BAPATLA ENGINEERING COLLEGE (Autonomous) :: BAPATLA

CIVIL ENGINEERING DEPARTMENT

SCHEME OF EVALUATION

III/IV B.Tech (Regular) Degree Examination

(Fifth Semester-February-2021)

Subject: **SOIL MECHANICS**

Subject Code : **18CE506**

Prepared by	Verified by	Verified by
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Hall Ticket Number

III/IV B.Tech (Regular) Degree Examination

February, 2021 | **Civil Engineering**

Fifth Semester | **SOIL MECHANICS**

Time: Three Hours | Maximum: 50 Marks

Answer all Questions from PART-A (1 x 10 = 10 Marks)

Answer *ANY FOUR* questions from *PART-B* (4 x 10 = 40 Marks)

Part- A

1. Answer all questions
   - a) What are the types of soil formation? (CO1)
   - b) Differentiate void ratio and porosity (CO1)
   - c) State Darcy's law and it's validity (CO2)
   - d) Draw the plasticity chart (CO2)
   - e) What are the different types of heads in flow condition? (CO2)
   - f) Define degree of compaction and zero air void lines (CO3)
   - h ~~g)~~ Differentiate compaction and consolidation of soils (CO4)
   - i ~~h)~~ What are the types of drainage conditions in triaxial tests? Explain briefly. (CO4)
   - j ~~i)~~ What are the different laboratory and field tests to be conducted to find shear strength of soils and their suitability? (CO4)
   - g ~~j)~~ Differentiate standard proctor and modified proctor tests. (CO3)

Part - B

2. a) Explain in detail how soils are formed and various types of soils formed by the methods of transportation and deposition. (CO1) **(5 M)**

   b) Explain in detail regional soil deposits of India (CO1) **(5 M)**

3. a) Derive relationship among void ratio(e), degree of saturation (s), water content (w) and specific gravity (G) (CO1) **(5 M)**

   b) An embankment having a total volume of $15000 m^3$ has a water content of 16% and dry density of 1.75g/cc. It was constructed from a barrow pit having water content 13% and void ratio 0.6. Calculate the quantity of soil which was excavated for construction of above embankment. Take G = 2.68 (CO1) **(5 M)**

4. a) Explain in detail IS soil classification system and draw flow chart (CO2) **(5 M)**

   b) What are the factors affecting permeability of soils ? Explain in detail (CO2) **(5M)**

5. a) Explain falling head method of determining coefficient of permeability with a neat diagram (CO2) **(5 M)**

   b) A constant head permeability test was conducted on a cylindrical specimen of diameter 7.5 cm having a head of 24.7 cm over a sample of length 18 cm. the quantity of water collected in 60 sec was 626 ml. Calculate coefficient of permeability. (CO2) **(5 M)**

6. a) Write a short notes on principle of effective stress and physical meaning of effective stress

(CO3) (**5 M**)

b) Derive equation for critical hydraulic gradient for quick sand condition (CO3) (**5 M**)

7. a) Explain in detail various factors affecting compaction (CO3) (**5 M**)

b) Calculate the maximum dry density and optimum water content for the following results obtained from a standard proctor test (SPT) of a sample. Volume of mould is 950 ml.

Water content (%)	12	14	16	18	20	22
Mass of wet soil (kg)	1.68	1.85	1.91	1.87	1.87	1.85

(CO3) (**5 M**)

8. a) Compare the two methods of determining coefficient of consolidation. (CO4) (**5 M**)

b) A 8 m thick clay layer with single drainage settles by 120 mm in two layers. The coefficient of consolidation for this clay was 6 x 10 $^{-3}$cm^2/sec. Calculate the ultimate consolidation settlement. (CO4) (**5 M**)

9. a) Explain three types of triaxial tests based on drainage conditions (CO4) (**5 M**)

b) A series of direct shear tests was conducted on a soil, each test was carried out till the sample failed. The following results were obtained. Determine strength parameters.(CO4)(**5M**)

Sample No.	Normal stress (kN/m^2)	Shear stress (kN/m^2)
1	15	18
2	30	25
3	45	32

SCHEME OF EVALUATION

III/IV B.Tech (Regular) Degree Examination

18CE405 - Soil Mechanics

1. **Answer all questions** **(10x1 = 10 Marks)**

a) Soil formation is due to weathering of rocks. Some of the products of rock weathering are still located at the parent rock and these are called residual soils. Some of the rock weathering are transported from its place of origin by wind, ice, water or any other agency and redeposited, is called a transported soil.

b) **Void ratio :** Void ratio (e) of a soil is the ratio of the volume of voids to the volume of solid. Thus, e =Vv/Vs

Porosity: The porosity (n) of a soil is the ratio of the volume of voids to the total volume of the soil. Thus, n = (Vv/ V} x100

The porosity cannot be greater than 100%. As this the ratio of two volumes, it is unit less.

