GUJARAT TECHNOLOGICAL UNIVERSITY

4th Semester Civil Engineering – PDDC

Subject Code & Name : X40603 - Soil Engineering

Tutorial – 1

Date : 27-03-2015

1. Differentiate between standard proctor test and Modified proctor test.
2. The following data have been obtained in a standard laboratory proctor compaction test on glacial till

Water content %	5.02	8.81	11.25	13.05	14.40	19.25
Wt. of container with compacted soil (N)	35.8	37.3	39.32	40.00	40.07	39.07

   The specific gravity of soil particle is 2.77. The container is 9.44 cm3 in volume and its weight is 19.78 N. Plot the compaction curve and find out OMC and MDD.
3. Write short note on Compaction needle.
4. What is the effect of compaction on the engineering properties of the soil?
5. Discuss shear tests based on different drainage conditions.
6. Enlist the method for determination of coefficient of consolidation and explain any one in detail.
7. Differentiate between consolidation and Compaction with examples.
8. What are the advantages of triaxial shear test over direct shear test?
9. In a consolidation test following result have been obtained when the load was changed from 100 KN/m2 to 200 KN/m2, void ratio changed from 0.7 to 0.65. Determine the coefficient of volume decrease (mv) and compression index (Cc).
10. In an unconfined compression test a sample of clay 100mm long and 50mm in diameter fails under a load of 150N at 10% strain. Calculate the shearing resistance taking into account the effect of change in cross-section of the sample.
11. Explain Mohr-coulomb's strength theory.
12. A stratum of clay is 2m thick and has an initial overburden pressure of 50 KN/m2 at its middle. Determine the final settlement due to an increase in pressure of 40 KN/m2 at the middle of the clay layer. The clay is over-consolidated, with a reconsolidation pressure of 75 KN/m2. The values of the coefficient of recompression and compression index are 0.05 and 0.25, respectively. Take initial void ratio as 1.40.
13. A standard specimen of cohesionless sand was tested in triaxial compression and the sample failed at deviator stress of 460KN/m2, when the cell pressure was 150KN/m2, under drained conditions. Find the effective angle of shearing resistance of sand. What would be the deviator stress and the major principle stress at failure for another identical specimen of sand if it is tested under a cell pressure of 200KN/m2?
14. Explain the modified Mohr-coulomb theory.

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1. Differentiate between standard proctor test and modified proctor test.

Light compaction test	Heavy compaction test
1) Mass of rammer is 2.6 kg	1) Mass of rammer is 4.89 kg
2) Height of free fall is 31 cm	2) Height of free fall is 45 cm
3) Dimensions of mould are Diameter = 100mm Height = 127.3 mm volume = 1000 cm^3	3) Dimensions of mould Diameter = 100mm Height = 127.3mm volume = 1000 cm^3
4) soil is compacted in the mould in 3 equal layers.	4) soil is compacted in the mould in 5 equal layers.
5) Each soil layer is subjected to 25 blows of rammer	5) Each soil layer is subjected to 25 blows of rammer
6) compactive effort is 592 kJ/m^3	6) compactive effort is 2700 kJ/m^3
7) It is also called standard proctor test	7) It is also known as modified proctor test

2. The following data have been obtained in a standard laboratory proctor compaction test on glacial till.

water content %	wt. of container with compacted soil (N)
5.02	35.8
8.81	37.3
11.25	39.32
13.05	40.00
14.40	40.07
19.25	39.07

The specific gravite of soil particle is 2.77 The coontainee is 9.44 cm^3 1m volume and its weiand 19.78 N. plot the compaction curve and find out omc and MDD.

SR. NO.	Water Comtemt	wt. of condtainer with comp. soil (N) w_1	weight of Container w_2	weigtout soil $w_b = w_2 - w_1$ (N)	bulk density $\gamma_b = w_b / N$ N/cm³	bulk bensity $\gamma_d = \frac{\gamma_b}{1+w}$ N/cm³
1	5.02 0.0502	35.8	19.78	16.02	1.70	= 1.618
2	8.81 0.088	37.3	19.78	17.52	1.85	= 1.700
3	11.25 0.1125	39.32	19.78	19.54	2.07	1.860
4	13.05 0.1305	40.00	19.78	20.22	2.14	1.892

