Stabilization of Soil By Using Stone Dust

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Abstract- *In this project we will study the general properties of different types of soil like black cotton soil, red soil and moorum soil. A series of laboratory experiments like Atterberg limits, Standard proctor compaction test, California bearing ratio test, sieve analysis, consolidation test, unconfined compression test, core cutter method test and direct shear test were conducted on different types of soils.*

Black cotton soil is considered to be problematic soil as this soil undergo large volumetric changes with the change in moisture content. Increase in moisture content causes swelling and the soil losses its strength and decreases in moisture content results in soil shrinkage.

Red soil is a type of soil that develops in warm temperatures. Red soil is generally derived from crystalline rock. They are usually poor growing soil, low in nutrients and humus and is difficult to cultivate because of low water holding capacity. Red soil denotes the third largest soil group in India.

Moorum is a soil of humid tropical or equatorial zones. It is characterized by a deep weathered layer from which silica has been leached. The yellowish color of the soil is moorum is typically an Indian term. But it is called as laterite. Laterite is a soil of rock type rich in iron and aluminum and is commonly considered to have formed in hard and wet tropical areas.

I. INTRODUCTION

SOIL

Soil is a mixture of minerals, organic matter, gases, liquids, and countless organisms that together support life on Earth. Soil is a natural body called the pedosphere which has four important functions: it is a medium for plant growth; it is a means of water storage, supply and purification; it is a modifier of Earth's atmosphere; it is a habitat for organisms; all of which, in turn, modify the soil.

Soil is called the Skin of the Earth and interfaces with the lithosphere, the hydrosphere, the atmosphere, and the biosphere. The term pedolith, used commonly to refer to the soil, literally translates ground stone. Soil consists of a solid phase of minerals (the soil matrix) and organic matter, as well as a porous phase that holds gases (the soil atmosphere) and water (the soil solution). Accordingly, soils are often treated as a three-state system of solids, liquids, and gases.
Soil is a product of the influence of climate, relief (elevation, orientation, and slope of terrain), organisms, and its parent materials (original minerals) interacting over time. Soil continually undergoes development by way of numerous physical, chemical and biological processes, which include weathering with associated erosion. Given its complexity and strong internal connectedness soil has been considered as an ecosystem by soil ecologists.[8]

Most soils have a dry bulk density (density of soil taking into account voids when dry) between 1.1 and 1.6 g/cm^3, while the soil particle density is much higher, in the range of 2.6 to 2.7 g/cm^3. Little of the soil of planet Earth is older than the Pleistocene and none is older than the Cenozoic, although fossilized soils are preserved from as far back as the Archean.

Soil science has two basic branches of study: edaphology and pedology. Edaphology is concerned with the influence of soils on living things. Pedology is focused on the formation, description (morphology), and classification of soils in their natural environment. In engineering terms, soil is referred to as regolith, or loose rock material that lies above the solid geology. Soil is commonly referred to as earth or dirt; technically, the term dirt should be restricted to displaced soil.

As soil resources serve as a basis for food security, the international community advocates its sustainable and responsible use through different types of soil governance.

TYPES OF SOIL

In our experiment we have used the following three types of soil:

1.1.1 Red Soil
1.1.2 Black Cotton Soil

1.1.3 Moorum Soil

Red Soil

Red soil is a type of soil that develops in a warm, temperate, moist climate under deciduous or mixed forests and that have thin organic and organic-mineral layers overlying a yellowish-brown leached layer resting on an alluvial red layer. Red soil generally derived from crystalline rock. They are usually poor growing soils, low in nutrients and humus and difficult to cultivate because of its low water holding capacity. Red soils denote the third largest soil group of India covering an area of about 3.5 lakhs sq. km (10.6% of India's area) over the Peninsula from Tamil Nadu in the south to Bundelkhand in the north and Rajmahal hills in the east to Katch in the west. They surround the black soils on their south, east and north. These soils are found in large tracts of western Tamil Nadu, Karnataka, southern Maharashtra, Chhattisgarh, Telangana], Andhra Pradesh, Odisha and Chotanagpur plateau of Jharkhand. Scattered patches are also seen in Birbhum (West Bengal), Mirzapur, Jhansi, Banda, Hamirpur (Uttar Pradesh), Udaipur, Chittaurgarh, Dungarpur, Banswara and Bhilwara districts (Rajasthan).

