Stablization of clayey soils using Surkhi and Plastic bottles

A Thesis

Submitted by

Nishant Srivastava

(2K19/GTE/09)

In partial fulfillment of the requirements

for the award of the degree of

Master of Technology
In
Civil Engineering
(Geotechnical Engineering)
Department of Civil Engineering

Delhi Technological University

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CANDIDATE’S DECLARATION

I Nishant Srivastava, Roll No. 2K19/GTE/09 student of M.tech (Civil, Geotechnical Engineering), hereby announce that the project Dissertation titled “Soil stabilization using surkhi and plastic bottles” which is submitted by me to the Department of Civil Engineering, Delhi Technical University, Delhi in partial fulfillment of the requirement for the award of the degree of Master of Technology, is actual and not duplicated from any source without proper citation. This work has not formely formed the basis for the award of any degree, Diploma Associate ship, Fellowship or other alike title or recognition.

Place: Delhi
Date: 22/07/2021

NISHANT SRIVASTAVA
Department of Geotechnical Engineering
2K19/GTE/09

CERTIFICATE

I hereby confirm that the Project Dissertation titled "Soil stabilization using surkhi and plastic bottles" which is submitted by Nishant Srivastava, 2K19/GTE/09, to department of Civil Engineering, Delhi Technical University, Delhi in partial accomplishment of the requirement for the award of the degree of Master of Technology, is a record of the project work carried out by the students under my supervision. To the best of my knowledge this work has not been submitted in part or full for any Degree or Diploma to this University or elsewhere.

Place: Delhi — Prof. KONGAN ARYAN SIR

Date: 22/07/2021 — SUPERVISOR

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Last but not the least I would like to thank my family for giving me this stage for learning and their help as and when needed.

ABSTRACT

A significant part of entire country is surrounded by clayey soil. Clay soil is not suitable for settlement point of view because it goes for long term settlement. Clay soil has lower shear strength because of low value of angel of internal friction.

Hence, clayey soils need to be stabilized to increase it’s strength, durability. Numerous researches have been completed on clayey soils to upgrade it’s properties. Soil stabilization is the most accurate method to enhance the geotechnical properties of soil. It is chiefly using for constructing the structures.

This project focuses to conduct an investigation to examine the developments in properties of clayey soil analyzing physical properties of soil stabilized with surkhi and raw plastic bottles such as Compaction Curve (OMC and MDD), Unconfined Compression Strength (UCS) test, Liquid Limit Test and Plastic Limit Test.

The tests were conducted in three phases. In first phase, the physical properties of pure soil were determined.

In the second phase, various tests were performed on the soil with varying percentage of surkhi. The varying percentages of surkhi are as 5%, 10%, 15%, and 20% to 45%.

In the third phase, various tests were performed on the soil with varying percentage of raw plastic bottles. The varying percentage of plastic bottles is as 5%, 10%, 15%, 20% to 25%.

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CHAPTER 1 – INTRODUCTION

Soil is essentially made up of solid particles, with spaces or voids in between the assembles of particles in contact is usually reffered to as the ‘soil matrix’ or the soil skelton. The intermittent void spaces are filled up by either air or water or both air and water.This means that an element of soil may be considered as a three-phase material, comprising some solid (soil grains), some liquid (pore water) and some gas.

Clay minerals are hydrous aluminium silicate with other metallic ions in a sheet like structure. Their particles are very flaky in shape and thus have considered surface area. These clay minerals are developed mostly from the chemical weathering of particular rock minerals. The crystalline mineral whose surface activity is high are clay minerals. These clay minerals imparts cohesion and plasticity.So the study of clay minerals is essential for understanding the behavior of clayey soilids.

The soils found in Maharashtra, Saurashtra, Malwa, Madhya Pradesh, Chhattisgarh hold necessary clay minerals as montmorillonite. These soils surround a large area of 300,000 km^2. The geotechnical properties of clayey soils are -

- Large compressibility
- Low carrying capability
- Low shearing strength

We have a building works which accomplish our requirements and goals. Our main aim is to find the ultimate relevant properties of surkhi and plastic bottles to calculate the carrying capability of the clayey soil. Here, the study of this project based on that how the waste materials like surkhi and plastic bottles can be used for stabilizing the clayey soils and for increasing the strength of soil.

1.1) STABILIZATION- Stabilization is the method by which the strength and stability of soil mass is upgraded and enhanced. Soil stabilization a common term for any physical, chemical, mechanical, biological or mixed technique of replacing a natural soil to develope the engineering properties which includes enhancing the weight carrying capacities, tensile strength, and gross presentation of in-situ subsoil's sands, and unwanted materials to produce strength in road pavement.

Stabilized soils give a powerful foundation for all remaining parts of projects. After stabilization sick soils can be stabilized by performing the constant pozzolanic reactions. In addition, soils that have stabilized can also under go for some modification. By the stabilization process, the plasticity reduces and the compaction process becomes easier and the physical properties of soil get also changed and this makes easier for achieving maximum dry density. Plasticity index is equal to the difference between LL and PL. Clay soils which holds larger amount of liquid limit and plasticity index are known as highly plastic or flat clays and those which contain low amount of liquid limit and plastic limit are explained as lean clays. The different methods are soil stabilization are as follows-

1.2) Method of soil stabilization- The different methods are soil stabilization are as follows-

1.2.1) Chemical Soil Stabilization-The chemical soil stabilization is used to-

1. Reduce the permeability of soil.
2. Increase shear strength.
3. Enhance carrying capacity.

Chemical stabilization warns the chemical properties of the soil by applying the admixtures. There are 18 various chemical mechanisms which are giving and taking of cations and anions, adsorption, fixation, origination of new minerals, cementation minerals etc.

1.2.2) Mechanical Soil Stabilization- Sand and clays show opposite properties to each other. For gaining the better results of sand and clay, it is necessary to mix both the soils simultaneously. Mechanical soil stabilization includes of-

1. The grading of soil particles i.e., by replacing the constitution of the soil mass by including or extracting the unlike soil particles.
2. Compact the soil to increase the firmness and strength.

In the process of mechanical stabilization no chemicals are used. Mechanical stabilization is applied in making base courses of roads.

1.3) ADVANTAGE OF SOIL STABILIZATION-

1. Saves costs.
2. Savings by designing process.
3. Saves time and work.
4. Winter working.
5. Saves environmental impact.
6. Saves wastage materials.
7. Saves landfill taxes.
8. Improves strength properties.
9. Energy conservation.

1.4) Objective of this project-

1. To observe the change in strength (i.e. stability) of soil with addition of different amount plastic bottle strips of 5%,10%,15%,20% and 25% and small amount of surkhi (10%,20%,30% and 40%).
2. To compare the change in strength of soil with different content of plastic bottle strips.
3. To find out the optimum plastic bottle strips content (w/w) for maximum strength of soil.
4. To compare the change in strength of soil with different content of surkhi.
5. To conduct various tests just like Unconfined Compression Test, Standard Proctor Test, Liquid Limit Test, and Plastic Limit Test and for finding geotechnical properties of soil.
6. Use the soil with a cheap material or unwanted industrial materials.

1.5) Clay- It is an aggregate of mineral particles of microscopic and submicroscopic range. Clay may be organic or inorganic. Kaolin (china clay) is a very pure form of white clay, which is extensively used in ceramic industry. Varved clays are sedimentary deposits consisting of thin layer of silt and clay. These clays are the result of deposition in lakes during periods of alternate high and low waters. Clays shows plasticity in wetting conditions, because of a molecular film of water bordering the clay particles, but turn into firm, breakable and non–plastic in drying conditions. Maximum pure clay minerals are white coloured, but native clays are of reddish or brownish colour from low quantities of iron oxide. Clay has the size less than 2 micron. Clay is the most porous sediment but it has very low permeability. Clay is an aquitard impeding the flow of the water. There are many tests can be used to identify clay soil. It sticks to your finger when you rubbed between your fingers.

Clay soils are normally associated with water and their properties are greatly influenced by the presence of water. Whereas, there is no impact structural water on granular soils except for reduction in void due to submergence. The surface of clay particles carry negative charges. The edges of a clay particle may have a positive or a negative charge. Including materials such as organic compost, pine bark, composted leaves and gypsum to heavy **clay** can upgrade it's structure and can support to reduce drainage and compaction difficulties. Keep away putting sand or peat moss to **clay**; they can build those difficulties unacceptable. As it decomposes, it continues to gradually improve **clay soil**.

