2 CHAPTER

Properties of Soils

Q.1 Consider the following statements:
1. In three phase system, soil contains solids, water and air.
2. In two phase system, soil always contains solids and air.

Which of the following is correct?
(a) Both statements are correct
(b) Statement 1 is correct and 2 is false
(c) Statement 2 is correct and 1 is false
(d) Both statements are false

Q.2 Match the Column-I with Column-II.

Column-I	Column-II
A. Void ratio	1. $\frac{V_a}{V_v}$
B. Porosity	2. $\frac{V_a}{V}$
C. Air content	3. $\frac{V_v}{V_s}$
D. Percentage air voids	4. $\frac{V_v}{V}$

	A	B	C	D
(a)	1	2	3	4
(b)	3	4	2	1
(c)	3	4	1	2
(d)	2	1	3	4

Q.3 Which of the following can be used for determination of water content in the field as well as in laboratory?
(a) Oven drying method
(b) Pycrometer method
(c) Rapid moisture meter method
(d) Torsion balance moisture meter method

Q.4 Which of the following method is suitable for determination of in-situ unit weight in case of hard and gravelly soils?
(a) core-cutter method
(b) sand-replacement method
(c) water displacement method
(d) All of the above

Q.5 Consider the following statements regarding hydrometer analysis for sedimentation analysis
1. Meniscus correction is always positive
2. Temperature correction is negative if temperature is above 27°C
3. Temperature correction is positive if temperature is below 27°C

Which of the following statement(s) is(are) correct?
(a) Only 1 (b) 1 and 2
(c) 2 and 3 (d) 1, 2 and 3

Q.6 Relative density of a cohesionless soil is given by

(a) $\dfrac{\frac{1}{\gamma_{max}}-\frac{1}{\gamma}}{\frac{1}{\gamma_{max}}-\frac{1}{\gamma_{min}}}$ (b) $\dfrac{\frac{1}{\gamma_{min}}-\frac{1}{\gamma}}{\frac{1}{\gamma_{min}}-\frac{1}{\gamma_{max}}}$

(c) $\dfrac{\frac{1}{\gamma}-\frac{1}{\gamma_{max}}}{\frac{1}{\gamma_{min}}-\frac{1}{\gamma_{max}}}$ (d) $\dfrac{\frac{1}{\gamma}-\frac{1}{\gamma_{min}}}{\frac{1}{\gamma_{max}}-\frac{1}{\gamma_{min}}}$

Q.7 Value of coefficient of uniformity (C_u) for well graded gravel is
(a) more than 4
(b) more than 6
(c) between 1 and 3
(d) between 4 and 6

Q.8 The value of water content at which soil is just saturated is known as
(a) liquid limit
(b) optimum moisture carter
(c) plastic limit
(d) shrinkage limit

Q.9 Assertion (A): In a partially saturated soil, void ratio remains constant with change in water content.
Reason (R): In saturated soil mass, void ratio changes with change in water content due to change in volume of solids.
(a) both A and R are true and R is the correct explanation of A
(b) both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

Q.10 Assertion (A): If a non-plastic soil is mixed with high plastic soil (clay), then plasticity of clay reduces.
Reason (R): Due to mixing, liquid limit and plastic limit both reduces but loss in liquid limit is less than loss in plastic limit.
(a) both A and R are true and R is the correct explanation of A
(b) both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

Q.11 Minimum value of relative compaction is _____

Q.12 When a soil sample is placed in an oven for 24 hr at 105°C,
1. hygroscopic moisture is lost
2. capillary water is lost
3. free water is lost
4. saturated water is lost

Which of the above statements are correct?
(a) 1, 2 and 4 (b) 2 and 4
(c) 1, 2, 3 and 4 (d) 1, 2, and 3

Q.13 The relationship between water content (w%) and number of blows (N) in soils, as obtained from Casagrade's liquid limit device is given by

$$w = 20 - \log_{10} N$$

The value of 'N' for calculation of liquid limit is _____

Q.14 Consider the following regarding consistency index
1. If consistency index > 1, then soil is in either solid or semi solid state.
2. If consistency index is between 0 and 1, then soil is in plastic state.
3. If consistency index is less than zero, then soil is in liquid state.
4. Consistency index is directly related to liquidity index.

