SIGNIFICANCE OF VARIOUS LIMITS AND COMPACTION PROPERTIES OF SOIL WITH SPECIAL REFERENCE TO GEOTECHNICAL STUDIES

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ABSTRACT

A few soil tests play an important role for soil character like - Settlement criteria analysis by consolidation test, Strength criteria by Triaxial Shear test. If bearing capacity is very low and settlement increases, the locally available soil can be stabilized and their Geotechnical property can be improved. Similarly with the help of Plastic limit, Liquid limit and shrinkage limit test, an illustration of soil properties can make. This paper focuses on limits tests and compaction tests of soil.

Keywords : 1. Plastic Limit 2. Liquid Limit 3. Shrinkage Limit, 4. Compaction 5. Soil

Sub Area : Construction Technology & Management

Broad Area : Civil Engineering

INTRODUCTION:

Site feasibility study for geotechnical projects is of far most beneficial before a project can take off. Site survey usually takes place before the design process begins in order to understand the characteristics of subsoil upon which the decision on location of the project can be made. The following geotechnical design criteria have to be considered during site selection.

- Design load and function of the structure.
- Type of foundation to be used.
- Bearing capacity of subsoil.

Soil materials are a critical component of engineering design within the construction of buildings and roads. The mechanical aspect of soil in terms of how it moves when subjected to certain conditions derives from the physical and chemical properties of a particular soil type. Understanding different soil compositions, their respective strengths and structural make-ups enables engineers to treat soil as a construction material. Hence without determining geotechnical properties of soils beneath any area, no construction can be carried out.

Weak foundation soil conditions can result in inadequate support and reduce structural life. Soil properties can be improved through the addition of chemical or pozzolanic wast materials i.e stabilization. Soil stabilization refers to the procedure in which a soil, a pozzolanic wast material, or other chemical material is added to a parent soil to improve one or more of its properties. One may achieve stabilization by mechanically mixing the natural soil and stabilizing material together so as to achieve a homogenous mixture or by adding stabilizing material to an undisturbed soil deposit and obtaining interaction by letting it permeate through soil voids.

These chemical additives range from waste products to manufactured material which includes Portland cement, Rice husk ash, Fly ash, chemical stabilizers and cement kiln dust. These additives can be used with variety of soils to improve their native engineering properties. The effectiveness of these additives depends on the soil treated and the amount of additive used

The loading frame consists of two metal plates. The top plate is stationary and is attached to the load-measuring device. The bottom plate is raised and lowered by means of a

Crank on the front of the loading frame. After the soil sample has been placed between the plates, the bottom plate is gradually raised; the resistance provided by the stationary top plate applies an axial force to the sample. Although the loading frames in our laboratory are hand operated, electric motor-driven and hydraulic load frames are common. Loads are measured with a calibrated proving ring or an electronic load cell. Vertical deformations are measured with a dial gauge; the dial gauge is attached to the top plate and measures the relative movement between the top and bottom plates. We will be performing a strain-controlled test, in which the load is applied at a constant rate of strain or deformation .

For satisfactory performance of a structure, its foundation must satisfy the following three basic criteria:

a) Location and depth criterion

b) Shear failure or bearing capacity criterion

c) Settlement criterion

The properties influencing the above cited criterions i.e. shear strength as well as compressibility can be improved by stabilizing the weaker soil deposits. Generally, soil stabilization has been adopted in various civil engineering works. Some important applications are in foundations, retaining structures, stability of slopes, underground structure, earth dam etc. Hence, in broad sense, we can say:

1. Soil stabilization is the process of the improving the engineering properties of soil and thus making it more stable.

2. It required when soil available for construction is not suitable for intended purpose.

3. In broad, the soil stabilization includes compaction, pre-consolidation, drainage and many other processes.

4. A cementing material or a chemical is added to a natural soil for the purpose of stabilization.

5. Soil stabilization is used to reduce the permeability and compressibility of soil mass in earth structures and to increase its shear strength.

PROCEDURE

1. The first step in the procedure is to examine the loading frame. Turn the crank and learn how to read the load and deformation dial gages. Determine the calibration constant for the proving ring and the units of the deformation dial gauge.