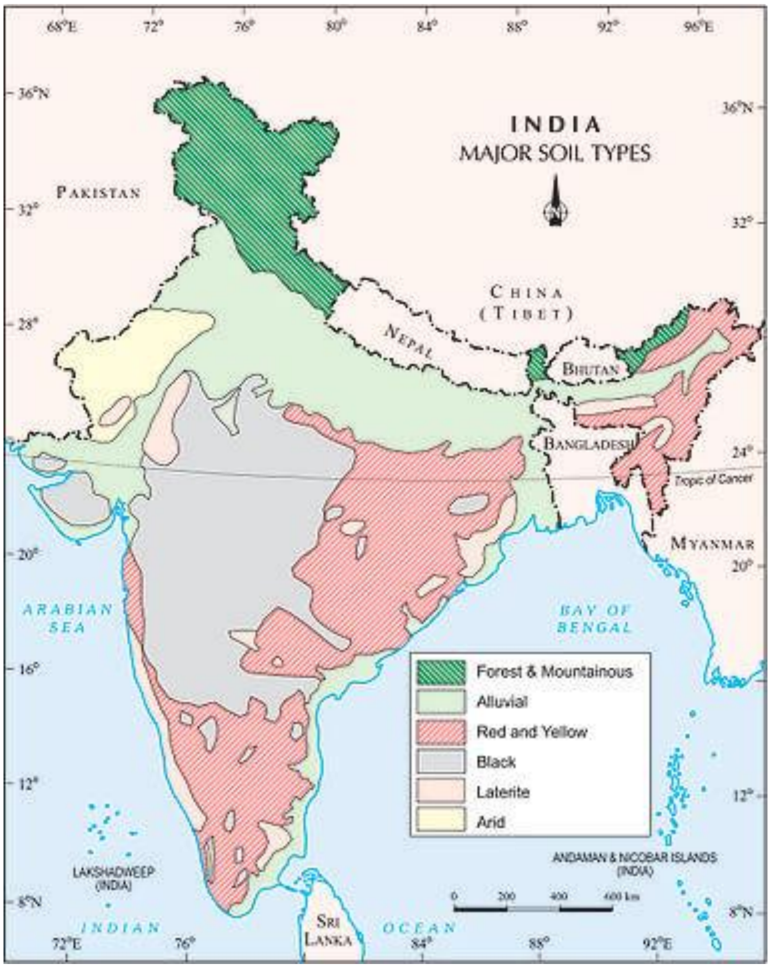

Figure 1.1 Location of different soil in India

1.5.1) Uses of Clay soil-

1. Growing.
2. Construction-clay can be used for construction purpose because of it possess some important properties.
3. Ceramics.
4. Pottery.
5. Medicinal

1.6) Surkhi- Surkhi, is powdered shattered brick (burnt brick) and it is utilized as fine aggregate in lime mortar. Surkhi can be prepared by burning the good quality of bricks free from under burnt particles of soluble salts, pyrites and adherent coatings of soil or silt. The largest amount of clay, fine silt and fine dust is 5% per cent by weight.

Waterproof cement mortars and concrete are made up of surkhi. Concrete can resists the alkalis and salt solutions with the help of surkhi. It can be used as sand because it contains the same properties as that of sand and it also imparts strength and hydraulicity. Burnt bricks is used to prepare the surkhi. Under-burnt or over-burnt bricks and bricks which contains large amount of sand should not use for making surkhi.

The inclusion of 10 to 20% of quick lime is necessary for improving the quality when clay is burnt to make surkhi.

Figure 1.2 Surkhi from Narela Villege

1.6.1) Uses of Surkhi- Surkhi can be used in following purpose-

1. Imparts strength and hydraulicity.
2. To develope more strength in clayey soils.
3. Surkhi can be used as a sand for economic purpose.

1.7) Plastic bottles- High-density or low density plastic helps to make the plastic bottles. Plastic bottles are used to reserve water, soft drinks, cold drinks and hot drinks. Raw plastic bottles is a very good technique for the improving the subgrade soil of pavement in soil stabilization. It can increase the qualities of the soil and thus threw this way the soils can be used in the construction of road infrastructure.

Plastic is a non-renewable source and bio-degradable. It creates environmental pollution by disposing it as a waste. it's a sustainable waste. Plastic can be used for making the useful products by reusing and reprocessing. Plastics wastes can be utilized as addition for stabilized soil. Utilization of plastic products such as cigarette butts, food wrappers, grocery bags and straws and stirrers etc. is enhancing per day. It is very difficult to use the plastic waste without harming our environment.

There is lack of good quality soil material for embankments and filling. So to use plastic bottles for soil stabilization is very economic and useful also. Thus the study of this project is based on that to convert non-useful wastage materials into a useful material by reducing the amounts of plastic wastages and to make the sustainable society.

Figure 1.3 Plastic Bottles

CHAPTER 2- LITERATURE REVIEWS

Dr. Robert M. Brooks explained about the performance of unconfined compressive strength, when the stress and strains enhanced by 106% and 50% sequentially then the flyash content also enhanced from 0 to 25% simultaneously. Unconfined Compressive Stress increased by 97% by increasing the RHA (Rice husk ash) amount from 0 to 12%. After completing 3 cycles of swelling and shrinkage the vertical movement of clay soils is stabilises with cushioning material.

Ankit Singh Negi and Mohammed Faizan studied that highly active soils which undergo quick expansion and shrinkage can be stablised by using lime. Carrying, bearing capability of soil, protection to shrinkage in moist states, decrease in plasticity index, enhance in CBR these properties can be improve by using lime.

Nurhayat Degirmenci studied that the soil treated with phosphogypsum, fly ash and cement generally reduces the plasticity index. For increasing maximum dry unit weight of phosphogypsum stabilized soils, it is necessary to increase phosphogypsum content. It was observed that maximum dry unit weight is reduced by increasing the amount of fly ash. It was found that by adding fly ash, cement and phosphogypsum, optimum moisture content also decreases.

Yaolin Yi et. all investigated various properties by performing unconfined compressive strength, X-ray diffraction, and scanning electron microscopy and used gaseous CO_2 which is prepared in lab through reactive MgO-treated soil samples in a triaxial cell set-up. The strength of carbonated MgO-used soils could be reached the strength equal to 28 day Portland cement (PC)-stabilized soils.

Nilo Cesar Consoli and Eduardo Jose Bittar Marin concluded that the process of soil treatment with unwanted industrial and domestic materials such as ground glass, coal and carbide lime is a sustainable method for the manufacturing of engineered fills and bases of pavements. They demonstrated that the porosity/binder index (η/Bivη/Biv) (identical to porosity divided by the volumetric content of pozzolan plus carbide lime) executes an important role in the evaluation of the goal blend strength and suggested a common model that commands the strength-porosity/binder index action of sandy soil-pozzolan-lime blends.

Pooria Ghadir et. all studied that the geopolymer is an another climate favorable clayey soil stabilizer to the OPC in dry and wet states. The compressive strength of the unused clayey soil specimens can be increase from 0.2 to 4 MPa and 2 to 12 MPa at the OC and DC states sequentially, by replacing the soil fractionally with 15 wt% of the binders. The VA-geopolymer stabilized soil showed 200% development in compressive strength rather than complementary OPC specimens at the DC state.

Omer Nawaf Maaitah investigated that soil treated with LSS-mix is suggested to be used to upgrade soil. Shear strength increased as LSS content increased. Using 5 % lime and 2 % sodium silicate were enough for the short term reaction mentioned to as the initial LSS-mix utilization. For monitoring the progress of pozzolanic reactions according with time, it is necessary to variate the pH of the LSS-mix–soil mixtures. Treated soil with LSS reduced the responsiveness of shear strength toward change in the degree of saturation.

Juan M. Manso et.all concluded that the combination of clayey soils and LFS slag had outcome in development to their carrying capability in parallel to the native ground soil. The soil and LFS slag combination and the soil and lime combination decreased the plasticity index (IP) and free swelling. They also remarkably increased compressive strength. The checking of the pH solution, during the water-immersion curing techniques of combinations, revealed that the appearance of LFS slag led to larger curing times. They concluded that durability index of the soil and LFS slag combinations is greater than that of the soil and lime mixtures.

Mousa F. Attom investigated that burned olive waste act as a stabilizing agent on some soils. The maximum dry density and unconfined compressive strength increased by adding 2.5% of the unwanted burned olive by weight. The highest dry density and unconfined compressive strength were reduced by larger percentage. Swelling pressure was extracted at a 7.5% and larger inclusion by weight of the unwanted burned olive.

