"STABILISATION OF BLACK COTTON SOIL USING INDUSTRIAL EFFLUENTS"

A PROJECT

Submitted in partial fulfilment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under the supervision of

Mr. Niraj Singh Parihar
Assistant Professor

By

Aayush Garg (141607)
Samridhi Aggarwal (141637)
Jashandeep Singh Mann (141648)

to

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY
WAKNAGHAT, SOLAN – 173234
HIMACHAL PRADESH, INDIA

MAY - 2018

CERTIFICATE

This is to certify that the work which is being presented in the project report titled "Stabilisation OF BLACK COTTON SOIL USING INDUSTRIAL EFFLUENTS" in partial fulfilment of the requirements for the award of the degree of Bachelor of Technology in Civil Engineering and submitted to the Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by Aayush Garg (141607), Samridhi Aggarwal (141637) and Jashandeep Singh Mann (141648) during a period from July 2017 to May 2018 under the supervision of Mr. Niraj Singh Parihar, Assistant Professor, Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of our knowledge.

Date: - ……

Dr. Ashok Kumar Gupta	Mr. Niraj Parihar.	External Examiner
Professor & Head of Department	Assistant Professor	
Civil Engineering Department	Civil Engineering Department	
JUIT Waknaghat	JUIT Waknaghat	

AUTHOR'S DECLARATION

We hereby declare that we are the sole authors of this report. This is a true copy of the Report, including any required final revisions, as accepted by our examiners.

We understand that my report may be made electronically available to the public.

Aayush Garg **Samridhi Aggarwal** **Jashandeep Singh Mann**

ACKNOWLEDGEMENTS

The completion of any project depends upon cooperation, co-ordination and combined efforts of several sources of knowledge. We are grateful to our project guide Mr. Niraj Singh Parihar for his eager willingness to give us valuable advice and direction whenever we approached him with any problem. We are thankful to him for providing immense guidance for this project.

We, Aayush Garg, Samridhi Aggarwal and Jashandeep Singh Mann would like to acknowledge our work on "Stabilisation Of Black Cotton Soil Using Industrial Effluents" and hence express our special thanks of gratitude to Dr. Ashok Kumar Gupta (Professor & Head, Department of Civil Engineering) and all the faculty members for their immense cooperation and motivation for the research of our project.

We are also thankful to lab assistants Mr. Jaswinder Singh and Mr. Itesh Singh who gave us full information regarding various lab equipments.

CONTENTS

Chapter 1
Introduction

Soils such as Black Cotton soil, clays of soft nature, organic deposits etc have a tendancy to swell and shrink considerably and are thus thought as undesirable for construction purposes. Changes in moisture content can cause severe problems on account of changing volume. Black cotton soil is so called because of its characteristic colour and its usage in cotton plantations. This type of soil is known to expand in the rainy seasons and lose its bearing capacity considerably. When the season tends to be on the drier side, Black cotton soil undergo a shrinkage on account of excessive evaporation of water and become harder.

1.1 mineralogical structure of clay particles :

Minerals of Clay are Fe, Al and Mg silicates. They have two fundamental crystals, which result in the formation of the mineral. They are 1) a silicon-oxygen tetrahedral 2) an aluminium or magnesium octahedron.

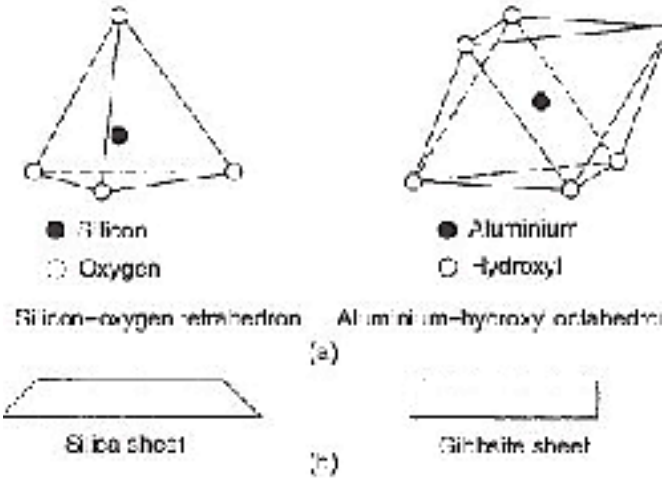


Fig 1.1 : Basic unit of clay minerals

Minerals of clay resemble a plate-like structure. A particle size of <0.002 mm is characteristic of these minerals. The soil in question, Black Cotton Soil, contains minerals such as illite, kaolinite and montmorillonite amidst other compounds such as calcium carbonate and oxides of iron. These compounds are considered the primary reason for the expansion observed in this soil type. The montmorillonite is about 10 times as active in absorbing cations as kaolinite.

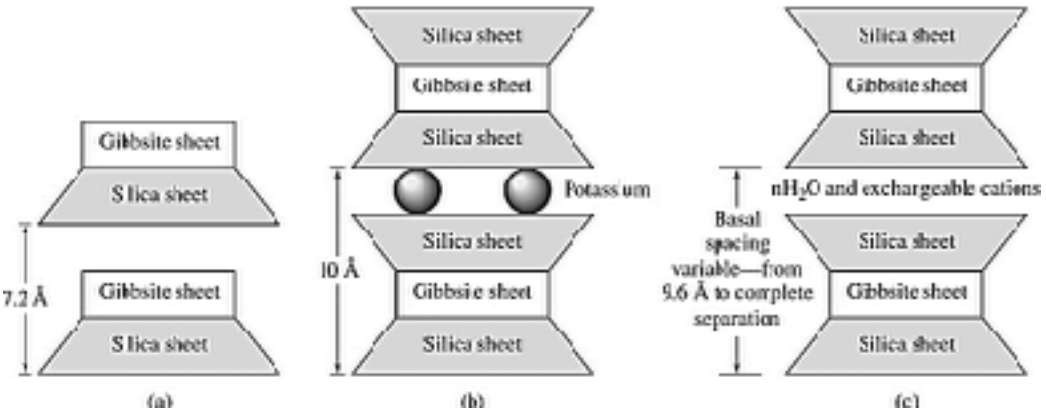


Fig 1.2 : Diagram of structures of a) kaolinite b) illite c) montmorillonite

1.2 Interaction of water and clay particles

A negative charge is observed in clay particles. This phenomenon can be attributed to the chemical term isomorphic substitution - the occupation of the positions available for metal ions by ions that are of similar physical size. This process is accompanied by a release of protons. AsA result of this net negative charge at the particle surface of clay, there exist forces of electrostatic nature between the cations that can be exchanged and the surface itself. The concentration of ions present in water and their type holds sway and these electrical forces. This is the cause for expansion and consequent drying and reduction in volume in clay minerals.

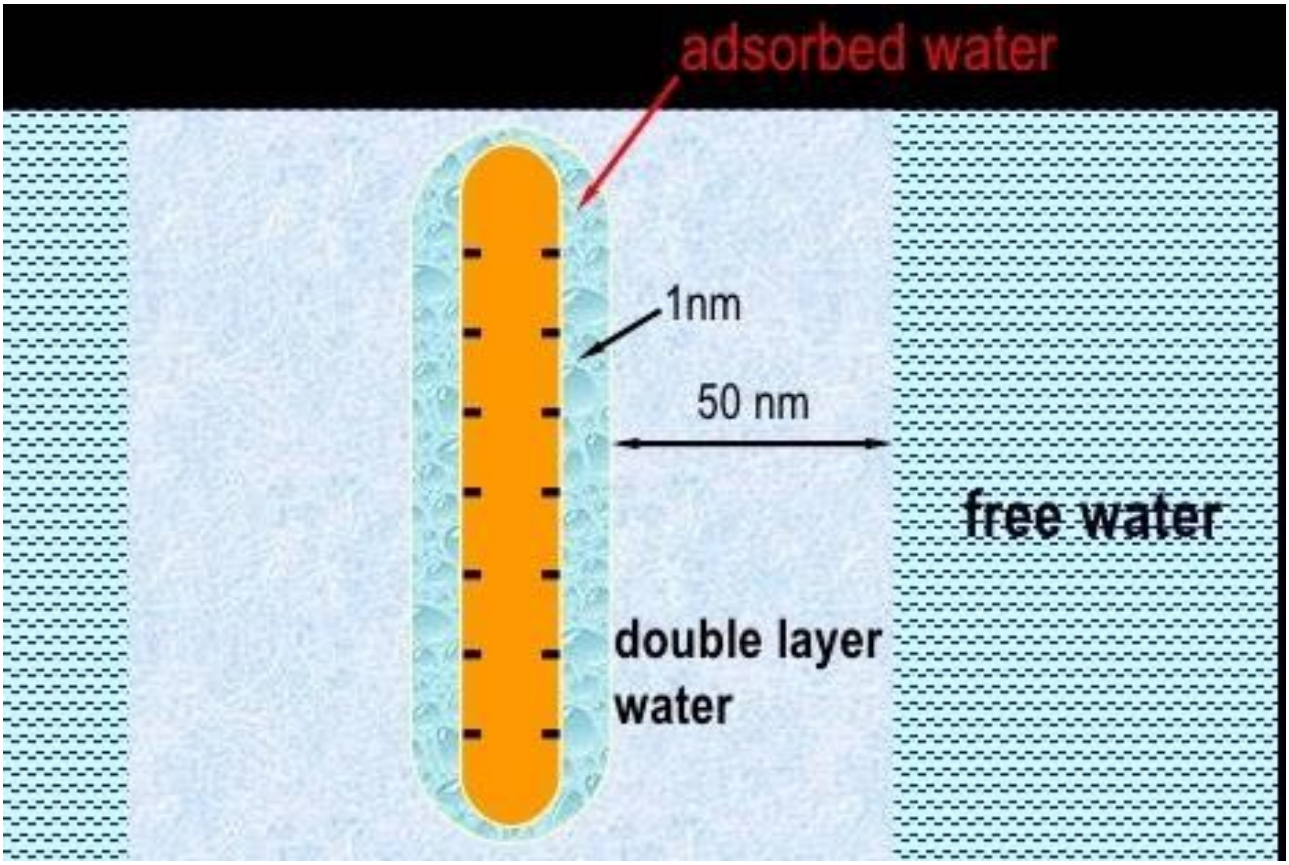


Fig 1.3: Clay particles in water

Since there exists a negative charge on the clay particle, these particles are known to attract cations. Three basic reasons for the attraction of particles towards water molecules are 1) hydrogen bond 2) ions hydration 3) osmotic pressure. The region where the clay particles holding a negative charge and the positively charged ions occurring in the solution exist together is called the diffuse double layer, which occurs at the interface between the soil solution and the surface of the clay particles. It is thus consisting of - 1) the permanent negative charge of the clay and 2) the cations in the soil solution that balance the negative charge.

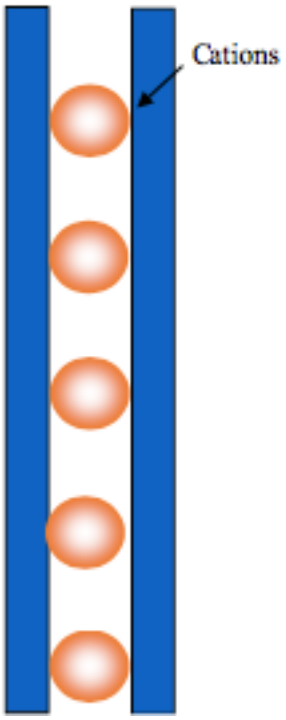


Fig 1.4: Dry Condition. (Interlayer)

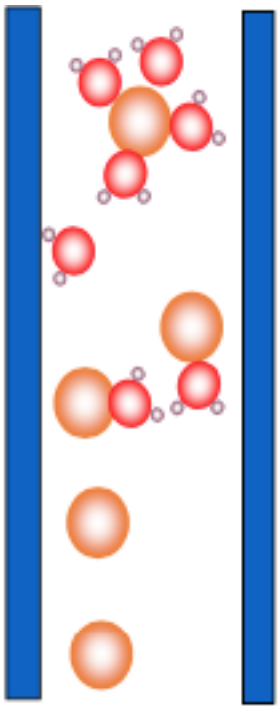


Fig 1.5: The water molecules in the interlayer after adding water.

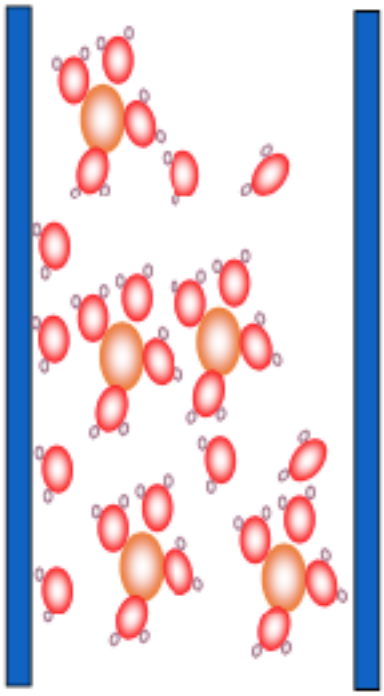


Fig 1.6: The cations are fully hydrated, which causes repulsive forces and expansion

The attractive force experienced between water and clay particles goes on decreasing as the distance from the particle surface increases.It should be noted that for a positively charged ion to exit the double layer it should be substituted by another one from the solution.