Which of the above statements are correct?
(a) 1, 2 and 4 (b) 1, 2 and 3
(c) 2, 3 and 4 (d) 1, 2, 3 and 4

Q.15 Which of the following can be determined for both undisturbed and remoulded soils?
(a) Liquid limit (b) Plastic limit
(c) Shrinkage limit (d) None of these

Q.16 Match the Column-I with Column-II.

Column-I	Column-II
A. Toughness index	1. $\dfrac{\left(\frac{V_1-V_2}{V_d}\right)\times 100}{w_1-w_2}$
B. Volumetric shrinkage	2. $\dfrac{V_i-V_d}{V_i}\times 100$
C. Degree of shrinkage	3. $\dfrac{V_i-V_d}{V_d}\times 100$
D. Shrinkage ratio	4. $\dfrac{I_p}{I_f}$

	A	B	C	D
(a)	4	3	2	1
(b)	3	2	4	1
(c)	2	3	1	4
(d)	1	2	3	4

Q.17 The minimum water content at which the soil just begins to crumble when rolled into threads of 3 mm diameter is known as
(a) liquid limit
(b) plastic limit
(c) shrinkage limit
(d) optimum water content

Q.18 Water content is accurately determined by
(a) Calcium carbide method
(b) Sand bath method
(c) Alcohol method
(d) Oven-drying method

Q.19 Which of the following statement(s) is(are) true about sensitivity of soil?
1. It is ratio of confined compressive strength of disturbed soil to that of remoulded soil.
2. Gravels are sensitive in nature.
(a) Both 1 and 2
(b) Statement 1 is true but 2 is false
(c) Statement 2 is true but 1 is false
(d) Both statements are false

Q.20 When water content is decreased, reduction in volume is observed in
(a) liquid state (b) plastic state
(c) semisolid state (d) All of these

Q.21 The fundamental equation of percentage air void, degree of saturation and void ratio (e) is
(a) $\eta_a = \frac{e(1-s)}{1-e}$ (b) $\eta_a = \frac{e(1+s)}{1+e}$
(c) $\eta_a = \frac{e(1-s)}{1+e}$ (d) $\eta_a = \frac{e(1+s)}{1-e}$

Q.22 The unit weight of soil composed of 50% quartz, 25% mica and 25% iron oxide in kN/m^3 is _____
Average G for quartz = 2.66
Average G for mica = 3.0
Average G for iron oxide = 3.8
Assume soil is saturated with void ratio of 0.7.
(a) 21.52 (b) 20.41
(c) 22.24 (d) 31.33

Q.23 A clayey soil has saturated moisture content of 18%. Its saturation percentage is 70%. The soil is allowed to absorb water and saturation increases to 92% after some time. Assume specific gravity of soil to be 2.72, the water content of soil in later case is
(a) 20.26 (b) 23.66
(c) 21.24 (d) 25.61

Q.24 For a fully saturated soil mass, the value of specific gravity, G = 2.65, and ratio, e = 0.65. The value of modified water content is
(a) 24.53% (b) 19.7%
(c) 28.0% (d) 22.24%

Linked Question Q.25-Q.26
A natural deposit of loose, dry sand of 6 m thickness, having unit weight of 15 kN/m^3 is compacted and surface settles by 0.5 m. Relative density of sand after compaction is 90%. The dry unit weight in loosest state is 11 kN/m^3.

Q.25 Calculate the unit weight of soil after compaction in kN/m^3
(a) 15.55 (b) 16.36
(c) 17.54 (d) 14.4

Q.26 Calculate the dry unit weight in the densest state in kN/m^3
(a) 16.85 (b) 17.29
(c) 18.36 (d) 19.46

Q.27 One cubic metre of soil weighs 1624 kg and after drying, 1400 kg. If specific gravity of solids is 2.65, determine the degree of saturation of soil
(a) 45.23% (b) 47.49%
(c) 50.51% (d) 16%

Q.28 A sampler with a volume of 45 cm^3 is filled with a soil sample. When the soil is poured into a graduated cylinder, it displaces 25 cm^3 of water. The value of porosity of the soil is
(a) 0.8 (b) 0.44
(c) 0.5 (d) 0.58