Hasan Ghasemzadeh and Farzaneh Modirib evaluated the usefulness of plant gum the tests were duplicated for xanthan and guar gum as two mainly explored gums in soil stabilization. By performing unconfined compressive strength test the optimum contents of xanthan, guar, dry and wet combined Persian gum were found as 1.5, 1, 2 and 2.5%. Increment of the unconfined compressive strength outcomes at optimum Persian gum level for dry and wet combined samples of 28 days curing gained 200% and 300% compared to the pure kaolinite individually. The potential presentation of this gum in soil stabilization is represented by increased strength of soil at such low amounts of carbohydrate polymer (2 and 2.5%).

CHAPTER 3- MATERIALS AND METHODOLOGY

3.1) Materials used –

3.1.1) Soil- Soil is utilized for upper layer of the earth surface which supports plants. Soil is explained as the uncemented aggregate of mineral grains and decomposed organic matter with liquid and air in the voids between the solid particles. In this project soil is taken from Narela villege which is about 25 km away from Delhi Technological University. Then this soil is passed from 425 micron sieve to evaluate it's geotechnical properties and to perform tests.

3.1.2) Properties of soil used- The soil is performed under different lab tests. Soil properties are as following-

Tests as per IS code	Results
Specific Gravity (as per IS 2720 Part-3)	2.30
Liquid Limit (%)	31.50
Plastic Limit (%)	21.16
Plasticity Index (%)	10.34
OMC (%)	21.46
MDD (gm/cc)	1.77

Table 3.1 Basic properties of soil

3.1.3) Plastic Bottle Strips- In this project study aquafina water drink bottles are used and the dimension of length and width are 14mm and 7mm respectively and it is of in 2:1 ratio. These strips are added in the soil in different proportion by weight. The strips are 5%, 10%, 15%, 20% and 25% of dry weight of soil used in this project. A image of strips is shown below.

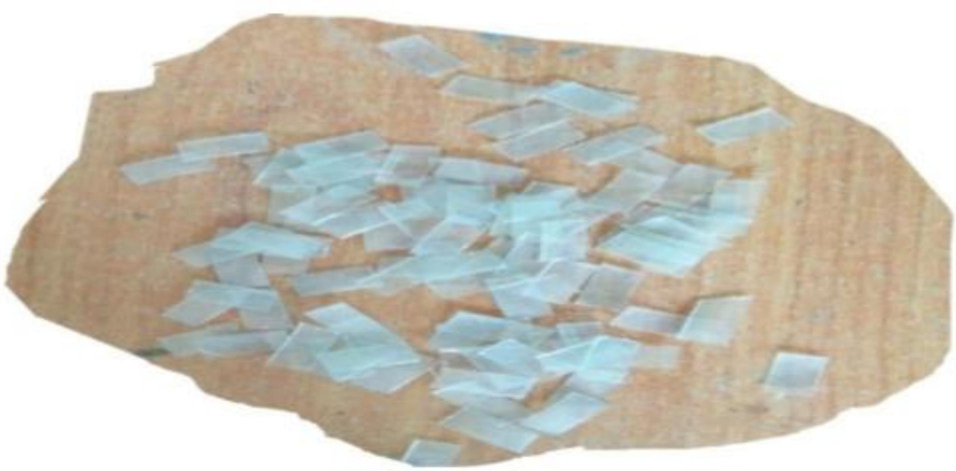

Figure 3.1 Plastic bottle strips

3.1.4) Plastic Bottle Cutter- The length and width of plastic bottles cutter for cutting the plastic bottles into strips are 18cm and 3cm respectively. This Plastic bottle cutter is made by cutting a wood. The base cross section of this plastic bottle cutter is 3.25cm × 2cm. There are two cuts, one is along length up to a depth of 5.00 cm and another one is across length up to 1.50 cm deep.

3.1.5) Mould- Cylindrical soil sample is made with the help of mould for performing the test. For performing (UCS) unconfined compression test the depth and diameter ratio of mould is is 2:1. The mould which is used in this project has the diameter and height of 50mm and 100mm.

3.1.6) Water- Water is used for preparing the soil sample for conducting the test. The proctor test gives the idea of amount of water used. For finding the value of optimum water content and maximum dry density, Proctor test is performed. Proctor test is conducted before unconfined compression test for determining the optimum water content of soil

3.2) METHODOLOGY-

3.2.1) Proctor Compaction Test-

To find the water content-dry density relation, modified compaction tests (heavy compaction test) were conducted as per IS-2720-Part-8 on normal soil. For finding the optimum water content and maximum dry density the test was performed on normal soil sample by changing the percentage of water. Later, this test was conducted on soil mixed with surkhi by dry weight of soil.

3.2.2) Apparatus-

1. Metal mould (volume = 1000 cm3).
2. Balance (capacity = 10 kg, least count = 1g).
3. Oven (105 to 110°C).
4. Sieve (19 mm, 37.5 mm, and 4.75mm).
5. Metal rammer (weight = 4.9 kg).

3.2.3) Test Procedure-

The steps for performing the Proctor Compaction Test are-

1. 7 kg of clayey soil is used.
2. Pass the soil through the 4.75 mm sieve.
3. Weight the soil mass and the mould without the collar (W_m).
4. Attain required moisture content by including water slowly in the mixer.
5. Use lubricant to the collar.
6. Put the soil into the mould in 5 layers. Then each layer is compacted by 25 blows. The drops are utilized manually or mechanically at a consistent rate.
7. The soil is removed from the collar very carefully and the soil that extends above the mould is to be trimmed with a sharpened straight edge.
8. Calculate the weight of the mould and the holding soil.
9. Use metallic remover to extrude the soil from the mould. Take all precautions of that the remover and the mould are in same line.
10. Compute the water content from every part of the sample.
11. Put the soil again in the mixer and include water for gaining larger water content.

3.2.4) Calculation- Using following equation bulk density, γ_b in gm/cm^3 can be calculated for each soil samples.

$$\gamma_b = \frac{W_2 - W_1}{V_m}$$

where,

W_1 = Weight of mould (gm)

W_2 = Weight of mould + Compacted soil (gm)

W= Weight of compacted soil (gm) = $W_2 - W_1$

V_m = Volume of mould i.e. 1000 cm^3.

Using following equation dry density, γ_d in gm/cm^3 can be calculated for each soil samples.

$$\gamma_d = \frac{\gamma_b}{(100+w)} \times 100$$

Where,

γ_b = Bulk density of soil (gm/cm^3).

w = Water content of soil (%).

3.2.5) Experimental Results- The test is performed on normal clayey soil. The results are as following-

Volume of the mould V(cc)	1000	1000	1000	1000	1000
Wt. of muold,W_1 (gm)	4810	4810	4810	4810	4810
Wt. of mould +compacted soil, W_2 (gm)	6726	6850	6960	6940	6910
Wt. of compacted soil,$W=W_2-W_1$ (gm)	1916	2040	2150	2130	2100
Bulk density =W/V (gm/cc)	1.92	2.04	2.15	2.13	2.10
Water Content w (%)	12.28	17.24	21.46	26.03	26.50
Dry density (gm/cc)	1.71	1.74	1.77	1.69	1.66

Table 3.2 Experimental Results of Proctor Comapaction Test of normal soil

3.2.6) Relationship between OMC and Dry Density of plain clayey soil-

After experiment it found that by increasing water content firstly the dry density increases to a maximum value of 1.77 gm/cc and then after it decreases to 1.66 gm/cc. The moisture content at which the density is maximum is 21.46% and it is known as Optimum Moisture Content O.M.C.) of soil.

By plotting the graph on X-Y plane in which there is moisture content in X-axis in percentage and in Y-axis there is dry densities in gm/cc. The graph is opening downwards.

