K. K. Wagh Institute of Engineering Education and Research, Nashik

(An Autonomous Institute from A. Y. 2022-23)

Model Answer (Set 1)

End-Sem Examination-I, Winter 2025

Academic Year: 2025-2026	Semester: II
Class: M.Tech	Program: Structural Engineering
Branch Code: CIV	Pattern: 2024
Name of Course: Advanced Design of Concrete Structures	Course Code: 2404513

Q.1

a) What are the assumptions in yield line theory? 6 makrs

1. The slab behaves as a rigid–plastic material
   At collapse, the slab develops plastic hinges (yield lines), and the portions between these yield lines behave as rigid plates.
2. Collapse occurs by formation of a mechanism
   Enough yield lines form such that the slab transforms into a collapse mechanism made of rotating rigid segments.
3. Yield lines are straight
   Yield lines are assumed to be straight between two points because straight-line mechanisms require the least energy for failure.
4. Plastic moment capacity is fully developed
   Reinforcement reaches its yield stress, allowing the slab to develop a constant plastic moment capacity (Mp) along the yield lines.
5. Deformations occur only along yield lines
   Deflection and rotation are concentrated along the yield lines.
   The rest of the slab remains undeformed and rigid.
6. Principle of virtual work applies
   At collapse, the external work done by loads equals the internal work done along yield lines.

   $$\text{External Work} = \text{Internal Work}$$
7. No premature failure
   It is assumed that failure due to shear, bond, or anchorage does not occur before flexural failure.
   Adequate rotation capacity is available at yield lines.
8. Actual collapse corresponds to the minimum load

Several possible yield line patterns may form, and the correct collapse load is the **least** load obtained from all possible mechanisms.

Q.2

a) **Explain what a flat slab is and the different types of flat slab. (6 marks)**

Types of flat slab

A **flat slab** is a two-way reinforced concrete slab that directly rests on supporting columns without the use of beams or drop panels. This structural system provides a flat, uninterrupted ceiling surface, which offers architectural flexibility, simplified formwork, and reduced construction height compared to traditional beam-and-slab construction.

Types of Flat Slabs

The different types of flat slabs are primarily categorized based on how the connection between the slab and column is designed to manage shear stress (punching shear) and bending moments, which are critical at these intersection points.

The main types include:

	• **Simple Flat Slab (or Flat Plate):** This is the most basic type, where the slab of uniform thickness rests directly on the columns. This design is typically suitable for lighter loads and shorter spans, often found in residential buildings and hotels, due to its vulnerability to high punching shear stress around the columns. • **Flat Slab with Drop Panels:** In this type, the slab thickness is increased near the columns by incorporating "drop panels" (rectangular or circular thickened areas). These panels increase the shear strength and stiffness at the column-slab junction, making this design suitable for heavier loads and longer spans. • **Flat Slab with Column Heads (or Capitals):** Here, the top of the column is flared out to form a capital (or mushroom head). The column head effectively increases the perimeter over which the slab is supported, thereby distributing the load over a larger area and significantly reducing the punching shear stress at the connection. This design is often used in industrial buildings and car parks where heavy loads are expected. • **Flat Slab with Both Drop Panels and Column Heads:** This type combines the advantages of both drop panels and column heads, providing maximum strength and stiffness at the column connections. It is the most robust design and is used for the heaviest loads and largest spans.
Q.3	a) **Explain behavior and design principles of RC deep beams. (8 Marks)** Answer: Deep Beams have span/depth ratio ≤ 2.0. Behavior: • Plane sections do not remain plane. • Load transfers through compression struts. • Shear dominates over flexure. Design Principle: • Use Strut-and-Tie Model • Identify load paths • Design compression struts, tension ties, and nodal zones • Provide adequate anchorage and confinement reinforcement **b) Explain behavior of beams curved in plan. (8 Marks)** Curved Beams experience: • Bending • Torsion • Radial shear Behavior: • Loads produce twisting moments • Inner edge under compression • Outer edge under tension Design Considerations: • Combined bending and torsion • Increased reinforcement near curvature • Careful detailing to avoid cracking

	c) Explain shear failure and design procedure of deep beams. (8 Marks Answer: Shear Failure Modes: • Diagonal splitting • Crushing of compression strut • Anchorage failure Design Steps: 1. Determine load path 2. Identify struts and ties 3. Calculate forces 4. Design steel reinforcement 5. Provide web reinforcement 6. Ensure bearing stresses within limits (IS 456 & IS 13920 principles apply) **d) Explain design methodology of curved beams. (8 Marks)** Answer: Design Steps: 1. Resolve loads into radial and tangential components 2. Calculate bending moment and torsion 3. Design longitudinal reinforcement 4. Provide closed stirrups for torsion 5. Ensure serviceability criteria (IS 456 torsion provisions apply)
Q.4	**a) Design a rectangular water tank open at the top, resting on ground having a size of 9.6m × 8.0m × 6.4m high. Use M30 and Fe 500 grade material. Use the IS code method. (Design of base slab and reinforcement detailing is not required). (8 Marks** 1. Analysis for moment and tensile force 3. Design for vertical moment 4. Area of main steel 5. Vertical Reinforcement **b)** Explain the **Design step of circular ESR. (8 Marks)** Answer: Stress Types: • Hoop tension • Vertical bending Design Aspects: • Wall designed for hoop tension • Base slab for radial bending

