STUDY ON PERFORMANCE OF CHEMICALLY STABILIZED EXPANSIVE SOIL

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CERTIFICATE

This is to certify that the project report titled "**STUDY ON PERFORMANCE OF CHEMICALLY STABILISED EXPANSIVE SOIL**", submitted by "**Siddharth Gupta**", "**Rahul Garg**", "**Meenal Thakur**", "**Richa Mahajan**", "**Arpit Kumar Singh**" and "**Abhishek Dahiya**" is submitted in partial fulfillment for the award of B.Tech of Jaypee University of Information Technology, Waknaghat has been carried out under my supervision.This work has not been submitted partially or fully to any other University or Institute for the award of this or any other degree or diploma.

28/05/13

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Working on this project has been a great learning experience for us. Our experience while working in this project ranges from the moment of anxiety, when we could not solve for several days, to moments of ecstasy when after struggling for several days we were ultimately able to find a solution to our problems. It would not have been possible for us to work on this project without the help of many people. We would like to express our gratitude to all of them but some omissions are inevitable.

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ABSTRACT

Black cotton soils are widely distributed in central India. They cover an area of 5,00,000 square kilo meters. Black cotton region extends over the states of Andhra Pradesh, Madhya Pradesh, Gujarat, Karnataka, Tamil Nadu , Maharashtra & districts of Deccan. It covers about 15 to 20% of the total area of the country. These soils are dark in color due to the presence of iron and magnesium minerals delivered from basalt. In India black cottons soil have a high percentage of clay minerals and iron oxide, some calcium carbonate and a low organic content .They are predominantly rich in montomonarliteic clays of high base exchange capacity which generally ranges from 50 to 70 milli eqivalents/100 grams. Black cotton soil sub grade is problematic to high way engineer mainly because of its high swelling and shrinkage properties. It is very hard when dry, but loses its stability completely when wet. On drying it splits into cracks of about 15 cm width and about 3meters depth.

Expansive soils, such as black cotton soils, are basically susceptible to detrimental volumetric changes, with changes in moisture. This behavior of soil is attributed to the presence of mineral montmorillonite, which has an expanding lattice. Understanding the behavior of expansive soil and adopting the appropriate control measures have been great task for the geotechnical engineers. Extensive research is going on to find the solutions to black cotton soils. There have been many methods available to controlling the expansive nature of the soils. Treating the expansive soil with electrolytes is one of the techniques to improve the behavior of the expansive ground. Hence, in the present work, experimentation is carried-out to investigate the influence of electrolytes i.e., potassium chloride on the properties of expansive soil.

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ABBREVIATIONS

B.C.	**Black cotton**
F.Y.	**Fly ash**
P.I.	**Plastic index**
L.L.	**Liquid limit**
P.L.	**Plastic limit**
S.L.	**Shrinkage limit**
C.B .R.	**California bearing ratio**
U.C.S.	**Unconfined compressive strength**
O.M.C.	**Optimum moisture content**
ASTM	**American society for testing and material**
D.P.	**Degradation product**
I.S.	**Indian standard**
B.S.	**British Standard**

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CHAPTER 1

INTRODUCTION

1.1 GENERAL

Expansive soil is one of the most widely distributed soils in India .It is known as black cotton soil due its color and texture. Major area of their influence is almost the entire Deccan plateau. They cover an area of about 5 lac square km which is about 20 percent the total land area in India. These soils are dark in color due to the presence of iron and magnesium minerals delivered from basalt..In India black cotton soils have a high percentage of clay minerals and iron oxide, some calcium carbonate and a low organic content they are predominantly rich in Montmorillonite clays.Primary problem associated with these soils is deformations are significantly greater than elastic deformations. Montmorillonite mineral is the reason behind such destructive swelling in such soils upon the action of moisture. Proper remedial measures are to be adopted to modify the soil or to reduce its detrimental effects if expansive soils are indentified in a project. Modification of BC soil by chemical admixture is a common method for stabilizing the swell-shrink tendency of expansive soil. Advantages of chemical stabilization are that they reduce the swell – shrink tendency of expansive soils and also render the soils less plastic. The electrolytes like potassium chloride, calcium chloride and ferric chloride can be effectively used in place of the conventionally used lime, because of their ready dissolvability in water and supply of adequate cations for ready cation exchange.

The engineering properties of this type of soils are usually with in the following ranges.

- Liquid limit.................................40 to 100%
- Plasticity index.............................15 to 55%
- Shrinkage limit..............................7 to 12 %
- Sand content ....10 to 20 %
- Silt content.................................15 to 45 %

- Clay content…………………………….30 to 70 %
- Swelling………………………………..10 to 20 %
- O.M.C…………………………………20 to 30 %
- Standard proctor density (gr./cc)………1.3 to 1.7
- I.S. classification……………………….CH

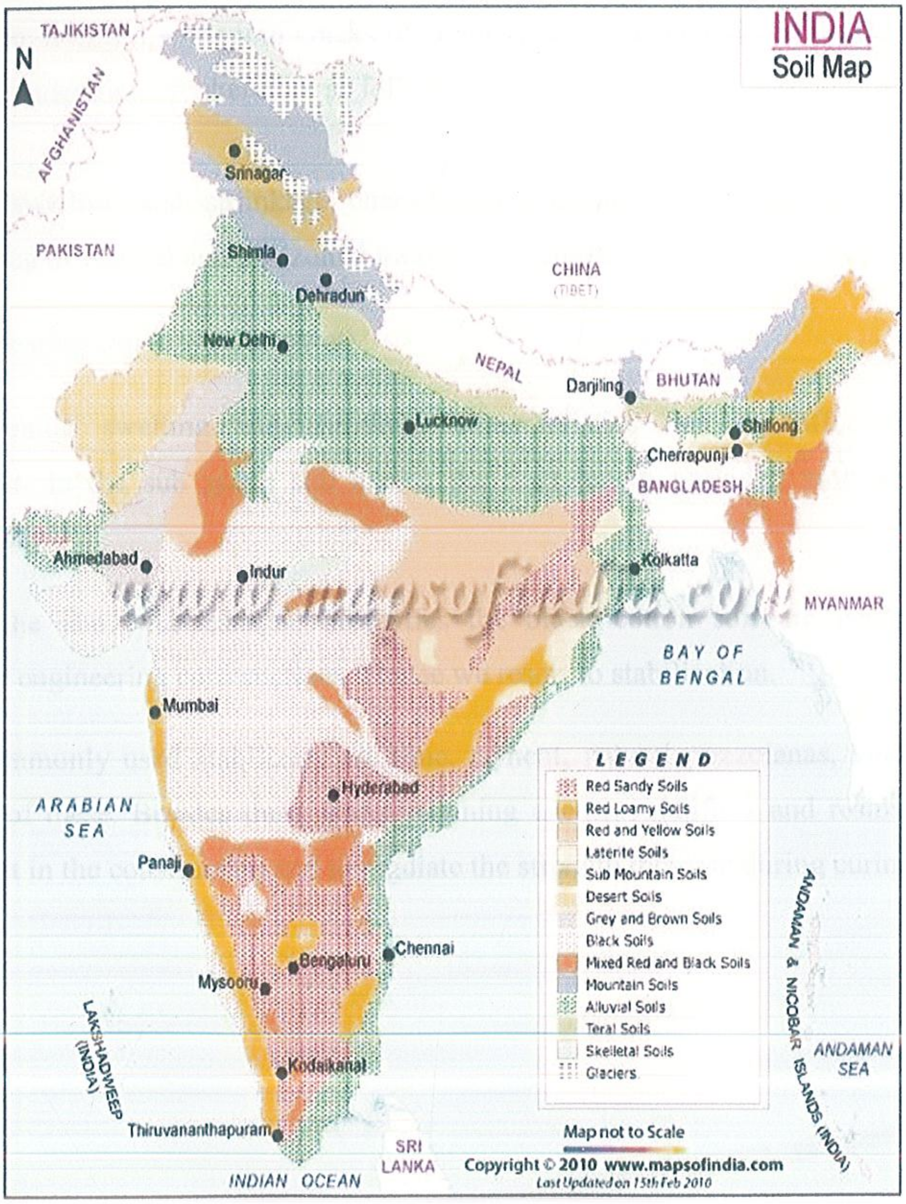


Figure 1.1 Soil map of India

1.2 VARIOUS PROBLEMS ASSOCIATED WITH B.C. SOIL

The damage caused by these soils to roads, canals, buildings and other structures is of the order of 2255 million dollars per annum as estimated by Jones and Holts (1973). It was reported that this loss exceeds combined losses due to floods, hurricanes, earth quakes, tornadoes i.e. natural catastrophes.

Black cotton soil sub grade is problematic to high way engineer mainly because of its high swelling and shrinkage properties. It is very hard when dry, but loses its stability completely when wet. On drying it splits into cracks of about 15 cm wide and about 3 meters depth. The points for consideration are therefore as follows:

- High swelling and shrinkage characteristics during drying and wetting processes resulting in vertical and horizontal moment of soil mass.
- Low bearing capacity (when wet).
- Differential swelling and shrinkage characteristics due to differential moisture content. In the sub grade soil across the road length provided with an impervious surfacing.

Because of the above undesirable properties the black cotton soil are generally regarded unsuitable for engineering constructions. Hence we resort to stabilization.

The most commonly used stabilizers are lime, cement, natural pozzolanas, volcanic ash and combination of these. Besides these water retaining agents, modifiers and resins etc, are also added to assist in the construction and to regulate the strength increase during curing.

1.3 NECESSITY OF THIS PROJECT

This project mainly includes the stabilization of black cotton soil with potassium chloride chemical. It is very important to know the behavior of black cotton soil and its problems so that construction could be done efficiently. This project can be utilized for the construction of flexible pavements, rigid pavement, multi-storied buildings, Canal lining, bridge construction and the other structures which are constructed on this soil. The admixtures used in this project are easily available and are economical beneficial.

1.4 OBJECTIVES OF THIS PROJECT

- To stabilize the black cotton soil by using Potassium Chloride (KCl) chemical.
- To find the optimum percentage at which the chemical (KCl) should be mixed with black cotton soil procured from J.U.E.T campus.
- To develop alternative stabilizers.

1.5 CONCLUSIONS

This chapter describes about the area wise distribution of black cotton soil in India and various engineering associated with it. It also describes the various problems encountered in black cotton soil especially swelling and shrinkage characteristics. It also includes the project importance in practical fields and the objectives which are to be fulfilled in this project.

CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL

The black cotton soils are found in many parts of Andhra Pradesh, Madhya Pradesh, Gujarat, Karnataka, Tamilnadu, Maharashtra & districts of Deccan. The damage caused by these soils to roads, canals, buildings and other structures is of the order of 2255 million dollars per annum as estimated by Jones and Holts (1973). It was reported that this loss exceeds combined losses due to floods, hurricanes, earth quakes, tornadoes i.e. natural catastrophes. The problems created by black cotton soils made the engineers to take up the challenge and study the soil thoroughly. Investigators and research works are taken up through out the world to understand the behaviour and predict satisfactorily the solutions to these problems.