c) **Darcy's Law:**

For flow through soils, V=ki or Q = k.i.A

Where V = discharge velocity of flow = Q/A = Discharge /Area

i = hydraulic gradient = Δh/l = loss of head/seepage length

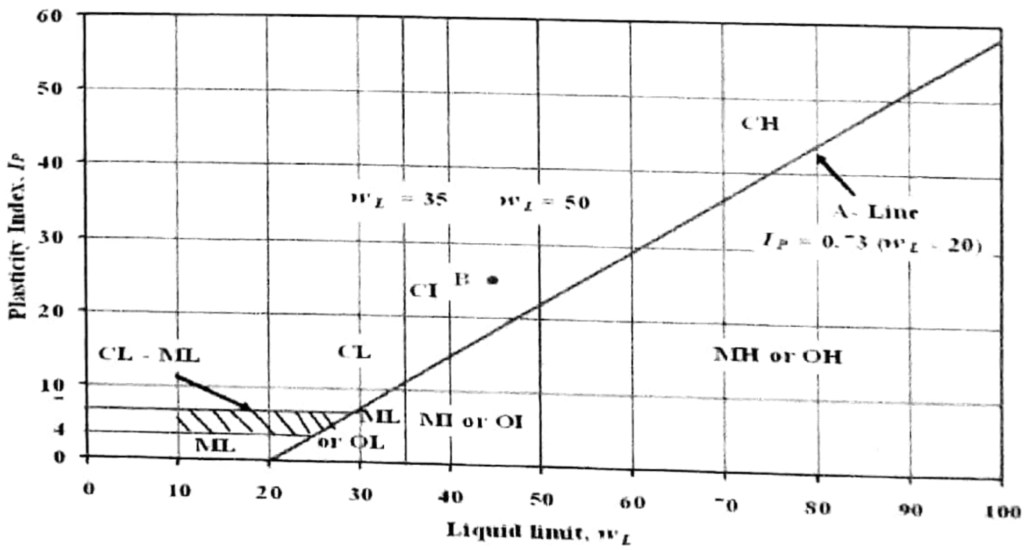
A = perpendicular coss sectional area

k = coefficient of permeability – cm/sec or m/sec

Validity of Darcy's Law:

- For laminarflow conditions only
- Generally, laminar flow will prevail in clays, silts and fine sands
- Flow will be laminar as long as Reynolds number <1, when Re is calculated considering characteristic length as the average particle diameter.

d) Plasticity Chart



Plasticity chart as per Indian Standard Soil Classification System

e) **Different types of heads in flow condition** :

- Velocity head ($v^2/2g$):
- Pressure head (p/γ_w): The pressure head is the pressure of water at the point p divided by its unit weight γ_w
- Elevation head (z) : The elevation head at a point is the vertical distance of that point measured from an assumed datum plane whch is normally taken at the tail water elevation, for convenience.

f) **Degree of compaction** : The degree of compaction of a soil is measured in terms of the dry density, which is the mass of soil solids per unit volume of the soil. The degree of compaction contributes to the shear strength, permeability, compressibility, and sustainability for repeated loads.

Zero air void lines : Zero air void density is calculated for different water content values and plotted alongside the compaction curve, a zero air void curve is obtained (S=100% curve). The zero air void line is obtained for S=100%.

g) **Compaction :** Compaction is a rapid process of reduction of volume by mechanical means such as rolling , tamping and vibration. Compaction means pressing the soil particles close to each other by mechanical methods. Air during compaction is expelled from the void space in the soil mass and therefore the mass density is increased.

Consolidation of soils: In a saturated soil mass having its void filled with incompressible water, decrease in volume or compression can take place when water is expelled out of the voids. Such a compression resulting from a long time static load and the consequent escape of pore water is termed as consolidation

h) **Drainage conditions in triaxial tests:**

1. **Unconsolidated-Undraiined Condition:** In this type of test, no drainage is permitted during the consolidation stage .the drainage is also not permitted in the shear stage.
2. **Consolidated Undrained Condition:** The specimen is allowed to consolidate in the first stage. The drainage is permitted until the consolidation is complete
3. **Consolidated Drained Condition:** The drainage of the specimen is permitted in both the stages

i) **Laboratory tests to be conducted to find shear strength of soils:**

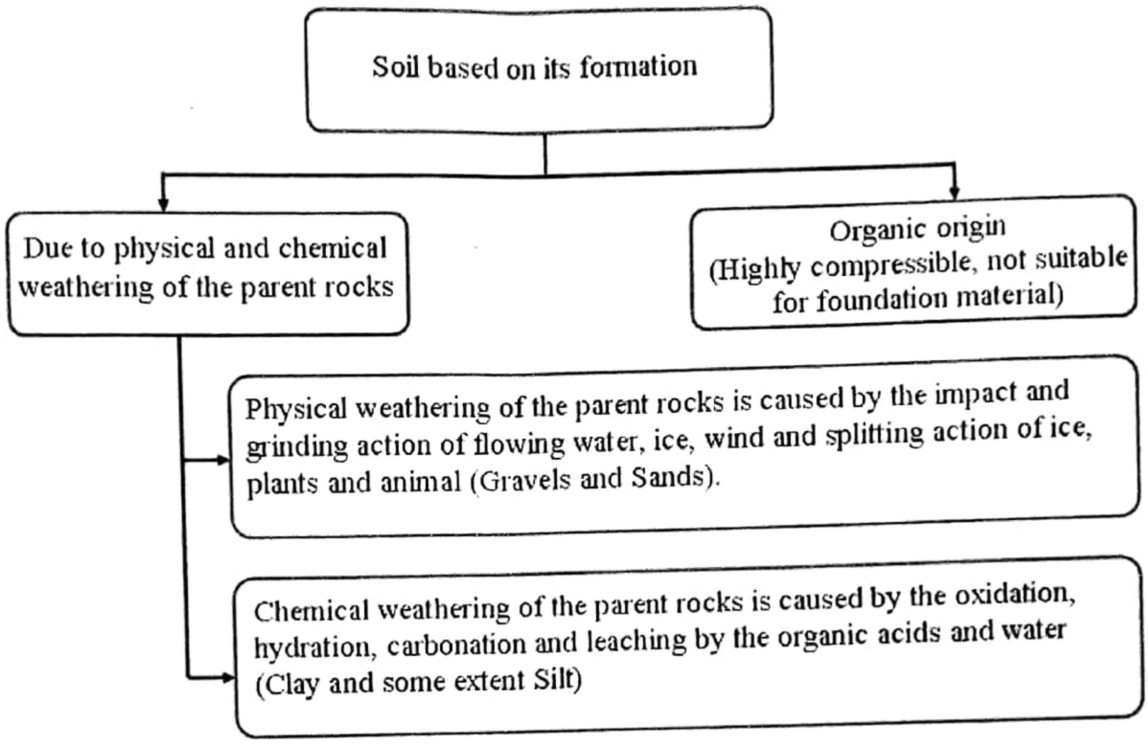
1. Direct shear test : for sandy soils and c-ϕ soils
2. Uncnfined compressiontest : for stiff clay soils
3. Triaxial tests : for stiff to hard clay soils
4. Vane shear test : for soft soils