Q.29 A soil is having natural moisture content of 20% and unit weight of 19.34 kN/m^3 with minimum and maximum void ratio as 0.45 and 0.8 respectively. The relative density of soil if value of G = 2.65, is
(a) 61.3% (b) 53.43%
(c) 96.46% (d) 45.28%

Q.30 Two samples A and B having following data are mixed and compacted to form 1 m^3 of soil mass. The porosity of compacted soil will be _____

Sample A	Sample B
e = 1	e = 2
V = 1 m^3	V = 1 m^3

Q.31 800 g of wet sandy sample was placed in a pycnometer. The mass of the pycnometer, sand and water full to the top is 2200 g and mass of pycnometer filled with water only is 1800 g. The value of water content if G = 2.65 is _____

Q.32 In a liquid limit test, the moisture content at 10 blows was 70% and that at 100 blows was 20%, the liquid limit of the soil is
(a) 35% (b) 61.67%
(c) 50.1% (d) 65%

Q.33 The liquid limit and plastic limit of soil are 50% and 30% and percentage of particles coarser than 2 microns in clay is 60%. Then activity of soil is
(a) 0.33 (b) 0.5
(c) 1.0 (d) 1.33

Q.34 Which of the following is not an assumption of Stoke's law (Grain size analysis of soils)?
(a) The falling soil particle (grain) is spherical
(b) The velocity of a free fall of a single sphere is in suspension of infinite extent
(c) An average value of specific gravity of grains is used in computing the Stoke's formula
(d) The finer particles of soil do not have tendency for floc formation

Q.35 A sample of dry soil having specific gravity of 2.74 and having a mass of 133.7 g is uniformly dispersed in water to form 1000 cc of suspension. The density of suspension immediately after it is prepared will be (in kg/m^3)
(a) 1085 (b) 951
(c) 134 (d) 400

Q.36 If the material of the base of the Casagrande's standard liquid limit test apparatus is softer than the standard hard rubber, then
(a) the liquid limit will always increase
(b) the liquid limit will always decrease
(c) the liquid limit may sometimes increase and sometimes decrease, depending upon the soil type
(d) the liquid limit will not be affected

Q.37 The addition of coarser particle soils like sand or silt, causes
(a) decrease in liquid limit as well as in plasticity index
(b) decrease in liquid limit and increase in plasticity index
(c) increase in liquid limit as well as in plasticity index
(d) decrease in liquid limit and no change in plasticity index

Q.38 A soil attains the maximum dry unit weight of 18.6 kN/m^3 at a water content of 15%, during a compaction test. If specific gravity of soil is 2.7 then air content of the soil per m^3 of soil is
(a) 0.45 (b) 0.95
(c) 0.045 (d) 4.5

Q.39 The following index properties were determined for four soil samples A, B, C and D.

Soil	A	B	C	D
Liquid Limit	0.50	0.49	0.43	0.47
Plastic Limit	0.23	0.17	0.21	0.26

Which one of these soil samples contains maximum clay particles?
(a) A (b) B
(c) C (d) D

Q.40 Consider the following statements:
I. Consistency as applied to clay is an indicator of its moisture content.
II. Rock dust particles, oven of clay size, are non-plastic.
III. Liquidity index can have a negative value.
Which of the above statements are CORRECT?
(a) I, II and III (b) I and II
(c) II and III (d) I and III

Q.41 A soil may be classified as of medium plasticity, if the plasticity index (PI) lies between
(a) 0 to 11 (b) 11 to 22
(c) 22 to 36 (d) 36 to 51

Q.42 The slope of the flow curve (I_f) is given by

(a) $\dfrac{w_2 - w_1}{\log_{10}\dfrac{N_1}{N_2}}$ (b) $\dfrac{w_2 - w_1}{\log_{10}\dfrac{N_2}{N_1}}$

(c) $\dfrac{w_1 - w_2}{\log_{e}\dfrac{N_1}{N_2}}$ (d) None of these

Q.43 Pycnometer is used for the determination of

1. water content 2. void ratio
3. specific gravity

The correct answer is

(a) both 1 and 2 (b) both 2 and 3
(c) both 1 and 3 (d) 1, 2 and 3

Q.44 Consider the following statements:

1. A soil is said to be well graded when it has good representation of particles of all sizes.
2. A soil is said to be uniformly graded if it has an excess of certain particles and deficiency of others.
3. Uniformity coefficient is the measure of particle size range.