Studies on expansive soils by various research workers are mostly directed towards understanding the nature and development of swelling pressure. However to understand the behaviour of this soil thoroughly shear strength are also to be given due importance.

2.2 PAST INVESTIGATIONS

- P.VenkaraMuthyalu.et al.(2012). "STUDY ON PERFORMANCE OF CHEMICALLY STABILIZED EXPANSIVE SOIL", UCE, Kakinada.Studied the influence of electrolytes on the physical properties of the expansive soil like liquid limit, plastic limit and shrinkage limit.

- T William lambe, Robert v Whitman "soil mechanics version" John Wiley & Sons, 01-Sep-2008, was referred to study the soil mechanics.

- ❖ Abhilash Shukla .et al. "STRENGTH AND COMPRESSIBILITY BEHAVIOR OF BLACK COTTON SOIL STABLIZED WITH LIME AND FLY ASH",JIET, M.P.Concluded that based on the test results expansive soil can be successfully stabilized by fly ash.

- ❖ Saranjeet soni.et al. "Disposal of solid waste for black cotton soil Stabilization", Nagpur have concluded that adding fly ash to the black cotton soil not only helps to improve the engineering properties, but also helps in the utilization of fly ash, which can reduce the disposal and pollution problems.

- ❖ T.L Ramadas.et al. "Study on strength and swelling characteristics of three expansive soils treated with cacl2", JBIET, Hyderabad. Various percentages of cacl2 from 0-2% were added to the 3 soils and its effect on unconfined compressive strength, consistency limits and swell properties are discussed.

- ❖ P. Hari Prasad Reddy .et al. "CONTROL OF ALKALI INDUCED HEAVE IN BLACK COTTON SOIL USING POTASSIUM AND MAGNESIUM SALTS", NIT Warangal. An attempt has been made in this paper to understand the undesirable volume changes in soil, due to interaction with high concentration of alkali solution, and its control using potassium and magnesium chloride salt solution.

- ❖ Oriola, Folagbade.et al. "Groundnut Shell Ash Stabilization of Black CottonSoil", successfully stabilized by Ground nut ash.

- ❖ Dr. K.R Arora "soil mechanics and foundation engineering", 2011, was referred to study the mineralogy of the crystal montmorillonite.

2.3 ROUTE CAUSE OF UNDESIRABLE PROPERTIES OF B. C. SOILS

The route cause of these undesirable properties is presence of MONTMORILLONITE. Montmorillonite is the most common clay mineral of all that in expansive clay soils like black cotton soil. Basic structure of each is made up of gibsite sheet sand witched between two silica sheets of each unit about 10 A0 and the dimensions in the other two directions are indefinite. The gibsite layer may include atom of aluminum, iron, magnesium or a combination of these. In addition these silicon atoms of tetrahedron may inter change with aluminum atoms .These structural changes are called amorphous changes and (++, K +) are attracted to the negatively charged clay plates and exist in a continuous state of inter change. The basic 10 A0 thick units are stacked one above the other. There is very week bonding between the successive units and water may enter between the sheets causing the mineral to swell as shown in fig 2.1. The spacing between successive units depend upon the amount of available water occupy the space. For this reason montmorillonite is said to have an expanding lattice. Each thin unit has a power to attract to each flat surface layer of adsorbed water approximately 200 A0 under zero pressure .in the presence of abundance of water the mineral can in some cases split into about an individual unit layer of 10 A0 thick soil containing montmorllonite mineral exhibit high shrinkage and swelling characteristics.

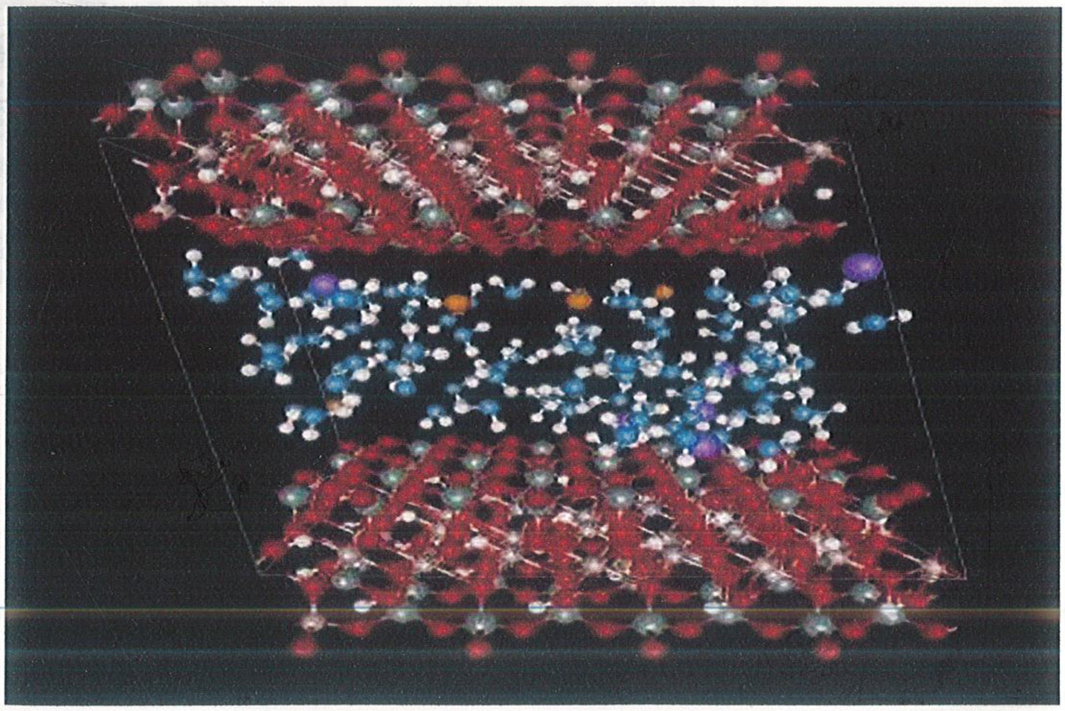


Figure 2.1 Molecular dynamics "snapshot" of water molecules (blue and white), sodium ions(purple), and methane molecules (yellow-brown) intercalated simultaneously between two layers of montmorillonite, a common clay mineral.

2.4 CHEMICAL AND PHYSICAL PROPERTIES OF MONTMORILLONITE

It is the main constituent of volcanic ash weathering product Bentonite.

System: monoclinic crystal

Diaphaneity: Translucent to Opaque

Luster: dull

Density: 2-3g/cm3

Chemical Formula: Na, Ca) 0, 3(Al, Mg) 2Si4O10 (OH) 2•n (H2O)

Weak Vander-wall forces predominately large High base exchange capacity of 50-70 meq/ 100 g e specific surface i.e. The ratio of surface area to its volume is large.

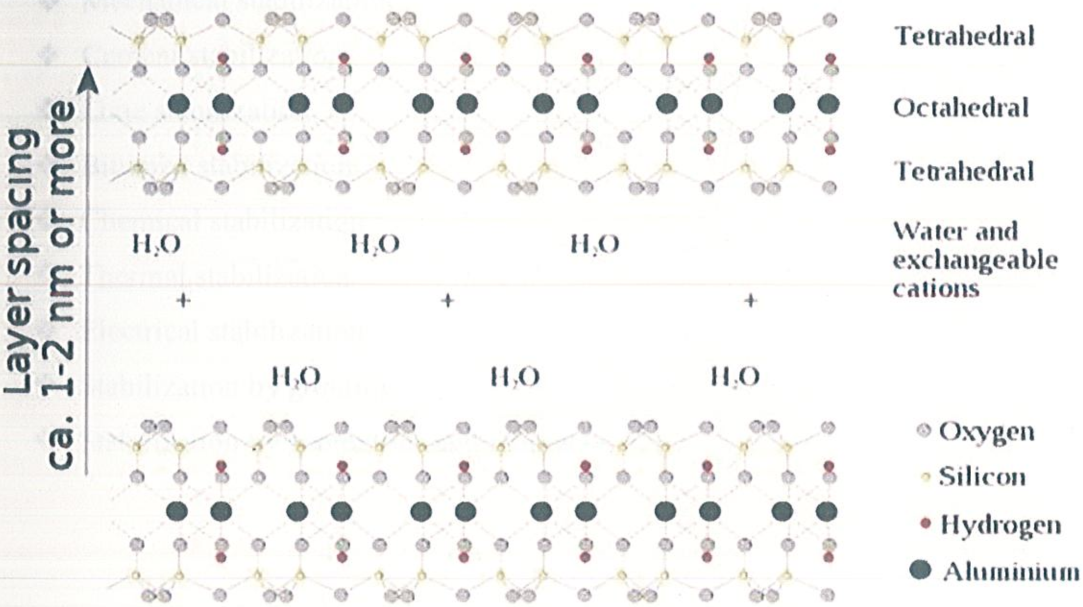


Fig 2.2 Structure of Montmorillonite

2.5 VARIOUS STABILIZATION TECHNIQUES FOR SOIL

Natural soil is both a complex and variable material. Yet because of its universal availability and its low cost it offers great opportunities for skillful use as an engineering material.

Not uncommonly, however the soil at any particular locality is unsuited wholly or partially to the requirements of construction engineer .a basic decision must therefore be made whether to:

1. Accept the site material as it is and design to standards sufficient to meet the restrictions imposed by its existing quality. (OR)

2. Remove the site material and replace with superior material. (OR)

3. Changing or altering the properties of the existing soil so as to create a new site material capable of better to meeting the requirements of the task in hand. The last choice is known assoil stabilization.

The various types of stabilization techniques are

- Mechanical stabilization
- Cement stabilization
- Lime stabilization
- Bitumen stabilization
- Chemical stabilization
- Thermal stabilization
- Electrical stabilization
- Stabilization by grouting
- Stabilization by geotextiles and fabrics

2.6 CHEMICAL STABILISATION

Modification of BC soil by chemical admixture is a common method for stabilizing the swell-shrink tendency of expansive soil. Advantages of chemical stabilization are that they reduce the swell shrink tendency of expansive soils and also render the soils less plastic. Among the chemical stabilization methods for expansive soils, lime stabilization is mostly adopted for improving the swell shrink characteristics of expansive soils. The reaction between lime and clay in the presence of water can be divided in to two distinct processes. The use of calcium chloride in place of lime, as calcium chloride is more easily made into calcium charged supernatant than lime. The electrolytes like potassium chloride, calcium chloride and ferric chloride can be effectively used in place of the conventionally used lime, because of their ready dissolvability in water and supply of adequate cations for ready cation exchange.

Calcium chloride is known to be more easily made into calcium charged supernatant than lime an helps in ready cation exchange reactions. The CaCl2 might be effective in soils with expanding lattice clays. The stabilization to the in-situ soil using KOH solution was made and revealed that the properties of black cotton soils in place can be altered by treating them with aqueous solution of KOH. The laboratory tests reveals that the swelling characteristics of expansive soils can be improved by means of flooding at a given site with proper choice of electrolyte solution more so using chloride of divalent or multivalent cations. The influence of CaCl2 and KOH on strength and consolidation characteristics of black cotton soil is studied and found an increase in the strength and reduction in the settlement and swelling. 5% FeCl3 solution to treat the caustic soda contaminated ground of an industrial building in Bangalore. In this work an attempt made to study the effect of electrolytes like KCl, CaCl2 and FeCl3 on the properties of expansive soil.

