Study of effect of addition of KCl on Dumehar Soil

Submitted in partial fulfilment of the Degree of

Bachelor of Technology

MAY 2014

Akash Sood 101644

Name of Supervisors – Prof. Dr. Ashok Kumar Gupta

&

Mr. Niraj Singh Parihar

DEPARTMENT OF CIVIL ENGINEERING

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

WAKNAGHAT

Certificate

This is to certify that project report entitled "**Study of effect of addition of KCl on Dumehar Soil**", submitted by **AKASH SOOD** in partial fulfillment for the award of degree of Bachelor of Technology in Civil Engineering to Jaypee University of Information Technology, Waknaghat, Solan 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.

Supervisor's Name

Designation

Supervisor's Name

Designation

Date:

ACKNOWLEDGEMENT

I express my sincere gratitude to my respected project supervisors Prof. Dr. Ashok Kumar Gupta & Mr. Niraj Singh Parihar, Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat under whose supervision and guidance this work has been carried out. His whole hearted involvement, advice, support and constant encouragement throughout, have been responsible for carrying out this project work with confidence. I am thankful to him for showing confidence in me to take up this project. It was due to his planning and guidance that I was able to complete this project in time.

I am sincerely grateful to Dr. Ashok Kumar Gupta, Professor and Head of Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat for providing all the necessities for the successful completion of our project.

I would also like to thank the laboratory staff of Department of Civil Engineering for their timely help and assistance.

Date: 20/05/2014

Akash Sood (101644)

ABSTRACT

Expansive soils containing high clay content are susceptible to detrimental volumetric changes with change in their moisture content. This behaviour is attributed to the presence of mineral montmorillonite. Understanding the behaviour of expansive soil and adopting appropriate control measures has always been a task of paramount importance for engineers. Extensive research is going on to find out solution to this unwanted expansion in soils. Many methods have been found to control this expansion in soils. Treating the expansive soil with electrolytes is one of the methods to improve the nature of expansive ground. Hence in the present project experimentation is being carried out on an expansive soil in order to observe its behaviour under the influence of the electrolyte at different concentrations.

Table of Contents

List of Tables

List of Graphs

CHAPTER 1

INTRODUCTION

1.1) General

Soils susceptible to detrimental expansion in volume are known as expansive soils. Such soils usually have high clay content. Such soils are called expansive soils and are usually found in large parts of India. Black cotton soil is one such example of an expansive soil and is widely distributed in India. It’s called so due to its texture and black color which is a result of high iron and magnesium minerals derived from basalt. Black cotton soil has shows quite significant volumetric change upon absorption of moisture which causes problems to geotechnical engineers during construction. The Dumehar soil used in this project too has similar properties to black cotton soil as in it too has a considerable clay content which was confirmed by checking its liquid limit. Primary problem associated with such soils is that deformations associated are more significant than elastic deformations. Montmorillonite is the main reason behind such destructive swelling in expansive soils. Proper remedial measures are to be adopted to modify the soil or reduce the detrimental effects if expansive soil is identified in the project. Modification of soil by addition of chemical admixture is one of the techniques for stabilizing the swell shrink tendency of expansive soil. Advantage of chemical stabilization is that they reduce the swell shrink tendency of the soil and also render the soil less plastic. Electrolytes like potassium chloride calcium chloride or 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.

1.2) Problems Associated

The damage caused by such expansive soils to roads, canals and buildings is of the order of 2255 million dollars per annum as estimated by John and Hollts (1973). It was reported that this loss exceeds the loss caused by combined effects of floods, earthquakes and hurricanes.

A sub grade made of such expansive soils is problematic due to its tendency undergo shrinkage and swelling. It is very hard when dry but loses its stability when wet. On drying such soils develop cracks of up to 15 cm dry and 3 meters depth. Therefore following points must be taken into consideration:

- Shrinkage and swelling characteristics should be kept in mind.
- Liquid and plastic limit should be checked
- Changes in strength should be noted as per the change in moisture content

Such undesirable properties make such expansive soils unsuitable for construction hence stabilization of such soils using various methods is required.

The most commonly used stabilizers used are lime, cement, natural pozzolanas, volcanic ash and combination of these. Besides these water retaining agents, modifiers and resins are also added during construction.

