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SSC - JE

JUNIOR ENGINEER

Civil Engineering

Staff Selection Commission

Volume - 4

SOIL Foundation Engineering

SIERRA INNOVATIONS

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CHAPTER

1

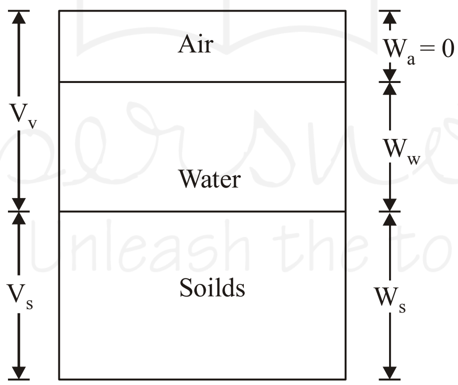
PROPERTIES OF SOILS

THEORY

2.1 Properties of Soils

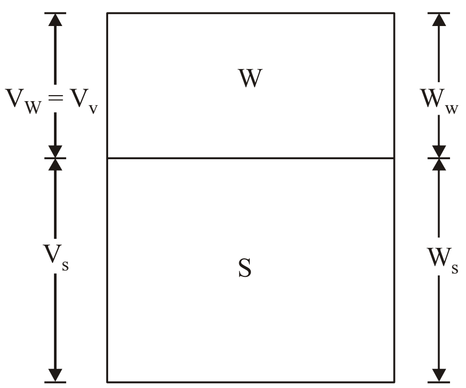
2.1.1 Phase Diagram

- Soil mass is in general a three phase system composed to solid, liquid and gaseous matter.
- The diagrammatic representation of the different phases in a soil mass is called the “phase diagram.”
- A 3-phase system is applicable for partially saturated soil whereas, a 2-phase system is for saturated and dry states of soil.

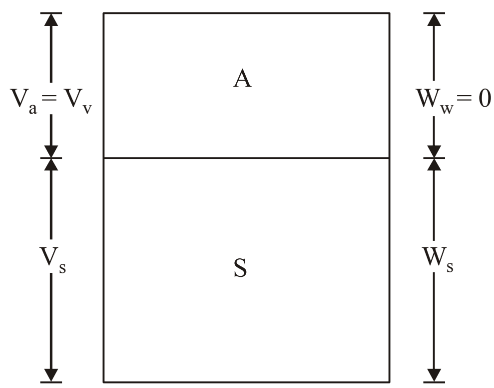


3-Phase

(Partially Saturated)



2-Phase (Saturated)



2-Phase (Dry)

2.1.2 *Water Content*

$$w = \frac{W_w}{W_s} \times 100$$

W_w = Weight of water

W_s = Weight of solids

There can be no upper limit to water content. i.e., $w \geq 0$

2.1.3 *Void Ratio*

$$e = \frac{V_v}{V_s}$$

V_v = Volume of voids

V_s = Volume of solids

Void ratio of fine grained soils are generally higher than those of coarse grained soils.

In general $e > 0$ i.e., no upper limit for void ratio.

2.1.4 *Porosity (% voids)*

$$n = \frac{V_v}{V} \times 100$$

V_v = Volume of voids

V = Total volume of soil

Porosity cannot equal to 100% i.e.,

$0 < n < 100$

Note : In comparison to porosity, void ratio is more frequently used because volume of solids remains same, whereas total volume changes.

2.1.5 *Degree of Saturation*

$$S = \frac{V_w}{V_v} \times 100$$

where V_w = Volume of water

V_v = Volume of voids

$0 \leq S \leq 100$

for perfectly dry soil $S = 0$

for Fully saturated soil $S = 100\%$

2.1.6 *Air Content*

$$a_c = \frac{V_a}{V_v} = 1 - S$$

$$0\% \leq a_c \leq 100\%$$

Percentage air voids (n_a)

$$n_a = \frac{V_a}{V} \times 100$$

$$0\% \leq a_c < 100\%$$

Where

V_a = Volume of air

V = Total Volume

2.1.7 Unit Weight

(a) Bulk Unit Weight

$$\gamma = \frac{W}{V} = \frac{W_s + W_w}{V_s + V_w + V_a}$$

Thus Bulk unit weight is total weight per unit volume.