This soil, also known as the omnibus group, have been developed over Archaean granite, gneiss and other crystalline rocks, the sedimentaries of the Cuddapah and Vindhayan basins and mixed Dharwarian group of rocks. Their colour is mainly due to ferric oxides occurring as thin coatings on the soil particles while the iron oxide occurs as haematite or as hydrous ferric oxide, the colour is red and when it occurs in the hydrate form as limonite the soil gets a yellow colour. Ordinarily the surface soils are red while the horizon below gets yellowish colour.

The texture of red soils varies from sand to clay, the majority being loam. Their other characteristics include porous and friable structure, absence of lime, kankar and free carbonates, and small quantity of soluble salts. Their chemical composition include non-soluble material 90.47%, iron 3.61%, aluminium 2.92%, organic matter 1.01%, magnesium 0.70%, lime 0.56%, carbon-Di-oxide 0.30%, potash 0.24%, soda 0.12%, phosphorus 0.09% and nitrogen 0.08%. However significant regional differences are observed in the chemical composition.

In general these soils are deficient in lime, magnesia, phosphates, nitrogen, humus and potash. Intense leaching is a menace to these soils. On the uplands, they are thin, poor and gravelly, sandy, or stony and porous, light-colored soils on which food crops like bajra can be grown. But on the lower plains and valleys they are rich, deep, dark colored fertile loam on which, under irrigation, they can produce excellent crops like cotton, wheat, pulses, tobacco, jowar, linseed, millet, potatoes and fruits. These are also characterized by stunted forest growth and are suited to dry farming.

BLACK COTTON SOIL

Black cotton soil are found in extensive region of Deccan Trap in Indian. They are of variable thickness, underlain by black sticky material known as “black soil”. Black cotton soil when comes in contact with water it either swells or shrinks and resulting in moments to the structure which are generally not related to direct effect of loading. On account of its high volumetric changes it is not suitable for construction. It swells and shrinks excessively due to present of fine clay particles. Alternate swelling and shrinking of soil is responsible for differential settlement of structure so black cotton soil must be treated by using suitable admixtures to stabilize it. In my research work stabilization of black cotton soil is done by using lime as an admixture. Experimental work has been carried out with 3% and 5% of lime content.

Characteristics of Black cotton soil Black cotton soil are generally reddish brown to black in color. They occur 0.50m to 10 m deep possessing high compressibility. Due to their peculiar nature Black Cotton soils are challenge for engineers everywhere in the world, and more so in tropical countries like India because of wide variation in temperature and because of distinct dry and wet seasons, leading to wide variations in moisture content of soils. The following problems generally occur in black cotton soil – High Compressibility: Black Cotton soils are highly plastic and compressible, when they are saturated. Footing, resting on such soils under goes consolidation settlements of high magnitude.

Swelling: A structure built in a dry season, when the natural water content is low shows differential movement as result of soils during subsequent wet season. This causes structures supported by such swelling soils to lift up and crack. Restriction on having developed swelling pressures making the structure suitable. Shrinkage: A structure built at the end of the wet season when the natural water content is high, shows settlement and shrinkage cracks during subsequent dry season. The main engineering properties of soil are permeability, plasticity, compaction, compressibility and shear strength.

Permeability: The permeability is defined as the property of a porous material which permits the passage or seepage of water through its interconnecting voids.

Plasticity: It is defined as the property of a soil which allows it to be deformed rapidly, without elastic rebound, without volume change.

Compaction: Compaction is a process by which the soil particles artificially rearrange and packed together into a closer state of contact by mechanical means in order to decrease the porosity of the soil and thus increase its dry density.

Compressibility: The property of soil mass pertaining to its susceptibility to decrease in volume under pressure is known as compressibility.

Shear Strength: This is the resistance to deformation by continuous shear displacement of soil particles or on masses upon the action of a shear stress.