2.7CONCLUSIONS

This chapter includes all the literature review that has been collected as per the project prospective. It covers all the past investigations that have been done by various research scholars in the past years. This chapter also emphasizes the route cause of undesirable properties of black cotton soils and stabilizations techniques.

CHAPTER 3

PLANNING AND LABORATORY WORK

3.1 GENERAL

Various activities Involved in this stage are:

1. Collection of materials
2. Methodology
   (A) Black Cotton Soil
   (B) Combination of Black Cotton Soil + KCl(0.5%,1%)
3. Preparation of samples
4. Testing of prepared samples.

3.2 COLLECTION OF MATERIALS

(A) B.C. Soil: The black cotton soil is collected from the J.U.E.T.–campus, in a disturbed form.

(B) Chemicals: KCl was procured from Chemistry laboratory.

3.3 TEST PROGRAM

Electrolyte KCl, is mixed in different proportions to the expansive soil and the physical properties like liquid limit, plastic limit, shrinkage limit of the stabilized expansive soil are determined to study the influence of electrolytes on the physical properties of the expansive soil. Furthermore the stabilized expansive soil with different percentage of the electrolyte(KCl) are tested for engineering properties, like permeability, compaction, unconfined compressive strength and shear strength properties to study the influence of it on expansive soil .

3.3 CONCLUSIONS

This chapter gives the brief idea on the various activities which are performed in the geotechnical engineering laboratory. The activities includes collection of materials, preparation of various samples prepares and the testing of prepared samples. It also gives a brief idea of planning of laboratory work.

CHAPTER 4
RESULTS AND DISCUSSION

In this Chapter the result are given in table and also in the graphical representations.

4.1 Results on black cotton soil

S.NO	NAME OF EXPERIMENT	PLAIN BLACK COTTON SOIL	BLACK COTTON SOIL WITH 0.5% KCl	BLACK COTTON SOIL WITH 1% KCl
1	Standard proctor Test	M.D.D = 1.84 g/cc OMC = 27%	M.D.D = 1.493 g/cc OMC = 22.5%	M.D.D = 1.416 g/cc OMC = 31.1%
2	Liquid limit (%)	73	70	44
3	Plastic limit (%)	38.6	38	30.2
4	Plasticity index (%)	34.4	32	13.8
5	Shrinkage limit (%)	10	12	—
6	Unconfined compression test (Kg/sq.cm)	0.018	0.031	0.00495
7	Unsoaked CBR (%)	5.09	62.40	41.60
8	Swelling test (mm)	0.214	—	0.106

TABLE 4.1

4.2 TABLES

TESTS ON BLACK COTTON SOIL

STANDARD PROCTOR TEST (0% KCl)

S.No	Observation	10% water	15% water	25% water
1	Mass of mould + base plate (in kg)	6.240	6.240	6.240
2	Mass of mould + base plate + compacted soil (in kg)	7.876	8.585	8.035
3	Mass of compacted soil (in g)	1636	2345	1795
4	Bulk density ρ (g/ml)	1.636	2.345	1.795
5	Water content (w %)	17.8	27.4	46.3
6	Dry density ,ρ_d $=\{\rho/(1+w)\}$ g/cc	1.388	1.840	1.2269

TABLE 4.2

Result: M.D.D = 1.84 g/c.c

O.M.C = 27.4 %

STANDARD PROCTOR TEST (0.5% KCl)

S.No	Observation	10% water	20% water	25% water
1	Mass of mould + base plate (in kg)	6.240	6.240	6.240
2	Mass of mould + base plate + compacted soil (in kg)	7.876	8.585	8.035
3	Mass of compacted soil (in g)	1636	2345	1795
4	Bulk density ρ (g/ml)	1.623	1.708	1.83
5	Water content (w %)	17. 9	18.51	22.5
6	Dry density ,ρ_d ={ρ/(1+w)} g/cc	1.3 7	1.441	1.493

TABLE 4.3

Result:

OMC =22.5%

MDD= 1.48g/cc

STANDARD PROCTOR TEST (1% KCl)

S.No	Observation	10% water	26% water	29% water	32% Water
1	Mass of mould + base plate (in kg)	4.370	4.370	4.370	4.370
2	Mass of mould + base plate + compacted soil (in kg)	5.674	6.1649	6.2266	6.1895
3	Mass of compacted soil (in g)	1304	1795	1857	1820
4	Bulk density ρ (g/ml)	1.304	1.795	1.857	1.820
5	Water content (w %)	9.75	11.76	31.1	4.34
6	Dry density ,ρ_d ={ρ/(1+w)} g/cc	1.188	1.606	1.416	1.74

TABLE 4.4

Result: OMC = 31.1%
M.D .D = 1.416g/cc

LIQUID LIMIT (0%KCl)

S.No	Observation and calculation	Container 1	Container 2	Container 3
1	No. of Blows	52	8	98
2	Mass of empty container (M_1)(g)	26.35	27.25	26.35
3	Mass of empty container with wet soil (M_2)(g)	33.5	32	37.95
4	Mass of container with dried soil (M_3)(g)	30.55	30.15	33.15
5	Water content (%) $\% = ((M_2-M_3)/(M_3-M_1))\times 100$	70.238	75.862	63.793

TABLE 4.5

Result: Liquid limit is 73%

LIQUID LIMIT (0.5%KCl)

S.No	Observation and calculation	Container 1	Container 2	Container 3
1	No. of Blows	5	8	9 8
2	Mass of empty container (M_1)(in grams)	22.20	28.10	27.60
3	Mass of empty container with wet	31.85	39.10	34.35
4	Mass of container with dried soil	27.85	34.45	31.55
5	Water content (%) $\% = ((M_2-M_3)/(M_3-M_1))\times 100$	75	73	66

TABLE 4.6

Result: Liquid Limit is 70%

LIQUID LIMIT (1%KCl)

S.No	Observation and Calculation	Container 1	Container 2	Container 3	Container 4
1	No. of Blows	34	14	13	7
2	Mass of empty container (M_1)(g)	26.35	26.20	26.45	27.70
3	Mass of empty container with wet soil (M_2)(g)	28.45	26.75	28.40	29.35
4	Mass of container with dried soil (M_3)(g)	28.1	26.45	27.60	28.6
5	Water content (%) $\% = ((M_2-M_3)/(M_3-M_1))\times 100$	20	120	69.6	83.3

TABLE 4.7

Result: Liquid limit is 44%

PLASTIC LIMIT (0%KCl)

S.no	Observation and calculation	Container 1	Container 2
1	Mass of empty container (M_1)(in grams)	26.67	28.1
2	Mass of empty container with wet soil (M_2)(in grams)	28.15	29.70
3	Mass of container with dried soil (M_3)(in grams)	28.15	29.25
4	Water content (%) $\% = ((M_2-M_3)/(M_3-M_1)) \times 100$	38.095	39.13

TABLE 4.8

Result:

Plastic limit = 38.6125 or 39 %

Plasticity index = 34

PLASTIC LIMIT (0.5%KCl)

S.no	Observation and calculation	Container 1	Container 2
1	Mass of empty container (M_1)(g)	26.3	26.70
2	Mass of empty container with wet soil (M_2) (g)	27.55	27.60
3	Mass of container with dried soil (M_3)(g)	27.20	27.35
4	Water content (%) $\% = ((M_2-M_3)/(M_3-M_1)) \times 100$	38	38

TABLE 4.9

Result:

Plastic limit = 38 %

Plasticity index = 32%

PLASTIC LIMIT (1%KCl)

S.no	Observation and calculation	Container 1	Container 2
1	Mass of empty container (M_1)(g)	29.25	26.45
2	Mass of empty container with wet soil (M_2) (g)	30.1	28.20
3	Mass of container with dried soil (M_3)(g)	29.9	27.80
4	Water content (%) $\% = ((M_2\text{-}M_3)/(M_3\text{-}M_1)) \times 100$	30.77	29.63

TABLE 4.10

Result:

Plastic limit = 30.2%

Plasticity index = 13.88

SHRINKAGE LIMIT`(0%KCl)

S.no	Observation and Calculation	Sample 1	Sample 2
1	Mass of empty mercury dish(g)	25.55	25.55
2	Mass of mercury dish + mercury equal to the volume of shrinkage dish(g)	312.45	312.45
3	Mass of mercury = (2)-(1)(g)	286.9	286.9
4	Volume of shrinkage dish, V_1 = (3)/13.6(c.c)	21.09	21.09
5	Mass of empty shrinkage dish(g)	34.6	24.45
6	Mass of shrinkage dish + wet soil(g)	72.95	65.30
7	M_1 =(6)-(5)(g)	38.35	40.85
8	Mass of shrinkage dish + dry soil(g)	38.35	56.6
9	M_s=(8)-(5)(g)	30.8	32.15

S.no	Observation and Calculation	Sample 1	Sample 2
10	Mass of mercury dish + mercury equal in volume of dry pat(g)	236	247.05
11	Mass of mercury displaced by dry pat = (10)-(1) (g)	210.45	221.5
12	Volume of dry pat , V_2=(11)/13.6(c.c)	15.474	16.286

TABLE 4.11

Result:

- Sample 1:

  $W_s = \{(M_1-M_s)-[(V_1-V_2)\times d_w]/M_s\} \times 100$

  $= 6.27\ \%$

- Sample 2:

  $W_s = 12.11\ \%$

  Shrinkage limit =10%

SHRINKAGE LIMIT`(0.5%KCl)

S.no	Observation and Calculation	Sample 1
1	Mass of empty mercury dish	25.50
2	Mass of mercury dish + mercury equal to the volume of shrinkage dish(g)	362
3	Mass of mercury = (2)-(1)(g)	336.5
4	Volume of shrinkage dish, V_1 = (3)/13.6(c.c)	24.74
5	Mass of empty shrinkage dish(g)	24.65
6	Mass of shrinkage dish + wet soil(g)	62.1
7	M_1 =(6)-(5)(g)	37.45
8	Mass of shrinkage dish + dry soil(g)	59.30
9	M_s=(8)-(5)	25.65
10	Mass of mercury dish + mercury equal in volume of dry pat(g)	251.3
11	Mass of mercury displaced by dry pat = (10)-(1) (g)	225.8
12	Volume of dry pat , V_2=(11)/13.6(c.c)	15.13

TABLE 4.12

Result:

Sample 1:

$W_s = \{(M_1-M_s)-[(V_1-V_2) \times d_w]/M_s\} \times 100 = 13\%$

Shrinkage limit = 13%

SPECIFIC GRAVITY

S.No	DETERMINE	SAMPLE 1	SAMPLE 2
1	Weight of pycnometer W_1 (g)	461.2	443.95
2	Weight of pycnometer +soil W_2 (g)	658.30	641.30
3	Weight of pycnometer +soil +water W_3 (g)	1364.85	1347.85
4	Weight of pycnometer +water W_4 (g)	1260.65	1243.65
5	Gs=(W2- W1)/((W2-W1)-(W3-W4)) (g/cc)	2.121	2.118

TABLE 4.13

Result: Average specific gravity = 2.12 g/c.c

(UNSOAKED) CALIFORNIA BEARING RATIO TEST (0%KCl)

S.NO	DIAL GAUGE	PROVING RING
1	0.5	6
2	1	11
3	1.5	18
4	2	25
5	2.5	34
6	3	39
7	3.5	44
8	4	48
9	4.5	52
10	5	55
11	5.5	58
12	6	59
13	6.6	59.5
14	7	59.5
15	7.5	59.5
16	8	60
17	8.5	60
18	9	60
19	9.5	60
20	10	60

TABLE 4.14

RESULT:

- Since the curve is consistently concave it does not need correction.
- CBR value at 2.5 mm is 4.7%
- CBR value at 5 mm is 5.09%

CBR value is 5.09%

(UNSOAKED) CALIFORNIA BEARING RATIO TEST (0.5%KCl)

S.NO	DIAL GAUGE	PROVING RING
1	0.5	44
2	1	84
3	1.5	125
4	2	170
5	2.5	220
6	3	271
7	3.5	317
8	4	363
9	4.5	408
10	5	450
11	5.5	498
12	6	532
13	6.6	557
14	7	568

TABLE 4.15

RESULT:

- Since the curve is consistently concave it does not need correction.
- CBR value at 2.5 mm is 30.51 %
- CBR value at 5 mm is 62.40 %

CBR value is 62.40 %

(UNSOAKED) CALIFORNIA BEARING RATIO TEST (1%KCl)

S.NO	DIAL GAUGE	PROVING RING
1	0.5	48
2	1	78
3	1.5	105
4	2	133
5	2.5	160
6	3	192
7	3.5	222
8	4	250
9	4.5	278
10	5	300
11	5.5	319
12	6	336
13	6.6	351
14	7	

TABLE 4.16

RESULT:

CBR value is 41.6 %

UNCONFINED COMPRESSION TEST (0%KCl)

- Weight of sample = 161.5 g
- Area of cross section of sample (a) = 1134.115 mm^2
- Diameter of sample =38mm
- Length = 76mm
- Volume = 86.14cm^3
- Cell Pressure = 0.5 kg/ cm^2
- Load gauge constant = 0.274kg/div.

SAMPLE 1

S.NO	ELAPSED TIME(sec)	DIAL GAUGE		PROVING RING		Strain $\varepsilon=\Delta L$ / L (in %) X 10^{-2}	A= a/1- ε	σ= P/A (kg/cm^2) X 10^{-2}
		Readin g	ΔL (mm)	reading	P(kg)			
1	30	64	.64	16	4.32	.84	1143.6	.377

S.NO	ELAPSED TIME(sec)	DIAL GAUGE		PROVING RING		Strain ε=ΔL / L (in %) X 10^{-2}	A= a/1- ε	σ= P/A (kg/cm²) X 10^{-2}
		Reading	ΔL (mm)	reading	P(kg)			
2	60	123	1.23	31	8.37	1.6	1152.44	.726
3	90	185	1.85	46	12.42	2.4	1161.88	1.06
4	120	243	2.43	56	15.12	3.2	1171.49	1.29
5	150	309	3.09	69	18.63	4	1181.25	1.57
6	180	374	3.74	81	21.87	4.9	1192.43	1.83
7	210	430	4.30	93	25.11	5.6	1201.27	2.09
8	240	498	4.98	106	28.62	6.5	1212.83	2.36
9	270	555	5.55	118	31.86	7.3	1223.3	
10	300	611	6.11	131	35.37	8	1232.60	
11	330	680	6.80	143	38.61	8	1232.60	
12	360	745	7.45	152	41.04	9.8	1257.2	
13	390	805	8.05	154	41.58	10.6	1268.4	

TABLE 4.17(a)

SAMPLE 2

S.NO	ELAPSED TIME(sec)	DIAL GAUGE		PROVING RING		Strain ε=ΔL/L (in %) X 10^{-2}	A= a/1- ε	σ= P/A (kg/cm^2) X 10^{-2}
		Reading	ΔL (mm)	reading	P(kg)			
1	30	49	.49	17	4.59	.64	1141.3	.402
2	60	104	1.04	54	14.58	1.36	1149.6	1.268
3	90	168	1.68	79	21.33	2.22	1159.7	1.84
4	120	229	2.29	98	26.46	3	1169	2.26
5	150	293	2.93	122	32.94	3.8	1178.8	2.794
6	180	357	3.57	139	37.53	4.7	1189.9	3.15
7	210	419	4.19	156	42.12	5.5	1200	3.51
8	240	480	4.80	168	45.36	6.3	1210.2	3.75
9	270	539	5.39	179	48.33	7	1219.3	3.96
10	300	600	6	185	49.95	7.9	1231.27	4.056

TABLE 4.17(b)

Result:

C = 0.018 kg/cm^2 , ø = 0

UNCONFINED COMPRESSION TEST(0.5%KCl)

- Weight of sample = 161.5 g
- Area of cross section of sample (a)= 1134.115 mm^2
- Diameter of sample =38mm
- Length = 76mm
- Volume = 86.14cm^2
- Cell Pressure = 0.5 kg/ cm^2
- Load gauge constant = 0.274kg/div.

S.NO	ELAPSED TIME(sec)	DIAL GAUGE		PROVING RING		Strain $\varepsilon=\Delta L/L$ (in %) X 10^{-2}	A= a/1- ε	σ= P/A (kg/cm^2) X 10^{-2}
		reading	ΔL (mm)	reading	P(kg)			
1	30	55	.55	28	7.56	.72	1142.34	6.62
2	60	113	1.13	73	19.71	1.49	1151.27	17.12
3	90	173	1.73	125	33.75	2.28	1160.58	29.08
4	120	235	2.35	172	46.44	3.09	1170.28	39.68

S.NO	ELAPSED TIME(sec)	DIAL GAUGE		PROVING RING		Strain $\varepsilon=\Delta L/L$ (in %) X 10^{-2}	A= $a/1-\varepsilon$	$\sigma=$ P/A (kg/cm^2) X 10^{-2}
		reading	ΔL (mm)	reading	P(kg)			
5	150	307	3.07	215	58.05	4.04	1181.86	49.12
6	180	362	3.62	252	68.04	4.76	1190.80	57.14
7	210	426	4.26	276	74.52	5.61	1201.52	62.02

TABLE 4.18

Result:

Cohesion(C) = 0.031 kg/cm^2

Angle of internal friction(ø) = 0

CONFINED COMPRESSION TEST (1%KCl)

- Weight of sample = 161.5 g
- Area of cross section of sample (a)= 1134.115 mm^2
- Diameter of sample =38mm
- Length = 76mm
- Volume = 86.14cm^3

- Cell Pressure = 0.5 kg/ cm^2
- Load gauge constant = 0.274kg/div.

SAMPLE 1

S.NO	ELAPSED TIME(sec)	DIAL GAUGE		PROVING RING		Strain $\varepsilon=\Delta L/L$ (in %) X 10^{-2}	A= a/1- ε	σ= P/A (kg/cm²) X 10^{-2}
		reading	ΔL (mm)	reading	P(kg)			
1	30	59	.59	11	2.97	.78	1143.03	2.6
2	60	123	1.23	17	4.59	1.62	1152.79	3.98
3	90	188	1.88	23	6.21	2.47	1162.84	5.34
4	120	250	2.5	28	7.56	3.29	1172.70	6.45
5	150	316	3.16	32	8.64	4.16	1183.34	7.30
6	180	379	3.79	35	9.45	4.99	1193.68	7.92
7	210	441	4.41	38	10.26	5.80	1203.94	8.52
8	240	505	5.05	41	11.07	6.64	1214.78	9.11

TABLE 4.19(a)

SAMPLE 2

S.NO	ELAPSED TIME(sec)	DIAL GAUGE		PROVING RING		Strain $\varepsilon=\Delta L/L$ (in %) X 10^{-2}	A= a/1- ε	σ= P/A (kg/cm²) X 10^{-2}
		reading	ΔL (mm)	reading	P(kg)			
1	30	53	0.53	9	2.43	0.70	1142.11	2.13
2	60	115	1.15	14	3.78	1.51	1151.50	3.28
3	90	176	1.76	20	5.4	2.32	1161.05	4.65
4	120	243	2.43	28	7.56	3.20	1171.61	6.45
6	180	365	3.65	40	10.8	4.80	1191.30	9.07
7	210	430	4.30	44	11.88	5.66	1202.16	9.88
8	240	493	4.93	48	12.96	6.49	1212.83	10.69

TABLE 4.19(b)

Result: C = 0.00495 kg/cm² , ø = 0

SWELLING TEST(0%KCl)

INITIAL READING	1.064 mm (after 1 hour)
FINAL READING	0.85mm (after 24 hours)

TABLE 4.20

PENETRATION: 0.214mm (0.1kg/cm^2)

SWELLING TEST (1%KCl)

INITIAL READING	1.854 mm (after 1 hour)
FINAL READING	1.748 mm (after 24 hour)

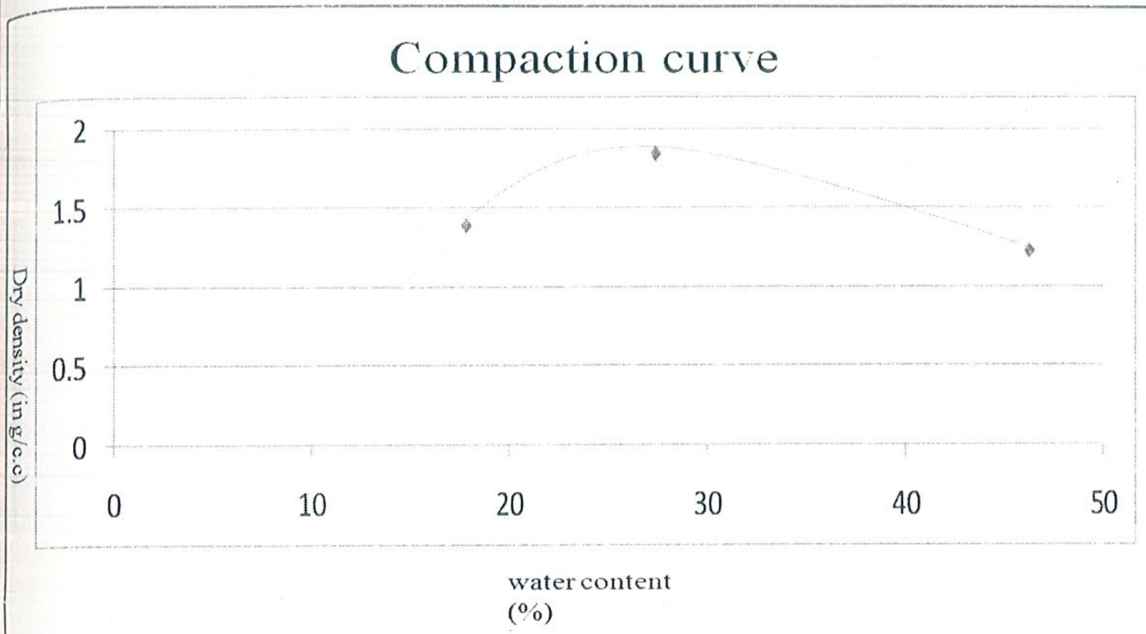
TABLE 4.21

PENETRATION: 0.106 mm (0.1kg/cm^2)

