B. Tech.
(SEM. V) ODD SEMESTER THEORY EXAMINATION, 2016-17
GEOTECHNICAL ENGINEERING

Time : 3 Hours **Max. Marks : 100**

Note : i. Attempt **all** questions.
ii. Marks are indicated against each question.
iii. Assume any data suitably, if required.

1. Attempt **all** parts. Each part carries equal marks. **(10 × 2 = 20)**

a. **Define the shear strength of soil.**

Ans. Refer Q. 4.1, 2 Marks Questions, Page SQ–10A, Unit-4.

b. **Explain the coefficient of permeability.**

Ans. Refer Q. 2.5, 2 Marks Questions, Page SQ–5A, Unit-2.

c. **What do you mean by hydraulic conductivity ?**

Ans. Refer Q. 2.9, 2 Marks Questions, Page SQ–6A, Unit-2.

d. **Define void ratio, bulk unit weight and specific gravity.**

Ans. Refer Q. 1.7, Page 1–6A, Unit-1.

e. **The void ratio of soil sample is 1, determine the corresponding porosity of the soil sample.**

Ans. Refer Q. 1.20, 2 Marks Questions, Page SQ–4A, Unit-1.

f. **Explain the isobar.**

Ans. Refer Q. 1(f), Page SP–16A, Solved Paper 2015-16.

g. **Briefly explain the flocculant grain structure.**

Ans. Refer Q. 1.8, 2 Marks Questions, Page SQ–2A, Unit-1.

h. **State the Darcy's law.**

Ans. Refer Q. 2.4, 2 Marks Questions, Page SQ–5A, Unit-2.

i. **Define index properties of soil.**

Ans. Refer Concept Outline : Part-2, Page 1–18A, Unit-1.

j. **Define active earth pressure in brief.**

Ans. Refer Q. 4.8, 2 Marks Questions, Page SQ–11A, Unit-4.

2. Attempt any **five** questions : **(5 × 10 = 50)**

a. **Explain SPT test. Write the procedure in brief.**

Ans. Refer Q. 5.6, Page 5–9A, Unit-5.

b. **A soil sample 40 mm thick takes 40 minute to reach 40 % consolidation. Find the time taken for a clay layer 8 m thick to reach 80 % consolidation. Assume double drainage in both cases.**

Ans. Refer Q. 3.18, Page 3–24A, Unit-3.

c. **Compare between compaction and consolidation.**

Ans. Refer Q. 3.10, Page 3–12A, Unit-3.

d. **A soil specimen has a water content of 15 % and a wet unit weight of 25 kN/m³. If the specific gravity of solids is 2.70, determine the dry unit weight, void ratio and the degree of saturation, take γ_w = 10 kN/m³.**

Ans. Refer Q. 1.14, Page 1–16A, Unit-1.

e. **A square footing has dimensions of 2 m × 2 m and a depth of 3 m. Determine its ultimate bearing capacity in pure clay with an unconfined strength of 0.15 N/mm², ϕ = 0° and γ = 1.7 g/cm³. Assume Terzaghi's factors for ϕ = 0, as N_c = 5.7, N_q = 1 and N_γ = 0.**

Ans. Refer Q. 5.9, Page 5–13A, Unit-5.

f. **Write the short notes on :**

i. **Field compaction control.**

Ans. Refer Q. 3.4, Page 3–6A, Unit–3.

ii. **Proctor needle method.**

Ans. Refer Q. 3.4, Page 3–6A, Unit–3.

g. **Drive the Laplace's equation of continuity with all assumptions.**

Ans. **Assumptions made for Deriving the Laplace Equation :**

1. The flow is two dimensional.
2. Water and soil are incompressible.
3. Soil is isotropic and homogeneous.
4. The soil is fully saturated.
5. The flow is steady, *i.e.*, flow conditions do not change with time.
6. Darcy's law is valid.

Derivation : Refer Q. 2(c), Page SP–2A, Solved Paper 2013-14.

h. **Define the Skempton's pore pressure parameters. Derive an expression between pore water pressure and applied stress.**

Ans. Refer Q. 4.10, Page 4–12A, Unit-4.

3. **Attempt any two parts of the following :** (2 × 15 = 30)

a. **Explain the field methods for compaction of soil in details.**

Ans. Refer Q. 3.3, Page 3–4A, Unit-3.

b. **A soil sample of saturated soil has a water content of 35 % and bulk unit weight of 25 kN/m³. Determine dry density, void ratio and specific gravity of solid particles. What would be the bulk unit weight of the same soil at the same void ratio but at a degree of saturation 60 %, take γ_w = 10 kN/m³.**

Ans. Refer Q. 1-15, Page 1–17A, Unit-1.

c. **What do you mean by site investigation ? What are the different purposes for which site investigation is done ?**

Ans. Refer Q. 5(a), Page SP-13A, Solved Paper 2014-15.

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B.Tech.

(SEM. V) ODD SEMESTER THEORY EXAMINATION, 2017-18
GEOTECHNICAL ENGINEERING

Time : 3 Hours **Max. Marks : 100**

Note : Attempt **all** sections. If any missing data required, then choose suitably.

SECTION – A

1. Attempt **all** questions in brief. **(2 × 10 = 20)**

a. What do you understand about index properties ?

Ans. Refer Concept Outline : Part-2, Page 1–18A, Unit-1.

b. What is meant by 'primary valence bond' and 'secondary valence bond' ?

Ans. Refer Q. 1.17, Page 1–19A, Unit-1.

c. Write methods to determine the water content.

Ans. Refer Q. 1.3, 2 Marks Questions, Page SQ–1A, Unit-1.

d. Define bulk unit weight. Write the relation between bulk unit weight and dry unit weight.