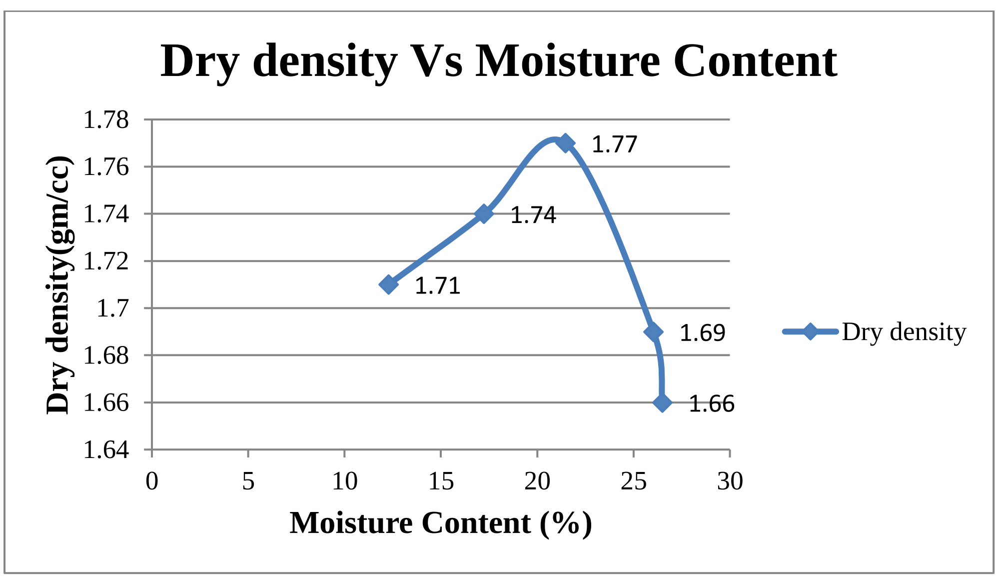

Figure 3.2 Dry density vs. Water content curve of normal soil

3.3) Proctor Compaction Test with Surkhi-

3.3.1) The test is performed on clayey soil with different proportion of surkhi-

The soil sample should be oven dried at approximately 105°C. The amounts of surkhi are 30%, 35%, 40% and 45%. With the help of hand surkhi was added into the air-dried soil sample in few amounts. A satisfactory analogous mixture was found by adding water. The Optimum Surkhi percentage was found by performing the test as per IS 2720 (Part 7.1980). To obtain the optimum amount of surkhi, compaction test was done on soil with varying percentage of surkhi. After adding water into the mix, the wet soil specimen was compacted in mould in five layers, by standard proctor rammer of 4.9 kg. The MDD and OMC for various samples were found by conducting the test.

3.3.2) Experimental Results- It is noticed that with the addition of surkhi, the MDD enhanced up to 35% surkhi inclusion and then lowered. On addition of 35% surkhi with soil, the optimum value of MDD was determined.

Sample No.	Soil %+Surkhi %	MDD (gm/cc)	OMC (%)
1.	70%+30%	1.63	11
2.	65%+35%	1.74	13.5
3.	60%+40%	1.66	14
4.	55%+45%	1.64	15

Table 3.3 Experimental Results of Proctor Compaction Test with surkhi addition

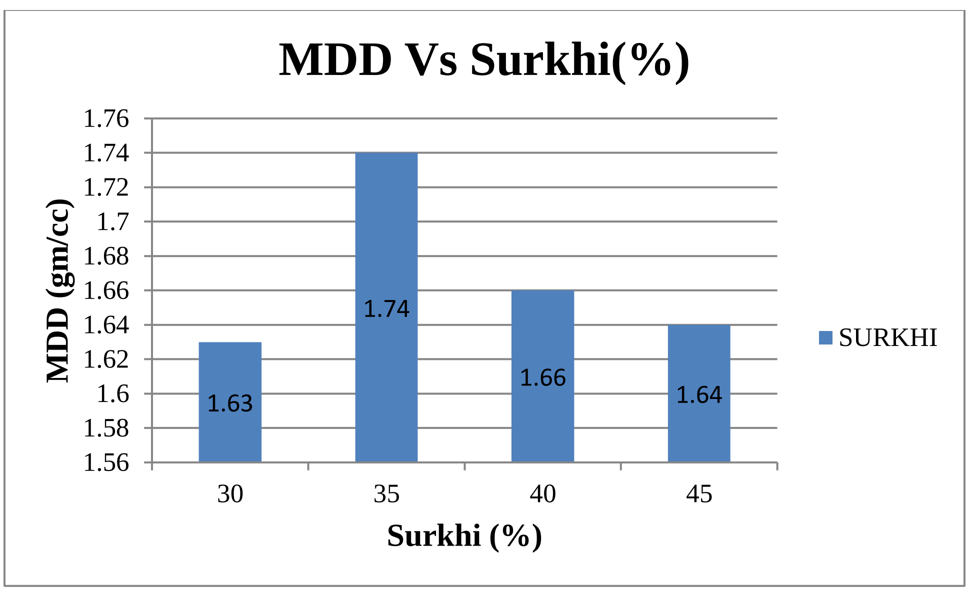

Figure 3.3 Maximum dry densities vs. Surkhi curve (%)

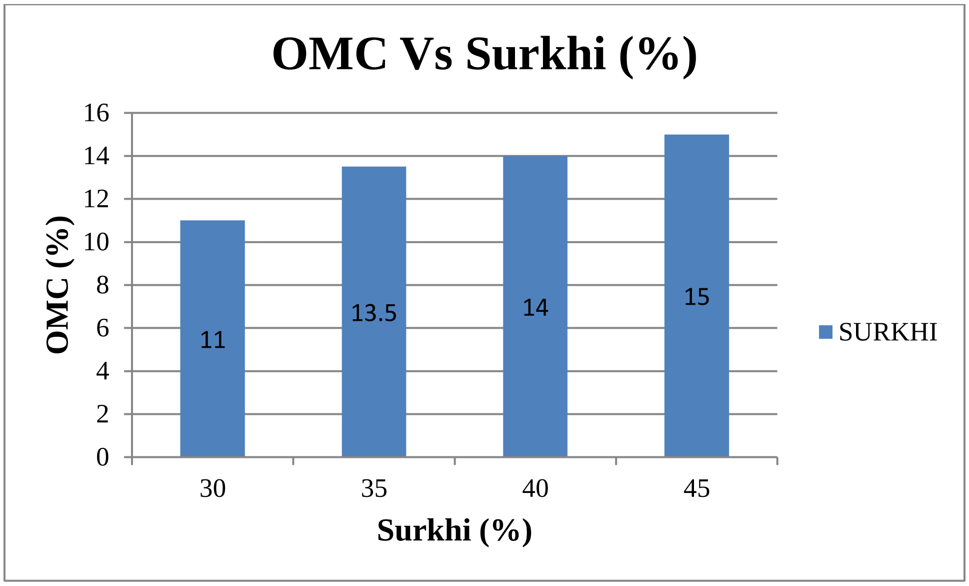

Figure 3.4 Optimum moisture content Vs surkhi curve (%)

3.4.1) The test is performed on clayey soil with different proportion of Raw plastic bottles- By changing the percentage of plastic bottles from 5% to 20% ,the clayey soil sample are stabilized and results are tabulated in Table 3.4. It was found that, we have to take 7 kg soil sample for performing the by standard test procedure. By doing the test we can gain the values of Maximum dry density and optimum moisture content and with the help of these values we can draw the graph between optimum moisture content and maximum dry density.

3.4.2) Experimental Results- It is noticed in Table 3.4 and Figure 3.5 that with the addition of raw plastic bottles, MDD decreased up to 10% raw plastic bottles addition and then increased. On inclusion of 10% raw plastic bottles with soil, the optimum value of MDD was obtained.

Trial	Proportions	OMC (%)	MDD (gm/cc)
1.	Soil+5% plastic bottles	13.5	1.75
2.	Soil+10% plastic bottles	15.8	1.74
3.	Soil+15% plastic bottles	14.5	1.76
4.	Soil+20% plastic bottles	14	1.80

Table 3.4 Experimental Results of Proctor Compaction Test with Plastic bottles addition

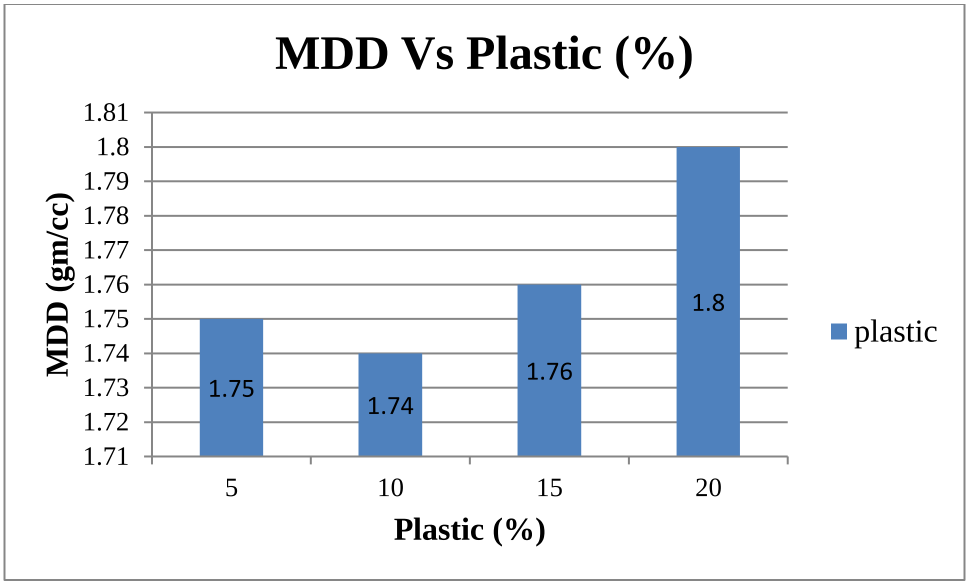

Figure 3.5 Maximum dry densities vs. plastic content curve (%)