Field tests : Field vane tests : for soft soils

j) Differences between standard proctor and modified proctor tests.

Standard proctor test	**Modified proctor test**
Known as Indian standard light compaction	Known as Indian standard heavy compaction
Results used for highways, embankments, canal banks	Results used for modern expressways, runways
Mould volume is 1 litre, compaction in 3 layers, each layer is given 25 blows, hammer weight is 2.60 kg and height of fall 31 cm	Mould capacity 2.25 litre, compaction in 5 layers, each layer is given 56 blows, hammer weight is 4.90kg and height of fall 45 cm

2(a)



Soil formation and types

Depending upon the way of formation, the transported soil can be divided into five types:

i) Alluvial deposit: The Alluvial soils are deposited from the suspension of flowing water.
ii) Aeolian deposit: The soils are called Aeolian if they have been transported by wind.
iii) Glacial deposit: If the soils have been transported by ice are called Glacial deposit.
iv) Lacustrine deposit: Lacustrine soils have been deposited from the suspension in still and fresh water of lakes.
v) Marine deposit.. Marine soils have been deposited from the suspension in sea water.

b) **Regional Soils of India:**

The soils of India can be broadly divided into the following groups, based on the climatic conditions, topography and geology of their formation:

(i) **Marine deposits:** These soils are found along the coast in narrow tidal plains. These are very soft with low shear strength and high compressibility. Construction of structures on these soils is very challenging due to low bearing capacity and excessive settlement.

(ii) **Laterites and lateritic soils:** These soils are found in Kerala, Karnataka, Maharashtra, Orissa, and West Bengal. These are formed due to the decomposition of rocks and reddish in color.

(iii) **Black cotton soils:** These are expansive soils found in Maharashtra, Gujarat, Madhya Pradesh, Karnataka, Tamil Nadu, Andhra Pradesh and Uttar Pradesh.

(iv) **Alluvial soils:** These are found in Assam to Punjab covering a large part of northern India. These soils have alternating layers of sand, silt and clay.

(v) **Desert soils:** These are found in large parts of Rajasthan.

(vi) **Boulder deposits:** These are found in the sub-Himalayan regions of Himachal Pradesh and Uttar Pradesh.

3(a) **Relationship between e,w,G and S**

$e = (V_v / V_s)$

$= (V_v / V_w) . (V_w / V_s)$

$= (V_v / V_w). [(W_w/\gamma_w) / (Ws/\gamma_s)]$

$= (V_v / V_w). (W_w /W_s). (G_s. \gamma_w / \gamma_s)$

$= (1/S).w.G_s$

Therefore $e = wG_s / S \simeq \frac{wG}{S}$

b) **Given Data:**

total volume = 15000m^3

water content = 16%

dry density γ_d = 1.75 g/cc

water content of borrow pit = 13%

void ratio (e) = 0.6

G = 2.68

To determine : Quantity of soil which was excavated for construction of embankment.

Solution:

Dry unit weight of the embankment soil : W_s/V = 1.75 g/cc = 1.75 t/m^3

i.e., V=1 cum and W_s = 1.75 t

hence for 15000 m^3 , W_s required is 15000 x 1.75 = 26250t

Dry unit weight of the soil in borrow pit, $\gamma_d = G\, \gamma_w / (1+e)$ = 2.68x1.0 / (1+ 0.6)

= **1.675 t/ m^3**

$\gamma_d = W_s / V$ = 1.675 t/m^3

for W_s , 26250t, the volume of soil that has to be taken out from the borrow pit.

$V = W_s/ \gamma_d$ = 26250/1.675 t/m^3 = **15671 t/m^3**

W_s = 26250 t, both from the borrow pit which has a natural moisture content (w) of 16% given by W = 26250 (1 + 0.16) = **30450 t**

4 (a) **Indian Standard Soil Classification System (ISSCS)**

According to this system, the symbols of the various soils are as: Gravel (G), Sand (S), Silt or Silty (M), Clay or Clayey (C), Organic (O), Peat (Pt), Well graded (W), Poorly graded (P). To classify the fine-grained soil, plasticity chart (as shown in Figure 2) is used. The difference between the plasticity charts used for Unified Soil Classification System (USCS) and Indian Standard Soil Classification System (ISSCS) is that in USCS, the soil is classified as High Plasticity (if liquid limit >50%) or Low Plasticity (if liquid limit < 50%) soil, but in ISSCS, the soil is classified as High Plasticity (if liquid limit >50%) or Intermediate Plasticity (if liquid limit is in between 35% to 50%) or Low Plasticity (if liquid limit < 35%). For example, if a soil sample has liquid limit (w_L) 45% and plasticity index (I_P) 25, according to the Unified Soil Classification System (USCS) the point is above 'A' line and it is classified as CL. However, according to Indian Standard Soil Classification System (ISSCS) the point is also above 'A' line, but it is classified as CI.

