**1. Draw the phase diagram of the soil**



**2. What Is Void Ratio?**

‘Void ratio’ of a soil mass is defined as the ratio of the volume of voids to the volume of solids in the soil mass.

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**3. What is Porosity?**

‘Porosity’ of a soil mass is the ratio of the volume of voids to the total volume of the soil mass.



**4. Define Degree of saturation.**

‘Degree of saturation’ of a soil mass is defined as the ratio of the volume of water in the voids to the volume of voids.

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**5. Define percentage of air voids .**

‘Percent air voids’ of a soil mass is defined as the ratio of the volume of air voids to the total volume of the soil mass.



**6. Define air content.**

‘Air content’ of a soil mass is defined as the ratio of the volume of air voids to the total volume of voids.



**7.Define Water Content**

‘Water content’ or ‘Moisture content’ of a soil mass is defined as the ratio of the weight of water to the weight of solids (dry weight) of the soil mass.

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**8.Define *Bulk* (*Mass*) *Unit Weight.***

‘Bulk unit weight’ or ‘Mass unit weight’ of a soil mass is defined as the weight per unit volume of the soil mass.



**9. Define Unit Weight of Solids**

‘Unit weight of solids’ is the weight of soil solids per unit volume of solids alone. It is also sometimes called the ‘absolute unit weight’ of a soil



**10.Define unit weigt of water.**

 ‘Unit weight of water’ is the weight per unit volume of water.





**11. Define Submerged (Buoyant) Unit Weight**

The ‘Submerged unit weight’ or ‘Buoyant unit weight’ of a soil is its unit weight in the submerged condition.



**12. Define Dry Unit Weight**

The ‘Dry unit weight’ is defined as the weight of soil solids per unit of total volume ; the former is obtained by drying the soil, while the latter would be got prior to drying.



**13. Define Specific Gravity of Solids**

The ‘specific gravity of soil solids’ is defined as the ratio of the unit weight of solids to the unit weight of water .



**14. Define: Density Index or Relative Compaction .**

The density index is defined as the ratio of the differences between the voids ratio of the soil in the loosest state and its natural voids ratio ratio & to the differences between voids ratio in the loosest and densest states.



**15. What are the methods available for sieve analysis?**

a) Dry sieve Analysis

b) Wet sieve analysis

**16. Define Atterberg limits or consistency limits.**

The limit at which the soil, changes from one state to another state, is termed as atterberg limits.

**16. Define Liquid limit.**

 ‘Liquid limit’ (*LL* or *wL*) is defined as the arbitrary limit of water content at which the soil is just about to pass from the plastic state into the liquid state. In other words, the liquid limit is the minimum moisture content at which the soil tends to flow as a liquid.

**17. What is plastic limit?**

‘Plastic limit’ (*PL* or *wp*) is the arbitrary limit of water content at which the soil tends to pass from the plastic state to the semi-solid state of consistency. Thus, this is the minimum water content at which the change in shape of the soil is accompanied by visible cracks.

**18. Define Shrinkage Limit**

‘Shrinkage limit’ (*SL* or *ws*) is the arbitrary limit of water content at which the soil tends to pass from the semi-solid to the solid state. In other words, it is the maximum water content at which further reduction in water content will not cause a decrease in volume of the soil mass.

***19.Define Plasticity Index***

It is the difference between liquid and plastic limits.

*PI*(or *Ip*) = (*LL* – *PL*) = (*wL* – *wL*)

**20. What is compaction?**

‘Compaction’ of soil may be defined as the process by which the soil particles are artificially rearranged and packed together into a state of closer contact by mechanical means in order to decrease its porosity and thereby increase its dry density. This is usually achieved by dynamic means such as tamping, rolling, or vibration. The process of compaction involves the expulsion of air only.

**21. Aim of the compaction**

i) To increase the shear strength soil

ii) To improve stability and bearing capacity

iii) To reduce the compressibility

iv) To reduce the permeability of the soil.

***22. Briefly explain soil classification system.***



**Indian Standard Soil Classification System**

IS: 1498-1970 describes the Indian Standard on Classification and Identification of Soils for general engineering purposes .

