Reason (R): Shear reinforcement provides warning through large deformation before failure.

- a) Assertion is true, but Reason is false
- b) Both Assertion and Reason are true, and Reason is the correct explanation
- c) Both Assertion and Reason are true, but Reason is not the correct explanation
- d) Assertion is false, but Reason is true

Answer: a

23. Assertion (A): Nominal shear stress in a rectangular beam is calculated using $\tau_v = V_u / (bd)$.

Reason (R): Nominal shear stress is based on the effective width and effective depth of the beam section.

- a) Assertion is false, but Reason is true
- b) Both Assertion and Reason are true, but Reason is not the correct explanation
- c) Both Assertion and Reason are true, and Reason is the correct explanation
- d) Assertion is true, but Reason is false

Answer: c

24. Assertion (A): Minimum shear reinforcement is required even when the nominal shear stress is less than the design shear strength of concrete.

Reason (R): Minimum shear reinforcement helps control diagonal cracking and provides resistance against unexpected shear effects.

- a) Assertion is false, but Reason is true
- b) Both Assertion and Reason are true, but Reason is not the correct explanation
- c) Assertion is true, but Reason is false
- d) Both Assertion and Reason are true, and Reason is the correct explanation

Answer: d

25. Assertion (A): The design shear strength of vertical stirrups depends on the area of stirrup legs crossing the shear crack.

Reason (R): The area of shear reinforcement directly influences the tensile force that can be resisted by the stirrups.

- a) Assertion is false, but Reason is true
- b) Both Assertion and Reason are true, and Reason is the correct explanation
- c) Assertion is true, but Reason is false
- d) Both Assertion and Reason are true, but Reason is not the correct explanation

Answer: b

26. **Assertion (A):** Inclined stirrups can contribute to the shear resistance of a reinforced concrete beam.

Reason (R): The inclined reinforcement has a vertical component that resists part of the applied shear force.

- a) Both Assertion and Reason are true, but Reason is not the correct explanation
- b) Assertion is false, but Reason is true
- c) Both Assertion and Reason are true, and Reason is the correct explanation
- d) Assertion is true, but Reason is false

Answer: c

27. **Assertion (A):** Bent-up bars can be considered as shear reinforcement when they satisfy the requirements of IS 456:2000.

Reason (R): Bent-up bars can cross diagonal shear cracks and develop a component of force resisting shear.

- a) Assertion is true, but Reason is false
- b) Assertion is false, but Reason is true
- c) Both Assertion and Reason are true, and Reason is the correct explanation
- d) Both Assertion and Reason are true, but Reason is not the correct explanation

Answer: c

28. **Assertion (A):** A staircase provides vertical access between different floors of a building.

Reason (R): A staircase consists of steps arranged to provide a convenient change in level.

- a) Both Assertion and Reason are true, but Reason is not the correct explanation
- b) Assertion is true, but Reason is false
- c) Both Assertion and Reason are true, and Reason is the correct explanation
- d) Assertion is false, but Reason is true

Answer: c

29. **Assertion (A):** A dog-legged staircase has two flights running in opposite directions.

Reason (R): The two flights are connected by an intermediate landing.

- a) Assertion is true, but Reason is false
- b) Both Assertion and Reason are true, and Reason is the correct explanation
- c) Assertion is false, but Reason is true
- d) Both Assertion and Reason are true, but Reason is not the correct explanation

Answer: b

30. **Assertion (A):** A landing is provided between flights of a staircase.

Reason (R): A landing provides a resting area and may also facilitate a change in direction.

- a) Assertion is true, but Reason is false
- b) Assertion is false, but Reason is true
- c) Both Assertion and Reason are true, but Reason is not the correct explanation
- d) Both Assertion and Reason are true, and Reason is the correct explanation

Answer: d

UNIT III DESIGN OF T-BEAMS AND CONTINUOUS BEAMS

1. A reinforced concrete T-beam is generally formed when:

- a) A beam is supported by a column at both ends
- b) A beam and slab are cast monolithically, allowing a portion of the slab to act as the compression flange
- c) A beam is reinforced only at the top
- d) A slab is supported independently without any beam

Answer: b) A beam and slab are cast monolithically, allowing a portion of the slab to act as the compression flange

2. In a conventional T-beam subjected to positive bending, the flange primarily acts as:

- a) The tension zone
- b) The compression zone
- c) The shear reinforcement
- d) The neutral axis

Answer: b) The compression zone

3. An L-beam differs from a T-beam primarily because:

- a) An L-beam has a flange extending on only one side of the web
- b) An L-beam has no web
- c) An L-beam always carries only axial load
- d) An L-beam cannot be reinforced

Answer: a) An L-beam has a flange extending on only one side of the web

4. The effective flange width of a T-beam is introduced primarily because:

- a) The entire slab width always acts uniformly in compression
- b) The actual compression stress distribution across the slab flange is non-uniform
- c) The web carries no compression
- d) The beam width is always equal to the slab width

Answer: b) The actual compression stress distribution across the slab flange is non-uniform

5. According to IS 456:2000, the effective flange width (b_f) of an isolated T-beam is governed by parameters including:

- a) Effective span, web width and flange thickness
- b) Only the overall beam depth
- c) Only the diameter of reinforcement
- d) Only the concrete grade

Answer: a) Effective span, web width and flange thickness

6. For a T-beam, the effective flange width is generally:

- a) Equal to the entire slab width irrespective of span
- b) Greater than the actual slab width
- c) Limited according to the provisions of IS 456:2000
- d) Always equal to the web width

Answer: c) Limited according to the provisions of IS 456:2000

7. For a T-beam subjected to sagging moment, if the neutral axis lies within the flange, the section can be designed essentially as:

- a) A rectangular section of width equal to the web width
- b) A rectangular section of width equal to the effective flange width
- c) A doubly reinforced rectangular section only
- d) A circular section

Answer: b) A rectangular section of width equal to the effective flange width

8. If the neutral axis of a singly reinforced T-beam lies below the flange, the compression zone consists of:

- a) Flange only
- b) Web only
- c) Flange plus a portion of the web
- d) Tension reinforcement only

Answer: c) Flange plus a portion of the web

9. For a singly reinforced T-beam with the neutral axis below the flange, the total compressive force is composed of:

- a) Compression in the flange only
- b) Compression in the web only
- c) Compression contribution from the flange overhangs plus compression in the web
- d) Tension in concrete plus compression in steel

Answer: c) Compression contribution from the flange overhangs plus compression in the web

10. A T-beam has an effective flange width of 1000 mm and web width of 300 mm. If the neutral axis lies within the flange, the appropriate width to use for calculating the compression block is:

- a) 300 mm
- b) 650 mm
- c) 1000 mm
- d) 1300 mm

11. The primary advantage of a continuous beam over a simply supported beam is that continuity:

- a) Eliminates all bending moments
- b) Redistributes bending moments between spans and supports
- c) Eliminates shear forces
- d) Makes reinforcement unnecessary

Answer: b) Redistributes bending moments between spans and supports

12. For the use of bending moment coefficients specified in IS 456:2000, which condition is generally associated with their applicability?

- a) Unequal spans with arbitrary loading
- b) Equal or approximately equal spans and specified loading conditions
- c) Cantilever beams only
- d) Beams subjected exclusively to concentrated loads

Answer: b) Equal or approximately equal spans and specified loading conditions

13. In a continuous beam, sagging moment generally occurs:

- a) Over the supports only
- b) In the spans between supports
- c) Only at the free end
- d) Only at points of zero shear

Answer: b) In the spans between supports

14. In a continuous beam, hogging moment generally occurs:

- a) Near or over the intermediate supports
- b) Only at the centre of every span
- c) At the free end of every span
- d) Only where shear force is zero

Answer: a) Near or over the intermediate supports

15. The reinforcement provided near the bottom of a continuous beam at a region of maximum sagging moment is primarily intended to resist:

- a) Compression
- b) Tension
- c) Torsion only
- d) Shear only

Answer: b) Tension

16. At an interior support where maximum hogging moment occurs, the principal flexural tension reinforcement should generally be provided:

- a) Near the bottom face
- b) Near the top face
- c) At the neutral axis
- d) Outside the beam section

Answer: b) Near the top face

17. When IS 456:2000 bending moment coefficients are used for the design of continuous beams, the coefficients primarily account for:

- a) Only the concrete grade
- b) The effects of continuity and critical loading patterns
- c) Only the beam width
- d) Only the reinforcement grade

Answer: b) The effects of continuity and critical loading patterns

18. Which of the following is an appropriate method for analyzing a continuous beam when coefficient methods are not applicable?