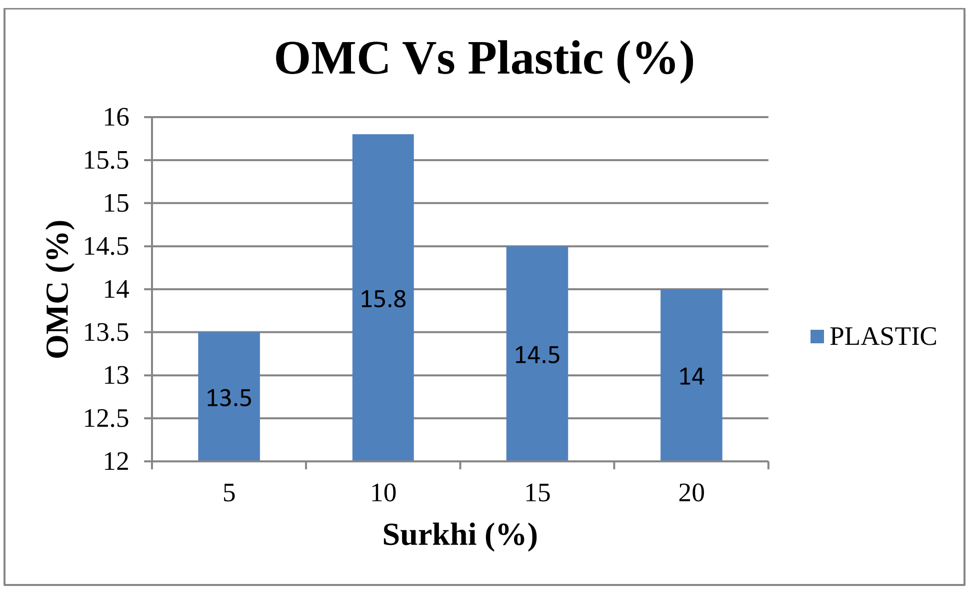

Figure 3.6 Optimum moisture content vs. plastic content curve (%)

3.5) Unconfined Compression Strength Test- It is a unique case of triaxial test in which confining pressure is nil. In this unconfined compression strength test axial or vertical compressive stress is applied only. This test is called as unconfined compression test because it is laterally unconfined. There are two principal stresses, one is major principal stress and that is axial or vertical compressive stress and other minor principal stress is equal to zero. Since there is no cell pressure, no rubber membrane required. Therefore, without rubber membrane, sandy or dry soil can't be used. Hence this test is applicable only for saturated clays and silts or only for cohesive soil.

The untrained shear strength (s_u) for clays is generally found out by performing an unconfined compression test. The soil which having angle of shearing resistance, ∅ = 0 (saturated clays under undrained states, frictionless clays) the undrained shear strength or cohesion of the soil is equal to 50% of the Unconfined compression strength. It is given as-

$$s_u = c = \frac{q_u}{2}$$

And;

s_u = Undrained shear strength of cohesive soil, and

q_u = Unconfined Compression Strength of cohesive soil

Figure 3.7 UCS Test Setup

3.5.1) Apparatus-

1. Loading frame of capacity of 2 t.
2. For soft soils proving ring of 0.01 kg sensitivity and for stiff soils proving ring of 0.05 kg sensitivity.
3. Trimmer for soil.
4. Frictionless end plates having diameter of 75 mm.
5. Evaporating dish.
6. Soil sample of 75 mm length.
7. Dial gauge of 0.01 mm accuracy.
8. Balance of capability 200 gm. and sensitivity to weight 0.01 gm.
9. Oven thermostatically checked with inside of non-decaying material to keep the temperature.
10. Sample remover to remove the sample and split sampler.
11. Dial gauge of sensitivity 0.01 mm.
12. Vernier calipers.

3.5.2) Test Procedure-

1. Put the soil sample at the required water content.

2. Extract the sampling tube filled with the soil after pushing the sampling tube into the large mould.

3. Soil sample is to be saturated in the sampling tube by a approciate method.

4. Take the weight of the mould after coating the split mould with a thin layer of grease.

5. By using the sample remover and knife, remove the sample from the sampling tube into the split mould.

6. Weight the mould with the specimen after trimming the two ends of the specimen in the split mould.

7. Remove the specimen into two parts from the split mould.

8. Measure the length and diameter of the specimen by using vernier calipers.

9. Arrange the upper plate to make connect with the specimen by putting the specimen on the bottom plate of the compression machine

10. Arrange the dial and the proving ring gauge equal to zero.

11. Use the compression load to generate an axial strain at the of ½ to 2% per minute.

12. Read the dial gauge and proving ring readings after every thirty seconds until a strain of 6% has not achieved. Take the reading after every 60 seconds for a strain value of 6% and 12% and then after every 2 minutes for a strain value greater than 12%.

13. Repeat the test until non-success surface has not clearly appeared or until an axial strain of 20% has not achieved.

14. Measured the angle between the failure surfaces and the horizontal.

15. Take the sample out of the failure zone of the specimen to determine the water content of soil.

3.5.3) Experimental Results-

The test is performed on plain clayey soil. The results are as following-

Sample	**Soil (%)**	**UCS VALUE (Kpa)**
1.	100%	102.3

Table 3.5 Experimental Results of Unconfined Compression Test of normal soil

Figure 3.8 UCS Sample

Figure 3.9 Plain Soil sample after UCS

3.6.1)The test is performed on clayey soil with different proportion of surkhi-

The sample was removed from the mould for the upcoming test. The samples were arranged by adding surkhi in 10% to 40% of dry weight of soil. It was found that Unconfined Compression Strength increases by adding surkhi in clayey soil. The experiments were adjusted at a steady strain rate of 0.125 mm per minute according to Indian Standard 2720 (part 10) 1991. Four samples were analyzed for each percentage of surkhi.

3.6.2) Experimental Results-

The results are as following-

Sample No.	Soil% + Surkhi (%)	UCS (KPa)
1.	90%+10%	154.2325
2.	80%+20%	206.165
3.	70%+30%	258.0975
4.	60%+40%	310.03

Table 3.6 Experimental Results of Unconfined Compression Test with surkhi addtion

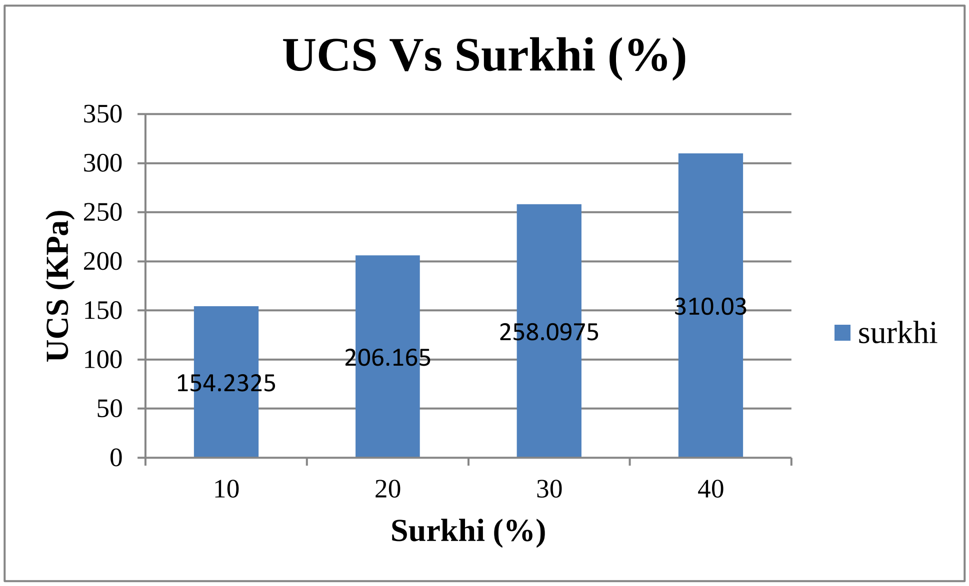

Figure 3.10 UCS Vs. Surkhi content curve (%)

3.7.1) The test is performed on clayey soil with different proportion of Raw plastic bottles-

The Unconfined Compressive Strength test was performed on clayey soil sample with varying raw plastic bottles such as 5%, 10%, 15%, 20% and 25%. From the unconfined strength charactertics results, it is found that initially the unconfined compression strength increases with the addition of 5% to 20% plastic content and then after it decreases from 20%to 25%. It is found that the optimum proportion for increasing the compaction property of soil is at 20%.