Ans. Refer Q. 1.5, 2 Marks Questions, Page SQ–1A, Unit-1.

e. What is Muck ?

Ans. Refer Q. 1.2, 2 Marks Questions, Page SQ–1A, Unit-1.

f. Define Consistency limits.

Ans. Refer Q. 1.6, 2 Marks Questions, Page SQ–2A, Unit-1.

g. Differentiate between Activity and Sensitivity.

Ans. Refer Q. 1.12, 2 Marks Questions, Page SQ–3A, Unit-1.

h. Differentiate Active and passive earth pressure.

Ans. Refer Q. 4.8, 2 Marks Questions, Page SQ–11A, Unit-4.

i. What are the assumptions made in the derivation of Terzaghi's bearing capacity theory ?

Ans. Refer Q. 5.5, 2 Marks Questions, Page SQ–14A, Unit-5.

j. What is Mohr's circle ? Discuss its important characteristics.

Ans. Refer Q. 4.1, Page 4–2A, Unit-4.

SECTION-B

2. Attempt any **three** of the following : **(3 × 10 = 30)**

a. Determine the ultimate bearing capacity of a strip footing, 1.20 m wide, and having the depth of foundation of 1.0 m. Use Terzaghi's theory and assume general shear failure. Take $\varphi = 35°$, $\gamma = 18\ kN/m^3$, and $c' = 15\ kN/m^2$.

Ans. Refer Q. 5.10, Page 5–13A, Unit-5.

b. What are the basic characteristics of the failure mechanisms in general shear failure, local shear failure and punching shear failure ? Also differentiate between ultimate bearing capacity, safe bearing capacity, safe bearing pressure and allowable bearing pressure.

Ans. Refer Q. 5.5, Page 5–8A, Unit-5.

c. For a sedimentary soil deposit, which solution is more appropriate Boussinesq's or Westergaard's. Why ? State the assumptions involved in the Westergaard's theory. A concentrated load of 40 kN acts on the surface of a soil. Determine the vertical stress increment at points directly beneath the load upto a depth of 10 m and draw a plot for the vertical stress variation upto depth of 10 m.

Ans.

A. For a sedimentary soil deposit, Westergaard's solution is more appropriate because Westergaard's solution represents more closely the actual sedimentary deposits.

B. Westergaard's Theory Assumptions : Assumptions made in Westergaard's theory are as follow :

1. Soil is homogenous, elastic, semi-infinite and non-isotropic.
2. Medium is assumed to be laterally reinforced with numerous closely spaced sheets of negligible thickness.
3. In this theory medium is assumed to be horizontally rigid but vertically elastic.

C. Numerical :

Given : Vertical load = 40 kN, Depth = 10 m
To Find : Vertical stress variation upto depth 10 m.

1. Vertical stress is given by,

$$\sigma_z = \frac{3Q}{2\pi z^2} \frac{1}{\left[1 + \left(\frac{r}{Z}\right)^2\right]^{5/2}}$$

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2. Radial distance, $r = 0$

3. Vertical stress, $\sigma_z = \frac{3Q}{2\pi} \times \frac{1}{z^2} = \frac{3 \times 40}{2 \times \pi} \times \frac{1}{z^2} = \frac{19.10}{z^2}$

4. When

$z = 1$, $\sigma_z = \frac{19.10}{1} = 19.10 \text{ N/mm}^2$

$z = 2$, $\sigma_z = \frac{19.10}{4} = 4.77 \text{ N/mm}^2$

$z = 3$, $\sigma_z = \frac{19.10}{9} = 2.12 \text{ N/mm}^2$

$z = 4$, $\sigma_z = \frac{19.10}{16} = 1.194 \text{ N/mm}^2$

$z = 5$, $\sigma_z = \frac{19.10}{25} = 0.764 \text{ N/mm}^2$

$z = 6$, $\sigma_z = \frac{19.10}{36} = 0.53 \text{ N/mm}^2$

$z = 7$, $\sigma_z = \frac{19.10}{49} = 0.39 \text{ N/mm}^2$

$z = 8$, $\sigma_z = \frac{19.10}{64} = 0.298 \text{ N/mm}^2$

$z = 9$, $\sigma_z = \frac{19.10}{81} = 0.236 \text{ N/mm}^2$

$z = 10$, $\sigma_z = \frac{19.10}{100} = 0.191 \text{ N/mm}^2$

D. Graph : Plot for the vertical stress variation is shown in Fig. 1.

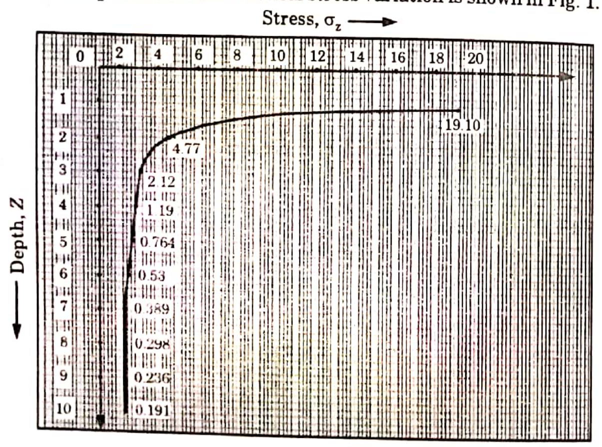

Fig. 1.

d. i. Let us suppose as a geotechnical expert, you have a challenge to control the compaction in a site; so how will you control the compaction by the Proctor's needle method ?

Ans. Refer Q. 3.4, Page 3–6A, Unit-3.

ii. As a geotechnical engineer for the design of a filter of an earth dam, the proper selection of filter material is required to prevent the piping failure; so what are the conditions, you will keep in your mind at the time of filter design ?