1.3) Necessity of this project

The main reason behind this project is to check the stabilizing effects potassium chloride can have on expansive soils. If the desired results are achieved, this project would be useful in many fields of construction such as construction of flexible pavements, rigid pavements, multi storey building construction, canal lining and bridge construction. Another advantage is that the admixture used in this project is easily available and thus this project is economically viable also, thus providing the engineers with a cheaper alternative to other more expansive methods available.

Various Stabilization Techniques

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

The method used in this project is *Chemical stabilization*

1.4) Chemical Stabilization

Modification of expansive soils using chemical admixture is a common method for stabilizing the swell shrink tendency of expansive soils. Advantages of chemical stabilization are that they reduce the swell shrink tendency of the soil and also render the soil plastic. Among the common stabilization methods used for expansive soils, lime stabilization is the most commonly adopted for improving the swell shrink tendency of the expansive soil. The reaction between clay and lime can be divided into 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. Electrolytes such as potassium chloride, calcium chloride and ferric chloride can be effectively used in place of 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 and helps in ready cation exchange. The calcium chloride might be effective in soils with expanding lattice. Laboratory tests reveal that swelling characteristics of expansive soils can be improved by flooding the construction site with proper electrolyte.

Spraying electrolyte at the construction site

CHAPTER 2

LITERATURE REVIEW

Study of performance of chemical stabilized expansive soil in foundations and pavement design. (P.Venkara Muthaylu, 2002). The effect of calcium chloride on black cotton soil was studied in this research paper.

Soil Mechanics and Foundation Engineering (K.R Arora). The various parameters of expansive soil were studied from this book.

Soil Mechanics version (T. William Lambe and Robert Whitman). Soil classification of fine grained particles and other attenburg limits were studied from this book.

The effect of different concentrations of electrolytes on soil samples. (Study on strength and swelling characteristics of three expansive soils. T.L Ramdas, 1996)

The various cation exchange processes that occur in montmorillonite present in expansive soils upon the addition of electrolytes to the soil. (Electrolytic reactions in clayey soils, J Borghusen and W. White, 1996).

The variation in swelling and strength of expansive soils was referred to from this research paper. The significance and inferences were drawn from this paper comparing the results obtained from this project and the results in the research paper. (Electrochemical clayey soil stabilization, D.H Gray and J.Schloker, 1969).

Results obtained for Dumehar Soil were compared to the results obtained from tests on black cottons soil. (Strength and compressibility behavior of black cotton soil stabilized with fly ash, JIET Madhya Pradesh, Abhilash Shukla.)

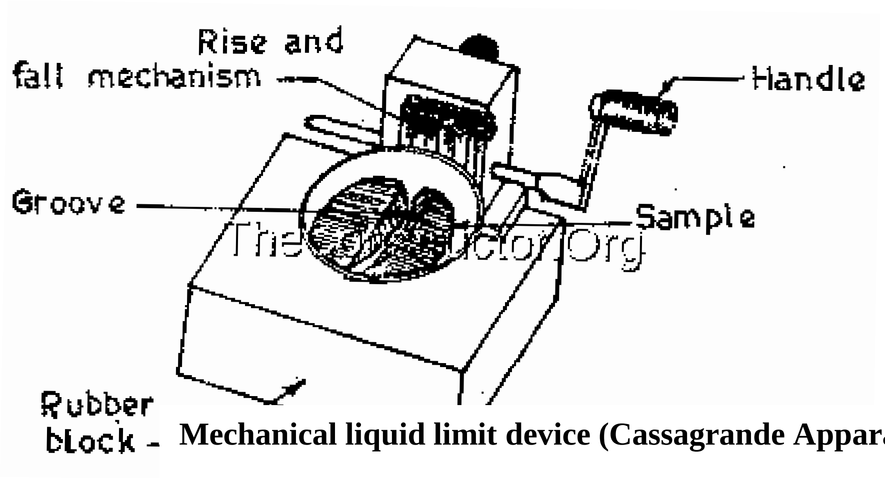
CHAPTER 3

MATERIALS & METHODS

3.1) Liquid Limit

Apparatus

- Mechanical liquid limit device (Cassagrande Apparatus)
- Grooving Tool
- Balance
- Oven
- Wash bottle or Beaker
- Containers



Mechanical liquid limit device (Cassagrande Apparatus)

Procedure

- About 120 gm of the soil sample passing 425-micron IS sieve shall was mixed thoroughly with distilled water in the evaporating dish or on the flat glass plate to from a uniform paste. The paste had a consistency that will require 30 to 35 drops of the cup to cause the required closure of the standard groove.

