SCAD ENGINEERING COLLEGE

SCAD NAGAR, CHERANMAHADEVI-627 414,
TIRUNELVELI (DT).

DEPARTMENT: CIVIL **SEM/YEAR: VII/IV**

SUBJECT CODE /NAME: CE 2401/DESIGN OF REINFORCED CONCRETE & BRICK MASONRY STRUCTURES

UNIT – I

RETAINING WALLS Part – A Questions and answers

1. What is a Retaining wall?

Retaining walls are generally used to retain earth or such materials to maintain unequal levels on its two faces. The soil on the back face is at a higher level and is called back fill. Retaining walls are extensively used in the construction of basements below ground level, wing walls of bridge and to retain slopes in hilly terrain roads.

2. What are the disadvantages of gravity retaining walls?

Gravity walls of stone masonry were generally used in the earlier days to the height of the earth fill. The advent of reinforced concrete has resulted in thinner retaining walls.

3. What are the types of retaining walls?

Retaining wall can be classified structurally as

1. Cantilever retaining wall
2. Counter fort retaining wall

4. What is a cantilever retaining wall?

The most common and widely used retaining wall is of cantilever type. Vertical stem resisting earth pressure one side and the slab bends like a cantilever. The thickness of the vertical slab is large at the bottom and decreases towards the top in proportion to the varying soil pressure.

5. What is a counter fort retaining wall?

Counter fort retaining walls are used for large heights exceeding 5 mts of earth fill. In counter fort retaining wall the vertical stem is designed as a continuous slab spanning between the counter forts. Counter forts are designed as cantilever beams from the base slab.

6. What are the forces acting on a retaining wall?

Forces acting on a retaining wall are

1. Lateral earth pressure due to the back fill
2. Vertical forces including weight of soil, stem, heel, toe, and soil fill above the toe.
3. The soil pressure developed to resist the earth pressure and other vertical forces acting on the heel and toe.

7. Define Active Earth pressure and passive earth pressure.

If the soil exerts a push against the wall by virtue of its tendency to slip laterally and seek its natural slope (angle of repose) thus making the wall to move slightly away from the back filled soil mass. This kind of pressure is known as AEP.

The pressure or resistance which soil develops in response to movement of the structure towards it is called the Passive Earth Pressure.

8. Give the criteria for the design of gravity retaining wall.

1. Maximum pressure should not exceed the bearing capacity of soil (Base width).
2. No tension should be developed anywhere in the wall

$$e < \frac{b}{6} \qquad \text{i.e. } \bar{x} \leq \frac{2b}{3}$$

3. The wall must be safe against sliding.
4. The wall must be safe against sliding.
5. The wall must be safe against overturning.

9. What are the stability conditions should be checked for the retaining walls.

The stability of retaining walls should be checked against the following conditions

(a) The wall should be stable against sliding
(b) The wall should be stable against Overturning
(c) The wall should be stable against bearing capacity failure.

10. Give the minimum factor of safety for the stability of a retaining wall.

(a) The wall should be stable against sliding = 1.5
(b) The wall should be stable against Overturning
    For Granular Backfill = 1.5
    For cohesive backfill = 2.0
(d) The wall should be stable against bearing capacity failure.
    For Granular Backfill = 1.5
    For cohesive backfill = 2.0

11. If a retaining wall of 5 m high is restrained from yielding, what will be the total earth pressure at rest per meter length of wall? Given: the back fill is cohesion less soil having $\phi = 30°$ and $\gamma = 18$ kN/m^3.

Solution

$K_o = 1 - \sin\phi = 1 - \sin 30° = 0.5$

$$P_o = \frac{1}{2} K_o \gamma H^2 = \frac{1}{2} x0.5x18x5^2 = 112.5 kN/m \text{ length of wall}$$

12. A cantilever retaining wall of 7 meter height retains sand. The properties of the sand are γ_d = 17.66KN/m3 and γ_{sat} = 29.92 KN/m3 $\phi = 30°$. using Rankine's theory determine active earth pressure at the base when the backfill is (i) Dry, (ii) Saturated and (iii) Submerged.