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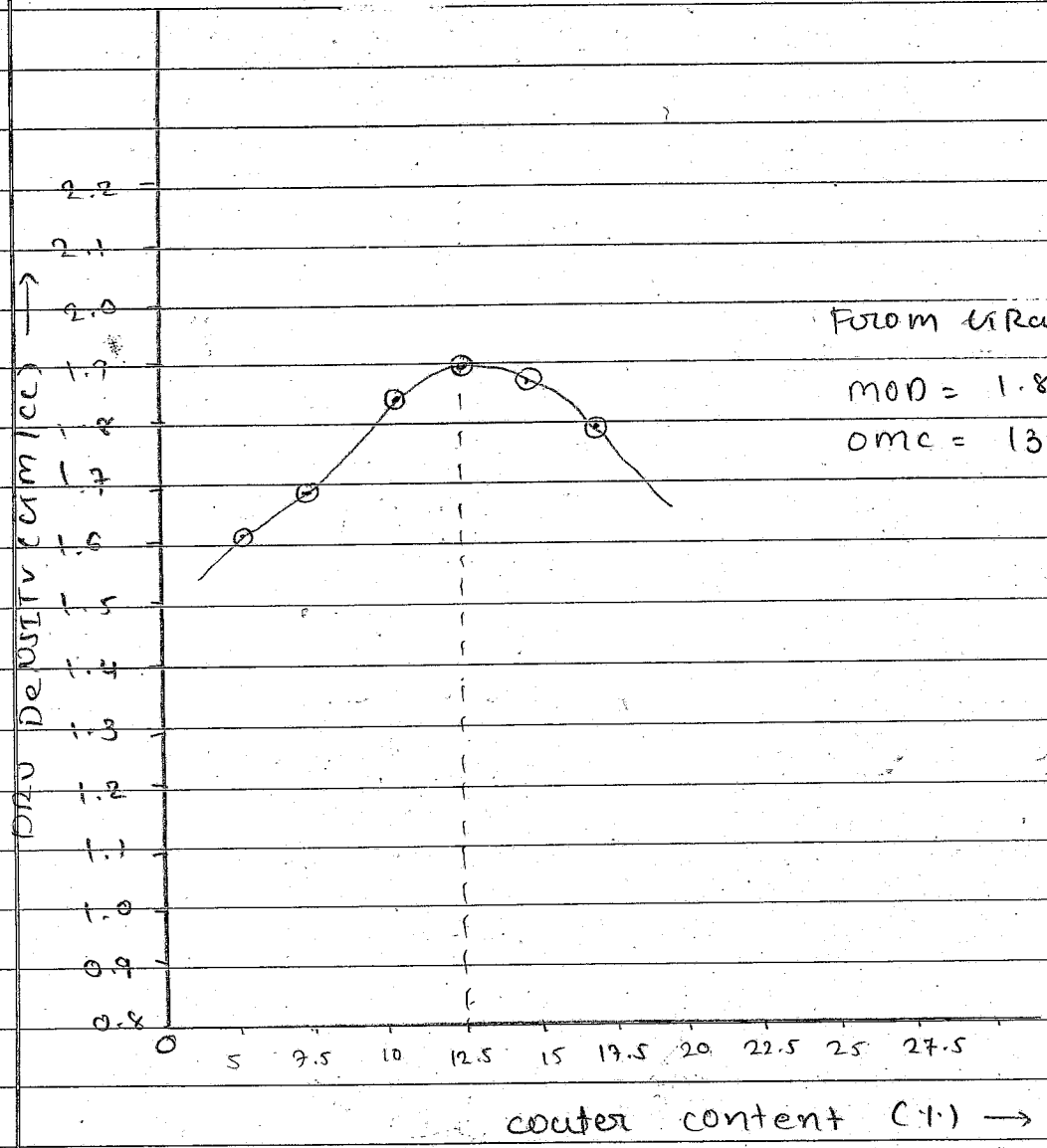
5	14.40	40.07	19.78	20.29	2.15	= 1.879
	0.1440					
6	19.25	39.07	19.78	19.29	2.04	= 1.710
	0.1925					



From Graph

MDD = 1.89 (GM/c.c)

OMC = 13.05%

MDD - OMC CURVE

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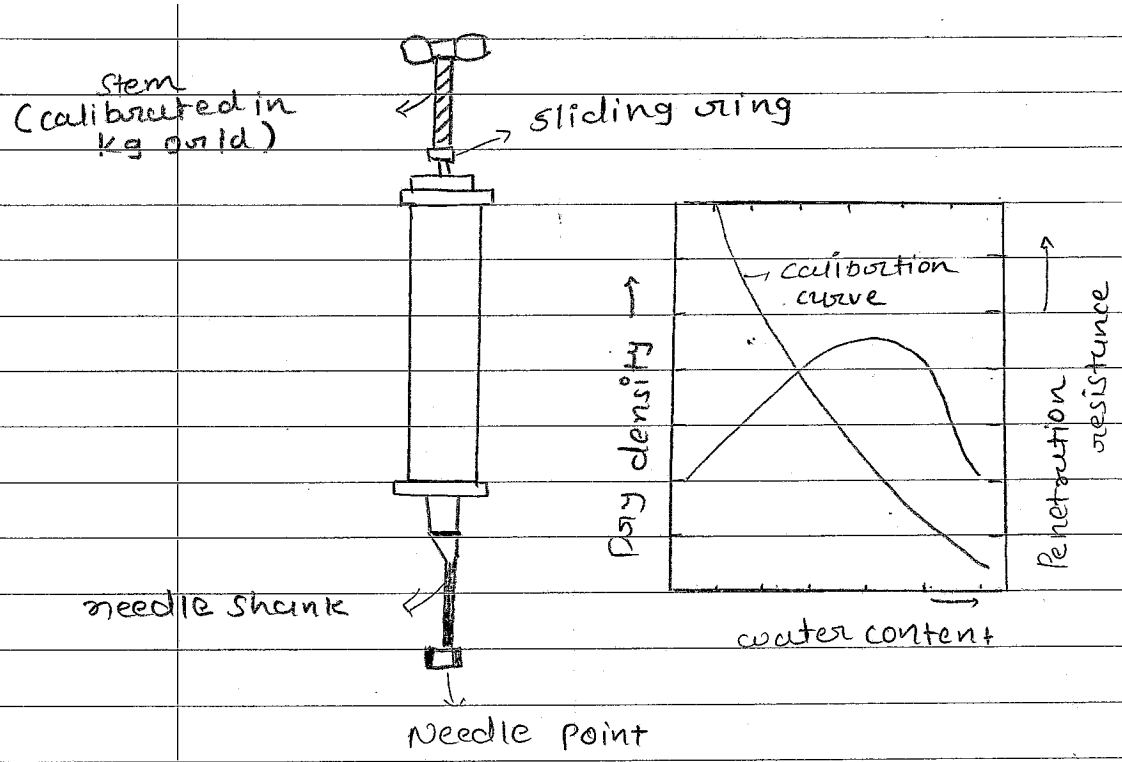
3. Write short note on compaction needle