- a) Moment distribution method
- b) Rankine's earth pressure method
- c) Darcy's method
- d) Euler buckling method

Answer: a) Moment distribution method

19. For an interior support of a continuous beam, the hogging moment is important in design because it:

- a) Produces tension at the top of the beam near the support
- b) Produces tension only at the bottom
- c) Eliminates the need for top reinforcement
- d) Produces no tensile stress in concrete

Answer: a) Produces tension at the top of the beam near the support

20. A designer calculates the maximum sagging moment in a continuous beam using the coefficient method but places the main tension reinforcement at the top at midspan. This arrangement is:

- a) Correct because sagging produces top tension
- b) Incorrect because the principal tension reinforcement for sagging is generally required near the bottom
- c) Correct only for simply supported beams
- d) Correct if the beam has equal spans

Answer: b) Incorrect because the principal tension reinforcement for sagging is generally required near the bottom

21. A continuous beam is a beam that:

- a) Has only one support
- b) Extends over two or more spans with intermediate supports
- c) Is fixed at both ends only
- d) Carries only uniformly distributed loads

Answer: b) Extends over two or more spans with intermediate supports

22. Assertion (A): A T-beam consists of a flange and a web acting together to resist flexure.

Reason (R): In a monolithic reinforced concrete floor system, the slab may act as the flange of the beam.

- a) Both Assertion and Reason are true, but Reason is not the correct explanation
- b) Assertion is true, but Reason is false
- c) Both Assertion and Reason are true, and Reason is the correct explanation
- d) Assertion is false, but Reason is true

Answer: c

23. Assertion (A): The entire slab width cannot always be considered as the effective flange width of a T-beam.

Reason (R): The effective flange width is limited because the longitudinal compressive stress is not uniformly distributed over the entire slab width.

- a) Both Assertion and Reason are true, and Reason is the correct explanation
- b) Assertion is false, but Reason is true
- c) Assertion is true, but Reason is false
- d) Both Assertion and Reason are true, but Reason is not the correct explanation

Answer: a

24. Assertion (A): The effective width of the flange is important in the flexural design of a T-beam.
Reason (R): The effective flange width is used to determine the compression area contributing to flexural resistance.

- a) Assertion is true, but Reason is false
- b) Assertion is false, but Reason is true
- c) Both Assertion and Reason are true, but Reason is not the correct explanation
- d) Both Assertion and Reason are true, and Reason is the correct explanation

Answer: d

25. Assertion (A): When the neutral axis lies within the flange, the T-beam can be designed similar to a rectangular beam of width equal to the effective flange width.
Reason (R): The compression zone is completely contained within the flange.

- a) Assertion is false, but Reason is true
- b) Both Assertion and Reason are true, but Reason is not the correct explanation
- c) Both Assertion and Reason are true, and Reason is the correct explanation
- d) Assertion is true, but Reason is false

Answer: c

26. Assertion (A): A continuous beam is supported at more than two points and extends over two or more spans.
Reason (R): Continuity of the beam produces bending moments at intermediate supports.

- a) Assertion is true, but Reason is false
- b) Both Assertion and Reason are true, and Reason is the correct explanation
- c) Both Assertion and Reason are true, but Reason is not the correct explanation
- d) Assertion is false, but Reason is true

Answer: b

27. Assertion (A): Sagging moment generally occurs within the spans of a continuous beam.
Reason (R): The central region of a loaded span tends to deflect downward, producing positive bending.

- a) Assertion is true, but Reason is false
- b) Both Assertion and Reason are true, but Reason is not the correct explanation
- c) Both Assertion and Reason are true, and Reason is the correct explanation
- d) Assertion is false, but Reason is true

Answer: c

28. Assertion (A): IS 456:2000 provides bending moment coefficients for certain continuous beams under specified conditions.
Reason (R): The coefficient method simplifies the analysis of continuous beams for the specified loading and support conditions.

- a) Assertion is true, but Reason is false
- b) Assertion is false, but Reason is true
- c) Both Assertion and Reason are true, and Reason is the correct explanation
- d) Both Assertion and Reason are true, but Reason is not the correct explanation

Answer: c

29. Assertion (A): In the design of a continuous beam, the reinforcement arrangement for sagging and hogging moments is different.

Reason (R): The tension zone occurs at the bottom in sagging regions and generally at the top over intermediate supports for hogging regions.

- a) Assertion is true, but Reason is false
- b) Both Assertion and Reason are true, but Reason is not the correct explanation
- c) Assertion is false, but Reason is true
- d) Both Assertion and Reason are true, and Reason is the correct explanation

Answer: d

30. Assertion (A): In the design of a singly reinforced continuous beam, the required tension reinforcement is determined from the design bending moment.

Reason (R): The area of tension reinforcement is related to the moment of resistance of the reinforced concrete section.

- a) Assertion is false, but Reason is true
- b) Both Assertion and Reason are true, and Reason is the correct explanation
- c) Assertion is true, but Reason is false
- d) Both Assertion and Reason are true, but Reason is not the correct explanation

Answer: b

UNIT IV DESIGN OF SLABS

1. A rectangular slab panel has dimensions 3 m × 7 m and is supported on all four sides. Based on its aspect ratio, it will generally behave as:

- a) A two-way slab
- b) A one-way slab
- c) A flat slab
- d) A circular slab

Answer: b) A one-way slab

2. In a one-way slab, the principal flexural reinforcement is generally provided:

- a) Along the longer span
- b) Along the shorter span
- c) Equally in both directions
- d) Only along the support line

Answer: b) Along the shorter span

3. The dead load of a reinforced concrete slab is primarily calculated from:

- a) Live load only
- b) Self-weight based on slab thickness and unit weight of concrete
- c) Wind load only
- d) Impact load only

Answer: b) Self-weight based on slab thickness and unit weight of concrete

4. For the design of a floor slab, imposed load or live load is primarily determined based on:

- a) IS 456 only
- b) IS 875 (Part 2) according to the occupancy and use of the building

- c) IS 800 only
- d) IS 1893 only

Answer: b) IS 875 (Part 2) according to the occupancy and use of the building

5. A slab is designed using a factored load obtained from characteristic dead and imposed loads. For the usual limit state of collapse combination of dead load and imposed load, the factored load is:

- a) $(1.0(DL+IL))$
- b) $(1.2(DL+IL))$
- c) $(1.5(DL+IL))$
- d) $(2.0(DL+IL))$

Answer: c) $(1.5(DL+IL))$

6. For a one-way slab spanning simply between supports, the maximum positive bending moment due to uniformly distributed load occurs:

- a) At the supports
- b) At the centre of span
- c) At one-quarter span only
- d) At the point of maximum shear

Answer: b) At the centre of span

7. In a cantilever slab subjected to downward loading, the principal flexural tension reinforcement near the fixed support is placed:

- a) At the bottom face
- b) At the top face
- c) At the centre of slab thickness
- d) Only perpendicular to the span

Answer: b) At the top face

8. According to IS 456:2000, the minimum reinforcement in either direction in a slab using HYSD bars is generally:

- a) 0.10% of gross cross-sectional area
- b) 0.12% of gross cross-sectional area
- c) 0.15% of gross cross-sectional area
- d) 0.20% of gross cross-sectional area

Answer: b) 0.12% of gross cross-sectional area

9. For a slab reinforced with mild steel, the minimum reinforcement specified by IS 456:2000 is generally:

- a) 0.10%
- b) 0.12%
- c) 0.15%
- d) 0.20%

Answer: c) 0.15%

10. The maximum diameter of reinforcing bars used in a slab, according to IS 456:2000, should generally not exceed:

- a) One-fourth of slab thickness
- b) One-third of slab thickness
- c) One-half of slab thickness
- d) Three-fourths of slab thickness

Answer: a) One-fourth of slab thickness

11. The fundamental difference between one-way and two-way slab action is that a two-way slab:

- a) Transfers load predominantly in one direction only
- b) Develops significant bending and load transfer in both orthogonal directions
- c) Does not require reinforcement
- d) Can only be supported on two sides

Answer: b) Develops significant bending and load transfer in both orthogonal directions

12. A square slab panel supported on all four sides is subjected to a uniformly distributed load. The load is primarily transferred:

- a) Only along one direction
- b) Only through the longer span
- c) In both orthogonal directions
- d) Directly to the centre of the slab

Answer: c) In both orthogonal directions

13. The effective span of a two-way slab should be determined:

- a) Independently of support conditions
- b) According to the relevant provisions of IS 456:2000, considering the support arrangement
- c) Always equal to the longer clear span
- d) Always equal to the shorter clear span

Answer: b) According to the relevant provisions of IS 456:2000, considering the support arrangement

14. In a two-way slab, the middle strip is defined primarily to:

- a) Carry all the load independently
- b) Represent the central portion of the slab used for distributing design moments and reinforcement
- c) Eliminate edge reinforcement
- d) Transfer load directly to the foundation

Answer: b) Represent the central portion of the slab used for distributing design moments and reinforcement

15. In the conventional design procedure for a two-way slab, the total design moment in a particular direction is distributed between:

- a) Only the edge strips
- b) Middle strip and edge strips
- c) Columns and foundations
- d) Concrete and shear reinforcement

Answer: b) Middle strip and edge strips

16. The principal purpose of dividing a two-way slab into middle and edge strips is to:

- a) Account for the non-uniform distribution of bending moments across the slab width
- b) Reduce the effective span to zero
- c) Eliminate the need for transverse reinforcement
- d) Make the slab behave as a beam

Answer: a) Account for the non-uniform distribution of bending moments across the slab width

17. For a simply supported two-way slab with corners held down against lifting, the IS 456 coefficient method is applicable for determining:

- a) Only shear force
- b) Design bending moments in the two orthogonal directions
- c) Only punching shear
- d) Only deflection

Answer: b) Design bending moments in the two orthogonal directions

18. In a two-way slab, the bending moment in the shorter-span direction is generally:

- a) Lower than the moment in the longer-span direction for all aspect ratios
- b) Greater than the moment in the longer-span direction for comparable loading and support conditions
- c) Always zero
- d) Independent of the aspect ratio

Answer: b) Greater than the moment in the longer-span direction for comparable loading and support conditions

19. The thickness of a two-way slab is initially selected considering:

- a) Only architectural appearance
- b) Strength, stiffness/deflection control, durability and other code requirements
- c) Only live load
- d) Only reinforcement diameter

Answer: b) Strength, stiffness/deflection control, durability and other code requirements

20. A two-way slab satisfies its ultimate flexural strength requirement but exceeds the permissible deflection. The most appropriate modification is generally to:

- a) Reduce slab thickness
- b) Increase effective depth/slab thickness or otherwise improve stiffness
- c) Remove distribution reinforcement
- d) Ignore the deflection check

Answer: b) Increase effective depth/slab thickness or otherwise improve stiffness

21. For a continuous two-way slab, negative bending moments are generally developed:

- a) At the middle of the panel only
- b) Over the supports
- c) Only at the corners
- d) Nowhere because the slab is continuous

Answer: b) Over the supports

22. Assertion (A): A one-way slab primarily bends in one direction.

Reason (R): In a one-way slab, the load is mainly transferred to the supports along the shorter span.

- a) Both Assertion and Reason are true, and Reason is the correct explanation
- b) Assertion is true, but Reason is false
- c) Both Assertion and Reason are true, but Reason is not the correct explanation
- d) Assertion is false, but Reason is true

Answer: a

23. Assertion (A): A slab supported on two opposite sides generally behaves as a one-way slab.

Reason (R): The slab primarily transfers load to the two supporting sides and bends perpendicular to them.

- a) Assertion is false, but Reason is true
- b) Both Assertion and Reason are true, and Reason is the correct explanation
- c) Assertion is true, but Reason is false
- d) Both Assertion and Reason are true, but Reason is not the correct explanation

Answer: b

24. Assertion (A): The effective span is an important parameter in the design of a one-way slab.

Reason (R): The effective span is used in calculating the design bending moment and shear force.

- a) Assertion is true, but Reason is false
- b) Assertion is false, but Reason is true
- c) Both Assertion and Reason are true, and Reason is the correct explanation
- d) Both Assertion and Reason are true, but Reason is not the correct explanation

Answer: c

25. Assertion (A): Adequate slab thickness is required to satisfy both strength and stiffness requirements.

Reason (R): Slab thickness influences its load-carrying capacity and deflection behaviour.

- a) Assertion is true, but Reason is false
- b) Both Assertion and Reason are true, and Reason is the correct explanation
- c) Assertion is false, but Reason is true
- d) Both Assertion and Reason are true, but Reason is not the correct explanation

Answer: b

26. Assertion (A): A two-way slab transfers load to supports in two perpendicular directions.

Reason (R): Bending occurs in both principal directions when the slab is supported appropriately on four sides.

- a) Assertion is false, but Reason is true
- b) Both Assertion and Reason are true, and Reason is the correct explanation
- c) Assertion is true, but Reason is false
- d) Both Assertion and Reason are true, but Reason is not the correct explanation

Answer: b

27. Assertion (A): Middle strips and edge strips are considered in the design of two-way slabs.
Reason (R): The bending moment and reinforcement distribution in a two-way slab are not necessarily uniform across its entire width.

- a) Both Assertion and Reason are true, and Reason is the correct explanation
- b) Assertion is false, but Reason is true
- c) Assertion is true, but Reason is false
- d) Both Assertion and Reason are true, but Reason is not the correct explanation

Answer: a

28. Assertion (A): In a simply supported two-way slab, reinforcement is provided in both directions.

Reason (R): The slab develops bending moments in both directions and therefore requires flexural reinforcement in both directions.

- a) Assertion is true, but Reason is false
- b) Both Assertion and Reason are true, but Reason is not the correct explanation
- c) Assertion is false, but Reason is true
- d) Both Assertion and Reason are true, and Reason is the correct explanation

Answer: d

29. Assertion (A): A two-way slab transfers load to supports in two perpendicular directions.

Reason (R): Bending occurs in both principal directions when the slab is supported appropriately on four sides.

- a) Assertion is false, but Reason is true
- b) Both Assertion and Reason are true, and Reason is the correct explanation
- c) Assertion is true, but Reason is false
- d) Both Assertion and Reason are true, but Reason is not the correct explanation

Answer: b

30. Assertion (A): IS 456:2000 provides bending moment coefficients for the design of certain simply supported and continuous two-way slabs.

Reason (R): The coefficient method provides a simplified approach for determining design bending moments under specified support and loading conditions.

- a) Assertion is false, but Reason is true
- b) Both Assertion and Reason are true, but Reason is not the correct explanation
- c) Both Assertion and Reason are true, and Reason is the correct explanation
- d) Assertion is true, but Reason is false

Answer: c

UNIT V DESIGN OF R.C.C. COLUMNS AND COLUMN FOOTINGS

1. Under the Limit State of Collapse in Compression, the design of an RCC column primarily aims to ensure adequate resistance against:

- a) Flexural cracking only
- b) Compression failure considering the effects of eccentricity and slenderness
- c) Shear failure only
- d) Deflection of slabs

Answer: b) Compression failure considering the effects of eccentricity and slenderness

2. According to IS 456:2000, a compression member is classified as a short column when the ratios of effective length to the corresponding lateral dimensions satisfy:

- a) Both ratios are less than 10
- b) Both ratios are not less than 12
- c) Both ratios do not exceed 12
- d) At least one ratio is less than 20

Answer: c) Both ratios do not exceed 12

3. For a short axially loaded RCC column, the maximum design compressive strength is based on the combined contribution of:

- a) Concrete only
- b) Longitudinal reinforcement only
- c) Concrete and longitudinal reinforcement
- d) Transverse reinforcement and cover only

Answer: c) Concrete and longitudinal reinforcement

4. The effective length of a compression member is primarily influenced by:

- a) Concrete grade only
- b) End restraints and support conditions
- c) Diameter of longitudinal bars only
- d) Concrete cover only

Answer: b) End restraints and support conditions

5. The effective length of a column is 4.2 m and its least lateral dimension is 350 mm. The slenderness ratio about the corresponding axis is:

- a) 8
- b) 10
- c) 12
- d) 14

Answer: c) 12

6. A column is classified as a long column when:

- a) Both slenderness ratios are less than 12
- b) Both slenderness ratios are exactly 12
- c) The slenderness ratio in either direction exceeds 12
- d) Its cross-sectional area exceeds 1 m²