Ans. Refer Q. 2.19, Page 2–26A, Unit-2.

e. i. What do you understand by residual soils and transported soils ? Give the grain size range of different soil types according to IS specifications.

Ans. **Residual and Transported Soil :** Refer Q. 1.2, Page 1–3, Unit-1.
Grain Size Range : Refer Q. 1.29, Page 1–30A, Unit-1.

ii. Establish the following relationship

$$Se = wG$$

where, S = Degree of saturation.
e = Void ratio.
w = Water content.
G = Specific gravity of soil solids.

Ans. Refer Q. 1.8(B), Page 1–7A, Unit-1.

SECTION-C

3. Attempt any **one** part of the following : **(1 × 10 = 10)**

a. A mass of soil is coated with thin layer of wax, weight of soil and wax is 690.6 gm. Soil alone has 683 gm. When this sample is immersed in water it displaces 350 ml of water. Sp. Gravity of solids is 2.73 and that of wax 0.89. Find Void ratio and degree of saturation if water content in the soil is 17 %.

Ans. Refer Q. 1.16, Page 1–17A, Unit-1.

b. i. Illustrate by schematic diagrams, how the clay minerals kaolinite, illite and montmorillonite are formed.

Ans. Refer Q. 1.19, Page 1–21A, Unit-1.

ii. An oven dry soil sample of volume 250 cc weighs 430 g. If the specific gravity of solids is 2.70, what is the water content when the soil becomes fully saturated without any change in its volume ? What will be the water content which will fully saturate the sample and also cause an increase in volume equal to 10 % of the original dry volume ?

Ans. Refer Q. 1.10, Page 1–13A, Unit-1.

4. Attempt any one part of the following : (1 × 10 = 10)

a. What are different methods for determination of the coefficient of permeability in a laboratory ? Discuss their limitations.

Ans. Refer Q. 2.7, Page 2–8A, Unit-2.

b. Explain how upward flow of seepage water causes the effective stress. What is the role of the pore water pressure in the quick sand condition ?

Ans. Refer Q. 2.16, Page 2–23A, Unit-2.

5. Attempt any one part of the following : (1 × 10 = 10)

a. Derive an expression for the vertical stress under a circular area. Determine the vertical stress at a point P which is 3 m below and at a radial distance of 3 m from the vertical load of 100 kN. Use Westergaard's solution.

Ans.

A. Vertical Stresses Under a Circular Area :

1. Let us determine the vertical stress at the point P at depth z below the centre of a uniformly loaded circular area as shown in the Fig. 2.
2. Let the intensity of the load be q per unit area and R be the radius of the loaded area. Boussinesq's solution can be used to determine σ_z.
3. The load on the elementary ring of radius r and width dr is equal to $q(2\pi r)\,dr$.
4. The load acts at a constant radial distance r from the point.

$$\Delta\sigma_z = \frac{3(q \times 2\pi r dr)}{2\pi} \times \frac{1}{z^2} \times \frac{1}{[1+(r/z)^2]^{5/2}}$$

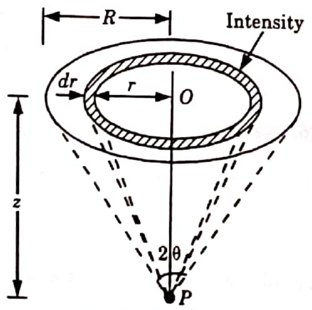

Fig. 2. Circular load.

5. The vertical stress due to entire load is given by,

$$\sigma_z = 3qz^3 \int_0^R \frac{r\,dr}{(r^2+z^2)^{5/2}} \quad ...(1)$$

6. Let $r^2 + z^2 = u$. Therefore, $2r\,dr = du$

Eq. (1) becomes,

$$\sigma_z = 3qz^3 \int_{z^2}^{(R^2+z^2)} \frac{du}{2u^{5/2}}$$

$$= \frac{3}{2}qz^3\left(-\frac{2}{3}\right)\left[u^{-3/2}\right]_{z^2}^{R^2+z^2}$$

$$= -qz^3\left[\frac{1}{(R^2+z^2)^{3/2}} - \frac{1}{(z^2)^{3/2}}\right]$$

$$= qz^3\left[\frac{1}{z^3} - \frac{1}{(R^2+z^2)^{3/2}}\right]$$

or $$\sigma_z = q\left[1 - \left\{\frac{1}{1+(R/z)^2}\right\}^{3/2}\right]$$

or $$\sigma_z = I_c \times q$$

where I_c is the influence coefficient for the circular area, and is given by,

$$I_c = \left[1 - \left\{\frac{1}{1+(R/z)^2}\right\}^{3/2}\right] \quad ...(2)$$

7. Eq. (2) for the influence coefficient I_c can be written in terms of the angle 2θ subtended at point P by the load.

Let $\tan\theta = R/z$. Therefore

$$I_c = \left[1 - \left\{\frac{1}{1-\tan^2\theta}\right\}^{3/2}\right]$$

$$I_c = 1 - (\cos^2\theta)^{3/2} = 1 - \cos^3\theta \quad ...(3)$$

8. Eq.(3) indicates that as θ tends to 90°, the value of I_c approaches unity. In other words, when a uniformly loaded area tends to by very large in comparison with the depth z, the vertical stress at the point P is approximately equal to q.

Numerical :

Given : Depth of point P, $z = 3$ m
Radial distance of point P, $r = 3$ m, Load at point P, $Q = 100$ kN
To Find : Vertical stress at point P.