2. We will be shearing the samples at a strain rate of about 1% per minute. From the length of your soil sample, determine the deformation at about 1% strain. Depending on the units of the vertical deformation dial gauge, determine the number of dial divisions per 1 strain- Practice turning the crank at his number of dial divisions/minute. It is important that the soil sample not be sheared faster than this specified rate

3. Measure the initial height and diameter of the soil sample with calipers. It is unlikely that the sample will be a perfect right cylinder. Therefore, it will be necessary to find the average height and diameter by taking several measurements in different places along the soil sample. The measurements should be taken by more than one member of a lab team to be sure that the calipers are read correctly. If you have any questions about how to take measurements with calipers, ask the laboratory instructor for instruction.

4. Record the weight of the soil sample and determine the total (moist) unit weight. 5. Place the soil sample in the loading frame, seat the proving ring and zero the dials.

6. During this lab you will record the load applied at specified strain values. It is recommended that readings be taken at strains of 0,0.2,0.4, 0.8, 1,2,4,6,8, 10, 12 15 and 25%. You should prerecord the vertical deformation dial readings at these strain values. With the measured initial height of sample (H0), the desired percent strain (ε) and the initial dial reading (S0), calculate the dial readings (S) 7. Readings of force (F) are taken from the proving ring dial gauge and the stress applied to the ends of the sample (01, or major principal stress) is computed as follows: where A is the cross-sectional area of the sample. Because the soil sample height decreases during shear and the volume of the sample remains constant, the cross sectional area must increase. For a saturated soil that undergoes no volume change during shear (no flow of water into or out of the sample), the equivalent or average area (A) at any strain (e) is computed from the initial area (Ac) and the assumption that volume is conserved:

8. Shear the sample at a strain rate of 1% per minute. Typically, the sample fails in one of two ways. In stiffer clays, a distinct failure plane forms. For this type of failure, it is likely that the point of failure will be indicated by the measurement of a peak and then a decrease in load. If this is the case, continue to take four or five readings past the point of failure. (Caution: before you stop shearing the sample, be sure that the sample has failed.) A "barreling" failure is more typical for softer clays. In this type of failure, a distinct failure plane doesn't form, rather the sample bulges in the middle the unconfined compressive strength (qu) is the maximum value σ1, which may or may not coincide with the maximum force measurement (depending on the area correction). It is also equal to the diameter of Mohr's circle as indicated in Fig. 1. The untrained shear strength (su) is typically taken as the maximum shear stress, or: If σ1 continues to increase up until 20 vertical strain, i.e. does not reach a maximum and then decrease, the sample has failed by "barreling". In this case, qu is defined as the value of σ1 measured at 20% strain.

9. When your lab team has completed the experiment, dismantle the loading frame and measure the water content of the soil sample. It is recommended that you reduce the data for this test during the lab period.

Shrinkage limit test (clay+5% rice husk ash)

PROCEDURE

1. A shrinkage dish is taken.
2. The Wt. of empty dish is 40 gm is recorded.
3. A soil sample is taken and water mixed into the mixture of clay and rice husk ash
4. Wt. of wet soil with dish is 80 gm is recorded. It placed into oven for drying for a period of 24 hours.
5. After drying the Wt. of dry pat with dish is 62 is recorded.
6. After this procedure a weighing dish Wt. is recorded i.e. 40 gm.
7. Mercury is placed in the weighing dish. Wt. of mercury with weighing dish is 368 gm.
8. After this the dry soil pat is placed into the weighing dish, mercury is displaced through weighing dish.
9. The wt of weighing dish with mercury displaced is 328 gm.

Material used

a) Locally available clay: Clay is collected from the ground at Kaithal.

b) Rice Husk Ash

c) Fly-Ash

d) Simple water

EXPERIMENTS

Liquid limit and plastic limit test

The Liquid limit of fine grained soil is the water content at which soil behaves practically like a liquid, bit has small shear strength. If flow close the groove in just 25 blows in cassagrandes liquid limit device. It is one of the Atterbergs limit. The Atterbergs limits consist of liquid limit and shrinkage limit. As it difficult to get exactly 25 blows in the test. 3 to 4 tests are conducted, and the number of blows (N) required in each test determined. A semi-log plot is drawn between log N and the water content (w).