Which of these statements is/are correct?

(a) only 2 (b) both 2 and 3
(c) both 1 and 3 (d) 1, 2 and 3

Q.45 Which of the following statement is correct?

(a) In soils, the flow index indicates variation in shear strength with water content.
(b) Plastic limit minus shrinkage limit, is known as shrinkage index of the soil.
(c) The ratio of the plasticity index to the flow limit, is known as toughness index of the soil.
(d) All of the above

Q.46 If W_1, W_2, W_3 and W_4 are the sequential weights obtained during observations in pycnometer method for determining water content, the formula to be used, is

(a) $w = \left[\left(\dfrac{W_2 + W_1}{W_3 + W_4}\right)\left(\dfrac{G-1}{G}\right) - 1\right] \times 100$

(b) $w = \left[\left(\dfrac{W_3 - W_1}{W_2 - W_4}\right)\left(\dfrac{G-1}{G} + 1\right)\right] \times 100$

(c) $w = \left[\left(\dfrac{W_2 - W_1}{W_3 - W_4}\right)\left(\dfrac{G-1}{G}\right) - 1\right] \times 100$

(d) $w = \left[\left(\dfrac{W_2 + W_1}{W_3 + W_4}\right)\left(\dfrac{G+1}{G} - 1\right)\right] \times 100$

Q.47 List-I and List-II contain respectively terms and expressions. Match the two lists and select the correct answer using the codes given below the lists:

List-I

A. Activity number
B. Liquidity index
C. Sensitivity

List-II

1. (Liquid limit – water content)/plasticity index
2. Plasticity index/Percent finer than 2 microns
3. (Natural moisture content – plastic limit)/ Plasticity index
4. Unconfined compressive strength of undisturbed soil sample/Unconfined compressive strength of remolded soil sample

Codes:

	A	B	C
(a)	1	3	4
(b)	1	2	3
(c)	3	2	1
(d)	2	3	4

Q.48 Match List-I with List-II and select the correct answer using codes given below the lists:

List-I

A. Stoke's law
B. Clay
C. Sand
D. Atterberg's experiments

List-II

1. Very plastic soil
2. Least plastic soil
3. Determination of plasticity of soils
4. Settling of soil particles in a soil suspension

Codes:

	A	B	C	D
(a)	1	2	4	3
(b)	4	2	3	1
(c)	1	4	3	2
(d)	4	1	2	3

Q.49 Match List-I (Name of person) with List-II (Field of contribution) and select the correct answer using the codes given below the lists:

List-I

A. Stoke
B. Darcy
C. Poiseuille
D. Atterberg

List-II

1. Flow through capillary
2. Classification of soils
3. Consistency limits
4. Flow of water through a soil mass
5. Velocity of settling particle

Codes:

	A	B	C	D
(a)	5	4	1	3
(b)	4	1	5	2
(c)	1	5	4	2
(d)	3	2	1	5

Q.50 Match List-I with List-II and select the correct answer using codes given below the lists:

List-I

A. Taylor (1948)
B. Darcy (1856)
C. Poiseuille
D. Muskat (1937)

List-II

1. The relationship governing the laminar flow of water through capillary tube
2. Relationship between physical permeability and Darcy's coefficient of permeability
3. In laminar flow, the discharge is proportional to the hydraulic gradient
4. In turbulent flow, the paths are irregular and twisting, crossing and recrossing at random.

Codes:

	A	B	C	D
(a)	1	2	3	4
(b)	4	3	1	2
(c)	3	2	4	1
(d)	4	1	2	3

Q.51 Consider the following statements:

1. Increase in volume of a soil sample without external constraints on submergence in water is termed as the 'free swell of soil'.
2. Clay soil rich in montmorillonite exhibits very low swelling characteristic.
3. Generally, free swell of soil sample ceases when its water content reaches the plastic limit.

Which of these statements are correct?