- The soil was re-mixed thoroughly before the test. A portion of the paste was placed in the cup above the spot where the cup rests on the base, squeezed down and spread into position shown in Fig above, with as few strokes of the spatula as possible and at the same time trimmed to a depth of one centimeter at the point of maximum thickness, returning the excess soil to the dish.
- A little extra of the soil mixture was added to cup and mixed with the soil in the cup. The pat was made in the cup and the test repeated as in no case was dried soil added to the thoroughly mixed soil that was being tested. The procedure given in and in this clause shall be repeated until two consecutive runs give the same under of drops for closure of the groove.
- A representative slice of soil approximately the width of the spatula extending from about edge to the soil cake at right angle to the groove and including that portion of the groove in which the soil flowed together, was taken in a suitable container and its moisture content expressed as a percentage
- The operation specified was repeated for at least three more additional trails.

3.2) Plastic Limit

Apparatus

- Porcelain Evaporating Dish
- Flat glass Plate
- Spatula
- Palette Knives
- Surface for Rolling
- Containers
- Balance
- Oven
- Rod

Procedure

- The soil sample was mixed thoroughly with distilled water in an evaporating dish or on the flat glass plate till the soil mass becomes plastic enough to be easily molded with fingers.
- A ball was formed with about 8 gm of this plastic soil mass and rolled between the fingers and the glass plate with just sufficient pressure to roll the mass into a thread of uniform diameter throughout its length.
- The rate of rolling was between 80 and 90 strokes/min counting a stroke as one complete motion of the hand forward and back to the starting position again.
- The rolling was done till the threads are of 3mm diameter.
- The soil was then be kneaded together to a uniform mass and rolled again.
- This process of alternate rolling and kneading was continued until the thread crumbled under the pressure required for rolling and the soil can no longer be rolled into a thread.
- The crumbling occurred when the thread had a diameter greater than 3 mm.
- This was considered a satisfactory end point
- The moisture content determined.

3.3) Proctor Compaction Test

Objective

The method for the determination of the relation between the water content and the dry density of soils using light compaction. In this test a 2.6 kg rammer falling through a height of 310 mm is used.

Apparatus

- Cylindrical metal mould--- 100 mm diameter and 1000 cm^3 volume and shall conform to IS: 10074-1982.
- Sample Extruder (optional)
- Balances
- Oven
- Container
- Steel Straightedge
- Sieve— 4.75 mm and 19 mm
- Mixing Tools

Procedure

- A 5 kg sample of air dried soil passing the 19 mm IS test sieve was taken.
- The sample was mixed thoroughly with a suitable amount of water depending on the soil type
- The mould of 1000 cm^3 capacity with base plate attached was weighed to the nearest 1gm.
- The mould was placed on a solid base, such as a concrete floor or plinth and the moist soil was compacted into the mould, with the extension attached, in three layers of approximately equal mass, each layer being given 25 blows from the 2.6 Kg rammer dropped from a height of 310 mm above the soil. The blows were distributed uniformly over the surface of each layer. The operator ensured that the tube of the rammer was kept clear of soil so that the rammer always fell freely. The amount of soil used was sufficient to fill the mould, leaving not more than about 6 mm to be struck off.
- The extension was removed and the compacted soil was leveled off carefully to the top of the mould by means of the straightedge. The mould and was then be weighed to 1gm.
- The compacted soil specimen was removed from the mould and placed on the mixing tray. The water content of a representative sample of the specimen was then subsequently determined.

- The remainder of the soil specimen was broken up, rubbed through the 19 mm IS test sieve, and then mixed with the remainder of the original sample. Suitable increments of water were added successively and mixed into the sample, and the above procedure from operation was repeated for each increment of water added. The total number of determinations made was at least five, and the range of moisture contents should be such that the optimum moisture content, at which the maximum dry density occurs, is within that range.