Westergaard's equation is given by,

Vertical stress, $$\sigma_z = \frac{1}{\pi[1+2(r/z)^2]^{3/2}} \times \frac{Q}{z^2}$$

$$\sigma_z = \frac{1}{\pi[1+2(3/3)^2]^{3/2}} \times \frac{100}{(3)^2} = 0.681 \text{ kN/m}^2$$

b. Give the assumptions of the Terzaghi's theory for calculating the rate of 1D-consolidation and prove that

$$\frac{\partial u}{\partial t} = c_v \frac{\partial^2 u}{\partial z^2}$$

Ans. Refer Q. 3.12, Page 3–14A, Unit-3.

6. Attempt any **one** part of the following : **(1 × 10 = 10)**

a. According to Mohr - Coulomb criterion, how is the failure plane recognized and how is shear strength defined ? The effective stress shear strength parameters of completely saturated clay are : c′ = 20 kN/m², φ′ = 25°. A sample of this clay was tested in an unconsolidated undrained test under a cell pressure of 200 kN/m² and the principal stress difference at failure was 110 kN/m². What was the value of pore water pressure at failure ?

Ans. **Mohr-Coulomb Theory :** Refer Q. 4.2, Page 4–3A, Unit-4.
Numerical : Refer Q. 4.13, Page 4–16A, Unit-4.

b. In an in-situ vane shear test on saturated clay, a torque of 35 N-m was required to shear the soil. The diameter of the vane was 50 mm and length 100 mm. Calculate the undrained shear strength of the clay. The vane was then rotated rapidly to cause remoulding of the soil. The torque required to shear the soil in the remoulded state was 5 N-m. Determine the sensitivity of the clay.

Ans. Refer Q. 4.15, Page 4–17A, Unit-4.

7. Attempt any **one** part of the following : **(1 × 10 = 10)**

a. Differentiate between gross and net bearing capacity. What are the assumptions made in the Terzaghi's bearing capacity theory ? Also discuss the failure zones in Terzaghi's theory with the help of its neat sketch.

Ans. **Difference :** Refer Q. 5.1, Page, 5–2A, Unit-5.
Assumptions and Failure Zones : Refer Q. 5.2, Page, 5–3A, Unit-5.

b. Determine the ultimate bearing capacity of a strip footing 2 m width, with its base at a depth of 1.5 m below the ground surface and resting on a saturated clay soil with the following properties :
γ_{sat} = 20 kN/m³; c_u = 40 kN/m², φ_u = 0; c′ = 10 kN/m²; φ = 20°
For φ = 20°; N_c = 17.7, N_q = 7.4, N_γ = 5.0
The natural water table is at 1 m depth below the ground level. Ignore the depth factors.

Ans. Refer Q. 5.8, Page, 5–12A, Unit-5.

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B.Tech.

(SEM. V) ODD SEMESTER THEORY EXAMINATION, 2018-19

GEOTECHNICAL ENGINEERING

Time : 3 Hours **Max. Marks : 70**

Note : Attempt **all** sections. If any missing data required, then choose suitably.

SECTION – A

1. Attempt **all** questions in brief. **(2 × 7 = 14)**

a. Define origin of soil.

Ans. Refer Concept Outline-1, Page 1–2A, Unit-1.

b. Draw the figure of element separated soil into three phases.

Ans. Refer Q. 1.6 [Fig. 1.6.1(b)], Page 1–5A, Unit-1.

c. Compute the range for capillary rise in silt deposits. Assume value of void ratio as 0.7.

Ans.

Given : Void ratio, $e = 0.7$
To Find : Range of capillary rise.

Assume, $D_{10} = 0.05$ mm, $C = 40$ mm^2

Capillary rise, $h_{(max)} = \frac{C}{eD_{10}} = \frac{40}{0.7 \times 0.05} = 1142.85$ mm

d. Define analogy method by Laplace equation.

Ans.

1. The electrical analogy method is based on the fact that the Darcy's law, which governs the flow of water through soils, is analogous to the Ohm's law governing the flow of electricity in a conducting medium.
2. In the analogy, the current being proportional to the voltage drop is similar to seepage being proportional to head dissipated.
3. An electrical model is made whose boundary conditions are similar to those of the soil model. The equipotential lines are drawn by joining the points of equal voltage.
4. The flow pattern obtained from the electrical model is used in the construction of flow net in the model.

e. What are the preconsolidated stress ?

Ans. Refer Q. 3.11, 2 Marks Questions, Page SQ–9A, Unit-3.

f. Define undrained shearing strength.

Ans. The shear strength of a fine grained soil under undrained condition is called the undrained shear strength.

g. What are the limitations of coulomb's theory ?

Ans. Limitations of Coulomb's Theory :

i. It neglects the effect of the intermediate principal stress.

ii. This theory, approx the failure envelope into straight line which may be a little curve for over consolidated clays.

iii. For some clay there is no fixed relationship between the normal and shear stresses on the plane of failure. This theory cannot be used for such soils.

iv. In case of pure clays, according to this theory, shear strength is constant with the depth. However in practice a little increase is observed.

SECTION-B

2. Attempt any **three** of the following : **(7 × 3 = 21)**

a. What is the use of particle size distribution curve ? With the help of particle size distribution curve.

Ans.

A. Particle Size Distribution Curve :

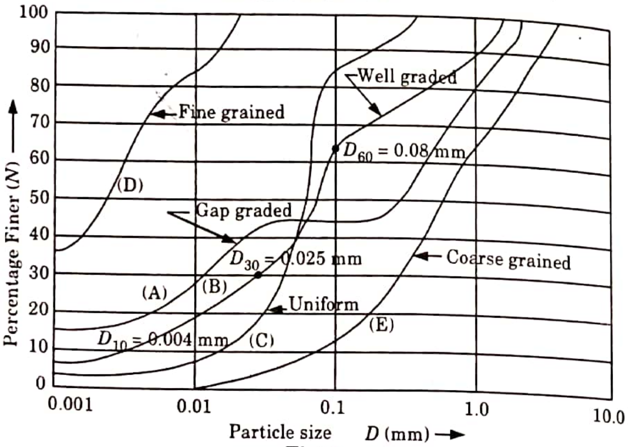


Fig. 1.