(b) Dry Unit Weight

is the weight of soil solids per unit volume.

$$\gamma_d = \frac{W_s}{V}$$

Dry unit weight is used as a measure of denseness of soil. More dry unit weight means more compacted soil.

(c) Saturated Unit Weight : It is the ratio of total weight of fully saturated soil sample to its total volume.

$$\gamma_{sat} = \frac{W_{sat}}{V}$$

(d) Submerged Unit Weight : $\gamma' = \gamma_{submerged} = \gamma_{sat.} - \gamma_{water}$. Buoyant unit weight ($\gamma'$). It is the submerged weight of soil solids per unit volume.

γ' is roughly $\frac{1}{2}$ of saturated unit weight.

Note : $\gamma_{solid} > \gamma_{sat} > \gamma_{bulk} > \gamma_{dry} > \gamma_{sub}$

(e) Unit Weight of Solids : It is the ratio weight of solids to the volume of solids present in given soil mass.

$$\gamma_{solid} = \frac{W_s}{V_s}$$

2.1.8 Specific Gravity

Absolute/true Specific Gravity : Specific gravity of soil solid (G) is the ratio of the weight of a given volume of solids to the weight of an equivalent volume of water at 4°C.

$$G = \frac{W_s}{V_s \cdot \gamma_w} = \frac{\gamma_s}{\gamma_w}$$

Apparent or Mass Specific Gravity (G_m) : Mass specific gravity is the specific gravity of the soil mass and is defined as the ratio of the total weight of a given mass of soil to the weight of an equivalent volume of water.

$$G_m = \frac{W}{V\gamma_w} = \frac{\gamma}{\gamma_w}$$

2.2 Some Important Relationships

Relation between W_s, W and w:

$$W_s = \frac{W}{1+w}$$

Relation between e and n

$$n = \frac{e}{1+e} \text{ OR } e = \frac{n}{1-n}$$

Relation between e, w, G and S:

$$Se = w.G$$

Bulk unit weight (γ) in terms of G, e, w and γ_w

$$\gamma = \frac{G\gamma_w(1+w)}{(1+e)}$$

Saturated unit weight (γ_{sat}.) in terms of G, e and γ_w (when S = 1)

$$\gamma_{sat} = \left[\frac{G+e}{1+e}\right].\gamma_w$$

Dry unit weight (γ_d) in terms of G, e and γ_w (when S = 0)

$$\gamma_d = \frac{G\gamma_w}{1+e}$$

Submerged unit weight (γ') in terms of G, e

and γ_w

$$\gamma' = \left(\frac{G-1}{1+e}\right).\gamma_w$$

Relation between γ, γ_d and γ_w

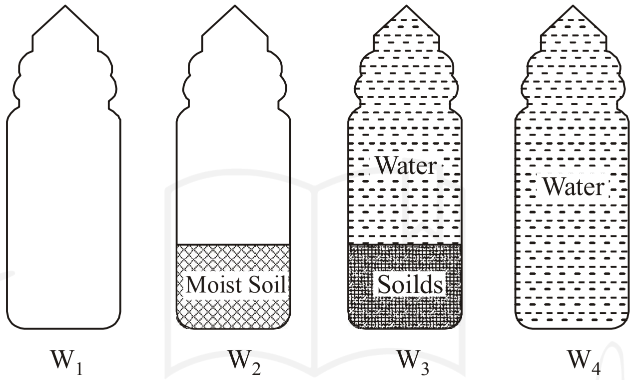
$$\gamma_d = \frac{\gamma}{1+w}$$

2.3 Methods for Determination of Water Content

2.3.1 Pycnometer Method

- Quick method
- Capacity of pycnometer = 900 ml.
- This method is more suitable for cohesionless soils.
- Used when Specific gravity of soil solids is known.

Let
W_1 = Wt. of empty dried pycnometer bottle
W_2 = Wt. of pycnometer + Moist Soil
W_3 = Wt. of pycnometer + Soil + Water
W_4 = Wt. of pycnometer + Water



Now, water content $w = \frac{W_w}{W_s} \times 100$

Weight of water $= (W_2 - W_1) - W_s$ ...(i)

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 will be:

$$W_4 = W_3 - W_s + \frac{W_s}{G\gamma_w} \cdot \gamma_w \qquad \left[\because V_s = \frac{W_s}{\gamma_s} \text{ and} G = \frac{\gamma_s}{\gamma_w}\right]$$

$\Rightarrow$
$$W_s = (W_3 - W_4) \cdot \frac{G}{G-1} \qquad \text{...(ii)}$$

From (i) and (ii)

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

2.3.2 Oven Drying Method

- Simplest and most accurate method
- Soil sample is dried in a controlled temperature (105 – 110° C).
- For organic soils, temperature is about 60° C.
- Sample is dried for 24 hrs.