3.4) Unconfined Compression Test

Objective

The purpose of this laboratory is to determine the unconfined compressive strength of cohesive soil sample. We will measure this with the unconfined compression test, which is an unconsolidated undrained (UU or Q-type) test where the lateral confining pressure is equal to zero (atmospheric pressure).

Apparatus

The loading frame consists of two metal plates. The top plate is stationary and is attached to the load-measuring device. The bottom plate is raised and lowered by means of a crank on the front of the loading frame. After the soil sample has been placed between the plates, the bottom plate is gradually raised; the resistance provided by the stationary top plate applies an axial force to the sample. Loads are measured with a calibrated proving ring or an electronic load cell. Vertical deformations are measured with a dial gauge; the dial gauge is attached to the top plate and measures the relative movement between the top and bottom plates.

Preparation of test Specimen

1) Undisturbed specimens were prepared from large undisturbed samples or samples secured in accordance with IS: 2132:1986.

2) When samples are pushed from the drive sampling tube the ejecting device shall be capable of ejecting the soil core from the sampling tube in the same direction of travel in which the sample entered the tube and with negligible disturbance of the sample. Conditions at the time of removal of the sample may dictate the direction of removal but the principal concern should be to keep the degree of disturbance negligible.

3) The specimen shall be handled carefully to prevent disturbance, change in cross section, or loss of water. If any type of disturbance is likely to be caused by the ejection device the sample tube shall be split lengthwise or be cut off in small sections to facilitate removal of the specimen without disturbance. If possible carved specimen should be prepared in a humid room to prevent, as far as possible, change in water content of the soil.

4) The specimen shall be of uniform circular cross section with ends perpendicular to the axis of the specimen.

5) Specimen of required size may be carved from large undisturbed specimen. When sample condition permits use of a vertical lathe which will accommodate the total sample the same may be used as an aid in carving the specimen to the required diameter Tube specimens may be tested without trimming except for squaring of ends.

6) Where the prevention of the possible development of appreciable capillary forces is required the specimen shall be sealed with rubber membranes, thin plastic coatings, or with a coating of grease or sprayed plastic immediately after preparation and during the entire testing cycle.

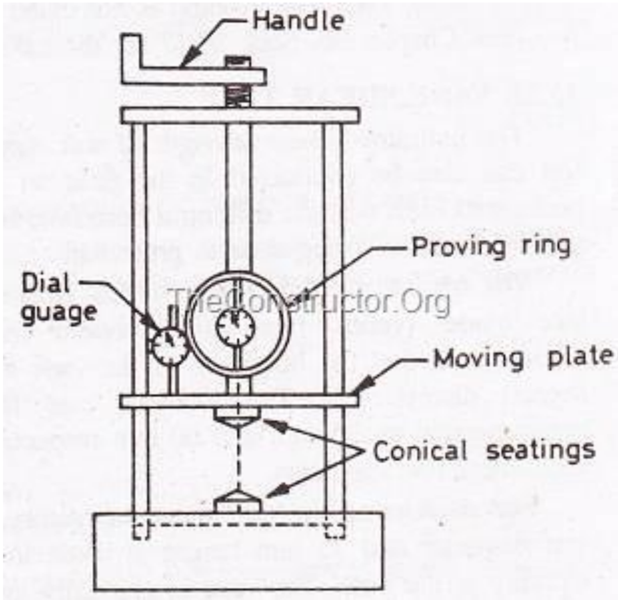
7) Representative sample cutting taken from the tested specimen shall be used for the determination of water content.

Procedure

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

- We will be shearing the samples at a strain rate of 1% per minute. From the length of your soil sample, determined the deformation at 1% strain. Depending on the units of the vertical deformation dial gauge (usually 0.001 inches or 0.0001 inches), determined the number of dial divisions per 1 strain- Practiced turning the crank at this number of dial divisions/minute. It is important that the soil sample not be sheared faster than this specified rate.

- Measured the initial height and diameter of the soil sample with calipers. It is unlikely that the sample will be a perfect right cylinder. Therefore, it was necessary to find the average height and diameter by taking several measurements in different places along the soil sample. The measurements were taken by more than one member of a lab team to be sure that the calipers are read correctly. If you have any questions about how to take measurements with calipers, ask the laboratory instructor for instruction.
- Recorded the weight of the soil sample and determined the total (moist) unit weight.
- Placed the soil sample in the loading frame, seat the proving ring and zero the dials.
- Recorded the load applied at specified strain values. It is recommended that readings be taken at strains of 0, 0.1, 0.2, 0.5, 1,2,3,4,5,6,8, 10, 12 14, 16, 18 and 20 percent. Prerecorded the vertical deformation dial readings at these strain values.