B. Uses : Following are the uses of particle size distribution curve :

1. It is used in the classification of coarse-grained soils.
2. The particle size is used to know the susceptibility of a soil to frost action.
3. It is required for the design of drainage filters.

4. It provides an index to the shear strength of the soil. Generally, a well-graded, compacted sand has high shear strength.
5. The compressibility of a soil can also be judged from its curve. A uniform soil is more compressible than a well-graded soil.
6. It is useful in soil stabilization and for the design of pavements.
7. It may indicate the mode of deposition of a soil. For example, a gap-graded soil indicates deposition by two different agencies.

b. The specific gravity of soil solids for a given soil sample was determined by density bottle method using kerosene. Following observations were recorded. Compute the specific gravity of soil solids at test temperature which was maintained at 27°. Also report the value at 4°C. Take specific gravity of kerosene at 27°C as 0.733.

Ans.

Given : Specific gravity of kerosene at 27°C, $G_k = 0.733$

Assumption : Following observations were recorded :

Mass of density bottle, $M_1 = 61.45$ g

Mass of bottle + soil, $M_2 = 82.24$ g

Mass of bottle + soil + kerosene, $M_3 = 261.12$ g

Mass of bottle + kerosene, $M_4 = 246.49$ g

To Find : Specific gravity of soil solids at 27°C and 4°C

1. Mass of soil solids, $M_d = M_2 - M_1 = 82.24 - 61.45 = 20.79$ g

2. We have, $M_4 - \dfrac{M_d}{G} + M_d = M_3$

$$G = \frac{M_d G_k}{M_d - (M_3 - M_4)}$$

$$= \frac{20.79 \times 0.733}{20.79 - (261.12 - 246.49)} = 2.474$$

$G_{27°C} = 2.474$

3. If the value of G has to be reported at 4°C, we have

$$G_{4°C} = G_{27°C} \times \frac{\text{Specific gravity of water at } 27°C}{\text{Specific gravity of water at } 4°C}$$

$$= 2.474 \times \frac{0.9965}{1.000} = 2.465$$

c. Define the terms :

i. Quick sand condition.

ii. Exit gradient.

iii. UU test.

Ans.

i. Quick Sand Condition : Refer Q. 2.16, Page 2–23A, Unit-2.

ii. Exit Gradient : The exit gradient is the hydraulic gradient at the downstream end of the flow line where percolating water leaves the soil mass and emerges into the free water at the downstream. It can be calculated as :

$$i_c = \Delta h / l$$

where, Δh = Potential drop in the last field.

l = Average length of the last field in the flow net.

iii. UU Test : Refer Q. 4.8, Page 4–8A, Unit-4.

d. In the laboratory a 2 cm thick soil sample takes 25 minutes to reach 30 % degree of consolidation. Find the time taken for a 5 m thick clay layer in field to reach 40 % consolidation. Assume double drainage both cases.

Ans.

Given : Thickness of sample = 20 mm, Time, t = 25 min, Degree of consolidation, U = 30 %, Thickness of clay layer = 5 m, Field degree of consolidation, U = 40 %

To Find : Time taken for reach 40 % consolidation.

1. For Soil Sample :

i. Drainage path, d = 20 / 2 = 10 mm

ii. Time, t = 25 × 60 = 1500 sec

iii. Time factor, $$T_v = \frac{\pi}{4}\left[\frac{U}{100}\right]^2 = \frac{\pi}{4}\left[\frac{30}{100}\right]^2 = 0.07$$

Time factor, $$T_v = C_v \frac{t}{d^2}$$

Coefficient of consolidation,

$$C_v = \frac{T_v d^2}{t} = 0.07 \times \frac{10^2}{1500} = 4.67 \times 10^{-3} \text{ mm}^2/\text{sec}$$

2. For Field Clay Layer :

i. For double drainage,

$$d = \frac{5000}{2} = 2500 \text{ mm}$$

ii. Time factor, $$T_v = \frac{\pi}{4}\left[\frac{U}{100}\right]^2 = \frac{\pi}{4}\left[\frac{40}{100}\right]^2 = 0.126$$

iii. Time taken, $$t = \frac{T_v d^2}{C_v} = \frac{0.126 \times (2500)^2}{4.67 \times 10^{-3}}$$

t = 168629550.3 sec

t = 1951.73 days

e. Using the Rankine's theory, the total active thrust on a vertical wall 10 m high, if the soil retained has the following properties, $\phi = 35°, \gamma = 19$ kN/m³.

Ans. Refer Q. 4.24, Page 4–28A, Unit-4.

SECTION-C

3. Attempt any one part of the following : (7 × 1 = 7)

a. The plastic limit of soils is 24 % and its plasticity index is 8 %. When the soil is dried from its state of plastic limit, the volume change is 26 % of its volume of plastic limit. The corresponding volume change from liquid limit to dry state is 35 % of its volume of liquid limit. Determine the shrinkage limit and the shrinkage ratio.

Ans.

Given : Plastic limit, w_p = 24 %, Plasticity index, I_p = 8 %
Volume change at liquid limit = 35 %
Volume change at plastic limit = 26 %

To Find : Shrinkage limit and Shrinkage ratio.

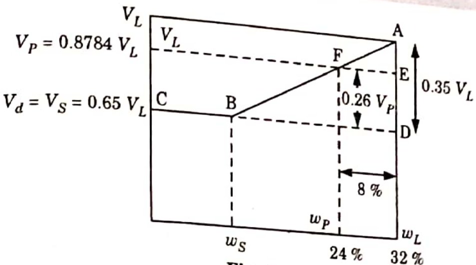


Fig. 2.