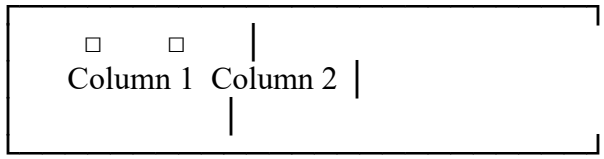
	• Ring beams provided at top and bottom c) **Design a rectangular water tank open at the top, resting on ground having a size of 6.5m × 4.0m × 3.5m high. Use M25 and Fe 500 grade material. Use the Approximate method. (Design of base slab and reinforcement detailing is not required) . (8 Marks** 1. Continuous frame action 3. Moment calculation 4. Design of long wall 5. Design of short wall 6. Cantilever action at base **d)** Explain the **Design principles of rectangular ESR. (8 Marks)** Answer: Forces Acting: • Hydrostatic pressure • Dead load • Wind and seismic forces Design Components: • Wall acts as vertical cantilever • Base slab designed for bending and shear • Proper water-tightness reinforcement provided
Q.5	a) **Explain pile group efficiency and factors affecting it. (8 Marks)** Answer: Pile Group Efficiency (η): $$\eta = \frac{\text{Capacity of pile group}}{\text{Sum of individual pile capacities}}$$ Factors Affecting Efficiency: • Pile spacing • Soil type • Method of installation • Pile arrangement Efficiency may be less than unity in cohesive soils due to overlapping stress zones. **b)Explain the suitability of various types of combined footings with the help of neat sketches. Also, describe in detail the step-by-step design procedure of a slab type rectangular combined footing . (8 Marks** Combined Footing 1. Suitability of Different Types of Combined Footing (with Neat Sketches)

A combined footing is provided when two or more columns are supported by a single footing slab.

(a) Rectangular Combined Footing
Suitability

- When two columns carry nearly equal loads
- When columns are symmetrically placed
- When soil bearing capacity is uniform
- When one column is near property boundary

Sketch (Plan View)



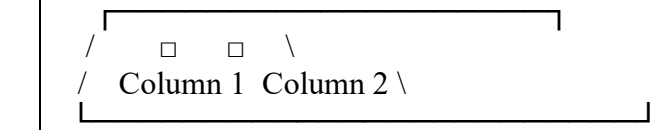
Remarks

- Simple geometry
- Uniform soil pressure possible
- Most commonly used type

(b) Trapezoidal Combined Footing
Suitability

- When column loads are unequal
- When heavier column is closer to property line
- To ensure centroid of footing coincides with centroid of loads

Sketch



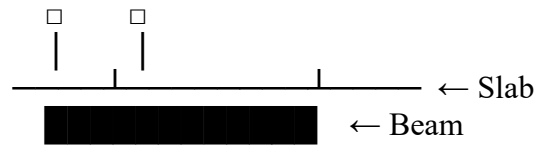
Remarks

- Unequal width helps balance load
- Economical compared to rectangular footing in unequal load cases

(c) Slab–Beam Type Combined Footing
Suitability

- When column loads are heavy
- When footing length is large
- When soil bearing capacity is low

Sketch (Section)



Remarks

- Beam resists bending
- Slab distributes soil pressure

- Used for industrial and heavy structures

(d) Strap (Cantilever) Footing
Suitability

- When one column is very close to property boundary
- When isolated footing cannot be centered
- When soil SBC is good

Sketch

Column Strap Beam Column

Remarks

- Strap beam transfers moment
- Footings act independently

c) **Explain the difference between raft foundation and pile foundation. (8 Marks)**
Answer:

Aspect	**Raft Foundation**	**Pile Foundation**
Load transfer	Through slab	Through piles
Soil condition	Moderate bearing	Weak soil
Settlement	Uniform	Controlled
Cost	Moderate	High
Construction	Simple	Complex

d) Explain the various methods adopted for the design of pile caps. Also, describe in detail the step-by-step design procedure of a pile cap resting on four piles with a centrally located column. Draw a neat sectional elevation of the pile cap showing the reinforcement detailing as per IS code provisions. **. (8 Marks**

ANS: Methods of design of pile cap

1) Sectional Method (design based on BM & S.F.)
2) Strut& Tie Model

Design procedure :

1) Fix size of pile cap 2) Calculate forces on pile cap.
3)Calculate B.M & Depth 4) Calculate Reinforcement
5)Check for one way shear 6)Check for punching shear
6) Sketch showing reinforcement details

Sketch for Sample R/F details for pile cap