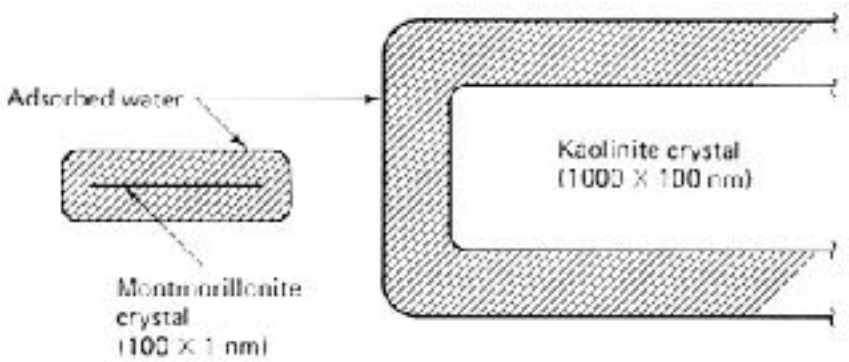


Fig 1.7: Relative sizes of adsorbed water layers on sodium montmorillonite and sodium kaolinite

Fig 1.7 shows a sodium montmorillonite and kaolinite crystal with layers of adsorbed water. The adsorbed water can be observed to have about the same thickness. Due to there being a size difference, the montmorillonite will show considerably higher levels of activity, along with higher values of plasticity and a greater tendency to expand and shrink.

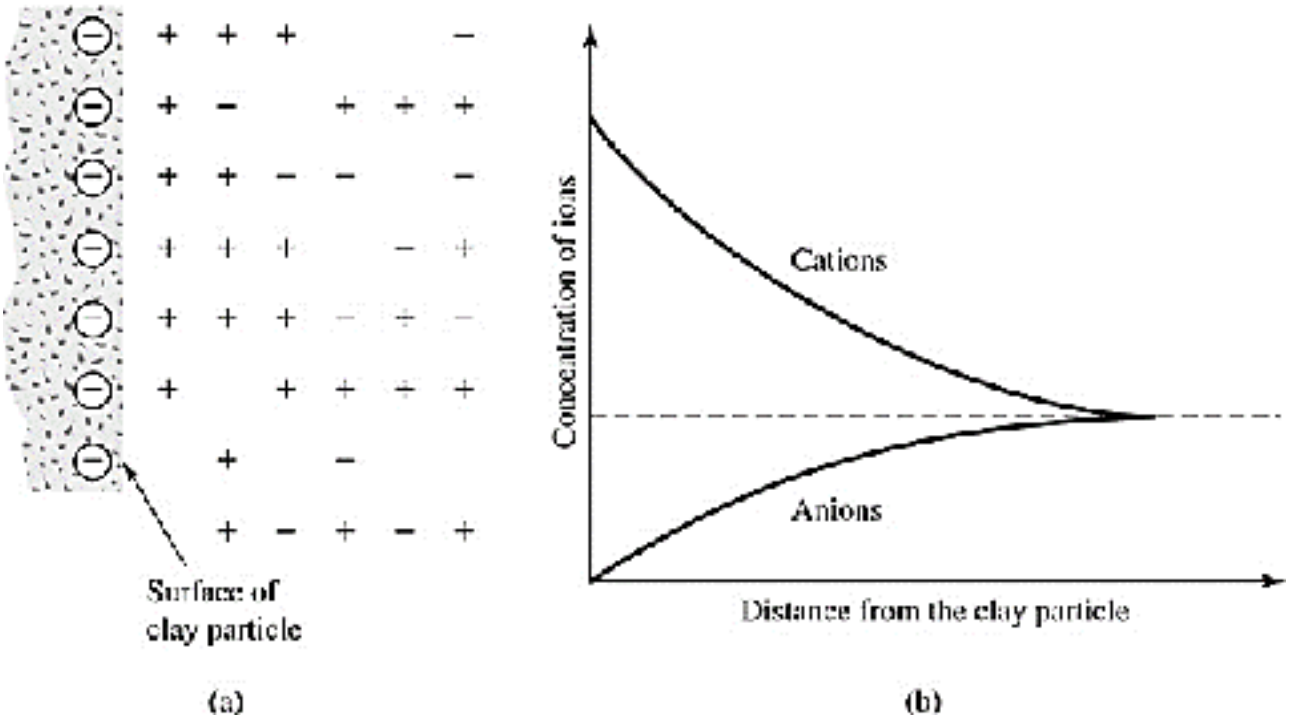


Fig 1.8 :Diffuse double layer

1.3 Problems associated with Pharmaceutical Industry Waste

Pharmaceutical compounds have a very heavy demand and are extremely beneficial in our general well being. The problem of the release of toxic contaminants however, is one that is caused by the neglect towards their harmful effects and the resource needed to dispose them properly by the industries that are involved in producing them. There also looms the risk of the compounds causing harm due to being discharged indirectly in ways such as seepage from storage sites, runoffs, discharge of wastewater etc

Even though various physical and biological processes occurring in aquatic ecosystem may cause reduction of many pharmaceutical compounds, trace concentrations of human and veterinary pharmaceutical compounds as well as their metabolites have been detected in different water bodies like surface water, groundwater and drinking water sources. The pharmaceutical industry in India is the world's third-largest and is growing at an unprecedented rate annually. There is a growing need to make the industries aware about the ill-effects of the problems associated with improper waste disposal and to make stringent norms to make pharmaceutical firms comply with environmental standards.

1.4 Problems associated with Leather Industry Liquid Waste

Leather processing comprises of series of operations that can be classified as pre-tanning, in which hides or skins are cleaned; tanning process, which permanently stabilises the hides and post-tanning or finishing operations, where final shape value is added for manufacturing of leather

Leather skins are processed on a very large scale throughout the world. A lot of chemicals used for the curing of leather are extremely hazardous and can cause death even if present in trace amounts. The effluent discharged from leather tanneries is often left untreated and can cause serious harm to all forms of life.

1.5 Soil Stabilisation

The process of improving the soil engineering properties by adding materials that would lead to increase in the firmness of particles, load bearing capacity and shearing resistance between soil particles is known as stabilisation. Soil stabilisation can be achieved by chemical or mechanical means thereby improving the desired engineering properties of such soils.

1.5.1 Mechanical Stabilisation

Mechanical stabilisation can be achieved by uniformly mixing the material and compacting the mixture, mechanical stabilisation is attained by compaction of interlocks of soil – aggregate particles. The grading of mixture should be such that a dense mixture is produced after compaction. Soils of different gradations can be mixed together to obtain the desired properties in the soil. Soil compaction leads to increase in the density of soil due to closer packing of the particles that leads to reduction in the air volume.

According to Bowles, compaction leads to elimination of soil pores due to which significant amount of soil air is forced out from the root zone leading to destructions of channels of continuity and least resistant to air movement and water movement.

1.5.2 Chemical Stabilisation

Chemical stabilisation involves addition of chemicals or other materials to improve the engineering properties of the soil. Addition of materials leads to effective binding of the soil particles. Usually cementing agents like lime, cement, fly ash, blast furnace slag are added to stabilise the soils.

1.5.3 Reinforced fiber stabilisation

In early times straws, plant roots, soil bricks were used to improve the properties of the soil . Usage of discrete fibres in reinforcing soil has been the main focus of modern geotechnical engineering.

Chapter 2

Literature Review

- R. Aiswarya Varsha, M. Anvar, G. Aswini , K.U. Athulya, R. K. Ratheesh, Gopika Unni (2017) studied the effect of Ayurvedic waste on the strength parameters of black cotton soil like compressive strength, CBR etc. The tests were conducted on soil samples containing 5%, 10% and 15% waste. The conclusions drawn from the experimental investigations done so as to bring out the effect of stabilisation of black cotton soil using Ayurvedic waste were:
- Addition of Ayurvedic waste in varying percentage resulted in the decrease of maximum dry density.
- They showed a similar trend in the variation of OMC. The OMC curve represented an overall increase in the OMC.
- Addition of waste resulted in the decrease of degree of expansiveness from 73.33% to 36.36%. Hence the strength of soil increased.

- Vijayarangam Murugaiyan, Raman Saravanane (2009) studied Influence of Pharmaceutical Effluent on the Physico–Chemical Behaviour and Geotechnical Characteristics of Clayey and Silty Soils. Two types of commercial soils (kaolinite and bentonite) were chosen for study to determine the independent behaviour of the above commercial soils when they are artificially contaminated with the surfactant effluent. The tests were conducted on two commercial soils and three natural soils. Liquid limit of kaolinite was not affected highly, due to (artificial) contamination . Bentonite exhibited identical behaviour. The LL of all soils were found to increase gently up to 30-45 days of contamination, beyond which, LL decreased up to the end of 138 days of contamination. Shrinkage limit was found to increase slightly for both soils.

- Hussein Elarabi (2012) explained the damage mechanism of expansive soil and stated how soil expansion leads to damage of structures. It is stated that significant processes leading to change in moisture content and temperature occur at foundations of the structure and moisture content at the surface is not same as moisture content in the layers located at depth. This leads to violation of equilibrium conditions and due to unsteady moisture cycles in soil mass, its properties changes which affects the constructions and causes damage to structures.

- RP Shukla, NS Parihar, A. Sood, Atterberg (2005) carried out various tests, including limit tests, unconfined compressive strength tests and compaction tests as per Indian standards. Addition of KCl resulted in a great reduction in the OMC, plasticity index and LL of black cotton soil. Shrinkage limit, maximum dry density and unconfined compressive strength all showed an increase by introducing KCl. Mixing excess of KCl also has adverse effects on soil characteristics. Excessive amounts reduced the cation exchange capacity and increased the water absorption.

Chapter 3
Objective

The following findings are desired through the fulfilment of this project -

- To study the effect of adding untreated pharmaceutical industry and leather industry effluent on the index properties of Black cotton soil.
- To obtain the optimum percentage of the addition of the effluent needed to achieve desired improvement of the index properties and compaction of Black Cotton Soil, if a marked benefit is found.
- To achieve the optimum mix proportion in which the sample needs to be added to water in order to gain the desired improvements as above.

Chapter 4
Materials Used

4.1 Black Cotton Soil

The black cotton soil upon which testing was carried out was procured from the vicinity of the city of Guna in Madhya Pradesh, India. The nomenclature of this soil resulted from the growth of cotton which this soil has facilitated in the region. This soil type has been found to be usually rich in calcium carbonate, potash, lime an magnesium carbonate. The soil procured was extremely fine in particle size, clayey in nature and had the capacity of holding considerable amounts of moisture. The soil became sticky on addition of moisture and developed cracks when it was dry.

4.2 Pharmaceutical Industry Effluent

The Pharmaceutical Industry effluent that was added to the soil was procured from an industrial plant in Baddi, Himachal Pradesh, India where the effluent consisted mainly of waste water being used to clean containers in which dermatological medicinal products were produced. The waste sample was grey in colour and had a pungent odour.

The pH of the pharmaceutical industry waste sample is 8.1.
Biological Oxygen Demand of the sample is 0.013 mg/l.
Chemical Oxygen Demand is as follows :

Dilution Factor	COD (mg/l)
1:5	748.8 mg/l
1:10	371.2 mg/l
1:20	184 mg/l

Chemical Analysis of the sample is as follows :

Parameters	Results (ppm)
Calcium	131
Magnesium	14
Iron	0.20
Sodium	88
Potassium	15

4.3 Leather Industry Liquid Waste

The leather Industry effluent added to the soil was obtained from a leather tannery located in Jalandhar, Punjab, India where the effluent consisted mainly of water being used as solvent to prepare wet-blue leather, a predecessor to the final leather products obtained. The waste was sea green in colour and had the smell of rotten flesh.
The pH of the leather industry liquid waste sample is 4.7

The Biological Oxygen Demand of the sample is 750 mg/L

The Chemical Oxygen Demand of the sample is 2860 mg/L

Chemical Analysis of the sample is as follows :

Parameters	Results (ppm)
Calcium	243
Sodium	20400
Chromium	2940

Chapter - 5
Testing Methodology

5.1 Particle size distribution

This experiment was recorded according to IS :2720 (Part V)-1985 .

5.1.1 Sieve Analysis

PROCEDURE

1. The weight of all the sieves was observed.
2. The weight of the sample of soil provided was observed.
3. It was ensured that the sieves were all assembled in ascending order of sieve numbers. The pan was placed below #200 sieve. The soil was poured carefully into the sieve placed at the top.
4. The sieves were then placed in the mechanical shaker and shaken well for 10 minutes.
5. The stack was removed from the shaker and carefully weighed. The weight of each sieve with its retained soil was recorded. The weight of the pan and the soil retained on it was also recorded.

5.1.2 Hydrometer Analysis

Since the soil contained a substantial quantity of fine particles, a wet sieve analysis was required.

PROCEDURE

1. Oven dried soil sample (200g) was soaked in water and stirred. .
2. The sample was left undisturbed for at 1 hour minimum.
4. The slurry formed thus was made to pass through a sieve of 4.75 mm sieve size and washed with a jet of water at the same time.
5. The material retained on the sieve was the gravel fraction, which was then dried in oven and weighed.
6. The material passing through 4.75 mm sieve was sieved through 75 micron sieve.
7. The material was washed until the water filtered became clear.
8. The soil retained on 75 micron sieve was collected and dried in oven.
9. It was then sieved through the sieve shaker for ten minutes and retained material on each sieve was collected and weighed.
10. The material that would have been retained on pan was equal to the total mass of soil minus the sum of the masses of material retained on all sieves.
11. The curve for the soil particle size vs % finer was plotted to obtain grain size distribution curve.

5.2 Liquid Limit

This experiment was performed in accordance to IS :2720 (Part V)-1985

Liquid Limit is the moisture content at which a soil is, for all sake and purposes, liquid but still provides some resistance against flow. It is also defined as the water content at which a groove made in a part of soil by a standard grooving tool will flow together for a distance of 13 mm when impacted by 25 blows in a liquid limit device of standard acceptance.