Answer: c) The slenderness ratio in either direction exceeds 12

7. According to IS 456:2000, the minimum eccentricity e_{min} for a column is taken as:

- a) $(L/500 + D/30)$, subject to a minimum of 20 mm
- b) $(L/500 + D/30)$, subject to a minimum of 40 mm
- c) $(L/300 + D/20)$, subject to a minimum of 20 mm
- d) $(L/1000 + D/60)$, subject to a minimum of 10 mm

Answer: a) $(L/500 + D/30)$, subject to a minimum of 20 mm

8. The minimum longitudinal reinforcement in an RCC column, according to IS 456:2000, shall generally not be less than:

- a) 0.4% of gross cross-sectional area
- b) 0.8% of gross cross-sectional area
- c) 1.0% of gross cross-sectional area
- d) 2.0% of gross cross-sectional area

Answer: b) 0.8% of gross cross-sectional area

9. According to IS 456:2000, the nominal diameter of longitudinal reinforcement in a column shall generally not be less than:

- a) 8 mm
- b) 10 mm
- c) 12 mm
- d) 16 mm

Answer: c) 12 mm

10. The primary functions of lateral ties in a tied RCC column include:

- a) Resisting all axial load independently
- b) Holding longitudinal bars in position and providing restraint against their buckling
- c) Increasing the effective length of the column
- d) Eliminating the need for longitudinal reinforcement

Answer: b) Holding longitudinal bars in position and providing restraint against their buckling

11. The primary function of an isolated RCC column footing is to:

- a) Increase the axial load carried by the column
- b) Transfer the column load safely to the supporting soil without exceeding its allowable bearing capacity
- c) Eliminate settlement completely
- d) Increase the height of the column

Answer: b) Transfer the column load safely to the supporting soil without exceeding its allowable bearing capacity

12. The area of an isolated footing is primarily determined from:

- a) Flexural strength of concrete only
- b) Column reinforcement area
- c) Service load and allowable bearing pressure of soil
- d) Diameter of column bars

Answer: c) Service load and allowable bearing pressure of soil

13. An isolated footing supporting a single column is generally preferred when:

- a) Columns are very closely spaced and overlap of footing areas occurs
- b) The column is sufficiently isolated and the soil has adequate bearing capacity
- c) The column is located exactly on the property boundary
- d) The soil has zero bearing capacity

Answer: b) The column is sufficiently isolated and the soil has adequate bearing capacity

14. A footing supporting two columns is commonly known as:

- a) Isolated footing
- b) Combined footing
- c) Strip footing
- d) Ring footing

Answer: b) Combined footing

15. A footing with a uniform thickness throughout its plan area is called:

- a) Stepped footing
- b) Sloped footing
- c) Flat/rectangular uniform-thickness footing
- d) Raft footing

Answer: c) Flat/rectangular uniform-thickness footing

16. One important advantage of a sloped footing over a uniform-thickness footing is that it:

- a) Always requires more concrete
- b) Can reduce concrete quantity while providing greater depth near the column where bending and shear are critical
- c) Eliminates reinforcement
- d) Eliminates punching shear

Answer: b) Can reduce concrete quantity while providing greater depth near the column where bending and shear are critical

17. According to IS 456:2000, the minimum depth of foundation below the ground surface is generally governed by:

- a) Only the diameter of column reinforcement
- b) Considerations such as soil properties, climatic effects, and the need to reach suitable bearing strata
- c) Only the width of footing
- d) Only the grade of concrete

Answer: b) Considerations such as soil properties, climatic effects, and the need to reach suitable bearing strata

18. For design of an isolated footing, the critical section for bending moment is generally taken at:

- a) The face of the column
- b) The centre of the footing
- c) The edge of the footing
- d) The outermost edge of reinforcement

Answer: a) The face of the column

19. The critical section for one-way or transverse shear in an isolated footing is generally located at a distance from the column face equal to:

- a) $(d/2)$
- b) (d)
- c) $(2d)$
- d) $(3d)$

Answer: b) (d)

20. The principal difference between one-way shear and punching shear in a footing is that:

- a) One-way shear is associated with a beam-type failure plane, whereas punching shear involves a perimeter around the loaded area
- b) One-way shear occurs only in columns
- c) Punching shear occurs only at the footing edge
- d) They are identical failure mechanisms

Answer: a) One-way shear is associated with a beam-type failure plane, whereas punching shear involves a perimeter around the loaded area

21. The main flexural reinforcement in an isolated rectangular footing is generally provided:

- a) Only at the top surface
- b) Near the bottom face in both principal directions
- c) Only vertically around the column
- d) At the neutral axis

Answer: b) Near the bottom face in both principal directions

22. Assertion (A): A reinforced concrete column is primarily designed to resist compression.

Reason (R): Columns transfer loads from beams and slabs to the foundation.

- a) Both Assertion and Reason are true, and Reason is the correct explanation
- b) Assertion is true, but Reason is false
- c) Both Assertion and Reason are true, but Reason is not the correct explanation
- d) Assertion is false, but Reason is true

Answer: a

23. Assertion (A): The limit state of collapse in compression is considered in the design of R.C.C columns.

Reason (R): A column may fail due to crushing or instability under compression.

- a) Assertion is false, but Reason is true
- b) Both Assertion and Reason are true, and Reason is the correct explanation
- c) Assertion is true, but Reason is false
- d) Both Assertion and Reason are true, but Reason is not the correct explanation

Answer: b

24. Assertion (A): The design of a short axially loaded column is based on the combined resistance of concrete and longitudinal steel.

Reason (R): Both concrete and longitudinal reinforcement contribute to carrying the compressive load.

- a) Both Assertion and Reason are true, but Reason is not the correct explanation
- b) Assertion is true, but Reason is false
- c) Both Assertion and Reason are true, and Reason is the correct explanation
- d) Assertion is false, but Reason is true

Answer: c

25. Assertion (A): A short column is less susceptible to buckling than a slender column.

Reason (R): The effective length-to-lateral-dimension ratio of a short column is within the limiting values specified for short columns.

- a) Assertion is true, but Reason is false
- b) Both Assertion and Reason are true, but Reason is not the correct explanation
- c) Both Assertion and Reason are true, and Reason is the correct explanation
- d) Assertion is false, but Reason is true

Answer: c

26. **Assertion (A):** Longitudinal reinforcement is provided in R.C.C columns.

Reason (R): Longitudinal reinforcement contributes to axial load resistance and helps improve the strength of the column.

- a) Both Assertion and Reason are true, and Reason is the correct explanation
- b) Assertion is true, but Reason is false
- c) Assertion is false, but Reason is true
- d) Both Assertion and Reason are true, but Reason is not the correct explanation

Answer: a

27. **Assertion (A):** The area of an isolated footing depends on the column load and the safe bearing capacity of soil.

Reason (R): The footing area should be adequate to keep the soil pressure within the permissible bearing capacity.

- a) Assertion is true, but Reason is false
- b) Both Assertion and Reason are true, and Reason is the correct explanation
- c) Assertion is false, but Reason is true
- d) Both Assertion and Reason are true, but Reason is not the correct explanation

Answer: b

28. **Assertion (A):** Punching shear is an important consideration in the design of isolated column footings.

Reason (R): The column load can cause a potential punching shear failure around the loaded area.

- a) Both Assertion and Reason are true, and Reason is the correct explanation
- b) Assertion is true, but Reason is false
- c) Assertion is false, but Reason is true
- d) Both Assertion and Reason are true, but Reason is not the correct explanation

Answer: a

29. **Assertion (A):** Development length is considered in the design of footing reinforcement.

Reason (R): Adequate development length is required to transfer the tensile force between reinforcement and surrounding concrete.

- a) Both Assertion and Reason are true, but Reason is not the correct explanation
- b) Assertion is true, but Reason is false
- c) Both Assertion and Reason are true, and Reason is the correct explanation
- d) Assertion is false, but Reason is true

30. **Assertion (A):** Minimum reinforcement and minimum edge thickness requirements are specified for reinforced concrete footings.

Reason (R): These requirements help ensure adequate structural performance, crack control and durability.