Submerged density

$\gamma b = \gamma sat - \gamma w = 20.92\text{-}9.81 = 11.1 kN/m3$

For $\phi = 30$, $K_A = \frac{1-\sin\phi}{1+\sin\phi} = \frac{1-\sin 30}{1+\sin} = \frac{1}{3}$

Active earth pressure at the base is

(i) for dry backfill,

$$P_a = K_A \gamma_d H = \frac{1}{3} x17.66x7 = 41.2 kN/m^2$$

(ii) for saturated backfill,

$$P_a = K_A \gamma_{sat} H = \frac{1}{3} x20.9x7 = 48.76 kN/m^2$$

(iii) for submerged backfill,

$$P_a = K_A \gamma_b H = \frac{1}{3} x11.1x7 = 25.9 kN/m^2$$

Part – B Questions

1. **Explain the steps to be followed in proportioning and design of retaining walls.**
2. **Design a reinforced concrete cantilever retaining wall to retain earth level with the top of the wall to a height of 5.5 m above ground level. The density of soil at site is 17 KN/Cu.mts with a safe bearing capacity of 120 KN/sq.mts. Assume the angle of shearing resistance of the soil as 35 degrees. Further assume a coefficient of friction between soil and concrete as 0.55. Adopt M20 grade concrete and Fe415 HYSD bars.**

3. A Cantilever type retaining wall is to be designed to support a bank of earth 4m above the ground level on the toe side of the wall. The backfill surface is inclined at an angle of 15 degrees with the horizontal. Assume that good soil is available for foundations at a depth of 1.25m below the ground level with a safe bearing capacity of 160KN/m^2 and an angle of shearing resistance of 30 degrees .Assume co-efficient of friction between soil and concrete as 0.5, Adopt M-20 grade concrete and Fe-415 HYSD reinforcement. Assume the unit weight of soil as 16kN/m^3.

4. Design a counter fort type retaining wall to support an earth fill of 7.5m above ground level. The foundation depth may be taken as 1.5m below the ground level. The safe bearing capacity of soil at site is 150KN/m^2.Unit weight of soil may be taken as 16KN/m^3 and an angle of shearing resistance of 30 degrees. Assume the value of coefficient of friction as .55.Adopt M-20 grade concrete and Fe-415 HYSD bars. Sketch the details of reinforcements in the retaining wall.

5. Design a cantilever retaining wall to retain earth with a backfill sloped 20 degrees to the horizontal .The top of the wall is 5.5m above the ground level. Assume the depth of foundation as 1.2 m below the ground level with a safe bearing capacity of capacity of 120Kn/m^3.The unit weight of backfill is 18KN/m^3 and an angle of shearing resistance of 35 degrees .Also assume the coefficient of friction between soil and concrete as 0.55.Adopt M-20 grade concrete and Fe-415HYSD steel bars.

UNIT – II

WATER TANKS

Part – A Questions and answers

1. Mention the grade of concrete which is used in the construction of water tank.

Richer concrete mix of grades M20 to M30 are commonly used in the construction of water tanks. High quality concrete, in addition to providing water tightness, also has higher resistance to tensile stresses developed in the tank walls.

2. Mention the three factors that must be considered while designing a RCC tank.

i. strength

ii. Water tightness

iii. Overall stability

3. **Water is the types of reinforced concrete water tanks?**

   i.Tanks resting on ground

   ii.Underground tanks

   iii.Elevated water tanks.

4. **Mention the reinforcement details that should be provided in a water tanks.**

   Minimum area of steel is 0.3 percent of gross area of section upto 100mm thick, reduced to 0.2 percent in section up to 450mm thick. For sections above 225mm thick, provide two layers of reinforcement. The percentage of reinforcement in base or floor slab resisting directly on ground must be not less than 0.15% of the concrete section.