Soils shall be broadly divided into three divisions :

**1. *Coarse-grained Soils:***More than 50% of the total material by weight is larger than 75-µIS Sieve size.

**2. *Fine-grained Soils:***More than 50% of the total material by weight is smaller than 75-µIS Sieve size.

**3. *Highly Organic Soils and Other Miscellaneous Soil Materials****:* These soils contain large percentages of fibrous organic matter, such as peat, and particles of decomposed vegetation. In addition, certain soils containing shells, concretions, cinders and other non-soil materials in sufficient quantities are also grouped in this division.

**Coarse-grained soils shall be divided into two sub-divisions :**

**(*a*) *Gravels*:** More than 50% of coarse fraction is larger than 4.75 mm IS Sieve size.

**(*b*) *Sands*:** More than 50% of Coarse fraction is smaller than 4.75 mm IS Sieve size.

**Fine-grained soils shall be divided into three sub-divisions:**

**(*a*) Silts and clays of low compressibility :** Liquid limit less than 35% (L).

**(*b*) Silts and clays of medium compressibility :** Liquid limit greater than 35% and less than 50% (I).

**(*c*) Silts and clays of high compressibility:** Liquid limit greater than 50% (H).

The coarse-grained soils shall be further sub-divided into eight basic soil groups, and the fine-grained soils into nine basic soil groups; highly organic soils and other miscellaneous soil materials shall be placed in one group.

***Classification Criteria for Fine-grained Soils***

The plasticity chart forms the basis for the classification of fine-grained soils, based on the laboratory tests. Organic silts and clays are distinguished from inorganic soils whichhave the same position on the plasticity chart.



***23.Briefly Explain In-Situ* Or Field Compaction Methods.**

**ROLLERS**

***(a) Smooth-wheeled rollers:***This type imparts static compression to the soil. There may be two or three large drums; if three drums are used, two large ones in the rear and one in the front is the common pattern. The compaction pressure is relatively low because of a large contact area. This type appears to be more suitable for compacting granular base courses and paving mixtures for highway and airfield work rather than for compacting earth fill.

**(*b*) *Pneumatic-tyred rollers:***This type compacts primarily by kneading action. The usual form is a box or container—mounted on two axles to which pneumatic-tyred wheels are fitted;the front axle will have one wheel less than the rear and the wheels are mounted in a staggered fashion so that the entire width between the extreme wheels is covered. The weight supplied by earth ballast or other material placed in the container may range from 120 kN to 450 kN ,although an exceptionally heavy capacity of 2000 kN may be occasionally used. This type is suitable for compacting most types of soil and has particular advantages with wet cohesive materials.

**(*c*) *Sheepsfoot rollers:***This type of roller consists of a hollow steel drum provided with projecting studs or feet; the compaction is achieved by a combination of tamping and kneading.The drum can be filled with water or sand to provide and control the dead weight. As rolling is done, most of the roller weight is imposed through the projecting feet.



Initially, the projections sink into the loose soil and compact the soil near the lowest portion of the layer. In subsequent passes with the roller, the zone of compaction continues to rise until the surface is reached, when the roller is said to “Walk-out”.

This type of roller is found suitable for cohesive soils. It is unsuitable for granular soils as the studs tend to loosen these continuously. The tendency of void formation is more in soils

Compacted with sheeps foot rollers.

**(*d*) *Grid rollers:***This type consists of rolls made from 38 mm steel bars at 130 mm centres, with spaces of 90 mm square. The weight of the roller ranges from 55 kN (5.5 t) to 110kN (11 t). This is usually a towed unit which is suitable for many types of soil including wet clays and silts.

 ***RAMMERS***

This type includes the dropping type and pneumatic and internal commission type, which are also called ‘frog rammers’. They weigh up to about 1.5 kN (150 kg) and even as much as 10kN (1 t) occasionally. This type may be used for cohesion less soils, especially in small restricted and confined areas such as beds of drainage trenches and back fills of bridge abutments.

***VIBRATORS***

These are vibrating units of the out-of-balance weight type or the pulsating hydraulic type. Such a type is highly effective for cohesion less soils. Behind retaining walls where the soil is confined, the backfill, much deeper in thickness, may be effectively compacted by vibration type of compactors.