- a) Assertion is false, but Reason is true
- b) Both Assertion and Reason are true, but Reason is not the correct explanation

- c) Assertion is true, but Reason is false
d) Both Assertion and Reason are true, and Reason is the correct explanation

Answer: d

Part-B

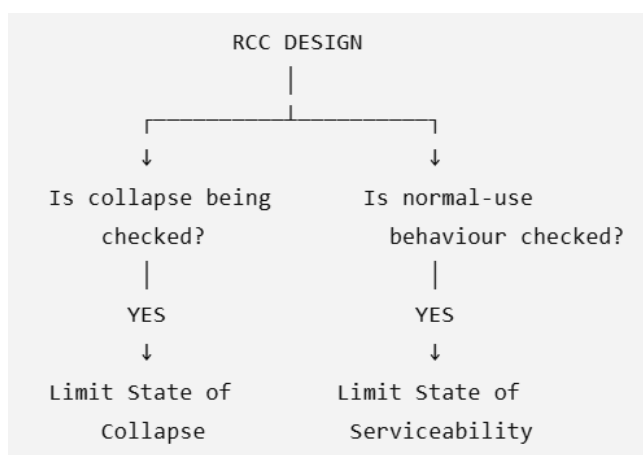
Unit 1

1. A reinforced concrete beam is supported on two walls 500 mm thick, spaced at a clear distance of 6 m. The beam carries a superimposed load of 9.8 kN/m. Design the beam using M20 concrete mix and Fe 415 steel.
2. A cantilever beam is subjected to a factored bending moment of 100 kNm. The breadth of the beam is 250 mm. Determine the effective depth and area of tension steel required for the beam if M25 grade concrete and Fe415grade steel are used.
3. A reinforced concrete simply supported beam of size 300mm x 450mm (effective) when M20 grade concrete and Fe415 grade steel are used. Determine the area of tension steel required for a balanced section. Also find the limiting value of ultimate moment of resistance of the section.
4. The cross section of the beam is 300 mm x 500 mm (effective) subjected to a bending moment of 90kNm. It is reinforced with 4 Nos. of 16 mm dia. bars as tension reinforcement. Use M20 grade concrete and Fe415 grade steel. State whether the section is safe or not?

5. i) Selection of Limit State

(2marks)

Flowchart:



Question:

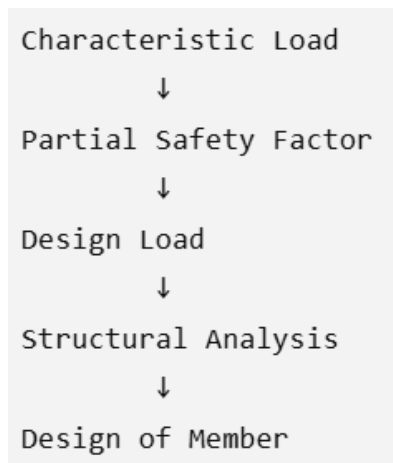
A beam is checked for **excessive deflection and cracking under normal working conditions**. Based on the flowchart, which limit state should be considered?

- a) Limit state of collapse
- b) Limit state of serviceability
- c) Limit state of compression only
- d) Limit state of flexure only

Answer: b) Limit state of serviceability

ii)

(2marks)



Question:

Which of the following represents the same process in a different form?

- a) Design Load → Characteristic Load → Safety Factor → Design
- b) Characteristic Load → Factored Load → Analysis → Design
- c) Design → Characteristic Load → Analysis → Safety Factor
- d) Analysis → Characteristic Load → Design Load → Design

Answer: b)

Justification:

The characteristic load is factored using the appropriate safety factor to obtain the **design load**, which is then used for structural analysis and design.

iii) Judgement on Safety and Serviceability

(2marks)

A proposed RCC beam has sufficient ultimate strength to resist the factored bending moment. During service conditions, however, calculations show that the beam will undergo excessive deflection. The excessive deflection may affect the appearance of the structure and may also damage partitions and finishes. Although the beam is not expected to collapse under the design load, its deformation is considered unacceptable during normal use.

Question:

What is the correct judgement regarding the beam?

- a) The beam is completely safe because it will not collapse
- b) The beam is acceptable because only collapse is considered in Limit State Method
- c) The beam fails the serviceability requirement and modification is necessary
- d) The beam should be checked only for compression

Answer: c) The beam fails the serviceability requirement and modification is necessary

Inference/Justification:

Limit State Method considers **both collapse and serviceability**. Excessive deflection is a serviceability problem. Therefore, even though the beam is safe against collapse, it is **not acceptable unless the serviceability requirement is satisfied**.

(iv) Inference from Reinforcement and Moment Capacity (2marks)

Inference from Reinforcement and Moment Capacity

☐	800 mm ²	80 kNm
☐	1000 mm ²	95 kNm

Tension Reinforcement and Moment Capacity

1200 mm ²	108 kNm
1400 mm ²	118 kNm

Question:

What inference can be made from the table regarding tension reinforcement and moment capacity?

- a) Moment capacity decreases with reinforcement
- b) Moment capacity is unaffected by reinforcement
- c) Moment capacity generally increases with reinforcement
- d) Reinforcement and moment capacity are unrelated

Answer: c) Moment capacity generally increases with reinforcement

Justification:

As the tension reinforcement increases from **800 mm² to 1400 mm²**, the moment capacity also increases from **80 kNm to 118 kNm**.

(v) Incomplete Development Length Calculation

(2 marks)

A reinforcing bar of diameter **20 mm** is used in a beam. The stress in steel and design bond stress are given as 415 N/mm² and 1.6 N/mm² respectively.

Question:

Complete the calculation and make a decision regarding the required development length.

- a) 648 mm
- b) 1,297 mm
- c) 2,075 mm
- d) 415 mm

Answer: b) 1,297 mm

Solution:

The development length is calculated using:

$$L_d = \frac{\phi \sigma_s}{4 \tau_{bd}}$$

$$L_d = \frac{20 \times 415}{4 \times 1.6}$$

$$L_d = \frac{20 \times 415}{6.4}$$

$$L_d = 1296.875$$

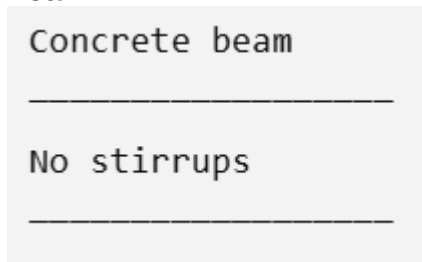
$$L_d \approx 1297 \text{ mm}$$

1. A simply supported rectangular beam of 300mm x 600mm overall size is reinforced with 4Nos. of 16mm dia. Fe415 grade steel bars as tension reinforcement at its mid span with a clear cover of 25mm. It carries an imposed load of 17 kN/m over an effective span of 7m. Use M20 grade concrete. Design the shear reinforcement for the support section by limit state method.
2. Explain the planning of a dog-legged staircase with a neat sketch.
3. A simply supported rectangular beam has an effective depth of 600mm and breadth of 300mm. The beam is reinforced with 3 bars of 20mm as tension reinforcement at the support. The beam is subjected to a factored shear force of 180kN at the support. Check the shear stress and design shear reinforcement. M20 grade concrete and Fe 250 steel are used. Use 8mm diameter 2 legged stirrups of Fe 415.
4. A doubly reinforced rectangular cantilever beam is subjected to a design shear of 250 kN. The breadth and effective depth of the beam are 305 mm and 610 mm, which are uniform throughout. The tension zone is reinforced with 5 nos. of 25 mm dia bars and concrete grade is M25. Determine the spacing of 8mm dia 2 legged stirrups of Fe 415 grade steel required near the support section.

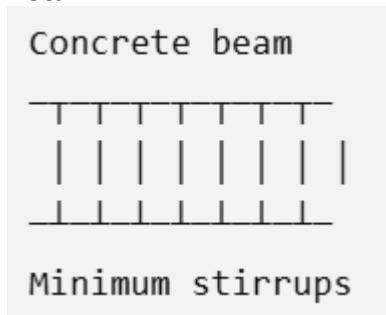
5. (I) **Infographic:**

(2MARKS)

Beam A



Beam B



Observation:

Even when calculated shear reinforcement is small, minimum shear reinforcement is provided.

Inference Question:

Why is the arrangement in Beam B preferred?

- a) To prevent sudden shear failure and control diagonal cracking
- b) To increase the beam span
- c) To eliminate flexural reinforcement
- d) To reduce concrete cover

Answer: a) To prevent sudden shear failure and control diagonal cracking

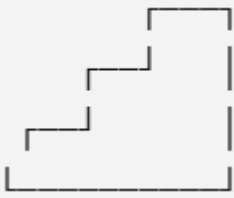
Explanation:

Minimum shear reinforcement is provided to control diagonal cracking and provide adequate shear resistance even when calculated shear reinforcement is small.