The water content can also be determined indirectly using a proctor needle. It is also known as plasticity needle. The proctor needle consists of a rod attached to a spring loaded plunger. The stem of the plunger is marked to read the resistance in newton. The sliding ring on the stem indicates the maximum resistance recorded during the test. The needle shank has graduations to indicate the depth of penetration. The equipment is provided with series of interchangable needle points of different cross-sectional areas (0.25, 0.50, 1.0 and 2.5 cm^2) to obtain a wide range of the penetration resistance. For cohesive soils, the needle points of large cross-sectional areas are required and for cohesionless soil, those of smaller cross-sectional areas are used.

After the soil has been compacted at a given water content in the proctor mould in the laboratory, the proctor needle is forced 7.5 cm into it at the rate of about 1.25 cm/sec. The maximum force used is found from the compression of the spring. From the known area of the needle point, the penetration resistance per unit area is computed.

A number of such measurements are made in the laboratory during the compaction test and a calibration curve is obtained between penetration resistance (R) and the water content as shown in fig. 2.9. It is observed that for a given degree of compaction the penetration resistance (R) decreases with an increase in water content.



To determine the water content of the compacted soil in the field the soil is compacted in the standard proctor mould in the field in the same manner as was

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used during the calibration of the needle. The penetration resistance of the compacted soil is measured. The moisture content is then obtained from the calibration curve.

This method is very rapid and reliable for fine grained soils. However, it does not give accurate results for cohesionless soils.

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4. What is the effect of compaction on the engineering properties of the soil?

→ 1. Soil structure :

The structure of a soil during compaction depends upon,
- type of soil
- water content
- type and amount of compaction

Course grained soils maintain a single grained structure at any possible void ratio or water content. However, the structure of composite soils after being compacted depend upon the relative proportion of coarse particles and fines and their structure can be either course grained skeleton structure or cohesive matrix structure.

2. permeability :

- The permeability of soil decreases with an increase in water content on the dry side of the optimum water content.

- As the dry density increases due to compaction, the voids go on reducing and hence the permeability goes on reducing.

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- If the compactive effort is increased, the permebility of soil decreases due to increased dry density and better orientation of particles.

3. Shrinkage:

For the same density, soil sample compacted dry of optimum shrink appreciably less than the sample compacted wet of optimum. The soils compacted wet of optimum shrinks more because the soil particles in the dispersed structure have nearly parallel orientation of particles and can pack more efficiently

4. Swelling:

A clayey soil sample compacted dry of optimum water content has higher water deficiency and more random orientation and hence exert greater swelling pressure. It imbibes more water than the sample compacted wet of the optimum, and has more swelling.

5. Pore water pressure:-

A sample compacted dry of the optimum has low water content, and develop lower pore water pressure that the sample compacted wet of optimum.

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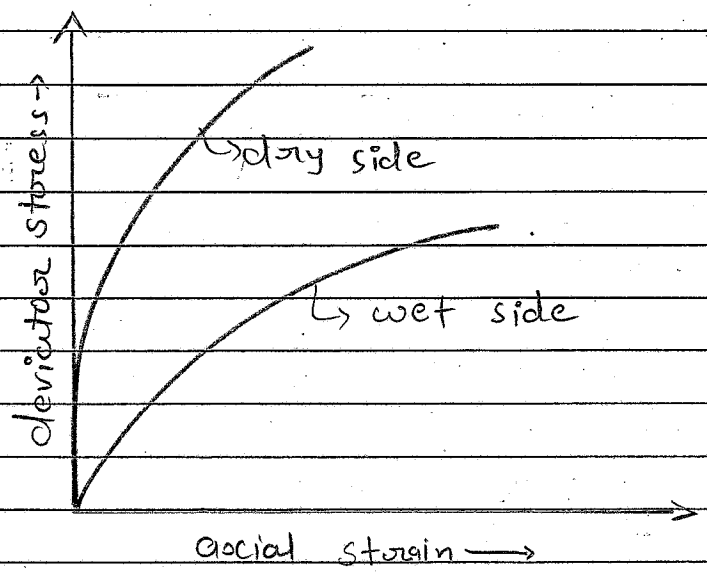
6. Compressibility:

The flocculated structure developed on the dry side of the optimum offers greater resistance to compression than the dispersed structure on the wet side. consequently, the soil on the dry side are less compressible

However, the compressibility of the soil depends upon a number of other factors. It increases with an increase in the degree of ~~satut~~ saturation. If the compaction curves very large stresses, the compressibility increases due to breakdown of the structure and greater orientation of the particles

7. Stress - strain relationship:



Stress - strain curve

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The soil compacted dry of the optimum have a steeper stress-strain curve than those on the wet side as shown in fig. The modulus of elasticity for the soils compacted dry of the optimum is therefore high. such soils have brittle failure like dense sands or over consolidated clays. The soils compacted wet of optimum have plastic failure.

8. Shear strength:

The shear strength of compacted clays depend upon,

- dry density
- water content
- soil structure
- methods of compaction
- drainage condition
- type of soil

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5. Discuss shear tests based on different drainage conditions

Depending upon the drainage conditions, there are three types of tests.

1. Unconsolidated un-drained test (UU test)

2. Consolidated un-drained test (CU test)

3. Consolidated Drained test (CD test)

1. Unconsolidated un-drained test :

In this type of test, no drainage is permitted during the consolidation stage. The 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 in a few minutes.

The test is also known as quick test (Q - test)

2. Consolidated un-drained test (CU test)

In this type of test, the specimen is allowed to consolidate in the first stage. The drainage is permitted until the consolidation is complete.

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In the second stage, when the specimen is sheared, no drainage is permitted.

The test is also known as R test.

Q used for quick test, S used for slow test and R falls between Q and S

3. Consolidated Drainged test [CD test]:
In this type of test, drainage 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 the excess pore water is zero

The test is also known as drained test or slow test (S test)

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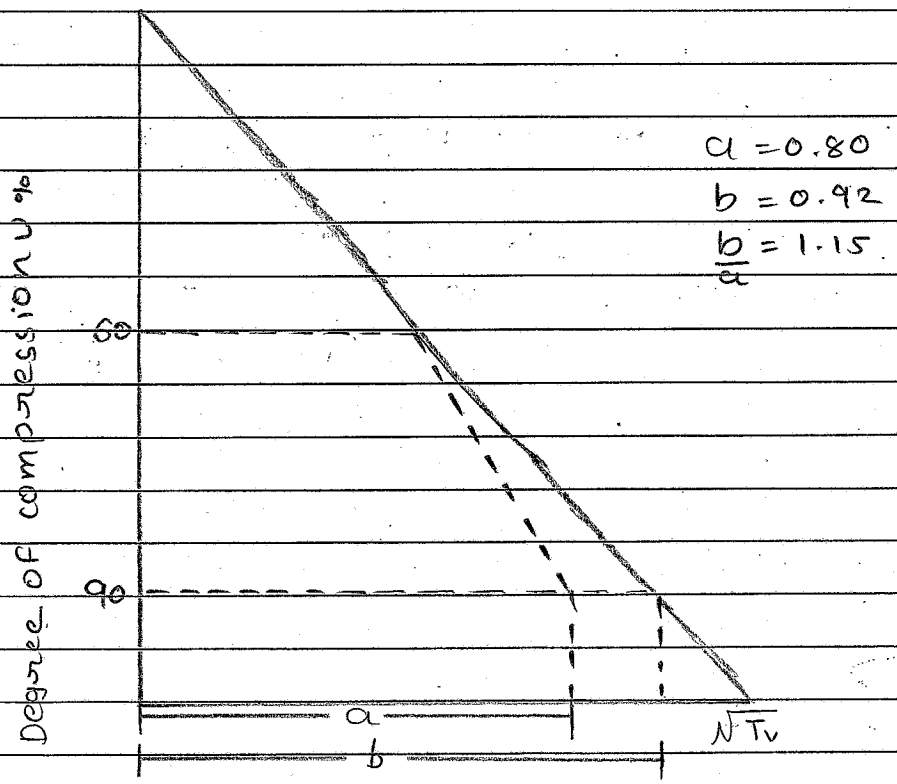
6. Enlist the method for determination of coefficient of consolidation and explain any one in detail.