MOORUM SOIL

Moorum is a soil of humid tropical or equatorial zones. It is characterized by a deep weathered layer from which silica has been leached. The reddish colour of these soils is Moorum or Moorum is typically an Indian term. But it is called as laterite. Laterite is a soil and rock type rich in iron and aluminium and is commonly considered to have formed in hot and wet tropical areas.

By considering all those engineering properties of soils we have to estimate the whether the land is beneficial for our constructions or not and what modifications to be done for getting better properties to that soil type. In the Dangs district, due to abundant forest vegetation and high annual rain fall laterities are developed. They are yellowish red in upper horizon, with thickness ranging from 20-40 cm. These are neutral to slightly acidic in reaction.

Tropical weathering (laterization) is a prolonged process of chemical weathering which produces a wide variety in the thickness, grade, chemistry and ore mineralogy of the resulting soils. The initial products of weathering are essentially kaolinized rocks called saprolites. A period of active laterization extended from about the mid-Tertiary to the mid-Quaternary periods (35 to 1.5 million years ago). Statistical analyses show that the transition in the mean and variance levels of O during the middle of the Pleistocene was abrupt. It seems this abrupt change was global and mainly represents an increase in ice mass; at about the same time an abrupt decrease in sea surface temperatures occurred; these two changes indicate a sudden global cooling. The rate of laterization would have decreased with the abrupt cooling of the earth. Weathering in tropical climates continues to this day, at a reduced rate.

Laterites are formed from the leaching of parent sedimentary
rocks (sandstones, clays, limestones); metamorphic
rocks (schists, gneisses, migmatites); igneous
rocks (granites, basalts, gabbros, peridotites); and mineralised proto-ores; which leaves the more insoluble ions, predominantly iron and aluminium. The mechanism of leaching involves acid dissolving the host mineral lattice, followed by hydrolysis and precipitation of insoluble oxides and sulfates of iron, aluminium and silica under the high temperature conditions of a humid sub-tropical monsoon climate.

An essential feature for the formation of laterite is the repetition of wet and dry seasons. Rocks are leached by percolating rain water during the wet season; the resulting solution containing the leached ions is brought to the surface by capillary action during the dry season. These ions form soluble salt compounds which dry on the surface; these salts are washed away during the next wet season. Laterite formation is favoured in low topographical reliefs of gentle crests and plateaus which prevents erosion of the surface cover. The reaction zone where rocks are in contact with water—from the lowest to highest water table levels—is progressively depleted of the easily leached ions of sodium, potassium, calcium and magnesium. A solution of these ions can have the correct pH to preferentially dissolve silicon oxide rather than the aluminium oxides and iron oxides.

The mineralogical and chemical compositions of laterites are dependent on their parent rocks. Laterites consist mainly of quartz, zircon, and oxides of titanium, iron, tin, aluminium and manganese, which remain during the course of weathering. Quartz is the most abundant relic mineral from the parent rock.

Laterites vary significantly according to their location, climate and depth. The main host minerals for nickel and cobalt can be either iron oxides, clay minerals or manganese oxides. Iron oxides are derived from mafic igneous rocks and other iron-rich rocks; bauxites are derived from granitic igneous rock and other iron-poor rocks. Nickel laterites occur in zones of the earth which experienced prolonged tropical weathering of ultramafic rocks containing the ferro-magnesian minerals olivine, pyroxene, and amphibole.

Moorum soil is also called as laterite, Murrum or Moram is typically an Indian term. The geological equivalent term is Lateritic soil. It is soils of humid tropical or equatorial zones. It is characterized by a deep weathered layer from which silica has been leached. There is no humus, but an accumulation of aluminium and iron oxides and hydroxides. The reddish colour of these soils is imparted by the iron compounds.

They are good material for building huts and paths, as they can be compacted easily to form hard surfaces. They are generally impervious.

II. LITERATURE REVIEW

Several researchers had carried out investigation to determine the properties of soil. The literature on the properties of soil is reviewed in this chapter.

Subrahmanyani G and Srinivasa Rao T (1989) studied the characcteristics of different soil. The friction between the soil and the reinforced strips is essential in reinforced earth. The experimental work is carried out in a modified direct shear box apparatus to find the adhesion and the angle of friction between the reinforcement given.