(a) 1 and 2 (b) 1 and 3
(c) 2 and 3 (d) 1, 2 and 3

Q.52 Clays are compressible because of

1. expulsion of water in between soil layers
2. bending of particles on elastic sheet
3. slipping of particles to different positions of greater density

Which of these statement/s is/are correct?

(a) Only 3 (b) Both 1 and 3
(c) Both 2 and 3 (d) 1, 2 and 3

Q.53 A soil has liquid limit of 50% and plastic limit of 30%. When the soil at its liquid limit was dried, the percentage decrease in volume was 40% of its dry volume. When it was dried from its plastic limit, the percentage decrease in volume was 20% of its dry volume. Shrinkage limit of soil will be

(a) 10% (b) 20%
(c) 25% (d) 50 %

Q.54 For sand of uniform spherical particles, the ratio of void ratios in the loosest and the densest states is:

(a) 2.6 (b) 3.5
(c) 4.6 (d) 3.0

Q.55 A sample of soil has the following properties:

Liquid limit = 45%
Plastic limit = 25%
Shrinkage limit = 17%
Natural moisture content = 30 %

The consistency index of the soil is

(a) 15/20 (b) 13/20
(c) 8/20 (d) 5/20

Q.56 A fill having a volume of 1,50,000 cum is to be constructed at a void ratio of 0.8. The borrow pit soil has a void ratio of 1.4. The volume of soil required (in cubic metres) to be excavated from the borrow pit will be

(a) 1, 87,500 (b) 2, 00, 000
(c) 2, 10, 000 (d) 2, 50, 000

■■■■

Answers Properties of Soils

1. (b)	2. (c)	3. (c)	4. (b)	5. (a)	6. (b)	7. (a)	8. (d)	9. (c)	10. (c)
11. (80)	12. (d)	13. (25)	14. (b)	15. (c)	16. (a)	17. (b)	18. (d)	19. (d)	20. (d)
21. (c)	22. (a)	23. (b)	24. (b)	25. (b)	26. (b)	27. (b)	28. (b)	29. (b)	
30. (0.17)	31. (24.53%)	32. (c)	33. (b)	34. (d)	35. (a)	36. (a)	37. (a)	38. (c)	
39. (b)	40. (a)	41. (b)	42. (a)	43. (c)	44. (d)	45. (d)	46. (c)	47. (d)	48. (d)
49. (a)	50. (b)	51. (b)	52. (d)	53. (a)	54. (a)	55. (a)	56. (b)		

Explanations Properties of Soils

1. **(b)**
In oven dried sample, soil contains solids and air, but in saturated sample, soil contains solids and water.

5. **(a)**
In hydrometer analysis, meniscus correction is always positive, temperature correction is positive if temperature is above 27° and it is negative if temperature is below 27°C.

8. **(d)**
At shrinkage limit, soil is just saturated and it remains saturated at higher water content.

9. **(c)**
In a saturated soil mass, if water is added, volume of voids changes, hence void ratio changes but not due to change in volume of solids.

11. **(80)**
Relative compaction
$= 80 + 0.2\,I_D$
Min. value of $I_D = 0$
∴ Relative compaction = 80

14. **(b)**
Consistency index,
$$I_C = \frac{W_L - W_N}{I_P} \propto \text{stiffness of soil}$$
The in-situ behaviour of a saturated, fine grained soil deposit at its natural water content may be studied by their consistency index/relative consistency.
Liquidity index,
$$I_L = \frac{W_N - W_P}{I_P}$$

19. **(d)**
Sensitivity is the ratio of unconfined compressive strength of undisturbed soil to that of remoulded soil.
Gravels are non-sensitive.

20. **(d)**
Volume is constant when water is below shrinkage limit i.e., solid state.