4.3 GRAPHS

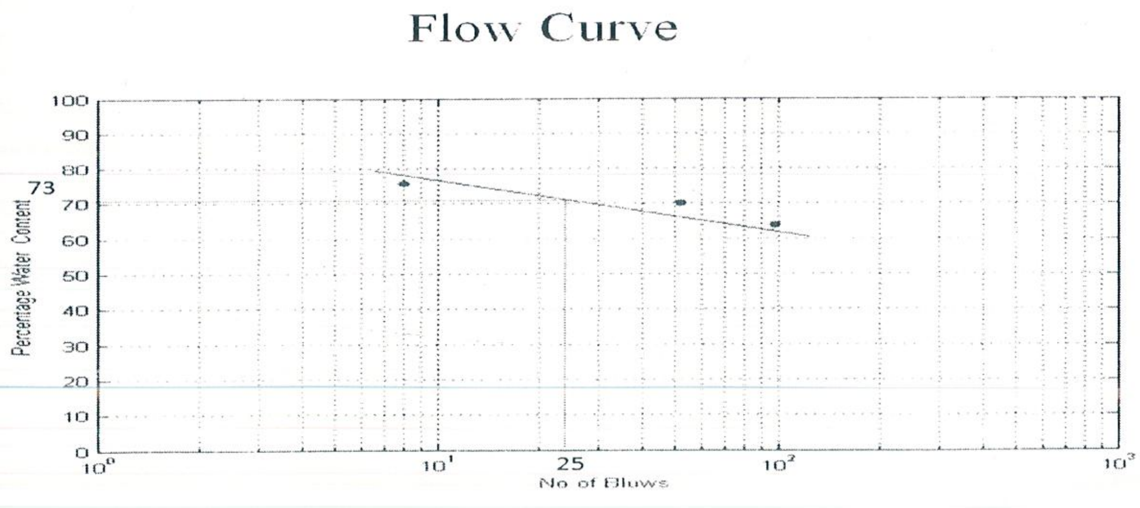
All the test results which have been given in tables above are represented in the graphical manner as shown

Standard Proctor test (0% KCl)



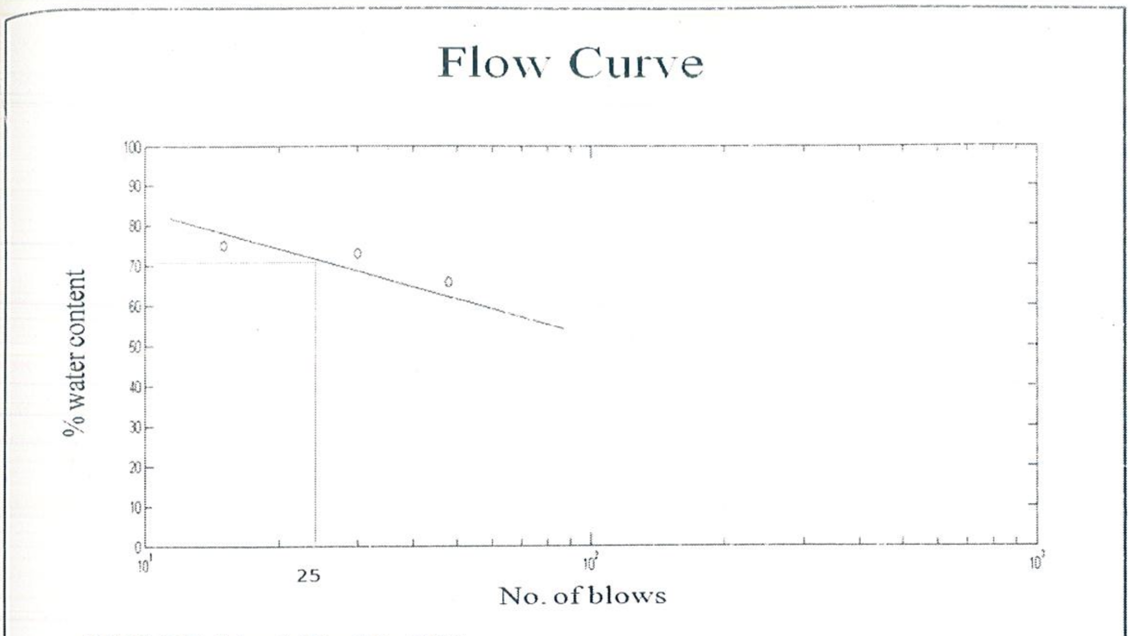
Result: M.D.D = 1.84 g/c.c
O.M.C = 27.4 %

Liquid limit (0% KCl)



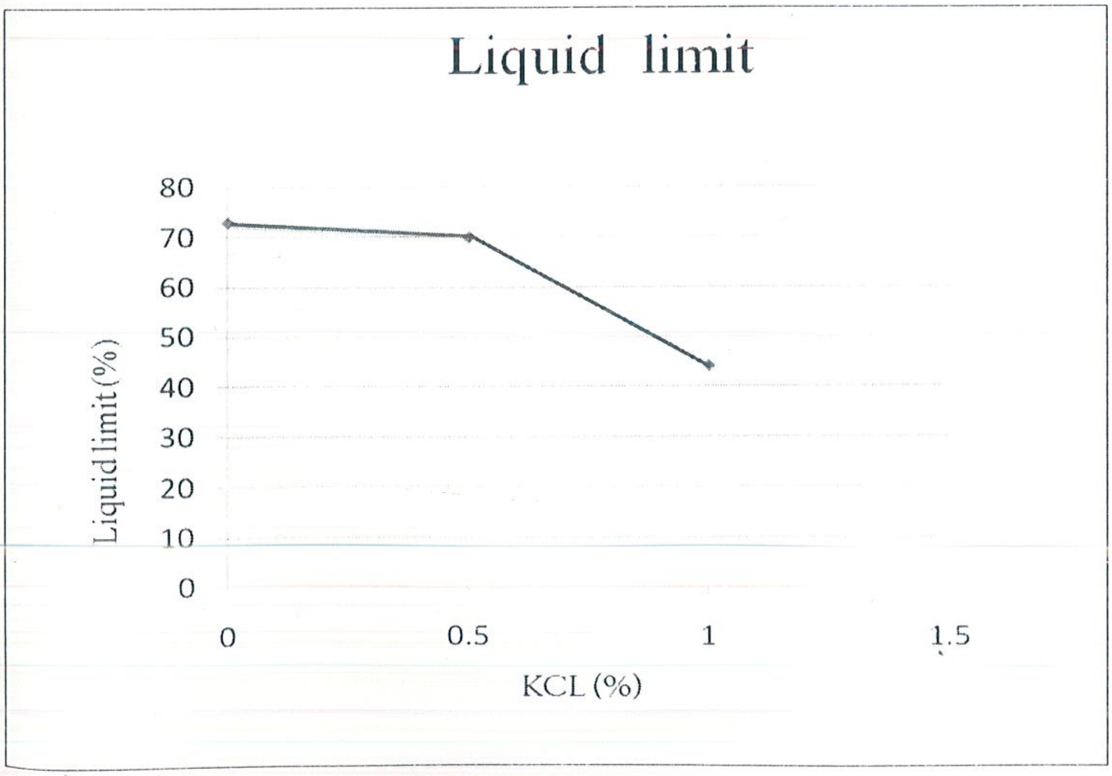
Result: liquid limit is 73%

Liquid Limit (0.5% KCl)