Figure 3 shows the flow chart to classify a soil according to the Indian Standard Soil Classification System. Figure 4 and Figure 5 show the classification of coarse-grained and fine-grained soil, respectively as per Indian Standard Soil Classification System.

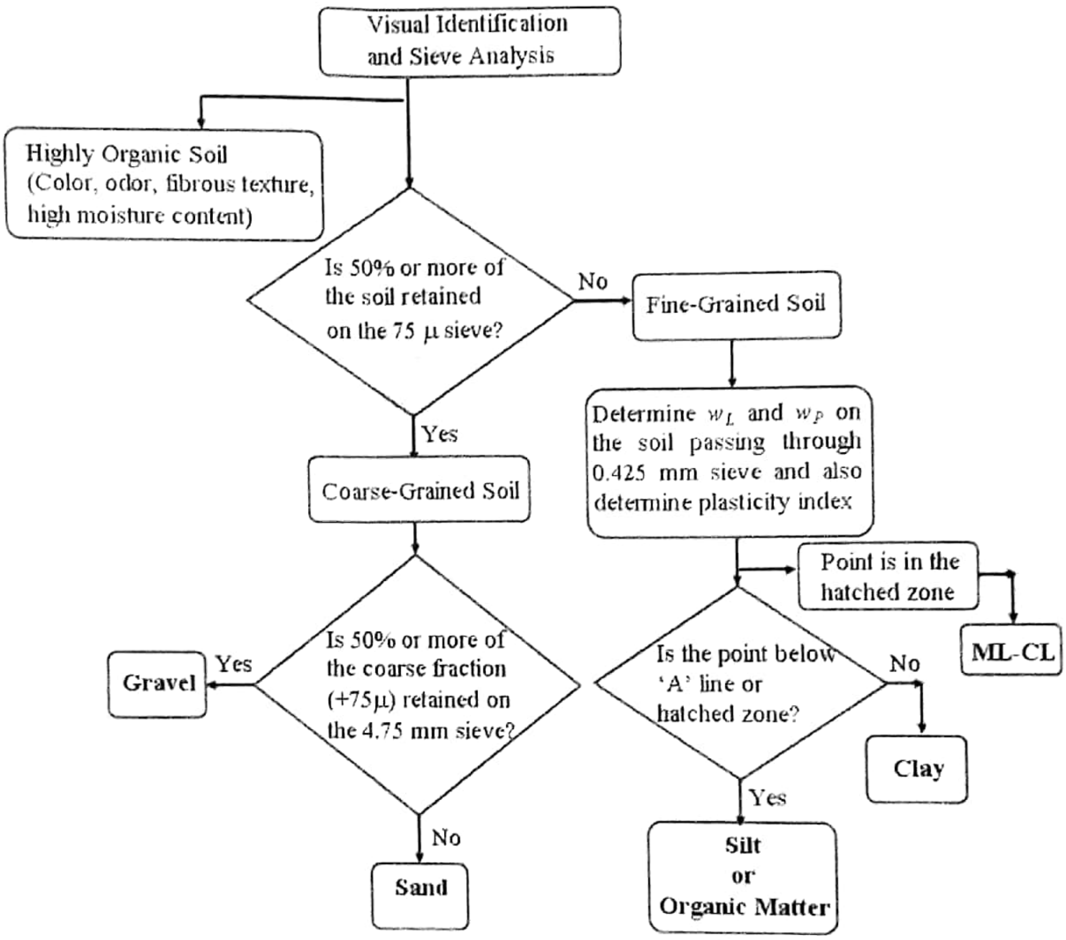
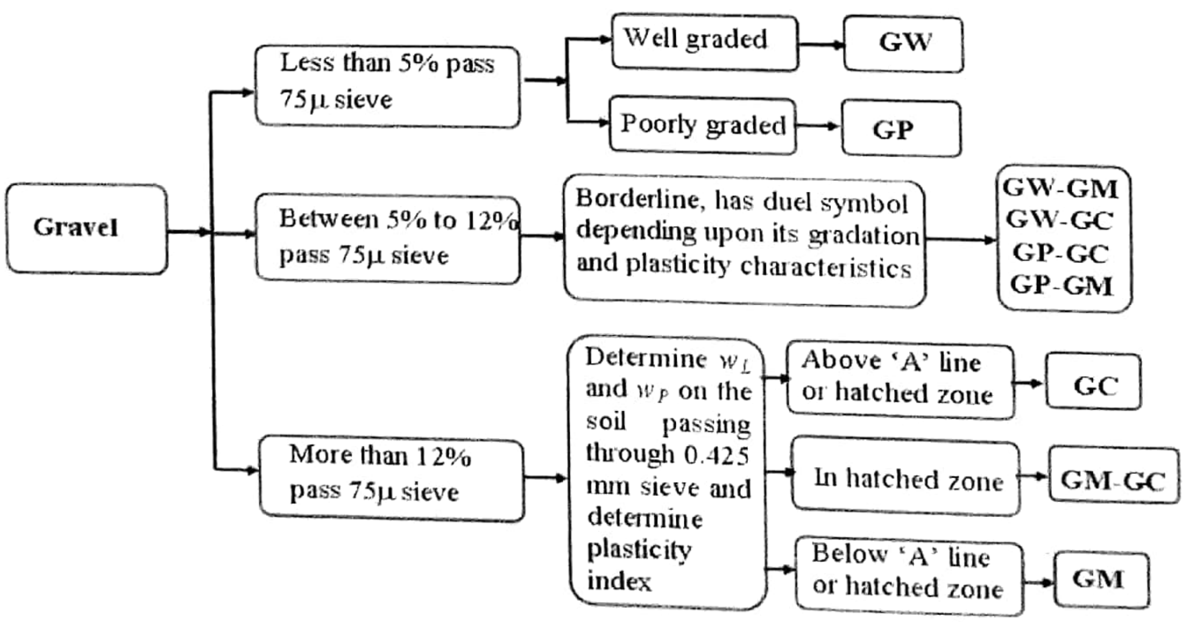
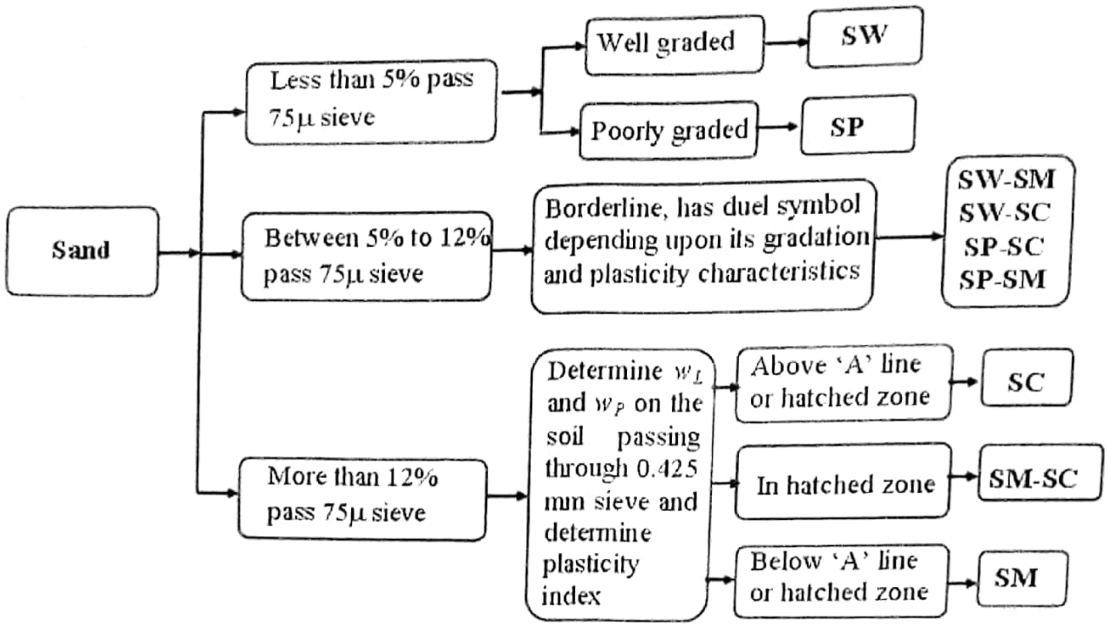