<u>3.7.2) Experimental Results-</u> The results of strength characteristics were as following-

Trial	Proportions	UCS (KPa)
1.	Soil+5% plastic	71.6
2.	Soil+10% plastic	78.4
3.	Soil+15% plastic	91.2
4.	Soil+20% plastic	96
5.	Soil+25% plastic	85.2

Table 3.7 Experimental Results of Unconfined Compression Test with plastic bottles addition

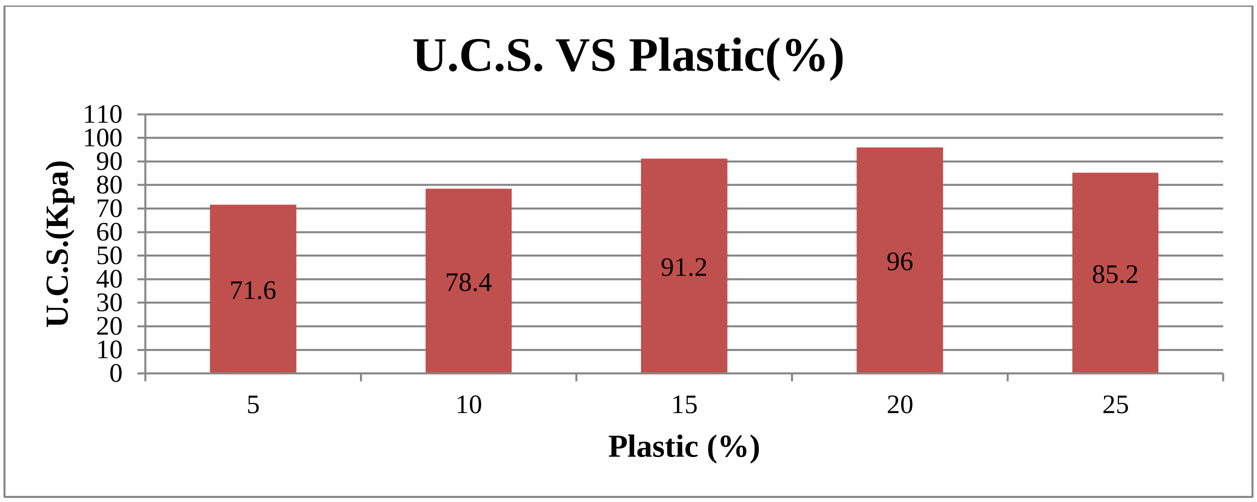

Figure 3.11 U.C.S Vs. Plastic content curve (%)

<u>3.8) Liquid Limit Test</u>- It is that minimum water content at which soil has propensity to flow. At liquid limit, consistency of soil changes from plastic state to liquid state. At this limit all soil has nearly negligible shear strength of 2.7KN/m^2.Compression index can be calculated by performing liquid limit test for analyzing settlement. The soil is soft when its natural moisture content is greater than liquid limit and soil is brittle and stiffer when its natural water content is less than liquid limit. Plasticity of soil can be estimated by doing liquid limit test.

3.8.1) Apparatus Required-

1. Balance
2. Casagrande Liquid Limit Device.
3. Casagrande Grooving Tool.
4. Mixing Dishes.
5. Spatula
6. Electric Oven.
7. Squeeze Bottle.

3.8.2) Test Procedure-

1. Obtain about 120 gm. of air dried soil which passed from 425 micron IS sieve.

2. Obtain uniform paste by adding water that have a consistency to gain 30 to 35 drops of cup to generate adjacent of standard groove for 12 mm length.

3. Permit this uniform paste for 24 hours for clayey soils.

4. After putting a part of this uniform paste in the cup of Mechanical Liquid Limit device, expand it into part with little strokes of spatula.

5. Trim the uniform paste of soil at the point of maximum thickness of 1 cm.

6. Obtain a clean sharp groove of proper dimension by casagrande's grooving tool.

7. Raise and fall the cup at the rate of two revolutions per second to make contact of two halves of the soil with each other for a length of 12 mm by flow.

8. Count the blows to produce the groove near for about 12 mm.

9. Take representative soil sample from the cup to determine the water content of the soil.

10. Do this test at least three times by changing the water contents and the blows should vary from 15 to 35.

3.8.3) Calculation-

Parameters	Observation No. 1	Observation No. 2	Observation No. 3	Observation No. 4
Container No.	1	2	3	4
Weight of Container(gm.) (W_1)	20.18	21.37	24.28	20.42
Weight of Container +Wet soil (gm.) (W_2)	38.24	36.10	40.14	39.58
Weight of Container +oven dry soil (gm.) (W_3)	33.52	32.46	36.43	35.32
Weight of water (gm.) (W_2-W_3)	4.72	3.64	3.71	4.26
Weight of dry soil (gm.) (W_3-W_1)	13.34	11.09	12.15	14.90
Moisture Content $w = \frac{W_2-W_3}{W_3-W_1} \times 100\%$	35.38	32.82	30.52	28.59
No. of blows	17	23	27	34

Table 3.8 Calculation of Liquid Limit Test

A flow curve is graphed on semi-log graph which represents the water content on arithmetic scale and no. of blows on logarithmic scale. It is a straight line which passes through the four or more plotted points. The liquid limit of the soil is the moisture content at 25 drops.

Flow index, $\mathbf{I_f} = \frac{W_1-W_2}{\log_{10}\frac{N_2}{N_1}}$

Where,

$I_f =$ Flow Index

W_1= Moisture content in percentage corresponding to N_1 drops, and

W_2= Moisture content in percentage corresponding to N_2 drops.

The liquid limit corresponding to 25 drops comes out to be **31.50%**

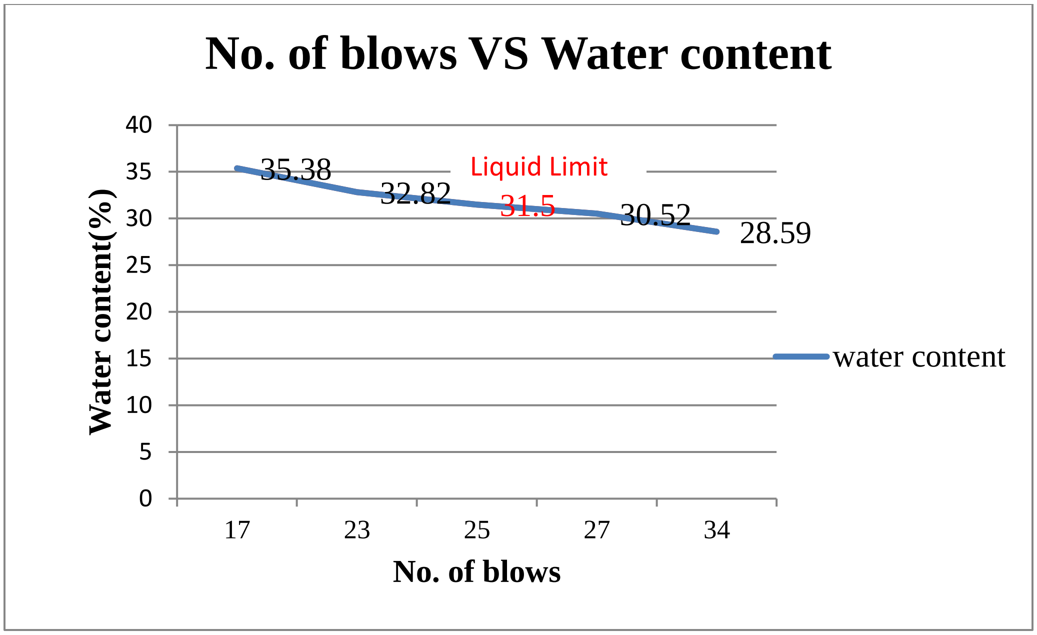

Figure 3.12 No.of blows Vs. Water content curve (%)

I_f can be calculated as-

$$I_f = \frac{W_1 - W_2}{\log_{10}\frac{N_2}{N_1}} = \frac{35.38 - 32.82}{\log_{10}\frac{23}{17}} = 19.54$$

Where W_1= 35.38%

W_2= 32.82%

N_1 = 17

N_2= 23

3.9) Plastic Limit Test – Computation of plastic limit is as prime as liquid limit. The water content at which soil sample converts from semi-solid to plastic condition is called as plastic limit. Plastic limit is also explained as the water content at which soil would just start to collapse when rolled into a thread of roughly 3 mm diameter. Plastic limit depends upon amount and type of clay mineral in soil. Hence clay containing fine soils have more plastic limit.