The Liquid limit is the water content corresponding to N = 25. This index property helps in classification.

The plastic limit of a fine-grained soil is the water content of the soil below which it ceases to be plastic. It begins to crumble when rolled in to threads of 3 mm diameter.

APPARATUS

1. Cassagrande's limit device
2. Grooving tools of both standard and ASTM types
3. Oven
4. Evaporating dish
5. Spatula
6. 425 micron IS sieve
7. Weighing balance with 0.01 g accuracy
8. Wash bottle
9. Air-tight and non-corrodible container for determination of content.

Figure1: Cassagrande Apparatus

Figure2: Dr. Arvind Dewangan - during analysis of Soil sample at HCTM , in Soil Mechanics Lab at Civil Engineering Department . HCTM Technical Campus Kaithal

PREPARATION OF SAMPLE

1. Airs dry the soil sample and break the clods. Remove the organic matter like tree roots, pieces of bark etc.
2. About 100 g of the specimen passing through 150 micron IS sieve is mixed thoroughly with water in the evaporating dish and left for 24 hours for soaking.

PROCEDURE

1. A portion of cup placed in the cup of the Liquid limit device.
2. Leveled the mix so as to have a maximum depth of 1 cm.
3. Grooving tool drawn through the sample along the symmetrical axis of the cup, holding the tool perpendicular to the cup.
4. After soil pat has been cut by proper grooving tool, the handle is rotated at the rate of about 2 resolution per second and the nos. of blows counted till the two parts of the soil sample come into contact for about 10 mm length.
5. 10 g of soil taken near the closed groove & water contend determined.
6. The soil of the cup is transferred to the dish containing the soil paste and mixed thoroughly after adding a little more water. The test is repeated for 3 times.
7. The range of blows comes out only between 15 to 35 blows.
8. Liquid limit is determined by plotting a ‘flow curve’ on the semi-log graph between nos. of blows on logarithm scale and water content on arithmetical scale.
9. Water content corresponding to 25 blows is the value of liquid limit.

10. After this procedure for finding plastic limit 8 g of soil taken and roll it with fingers on a glass plate.
11. The rate of rolling shall between 80 to 90 strokes per minutes to form a 3 mm diameter.
12. The diameter of the soil not became less than 3 mm.
13. The plastic limit of the soil sample is nearly about zero.

OBSERVATION TABLE

Determination No.	1	2	3
(1).No of blows	25	23	15
(2).Container No.	6	8	9
(3).Mass of container + wet soil, (gm.)	40	42	60
(4).Mass of container + dry soil, (gm)	34	36	46
(5).Mass of water (3) –(4), (gm.)	6	6	14
(6).Mass of container, (gm.)	12	15	21
(7).Mass of dry soil (4)-(6), (gm.)	22	21	25
(8).Moisture content (5)/(7)*100, (%)	27.27	28.57	56

Table1: Liquid Limit Determination

SHRINKAGE LIMIT TEST

To Shrinkage limit is the water content of the soil when the water is just sufficient to fill the pores of the soil and the soil is just saturated. The volume of the soil does not decrease when the water content is reduced below the Shrinkage limit. It can be determined from the following relation –