(II) **Infographic:**

(2MARKS)

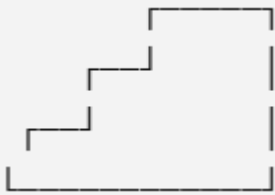
Staircase A



Rise = 180 mm

Tread = 250 mm

Staircase B



Rise = 150 mm

Tread = 300 mm

Inference Question:

Which staircase would generally provide a more comfortable ascent based on the relationship between rise and tread?

- a) Staircase A
- b) Staircase B
- c) Both are equally comfortable irrespective of dimensions
- d) Neither can be used as a staircase

Answer: b) Staircase B

Explanation:

A staircase with a **smaller rise and larger tread** generally provides a more comfortable and easier ascent, subject to applicable dimensional requirements.

(iii) Minimum Shear Reinforcement

(2MARKS)

Three beams have the following calculated shear reinforcement requirements:

Beam	Calculated A_{sv}/s	Minimum A_{sv}/s	Reinforcement to be provided
A	0.25	0.35	?
B	0.50	0.35	?
C	0.80	0.35	?

Which inference is correct?

- a) Beam A should be provided with 0.25
- b) Beam B should be provided with 0.35
- c) Beam A should be provided with at least 0.35
- d) Beam C should be provided with only 0.35

Answer: c) Beam A should be provided with at least 0.35

Explanation:

The shear reinforcement provided should not be less than the **minimum shear reinforcement** specified by IS 456. Therefore:

- Beam A → minimum governs → **0.35**
- Beam B → calculated governs → **0.50**
- Beam C → calculated governs → **0.80**

(IV) Decision on Shear Reinforcement

(2MARKS)

A simply supported RCC beam is being designed by the limit state method. During design, the factored shear force at the critical section is calculated as **120 kN**. The beam has an effective width of **250 mm** and effective depth of **400 mm**. From the relevant design table, the design shear strength of concrete corresponding to the concrete grade and percentage of tension reinforcement is found to be **0.55 N/mm²**. The maximum permissible shear stress for the concrete grade is **2.8 N/mm²**.

The designer calculates the nominal shear stress and compares it with the design shear strength of concrete before deciding whether shear reinforcement is necessary.

Which is the **most appropriate engineering decision**?

- a) No shear reinforcement is required because the beam is reinforced for flexure
- b) Shear reinforcement is required because the nominal shear stress exceeds the concrete shear strength
- c) Shear reinforcement is unnecessary because the nominal shear stress is less than the maximum shear stress
- d) The beam must be rejected because its shear stress is greater than zero

Answer: b) Shear reinforcement is required because the nominal shear stress exceeds the concrete shear strength

Explanation:

The nominal shear stress is:

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

$$\tau_v = \frac{120000}{250 \times 400} = 1.20 \text{ N/mm}^2$$

$$\tau_c = 0.55 \text{ N/mm}^2$$

$$\tau_v > \tau_c$$

Hence, the concrete alone cannot resist the design shear force and **designed shear reinforcement is required**.

However,

$$\tau_v = 1.20 < \tau_{c,max} = 2.8 \text{ N/mm}^2$$

Therefore, the beam is not necessarily required to be redesigned for maximum shear stress. The appropriate decision is to **provide shear reinforcement**, such as vertical stirrups, according to IS 456 requirements.

(V) Complete the Missing Data – Staircase Comfort (2MARKS)

A residential staircase is being planned. The designer has selected a rise of **150 mm** and tread of **300 mm**.

The incomplete design table is:

Parameter	Value
Rise, R	150 mm
Tread, T	300 mm
$2R + T$	_____
Typical comfort range considered	600–650 mm

Which conclusion is most appropriate?

- a) $2R+T=450$; staircase is too steep
- b) $2R+T=600\text{mm}$; the rise-tread relationship is reasonable
- c) $2R+T=750\text{mm}$; tread should be reduced
- d) $2R+T=900\text{mm}$; staircase is unsuitable

Answer: b) $2R+T=600$; the rise-tread relationship is reasonable

Explanation:

Using the commonly used comfort relationship:

$$2R+T = 2(150)+300=600 \text{ mm}$$

Thus:

$$2R+T=600 \text{ mm}$$

The rise and tread combination provides a reasonable relationship for comfortable movement, subject to the applicable building requirements and project standards.

UNIT-III

1. Design a RC continuous beam has three equal spans of 5 meters each. The beam has a rectangular cross-section of 300 mm in width and 650 mm in overall depth. It is subjected to a total factored udl of 50 kN/m along its entire length. Use M20 grade concrete and Fe 415 grade steel.

2. A R.C T-beam section has a flange of 1600mm x 100mm size and a web of 300mm x 650mm size (overall). It has to resist a design moment of 800 kNm. Use M25 grade concrete and Fe500 grade steel bars. Design the tension reinforcement for the beam.
3. A simply supported T-beam of clear span 6m carries an UDL of 30kN/m excluding self-weight. Design the mid span section using M25 concrete and Fe415 steel. Assume the width of support as 300mm.
4. A 'T' beam section has a flange of 1280 mm x 100 mm, effective depth of 700 mm and breadth of web of 280 mm. It is reinforced with 5 nos. of 25 mm diameter Fe415 grade steel bars in the tension zone. M20 grade concrete is used. Determine the moment of resistance of the section at the limit state of collapse.

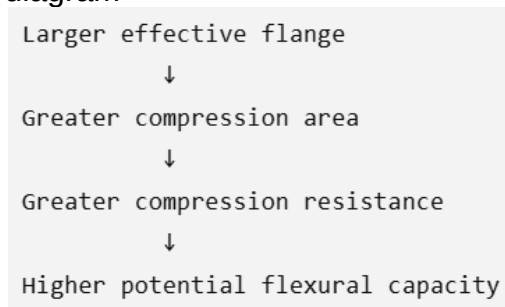
5. (I) Infographic

(2MARKS)

Beam	Effective Flange Width	Neutral Axis	Flexural Capacity
A	1000 mm	Within flange	High
B	600 mm	Within flange	Moderate
C	300 mm	Below flange	Different design treatment

Concept

diagram



Question

Based on the table and concept diagram, which conclusion is most appropriate?

- a) Effective flange width has no influence on T-beam flexural behaviour
- b) Increasing effective flange width can increase compression capacity, subject to the actual neutral-axis condition
- c) Smaller flange width always produces greater moment capacity
- d) Neutral axis location is irrelevant in T-beam design

Answer: b) Increasing effective flange width can increase compression capacity, subject to the actual neutral-axis condition

Explanation

In a T-beam, the flange generally forms part of the **compression zone** under positive bending.

An increase in effective flange width can increase the available compression area and consequently affect the flexural resistance.

However, the designer must first establish the **position of the neutral axis**.

If the NA lies within the flange, the compression block can be treated accordingly. If the NA lies below the flange, both flange and web contribute to compression.

Therefore, flange width and NA position must be considered together.

(II) Judgement Regarding Effective Flange Width (2MARKS)

Three designers are discussing the design of a T-beam supporting a slab.

- Designer A assumes that the entire slab width extending continuously on both sides of the beam is effective in compression.
- Designer B determines the effective flange width using the applicable code provisions.
- Designer C uses only the web width even though the beam and slab are monolithic and the flange is clearly participating in compression.

The beam is simply supported and subjected to UDL, producing positive bending.

Which designer demonstrates the most appropriate engineering judgement?

- a) Designer A, because larger flange width always gives the correct result
- b) Designer B, because effective flange width must be established using the applicable design provisions
- c) Designer C, because flange concrete never participates in flexure
- d) All three designers are equally correct

Answer: b) Designer B, because effective flange width must be established using the applicable design provisions

Explanation:

The concept of **effective flange width** is essential in T-beam design. Although the slab may physically extend a considerable distance on either side of the web, the complete slab width does not necessarily participate uniformly in compression.

The actual distribution of longitudinal compressive stress is influenced by shear lag and the geometry of the slab-beam system. Hence, design codes specify a procedure for determining an **effective flange width**.

Using the entire slab width without checking the code provisions may result in an **overestimation of flexural capacity**. Conversely, using only the web width may unnecessarily ignore beneficial flange action.

Therefore, Designer B has made the correct engineering decision by determining the effective flange width according to the applicable provisions.