- For sandy soils, complete drying can be achieved in 4 to 6 hrs.

  Water content is calculated as :

$$w = \frac{W_2 - W_3}{W_3 - W_1} \times 100\%$$

where W_1 = weight of container

W_2 = weight of container + moist sample

W_3 = weight of container + dried sample

Weight of water = $W_2 - W_3$

Weight of solids = $W_3 - W_1$

2.3.3 Calcium Carbide Method/Rapid Moisture Meter Method

Quick method (required 5 to 7 minutes) but may not give accurate results.

The reaction involved is

$$CaC_2 + 2H_2O \rightarrow C_2H_2 \uparrow + Ca(OH)_2$$

Soil sample weight 4 – 6 gms.

The gauge reads water content with respect to wet soil.

i.e.,

$$w_r = \frac{W_w}{W_s + W_w}$$

Water content of the soil is determined indirectly from the pressure of acetylene (C_2H_2) gas formed.

Actual water content

$$w = \frac{w_r}{1 - w_r} \times 100\%$$

2.3.4 Sand Bath Method

- Quick, field method
- Used when electric oven is not available.
- Soil sample is put in a container and dried by placing it in a sand bath, which is heated on kerosene store.
- Water content is determined by using same formula as in oven drying method.

2.3.5 Torsion Balance Moisture Meter Method

- Quick method for use in laboratory.
- Infrared radiations are used for drying samples.
- **Principle :** The torsion wire is prestressed accurately to an extent equal to 100% of the scale reading. Then the sample is evenly distributed on the balance pan to counteract the prestressed torsion and the scale is brought back to zero. As the sample dries, the loss in weight is continuously balanced by the rotation of a drum calibrated directly to read moisture % on wet basis.

2.4 Determination of Specific Gravity of Soil Solids

- Pycnometer method is used.
- Instead of pycnometer. Density bottle (50 ml) OR Flask (500 ml) can also be used.

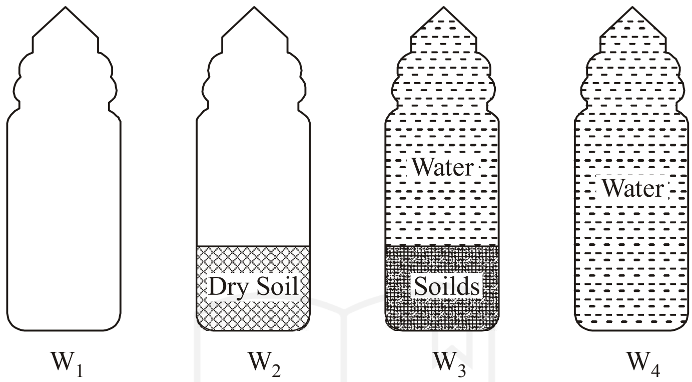
Let,

W_1 = Weight of empty pycnometer

W_2 = Weight of pycnometer + soil sample (oven dried)

W_3 = Weight of pycnometer + soil solids + water

W_4 = Weight of pycnometer + water



$$G = \frac{W_2 - W_1}{(W_2 - W_1) - (W_3 - W_4)}$$

$$\Rightarrow \qquad G = \frac{W_s}{W_s - W_3 + W_4}$$

Note : Specific gravity values are generally reported at 27° C (in India)

If T° C is the test temperature then Sp. Gr. at 27° C is given by,

$$G_{27°C} = G_T \frac{\text{Unit weight of water at T°C}}{\text{Unit weight of water at 27°C}}$$

If kerosene (better wetting agent) is used instead of water then.

$$G = \frac{W_s}{W_s - W_3 + W_4} \times K \qquad [K = \text{Sp. gr. of kerosene}]$$

G can also be determined indirectly by using shrinkage limit.