JURY.W,A(1985) This report contains a critical review of the literature on existing field studies of the spatial variability of soil water and chemical retention and chemical transport in unsaturated soils. The report covers static soil properties, water transport properties, solute concentration variations, and observations of maximum solute transport. Each section reviews the existing information and provides a tabular summary allowing readers to compare soil type, field size, methodology, and transport. Observed coefficients of variation for transport properties or solute concentrations were high enough to require large numbers of samples to be taken to determine field average characteristics accurately. Evidence suggests that the scaling factors inferred from measurements depend critically on the type of measurements made

HOLTZ. R D He presents data on soil behaviour, with emphasis on practical and empirical knowledge, required by geotechnical engineers for the design and construction of foundations and embankments. It deals with: index and classification properties of soils; soil classification; clay minerals and soil structure; compaction; water in soils (capillarity, shrinkage, swelling, frost action, permeability, seepage, effective stress); consolidation and consolidation settlements; time rate of consolidation; the Mohr circle, failure theories, and stress paths; shear strength of sands and clays. Four appendices deal with the following: application of the "SI" system of units to geotechnical engineering; derivation of Laplace's equation; derivation and solution of Terzaghi's one-dimensional consolidation theory; pore pressure parameters

III. EXPERIMENTAL INVESTIGATION

LIQUID LIMIT TEST

OBJECTIVE

- **i.** Find the relationship between water content and number of blows.
- **ii.** Draw flow curve.
- **iii.** Find out liquid limit.

NEED AND SCOPE Liquid limit is significant to know the stress history and general properties of the soil met with construction. From the results of liquid limit the compression index may be estimated. The compression index value will help us in settlement analysis.

THEORYThe liquid limit is the moisture content at which the groove, formed by a standard tool into the sample of soil taken in the standard cup, closes for 10 mm on being given 25 blows in a standard manner. At this limit the soil possess low shear strength.

APPARATUS REQUIRED

- i. Balance Liquid limit device (Casagrende's)
- ii. Grooving tool
- iii. Mixing dishes
- iv. Spatula
- v. Electrical Oven

Fig.01:Casagrande'sApparatus

PROCEDURE

About 120 gm of air-dried soil from thoroughly mixed portion of material passing 425 micron I.S sieve is to be obtained.
2. Distilled water is mixed to the soil thus obtained in a mixing disc to form uniform paste. The paste shall have a consistency that would require 30 to 35 drops of cup to cause closer of standard groove for sufficient length.
3. A portion of the paste is placed in the cup of liquid limit device and spread into portion with few strokes of spatula.
4. Trim it to a depth of 1cm at the point of maximum thickness and return excess of soil to the dish.
5. The soil in the cup shall be divided by the firm strokes of the grooving tool along the diameter through the centre line of the follower so that clean sharp groove of proper dimension is formed.
6. Lift and drop the cup by turning crank at the rate of two revolutions per second until the two halves of soil cake come in contact with each other for a length of about 1 cm by flow only.
7. The number of blows required to cause the groove close for about 1 cm shall be recorded.
8. A representative portion of soil is taken from the cup for water content determination.
9. Repeat the test with different moisture contents at least three more times for blows between 10 and 40.

PLASTIC LIMIT TEST

NEED AND SCOPE

Soil is used for making bricks, tiles, soil cement blocks in addition to its use as foundation for structures.

APPARATUS REQUIRED

i. Porcelain dish.
ii. Glass plate for rolling the specimen.
iii. Air tight containers to determine the moisture content.
iv. Balance of capacity 200gm and sensitive to 0.01gm
v. Oven thermostatically controlled with interior of non-corroding material to maintain the temperature around 105^0 and 110^0C.