Unconfined compression testing apparatus

3.5) Swelling Index Test

Objective

This standard covers the laboratory method of conducting one dimensional swelling pressure test using either fixed or the floating rings on both undisturbed and remoulded soils in the partially saturated condition to determine the swelling pressure of the soil. Two methods, namely consolidometer method in which the volume change of the soil is permitted and the corresponding pressure required to bring back the soil to its original volume is measured and the constant volume method in which the volume change is prevented and the consequent pressure is measured are covered

Apparatus

a) Consolidometer- A device to hold the sample in a ring either fixed or floating with porous stones (or ceramic discs) on each face of the sample. A consolidometer shall also provide means for submerging the sample, for applying a vertical load and for measuring the change in the thickness of the specimen. The provision for fixing of the dial gauge shall be rigid; in no case shall the dial gauge be fixed to a cantilevered arm ;suitable provision shall be made to enable the dial gauge to be fixed in such a way that then dial gauge records accurately the vertical expansion of the specimen.

i) Specimen Diameter- The specimen shall be 60 mm in diameter (specimens of diameters 50, 70 and 100 mm may also be used in special case).

ii) Specimen Thickness – The specimen shall be at least 20 mm thick in all cases. However, the thickness shall not be less than 10 times the maximum diameter of the grain in the soil specimen. The diameter to thickness ratio shall be a minimum of 3.

iii) Ring – The ring shall be made of a material which is non-corrosive in relation to the soil tested. The inner surface shall be highly polished or coated with a thin coating of silicon grease or with a low friction material. The thickness of the ring shall be such that under assumed hydrostatic stress conditions in the sample the change in diameter of the ring will not exceed 0.03 percent. Under the maximum load applied during the test. The ring shall have one edge beveled suitably so that the sample is pressed into the ring with least disturbance. The ring shall be placed with its cutting edge upwards in the consolidometer and clamped with a special clamp which should in no way damage the sharp edge. The clamp should be made circular with central hole equal in diameter of the porous stone and should be perfectly concentric with the sample. The ring shall be provided with a collar of internal diameter same as that of the ring and of effective height 20 mm. The collar shall rest securely on the specimen ring.

iv) Porous Stones – The stones shall be of silicon carbide or aluminum oxide and medium grade. it shall have a high permeability compared to that of the soil being tested. The diameter of the top stone shall be 0.2 to 0.5 mm less than the internal diameter of the ring. The thickness of the stone shall be a minimum of 15 mm. The top stone shall be loaded through a corrosion-resistant plate of sufficient rigidity and of minimum thickness 10 mm to prevent breakage of the stone. The loading plate shall have suitable holes for free drainage of water.

b) Dial Gauge – accurate to 0.01 mm with a traverse of at least 20 mm.
c) Water Reservoir- to keep the soil sample submerged.
d) Moisture Room- For storing samples and for preparing samples in climates where there is likelihood of excessive moisture loss during preparation (optional).
e) Soil Trimming Tools - Fine wire saw, knife, spatula, etc. for trimming sample to fit into the inside diameter of the consolidometer ring with minimum disturbances.
f) Oven - Thermostatically controlled oven with interior of non-corroding material to maintain the temperature between 105-1100C.
g) Desiccators – With any desiccating agent other than sulphuric acid.
h) Balance – Sensitive to 0.01 g.
i) Containers – for water content determination.