The more generally used fitting methods are the following

1. The square root of time fitting methods
2. The logrithm of time fitting method.

1. The square root of time fitting methods:

This method was developed by Taylor, which utilizes the theoretical relationship between U and $\sqrt{T_v}$ The relationship is linear up to the value



Theoretical curve between $\sqrt{T_v}$ and U

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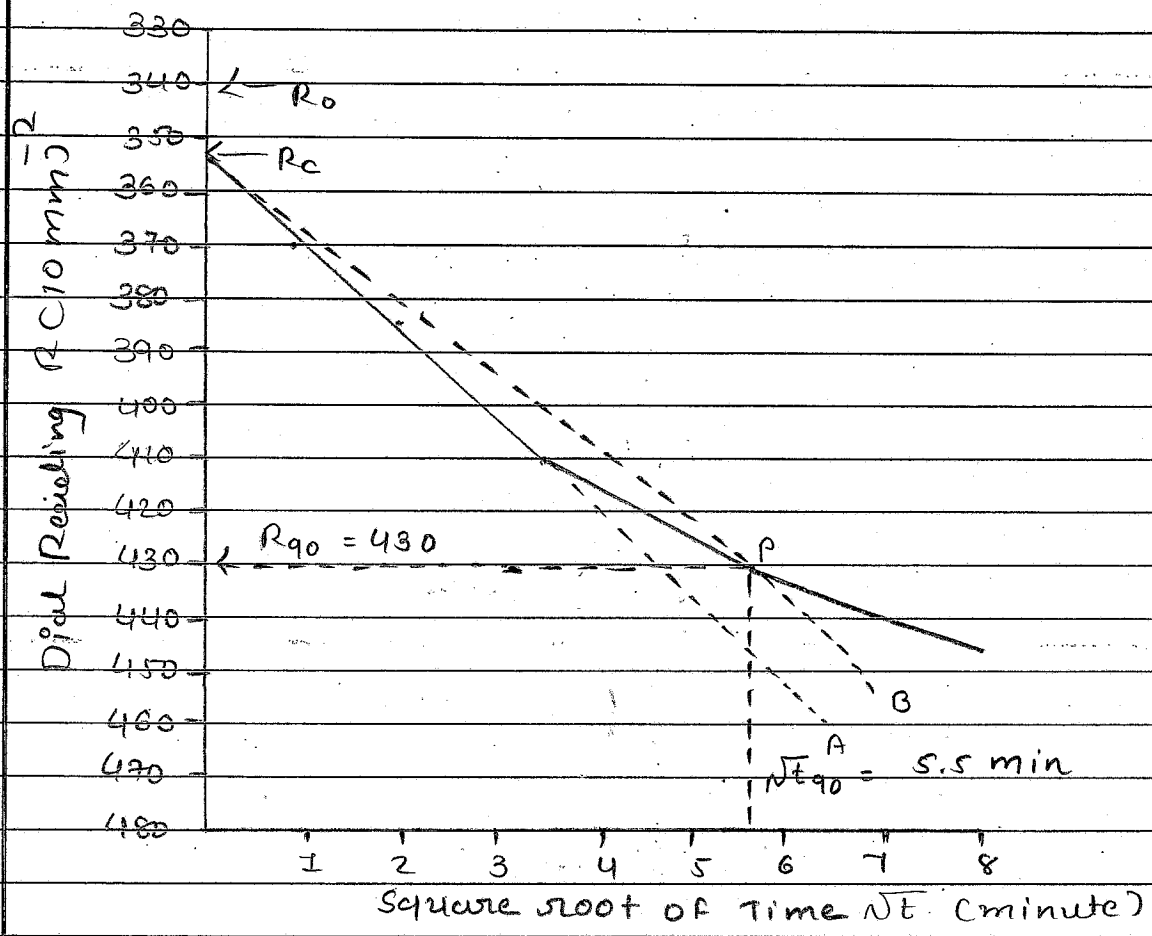
of a equal to about 60% (eq 1.13) It was observed that at U = 90%, the value of $\sqrt{T_v}$ is 1.15 times the value obtained by the extension of the initial straight tion portion.

A curve is plotted from the consolidation test results between the dial gauge reading (R) as ordinate and the $\sqrt{T}$ as abscissa

The initial dial reading R_0 corresponds to the time t=0 and U=0. The straight portion (line A) of the curve is produced back to meet the ordinate at R_c, which is called the corrected zero reading and the consolidation between R_0 and R_c is called initial consolidation. From R_c, another line B is so drawn that its abscissa at every point is 1.15 times that of line A. The intersection of line B with the consolidation curve gives a point P corresponding to 90% U whose dial reading and time may be designated as R_{90} and t_{90} respectively



TIME CONSOLIDATION CURVE

From the curve,

$\sqrt{t_{90}} = 5.5$ $\therefore$ $t_{90} = 30.1$ minutes

$\therefore$ coefficient of consolidation,

$$C_v = \frac{(T_v)_{90} \times d^2}{t_{90}} \qquad t_{90} = 30.1 \times 60 = 1806 \text{ sec.}$$

$$(T_v)_{90} = 1.7813 - 0.933 \log_{10}(100 - U)$$

$$= 1.7813 - 0.933 \log_{10}(100 - 90)$$

$$= 0.848$$

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d = average drainage path

$$= \frac{H}{2} = \frac{1}{2}\left[\frac{H_1 + H_f}{2}\right]$$

let, the pressure range is 80 kN/m^2 to 160 kN/m^2

let, initial height of specimen
= 1620 mm = H_1 (at 80 kN/m^2)
Final height of specimen
= 15.10 mm = H_f (at 160 kN/m^2)