PROCEDURE

i. Take about 20gm of thoroughly mixed portion of the material passing through 425 micron I.S. sieve obtained in accordance with I.S. 2720 (part 1).
ii. Mix it thoroughly with distilled water in the evaporating dish till the soil mass becomes plastic enough to be easily molded with fingers.
iii. Allow it to season for sufficient time (for 24 hrs) to allow water to permeate throughout the soil mass.
iv. Take about 10gms of this plastic soil mass and roll it between fingers and glass plate with just sufficient pressure to roll the mass into a threaded of uniform diameter throughout its length. The rate of rolling shall be between 60 and 90 strokes per minute.
v. Continue rolling till you get a threaded of 3 mm diameter.
vi. Kneed the soil together to a uniform mass and re-roll.
vii. Continue the process until the thread crumbles when the diameter is 3 mm.
viii. Collect the pieces of the crumbled thread in air tight container for moisture content determination.
ix. Repeat the test to atleast 3 times and take the average of the results calculated to the nearest whole number.

GRAIN SIZE ANALYSIS

OBJECTIVE

a) Select sieves as per *I.S* specifications and perform sieving.
b) Obtain percentage of soil retained on each sieve.

NEED AND SCOPE OF EXPERIMENT

The grain size analysis is widely used in classification of soils. The data obtained from grain size distribution curves is used in the design of filters for earth dams and to determine suitability of soil for road construction, air field etc. Information obtained from grain size analysis can be used to predict soil water movement although permeability tests are more generally used.

APPARATUS

i. Balance
ii. I.S sieves
iii. Rubber pestle and mortar.
iv. mechanical Sieve Shaker
v.

Fig.02: I.S Sieve

Fig.03: Standard Compaction Cylinder

STANDARD PROCTOR COMPACTION TEST
SCOPE

This method covers the determination of the relationship between the moisture content and density of soils compacted in a mould of a given size with a 2.5 kg rammer dropped from a height of 30 cm.

APPARATUS

1. Proctor mould having a capacity of 944 cc with an internal diameter of 10.2 cm and a height of 11.6 cm. The mould shall have a detachable collar assembly and a detachable base plate.
2. Rammer: A mechanical operated metal rammer having a 5.08 cm diameter face and a weight of 2.5 kg. The rammer shall be equipped with a suitable arrangement to control the height of drop to a free fall of 30 cm.
3. Sample extruder.
4. A balance of 15 kg capacity.
5. Sensitive balance.
6. Straight edge.
7. Graduated cylinder.
8. Mixing tools such as mixing pan, spoon, towel, spatula etc.
9. Moisture tins

PROCEDURE

1.Take a representative oven-dried sample, approximately 5 kg in the given pan. Thoroughly mix the sample with sufficient water to dampen it to approximately four to six percentage points below optimum moisture content.
2.Weigh the proctor mould without base plate and collar. Fix the collar and base plate. Place the soil in the Proctor mould and compact it in 3 layers giving 25 blows per layer with the 2.5 kg rammer falling through.
3.Remove the collar, trim the compacted soil even with the top of the mould by means of the straight edge and weigh.
4.Divide the weight of the compacted specimen by 944 cc and record the result as the wet weight g_{wet} in grams per cubic centimeter of the compacted soil.
5.Remove the sample from the mould and slice vertically through and obtain a small sample for moisture determination
6.Thoroughly break up the remainder of the material until it will pass a no.4 sieve as judged by the eye. Add water in sufficient amounts to increase the moisture content of the soil sample by one or two percentage points and repeat the above procedure for each increment of water added.
7.Continue this series of determination until there is either a decrease or no change in the wet unit weight of the compacted soil.

CALCULATION

Bulk Density = $\frac{Ws}{V}$ g/cc
Where, Ws = Weight of compacted soil
V = Volume

Water Content = $\frac{W2-W3}{W3-W1} X\ 100$
Where, W_1 = weight of empty can

$W_2 = W_1$ + Moist Soil
$W_3 = W_1$ + Dry Soil

CALIFORNIA BEARING RATIO TEST

OBJECTIVETo determine the California bearing ratio by conducting a load penetration test in the laboratory.

NEED AND SCOPE The California bearing ratio test is penetration test meant for the evaluation of subgrade strength of roads and pavements. The results obtained by these tests are used with the empirical curves to determine the thickness of pavement and its component layers. This is the most widely used method for the design of flexible pavement.