Procedure

a) The porous stones shall be saturated. all surfaces of the consolidometer which are to be enclosed shall be moistened. The porous stones shall be saturated by boiling in distilled water for at least 15 minutes. The consolidometer shall be assembled with the soil specimen (in the ring) and porous stones at top and bottom of the specimen, providing a filter paper rendered wet (Whitman No.1 or equivalent) between the soil specimen and porous stone. The loading block shall then be positioned centrally on the top porous stone.

b) This assembly shall then be mounted on the loading frame such that, the load when applied is transmitted to the soil specimen through the loading cap. The assembly shall be so centered that the load applied is axial.

c) In the case of the layer loading system, the apparatus shall be properly counterbalanced. If a jack with load measurement by platform scale is used as the loading system, the tare weight with the empty consolidation apparatus, excluding those parts which will be on top of soil specimen, which rest on the platform shall be determined before filling the ring with the soil and this tare weight shall be added to the computed scale loads required to give the desired pressure pressures at the time of loading the soil specimen.

d) The holder with the dial gauge to record the progressive vertical heave of the specimen under no load, shall then be screwed in place and adjusted in such a way that the dial gauge is near the end of its release run, allowing small margin for the compression of the soil, if any.

e) An initial setting load of 50 kgf/\cm2 (this includes the weight of the porous stone and the loading pad) shall be placed on the loading hanger and the initial reading of the dial gauge shall be noted.

f) The system shall be connected to a water reservoir with the level of water in the reservoir being at about the same level as the soil specimen and water allowed to flow in the sample. The soil shall then be allowed to swell.

g) The free swell readings shown by the dial gauge under the seating load of 5 kN/m2 (0.05 kgf/cm2) shall be recorded at different time intervals. For the purpose of record from 1 given in observation table shall be used and the total readings noted at total elapsed time since starting shown therein.

h) The dial gauge readings shall be taken till equilibrium is reached. This is ensured by making a plot of swelling dial reading versus time in hours, which plot becomes asymptotic with abscissa (time scale). The equilibrium swelling is normally reached over a period of 6 to 7 days in general for all expansive soil.

i) The swollen sample shall then be subjected to consolidation under different pressures. The compression dial readings shall be recorded till the dial readings attain a steady state for each load applied over the specimen. The consolidation loads shall be applied till the specimen attains its original volume

CHAPTER 4

TABLES AND CALCULATIONS

Sieve Analysis of soil sample

I.S sieve No. or size	Wt. of empty sieve(g)	Wt. of soil + sieve(g)	Wt. Retained on each sieve (g)	Cumulative mass retained	Cumulative %age retained on each sieve	% Finer
10 mm	503.5	503.5	0	0	0.00	100.00
4.75 mm	418.5	435	16.5	16.5	1.65	98.35
2 mm	402	478	76	92.5	9.25	90.75
1 mm	374.3	521	146.7	239.2	23.91	76.09
600 µ	362.8	440.9	78.1	317.3	31.72	68.28
425 µ	351	399.2	48.2	365.5	36.54	63.46
300 µ	354.6	378.2	23.6	389.1	38.90	61.10
212 µ	336.9	371	34.1	423.2	42.31	57.69
150 µ	357.9	375	17.1	440.3	44.02	55.98
75 µ	329.8	655.3	325.5	765.8	76.56	23.44
Pan	255.9	490.4	234.5	1000.3	100.00	0.00

<u>Discussion</u>

The various soil parameters calculated from the result obtained and the graph are as follows:

- Effective size , D_{10} of soil = 0.019 mm
- Uniformity Coefficient, $C_u = D_{60}/D_{10} = 0.27/0.019 = 14.21$
- Coefficient of Curvature, $C_c = D_{30}^2/(D_{60} \text{ X } D_{10}) = 1.949$
- % of gravel = 1.649%
- % of coarse sand = 7.59%
- % of medium sand = 27.29%

- % of fine sand = 40.017%
- % of silt and clay = 23.442%

Moisture Content

Weights	Sample 1	Sample 2	Sample 3
Weight of Empty container(gm)	28.30	28.90	26.80
Weight of Container & Soil(gm)	50.40	50.50	43.40
Weight of Container & Oven Dried Soil(gm)	49.26	49.43	42.50
Weight of Water(gm)	1.14	1.07	0.90
Weight of dry Soil(gm)	20.96	20.53	15.7
Moisture Content	5.4 %	5.2 %	5.7 %

Tab.4.1 Moisture Content

The moisture Content of soil was averaged out to be 5.43% from table number 4.1

Liquid Limit test (No KCl)

No. Of Blows	Wt. Of Empty container(gm)	Wt of Container & Soil(gm)	Wt. of Container & Dry Soil(gm)	Wt. of Water(gm)	Wt. of dry Soil(gm)	Moisture Content(%)
37	20.7	29.1	26.9	2.2	6.2	35.50
28	20.4	28.4	26.1	2.3	6.0	38.33
21	20.1	30.3	27.2	3.1	7.1	43.66