1. Liquid limit, w_L = 24 % + 8 % = 32 %

2. Dry volume, $V_d = V_S = V_L - 0.35\ V_L = 0.65\ V_L$ ...(1)

$V_d = V_P - 0.26\ V_P = 0.74\ V_P$ ...(2)

3. From eq. (1) and eq. (2), we get

$$V_p = \frac{0.65}{0.74} V_L = 0.8784\ V_L$$

4. ΔABD and ΔAFE are similar (Fig. 2),

$$\frac{BD}{AD} = \frac{FE}{AE} = \frac{0.32 - 0.24}{0.1216\ V_L}$$

$$BD = \frac{0.08}{0.1216\ V_L} \times 0.35\ V_L = 0.2302 = 23.02\ \%$$

5. Shrinkage limit, $w_S = w_L - \text{BD}$ = 32 % – 23.02 % = 8.98 %

6. Shrinkage ratio, $$SR = \frac{(V_L - V_d)/V_d}{W_L - W_S} \times 100$$

$$= \frac{0.35\ V_L / 0.65\ V_L}{32 - 8.98} \times 100$$

$SR = 2.339$

b. Define clay minerals. Also discuss montmorillonite with neat sketches.

Ans. Clay Minerals : Refer Concept Outline-2, Page 1–18A, Unit-1.
Montmorillonite : Refer Q. 1.19, Page 1–21A, Unit-1.

4. Attempt any **one** part of the following : **(7 × 1 = 7)**

a. Explain capillary siphoning with neat sketch. Also discuss about partially saturated soil.

Ans. Capillary Siphoning :

1. In an earth dam with an impervious core, capillary siphoning may occur as shown in Fig. 3.

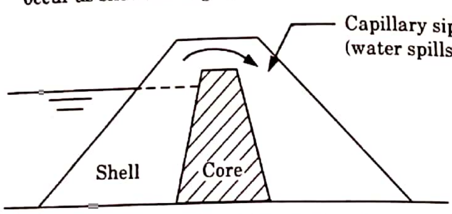


Fig. 3. Capillary siphoning.

2. The water rises in the outer shell due to capillary action. If the crest (top level) of the impervious core is in the reach of capillary rise, water flows from the storage reservoir to the downstream over the core.
3. Considerable quantity of stored water may be lost to capillary siphoning.
4. To prevent this, the crest of the impervious core should be kept sufficiently high.
5. In other words, the difference of top level of the core and water level in the reservoir should be more than the capillary rise in soil of the shell.

Partially Saturated Soil :

1. Generally the soil is made up of three phases, which are called as soil solid, water and air.
2. If the pore or void space in the soil is fully occupied by the water, then it is fully saturated.
3. If the voids space in the soil is partially occupied by water, the pore is said to be partially saturated.
4. It is found using the degree of saturation value.
5. If the value is in between 0 to 100 %, then the soil is partially saturated.

b. What are the assumption and limitations of Dupuits's theory ?

Ans. Assumptions : Following are the assumptions of Dupuits's theory :

1. The flow is laminar and Darcy's law is valid.
2. The soil mass is isotropic and homogeneous.
3. The well penetrates the entire thickness of aquifer.
4. The flow is steady.
5. The coefficient of permeability remains constant throughout.
6. The flow towards the well is radial and horizontal.
7. Natural ground water regime remains constant.

Limitations : Various assumptions have been made in the Dupuit's theory formulae. In actual practice, however, none of these conditions may get fulfilled , say for example :

i. An aquifer is not fully homogeneous.
ii. The well might have been dug half way through the aquifer.
iii. Permeability may not be uniform.
iv. The ground water table may be inclined and thus, the base of the cone may not be a circle.
v. The equilibrium conditions might have not fully reached.

5. Attempt any **one** part of the following : **(7 × 1 = 7)**

a. Find out the expression for the law of deflection of flow line at the interface of two dissimilar soils.

Ans. Refer Q. 2.9, Page 2–12A, Unit-2.

b. Write the difference between compaction and consolidation. The in-situ void ratio of a granular soil deposits is 0.50. The maximum and minimum soil ratio of the soil were determined to be 0.75 and 0.35, $G_s = 2.67$, also determine the relative density and relative compaction of the deposit.

Ans. Difference between Compaction and Consolidation : Refer Q. 3.10, Page 3–12A, Unit-3.
Numerical : Refer Q. 3.8, Page 3–10A, Unit-3.

6. Attempt any **one** part of the following : **(7 × 1 = 7)**

a. In a consolidation test, the void ratio of the specimen which was 1.068 under the effective pressure of 214 kN/m², changed to 0.994 when the pressure was increased to 429 kN/m². Calculate the coefficient of permeability, compression index. Also find the settlement of foundation resting on above type of clay, if thickness of layer is 8 m and the increase in pressure is 10 kN/m².

Ans.

Given : Initial void ratio = 1.068, Final void ratio = 0.994,
Initial effective pressure = 214 kN/m²,
Final effective pressure = 429 kN/m²,
Thickness of clay layer = 8 m, Increase in pressure = 10 kN/m²
To Find : Coefficient of permeability, Compression index and Settlement.