2.5 Methods for the Determination of in Situ Unit Weight

2.5.1 Core–Cutter Method

- Used in case of non-cohesive soils.
- Cannot be used in case of hard and gravelly soils.
- Method consists of driving a core-cutter (Volume = 1000 cc) into the soil and removing it, the cutter filled with soil is weighed. Volume of cutter is known from its dimensions and in situ unit weight is obtained by dividing soil weight by volume of cutter. $\gamma = \frac{W}{V}$

- If water content is known in laboratory, the dry unit weight can also be computed.

$$\gamma_d = \frac{\gamma}{1 + w}$$

2.5.2 Sand Replacement Method

- Used in case of hard and gravelly soils.
- A hole in ground is made. The excavated soil is weighed. The volume of hole is determined by replacing it with sand. In situ unit weight is obtained by dividing weight of excavated soil with volume of hole.

2.5.3 Water Displacement Method

- Suitable for cohesive soils only, where it is possible to have a lump sample.
- A regular shape, well trimmed sample is weighed. (W_1). It is coated with paraffin wax and again weighed (W_2). The sample is now placed in a metal container filled with water upto the brim. Let the volume of displaced water be V_w. Then volume of uncoated specimen is calculated as,

$$V = V_w - \left(\frac{W_2 - W_1}{\gamma_P}\right)$$

where γ_P = unit weight of paraffin wax

and bulk unit weight of soil $\gamma = \frac{W_1}{V}$

2.6 GRAIN SIZE DISTRIBUTION

Grain size analysis/particle size analysis involves the following methods :

(i) For coarse grained soils – sieve analysis further,

for coarser of coarse – Dry sieve analysis

for finer of coarse – Wet sieve analysis.

(ii) For fine grained soils – sedimentation analysis,

It involves two methods

(a) Hydrometer method

(b) Pipette method.

2.6.1 Analysis of Coarse Grained Soils

(a) Sieve Analysis : (For Coarse Grained Soils)

- The fraction retained on 4.75 mm sieve is called the gravel fraction which is subjected to coarse sieve analysis.
- The material passing 4.75 mm sieve is further subjected to fine sieve analysis if it is sand or to a combined wet sieve and sedimentation analysis if silt and clay sizes are also present.
- **Concept of "Percentage finer"**

$$\text{\% retained on a particular sieve} = \frac{\text{Weight of soil retained on that sieve}}{\text{Total weight of soil taken}} \times 100$$

Cumulative % retained = sum of % retained on all sieves of larger sizes and the % retained on that particular sieve.

"Percentage finer" than the sieve under reference = 100% – Cumulative % retained.

2.6.2 Analysis of Fine Grained Soils

Sedimentation Analysis : Most convenient for determining of grain size distribution of the soil fraction finer than 75 μm.

- The analysis is based on stokes's law.
- If a single sphere is allowed to fall freely through a liquid of infinite extent, its vertical velocity is first increased rapidly under the action of gravity, but a constant velocity called the terminal velocity is reached with in a short time.
- According to stokes law, the terminal velocity is given by,

$$V = \frac{g}{18} \frac{\rho_s - \rho_w}{\mu} D^2$$

ρ_s = density of grains (g/cm^3)

ρ_w = density of water (g/cm^3)

μ = dynamic viscosity of water

g = acceleration due to gravity (cm/s^2)

D = Diameter of grain (cm)

(i) By putting the values at 20° C, we get,

$$V \approx 91\ D^2 \qquad \text{..........at } 20° \text{ C}$$

where v is in cm/s

and D is in mm.

(ii) $$V \approx 107\ D^2 \qquad \text{........at } 27° \text{ C}$$

If 'h' the height through which particle falls in time 't', then

$$\frac{h}{t} = k.D^2$$

$$\therefore \qquad \frac{D_1}{D_2} = \sqrt{\frac{h_1}{h_2}.\frac{t_2}{t_1}}$$

- Stokes law is applicable for spheres of diameter between 0.2 mm and 0.0002 mm.
- Spheres of diameter larger than 0.2 mm falling through water cause turbulence, whereas, for spheres with diameter less than 0.0002 mm. Brownian motion takes place and the velocity of settlement is too small for a accurate measurement.
- **Limitations of Stokes Law :** The analysis is based on the assumption that the falling grain is spherical. But in soils, the finer particles are never truly spherical.
- Stoke's law considers the velocity of free fall of a single sphere in a suspension of infinite extent, whereas, the grain size analysis is usually carried out in a glass jar in which the extent of liquid is limited.
- The finer grains of the soil carry charge on their surface and have a tendency for floc formation. If the tendency to floc formation is not prevented, the diameter measured will be the diameter of the floc and not of the individual grain.