Tab.4.2 Liquid Limit without KCl

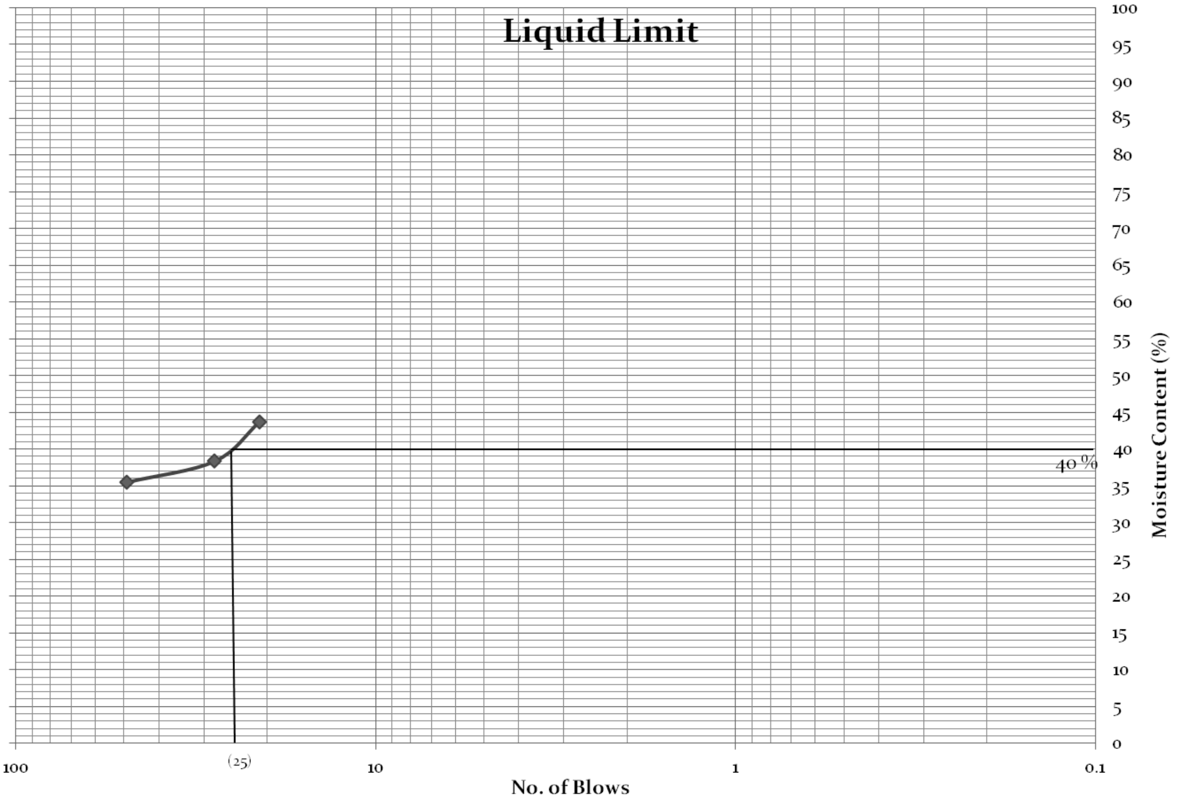


Fig 1. Graph for Liquid Limit without KCl

The liquid limit from the graph (fig 1) comes out to be 40%.

Liquid limit Test (5% KCl)

No. Of Blows	Wt. Of Empty container(gm)	Wt of Container & Soil(gm)	Wt. of Container & Dry Soil(gm)	Wt. of Water(gm)	Wt. of dry Soil(gm)	Moisture Content(%)
41	21	30.2	27.6	2.57	9.2	28.00
34	20.7	29.1	26.5	2.62	8.4	31.27
21	20.8	31.4	27.3	4.1	10.6	38.59