This instruction sheet covers the laboratory method for the determination of C.B.R. of undisturbed and remoulded /compacted soil specimens, both in soaked as well as unsoaked state.

PLANNING AND ORGANIZATION

Equipment and tools required

1.Cylindricalmould with inside diameter 150 mm and height 175 mm, provided with a detachable extension collar 50 mm height and a detachable perforated base plate 10 mm thick.
2. Spacer disc 148 mm in dia and 47.7 mm in height along with handle.
3. Metal rammers**.** Weight 2.6 kg with a drop of 310 mm (or) weight 4.89 kg a drop 450 mm.
4. Weights**.** One annular metal weight and several slotted weights weighing 2.5 kg each, 147 mm in diameter, with a central hole 53 mm in diameter.
5. Loading machine. With a capacity of at least 5000 kg and equipped with a movable head or base that travels at an uniform rate of 1.25 mm/min. Complete with load indicating device.
6. Metal penetration piston 50 mm diameter and minimum of 100 mm in length.
7. Two dial gauges reading to 0.01 mm.
8. Sieves. 4.75 mm and 20 mm I.S. Sieves.
9. Miscellaneous apparatus, such as a mixing bowl, straight edge, scales soaking tank or pan, drying oven, filter paper and containers.

DEFINITION OF C.B.R.

It is the ratio of force per unit area required to penetrate a soil mass with standard circular piston at the rate of 1.25 mm/min. to that required for the corresponding penetration of a standard material.

C.B.R. = Test load/Standard load � 100

The following table gives the standard loads adopted for different penetrations for the standard material with a C.B.R. value of 100%

PREPARATION OF TEST SPECIMEN

Undisturbed specimen

Attach the cutting edge to the mould and push it gently into the ground. Remove the soil from the outside of the mould which is pushed in . When the mould is full of soil, remove it from weighing the soil with the mould or by any field method near the spot.

Remoulded specimen

Prepare the remoulded specimen at Proctors maximum dry density or any other density at which C.B.R> is required. Maintain the specimen at optimum moisture content or the field moisture as required. The material used should pass 20 mm I.S. sieve but it should be retained on 4.75 mm I.S. sieve. Prepare the specimen either by dynamic compaction or by static compaction.
Dynamic Compaction Take about 4.5 to 5.5 kg of soil and mix thoroughly with the required water.

Fix the extension collar and the base plate to the mould. Insert the spacer disc over the base (See Fig.38). Place the filter paper on the top of the spacer disc.

Compact the mix soil in the mould using either light compaction or heavy compaction. For light compaction, compact the soil in 3 equal layers, each layer being given 55 blows by the 2.6 kg rammer. For heavy compaction compact the soil in 5 layers, 56 blows to each layer by the 4.89 kg rammer.

Remove the collar and trim off soil.

Turn the mould upside down and remove the base plate and the displacer disc.

Weigh the mould with compacted soil and determine the bulk density and dry density.

Put filter paper on the top of the compacted soil (collar side) and clamp the perforated base plate on to it.

Static compaction Calculate the weight of the wet soil at the required water content to give the desired density when occupying the standard specimen volume in the mould from the expression.

W =desired dry density * (1+w) V

Where W = Weight of the wet soil
w = desired water content
V = volume of the specimen in the mould = 2250 cm^3 (as per the mould available in laboratory)

Take the weight W (calculated as above) of the mix soil and place it in the mould.

Place a filter paper and the displacer disc on the top of soil.
Keep the mould assembly in static loading frame and compact by pressing the displacer disc till the level of disc reaches the top of the mould.

Keep the load for some time and then release the load. Remove the displacer disc.

The test may be conducted for both soaked as well as unsoaked conditions.

If the sample is to be soaked, in both cases of compaction, put a filter paper on the top of the soil and place the adjustable stem and perforated plate on the top of filter paper.

Put annular weights to produce a surcharge equal to weight of base material and pavement expected in actual construction. Each 2.5 kg weight is equivalent to 7 cm construction. A minimum of two weights should be put.

Immerse the mould assembly and weights in a tank of water and soak it for 96 hours. Remove the mould from tank.