- **Analysis of Fine Grained Soils :** First step involved is preparation of soil sample, which is mixed with water and suspension is made.

Treatment given to soil sample :

- **Pre Treatment :** given before making of soil suspension to remove organic matters and calcium compounds.
- For organic matter – oxidizing agent is used (e.g., H_2O_2)
- For calcium compounds – Acids are used (e.g., HCI)
- **Post Treatment :** Given after preparation of soil suspension to break the flocss formed due to presence of surface electric charges.
- The dispersing (deflocculating) agents used are sodium hexameta phosphate or calgon, sodium oxalate, etc.
- The analysis is carried out by the Hydrometer method or the pipette method. The principle of the test is same in both methods. The difference lies only in the method of making observations.
- **Pipette Method :** In this method, the weight of solids per cc of suspension is determined directly by collecting 10 cc of soil suspension from a specified sampling depth.
- If m_d = dry mass (obtained after drying the sample) then, mass present in unit volume of pipette.

$$= \frac{m_d}{\text{vol. of pipette}(V_p)} = \frac{m_d}{10\text{ml.}(V_p)}$$

- If M_d = total mass of soil dissolved in total volume of water (V). then mass/unit volume = $\frac{M_d}{V}$

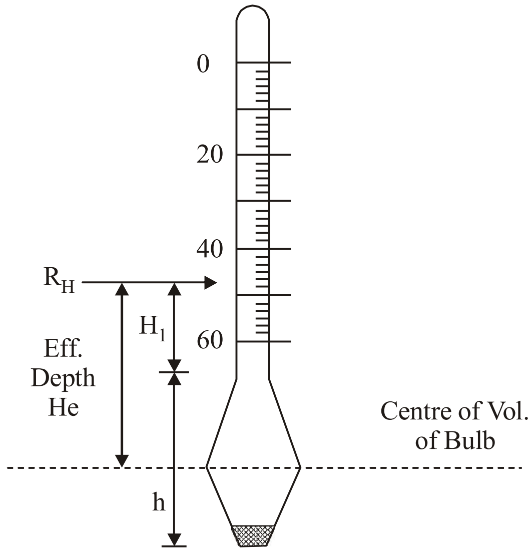
Therefore. % finer is given by $\% \; N = \dfrac{\frac{m_d}{V_p}}{\frac{M_d}{V}}$

- If m is the mass of dispersing agent dissolved in the total volume V. then actual % finer.

$$\% \; N = \frac{\frac{m_d}{V_p} - \frac{m}{V}}{\frac{M_d}{V}}$$

- **Hydrometer Method :** In this method the weight of solids present at any time is calculated indirectly by reading the density of soil suspension.

- Calibration of hydrometer : Establishing a relation between the hydrometer reading R_{11} and effective depth (H_e).
- The effective depth is the distance from the surface of the soil suspension to be the level at which the density of soil suspension is being measured.



- Effective depth is calculated as

$$H_e = H_1 + \frac{1}{2}\left(h - \frac{V_H}{A_j}\right)$$

where,

H_1 = distance (cm) between any hydrometer reading and neck.

h = length of hydrometer bulb

V_H = volume of hydrometer bulb

A_j = area of the cross section of the Jar.

Reading of Hydrometer is related to sp. gr. or density of soil suspension as:

$$G_{ss} = 1 + \frac{R_H}{1000}$$

Thus a reading of R_H = 25 means. G_{ss} = 1.025 and a reading of R_H = – 25 means. G_{ss} = 0.975

% finer is given as:

$$N = \frac{G}{G-1}.\gamma_w.\frac{V}{W}.\frac{R_H}{10}\%$$

where,

G = Specific gravity of soil solids

R_H = Final corrected value of hydrometer

V = Total volume of soil suspension

W = Weight of soil mass dissolved.

Corrections to Hydrometer Reading

Meniscus Correction: (C_m) : Hydrometer reading is always corresponding to the upper level of meniscus. But it should be taken at lower level, Since hydrometer reading increase down word, Therefore, meniscus correction is always positive ($+C_m$).