   The minimum cover to all reinforcement should be not less than 25mm or the diameter of the bar whichever is greater.

5. **Define the following terms:**

   i. Dome:

   A Dome is defined as a thin shell generated by the revolution of a regular curve about one of its axes.

   ii. Latitude:

   The circle of each ring in a dome is called Latitude.

   iii. Meridian circle:

   The circle drawn through two diametrically opposite points on a horizontal diameter and the crown is known as meridian circle.

   iv. Radial:

   The joint between successive horizontal rings is called radial.

   v. Meridian thrust:

   The reaction between the rings is tangential to the curved surface giving rise to compression along the medians. The compressive stress is called meridional thrust or meridional compression.

6. **Mention the thickness and steel requirement of dome.**

A minimum thickness of 7.5cm is provided to protect steel. Minimum steel requirement is 0.15% for mild steel bars and 0.12% for HYSD bars of the sectional area in each direction meridionally as well as along the latitudes.

7. **What are the three types of joints in water tank?**

i. Movement joints
   a. Contraction
   b. Expansion
   c. Sliding
ii. Construction joints
iii. Temporary open joints

8. **Find out the diameter of a circular tank which is having a flexible base for capacity of 200000 liters. The depth of water is to be 4m, including a free board of 200mm.**

Effective depth of water = 4 - 0.2

= 3.8m

Let D be the inside diameter of the tank.

Volume, $V = \Pi/4 \times D^2 \times \text{depth}$

$(200000 \times 10^3)/10^6 = \Pi/4 \times D^2 \times 3.8$

$D = \sqrt{(200 \times 4)/(\Pi \times 3.8)}$

$D = 8.18m$

$D = 8.2m$

9. **What is the foundation specification for small capacity tanks?**

For small capacity tanks individual footings for columns can be provided. Infact, the type of footing will depend upon the nature of soil and type of staging. In case of low lying areas of low safe bearing capacity with high ground water table, pile footings are provided.

In any case of foundation slab, lean mixes of 1:4:8, 150mm thick may be provided as levelling course.

10. What are the methods available for the analysis of circular tank?

i. IS code method

ii. Reissner's method

iii. Carpenter's method

iv. Approximate method

Part – B Questions

1. **An open rectangular tank 4m x 6m x 3m deep rests on firm ground. Design the tank. Use M20 mix.**
2. **Design a circular tank with flexible base for capacity of 400000 liters. The depth of water is to be 4m, including a free board of 200mm.Use M20 concrete.**
3. **Design an underground water tank 4m x 10m x 3m deep. The sub soil consist of sand having angle of repose of 30 degree and saturated unit weight of 17KN/m^3.The water table is likely to rise up to ground level. Use M20 concrete and HYSD bars. Take unit weight of water as 9.81KN/m^3.**
4. **Design a spherical dome over a circular beam for the following data:**
   i. **Inside diameter of room = 12m**
   ii. **Rise of dome = 4m**
   iii. **Live load due to wind, snow,etc = 1.5 KN/m^2**

   The dome has an opening of 1.6m diameter at its crown. A lantern is provided at its top, which causes a dead load of 22KN acting along the circumference of the opening. Use M20 concrete and Fe415 steel.
5. **Design a conical dome roof for a room with base diameter as 12m. The live load due to wind, snow, etc may be taken as 1000N/mm^2.The height of the roof is 4m.**

UNIT III & IV

SELECTED TOPICS & YIELD LINE THEORY

Part – A Questions and answers

1. Define the following terms:

Tread: The horizontal portion of a step was the foot rests is referred to, as tread.250 to 300 mm is the typical dimensions of a tread.

Riser: Riser is the vertical distance between the adjacent treads or the vertical projection of the step with value of 150 to 190 mm depending upon the type of building.

Going: Going is the horizontal projection of an inclined flight of steps between the first and last riser.