A few of this type are dealt with below:

(*a*) *Vibrating drum:* A separate motor drives an arrangement of eccentric weights so as to cause a high-frequency, low-amplitude, vertical oscillation to the drum. Smooth drums as well as sheepsfoot type of drums may be used. Layers of the order of 1 metre deep could be compacted to high densities.

(*b*) *Vibrating pneumatic tyre:* A separate vibrating unit is attached to the wheel axle. The ballast box is suspended separately from the axle so that it does not vibrate. A 300 mm thick layer of granular soil will be satisfactorily compacted after a few passes.

(*c*) *Vibrating plate:* This typically consists of a number of small plates, each of which is operated by a separate vibrating unit. These have a limited depth of effectiveness and hence

are used in compacting granular base courses for highway and airfield pavements.

(*d*) *Vibroflot:* A method suited for compacting thick deposits of loose sandy soil is called the ‘vibroflotation’ process. The improvement of density is restricted to the surface zone in the

case of conventional compaction equipment. The vibroflotation method first compacts deep zone in the soil and then works its way towards the surface. A cylindrical vibrator weighing

about 20 kN (2 t) and approximately 400 mm in diameter and 2 m long, called the ‘Vibroflot’, is suspended from a crane and is jetted to the depth where compaction is to start.

The jetting consists of a water jet under pressure directed into the earth from the tip of the vibroflot; as the sand gets displaced, the vibroflot sinks into the soil. Depths up to 12 m can

be reached. After the vibroflot is sunk to the desired depth, the vibrator is activated. The compaction of the soil occurs in the horizontal direction up to as much as 1.5 m outward from

the vibroflot. Vibration continues as the vibroflot is slowly raised toward the surface. As this process goes on, additional sand is continually dropped into the space around the vibroflot to

fill the void created. To densify the soil in a given site, locations at approximately 3-m spacings are chosen and treated with vibroflotation.

***24. Compare Compaction Versus Consolidation***



**25. What are the factors affecting compaction? Explain in brie**f?

i) Water content

a) At lower water content, the soil is stiff and others more resistance to compaction.

b) As water content is increases, the soil particles get lubricated.

c) Dry density of the soil increases with increases in the water content till the optimum water content is reached.

d) After the optimum water content is reached, it becomes more difficult to force air out and to further reduce the air voids.

ii) Amount of compaction

At water content less than the optimum, the effect of increased compaction is more predominant. At water content more than optimum, the volume of air voids

becomes almost constant and the effect of increased compaction is of significant.

iii) Type of soil

In general, coarse – grained soils can be compacted to higher dry density than fine grained soils. With the addition of even a small quantity of fines to a coarsegrained soil, the soil attains a much higher dry density for the same compactive effort.

Cohesive soils have air voids .Heavy clays of very high plasticity have very low dry density and very high optimum water content

iv) Method of compaction

The dry density achieved depends not only upon the amount of compactive effort; the dry density will depend upon whether the method of compaction utilizes

kneading action, dynamic or static action.

v)AdmixtureThe compaction characteristic of the soils is improved by adding other materials

known as admixtures. Ex; lime, cement and bitumen.

***26. An earth embankment is compacted at a water content of 18% to a bulk density of 19.2 kN/m3. If the specific gravity of the sand is 2.7, find the void ratio and the degree of saturation of the compacted embankment. ***

***27.A moist soil sample compacted into a mould of 1000 cm3 capacity and weight 35 N, weighs 53.5 N with the mould. A representative sample of soil taken from it has an initial weight of 0.187 N and even dry weight of 0.1691 N. Determine (a) water content, (b) wet density, (c) dry density, (d) void ratio and (e) degree of saturation of sample.***

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***28.One cubic metre of wet soil weighs 19.80 kN. If the specific gravity of soil particles is 2.70 and water content is 11%, find the void ratio, dry density and degree of saturation.***

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***29.* Determine the (*i*) Water content, (*ii*) Dry density, (*iii*) Bulk density, (*iv*) Void ratio and (*v*) Degree of saturation from the following data :**

***Sample size 3.81 cm dia. × 7.62 cm ht.***

***Wet weight = 1.668 N***

***Oven-dry weight = 1.400 N***

***Specific gravity = 2.7 Wet weight, W = 1.668 N***

***Oven-dry weight, Wd = 1.400 N***

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