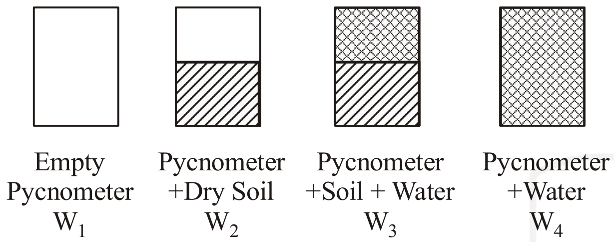
OBJECTIVE SHEET

1. The liquid limit and plastic limit of sample are 65% and 29% respectively. The percentage of the soil fraction with grain size finer than 0.002 mm is 24. The activity ratio of the soil sample is

(a) 0.50 (b) 1.00

(c) 1.5 (d) 2.00

2. The given figure indicate the weights of different pycnometers:



The specific gravity of the solids is given by

(a) $\dfrac{W_2}{W_4 - W_2}$

(b) $\dfrac{W_1 - W_2}{(W_3 - W_4) - (W_2 - W_1)}$

(c) $\dfrac{W_2}{W_3 - W_4}$

(d) $\dfrac{W_2 - W_1}{(W_2 - W_1) - (W_3 - W_4)}$

3. A soil sample has a shrinkage limit of 10% and specific gravity of soil solids as 2.7. The porosity of the soil at shrinkage limit is

(a) 21.2% (b) 27%

(c) 73% (d) 78.8%

4. In a wet soil mass, air occupies one-sixth of its volume and water occupies one-third of its volume. The void ratio of the soil is

(a) 0.25 (b) 0.5

(c) 1.00 (d) 1.50

5 ***Assertion (A):*** If the water table is very near to the subgrade of the road. It will ultimately cause cracking of the road surface.

Reason (R): The consistency of the soil will change from plastic to liquid state leading to its volumetric decrease.

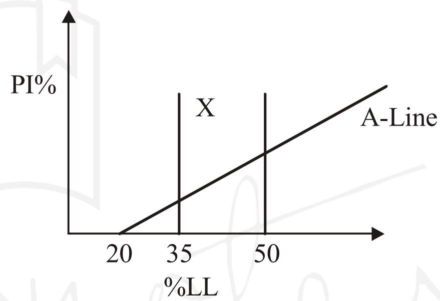
(a) Both A and R are true and R is the correct explanation of A

(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

6. The standard plasticity chart to classify fine grained soils is shown in the given figure.



The area marked X represents

(a) silt of low plasticity

(b) clay of high plasticity

(c) organic soil of medium plasticity

(d) clay of intermediate plasticity

7. A soil sample is having a specific gravity of 2.60 and a void ratio of 0.78. The water content in percentage required to fully saturate the soil at that void ratio would be

(a) 10 (b) 30

(c) 50 (d) 70

8. A dry soil has mass specific gravity of 1.35.If the specific gravity of solids is 2.7, then the void ratio will be

(a) 0.5 (b) 1.0 (c) 1.5 (d) 2.0

9. A clay sample has a void ratio of 0.50 in dry state and specific gravity of solids = 2. 70. Its shrinkage limit will be

(a) 12% (b) 13.5%

(c) 18.5% (d) 22%

10. A soil has liquid limit of 60% plastic limit of 35% and shrinkage limit of 20% and it has a natural moisture content of 50%. The liquidity index of soil is

(a) 1.5 (b) 1.25

(c) 0.6 (d) 0.4

11. Consider the following statements in relation to the given sketch:

Volume (cc)		Weight (g)
0.2	Air	0
0.3	Water	0.3
0.5	Solids	0.1

1. Soil is partially saturated at degree of saturation = 60%
2. Void ratio = 40%
3. Water content = 30%
4. Saturated unit weight = 1.5 g/cc

Which of these statements is/are correct?

(a) 1, 2 and 3 (b) 1, 3 and 4

(c) 2, 3 and 4 (d) 1, 2 and 4

12. A soil has a liquid limit of 45% and lies above the A-line when plotted on a plasticity chart. The group symbol of the soil as per IS soil Classification is

(a) CH (b) CI

(c) CL (d) MI

13. The dry density of a soil is 1.5 g/cc. If the saturation water content were 50% then its saturated density and submerged density would, respectively, be

(a) 1.5 g/cc and 1.0 g/cc

(b) 2.0 g/cc and 1.0 g/cc

(c) 2.25 g/cc and 1.25 g/cc

(d) 2.50 g/cc and 1.50 g/cc

14. 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 meters) to be excavated from the borrow pit will be

(a) 1,87,500 (b) 2,00,000

(c) 2,10,000 (d) 2,25,000

15. The moisture content of a clayey soil is gradually decreased from a large value. What will be the correct sequence of the occurrence of the following limits?