22. **(a)**
$e = 0.7$
$G = 0.5 \times 2.66 + 0.25 \times 3 + 0.25 \times 3.8$
$= 3.03$
$$\gamma_{sat} = \left(\frac{G+e}{1+e}\right)\gamma_w = \frac{3.03+0.7}{1.7} \times 9.81$$
$= 21.52\ \text{kN/m}^3$

23. **(b)**
Initially $w = 18\%$, $S = 70\%$, $G = 2.72$
$$e = \frac{Gw}{S} = \frac{0.18 \times 2.72}{0.7} = 0.699$$
After absorption
$S = 92\%$
$$w = \frac{Se}{G} = \frac{0.92 \times 0.699}{2.72} = 23.66\%$$

24. **(b)**
$Gw = Se$
$$w = \frac{1 \times 0.65}{2.65} = 0.245$$
$$\therefore \quad w' = \frac{w}{1+w} = 0.1968 = 19.68\%$$

25. **(b)**
$$\gamma_d = \frac{W_s}{V} = 15$$
$V = 6 \times 1 \times 1 = 6\ \text{m}^3$
$W_s = 15 \times 6 = 90\ \text{kN}$
After compaction,
$V = 5.5 \times 1 \times 1 = 5.5\ \text{m}^3$
γ_d after compaction
$$= \frac{90}{5.5} = 16.36\ \text{kN/m}^3$$

26. **(b)**
$$D_r = \frac{\gamma_{dmax}}{\gamma_d} \times \frac{\gamma_d - \gamma_{dmin}}{\gamma_{dmax} - \gamma_{dmin}}$$
$$0.9 = \frac{\gamma_{dmax}}{16.36} \times \frac{(16.36 - 11)}{\gamma_{dmax} - 11}$$
$$\Rightarrow \quad \gamma_{dmax} = 17.29\ \text{kN/m}^3$$

27. **(b)**
$m_w = 1624 - 1400 = 224\ \text{kg}$
$$V_w = \frac{224}{1000} = 0.224\ \text{m}^3$$
$m_s = m_d = 1400\ \text{kg}$
$$V_s = \frac{m_d}{G\rho_w}$$
$$= \frac{1400 \times 1000}{2.65 \times 1} = 0.5283\ \text{m}^3$$
$V_a = 1 - V_w - V_s$
$= 1 - 0.224 - 0.5283 = 0.2477$
$V_V = V_a + V_w$
$= 0.2477 + 0.2240 = 0.4717\ \text{m}^3$
$$\text{Water content} = \frac{224}{1400} = 16\%$$
$$\text{Void ratio} = \frac{0.4717}{0.5283} = 0.893$$
$$\therefore \quad S = \frac{2.65 \times 0.16}{0.893} = 47.49\%$$

28. **(b)**
$V_v = 45 - 25 = 20\ \text{cm}^3$
$$n = \frac{V_v}{V} = \frac{20}{45} = 0.44$$

29. **(b)**
$$e = \frac{G\gamma_w(1+w)}{\gamma} - 1$$
$$= \frac{2.65 \times 9.81 \times (1+0.2)}{19.34} - 1 = 0.613$$
$$I_D = \frac{e_{max} - e}{e_{max} - e_{min}} = 0.5343 = 53.43\%$$

30. **(0.17)**
$$V_{s_1} = \frac{V_1}{1+e_1} = \frac{1}{1+1} = 0.5$$

$$V_{s_2} = \frac{V_2}{1+e_2} = \frac{1}{1+2} = 0.33$$

$$V_s = V_{s_1} + V_{s_2}$$

$$= 0.5 + 0.33 = 0.83$$

$$V_v = 1 - 0.83 = 0.17$$

$$n = \frac{V_v}{V} = \frac{0.17}{1} = 0.17$$

31. (24.53%)

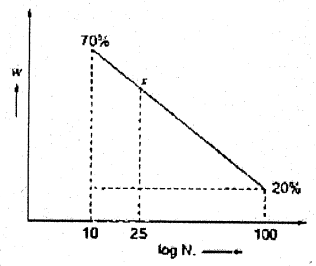
$$w = \left(\frac{m_2 - m_1}{m_3 - m_4} \times \frac{G-1}{G} - 1\right) \times 100$$

$$= \left(\frac{m}{m_3 - m_4} \times \frac{G-1}{G} - 1\right) \times 100$$

$$= \left(\frac{800}{2200 - 1800} \times \frac{2.65 - 1}{2.65} - 1\right) \times 100$$

$$= 24.53\%$$

32. (c)



$$\frac{x - 20}{70 - 20} = \frac{\log 100 - \log 25}{\log 100 - \log 10}$$

$$\Rightarrow \quad x = 50.1\%$$

33. (b)

$$I_p = w_L - w_p$$

$$= 50 - 30 = 20\%$$

$$c = 100 - 60 = 40\%$$

$$\text{Activity} = \frac{I_p}{F} = \frac{20}{40} = 0.5$$

34. (d)