$$\therefore d = \frac{1}{2}\left[\frac{H_1 + H_f}{2}\right]$$

$$= \frac{1}{2}\left[\frac{16.20 + 15.10}{2}\right]$$

= 7.83 mm
= 0.783 cm

$$\therefore C_v = \frac{(T_v)_{90} \times d^2}{t_{90}}$$

$$= \frac{0.848 \times (0.783)^2}{1806}$$

$$C_v = 2.88 \times 10^{-4} \ cm^2/s$$

Designed by Keyur Padashala

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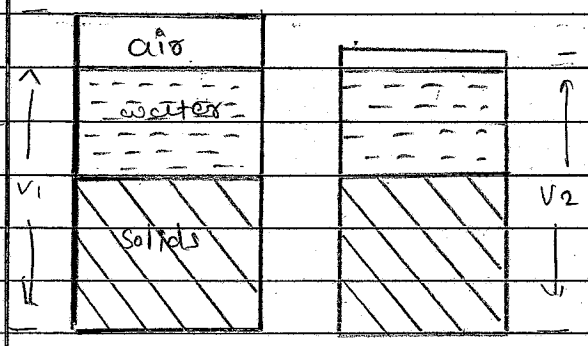
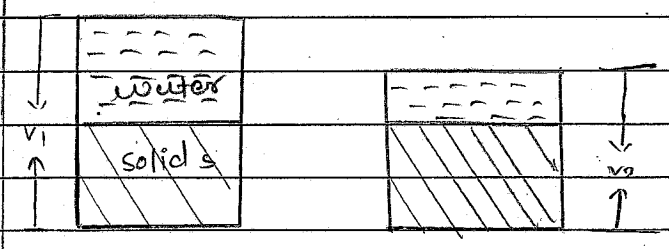
7 Differentiate between consolidation and compaction with examples.

	Compaction	Consolidation
1.	compaction is a process by which soil particles are artificially rearranged and packed together in a closer state of contact by mechanical means in order to decrease the void ration and increase its dry density.	When the soil is fully saturated compression of soil occurs mainly due to expulsion of water from the voids under static pressure. This process is known as consolidation.
2.	Decrease in volume of soil is due to removal of air from voids. 	Decrease in volume of soil is due to removal of water from voids 
3.	The load is dynamic i.e., rolling, tamping, vibration.	The load is static

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4	The process of compaction is rapid	The process of consolidation is very slow.
5.	compaction is an artifical process which is done to increase the density of soil	consolidation is a natural process in which the saturated soil deposits are subjected to static loads caused by the weight of the building and other structures.

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8. What are the advantages of triaxial shear test over direct shear test?

1. The shear tests under all the three drainage conditions can be performed with complete control.

2. Pore pressure and volumetric changes can be measured directly.

3. The stress distribution on the failure plane is uniform.

4. The specimen is free to fail on the weakest plane.

5. The state of stress during any stage of the test is known. The mohr circle can be drawn at any stage of shear.

6. The test is suitable for accurate research work.

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Q. In a consolidation test following result have been obtained when the load was changed from 100 kN/m² to 200 kN/m², void changed from 0.7 to 0.65. Determine the coefficient of volume decrease (mv) and compression index (cc.)

$e_0 = 0.70$

$e = 0.65$

$\therefore \Delta e = e_0 - e = 0.70 - 0.65$

$= 0.05$

$\Delta \sigma' = 100 - 100 = 100 \text{ kN/m}^2$

mv = coefficent of volume change

$$= \frac{-\Delta e}{1 + e_0} \times \frac{1}{\Delta \sigma'}$$

$$= \frac{-0.05}{1 + 0.75} \times \frac{1}{100}$$

$$= -2.97 \times 10^{-4} \text{ m}^2/\text{kN}$$

Compression index

$$C_c = \frac{e_0 - e}{\log_{10} \frac{\sigma'}{\sigma'_0}}$$

$\sigma'_0 = 100 \text{ kN/m}^2$

$\sigma' = 200 \text{ kN/m}^2$

$$= \frac{0.05}{\log_{10} (200/100)}$$

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$$= \frac{0.05}{0.301}$$

$$C_c = 0.166$$

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10) In an unconfined compression test a sample of clay 100mm long and 50mm in diameter fails under a load of 150N at 10% strain. Calculate the shearing resistance taking into account the ~~account~~ effect of change in cross-section of the sample.

$d_0 = 50\,mm$

$A_0 = \frac{\pi}{4} \times 50^2 = 1963.49\ mm^2$

$L_0 = 100\,mm$

$\varepsilon = 10\% = 0.10$

$\therefore A_\delta = \frac{A_0}{1-\varepsilon} = \frac{1963.49}{1-0.10} = 2181.66\ mm^2$