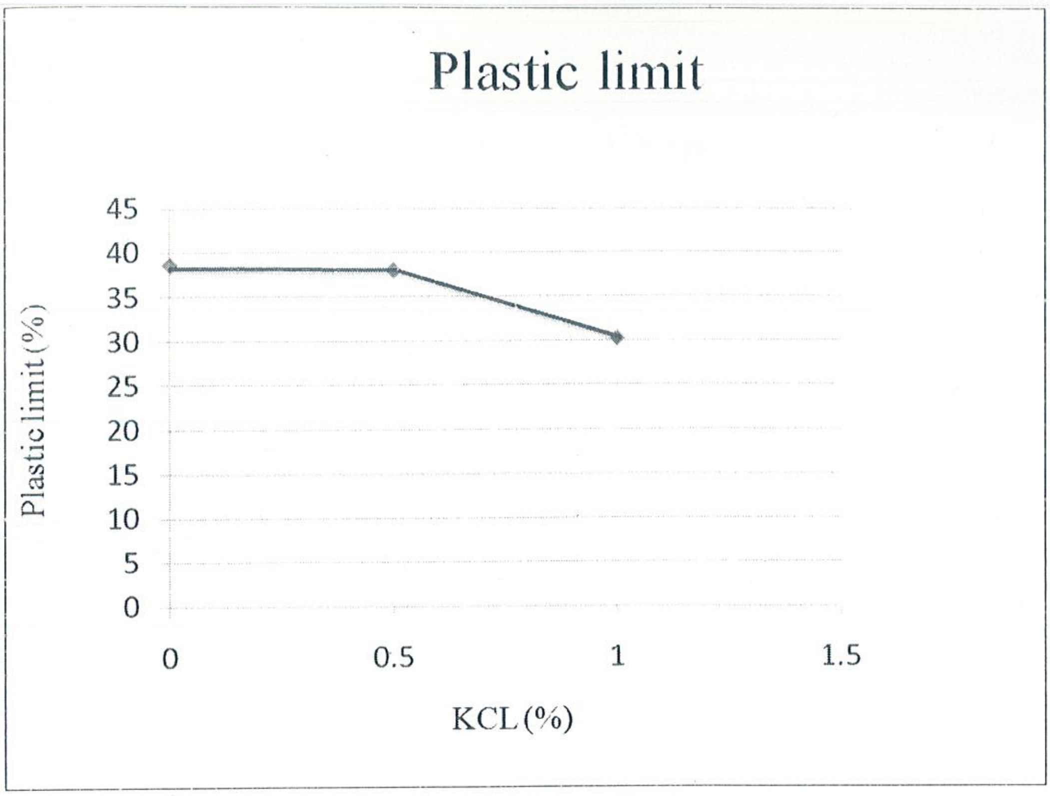


RESULT: Liquid limit is 70%

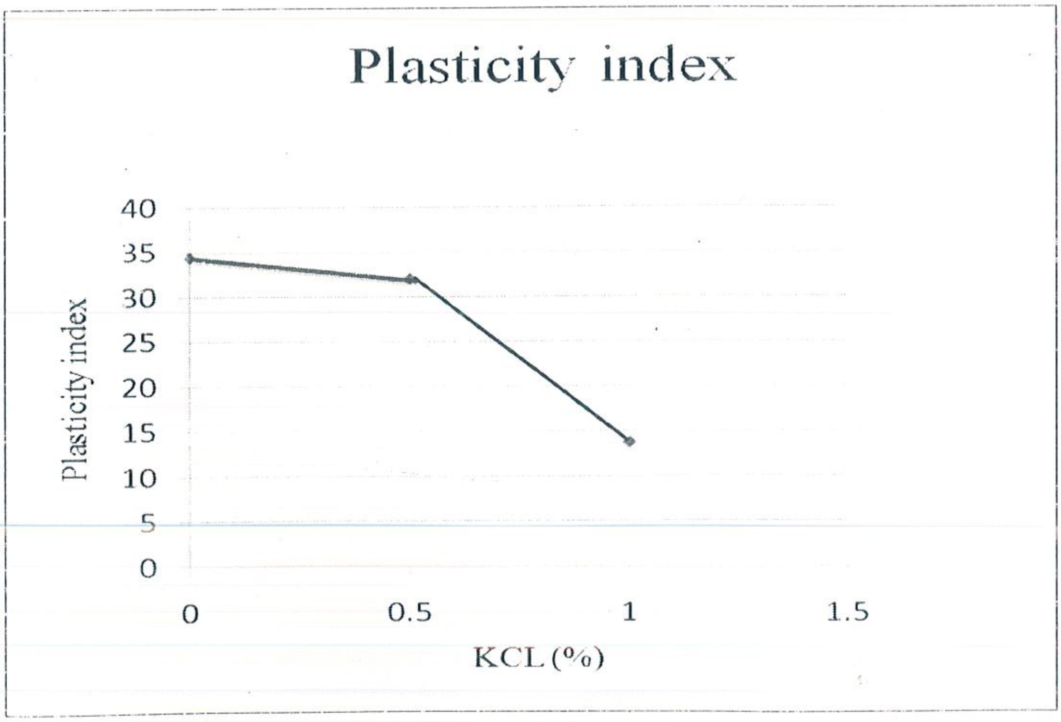
Comparative Graph



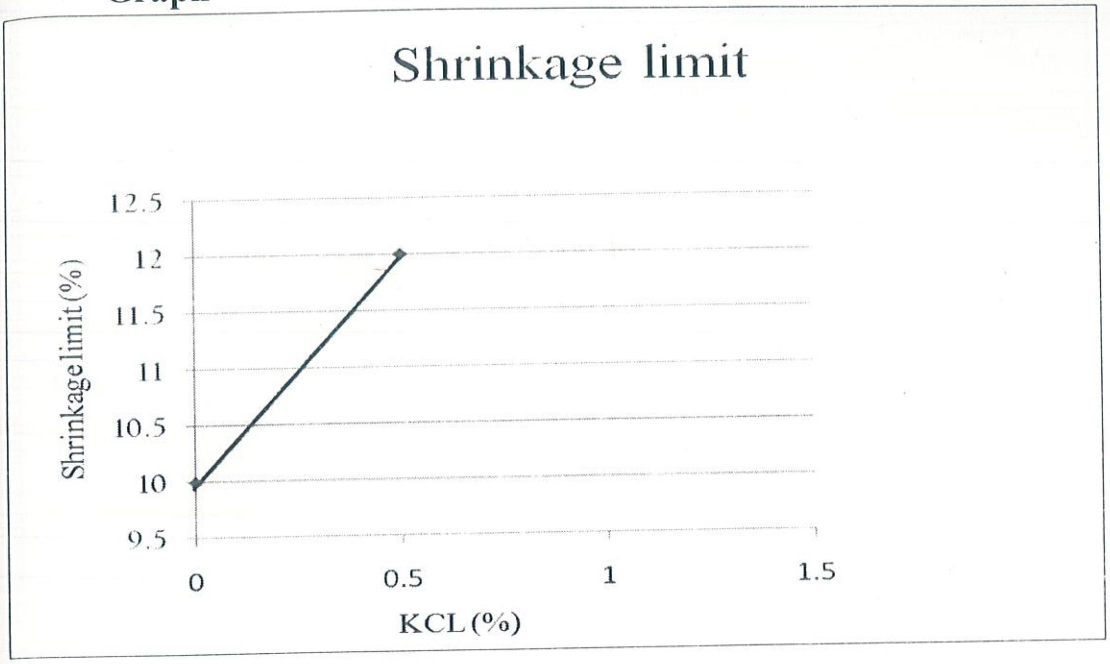
Comparative Graph



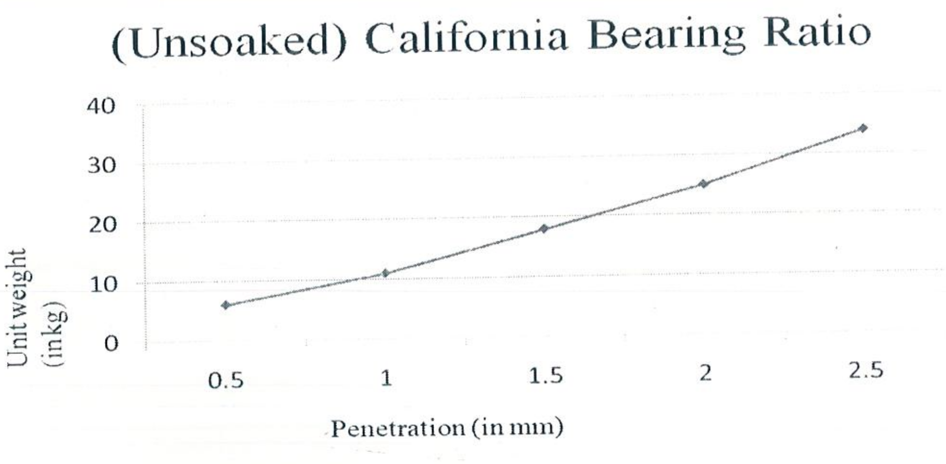
Comparative Graph



Comparitive Graph

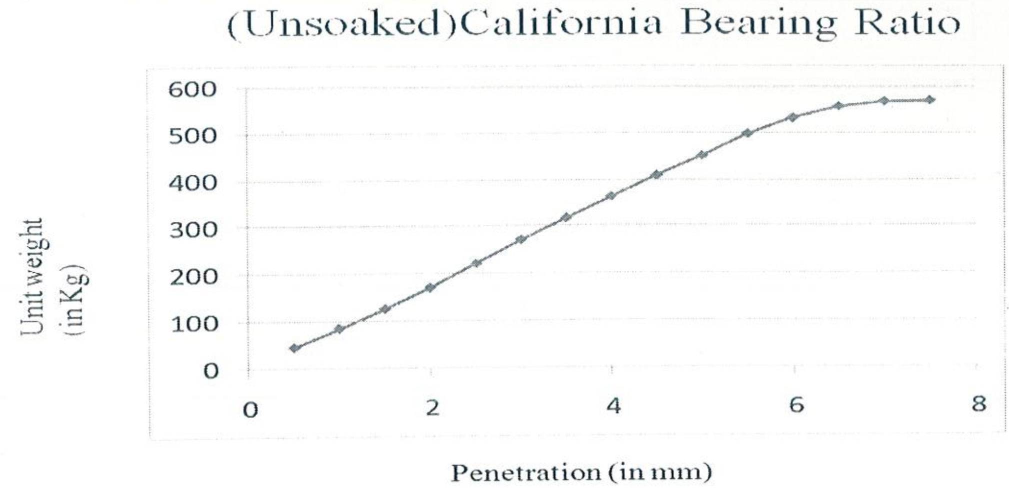


(Unsoaked) CBR (0%)



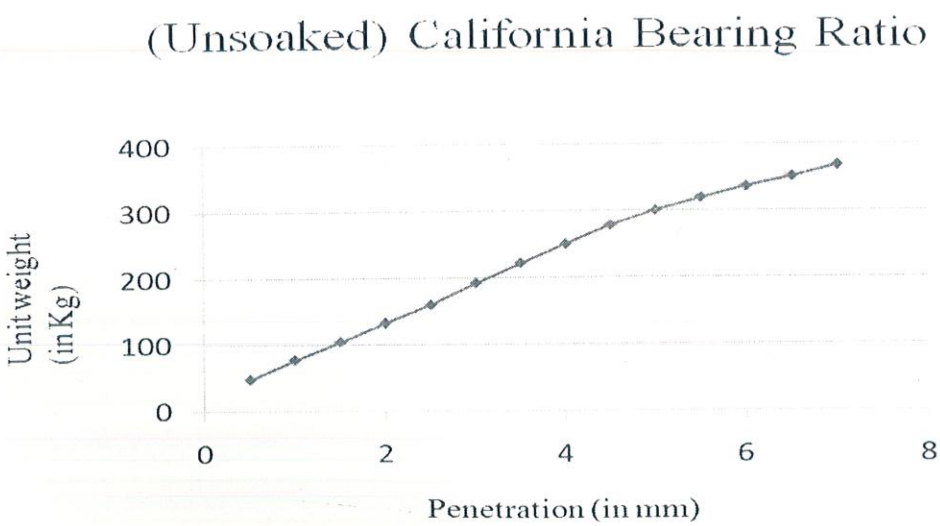
Since the curve is consistently concave it does not need correction.
CBR value at 2.5 mm is 4.7%
CBR value at 5 mm is 5.09%
Result : CBR value is 5.09%

(UNSOAKED) CBR (0.5% KCL)



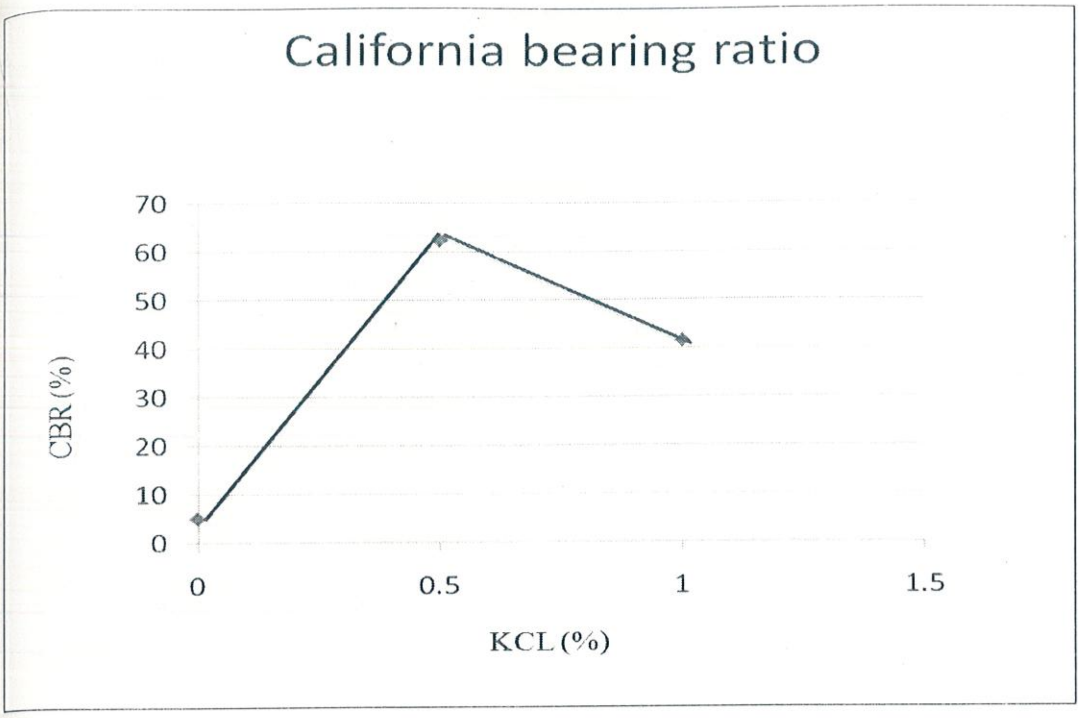
Since the curve is consistently concave it does not need correction.
CBR value at 2.5 mm is 30.51 %
CBR value at 5 mm is 62.40 %
Result : CBR value is 62.40 %