(III) Arrange the following steps in the **correct sequence** for designing a singly reinforced rectangular continuous beam: (2 MARKS)

1. Calculate the factored design load.
2. Calculate sagging and hogging design moments.
3. Determine the required tensile reinforcement for sagging moment.
4. Determine the required tensile reinforcement for hogging moment.
5. Check minimum reinforcement, spacing and detailing requirements.

Choose the correct sequence:

- A. 1 → 2 → 3 → 4 → 5
- B. 2 → 1 → 4 → 3 → 5
- C. 1 → 3 → 2 → 4 → 5
- D. 1 → 2 → 4 → 5 → 3

Answer: A

(IV) Match Column I with Column II and Column III

(2 MARKS)

Column I	Column II	Column III
Beam	Width of flange considered in design	Resists compression
Beam	Web	Located at the edge of slab
Effective flange width	Flange	Used in flexural design

Options:

- A. P-2-b, Q-3-a, R-1-c
- B. P-1-c, Q-2-a, R-3-b
- C. P-3-a, Q-2-b, R-1-c
- D. P-3-c, Q-1-b, R-2-a

Answer: C

(V) Neutral Axis Position in a Singly Reinforced T-Beam (2MARKS)

A simply supported reinforced concrete T-beam is subjected to a uniformly distributed load. Under gravity loading, the beam develops a positive bending moment at midspan. The flange is located at the top of the beam and therefore lies in compression in the central portion of the span. The designer examines the position of the neutral axis before selecting the appropriate flexural design procedure. If the neutral axis lies within the flange, the compression block is contained entirely within the flange. In such a situation, the compression zone resembles that of a rectangular section having the effective flange width as its breadth. If the neutral axis falls below the flange, the web also participates in the compression zone and the design becomes different.

Based on this information, which conclusion is most appropriate?

- A. If the neutral axis lies within the flange, the T-beam can be treated as a rectangular section of effective flange width for flexural design.
- B. If the neutral axis lies within the flange, the web alone must resist the compression force.
- C. If the neutral axis lies within the flange, the beam must always be designed as a doubly reinforced section.
- D. If the neutral axis lies within the flange, the flange should be ignored because it is subjected to compression.

Answer: A

Explanation:

For a T-beam subjected to positive bending, the **flange is generally in compression**.

When the neutral axis lies **within the flange**, the compression zone does not extend into the web. Hence, for flexural analysis, the section can effectively be treated as a **rectangular section with breadth equal to the effective flange width**.

Thus, **Option A** is the correct conclusion.

UNIT IV

- Design the interior panel of a continuous two-way slab of effective spans 5.5m x 4.5m to carry an imposed load of 4 kN/m^2 by limit state method. The floor finish will be 1 kN/m^2 . Use M20 grade concrete and Fe 415 steel
- Design a R.C slab simply supported on masonry walls 3.8m apart with 300mm thick walls. It carries an imposed load (not fixed) of 5 kN/m and a floor finish load of 0.5 kN/m . Use M20 grade concrete and Fe 415 steel.

3. A rectangular RC slab panel discontinuous and restrained all round, has effective spans of 3m x 5m. Design the slab for a live load of 2.5 kN/m and floor finish of 0.6 kN/m . Use M20 and Fe415. All corners are held down.
4. Design a simply supported RCC slab for an office floor having clear dimensions of 4m by 10m with 230 walls all around. Adopt M20 grade and Fe415 grade HYSD Bars.

5. (I) One-Way Slab – Stiffness and Thickness Decision

(2MARKS)

A simply supported one-way slab is being designed for a residential building. The calculated flexural strength is adequate for the selected slab thickness. However, when the designer checks the slab for serviceability, the calculated deflection is found to be excessive. Increasing the reinforcement alone would not necessarily solve the stiffness problem efficiently. The designer must select a suitable modification so that both strength and serviceability requirements are satisfied.

What is the most appropriate design decision?

- A. Ignore the deflection because the ultimate strength is adequate.
- B. Reduce the slab thickness because less dead load will act on the slab.
- C. Increase the slab thickness or otherwise satisfy the required span-to-depth/stiffness criteria.
- D. Remove the distribution reinforcement to reduce congestion.

Answer: C. Increase the slab thickness or otherwise satisfy the required span-to-depth/stiffness criteria.

Explanation:

A slab must satisfy **both strength and serviceability requirements**. Adequate moment capacity does not automatically guarantee acceptable deflection. If the slab is too flexible, excessive deflection can occur under service loads. Increasing the **effective depth/slab thickness** is an effective way to improve stiffness and reduce deflection. Therefore, the designer should modify the slab dimensions or reinforcement arrangement as permitted by the applicable provisions rather than simply ignoring the serviceability problem.

(ii) Match the following three columns

(2marks)

Column I	Column II	Column III
Flexural strength	Adequate moment capacity	Flexural failure
Shear strength	Adequate resistance to shear	Shear failure
Stiffness	Adequate thickness/depth	Excessive deflection

Options:

1. A–P–Y, B–Q–X, C–R–Z
2. A–P–X, B–Q–Y, C–R–Z
3. A–Q–Y, B–P–X, C–R–Z
4. A–R–Z, B–Q–Y, C–P–X

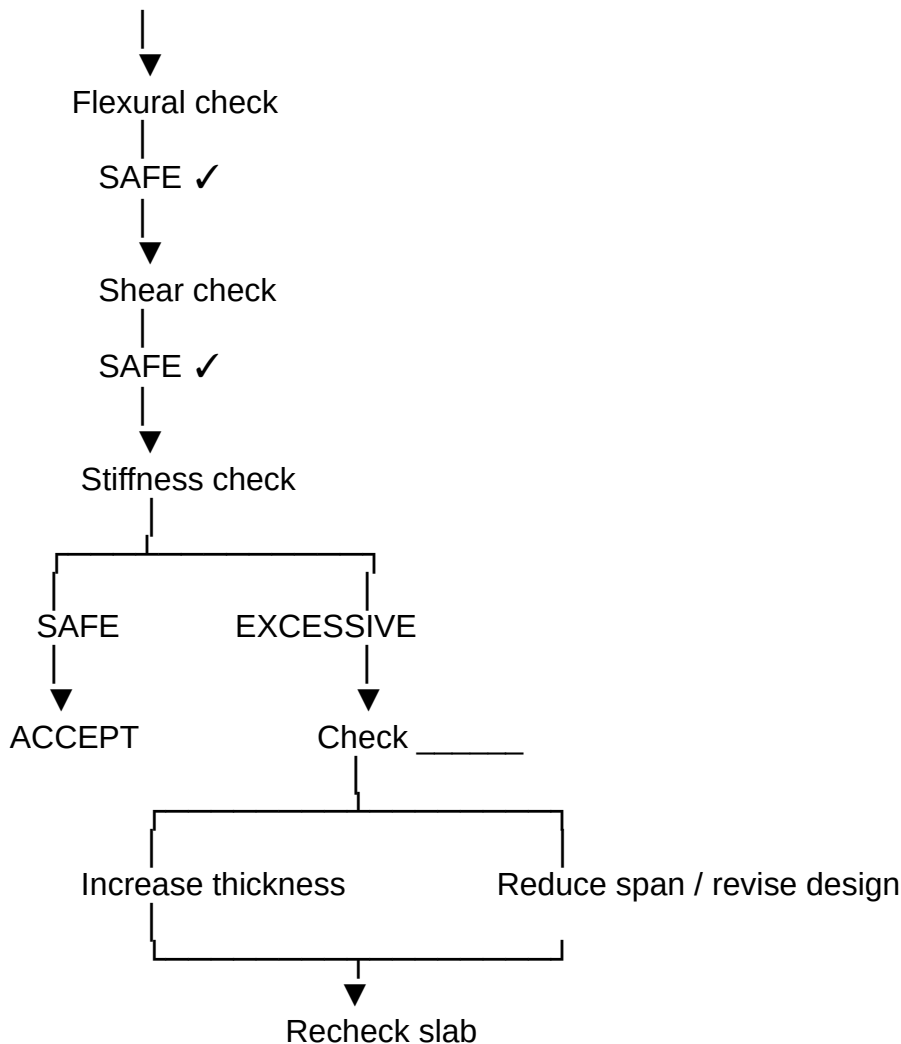
Answer: 2. A–P–X, B–Q–Y, C–R–Z

(iii) A designed one-way slab gives the following results:

(2marks)

- Flexural strength: **SAFE**
- Shear strength: **SAFE**
- Deflection: **EXCESSIVE**
- Reinforcement provided: **within permitted limits**

Use the following decision tree to determine the final design decision.