The finer particles of soil carry charge on their surface and have a tendency for floc formation. If the tendency of floc formation is not prevented, then the diameter computed will be diameter of the floc and not of the individual particle. In the test, therefore, the soil is treated with some deflocculating agent, such as sodium oxalate in order to prevent floc formation.

35. (a)

Mass of soil = 133.7 g

Volume of suspension = 1000 cc

Sp. gravity of soil = 2.74

Density of soil = 2.74 x 1 = 2.74 g/cc

$\therefore$ Volume of soil $= \frac{133.7}{2.74}$ cc = 48.8 cc

Volume of water in 1000 ml of suspension

= 1000 – 48.8 = 951.2 cc

Density of water = 1 g/cc = 1 g/ml

$\therefore$ Mass of water in 1000 ml of suspension

= 951.2 g

Total mass of suspension

= 951.2 + 133.7

= 1085 gm

$$\text{Density} = \frac{1085 \text{ gm}}{1000 \text{ cm}^3}$$

$$= 1085 \text{ kg/m}^3$$

38.(c)

$$\gamma_d = \frac{G\gamma_w}{1 + \frac{wG}{S}}$$

$w = 0.15$, $G = 2.7$

$\gamma_w = 9.81$ kN/m^3, $\gamma_d = 18.6$ kN/m^3

$$18.6 = \frac{2.7 \times 9.81}{1 + \frac{0.15 \times 2.7}{S}}$$

$$\Rightarrow \quad S = 0.955 \quad \text{i.e. } 95.5\%$$

$\therefore$ Air content (a_c) = 1 – S = 0.045 m^3/m^3 of soil.

39. (b)

The soil which has maximum plasticity index (I_p) will have maximum amount of clay.

Soil A: I_p = 0.50 – 0.23 = 0.27

Soil B: I_p = 0.49 – 0.17 = 0.32

Soil C: I_p = 0.43 – 0.21 = 0.22

Soil D: I_p = 0.47 – 0.26 = 0.21

Therefore, soil *B* has maximum amount of clay particles.

42. (a)

Slope of the flow curve is called flow index (I_f). Flow index indicates the rate of loss of shearing strength with increase in moisture content.

46. (c)

Water content, $w = \frac{W_W}{W_S} \times 100$

Weight of water = $(W_2 - W_1) - W_S$

If from W_3, the weight of solids W_S could be removed and replaced by the weight of an equivalent. Volume of water, the weight W_4 would be obtained

$$W_3 - W_S + \frac{W_S}{G\gamma_w}\gamma_w = W_4$$

$$\therefore \quad W_S = (W_3 - W_4)\frac{G}{G-1}$$

$\therefore$ Water content,

$$w = \left[\frac{(W_2 - W_1)}{(W_3 - W_4)}\left(\frac{G-1}{G}\right) - 1\right] \times 100$$

51. (b)

The clay mineral 'montmorillonite' is responsible for the excessive swelling and shrinkage characteristic of the soil.

53. (a)

$$w_s = w_L - \frac{V_L - V_d}{w_d} \times \gamma_w$$

$$= w_p - \frac{V_p - V_d}{w_d} \times \gamma_w$$

By solving

Gives $w_s = 10\%$

54. (a)

$$e_i = 0.91; \quad e_d = 0.35$$

$$\text{Ratio} = \frac{0.91}{0.35} = 2.6$$

55. (a)

Consistency Index,

$$I_c = \frac{w_L - w_N}{I_P} = \frac{w_L - w_N}{w_L - w_p} = \frac{45 - 30}{45 - 25} = \frac{15}{20}$$

56. (b)

Volume of solids in fill

$$= \frac{150000}{1.8} = 83333.33 \text{ m}^3$$

Volume of soil required to be excavated

= 83333.33 + 1.4 x 83333.33

= 200,000 m^3

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