(UNSOAKED) CBR (1% KCL)

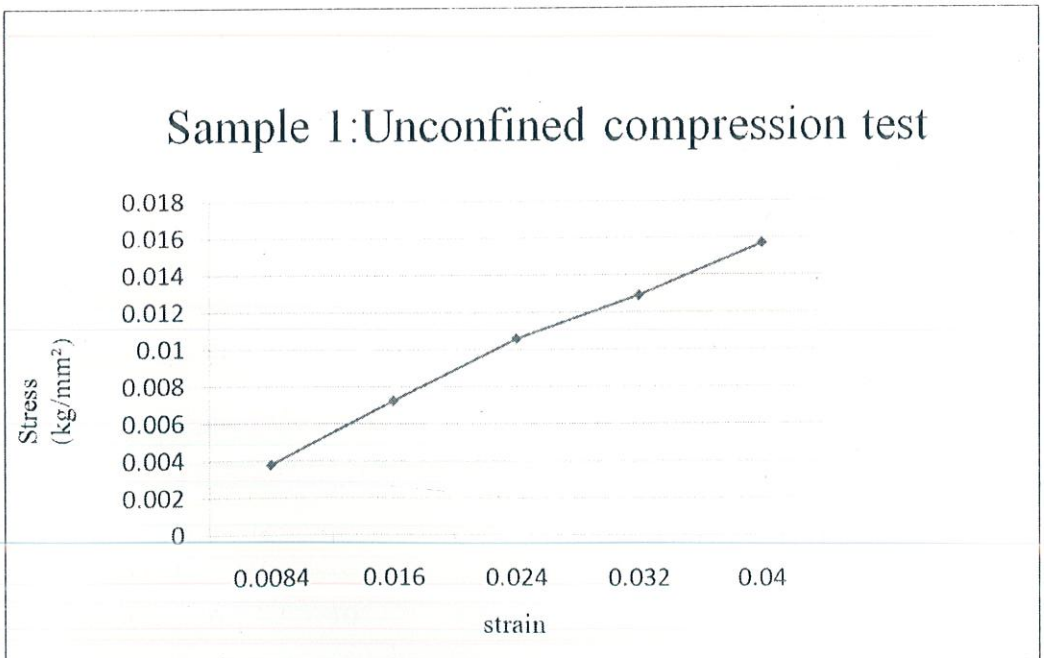


Since the curve is consistently concave it does not need correction.
CBR value at 2.5 mm is 22.19%
CBR value at 5 mm is 41.60 %
Result : CBR value is 41.6 %

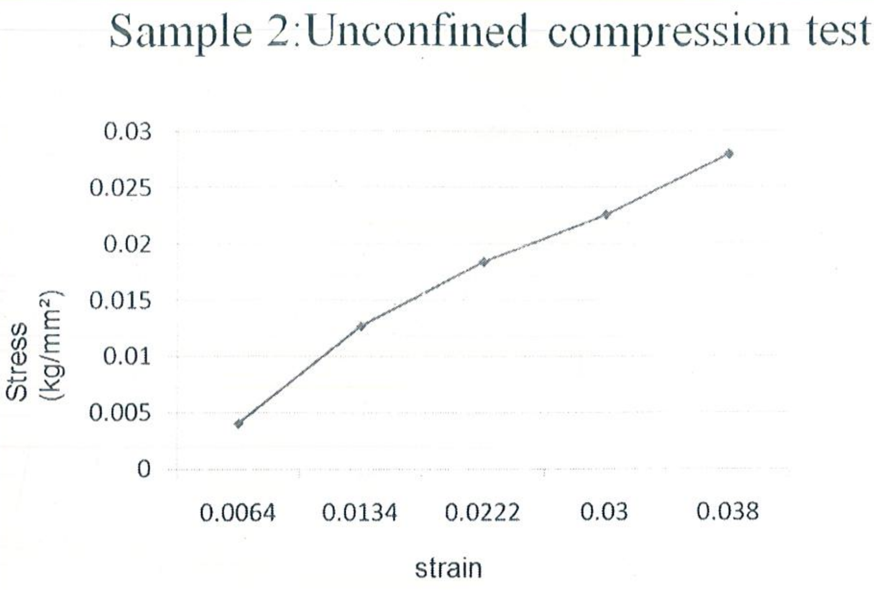
COMPARATIVE GRAPH



UNCONFINED COMPRESSION TEST (0%KCl)

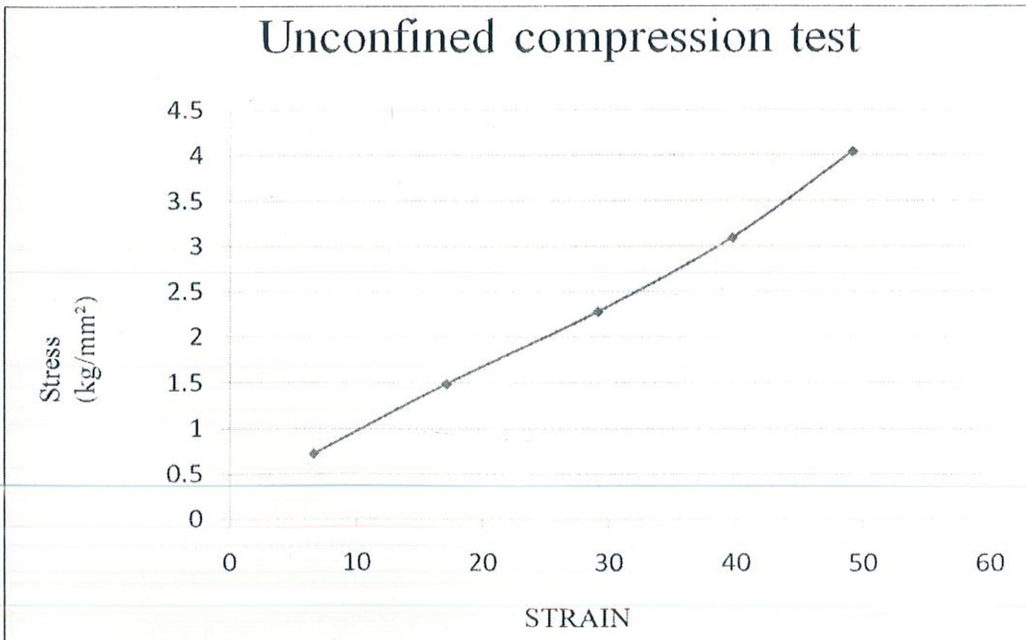


Result:
Cohesion(C) = 0.01635 kg/cm²
Angle of internal friction(ø) = 0



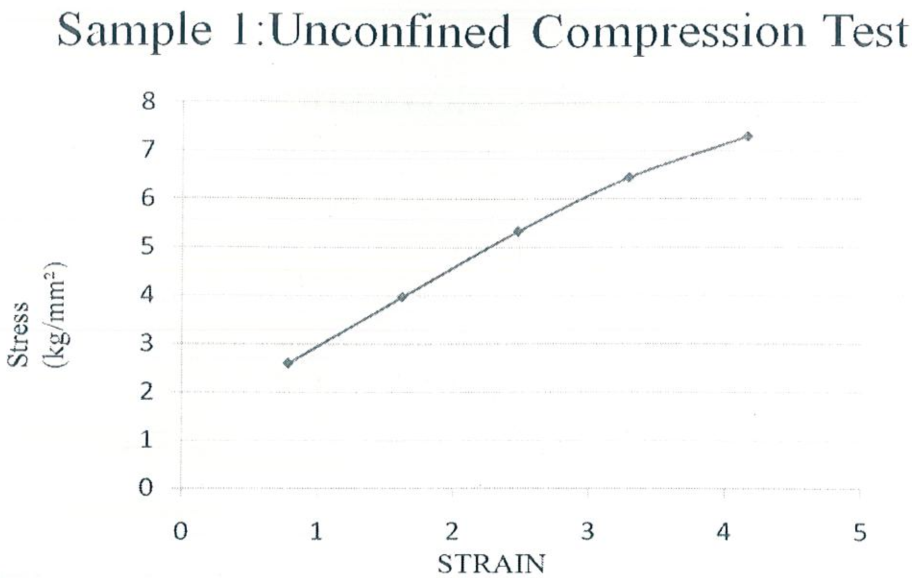
Result:
Cohesion(C) = 0.02028 kg/cm²
Angle of internal friction(ø) = 0

UNCONFINED COMPRESSION TEST (.5%KCl)

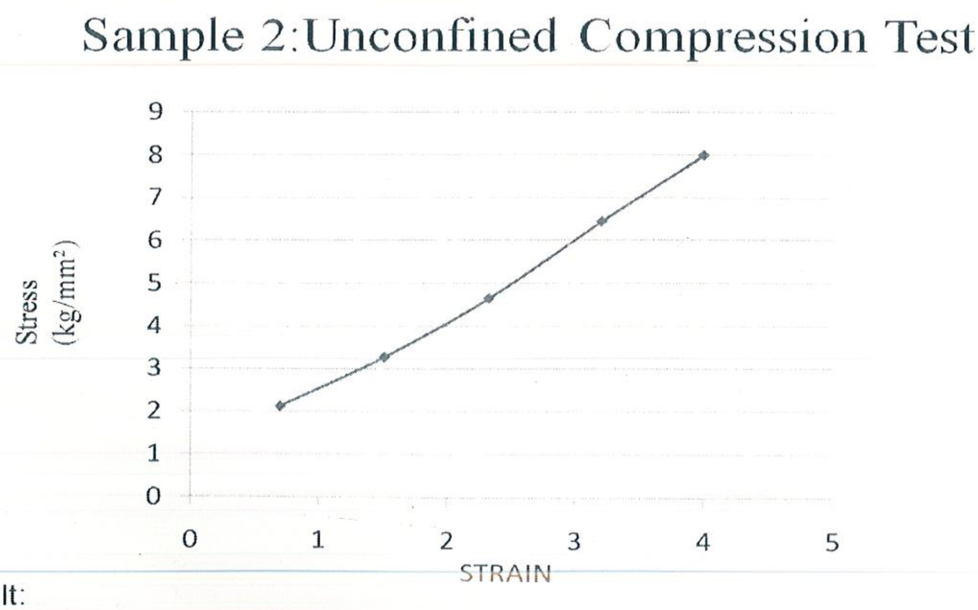


Result:
Cohesion(C) = 0.031 kg/cm²
Angle of internal friction(ø) = 0

UNCONFINED COMPRESSION TEST(1% KCl)