Fig. 3. Flow chart to classify soil (as per ISSCS).

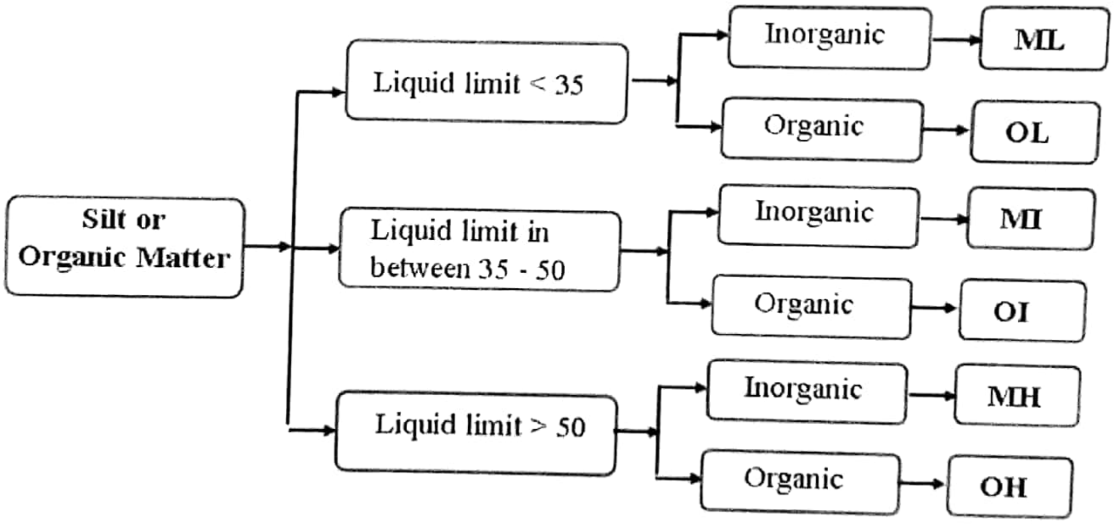


(a)

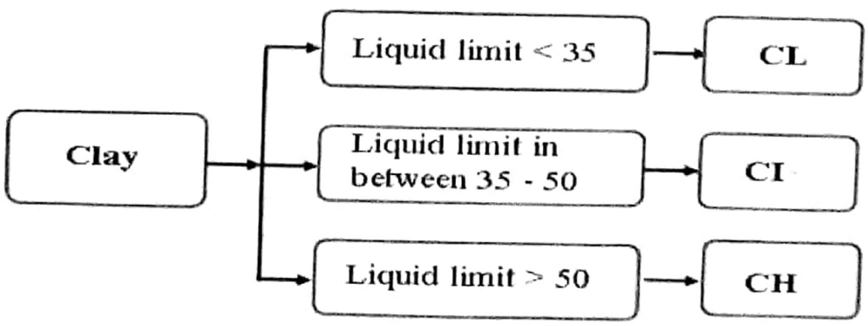


(b)

Fig. 4. Classification of coarse-grained soil: (a) Gravel (b) Sand (as per ISSCS).