Note the consolidation of the specimen.

PROCEDURE FOR PENETRATION TEST

Place the mould assembly with the surcharge weights on the penetration test machine.

Seat the penetration piston at the center of the specimen with the smallest possible load, but in no case in excess of 4 kg so that full contact of the piston on the sample is established.

Set the stress and strain dial gauge to read zero. Apply the load on the piston so that the penetration rate is about 1.25 mm/min.

Record the load readings at penetrations of 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0, 7.5, 10 and 12.5 mm. Note the maximum load and corresponding penetration if it occurs for a penetration less than 12.5 mm.

Detach the mould from the loading equipment. Take about 20 to 50 g of soil from the top 3 cm layer and determine the moisture content.

OBSERVATION AND RECORDING

For Dynamic Compaction

Optimum water content (%)
Weight of mould + compacted specimen g
Weight of empty mould g
Weight of compacted specimen g
Volume of specimen cmз
Bulk density g/cc
Dry density g/cc

For static compaction

Dry density g/cc
Moulding water content %
Wet weight of the compacted soil, (W)g
Period of soaking 96 hrs. (4days).

For penetration Test

Calibration factor of the proving ring1Div. = 1.176 kg
Surcharge weight used (kg) 20kg per 6 cm construction
Water content after penetration test %
Least count of penetrationdial 1Div. = 0.01 mm

If the initial portion of the curve is concave upwards, apply correction by drawing a tangent to the curve at the point of greatest slope and shift the origin (Fig. 40). Find and record the correct load reading corresponding to each penetration.

C.B.R. = P_T/P_S � 100

where P_T = Corrected test load corresponding to the chosen penetration from the load penetration curve.

P_S = Standard load for the same penetration taken

Interpretation and recording

C.B.R. of specimen at 2.5 mm penetration
C.B.R. of specimen at 5.0 mm penetration

C.B.R. of specimen at 2.5 mm penetration

The C.B.R. values are usually calculated for penetration of 2.5 mm and 5 mm. Generally the C.B.R. value at 2.5 mm will be greater that at 5 mm and in such a case/the former shall be taken as C.B.R. for design purpose. If C.B.R. for 5 mm exceeds that for 2.5 mm, the test should be repeated. If identical results follow, the C.B.R. corresponding to 5 mm penetration should be taken for design.

DETERMINATION OF SPECIFIC GRAVITY BY PYCNOMETER

OBJECTIVETo determine the specific gravity of soil fraction passing 4.75 mm I.S sieve by density bottle, degree of saturation etc

APPARATUS REQUIRED

- **i.** Density bottle of 50 ml with stopper having capillary hole.
- **ii.** Balance to weigh the materials (accuracy 10gm).
- **iii.** Wash bottle with distilled water.
- **iv.** Alcohol and ether

Fig.04: Pycnometer

PROCEDURE

1.Clean and dry the density bottle
  a. Wash the bottle with water and allow it to drain.
  b. Wash it with alcohol and drain it to remove water
  c. Wash it with ether, to remove alcohol and drain ether
2. Weigh the empty bottle with stopper (W_1)
3. Take about 10 to 20 gm of oven soil sample which is cooled in a desiccator. Transfer it to the bottle. Find the weight of the bottle and soil (W_2).
4. Put 10 ml of distilled water in the bottle to allow the soil to soak completely. Leave it for about 2 hours.
5. Again fill the bottle completely with distilled water put the stopper and keep the bottle under constant temperature water baths.
6. Take the bottle outside and wipe it clean and dry note. Now determine the weight of the bottle and the contents (W_3).
7. Now empty the bottle and thoroughly clean it. Fill the bottle with only distilled water and weigh it. Let it be W_4 at temperature.
s8. Repeat the same process for 2 to 3 times, to take the average reading of it.

CALCULATIONS

$$\text{Specific gravity of soil} = \frac{\text{Density of water at } 27\ \text{C}}{\text{Weight of water of equal volume}}$$

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

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

FREE SWELL INDEX TEST

Free Swell Index is the increase in volume of a soil, without any external constraints, on submergence in water.