$P = 150\ N$

$\therefore$ Unconfined compressive strength

$q_u = \sigma_1 = \frac{P}{A_\delta} = \frac{150}{2181.66} = 0.069\ N/mm^2$

$= 69\ kN/m^2$

$\therefore$ Shear stress at failure

$C = \frac{q_u}{2} = \frac{69}{2} = 34.5\ kN/m^2$

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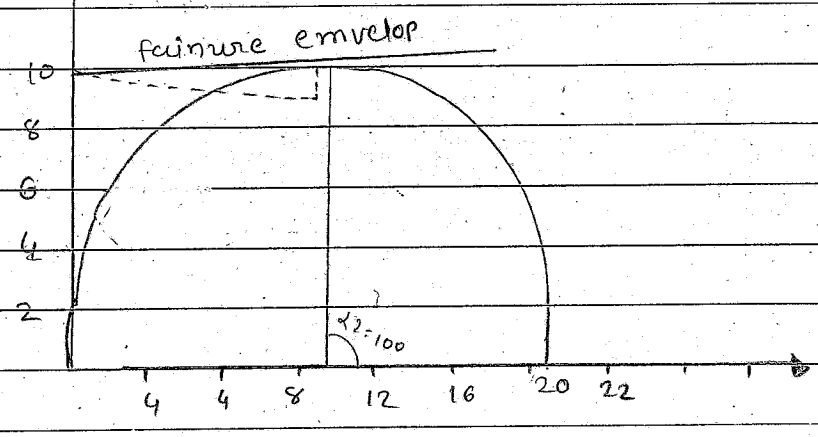
The cross pondling Mohr Circle is



Normal stress (kN/m³)

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11. Explain Mohr - coulomb's strength theory.

Coulomb (1776), in his investigations observed that one component of the shearing strength, called the intrinsic cohesion [apparent cohesion] is constant for a given soil and is independent of the applied stress. The other component, namely, the friction resistance, varies directly as the magnitude of the normal stress on the plane of rupture.

The shear strength (s) of a soil at a point on a particular plane was expressed by Coulomb as a linear function of the normal stress on that plane, as

$$S = c + \sigma \tan\phi \qquad (1.7.) \text{ coulomb's equation}$$

where

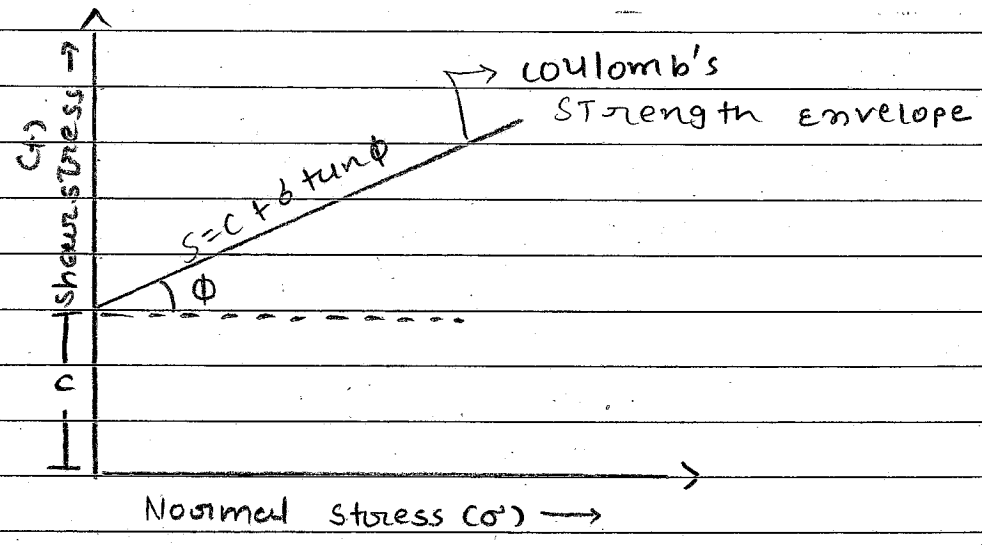
S = Shear strength of the soil

C = apparent cohesion

σ = Normal stress on the failure plane

ϕ = angle of internal friction.

C and ϕ are also referred to as the shear strength parameters of the soil

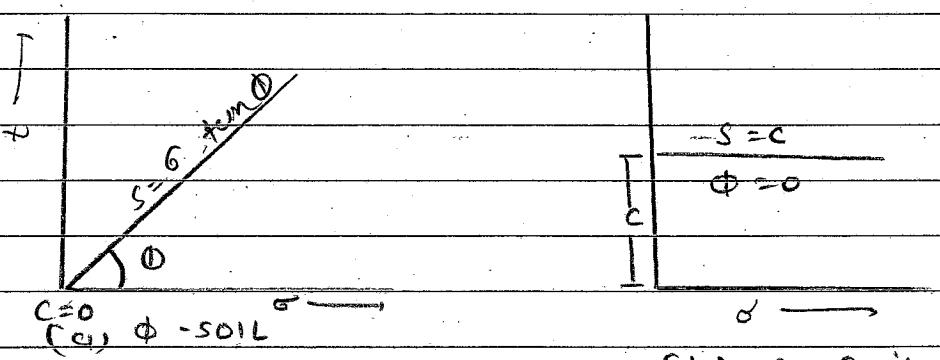


COULOMB'S STRENGTH ENVELOPE

Type of soils based on total strength:

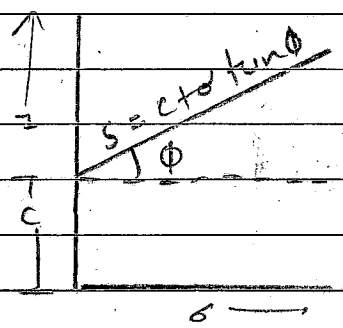
On the basis of shear strength, soils can be divided into three types

1. Cohesionless soil (ϕ - soil)
2. Purely cohesive soils (c - soil)
3. Cohesive - frictional soils [c - ϕ soil]



(a) ϕ - soil

(b) c - soil



(c) c - ϕ - soil

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1. Cohesionless soil (ϕ - soil)

- These are the soils which do not have cohesion $\therefore$ $c = 0$

- These soils derive the shear strength from the intergranular friction.