(a)



(b)

Fig.5. Classification of fine-grained soil: (a) Silt or Organic matter (b) Clay (as per ISSCS).

b) **Factors affecting permeability of soils :**

1. **Shape and size of the soil particles.**
   - Void ratio : Permeability increases with increase of void ratio.
   - Degree of `saturation : Permeability increases with increase of degree of saturation.
2. **Composition of soil particles:** For sands and silts this is not important; however, for soils with clay minerals this is one of the most important factors. Permeability in this case depends on the thickness of water held to the soil particles, which is a function of the cation exchange capacity, valence of the cations, etc. other factors remaining the same, the coefficient of permeability decreases with increasing thickness of the diffuse double layer.
3. **Soil structure :** Fire-grained soils with a flocculated structure have a higher coefficient of permeability than those with a dispersed structure. With the increase of moisture content the soil becomes more and more dispersed. With increasing degree of dispersion, the permeability decreases.
4. Viscosity of permeant :
5. Density and concentration of permeant :

5(a) **Falling-head test :**

The falling-head permeability test is more suitable for fine-grained soils. **Fig.** shows the general laboratory arrangement for the test. The soil specimen is placed inside a tube, and a standpipe is attached to the top of the specimen. Water from the standpipe flows through the specimen. The initial head difference h_1 at time t = 0 is recorded, and water is allowed to flow through the soil such that the final head difference at time t = t is h_2. .

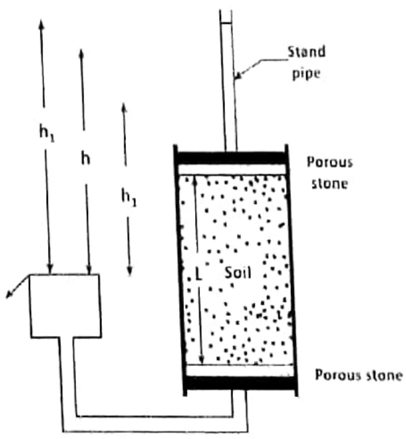


Fig. Falling-head laboratory permeability test

$$q = kiA = k\frac{h}{L}A = -a\frac{dh}{dt}$$

Where h = head difference at any time t ; A = area of specimen ; a = area of stand pipe L = Length of specimen

$$\int_o^t dt = \int_{h_1}^{h_2} \frac{aL}{Ak}\left(-\frac{dh}{h}\right)$$

From equation,

The values of a,L,A,t, h_1 and h_2 can be determined from the test, and then the coefficient of the permeability k for a soil can be calculated from equation..

b) Given Data :

Test : Constant head permeability

Specimen diameter d = 7.5 cm

Head h = 24.7 cm

Length L = 18 cm

Quantity of water collected Q = 626 ml

Time t = 60 sec

To determine : Coefficient of permeability

Solution:

$$A = (\pi/4)\ d^2 = (3.14/4)x\ 7.5x7.5 = 44.18\ cm^2$$

Coefficient of permeability k = Qx l / (Ath)

$= (626\ x18)/ 44.18x60x24.7$

$= 1.72\ x\ 10^{-1}$ cm/sec

6(a)

Principle of effective stress:

According to the concept of effective stress, the total vertical stress σ at a point 'O' in a soil mass is given by

$$\Sigma = h_1\gamma_d + h_2\gamma_{sat}$$

Where γ_d and γ_{sat} are dry unit weight and saturated unit weight respectively. calculation of total stress is the unit weight and thickness of the soil layers and the position of the ground water . the total stress is made up of two parts. One part is due to the pore water and is called the neutral stress or pore water pressure (u0.it is simply equal to the depth (h_2) below the ground water table of the point 'O' multiplied by the unit weight of water (γ_w)

Hence $u = h_2\ \gamma_w$

the neutral stress acts at all sides of the particles, but does not cause the soil particles to press against adjacent particles and no shear component. The other part of the total stress is due to the soil skeleton and is called the effective stress $\bar{\sigma}$, thus

$\sigma = \bar{\sigma} + u$ or $\bar{\sigma} = \sigma - u$ this si the effective stress equation

$\bar{\sigma} = \sigma - u = (h_1\gamma_d + h_2\gamma_{sat)} - h_2\gamma_w = h_1\gamma_d + h_2\gamma'$

where γ' is the submerged unit weight. For dry soils, u = 0 and therefore $\sigma = \bar{\sigma}$

the principle of effective stress can be spelt out as follows

- The effective stress equal to the total stress minus the pore water pressure
- The effective stress controls certain aspects of the behaviour of soil, the most important of which are the volume changes and the shearing resistance.