PROCEDURE

1. A sample which was passing through 425-micron sieve and having mass around 120 g was taken.
2. This sample was now mixed with distilled water and a paste was made.
3. This paste was now filled in the Casagrande apparatus' cup. A grooving tool was used along the cup and the soil was cut into two halves.
4. The machine was now switched on and operated on its own to provide blows to the soil in the cup. The number of blows needed to close the gap between the two halves was recorded.

5. A sample of the soil was taken to be measured for water content. The experiment was repeated and a graph between moisture content and no. of blows was used to obtain the moisture content at 25 blows i.e Liquid Limit.

5.3 Plastic Limit

This experiment was conducted according to IS:2720 (Part V)-1985.

Plastic limit is defined as the water content at which a soil would just undergo the development of cracks when rolled into threads of approximately 3mm diameter.

PROCEDURE-

1. A soil sample weighing around 20g of soil sample and getting passed on 425 micron sieve was taken.
2. Enough amount of water was added to this soil to create a mass that was plastic enough to be rolled into a ball.
3. This mass was now rolled between hand and a glass plate into a thread of uniform diameter. The rate of rolling was between 80 and 90 strokes/min.
4. The thread was broken into multiple pieces when its diameter became 3 mm. These pieces were made into a mass again and the rolling was repeated.
5. This process was continued until the thread crumbled and the soil was not able to be moulded into a thread anymore. This was noted as the end point.
6. The soil which was crumbled was now observed for its water content and it resulted in the plastic limit.

5.4 Shrinkage Limit

This experiment was conducted according to IS: 2720 (Part VI)-1972

Shrinkage limit is the maximum water content after which a decrease in moisture content does not cause a decrease in the volume of the soil mass. It is, hence the water content at which the soil can be considered saturated.

PROCEDURE

1. 100 g. of soil, passing through 425 micron sieve was taken.
2. A portion of this soil (30g) was then put in a dish and mixed with water to make a paste.
3. The shrinkage dish was cleaned and weighed.
4. The dish was now filled with the soil paste in three layers using a spatula. The new weight was recorded
5. The dish was kept in an oven for 24 hours and the weight was recorded after the drying as (W_0).
6. The dish with the soil was now placed in the evaporating dish and it was filled with mercury, till it overflowed to some degree. It was now pushed inwards with a plain glass plate by applying firm pressure on its top to remove excess mercury. The mercury that overflowed in this process was now poured into a measuring cylinder and its volume was calculated, along with volume of the shrinkage dish. This volume was then recorded as the volume of the wet soil pat (V).

7. The soil pat was placed on the the mercury in the cup and pressed using prongs of the plate. The displaced mercury was collected in the evaporating dish.
8. The volume of the mercury displaced was weighed and its volume calculated as (V_0)

CALCULATION

Shrinkage Limit = W - [(V-V_0)/Wo]*100

Where W = Moisture content

V = volume of wet soil, Vo= volume of dry soil, W_0 = weight of dry soil

5.5 Determination of Free Swell Index of Soil

This experiment was conducted according to IS: 2720 (Part 40)-1977

PROCEDURE

1. Two oven dried soil samples, weighing 10 g each and passing through 425 micron sieve were taken.
2. The samples were now poured in separate glass cylinders of 100 ml capacity.
3. One cylinder was filled with water (distilled) and the other with kerosene oil to the top of the 100 ml cylinder mark.
4. The entrapped air in the cylinder was removed by gently shaking and stirring with a glass rod.

Sample kept for free swell index :

5. The samples were allowed to settle in both the cylinders.
6. 24 hours were allowed for the soil sample to attain equilibrium state of volume without any further change in the volume of the soils.
7. The final volume of the sample of soil in each of the cylinders was observed.

CALCULATIONS

$$\text{Free Swell Index, (\%)} = \frac{V_d - V_k}{} \times 100$$

V_d = Volume of the soil specimen read from the graduated cylinder containing distilled water.

V_k = Volume of the soil recorded from the cylinder having kerosene.

5.6 California Bearing Ratio Test

This experiment was conducted according to IS: 2720 (Part 16)-1973

California Bearing Ratio (CBR) is defined as the ratio (%) of stress required to penetrate a soil mass with a circular plunger of 50 mm diameter at the rate of 1.25 mm/min to that required for corresponding penetration in a standard material.

PROCEDURE:

1. The weight of empty mould was taken.

2. The spacer disc was kept on the base plate and a filter paper on the disc. The mould was fixed to the base plate with the disc inside the mould and the the collar attached over the mould.

3. Water was added to the specimen and it was compacted in accordance to Standard proctor test or modified proctor test .

4. After compaction, the collar was removed and the surface levelled using cutting edge.

5. The base pate was detached and the spacer disc removed.

6. The weight of mould + compacted specimen was taken and the bulk density of the specimen was determined.

7. The sample was taken for moisture content determination and hence the dry density was found.

8. The filter paper was placed on the perforated base plate.

9. The mould was fixed upside down to the base plate so that surface of the specimen which was downwards was in contact with spacer disc during compaction was now turned upwards on which the penetration test was to be performed (for un-soaked condition).

10. For soaked condition, adjustable stem and perforated plate was fixed on the compacted soil specimen in the mould along with 2.5kg surcharge load.

11. The above set up was placed in the soaking tank for four days

12. After four days, the swell reading was measured and % swell with the help of dial gauge reading was found.

13. The mould from the tank was removed and the water allowed to drain.

14. Then the specimen was placed under the penetration piston and total surcharge load of 4kg (2.5kg during soaking + 1.5 kg during testing)

15. The load and deformation gauges were then set to zero.

16. Load was applied to the plunger into the soil at the rate of 1.25 mm per minute.

17. Reading of the load was taken at penetrations of 0.5, 1.0, 1.5, 2.0, 2.5, 4.0, 5.0, 7.5, 10.0 and 12.5 mm

18. The plunger was removed and the water content of the soil determined.

19. The load versus deformation curve was plotted.

5.7 Determination of maximum dry density and optimum moisture content

This test was done as per IS: 2720 (Part 7) – 1980.

PROCEDURE

1. Air-dried soil which was able to pass through 425 micron sieve was taken (5kg sample) and mixed with water.
2. The weight of the proctor test mould with its base plate firmly attached, was taken as W_1. This mould was now taken and placed on a base with solid support and the soil was compacted in the mould, with its top extension also attached, in three layers of about the same mass. Each layer was given 25 blows from the hammer which weighed 2.6 kg and these blows came from a height of 450mm above the soil. The soil used was enough in quantity to be able to fill the mould, leaving not more than about 6mm to be struck off when the extension was removed. The extension was now taken off and the soil was brought to a level with caution by using a straight edge. The mould and soil were then weighed (W_2).
3. The soil sample was now taken off from the mould and placed onto a tray. The water content of this sample (w) was determined.
4. The remaining soil specimen was broken up and then mixed with the remaining original sample. Suitable increments of water were added successively and mixed into the sample, and the above steps were repeated.

CALCULATION

Bulk Density (Y_m) = (W_1-W_2)/V Where

V= Volume of mould

Dry density (Y_d)= $100Y_m/(100+W)$, Where W=moisture content(%)

5.8 Chemical Tests

5.8.1 Determination of pH

PROCEDURE

For the determination of pH, the usage of A pH electrode came to place. A system of electrodes was formed, having two cells, a sensing half cell and a reference half cell. The sensing half cell was a thin semi permeable membrane that was pH sensitive. This membrane separated two solutions, i.e, the outer solution being the sample which was to be analysed and an internal solution of a standard pH value. Two electrical potentials were thus developed, and the difference in the potential was measured and was given as the pH.

5.8.2 Determination of Biological Oxygen Demand

Bio oxygen demand (B.O.D) is the amount of oxygen required for the microorganisms in the water to be able to create stable compounds such as CO_2 and H_2O from the organic compounds. The microorganisms (bacteria) which are put in contact with these compounds require these substances as

their food and thus utilise the compounds to create simpler compounds - CO_2 and H_2O. B.O.D can therefore be though of as a method to determine of organic content of the waste water.

CHEMICALS**:**

Manganese sulphate alkali iodide acid concentrated sulphate acid standard thiosulphate and star itch indicator.

PROCEDURE:

1. Two B.O.D tubes which were filled to the half mark with distilled water were taken.
2. 3ml of the water to be tested was added to these tubes using a pipette.
3. The tubes were now filled to the brim with distilled water and fixed with a stopper.
4. One tube was kept away in an incubator at 20^{O} C for 5 days.
5. alkali iodide oxide (2 ml) was added to the other tube and shaken well. If oxygen would have been present, the colour would be given off as brown. Otherwise, the colour would have been white)
6. 2ml of concentrated sulphuric acid was added and shaken well which gave a colour that could be likened to that of mustard oil.
7. 200ml of the solution was taken in a standard cylinder and 1ml of starch indicator was added to it. This imparted the solution a distinct yellow colour.
8. The cylinder was now placed below the burette. This burette had a standard solution of sodium thiosulphate. The initial reading was now noted.
9. The DO of the first tube was found out.
10. The B.O.D was found by using the formula

B.O.D (mg/l) = (0 day D.O - 5 days D.O) x 300/ml of the sample taken

5.8.3 Determination of Chemical Oxygen Demand

The Chemical Oxygen demand (COD) determines the amount of oxygen required for chemical oxidation of organic matter using a strong chemical oxidant, such as potassium dichromate under reflux conditions.

PROCEDURE

1. water sample was taken (10 ml) and poured in three 100 ml flasks.

2. Three more 100 ml flasks were taken and distilled water was filled in them.

3. Potassium Dichromate solution (5 ml) was added in each flask.

4. The flasks were all left for 1 hour inside a water bath which had a tempearature of 100^{O} C.

5. The samples were now taken out and left to cool off for 10 minutes .

6. Potassium Iodide (5 ml) was now added to the flasks.

7. Sulphuric acid (10 ml) was added to each of the flasks.

8. The contents of all the flasks were titrated with 0.1N Sodium thiosulphate. The titration was carried out until the blue colour vanished completely.

5.8.4 Determination of Alkalinity of sample

Alkalinity of water is a measure of the potential of water to absorb hydrogen without greatly changing the pH . Put in simpler words, alkalinity is a method of determining the capacity of the water to provide an acid buffering effect. The knowledge of the water's alkalinity is essential for checking the corrosion and in determining the amount of lime to be added to the water to soften it.

PROCEDURE:

1. Preparation of standard solutions :

A. Primary standard solution of Sodium carbonate was provided to be used
B. Secondary standard solution which consisted of hydrochloric acid was also provided to be used .
C. A standard solution was created out of the solutions of hydrochloric acid and sodium carbonate provided by taking 10 ml of the sodium carbonate solution in a flask, adding methyl orange indicator. A burette was now filled with a (N/10) solution of hydrochloric acid and the setup was titrated till the colour transformed from yellow to red.

2. Analysis of Water Sample

A. Water sample (20 ml) was taken in a conical flask and phenolphthalein indicator was added to the sample in the flask. This sample was now titrated against (N/10) hydrochloric acid. The end point of this experiment has the change of colour from pink to colourless. The burette reading was taken as V_1 .
B. 20 mL of the water sample was again taken in a 100 ml flask and methyl orange indicator was added to it. It was observed that the colour of the solution turned yellow. The titration was now continued against the (N/10) hydrochloric acid solution till the colour changed to red. The burette reading was recorded as V_2.