1. **Coefficient of Permeability :**

i. Coefficient of compressibility,

$$a_v = \frac{\Delta e}{\Delta \bar{\sigma}} = \frac{1.068 - 0.994}{429 - 214} = 3.44 \times 10^{-4}\ \text{m}^2/\text{kN}$$

ii. Coefficient of volume compressibility,

$$m_v = \frac{\Delta e}{\Delta \bar{\sigma}(1 + e_o)} = \frac{3.44 \times 10^{-4}}{1 + 1.068}$$

$$= 1.664 \times 10^{-4}\ \text{m}^2/\text{kN}$$

iii. Coefficient of permeability, $k = c_v\, m_v\, \gamma_w$

Assume, $c_v = 4.8 \times 10^{-6}$ m/min

$\gamma_w = 9.8$ kN/m^3

$k = 4.8 \times 10^{-6} \times 1.664 \times 10^{-4} \times 9.8$

$= 78.275 \times 10^{-8}$ m/min

2. Compression index,

$$C_c = \frac{\Delta e}{\log_{10}(\bar{\sigma}/\sigma_0)} = \frac{1.068 - 0.994}{\log_{10}\left(\frac{429}{214}\right)}$$

$$C_c = 0.245$$

3. Settlement, $S = \dfrac{C_c}{1 + e_0} H_0 \log_{10}\left(\dfrac{\bar{\sigma}_0 + \Delta\bar{\sigma}}{\bar{\sigma}_0}\right)$

$$= \frac{0.245 \times 8}{1 + 1.068} \log_{10}\left(\frac{214 + 10}{214}\right) = 0.0188 \text{ m}$$

$$S = 18.8 \text{ mm}$$

b. A rectangular area 2 m × 4 m carries a uniform load of 8 t/m^2 at the ground surface. Find the vertical pressure at 5 m below the centre and corner of the loaded area.

Ans.

Given : Size of rectangular = 2 m × 4 m, Load = 8 t/m^2.
To Find : Vertical pressure at 5 m below the centre and corner.

1. **Vertical Pressure below the Centre of Rectangular Area :**

i. The rectangular area divided into small rectangle is shown in Fig. 4.

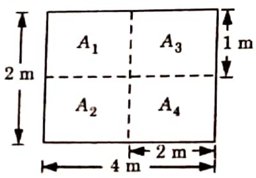


Fig. 4.

ii. $m = \dfrac{L}{Z} = \dfrac{2}{5} = 0.4$

iii. $n = \dfrac{B}{Z} = \dfrac{1}{5} = 0.2$

iv. Vertical pressure is given by,

$$\sigma_z = I_N q$$

v. For the centre of rectangular area, all the small rectangle are equal, so, vertical pressure,

$$\sigma_z = 4qI_N$$

$$I_N = \frac{1}{4\pi}\left[\frac{2mn(m^2 + n^2 + 1)^{1/2}}{m^2 + n^2 + m^2n^2 + 1} \times \frac{m^2 + n^2 + 2}{m^2 + n^2 + 1} + \tan^{-1}\frac{2mn(m^2 + n^2 + 1)^{1/2}}{m^2 + n^2 + 1 - m^2n^2}\right] \quad ...(1)$$

$$= \frac{1}{4\pi}\left[\frac{2 \times 0.4 \times 0.2(0.4^2 + 0.2^2 + 1)^{1/2}}{0.4^2 + 0.2^2 + 0.4^2 \times 0.2^2 + 1} \times \frac{0.4^2 + 0.2^2 + 2}{0.4^2 + 0.2^2 + 1} + \tan^{-1}\frac{2 \times 0.4 \times 0.2(0.4^2 + 0.2^2 + 1)^{1/2}}{0.4^2 + 0.2^2 + 1 - 0.4^2 \times 0.2^2}\right]$$

$$= 0.0328$$

$$= 8 \times 4 \times 0.0328 = 1.0496 \text{ t/m}^2$$

2. **Vertical Pressure 5 m below the Corner :**

i. $m = \dfrac{L}{Z} = \dfrac{4}{5} = 0.8$

ii. $n = \dfrac{B}{Z} = \dfrac{2}{5} = 0.4$

iii. Similarly, value of m and n put in eq. (1) and calculate,

$$I_N = 0.0931$$

iv. $\sigma_z = qI_N = 8 \times 0.0931 = 0.7448$ t/m^2

7. Attempt any **one** part of the following : **(7 × 1 = 7)**

a. A ground of 16 piles of 600 mm diameter is arranged in a square pattern with c/c spacing of 1.2 m the piles are 10 m long and are embedded in soft clay with cohesion of 30 kN/m^2. Bearing resistance may be neglected for the piles. Adhesion factor is 0.6. Determine ultimate load carrying capacity of the pile group.

Ans.

Given : Number of pile, N = 16, Diameter of pile = 600 mm, Spacing of pile = 1.2 m, Length of pile = 10 m, Cohesion C = 30 kN/m^2, Adhesion factor, α = 0.6
To Find : Ultimate load carrying capacity of pile group.

1. Length of pile group = 1.2 × 3 + 0.6 = 4.2 m
2. Width of pile group = 1.2 × 3 + 0.6 = 4.2 m
3. Ultimate load carrying capacity of single pile is given by,

$$Q = C N_c A_b + \alpha C_u A_s$$

4. According to question bearing resistance may be neglected, so equation becomes.

$$Q = \alpha C_u A_s = 0.6 \times 30 \times \pi \times 0.6 \times 10$$

$$= 339.2 \text{ kN}$$

5. Ultimate load capacity of pile group = NQ_u = 16 × 339.3

$$= 5428.67 \text{ kN}$$

6. Ultimate load capacity of the pile group by group failure is given by,

$$Q_{g(u)} = C_{ub} N_c A_b + P_b L C_u$$

7. According to question bearing resistance may be neglected, so

$$Q_{g(u)} = P_b L C_u$$

$$= 4 \times 4.2 \times 10 \times 30 = 5040 \text{ kN}$$

8. Ultimate load carrying capacity of pile group = 5040 kN (least value)

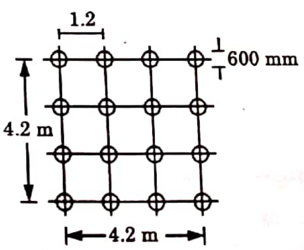


Fig. 4.

b. What are the cased cast-in-situ concrete piles ? Explain any two of them with neat sketches.