Physical meaning of effective stress:

It is known that the stress is a fictious parameter and is not physically meaningful.it is especially so in a material like soil, which is not continuous and contains both the soil grains and void spaces within its fabric. The intergranular stress, which is sometimes known as effective stress is really a misnomer for the reason that effective stress is really not the stress at particle contacts. The actual contact stress can be very large since the contact area between particles is very small. Effective stress is the sum of the contact forces divided by the gross area. This is the reason why effective stress is not physically meaningful and cannot be measured. The effective normal stress $\bar{\sigma}$ is equal to the sum of the components N' within the area A of the plane divided by the area A, or

$\bar{\sigma} = \sum N' / A$

the total normal stress $\sigma = P/A$

Since the pore water pressure can act only over the void area, the hydraulic force is equal to the pore water pressure (u) multiplied by the area of forces A_w

$\sigma = \bar{\sigma} + u\,(A_w/A)$

If A_w is taken approximately equal to A,

then $\sigma = \bar{\sigma} + u$

effective stress is a function of the particle contact force and for saturated sands and clays, the principle of effective stress holds considerable validity.

b) **Equation for critical hydraulic gradient for quick sand condition**

In an upward flow, it is possible to reach a condition when the effective stresses in the soil become equal to zero i.e.,

$$H\gamma' - iH\gamma_w = 0$$

This condition occurs when the hydraulic gradient $i = i_{cr} = \gamma' / \gamma_w$

i_{cr} is called the critical hydraulic gradient.when upward flow takes place at the critical hydraulic gradient, a soil such as sand loses all its shearing strength and it can not support any load. This phenomenon is known is quick sand condition is a hydraulic condition. Under this condition, the seepage pressure $iH\gamma_w$ has become equal to the effective pressure $H\gamma'$ so that the effective stress throughout the soil reduced to zero. as long as $i < i_{cr}$, only a part of the total head difference h ia used up in viscous friction with the seepage pressure reducing the net effective stress but not quite completely nullifying it.

Therefore $i_{cr} = (G-1)/(1+e)$

A second approach to obtain an expression for i_{cr} is to equate the total boundary pore water pressure and the total weight of all the material above that boundary.

Upward force due to water = $(h + H_1 + H)\,\gamma_w A$

Total downward force (due to soil +water) = $\gamma_{satHA} + \gamma_w H_1 A$

For quick condition, $(h + H_1 + H)\,\gamma_w A = \gamma_{satHA} + \gamma_w H_1 A$

Substituting for γ_{sat} and rearranging,

$h/H = i_{cr} = (G-1)/(1+e)$

7(a) **Factors affecting compaction :**

(i) the moisture content,
(ii) the compactive effect,
(iii) the type of soil, and
(iv) the method of compaction.

i. Moisture content :

- At lower levels of moisture content, the soil particles offer more resistance to compaction and the soil behaves like a stiff material. Increasing the moisture content helps the particles to move closer because of the lubrication effect.
- On further increasing the moisture content beyond a certain limit, the water starts to replace the soil particles.
- Thus, the dry density increases up to a limiting moisture content (optimum moisture content), beyond which an increase in the moisture content decreases the dry density.

- The effect of the formation of a structure with increasing moisture content is another meaning given for the increase in the dry density and the subsequent decrease beyond a certain limit (Lambe, 1958).

ii) Effect of Compactive Effort

- The maximum dry density and optimum moisture content are both affected by a change in the compactive effort. An increase in the compactive effort increases maximum dry density and decreases optimum moisture content.
- However, the air void ratio at the peak density remains approximately the same. Further, there will be a marginal increase in the density with an increase in the compactive effort. Heavy equipment is generally preferred for economic reasons as it can produce the required compactive effort more cheaply.

iii) Effect of Type of soil

- Well graded coarse grained soils with smooth rounded particles show a high dry density, whereas uniform sands have a low maximum dry density.
- Clayey soils have lower dry densities and higher optimum moisture contents than do sands. The effect of increasing the compactive effort is also more in clayey soils.

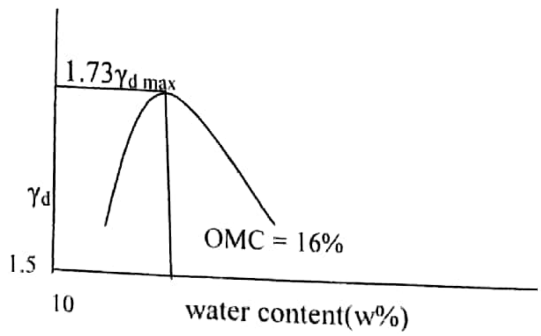
iv) Effect of Method of Compaction

- It is ideal to develop a laboratory test which could produce a reasonable moisture-density curve so as to assess the maximum dry density and optimum moisture content.
- As the processes of imparting energy to the soil are different in the field and laboratory, there may be different degrees of compaction depending on the method of compaction.
- Field compaction is essentially a rolling or kneading type of compaction, whereas the laboratory compaction is of the dynamic-impact type.

b) **Given data:**

Volume of mould = 950 ml

Water content (%)	12	14	16	18	20	22
Wt. of wet soil (kg)	1.68	1.85	1.91	1.87	1.87	1.85
Wt. of wet soil (gm)	1680	1850	1910	1870	1870	1850
Bulkdensity (γ) g/cc	1.768	1.947	2.011	1.968	1.968	1.947
Dry density (γ_d) g/cc	1.579	1.708	1.734	1.668	1.64	1.596
Rounded value of γ_d	1.58	1.71	1.73	1.67	1.64	1.60