Which option correctly completes the decision tree?

- A. shear → increase shear reinforcement only
- B. deflection → increase thickness or otherwise revise the slab and recheck
- C. cover → reduce concrete cover
- D. bending moment → remove distribution reinforcement

Answer: B

Explanation:

The slab is safe for **flexure and shear**, but the **stiffness/deflection requirement is not satisfied**. Therefore, the slab cannot be accepted in its present form.

A suitable corrective action is to **increase slab thickness**, reduce the span where possible, or otherwise modify the design to satisfy serviceability. The slab must then be **rechecked**.

The completed decision path is:

Flexure SAFE → Shear SAFE → Deflection EXCESSIVE → Revise slab → Recheck

Hence, **Option B** is correct.

(iv)

(2marks)

A designer initially designs a rectangular slab as **simply supported on all four sides** and selects the corresponding IS 456 moment coefficients.

Later, the architectural layout changes and the slab is made **continuous over one support**.

The contractor says:

“The slab dimensions and loading have not changed, so the previously selected moment coefficients can continue to be used.”

Which is the correct design decision?

- A. Continue using the same coefficients because dimensions and loads are unchanged
- B. Use the coefficients for the original simply supported condition because they are already calculated
- C. Reassess the slab's support condition and use the appropriate coefficients for the revised structural condition
- D. Ignore the change because moment coefficients depend only on slab thickness

Answer: C

Explanation:

This is an important practical condition that is easily overlooked.

Moment distribution in a two-way slab depends not only on:

- slab dimensions,
- thickness, and
- loading,

but also on the **support and continuity conditions**.

Changing a slab from simply supported to continuous changes its structural behaviour and therefore requires the designer to **reassess the appropriate moment coefficients and reinforcement arrangement**.

The practical decision chain is:

Support condition changes → Structural behaviour changes → Appropriate coefficients reassessed → Moments/reinforcement checked again.

Hence, **Option C** is correct.

(v)

(2marks)

A slab design has already established:

- Main reinforcement area = 850 mm²/m
- Secondary reinforcement area = 300 mm²/m
- Bar diameter = 10 mm
- Slab thickness = 125 mm

The drawing engineer is asked to specify the nominal concrete cover. However, the **exposure condition of the slab has not been identified**.

What should the engineer do?

- A. Specify the minimum possible cover to reduce slab thickness
- B. Use 5 mm cover for all slabs
- C. Obtain the applicable exposure/durability condition before finalising the cover requirement
- D. Determine cover only from the area of reinforcement

Answer: C

Explanation:

Concrete cover is not decided merely from the reinforcement area. The required nominal cover is influenced by **durability/exposure requirements**, along with the applicable provisions of IS 456.

Therefore, before finalising the cover, the designer needs the missing information regarding the **exposure condition**.

This is an important practical decision because inadequate cover can adversely affect durability and reinforcement protection.

UNIT V

1. A RC Column, 300mm square in size carries an axial load of 1000kN including its self weight. SBC of soil is 90kN/m². M20 grade concrete and Fe250 grade mild steel reinforcement are to be used. Determine the size and thickness required for the square base (with uniform depth) for the limit state of collapse in flexure
2. . Design a square R.C. Column to carry an axial load of 1300 kN. Take $f_{ck} = 20$ MPa, $f_y = 415$ MPa. The unsupported length of the column is 4m. The ends of the column are effectively held in position but not restrained against rotation.
3. A RC circular column of 350mm diameter, carrying an axial load of 500kN is to be provided with a square footing at uniform thickness on a soil of safe bearing capacity 150kN/m². Concrete grade M25 and steel grade Fe500 are to be used. Determine the size of footing and the thickness of footing required for the limit state of collapse in flexure
4. Design a short circular column with circular rings using concrete grade M20 and steel grade Fe 415 to carry an axial load of 700kN. The effective length of the column is 3.5m. Mild steel bars may be used for transverse reinforcement. Ignore minimum eccentricity.
5. (i) (2marks)

The longitudinal reinforcement provided in an R.C.C. column with lateral ties can be less than 0.8% of the gross cross-sectional area of the column.

Answer: False

Explanation:

For a reinforced concrete column, the **minimum longitudinal reinforcement is 0.8% of the gross cross-sectional area** of the column. The reinforcement must also satisfy the maximum percentage and spacing requirements specified in IS 456:2000.

- (ii) Match the following: (2marks)

mn I – Design Check	Column II – Critical Location	umn III – Main Failure / Design Consideration
ending moment	the face of column	exural action
he-way shear	a distance d from column face	eam-type shear
inching shear	ound the column at a perimeter generally $2d$ from column face	vo-way shear

ptions:

1. A–2–Q, B–3–R, C–1–P
2. A–3–R, B–1–P, C–2–Q
3. A–1–P, B–2–Q, C–3–R
4. A–1–R, B–3–P, C–2–Q

Answer: 3. A–1–P, B–2–Q, C–3–R

Explanation:

In the design of an isolated footing, different failure modes are checked at different critical sections.

- **Bending moment:** The critical section is normally taken at the **face of the column**.
- **One-way shear:** The critical section is taken at a distance **d** from the face of the column.
- **Punching shear:** The critical perimeter is generally located at **$d/2$** from the column face.
- The distinction is important because bending, one-way shear and punching shear represent different structural failure mechanisms.

(iii)

(2marks)

During the construction of an RCC column footing, a contractor proposes reducing the development length and anchorage of reinforcement to save steel and reduce fabrication costs. The structural engineer rejects the proposal.

What is the most appropriate conclusion regarding the financial impact?

- A. Reducing development length always produces a net financial saving
- B. Development length may be reduced whenever steel prices increase
- C. Code-compliant development length is essential because inadequate anchorage can result in structural failure and much higher financial losses
- D. Development length is necessary only for columns and not for footings

Answer: C. Code-compliant development length is essential because inadequate anchorage can result in structural failure and much higher financial losses

Explanation:

Development length ensures adequate **bond and transfer of forces between reinforcement and concrete**. Although reducing it may appear to save steel initially, inadequate anchorage can cause cracking, bond failure or structural failure. The resulting repair, reconstruction, delay and liability costs can be much greater than the initial saving. Hence, **financial optimization must never compromise mandatory structural requirements**.

(iv)

(2marks)

An isolated square footing is designed for a heavily loaded column.

Statement I: "Punching shear in an isolated footing is critical around the column because the concentrated column load can produce a punching action."

Statement II: "Punching shear need not be checked because bending moment is the only critical action in a footing."

Which option correctly justifies the statements?

- a) Statement I is correct because punching shear is checked around the column region, while Statement II is incorrect.
- b) Statement II is correct because footing thickness is controlled only by bending.
- c) Both statements are correct because punching shear is applicable only to beams.
- d) Both statements are incorrect because shear does not occur in isolated footings.

Answer: a) Statement I is correct because punching shear is checked around the column region, while Statement II is incorrect.

Explanation:

An isolated footing is subjected to **upward soil pressure and downward column load**. This creates significant shear stresses near the column. **Punching shear is checked around a**

critical perimeter surrounding the column, and the footing depth may need to be increased if the punching shear capacity is inadequate. Therefore, both bending and shear must be considered.

(v)

(2marks)

A designer is examining an RCC column supported between two floor levels. The effective length of the column is determined from its end conditions, and the effective dimensions of the column are then used to calculate slenderness ratios about both principal axes. The designer observes that the slenderness ratio in one direction exceeds the limiting value specified for a short column. Although the column has adequate concrete strength and reinforcement area, its geometric proportions indicate that lateral deflection effects may become significant. The designer therefore needs to decide whether the column can continue to be treated as a short compression member.

What is the most appropriate conclusion?

- a) The column can be classified as short because its concrete strength is adequate
- b) The column can be classified as short if reinforcement exceeds the minimum requirement
- c) The column should be treated as a slender column because the slenderness criterion is exceeded
- d) The column is automatically short when both ends are connected to beams

Answer: c) The column should be treated as a slender column because the slenderness criterion is exceeded

Explanation:

Classification of an RCC column as **short or slender** depends on its **slenderness ratios**, which involve effective length and lateral dimensions. Adequate concrete strength or reinforcement does not by itself make a geometrically slender column a short column. If the limiting slenderness criterion is exceeded about either principal axis, the column must be considered slender for design purposes. This ensures that additional effects associated with lateral deflection are appropriately considered.