Figure 3.13 Plastic Limit

Figure 3.14 Plastic limits on balance

3.9.1) Apparatus Required-

1. Porcelain dish.
2. Squeeze bottle and spatula.
3. Balance of capability 200 gm. and sensitive to 0.01 gm.
4. Ground glass plate for rolling the soil.
5. Holders for determining the water contents.
6. For maintaining the temperature around 105^0C to 110^0C an oven thermostatically control led is needed.

3.9.2) Test Procedure-

1. Take about 20 gm. of soil which passed from 425 micron I.S. sieve.
2. To mold the soil with fingers easily, merge the soil with distilled water in the evaporating dish.
3. Allow the soil for 24 hours to drain the water.
4. Roll about 10 gm. of this plastic soil mass in between fingers and glass plate for making a thread of constant diameter throughout its length. The rate of rolling should be 80-90 strokes per minute.
5. Keep rolling for getting a thread of 3 mm diameter.
6. Re-roll the soil of consistent mass.
7. Keep up the method until the thread collapses when the diameter is 3 mm diameter.
8. For determining the moisture content collect the pieces of the collapsed thread in air tight container.
9. Take the average of the results after completing the test 3 times.

3.9.3) Calculation-

Parameters	**Observation No. 1**	**Observation No. 2**	**Observation No. 3**
Container No.	1	2	3
Weight of Container(gm.) (W_1)	26.10	21.86	23.91
Weight of Container +Wet soil(gm.) (W_2)	32.29	34.74	30.15
Weight of Container+ oven dry soil (gm.) (W_3)	31.20	32.51	29.06
Weight of water (gm.) (W_2-W_3)	1.09	2.23	1.09
Weight of dry soil (gm.) (W_3-W_1)	5.10	10.65	5.15
Water Content(w) = $\frac{W_2-W_3}{W_3-W_1} \times 100\%$	21.37	20.94	21.17
Plastic Limit(Average of three determination)	**21.16%**		

Table 3.9 Calculation of Plastic Limit Test

3.9.4) Plasticity Index- $I_p = W_L - W_P = 31.50 - 21.16 = 10.34\%$

Where,

I_p= Plasticity Index

W_L=Liquid Limit

Wp = Plastic Limit

We can calculate Toughness Index, $I_t = \frac{I_p}{I_f} = \frac{10.34}{19.54} = 0.53$.

3.9.5) Experiment Results- The test is performed on plain clayey soil. The results are as following-

Sr.No	Soil type	Results (%)
1.	Parent Soil	LL=31.50%, PL=21.16%, PI=10.34

Table 3.10 Experimental Results of Liquid Limit Test and Plastic Limit Test of normal soil

3.10.1) The test is performed on clayey soil with different proportion of surkhi- The liquid limit test is performed on soil with addition of different percentage of surkhi. The percentage of surkhi is in 5%, 10%, 15% and 20% order.

3.10.2) Experiment Results- The results are as follows-

Sr.No.	Proportion	Results
1.	Parent Soil With 5% surkhi	LL=30.03, PL=20.50, PI=9.53
2.	Parent Soil With 10% surkhi	LL=28.30, PL=19.80, PI=8.50
3.	Parent Soil With 15% surkhi	LL=27.50, PL=19.30, PI=8.20
4.	Parent Soil With 20% surkhi	LL=26.40, PL=18.60, PI=7.80

Table 3.11 Experimental Results of Liquid Limit Test and Plastic Limit Test with surkhi addition

After completing experiments with addition of surkhi from 5% to 20%, the liquid limit starts decreasing from 31.50% to 26.40% and plastic limit starts decreasing from 21.16% to 18.60%.Plasticity index also decreases from 10.34 to 7.80.

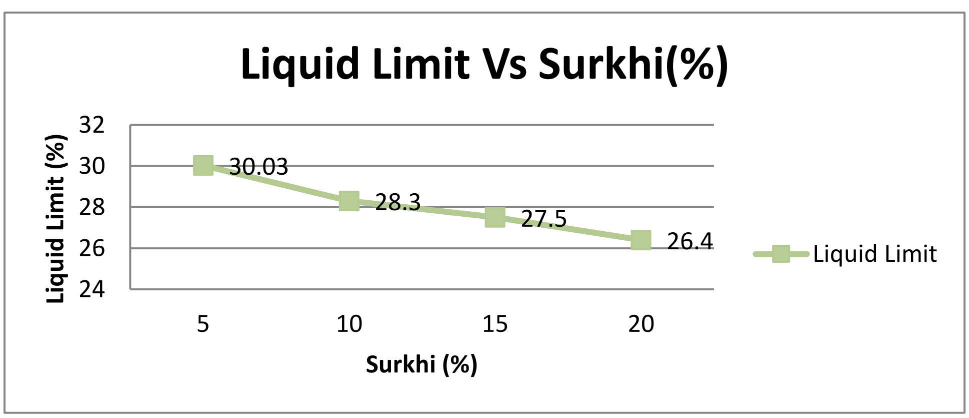

Figure 3.15 Liquid limit Vs Surkhi content curve (%)

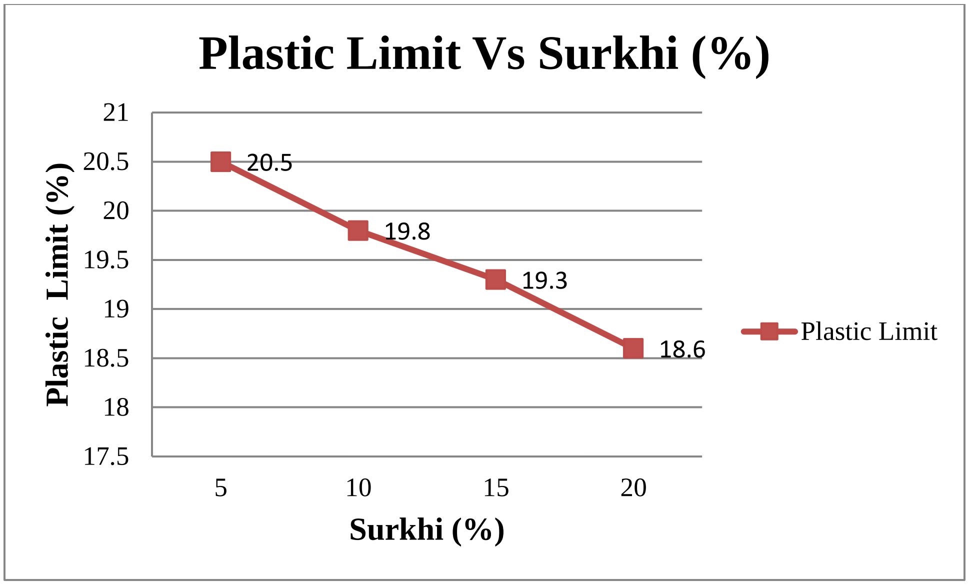

Figure 3.16 Plastic limit Vs. Surkhi content curve (%)

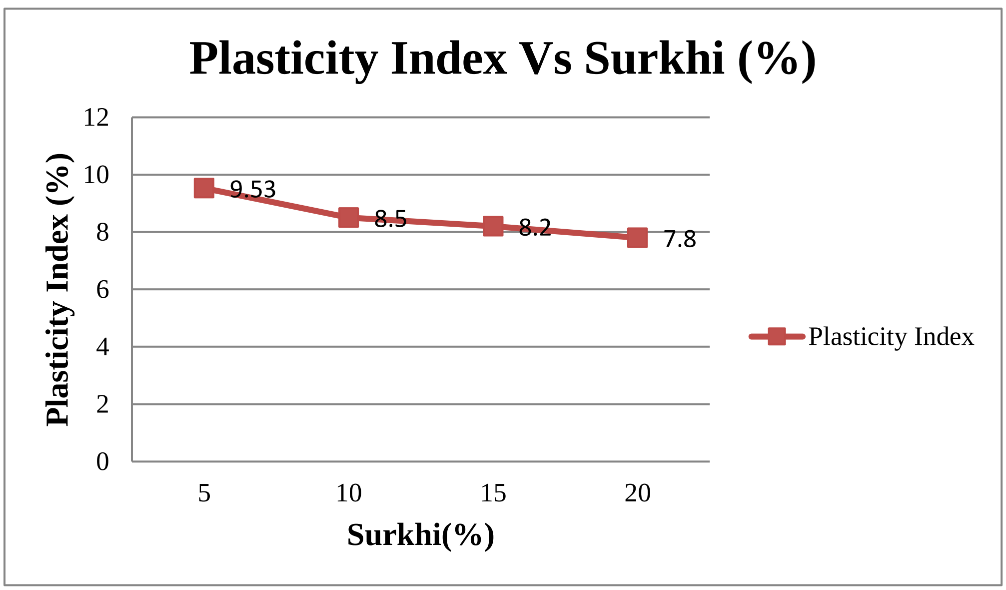

Figure 3.17 Plasticity index vs. surkhi content curve (%)

3.11.1) The test is performed on clayey soil with different proportion of Raw plastic bottles- The plastic limit test is performed on soil with inclusion of various percentage of raw plastic bottles. The percentage of raw plastic bottles is in 5%,10%,15% and 20% order.