2. What are the types of staircases?

They are broadly classified as

i. Straight stair
ii. Quarter turn stair
iii. Half turn stair
iv. Dog legged stair
v. Open newer stair with quarter space landing
vi. Geometrical stairs such as circular stair, spiral stair, etc.

3. Mention the places where the following footings can be used

a). Single flight staircase
b). Quarter turn staircase
c). Dog legged staircase
d). Open well staircase
e). Spiral staircase

Single flight staircase: Single flight staircase is used in cellars or attics where the height between floors is small and the frequency of its use is less.

Quarter turn staircase: Quarter turn staircase flight generally runs adjoining the walls and provides uninterrupted space at the centre of the room. Generally used in domestic houses where floor heights are limited to 3m.

Dog legged staircase: Dog legged staircase is generally adopted in economical Utilization of available space.

Open well staircase: Open well staircases are provided in public buildings where large spaces are available.

Spiral staircase: In congested locations, where space availability is small, Spiral Stairs are provided.

4. Define flat slab.

A flat slab is a typical type of construction in which a reinforced slab is built monolithically with the supporting columns and is reinforced in two or more directions, without any provision of beams.

5. What are all the components of flat slab?

i. Drop of flat slab
ii. Capital or column head & Panel

6.Write the different types of flat slabs?

i. Slabs without drops and column heads
ii. Slabs without drops
iii. Slab with drops and column with column head

7. What are all the assumptions made in equivalent frame method?

i. The structure is considered to be made of equivalent frames longitudinally and transversely.
ii. Each frame is analyzed by any established method like moment distribution method.
iii. The relative stiffness is computed by assuming gross cross section of the concrete alone in the calculation of the moment of inertia.
iv. Any variation of moment of inertia along the axis of the slab on account of provision of drops should be considered.

8. What is meant by yield lines?

The failure of reinforced concrete slabs of different shapes such as square, rectangular, circular with different types of edge conditions is preceded by a characteristic pattern of cracks, which are generally referred to as yield lines.

9.What are the characteristic features of yield lines?

i. Yield lines end at the supporting edges of the slab
ii. Yield lines are straight
iii. A yield line or yield line produced passes through the intersection of the axes of rotation of adjacent slab elements.
iv. Axes of rotation generally lie along lines of supports and pass over any columns.

10. Explain about box culvert shortly.

A box culvert is continuous rigid frame of rectangular section in which the abutment and the top and bottom slabs are cast monolithic. A box culvert is used where a small drain crosses a high embankment of a road or a railway or a canal- especially when bearing capacity of soil is low.

11. Give the names of various types of bridges.

i. Solid slab bridge or deck slab bridge.

ii. Deck girder bridge or T-beam bridge & Arch bridge.

iii. Balanced cantilever bridge & Bowstring Girder Bridge.

iv. Rigid frame culvert & Continuous girder or arch bridge.

Part – B Questions

1. Design one of the flights of stairs of a school building spanning between landing beams to suit the following data.

i. **Type of staircase : waist slab type**

ii. **Number of steps = 12**

iii. **Tread T =300mm**

iv. **Riser R =160mm**

v. **Width of landing beams = 400mm**

vi. **Materials: M-20 concrete and Fe-415 HYSD bars.**

2. Design a dog-legged stair for a building in which the vertical distance between floors is 3.6m.The stair hall measures 2.5m x 5m.The live load may be taken as 2500N/mm^2.Use M20 concrete, and HYSD bars.

3. Design the interior panel of a flat slab 5.6m x 6.6m in size, for a super imposed load of 7.75kN/m^2.Provide two-way reinforcement. Use M20 concrete and Fe 415 steel.