$W = ((W_1-W_s) - (V_1-V_2) Y_w)/W_s)*100$

Where W_1 = Initial wet mass, W_s = Dry mass

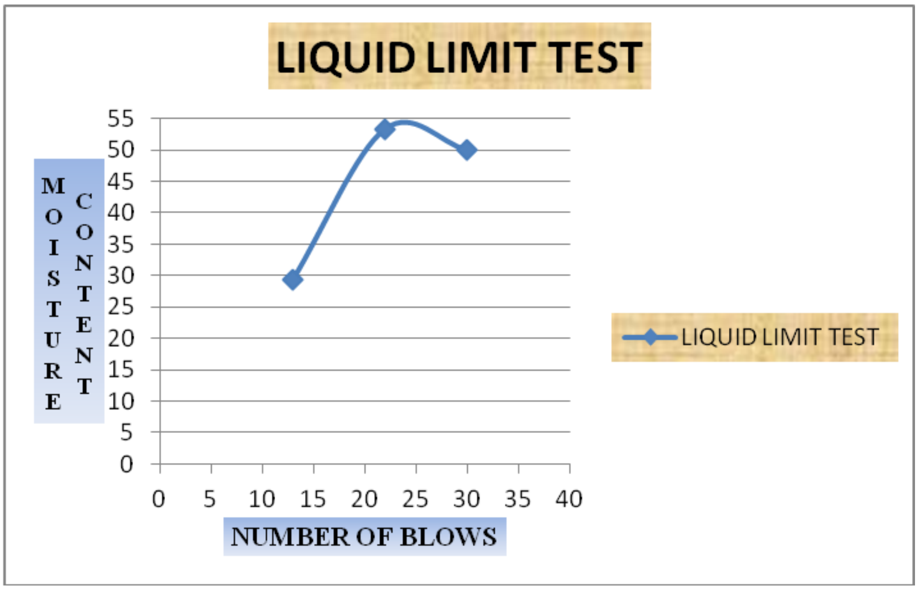
V_1 = Initial volume, V_2 = Volume after drying

APPARATUS

1. Shrinkage dish, having a flat bottom, 45 mm diameter and 15 mm height.
2. Two large evaporating dishes about 120 mm diameters, with a pour out and flat bottom.
3. One small mercury dish, 60 mm diameter.
4. Two glass plates, one with prongs, 75*75*3 mm size.
5. Glass cup, 50 mm diameter and 25 mm height.
6. IS sieve 150 micron.
7. Oven.
8. Desiccators.
9. Weighing balance, accuracy 0.01 g.
10. Spatula
11. Straight edge mercury.

ANALYSIS OF TEST RESULTS

LIQUID LIMIT AND PLASTIC LIMIT TEST



Graph 1: Moisture content Vs No. of blows

SHRINKAGE LIMIT TEST

Only Clay

Water content $(W_s) = ((W_1-W_s) - (V_1-V_2)\, y_w)/W_s)*100$

limit = $[w_1 - ((V_1 - V_2)\, y_w / W_s)]*100$

Clay + 15% Rice Husk Ash

Water content (W_s) = $((W_1\text{-}W_s) - (V_1\text{-}V_2)\ y_w)/W_s)*100$

Shrinkage limit = $[w_1 – ((V_1 – V_2)\ y_w / W_s)]*100$

COMPACTION TEST

Definition:Soil compaction is defined as the method of mechanically increasing the density of soil by reducing volume of air.

Factor Affecting Soil Compaction:

1- Soil Type

2- Water Content (wc)

3- Compaction Effort Required (Energy)

Optimum moisture content is that moisture content about which maximum dry density is obtained. It determines from the graph. i.e.

Optimum moisture content= 14.71%

Maximum dry density= 1.93

CONCLUSION

The study demonstrates the influence of rice husk ash and fly ash on the shrinkage and strength characteristics of highly compressible locally available clay. The following conclusions have been drawn based on the laboratory investigations carried out in this study:

1. Values of optimum moisture content (OMC) and maximum dry density (MDD) for parent clay were found to be 13.97 and 1.89 g/cc. It was observed that with increase in percentage of rice husk ash as stabilizer the value of OMC increases from 13.97% to 33.1% and value of MDD decreases from 1.89 g/cc to 1.49 g/cc. On the other hand, when fly ash was mechanically mixed with parent clay, no significant changes were observed in the values of OMC and MDD. Generally OMC increases and MDD decreases in case of fly ash stabilized clay samples. This significant increase in optimum moisture content can be attributed to water absorbing tendency of rice husk ash that too present in fly ash in small quantity. Decrease in MDD of stabilized samples can be attributed to the addition of a material of low specific gravity to parent clay. A considerable decrease in values of shrinkage limit was observed when soil was stabilized with fly ash and rice husk ash.

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