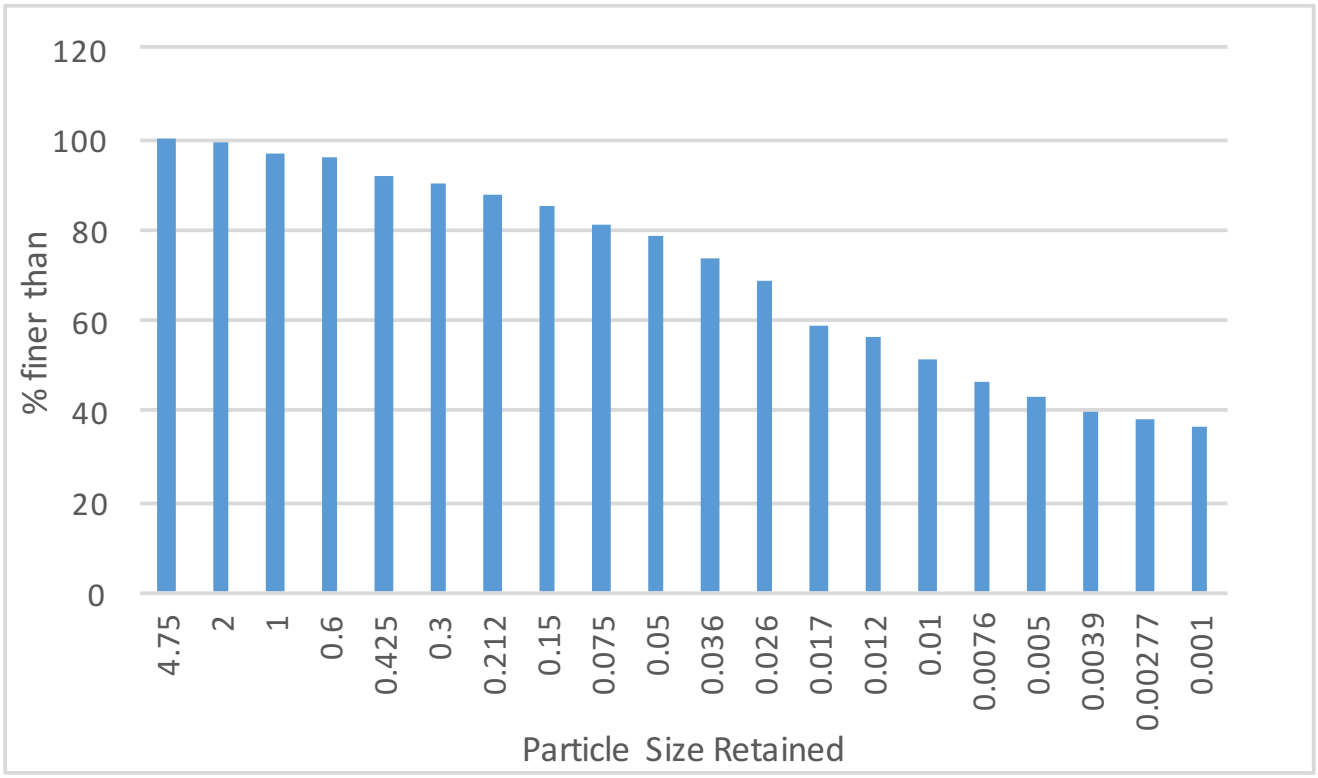
Chapter-6

RESULTS

6.1 Tests performed on Black Cotton Soil without the addition of effluents :

6.1.1 Particle Size Distribution :

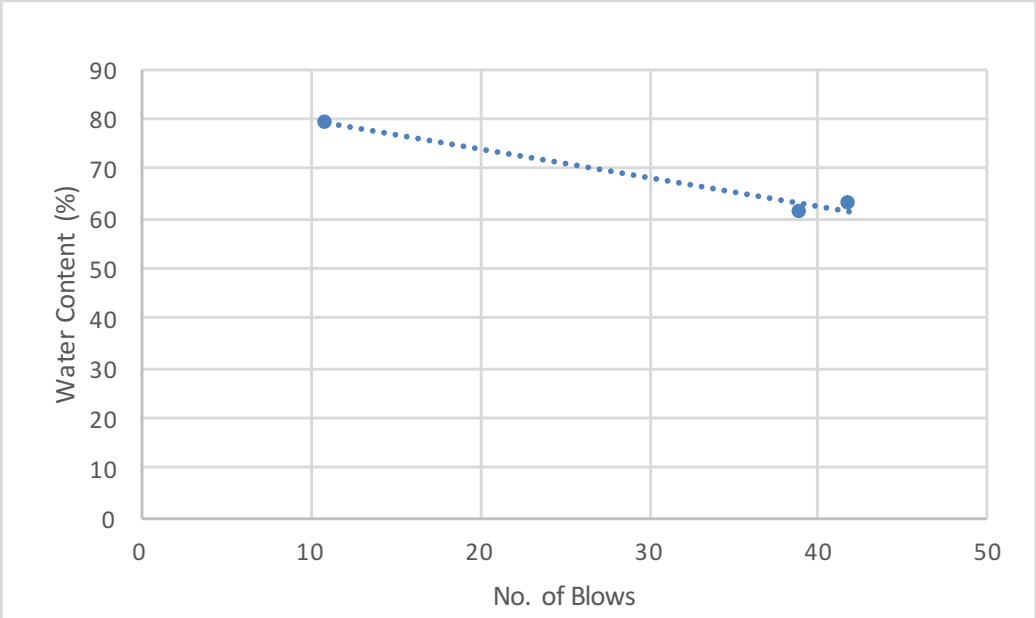
Graph 6.1 illustrates the results of particle size analysis carried out by sieve analysis and hydrometer analysis :



Graph 6.1 - Particle Size Distribution

6.1.2 Liquid Limit :

The results for the Liquid Limit are shown in graph 6.2 :



Graph 6.2 - no. of blows vs water content

6.1.3 Plastic Limit :

The plastic limit of Black Cotton Soil, as calculated is equal to 40% . The Plasticity Index, hence is equal to 29%

6.1.4 Shrinkage Limit :

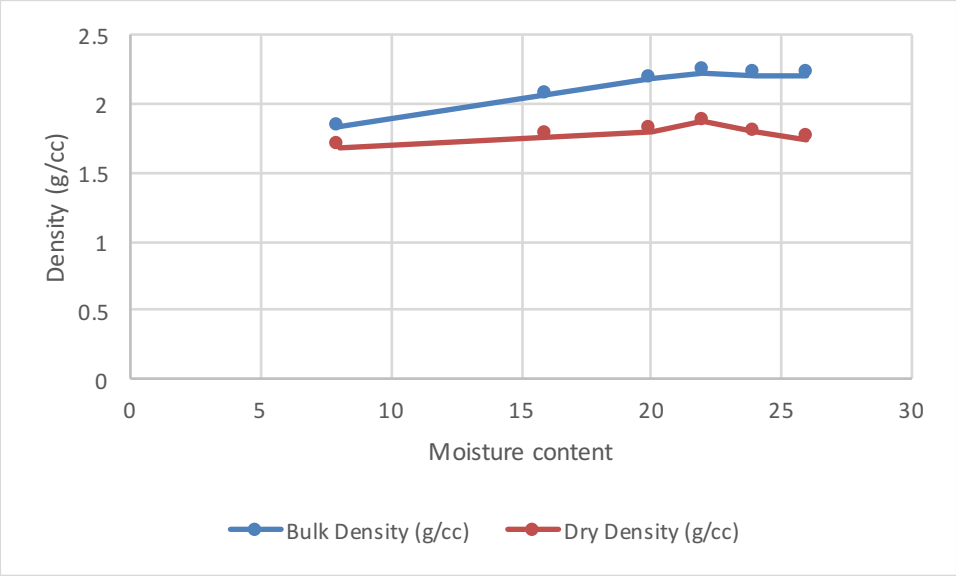
The Shrinkage limit of Black Cotton Soil, as calculated is equal to 16.74% .

6.1.5 Free Swell Index :

The free swell index of soil, as calculated is 66 % .

6.1.6 Optimum Moisture Content And Maximum Dry Density Of Soil :

The Optimum Moisture Content and Maximum dry density of the soil is illustrated by graph 6.3 :

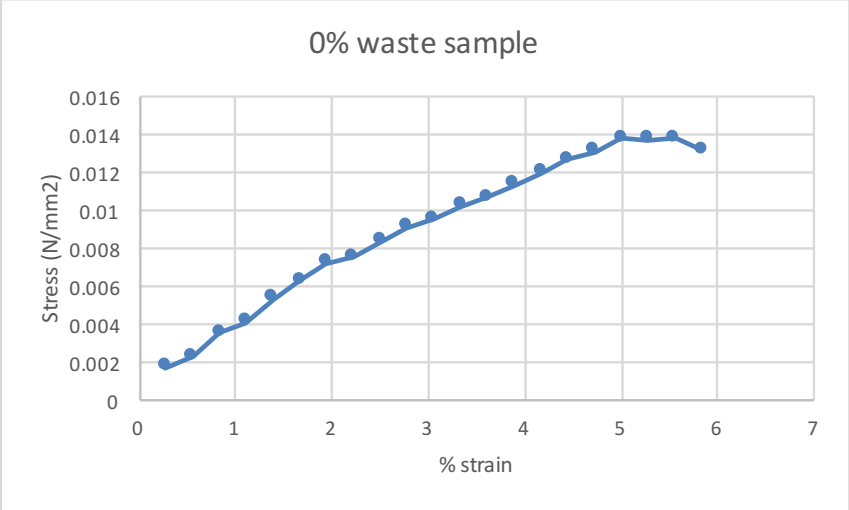


Graph 6.3 - Moisture Content vs Density

The Optimum Moisture Content is, hence equal to 22%

6.1.7 Unconfined Compression Test :

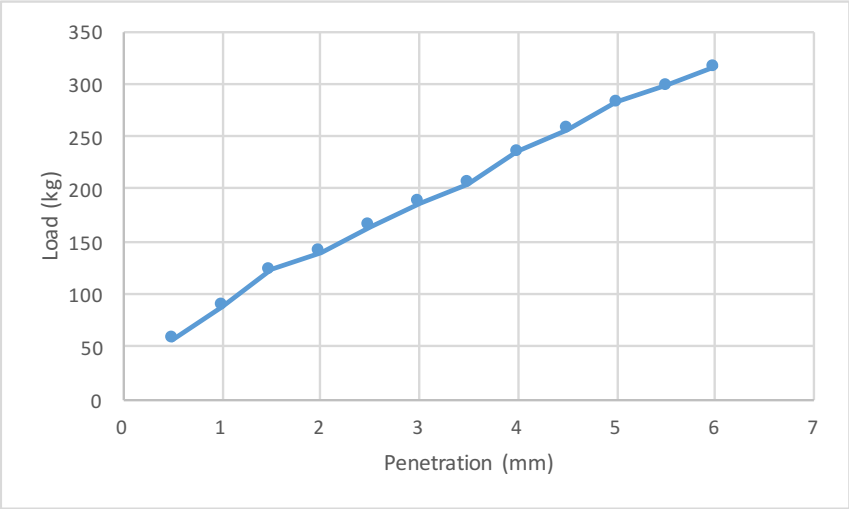
The findings for the Unconfined Compression Test are displayed in graph 6.4 :



Graph 6.4 - stress vs % strain graph

6.1.8 California Bearing Ratio :

The findings for the California Bearing Ratio Test are displayed in graph 6.5 :



Graph 6.5 Load vs Penetration

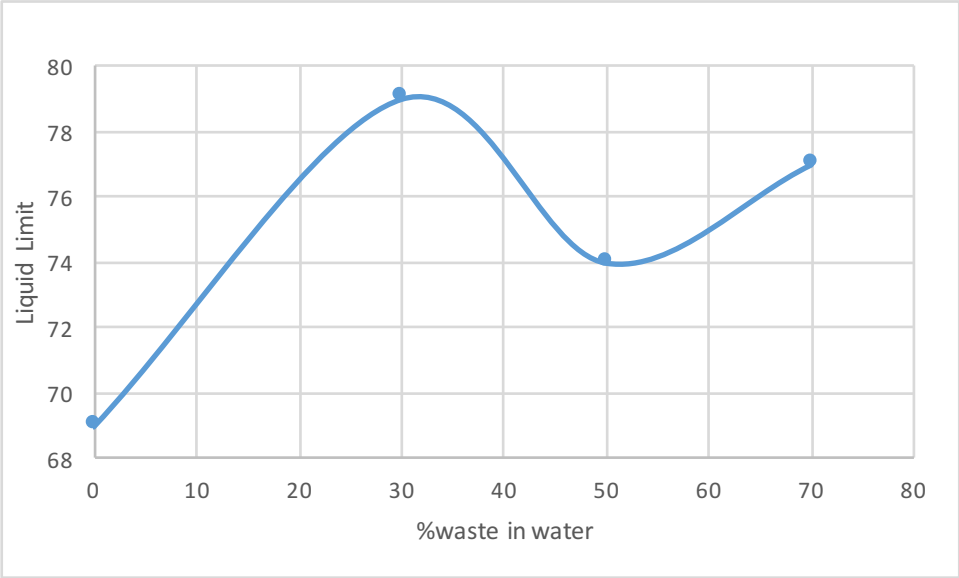
CBR Value at 2.5 mm = 12.04 mm

CBR Value at 5.0 mm =13.72 mm

6.2 Tests performed on Black Cotton Soil with the addition of Pharmaceutical Industry Waste :

6.2.1 Liquid Limit :

The Liquid Limits on addition of various percentages of waste concentration in water is given in graph 6.6

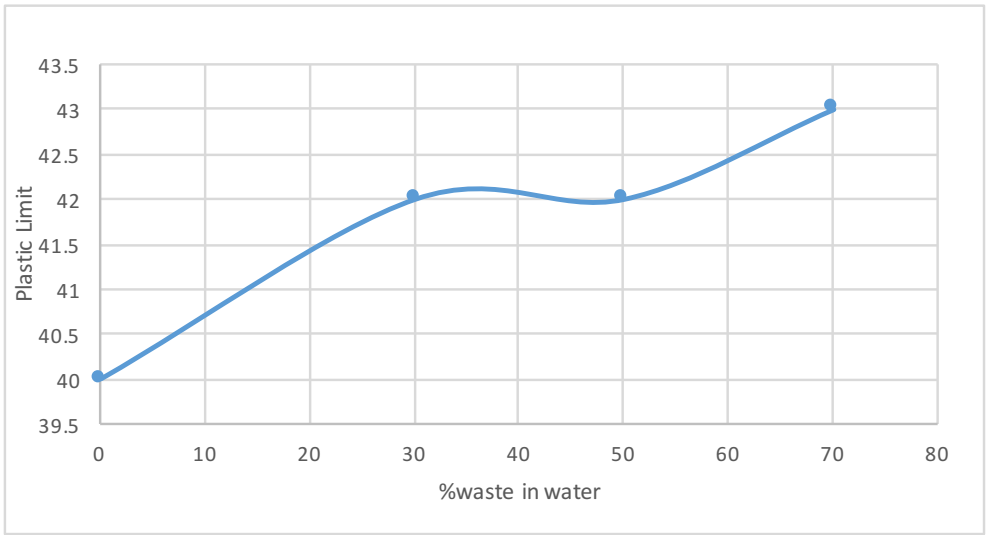


Graph 6.6 Liquid limit with various percentages of waste added to water

It is worth mentioning that a decrease in Liquid Limit would directly point towards decreasing compressibility of the soil an shall hence be viewed as a positive result. However, the least value of liquid limit measured with the addition of pharmaceutical industry waste sample (74%) is still greater than the value of liquid limit of the soil without the addition of any effluents, hence the results can be termed as non-favourable. The least value of liquid limit is obtained upon the addition of 50% of waste in water by weight.