4. Design the interior panel of a flat slab for a warehouse to suit the following data:

i. **Size of warehouse 24m x 24m divided into panels of 6m x 6m.**

ii. **Loading class-5kN/m^2.**

iii. **Materials: M-20 Grade concrete.**

iv. **Fe-415 grade HYSD bars.**

5. Design a box culvert having inside dimensions 3.5m x 3.5m.The box culvert is subjected to a superimposed dead load of 12000N/m^2 and a live load of 45000N/m^2 from the top. Assume unit weight of soil as 18000N/m^3 and angle of repose of 30degree.Use M20 concrete and Fe415 steel.

6. Design a solid slab bridge for class A loading for the following data.

Clear span = 4.5m

Clear width of road ways = 7m

Average thickness of wearing coat = 80mm

Use M_{20} mix. Take unit weight of concrete as 24000N/m^3

UNIT - V

BRICK MASONRY

Part – A Questions and answers

1. What is cross sectional area of Masonry unit?

Net cross sectional area of a masonry unit shall be taken as the gross cross sectional area minus the area of cellular space. Gross cross sectional area of cored units shall be determined to the outside of the coring but cross sectional area of groves shall not be deducted from the gross cross sectional area to obtain the net cross sectional area.

2. What is bond in brick masonry?

Arrangements of masonry units in successive courses to tie the masonry together both longitudinally and transversely; the arrangement is usually worked out to ensure that no vertical joint of one course is exactly over the one in the next course above or below it, and there is maximum possible amount of lap.

3. How will you calculating effective length, effective height and effective thickness?

The height of a wall to be column to be considered slenderness ratio. The length of a wall to be column to be considered slenderness ratio. The thickness of a wall or column to be considered for calculating slenderness ratio.

4. What meant by lateral support?

A support which enables a masonry element to resist lateral and/or restrains lateral deflection of a masonry element at the point of support.

5. What is the minimum thickness of basement walls?

S.No	Minimum thickness of basement wall (nominal) cm	Height of the ground above basement floor level with wall loading (permanent load)	
		More than 50kN/m (m)	More than 50kN/m (m)
1	40	2.50	2.00
2	30	1.75	1.40

6. What is the slenderness ratio for walls and columns?

For a wall, Slenderness ration shall be effective height divided by effective thickness or effective length divided by the effective thickness is less.

For column slenderness ration shall be taken to be the greater of the ratios of effective heights to the respective effective thickness in the two principal directions. Slenderness ratio for a load-bearing column shall not exceed 12.

7. What is effective length of a masonry wall with respect to its support condition?

Effective length of a masonry wall varies depending on its support conditions as below:

S.No	Conditions of support	Effective length
1	Where a wall is continuous and is supported by cross wall, and there is no opening within a distance of H/8 from the face of cross wall	0.8L
2	Where a wall is supported by a cross wall at one end and continuous with cross wall at other end	0.9L
3.	Where a wall is supported at each end by cross wall	1.0L
4	Where a wall is free at one and continuous with a cross wall at the other end	1.5L
5.	Where a wall is free at one end and supported at the other end by a cross wall	2.0L

8. What is effective height of a masonry wall with respect to its support condition?

S.No	Conditions of support	Effective Height
1	Lateral as well as rotational restraint at top and bottom	0.75 H
2	Lateral as well as rotational restraint at one end and only restrained at the other	0.85 H
3.	Lateral restraint without rotational restraint on both ends	1.00 H
4	Lateral as well as rotational restraint at bottom but have no restraints at top	1.50 H

9. What is slenderness ratio in brick masonry structures?

In brick masonry structures:

For a wall slenderness ratio shall be the effective height divided by the effective thickness or effective length divided by the effective thickness whichever is less.

For a column slenderness ratio shall be taken to be the greater of the ratios of effective height s to the respective effective thickness in the two principal directions. Slenderness ratio of a load-bearing column shall not exceed 12.

Part – B Questions

1. **Explain the factors to be considered while designing brick masonry with respect to stability and lateral supports on the structure.**
2. **What are the factors to be considered while determining the effective height of wall and columns and effective length of walls?**
3. **Explain the design procedure to design axially and eccentrically loaded brick walls.**