Ans.

A. Cased Cast-in-situ Concrete Piles :

1. Cased piles consists a shell around it and these piles when casted in site are called cased cast-in-situ concrete piles.

2. In case of cased cast in situ piles, the shell is usually made of steel. This type of piles is suitable for any types of soils.

B. Types of Cased Cast-in-situ Concrete Piles : Following are the different types of cased cast-in-situ concrete piles :

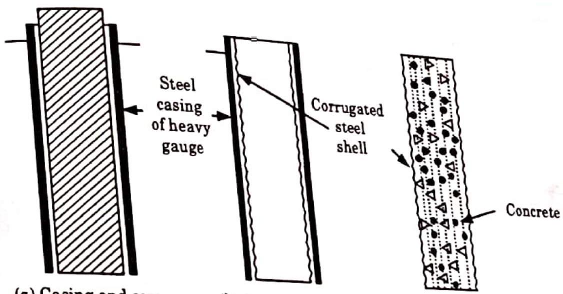
1. Raymond piles.
2. Mac-Arthur piles.
3. Union metal monotube pile.
4. Swage pile.
5. Western button bottom pile.

1. Mac-Arthur Piles :

i. Mac-Arthur piles generally in uniform diameter and shell is made of corrugated steel. But driving is done by the combination of steel casing of heavy gauge consisting core.

ii. After driven to require depth, the core is removed and corrugated steel shell is inserted in heavy gauge steel casing.

iii. Then, concrete is filled in the corrugated steel shell and outer hard casing is removed.



(a) Casing and core (b) Casing and shell (c) Shell and concrete

Fig. 6.

2. Swage Pile :

i. Swage piles are widely used in case of hard soils.

ii. Pre-cast concrete plug is attached at bottom of shell to drive the pile shell.

iii. Steel core is inserted in shell and driven and then shell is swaged out by the taper of the plug and form water tight joint.

iv. Next the whole arrangement is driven into the ground to a required depth.

v. After reaching desired depth, core is taken out and the pipe or shell is filled with concrete.

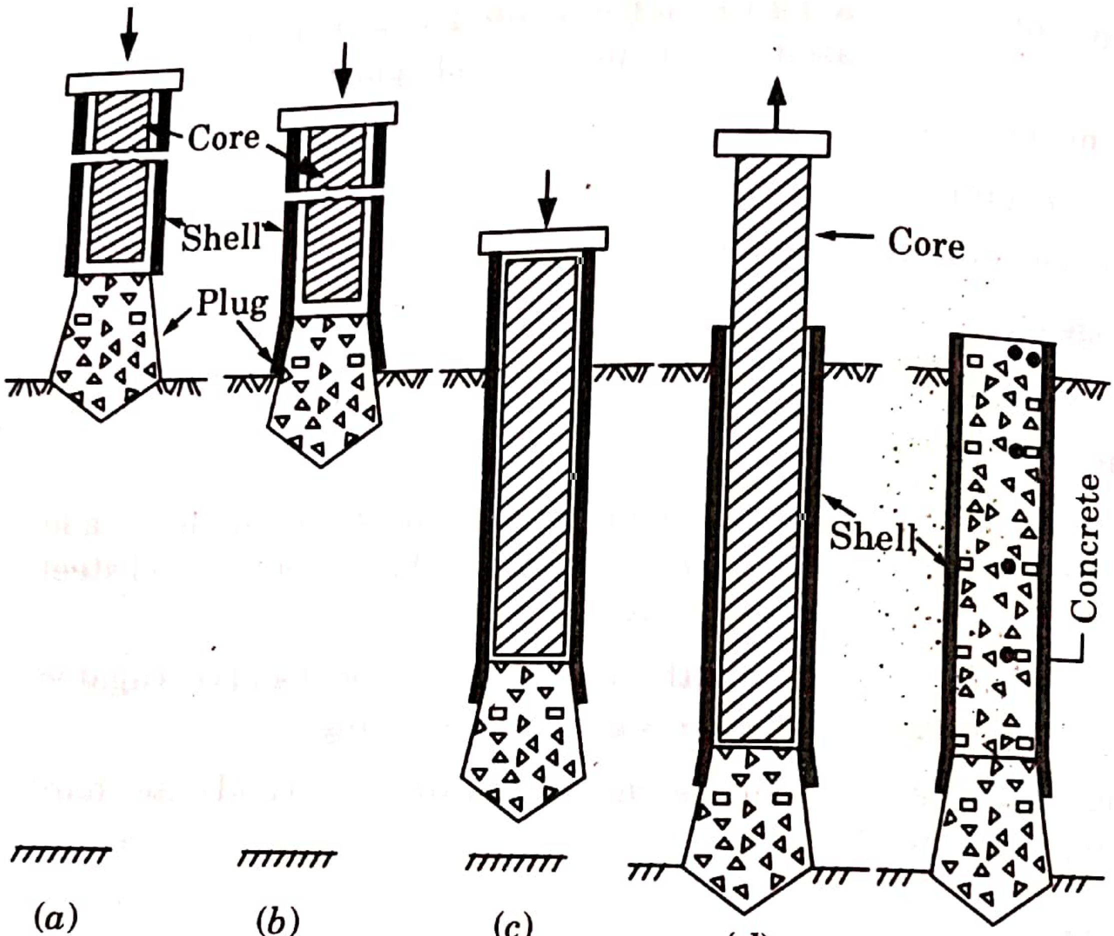


Fig. 7.

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