6.2.2 Plastic Limit :

The Plastic Limits on addition of various percentages of waste concentration in water is given in graph 6.7 :

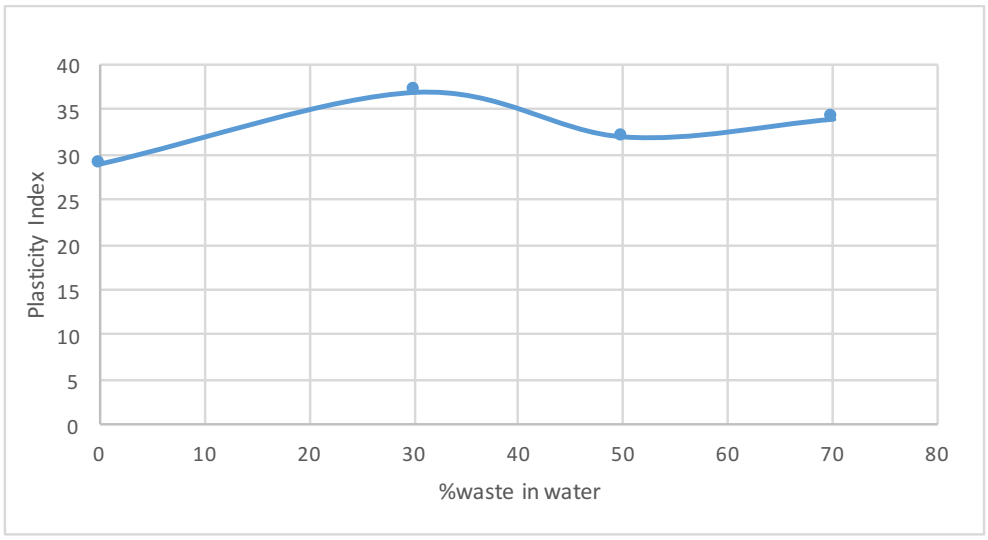


Graph 6.7 Plastic limit with various percentages of waste added to water

A decrease in the plastic limit would point straight away to the soil being in a plastic state at lower water contents. The results received, however indicate that the soil undergoes an increase in the plastic limit upon the addition of the pharmaceutical industry waste sample. Least value obtained is a constant 42 at 50% waste:water ratio

6.2.3 Plasticity Index :

The Plasticity Index on addition of various percentages of waste concentration in water is given in graph 6.8 :

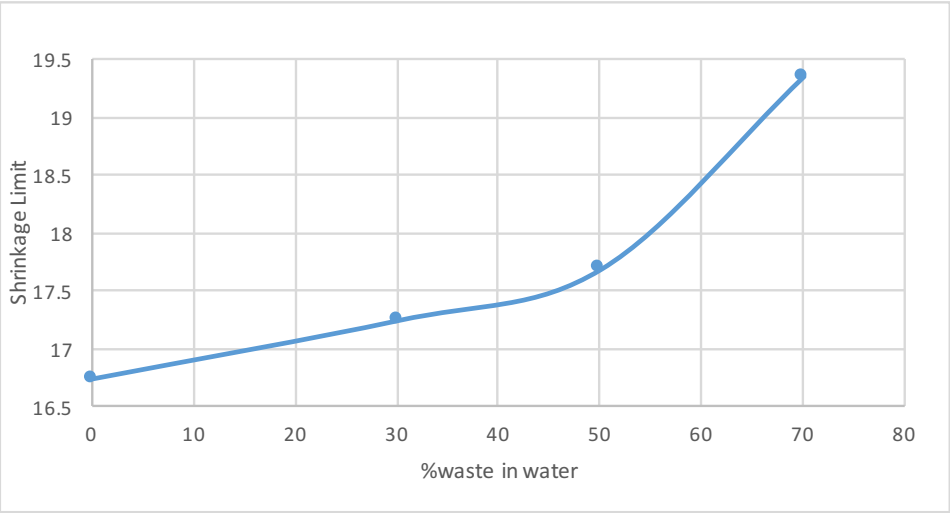


Graph 6.8 Plasticity Index with various percentages of waste added to water

It should be noted that a net decrease in the plasticity index would be viewed as a favourable property as it would imply that the thickness of the double diffuse layer was reducing. Such a trend however, is not observed when pharmaceutical industry waste sample is added to water and the plasticity index is calculated with the least value being 32 obtained at 50:50 waste:water ratio.

6.2.4 Shrinkage Limit :

The Shrinkage Limit on addition of various percentages of waste concentration in water is given in graph 6.9 :

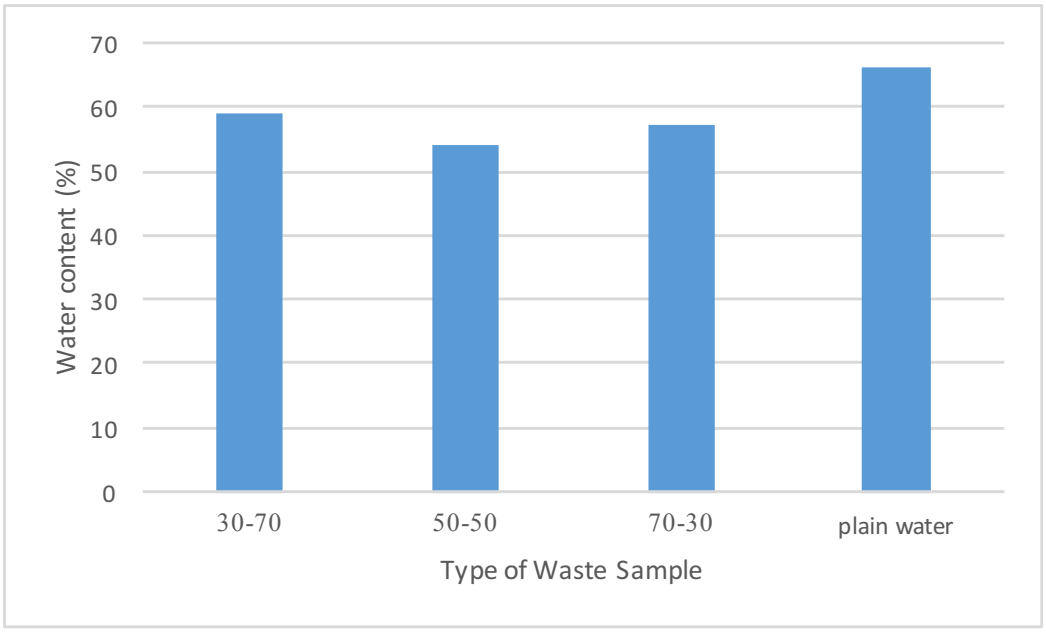


Graph 6.9 Shrinkage Limit with various percentages of waste added to water

An increase in the shrinkage limit of the soil is indicative of a greater percentage of water upon the addition of which the soil would start its swelling. The value of shrinkage limit increases most for the 70:30 ratio for waste:water ratio with its value equal to 19.46. These results therefore can be viewed as positive.

6.2.5 Free Swell Index :

Graph 6.10 illustrates the findings for free swell index upon the addition of the Pharmaceutical Industry Waste sample :



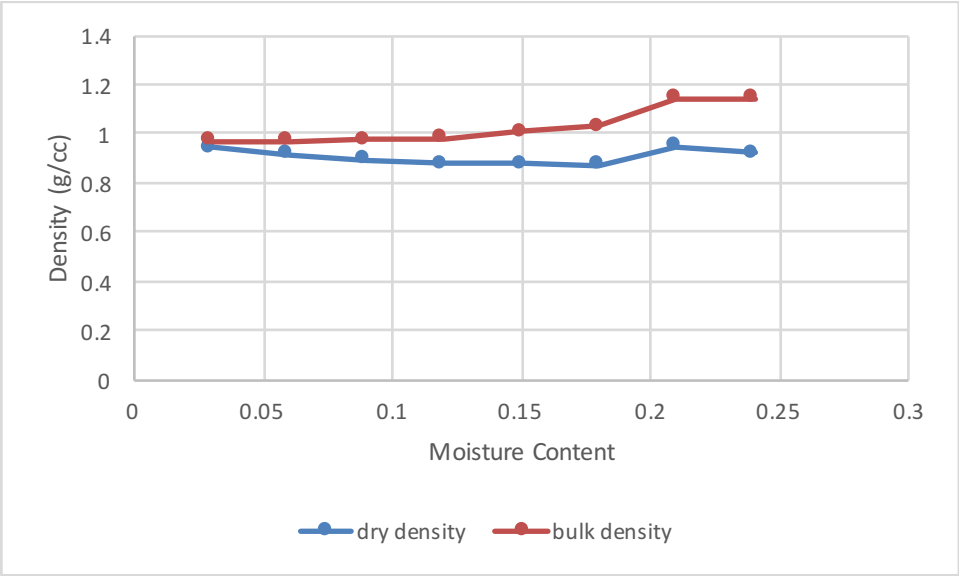
Graph 6.10 Free Swell Index with various percentages of waste added to water

The free swelling index is a direct measure of the amount of swelling that a soil sample undergoes upon the addition of water. Using Pharmaceutical Industry waste sample, a marked decrease was observed as compared to using water to calculate the free swell index.

Based on the above findings, it was observed that the addition of pharmaceutical Industry waste effluent to water and then mixing with soil results with optimum results when the ratio between waste:water is maintained as 50:50 by weight. The value of free swelling index at this ratio is 53% .

6.2.6 The Optimum Moisture Content and Maximum Dry Density of Soil sample with 50% Pharmaceutical Industry Waste :

The Optimum Moisture Content and Maximum dry density of the soil an 50% Pharmaceutical Industry Waste is illustrated by graph 6.11 :

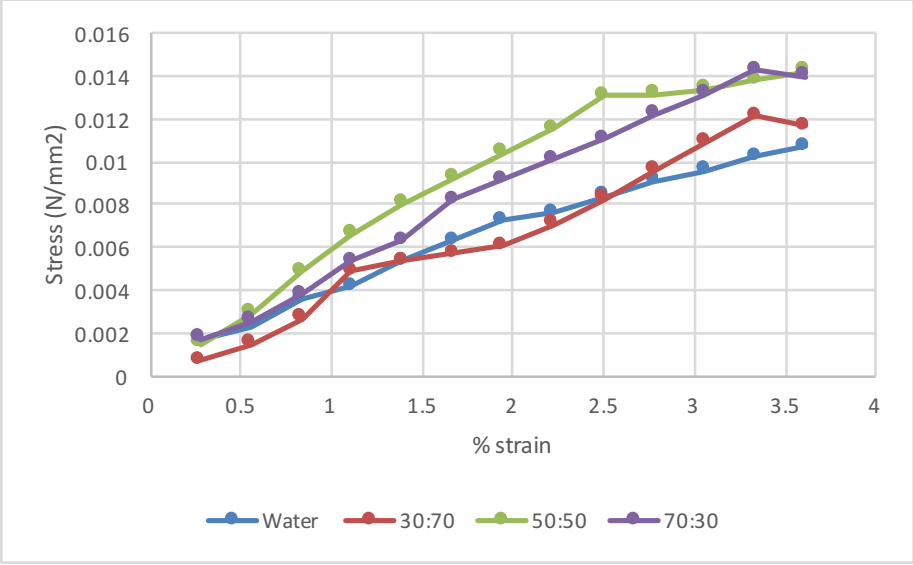


Graph 6.11 Density vs Moisture Content

Optimum Moisture Content as observed from graph is 21 % . Therefore there is seen a net decrease in the value of the optimum moisture content which is favourable. This decreases may have resulted due to the presence of Calcium in the composition of the Pharmaceutical Industry Waste Sample.

6.2.7 Unconfined Compression Test :

The Unconfined Compression Test yielded the following results :

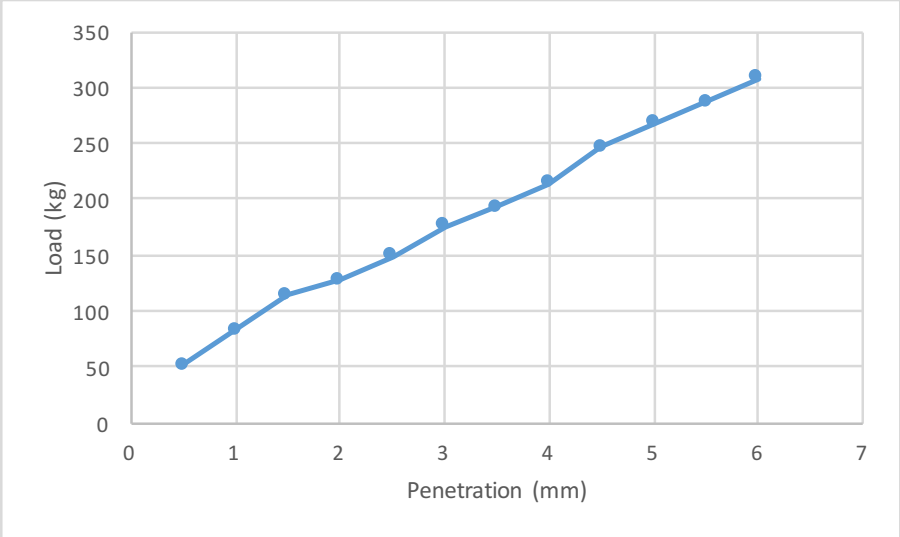


Graph 6.12 - stress vs % strain comparative graph

There is thus a net decrease of Compressive Strength of soil which is not favourable as far as improving the strength characteristics of the soil is concerned.