- These soils are also called Frictional soils.

- Equation for shear strength is,
  $S = \sigma \cdot \tan \phi$

- Examples : sands and gravels

2. Purely cohesive soil : (c - soil) :

- These are the soils which exhibit cohesion but, the angle of shearing resistance, $\phi = 0$

- These soils are called C - soils

- Equation for shear strength is
  $S = C$

- Example : saturated clays

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3. cohesive frictional soils : [C-ϕ soil]

- These are composite soil having c and ϕ both

- These are also called c - ϕ soils

- The equation for shear strength is

$$S = c + \sigma \cdot \tan \phi$$

- Example = clayey sand, silty sand, sandy clay

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12) A stratum of clay is 2m thick and has an intial overburden pressure of 50 kN/m² at its middle determine the final settlement due to an increase in pressure of 40 kN/m² at the middle of the clay layer. The clay is over-consolidated, with a reconsolidat pressure of 75 kN/m². The values of the coefficient of recompression and compression index are 0.05 and 0.25 respectively. Take intial void ratio as 1.40.

$$S_f = \frac{C_r}{1+e_0} H_0 \log_{10}\left(\frac{\bar{\sigma}_c}{\bar{\sigma}_0}\right) + \frac{C_c}{1+e_0} H_0 \log_{10}\left(\frac{\bar{\sigma}_0+\Delta\bar{\sigma}}{\bar{\sigma}_c}\right)$$

$$S_f = \frac{0.05 \times 2}{1+1.40} \log_{10}\left(\frac{75}{50}\right) + \frac{0.25 \times 2}{1+1.40} \log_{10}\left[\frac{50+40}{75}\right]$$

$$S_f = 7.34 \times 10^{-3} + 16.50 \times 10^{-3} m$$

$$S_f = 23.84 \times 10^{-3} m$$

$$= 23.84 \text{ mm}$$

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13) A standard specimen of cohesionless sand was tested in triaxial compression and the sample failed at deviator stress of 460 kN/m², when the cell pressure was 150 kN/m², under drained conditions. Find the effective angle of shearing resistance of sand. What would be the deviator stress and the major principle stress at failure for another identical specimen of sand if it is testend under a cell pressure of 200 kN/m²?

Soinition

deviator stress	cell pressure
460 kN/m²	150 kN/m²
(?)	200 kN/m²

The stress σ_1 inture first test =
$460 + 150 = 60$ kN/m²

$$\sin\phi = \frac{(610-150)/2}{(610+150)/2} = \frac{230}{380}$$

$$= 0.60$$

$$= 34.3774$$

There Foure $\sin\phi = \frac{(\sigma_1 - \sigma_3)/2}{(\sigma_1 + \sigma_3)/2}$

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$$= 0.60 = \frac{\sigma_1 - 150}{\sigma_1 + 150}$$

$$= 0.6061 + 90 - 61 + 150 = 0$$

$$= -0.461 + 240 = 0$$

$$= 0.461 - 240 = 0$$

$$\sigma_1 = \frac{240}{0.4}$$

$$= 600 \quad kN/m^2$$

$$\sigma_1 - \sigma_3 = 600 - 150 = 450 \ kN/m^2$$

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14. Explain the modified mohr- coulomb theory.

Equation 1.7 apparently indicates that the shearing strength of a soil is governed by total normal stress on the failure plane. However, according to Terzaghi, it is the effective stress on the failure plane that governs the shearing strength and not the total stress.

It may be expected intuitively that the denser a soil, the greater the shearing strength. It has been learnt that a soil deposit becomes densest under any given pressure after the occurance of complete consolidation the consequent dissipation of pore water pressure. Thus, complete consolidation, dependent upon the dissipation of pore water pressure and hence upon the increase in the effective stress, leads to increase in the shearing strength.

We know that,

effective stress = total stress − pore water pressure

$\therefore \sigma' = \sigma - u$

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If the pore water pressure is partially dissipated, u will decrease and σ' will increase. Thus, it is the effective stress in the case of a saturated soil and not the total stress which is relevant to the mobilisation of shearing stress.

In terms of effective stresses, the shear strength equation may be modified as

$$S = c' + \sigma' \tan \phi'$$

where,

c' = effective cohesion

ϕ' = effective angle of friction

$\sigma' = \sigma - u$ = effective normal stress

c' and ϕ' are called effective stress parameters

c and ϕ are called total stress parameters.