1. Shrinkage limit
2. Plastic limit
3. Liquid limit

Select the correct answer using the codes given below:

(a) 1, 2, 3 (b) 1, 3, 2

(c) 3, 2, 1 (d) 3, 1, 2

16. The initial and final void ratios of a clay sample in a consolidation test are 1 and 0.5, respectively. If initial thickness of the sample is 2.4 cm, then its final thickness will be

(a) 1.3 cm (b) 1.8 cm

(c) 1.9 cm (d) 2.2 cm

17. Given that Plasticity index (PI) of local soil = 15 and PI of sand = zero, for a desired PI of 6, the percentage of sand in the mix should be

(a) 70 (b) 60

(c) 40 (d) 30

18. A clayey soil has liquid limit = w_L; plastic limit = w_p and natural moisture content = w. The consistency index of the soil is given by

(a) $\frac{w_L - w}{w_L - w_P}$ (b) $\frac{w_L - w_p}{w_L - w}$

(c) $\frac{w_P - w}{w_L - w_P}$ (d) $\frac{w_L - w_p}{w_P - w}$

19. Consider the following statements:

1. ‘Relative compaction’ is not the same as ‘relative density’.
2. Vibrofloatation is not effective in the case of highly cohesive soils.
3. ‘Zero air void line’ and 100% saturation line are not identical.

Which of these statements is/are correct?

(a) 1 and 2 (b) 1 and 3

(c) 2 and 3 (d) 3 alone

20. A soil has mass unit weight γ, water content 'w' (as ratio)**.** The specific gravity of soil solids = G, unit weight of water = γ_w; S the degree of saturation of the soil is given by

(a) $S = \dfrac{1+w}{\dfrac{\gamma_w}{\gamma}(1+w) - \dfrac{1}{G}}$

(b) $S = \dfrac{w}{\dfrac{\gamma_w}{\gamma}(1+w) - \dfrac{1}{G}}$

(c) $S = \dfrac{(1+w)}{\dfrac{\gamma_w}{\gamma}(1-w) - \dfrac{1}{G}}$

(d) $S = \dfrac{w}{\dfrac{\gamma_w}{\gamma}(1+w) - \dfrac{1}{wG}}$

21. The saturated and dry densities of a soil are respectively 2000 kg/m^3 and 1500 kg/m^3**.** The water content (in percentage) of the soil in the saturated state would be

(a) 25 (b) 33.33
(c) 50 (d) 66.66

22. If a soil sample of weight 0.18 kg having a volume of 10^{-4} m^3 and dry unit weight of 1600 kg/m^3 is mixed with 0.02 kg of water then the water content in the sample will be

(a) 30% (b) 25%
(c) 20% (d) 15%

23. Match List-I (Terms) with List-II (Formulae) and select the correct answer using the codes given below the lists:

List-I	**List-II**
A. Void Ratio	**1.** $\dfrac{V_V}{V}$
B. Porosity	**2.** $\dfrac{W_W}{W_S}$
C. Degree of saturation	**3.** $\dfrac{V_W}{V_V}$
D. Water content	**4.** $\dfrac{W}{V}$
	5. $\dfrac{V_V}{V_S}$

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

24. If an unconfined compressive strength of 4 kg/cm^2 in the natural state of clay reduces by four times in the remoulded state, then its sensitivity will be

(a) 1 (b) 2
(c) 4 (d) 8

25. The value of porosity of a soil sample in which the total volume of soil grains is equal to twice the total volume of voids would be

(a) 75% (b) 66.66%
(c) 50% (d) 33.33%

26. A soil has a liquid limit of 40% and plasticity index of 20%. The plastic limit of the soil will be

(a) 20% (b) 30%
(c) 40% (d) 60%

27. A sample of saturated sand has a dry unit weight of 18 kN/m^3 and a specific gravity of 2.7. If density of water is 10 kN/m^3, the void ratio of the soil sample will be

(a) 0.5 (b) 0.6
(c) 0.4 (d) 0.9

Common Data for Questions :28 & 29

For constructing an embankment, the soil is transported from a borrow area using a truck which can carry 6m^3 of soil at a time. The details are as follows.