6.2.8 California Bearing Ratio :

The California Bearing Ratio Test yielded the following results :



Graph 6.13 Load vs Penetration

CBR Value at 2.5 mm = 10.87 mm

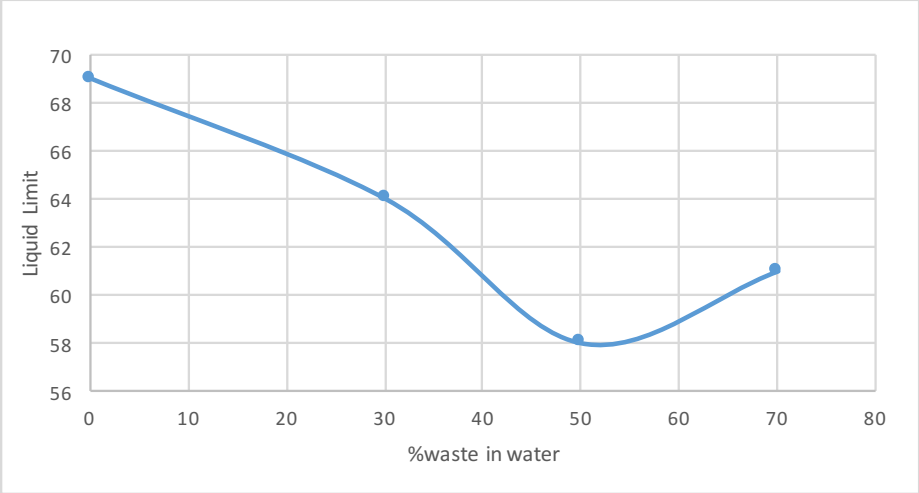
CBR Value at 5.0 mm =13.04 mm

The Pharmaceutical Industry Waste sample can therefore be said to have a non-favourable effect on the improvement of strength properties of the black cotton soil. This can be because of the presence of trace quantities of organic compounds in the waste sample which have affected the sample adversely as far as the stabilisation of black cotton soil is concerned.

6.3 Tests performed on Black Cotton Soil Using Leather Industry Liquid Waste :

6.3.1 Liquid Limit

The Liquid Limits on addition of various percentages of waste concentration in water is given in graph 6.14

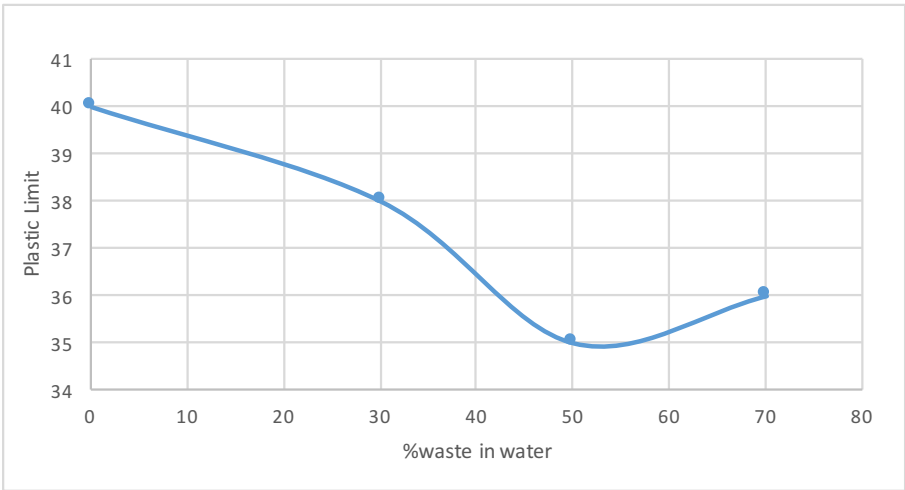


Graph 6.14 Liquid limit with various percentages of waste added to water

It is worth mentioning that a decrease in Liquid Limit would directly point towards decreasing compressibility of the soil an shall hence be viewed as a positive result. We have thus successfully been able to reduce the Liquid Limit upto 58% upon the usage of Leather Industry Liquid Waste and have curbed the compressibility of the soil in the due process, at the waste:water concentration of 50:50.

6.3.2 Plastic Limit

The Plastic Limits on addition of various percentages of waste concentration in water is given as :

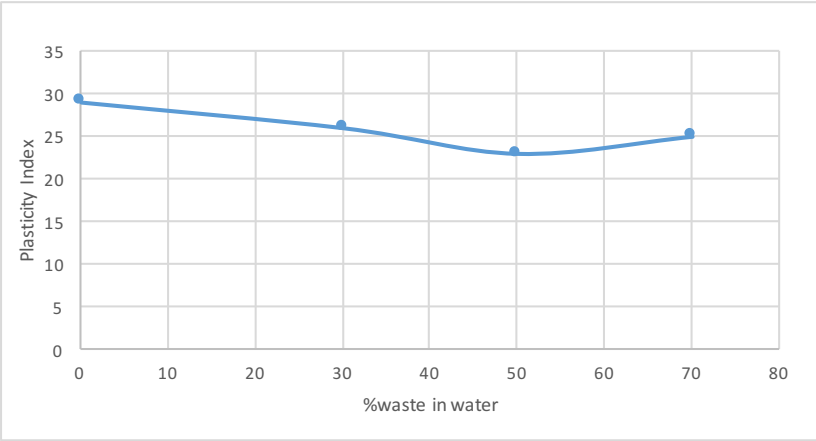


Graph 6.15 Plastic Limit with various percentages of waste added to water

A decrease in the plastic limit would point straight away to the soil being in a plastic state at lower water contents. The results received indicate the very same and it can be said that the soil undergoes a decrease in the plastic limit upon the addition of the pharmaceutical industry waste sample. Minimum value is 35% at a waste:water ratio of 50:50 .

6.3.3 Plasticity Index :

The Plasticity Index on addition of various percentages of waste concentration in water is given in graph 6.16 :

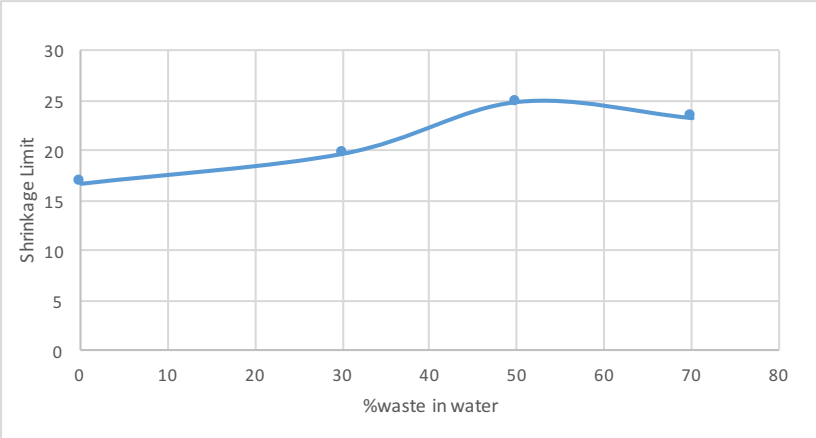


Graph 6.16 Plasticity Index with various percentages of waste added to water

It should be noted that a net decrease in the plasticity index would be viewed as a favourable property as it would imply that the thickness of the double diffuse layer was reducing. Such a trend is observed when Leather industry liquid waste sample is added to water and the plasticity index is calculated. Minimum value is 23% for a waste:water concentration of 50:50 .

6.3.4 Shrinkage Limit :

The Shrinkage Limit on addition of various percentages of waste concentration in water is given in graph 6.17 :

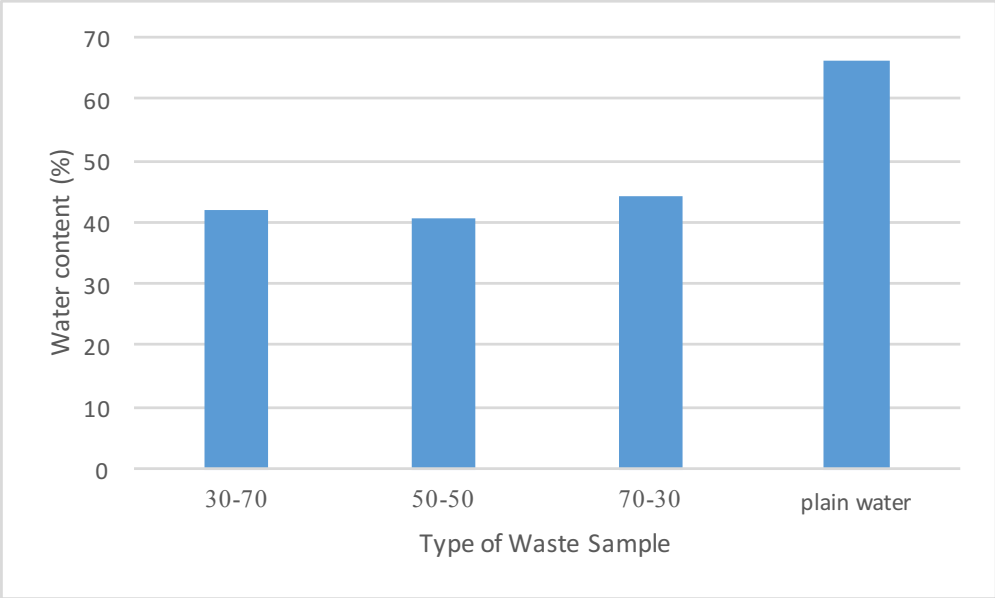


Graph 6.17 Shrinkage Limit with various percentages of waste added to water

An increase in the shrinkage limit of the soil is indicative of a greater percentage of water upon the addition of which the soil would start its swelling. These results therefore can be viewed as positive. Maximum value is 24.8% at a waste:water ratio of 50:50 .

6.3.5 Free Swell Index :

Graph 6.18 illustrates the findings for free swell index upon the addition of the Pharmaceutical Industry Waste sample :



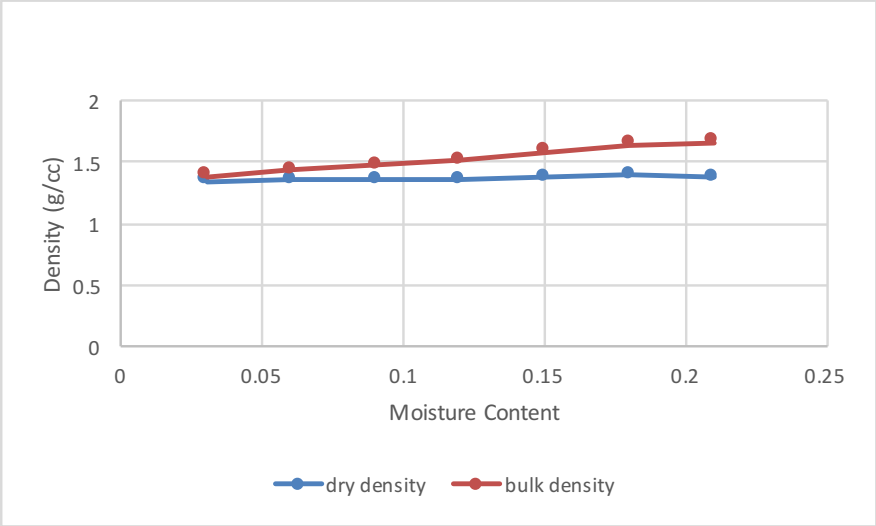
Graph 6.18 - Free Swell Index of Leather Industry Liquid Waste Sample

The free swelling index is a direct measure of the amount of swelling that a soil sample undergoes upon the addition of water. Using Leather Industry liquid waste sample, a marked decrease was observed as compared to using water to calculate the free swell index.

Based on the above findings, it was observed that the addition of Leather Industry Liquid waste to water and then mixing with soil results with optimum results when the ratio between waste:water is maintained as 50:50 by weight. The free swelling index at this concentration is 40.2 %

6.3.6 The Optimum Moisture Content and Maximum Dry Density of Soil sample with 50% Leather Industry Liquid Waste :

The Optimum Moisture Content and Maximum dry density of the soil an 50% Leather Industry Liquid Waste is illustrated by graph 6.19 :

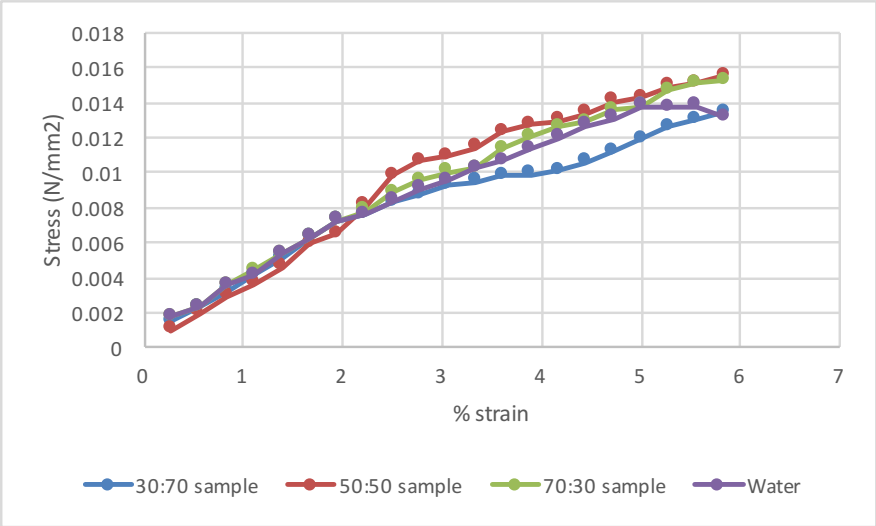


Graph 6.19 Density vs Moisture Content

Optimum Moisture Content as observed from graph is 18 % . Therefore there is seen a net decrease in the value of the optimum moisture content which is favourable. This decreases may have resulted due to the presence of Chromium, Sodium and Calcium in the composition of the Leather Industry Liquid Waste Sample.