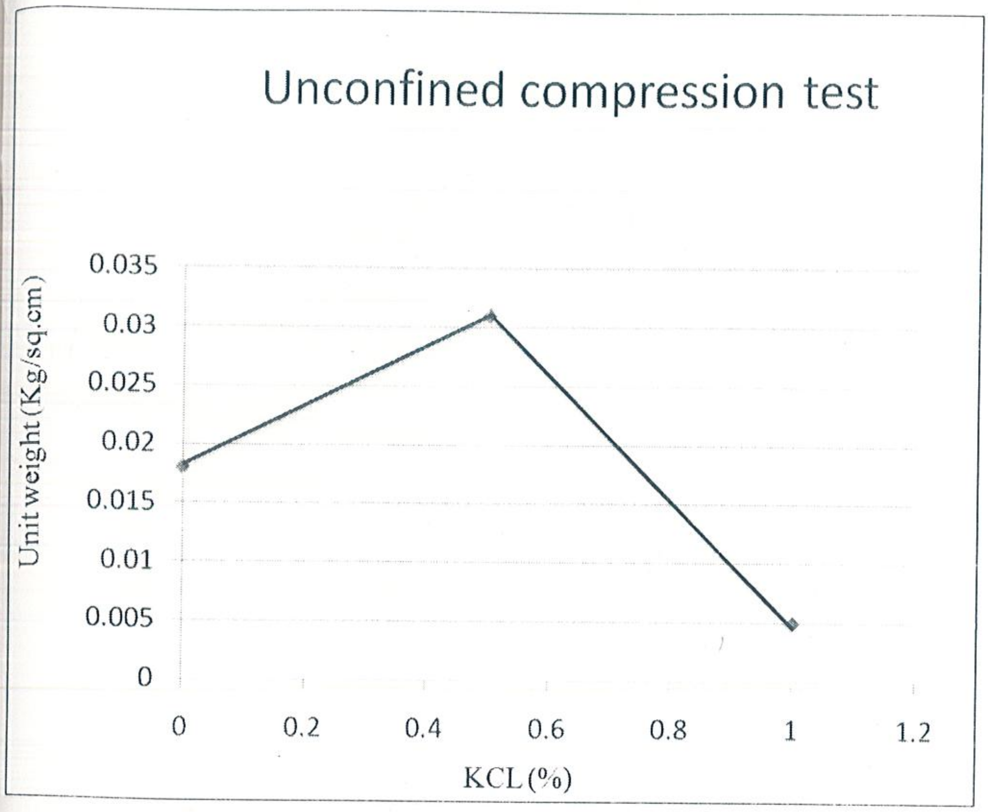


Result:
Cohesion(C) = 0.00455 kg/cm²
Angle of internal friction(ø) = 0



Result:
Cohesion(C) = 0.005345 kg/cm²
Angle of internal friction(ø) = 0

Comparative Graph



CHAPTER 5

CONCLUSIONS

5.1 CONCLUSIONS

The following conclusions can be drawn from the laboratory study carried out in this investigation.

- It was observed that the liquid limit value decreased by 40% with addition of 1% KCl chemical to the expansive clay . Similar is the case in plastic limit experiment.
- Decrease in plasticity index is recorded with addition of chemical to the expansive soil.
- The shrinkage limit is increasing with 0.5 % KCl addition.
- The (unsoaked)California Bearing Ratio Test values is increased by 7 times at 1% KCl.
- Unconfined Compression Test decreased by 72.5% for 1% of KCl,
- The results obtained at 0.5% KCl show the best results. Hence this percentage of KCl is the optimized result of our findings.

LABORATORY EQUIPMENTS

These are some laboratory equipments which we have used in the laboratory test.

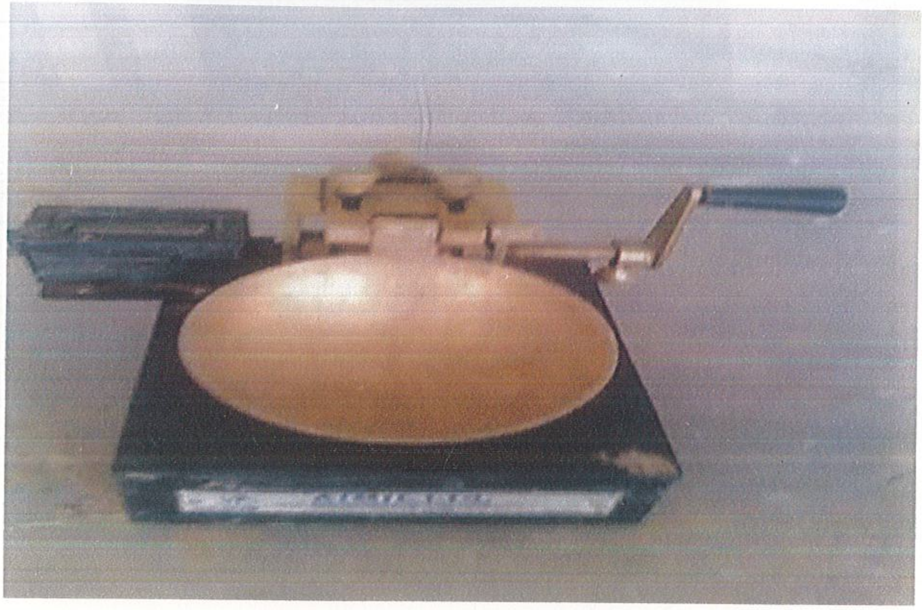


Fig 2.3 CASAGRANDE APPARATUS

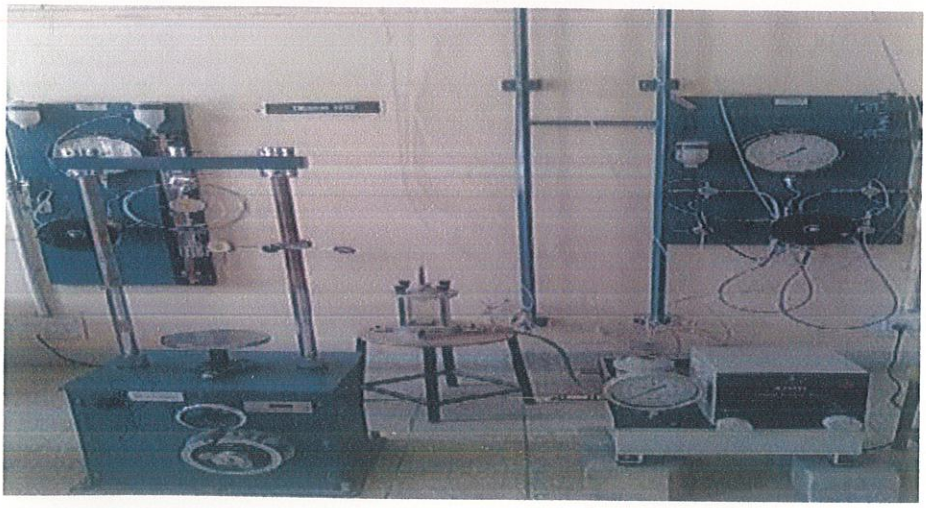


Fig 2.4 TRIAXIAL TEST EQUIPMENT

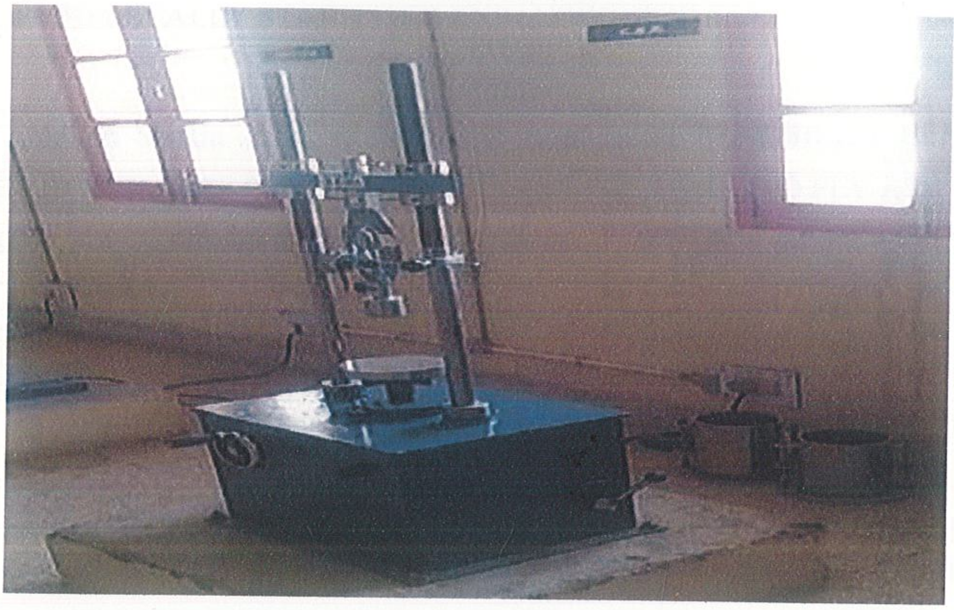


Fig 2.5 CBR TEST

REFERENCES

- P.VenkaraMuthyalu.et al.(2012). "STUDY ON PERFORMANCE OF CHEMICALLY STABILIZED EXPANSIVE SOIL",UCE,kakinda.

- Abhilash Shukla .et al. "STRENGTH AND COMPRESSIBILITY BEHAVIOR OF BLACK COTTON SOIL STABLIZED WITH LIME AND FLY ASH",JIET, M.P

- Oriola, Folagbade.et al."Groundnut Shell Ash Stabilization of Black Cotton Soil",Nigeria

- P. Hari Prasad Reddy .et al. "CONTROL OF ALKALI INDUCED HEAVE IN BLACK COTTON SOIL USING POTASSIUM AND MAGNESIUM SALTS"NIT Warangal.

- T.L Ramadas.et al. "Study on strength and swelling characteristics of three expansive soils treated with cacl2",JBIET ,Hyderabad.

- Saranjeet soni.et al. "Disposal of solid waste for black cotton soil Stabilization",Nagpur

- T William lambe, robert v Whitman "soil mechanics version" John Wiley & Sons, 01- Sep-2008

- Dr.K.R.Arora "soil mechanics and foundation engineering",2011