Property	Borrow area	Truck (loose)	Field (compacted)
Bulk density (g / cc)	1.66	1.15	1.82
Water content (%)	8	6	14

28. The quantity of soil to be excavated from the borrow pit, in m^3 for a compacted earth fill of 100 m^3 is

(a) 104 cum (b) 146 cum
(c) 98 cum (d) 87 cum

29. The number of truck loads of soil required to obtain 100m^3 of compacted earth fill

(a) 12 nos. (b) 56 nos.
(c) 25 nos. (d) 33 nos

30. When the product of rock weathering is not transported as sediment but remains in place, is called

(a) alluvial soil (b) glacial soil

(c) residual soil (d) aeoline soil

31. Aeolian soils are

(a) Residual soils (b) Wind deposits

(c) Gravity deposits (d) Water deposits

32. If the porosity of a soil sample is 20%, the void ratio is

(a) 0.20 (b) 0.80

(c) 1.00 (d) 0.25

33. Consistency Index for a clayey soil is [{LL= Liquid Limit, PI = Plasticity Index, w = natural moisture content]

(a) $\frac{LL - w}{PI}$ (b) $\frac{w - PL}{PI}$

(c) LL – PL (d) 0.5 w

34. If soil is dried beyond its shrinkage limit, it will show

(a) Large volume change

(b) Moderate volume change

(c) Low volume change

(d) No volume change

35. The toughness index of clayey soils is given by

(a) Plasticity index/Flow index

(b) liquid limit /Plastic limit

(c) Liquidity index /plastic limit

(d) Plastic limit/Liquidity index

36. A soil sample in its natural state has mass of 2.290 kg and a volume of 1.15×10^{-3} m^3. After being oven dried, the mass of the sample is 2.035 kg. G_s for soil is 2.68. The void ratio of the natural soil is

(a) 0.40 (b) 0.45

(c) 0.55 (d) 0.53

37. Principle involved in the relationship between submerged unit weight and saturated weight of a soil is based on

(a) Equilibrium of floating bodies

(b) Archimedes' principle

(c) Stokes' law

(d) Darcy's law

38. A soil sample has a void ratio of 0.5 and its porosity will be close to

(a) 50% (b) 66%

(c) 100% (d) 33%

39. A borrow pit soil has a dry density of 17 kN/m^3. How many cubic meters of this soil will be required to construct an embankment of 100 m^3 volume with a dry density of 16 kN/m^3.

(a) 94 m^3 (b) 106 m^3

(c) 100m^3 (d) 90m^3

40. The void ratio and specific gravity of a soil are 0.65 and 2.72 respectively. The degree of saturation (in percent) corresponding to water content of 20% is

(a) 65.3 (b) 20.9

(c) 83.7 (d) 54.4

41. A dry soil sample has equal amounts of solids and voids by volume. It void ratio and porosity will be

	Void ratio	**Porosity (%)**
(a)	1.0	100%
(b)	0.5	50%
(c)	0.5	100%
(d)	1.0	50%

42. The plasticity index and the percentage of grain size finer than 2 microns of a clay sample are 25 and 15, respectively. Its activity ratio is

(a) 2.5 (b) 1.67

(c) 1.0 (d) 0.6

43. A soil sample having a void ratio of 1.3, water content of 50% and a specific gravity of 2.60, is in a state of

(a) partial saturation (b) full saturation

(c) over saturation (d) under saturation

44. The natural void ratio of a sand sample is 0.6 and its density index is 0.6. If its void ratio in the loosest state is 0.9, then the void ratio in the densest state will be

(a) 0.2 (b) 0.3

(c) 0.4 (d) 0.5

45. Which one of the following correctly represents the dry unit weight of a soil sample which has a bulk unit weight of γ_t at a moisture content of w%?

(a) $\frac{w\gamma_t}{100}$ (b) $\gamma_t\left(1+\frac{w}{100}\right)$

(c) $\gamma_t\left(\frac{100}{100+w}\right)$ (d) $\frac{\gamma_t(100-w)}{100}$