6.3.7 Unconfined Compression Test :

The Unconfined Compression Test yielded the following results :

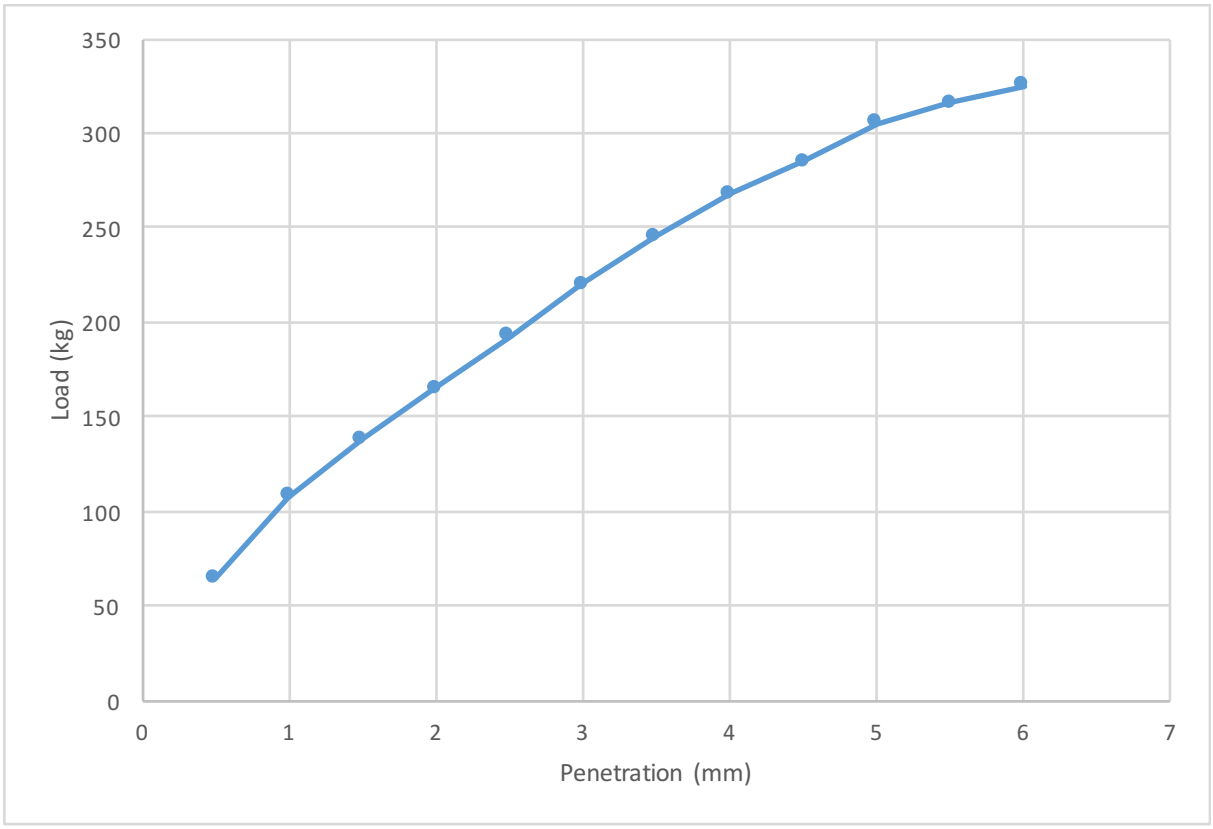


Graph 6.20 - stress vs % strain comparative graph

As observed, there is a net increase in the bearing capacity of the soil which is greatly favourable as the strength characteristics have hence been improved due to the addition of the Leather Industry Liquid Waste.

6.3.8 California Bearing Ratio

Following are the results yielded by the California Bearing Ratio test on the soil with waste :



Graph 6.21 - CBR Analysis on Soil + Leather Industry Liquid Waste

CBR Value at 2.5 mm = 14.014 mm

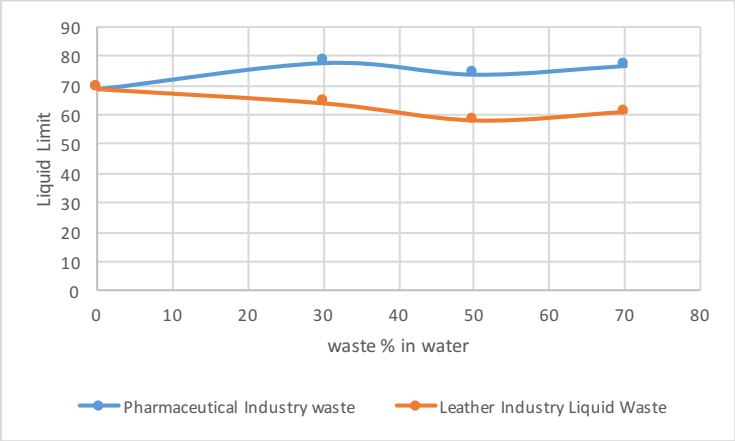
CBR Value at 5.0 mm = 14.84 mm

The CBR value has therefore increased which again points out the increased bearing capacity of the soil.

6.4 Comparison Of Results

6.4.1 Liquid Limit

Following is a comparison of the Liquid Limits of both the effluents used at various concentrations :

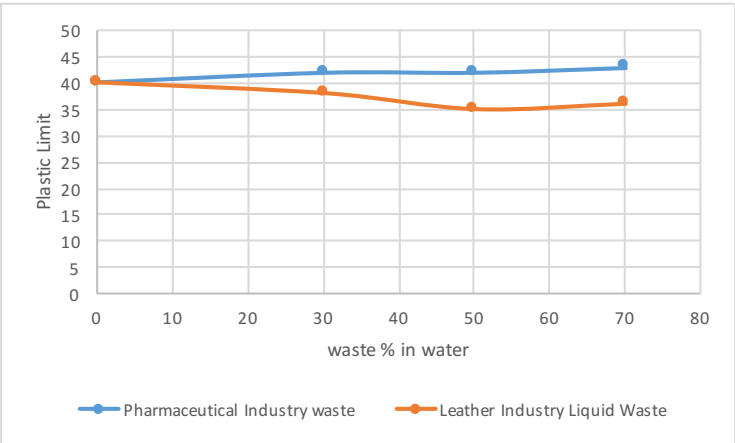


Graph 6.22 Comparative graph showing Liquid Limits of both effluents at various percentages of waste content in water

As is evident, the liquid limits for the pharmaceutical industry waste are of undesirable nature as they are even greater in value than that of using no waste at all. The liquid limits of for the leather industry liquid waste, however indicate a decrease which can be said to have curbed the compressibility of the black cotton soil sample.

6.4.2 Plastic Limit

Following is a comparison of the Plastic Limits of both the effluents used at various concentrations :

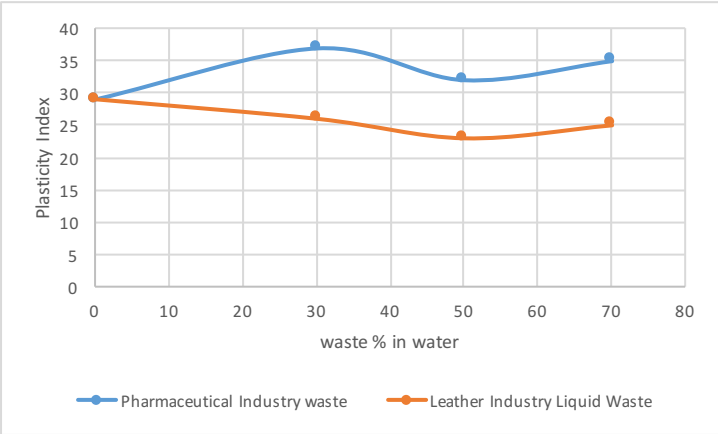


Graph 6.23 Comparative graph showing Plastic Limits of both effluents at various percentages of waste content in water

The plastic limits with the pharmaceutical waste sample show an increasing trend with all waste percentages, while the leather industry liquid waste shows decreasing values of the plastic limit, possibly due to the presence of high amounts of Chromium and Calcium ions which help in the stabilisation of the black cotton soil.

6.4.3 Plasticity Index

Following is a comparison of the Plasticity Index of both the effluents used at various concentrations :

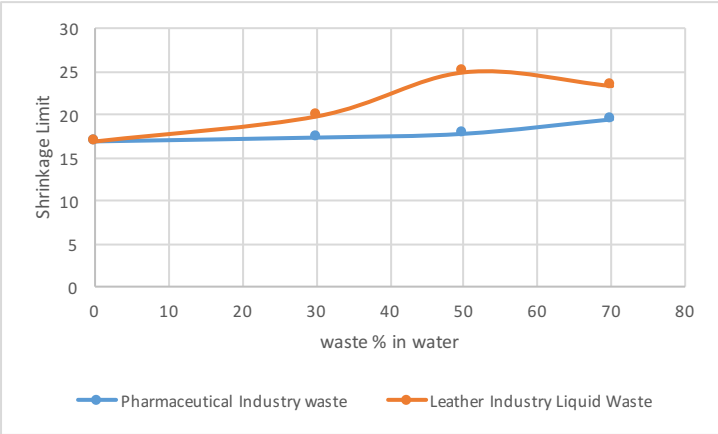


Graph 6.24 Comparative graph showing Plasticity Indices of both effluents at various percentages of waste content in water

The differences in the plasticity indices of both the effluents again highlights their action in stabilising the given black cotton soil sample. The pharmaceutical industry waste shows an upwards trend dipping slightly at a waste concentration of 50% whereas the leather industry liquid waste, showing a positive result, shows a downward trend which can be attributed to the reduction in size of the double diffuse layer.

6.4.4 Shrinkage Limit

Following is a comparison of the shrinkage limits of both the effluents used at various concentrations :

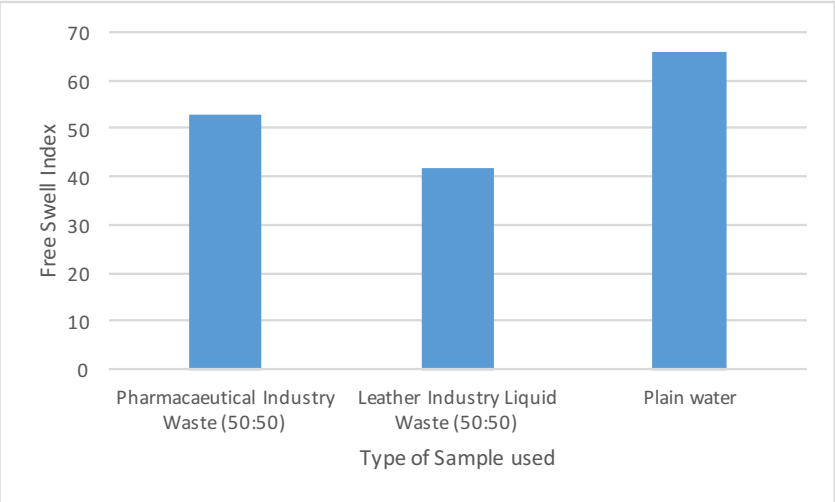


Graph 6.25 Comparative graph showing Shrinkage Limits of both effluents at various percentages of waste content in water

The shrinkage limits show an increase for both the effluents indicating a positive result as this would imply that the swelling for the soil would begin at a higher moisture content therefore providing better protection against the effects of swelling.

6.4.5 Free Swell Index

Following chart compares the values of free swell index for the two effluents in use :

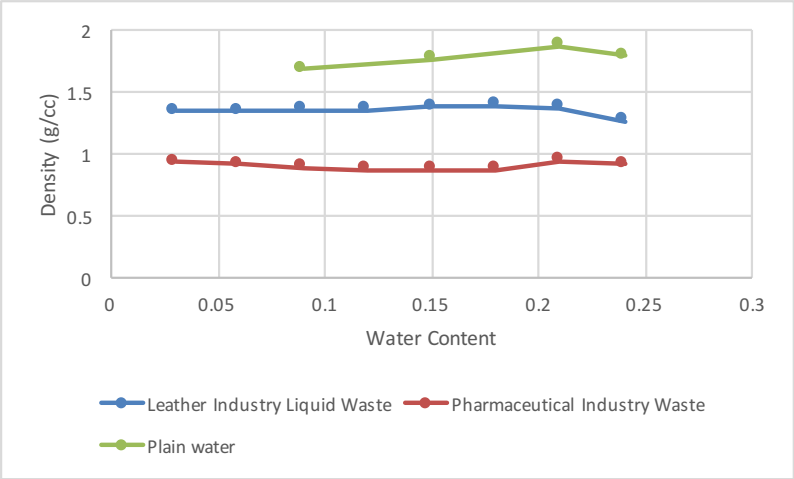


Graph 6.26 graph showing free swell indices of various samples used to stabilise the soil.

The bar chart clearly indicates that both the pharmaceutical industry waste and the leather industry liquid waste are successful in causing some levels of stabilisation with regards to the swelling of the black cotton soil. The leather industry liquid waste excels in this regard, when used in the ratio of 50:50 by weight in the water added.