APPARATUS

- 425 micron IS sieve
- Graduated glass cylinders of 100 ml capacity 2 Nos.
- Glass rod for stirring.
- Balance of capacity 500grams and sensitivity 0.01 gram.

PROCEDURE

- Take two representative oven dried soil samples each of 10 grams passing through 425 micro33n sieve
- Pour each soil sample in to each of the two glass graduated cylinders of 100ml capacity
- Fill one cylinder with kerosene and the other with the distilled water up to the100ml mark.
- Remove the entrapped air in the cylinder by gentle shaking and stirring with a glass rod. Sample kept for free swell index
- Allow the samples to settle in both the cylinders.
- Sufficient time, not less than 24 hours shall be allowed for soil sample to attain equilibrium state of volume without any further change in the volume of

the soils. • Record the final volume of the soils in each of the cylinders.

CALCULATION

Swelling Index = $\frac{Vd-Vk}{Vk} X\ 100$

Where V_d = Soil in water

V_k = Soil in kerosene

IV. RESULTS

RED SOIL:

Table 1

Area	Bogaram
Liquid limit	31
Plastic limit	18.63
Specific gravity	2.47
Free swell index	16.666
Optimum moisture content(OMC)	11%
Maximum dry density(MDD)	1.94 g/c.c

BLACK COTTON SOIL:

Table 2

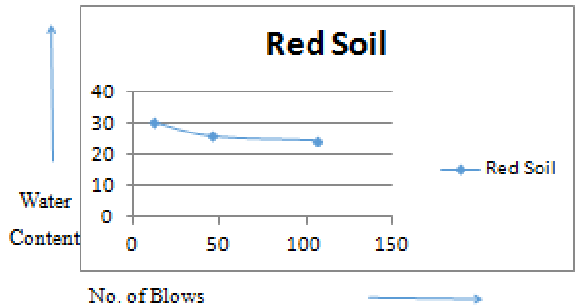
Area	Ghatkesar
Liquid limit	50
Plastic limit	27
Specific gravity	2.57
Free swell index	20.66
Optimum moisture content(OMC)	18%
Maximum dry density(MDD)	1.59g/c.c

MOORUM SOIL:

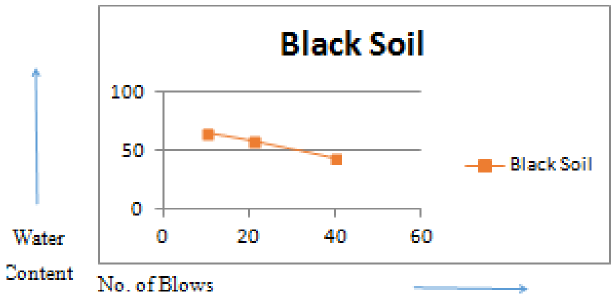
Table 3

Area	Kondapur
Liquid limit	28.5
Plastic limit	21.05
Specific gravity	2.85
Free swell index	9.09
Optimum moisture content(OMC)	7.94%
Maximum dry density(MDD)	1.91g/c.c

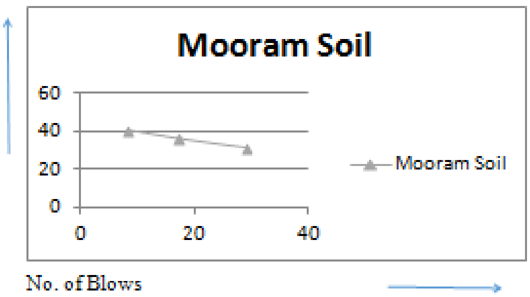
GRAPH: For Liquid limit



Graph No.01



Graph No.02



V. CONCLUSION

We have conducted the following experiment and got the result, both are mentioned below.

1. Liquid limit of the black soil is higher than others.
2. Plastic limit of the black is also higher than other soil.
3. Specific gravity of the morrum soil is high.
4. Optimum moisture content of the black soil is high.
5. Maximum dry density of the red soil is high.
6. Differential free swell index of the black soil is high.
7. Among above soil, the black soil obtained highest values, so we can considered as the black soil is problematic soil.

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