3.11.2) Experiment Results- The results are as follows-

Sr.No.	Proportion	Results (%)
1.	Parent Soil With 5% plastic bottles	LL=30.50, PL=20.30, PI= 10.20
2.	Parent Soil With 10% plastic bottles	LL=29.30, PL=19.50, PI= 9.80
3.	Parent Soil With 15% plastic bottles	LL=28.60, PL=18.95, PI= 9.65
4.	Parent Soil With 20% plastic bottles	LL=27.70, PL=18.20, PI= 9.50

Table 3.12 Experimental Results of Liquid Limit Test and Plastic Limit Test with plastic bottles addition

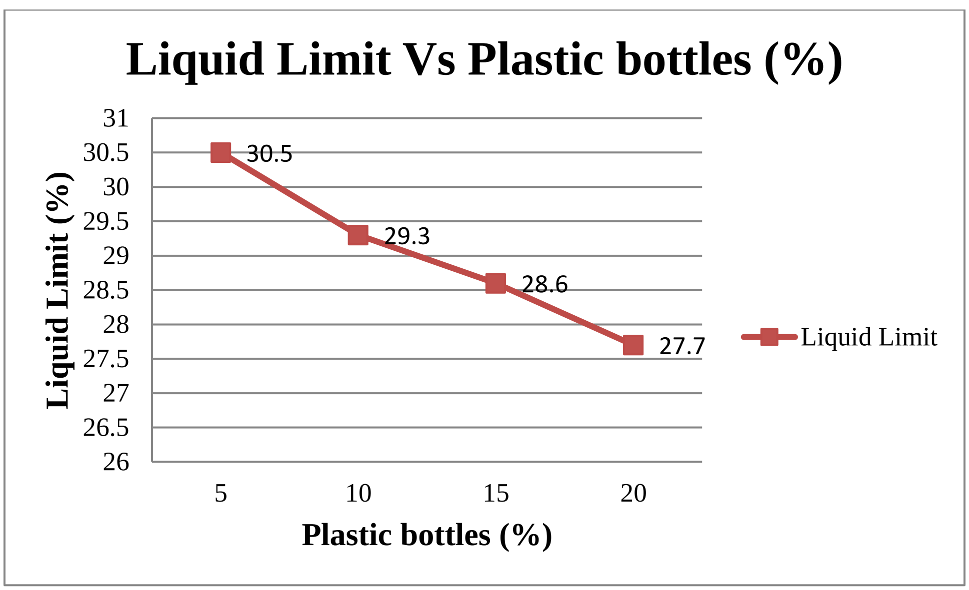

Figure 3.18 Liquid limit plastic vs. bottle strips content curve (%)

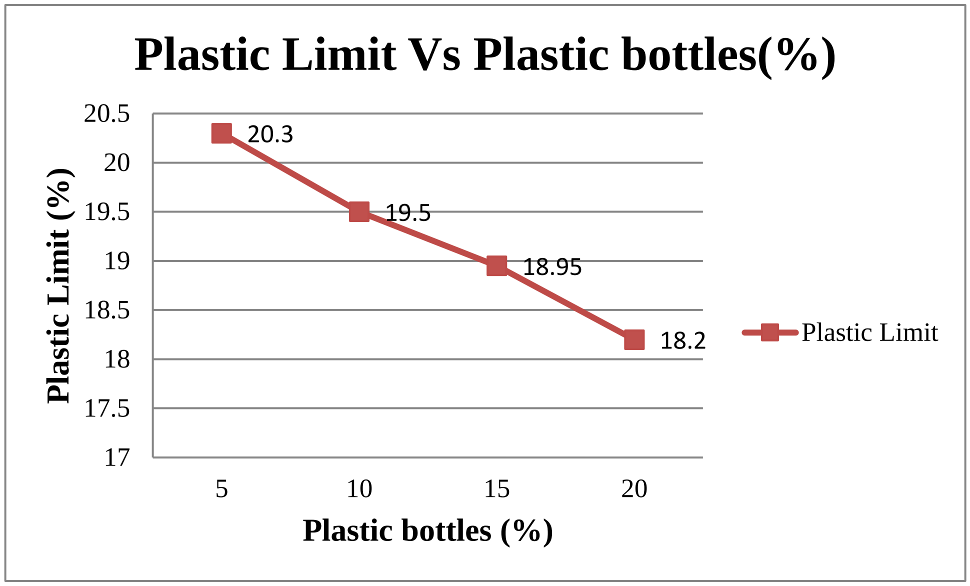

Figure 3.19 Plastic limit Vs. Plastic bottle strips content curve (%)

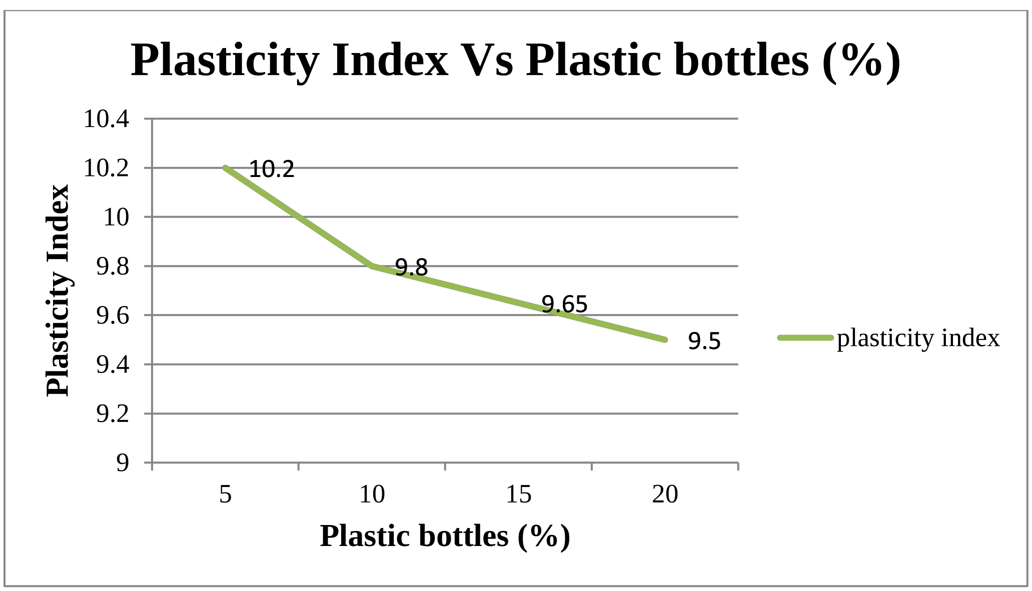

Figure 3.20 Plasticity index Vs. Plastic bottles strips content curve (%)

CHAPTER 4- CONCLUSION

After conducting test and observing the results obtained, following conclusions can be made-

1. There is a rise in strength of soil with addition in the value of surkhi included to the soil.
2. The soil having 0% surkhi has an strength of 102.3 Kpa while the soil having 10% surkhi and 20% surkhi has an strength of 154.23 Kpa and 206.105 Kpa respectively.
3. There is also increase in the strength of soil by increasing the amount of plastic bottle strips included to the soil.
4. There is enhance in strength of soil from 71.6 Kpa to 96 Kpa after adding the plastic strips from 5% to 20%.
5. But increasing the amount of plastic bottle strips beyond 20% of weight of dry soil will decrease the strength of soil.
6. After increasing the plastic bottle strips beyond 20%, there is decrease in the strength of soil.
7. The strength of soil at 20% plastic bottles strips content is 96 Kpa which decreases to 85.20 Kpa at a plastic bottle strips content of 25%.
8. So the optimum amount of plastic bottle strips to be added to enhance the strength of soil is at 20%.

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