6.4.6 Optimum Moisture Content and Maximum Dry Density :

GRAPH 6.27 shows the OMC and MDD for vaioys types of effluents used :

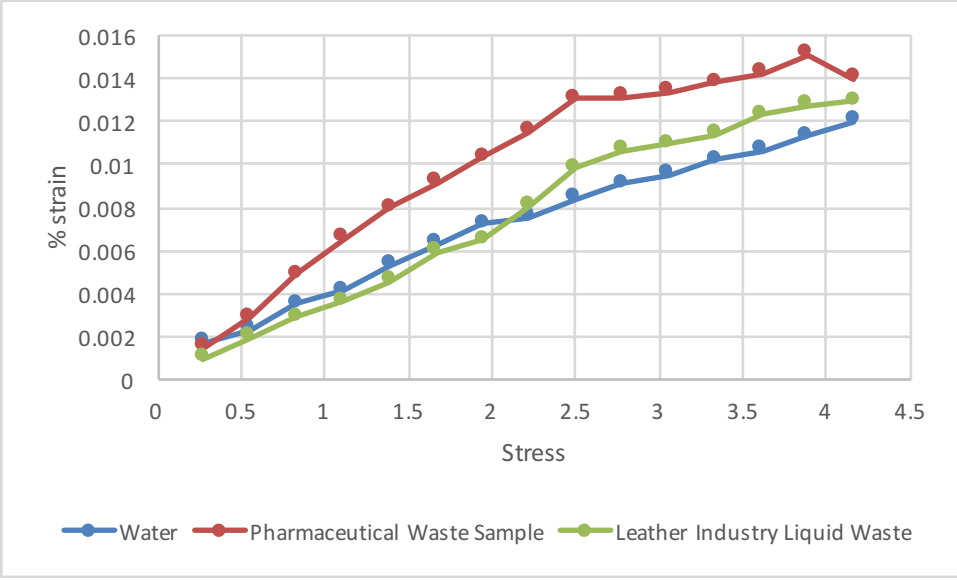


Graph 6.27 density vs water content for various types of effluents used

As is evident from the graph, the optimum moisture content shows a decrease as the leather industry liquid waste is mixed in an optimum ratio (50:50) . The Maximum dry density however, sees a decline using both the effluents, at OMCs of 19% and 21% respectively for leather industry liquid waste and pharmaceutical industry waste.

6.4.7 Unconfined Compression Test

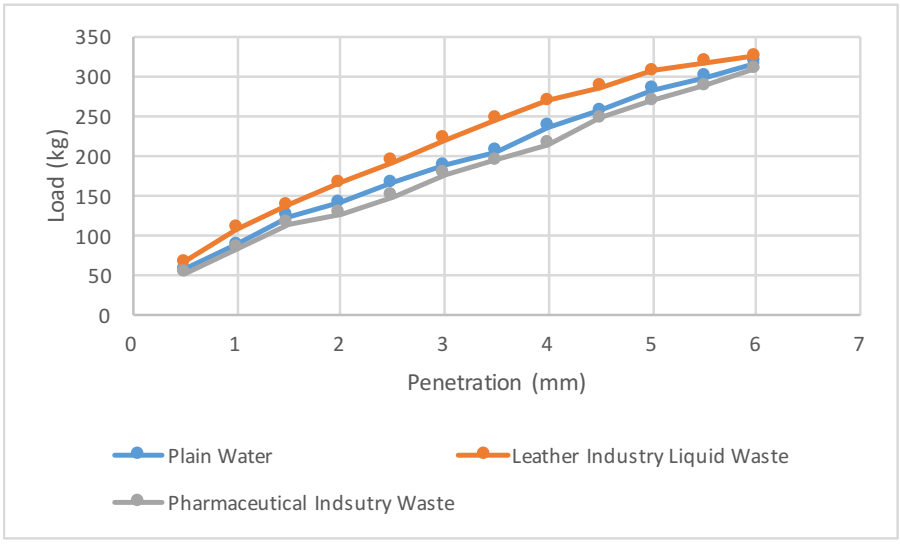
Following are the comparative results for the Unconfined Compression Test :



Graph 6.28 Stress vs % strain comparative graph

As observed, there is a net increase in the bearing capacity of the soil which is greatly favourable as the strength characteristics have hence been improved due to the addition of the Leather Industry Liquid Waste.

6.4.8 California Bearing Ratio Test



Graph 6.29 Load vs Penetration values

APPENDIX

Particle Size Analysis :

particle size retained (mm)	%finer than
4.75	100
2	99.2
1	96.88
0.6	95.75
0.425	91.96
0.3	90.2
0.212	87.37
0.15	85.28
0.075	80.81
0.05	78.4
0.036	73.6
0.026	68.8
0.017	59.2
0.012	56
0.01	51.2
0.0076	46.4
0.005	43.2
0.0039	40
0.00277	38.4
0.001	36.8

Fig 7.1 results for particle size analysis

Proctor Test

Using Pharmaceutical Industry Waste :

mass of empty mould(g)	mass with compacted soil(g)	mass of soil(g)	bulk density (g/cc)	water content	dry density (g/cc)
3681	5104	1423	0.96	0.03	0.94
3681	5108.7	1427.7	0.97	0.06	0.91
3681	5116.8	1435.8	0.97	0.09	0.89
3681	5122.4	1441.4	0.98	0.12	0.87
3681	5161.6	1480.6	1.007	0.15	0.87
3681	5192.1	1511.1	1.02	0.18	0.87
3681	5362.5	1681.5	1.143	0.21	0.94
3681	5360	1679	1.141	0.24	0.92

Fig. 7.2 results of proctor test using pharmaceutical industry waste

Using Leather Industry Liquid Waste :

mass of empty mould(g)	mass with compacted soil(g)	mass of soil(g)	bulk density (g/cc)	water content	dry density (g/cc)
3678.5	5065	1386.5	1.38	0.03	1.34
3678.5	5109.4	1430.9	1.43	0.06	1.3499
3678.5	5150.7	1472.2	1.47	0.09	1.350
3678.5	5192.8	1514.3	1.51	0.12	1.352
3678.5	5262.2	1583.7	1.58	0.15	1.37
3678.5	5318.2	1639.7	1.64	0.18	1.38
3678.5	5338	1659.5	1.65	0.21	1.37
3678.5	5244.3	1565.8	1.56	0.24	1.26

Fig. 7.3 results of proctor test using leather industry liquid waste

Unconfined Compressive Strength :

Using 0% waste :

corrected area	%strain	load (N)	stress(N/mm2)
1020.193872	0.277777778	1.75	0.00171536
1023.043575	0.555555556	2.375	0.002321504
1025.909244	0.833333333	3.625	0.003533451
1028.791011	1.111111111	4.25	0.004131063
1031.689014	1.388888889	5.5	0.005331064
1034.60339	1.666666667	6.5	0.006282601
1037.534278	1.944444444	7.5	0.007228677
1040.481818	2.222222222	7.875	0.007568609
1043.446154	2.5	8.75	0.008385675
1046.427429	2.777777778	9.5	0.009078508
1049.425788	3.055555556	10	0.009529021
1052.441379	3.333333333	10.75	0.010214346
1055.474352	3.611111111	11.25	0.010658715
1058.524855	3.888888889	12	0.011336531
1061.593043	4.166666667	12.75	0.012010252
1064.67907	4.444444444	13.5	0.012679877
1067.78309	4.722222222	14	0.013111277
1070.905263	5	14.75	0.013773394
1074.045748	5.277777778	14.75	0.013733121
1077.204706	5.555555556	14.875	0.013808889
1080.382301	5.833333333	14.25	0.013189775

Fig. 7.4 results of Unconfined Compression Test using 0% waste :

Using 50% Pharmaceutical Industry Waste :

corrected area	%strain	load (N)	stress(N/mm2)
1020.193872	0.277777778	1.5	0.001470309
1023.043575	0.555555556	3	0.002932426
1025.909244	0.833333333	5	0.004873725
1028.791011	1.111111111	6.75	0.006561099
1031.689014	1.388888889	8.25	0.007996596
1034.60339	1.666666667	9.5	0.009182263
1037.534278	1.944444444	10.75	0.010361103
1040.481818	2.222222222	12	0.011533118
1043.446154	2.5	13.625	0.013057693
1046.427429	2.777777778	13.75	0.013139946
1049.425788	3.055555556	14	0.013340629
1052.441379	3.333333333	14.5	0.013777489
1055.474352	3.611111111	15	0.01421162
1058.524855	3.888888889	16	0.015115375
1061.593043	4.166666667	14.875	0.014011961

Fig 7.5 results of Unconfined Compression Test using 50% pharmaceutical industry waste :

Using 50% Leather Industry Liquid Waste :

Area (mm2)	%strain	load (N)	stress(N/mm2)
1020.193872	0.277777778	1	0.000980206
1023.043575	0.555555556	2	0.001954951
1025.909244	0.833333333	3	0.002924235
1028.791011	1.111111111	3.75	0.003645055
1031.689014	1.388888889	4.75	0.004604101
1034.60339	1.666666667	6.125	0.005920143
1037.534278	1.944444444	6.75	0.006505809
1040.481818	2.222222222	8.375	0.008049156
1043.446154	2.5	10.25	0.009823219
1046.427429	2.777777778	11.125	0.010631411
1049.425788	3.055555556	11.5	0.010958374
1052.441379	3.333333333	12	0.01140206
1055.474352	3.611111111	13	0.012316737
1058.524855	3.888888889	13.5	0.012753598
1061.593043	4.166666667	13.75	0.012952233
1064.67907	4.444444444	14.25	0.013384315
1067.78309	4.722222222	15	0.014047797
1070.905263	5	15.25	0.014240289
1074.045748	5.277777778	16	0.014896945
1077.204706	5.555555556	16.25	0.015085341
1080.382301	5.833333333	16.75	0.015503771
1083.578698	6.111111111	17	0.015688754
1086.794065	6.388888889	17.875	0.016447458
1090.028571	6.666666667	17.5	0.016054625

Fig 7.6 results of Unconfined Compression Test using 50% leather industry liquid waste :

California Bearing Ratio :

Using 0% Waste :

penetration (mm)	load (Kg)
0.5	57
1	88
1.5	123
2	140
2.5	165
3	187
3.5	205
4	235
4.5	256
5	282
5.5	298
6	316

Fig 7.7 results of California Bearing Ratio test with 0% waste

Using Pharmaceutical Waste :

penetration (mm)	load (Kg)
0.5	51
1	83
1.5	114
2	127
2.5	149
3	176
3.5	193
4	214
4.5	246
5	268
5.5	287
6	308

Fig 7.8 results of California Bearing Ratio test with 50% pharmaceutical industry waste

Using Leather Industry Liquid Waste :

penetration (mm)	load (Kg)
0.5	65
1	108
1.5	138
2	165
2.5	192
3	220
3.5	245
4	268
4.5	285
5	305
5.5	316
6	325

Fig 7.9 results of California Bearing Ratio test with 50% leather industry liquid waste

Photographs During Experimentation :

Fig. 7.10 & 7.11 - wet sieve analysis in process

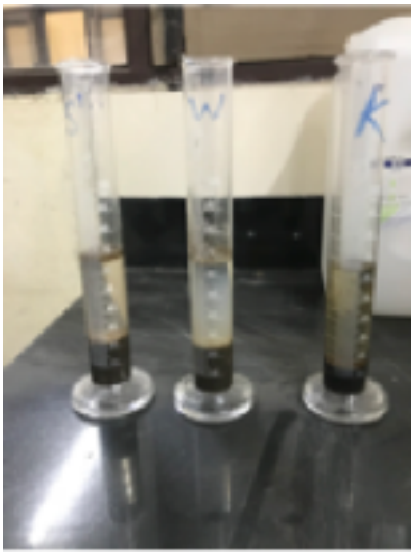


Fig. 7.12 Soil samples being tested for free swell index

Fig 7.13 Proctor test in progress

Fig 7.14 Samples being prepared for UCS determination

Fig 7.15 CBR test in progress.

CONCLUSION

As waste generation goes on increasing, there is a greater need to be able to utilise these otherwise unwanted substances in a manner that can serve strength, durability and economical purposes. This is the basic line of thought that runs throughout the the conceptualisation of this project. The project participants wish to come up with meaningful results as the project reaches its culmination and provide a wholesome solution to the issue of waste disposal by using it efficiently as a means to stabilise Black Cotton Soil.

REFERENCES

[1] Elarabi, H. , (2012), “Damage Mechanism Of Expansive Soils”, Building and Road Research Institute, University of Khartoum.

[2] R. Aiswarya varsha, M. Anvar,G. Aswini , K.U. Athulya , R. K. Ratheesh, Gopika Unni , “Stabilisation of Black Cotton Soil Using Ayurvedic Industrial Waste”. International Research Journal of Engineering and Technology (IRJET) (2017)Volume: 04 Issue: 05

[3] V. Murugaiyan , (2005), “Studies On The Influence Of Industrial Effluents On The Physico-Chemical behaviour and Geotechnical Characteristics Of Cohesive Soils” International Journal of Soil, Sediment and Waste (2005) Vol: 02 Issue: 03

[4] Shukla, R.P. ,Parihar, N.S. and Sood, A.K.(2015). “ Effect of potassium chloride on black cotton soil.” Journal of Discovery, Special Issue on: International Conference on Geo-Engineering and Climate Change Technologies for Sustainable Environmental Management, October 9-11, 2015, Motilal Nehru National Institute of Technology Allahabad, India,40(184), pp241-245