$\gamma_{d\,max}$ = 1.73 g/cc
OMC = 16%

5(a) **Comparison of the two methods of determining coefficient of consolidation.**

a) **Casagrande's log time method**

Casagrande (1938) proposed this method where the dial gauge reading is plotted against the logarithm of time. The curve consists of a parabolic curve followed by two straight-line segments. The intersection of the two straight line segments defines the 100% consolidation state, which is denoted by a dial gauge reading of d_{100}. A simple graphical construction using the properties of a parabola is required to define d_0, the reading corresponding to a time of 0'. Mark an arbitrary time t and then 4t on the time axis, and note the corresponding dial gauge readings, the difference being x. Mark this offset distance x above the dial gauge reading corresponding to t, and this defines d_o. The dial gauge reading corresponding to U 50% is computed as $d_{50} = (d_0 + d_{100})/2$. The time t_{50}, corresponding to d_{50} is read off the plot. This is the time when $U_{avg} = 50\%$. From Figure 8.9b, $T_{50} = 0.197$. Therefore:
$T_{50} = 0.197 = c_v t_{50}/H^2_{dr}$

where H_{dr}, is half the thickness of the sample if it is doubly drained and full thickness if singly drained. The coefficient of consolidation c_v can be determined from the above equation.

b). Taylor's square root of time method

Taylor's (1948) method requires plotting dial gauge readings against the square root of time. The early part of the plot is approximately a straight line, which is extended in both directions as shown by the dashed line. The intersection of this line with the dial gauge reading axis defines d_0. Another straight line is drawn through d_0 such that the abscissa is 1.15 times larger than the previous line. The intersection of this second line with the laboratory curve defines the 90% consolidation point. The value of $\sqrt{t_{90}}$ can be read off the plot:

$$T_{90} = 0.848 = c_v t_{90}/H^2_{dr}$$

Generally, Taylor's method gives larger values than Casagrande's method. Nevertheless, both laboratory values are often significantly less than the c_v values that are back-calculated in the field. In other words, consolidation in the field takes place at a faster rate, and the laboratory methods underestimate the coefficient of consolidation.

b) **Given data:**

thickness of clay layer H = 8 m (single drainage)
time t = 2x365x24x60x60s
$c_v = 6 \times 10^{-3} \times 10^{-2}$ m^2/sec
settlement s = 120 mm
To determine: Consolidation settlement

$T_v = c_v\, t/ H^2$
$= 6\times10^{-7} \times 2\times365\times24\times60\times60 / (8\times8)$
$= 0.5913$

Again, 0.5913 = 1.781 – 0.933 log (100 – U%)
1.2751 = log (100 – U%) therefore U% = 81.5%
As U% > 60%, use of the above equation is right.

$(S_c)_f = (S_c)_t / U_t = 120/0.815 = 147$ mm

Consolidation settlement = 147 mm

9(a) **Types of triaxial tests based on drainage conditions:**

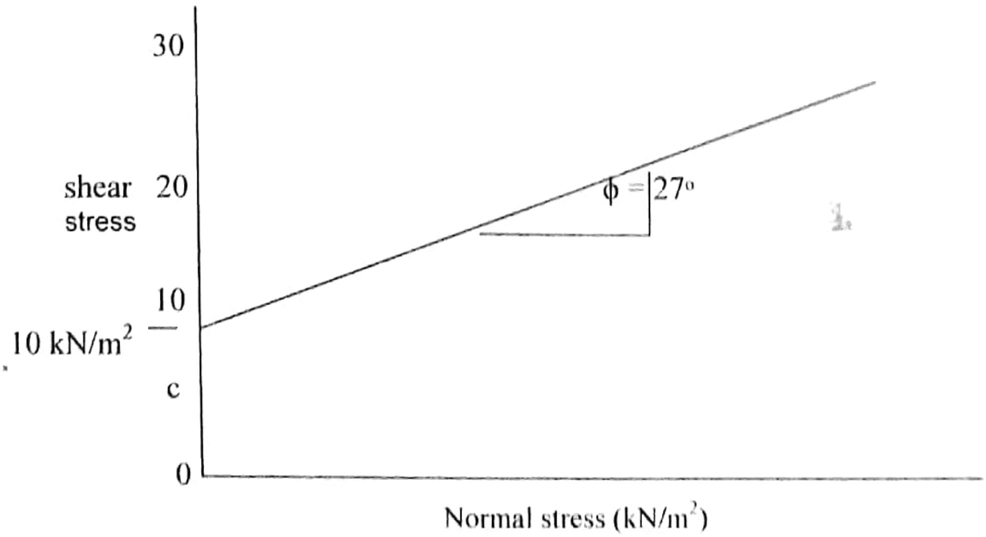
1. Unconsolidated-Undraiined Condition: In this type of test, no drainage is permitted during the consolidation stagethe drainage is also not permitted in the shear stage. As no time is allowed for consolidation or dissipation of excess pore water pressure, the test can be conducted quickly ina few minutes. The test is known as unconsolidated undrained test(UU test) or quick test (Q-test)

2. Consolidated Undrained Condition: The specimen is allowed to consolidate in the first stage. The drainage is permitted until the consolidation is complete. In the second stage, when the specimen is sheared, no drainage is permitted. The test is known as consolidated undrained test(CU test).

3. Consolidated Drained Condition: The drainage of the specimen is permitted in both the

   stages. The sample is allowed to consolidate in the first stage. When the consolidation is complete, it is sheared at a very slow rate to ensure that fully drained conditions exist and excess pore water is zero. This test is known as consolidated drained test (CD test) ro drained test. It is also known the slow test (S- test)

b)



Result : $C = 10$ kN/m^2

$\phi = 27°$