Tab 4.3 Liquid Limit with 5% KCl

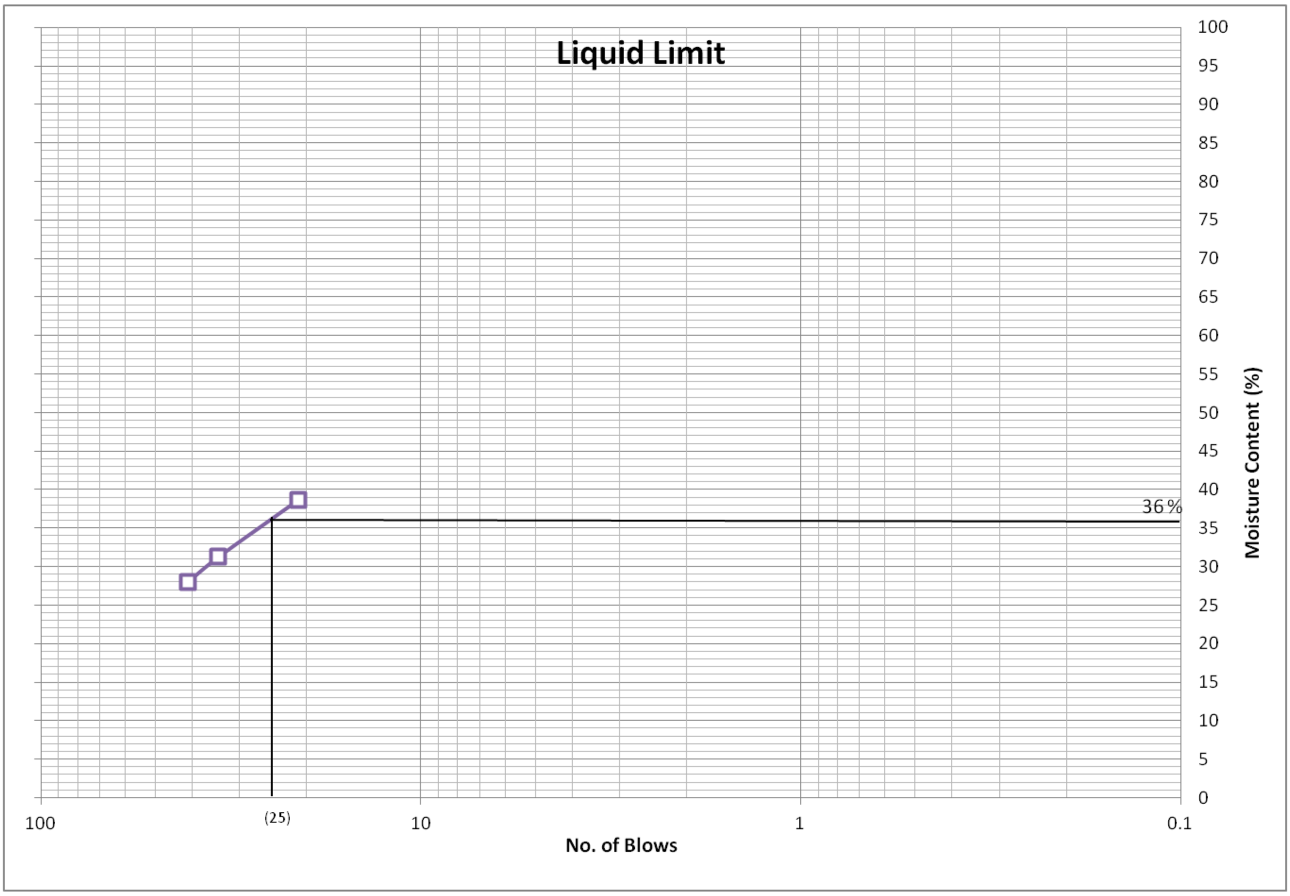


Fig 2. Liquid Limit test with 5% KCl

The liquid limit of the soil sample with 5% KCl comes out to be 36% from fig 2.

There is a reduction of 4% in liquid limit in this case

Liquid Limit test (10% KCl)

No. Of Blows	Wt. Of Empty container(gm)	Wt of Container & Soil(gm)	Wt. of Container & Dry Soil(gm)	Wt. of Water(gm)	Wt. of dry Soil(gm)	Moisture Content(gm)
45	20.4	28.2	26.27	1.93	7.8	24.72
32	21.1	31.4	28.5	2.90	10.3	28.23
19	21.2	30.7	27.27	3.55	9.5	37.44

Tab 4.4 Liquid Limit with 10% KCl

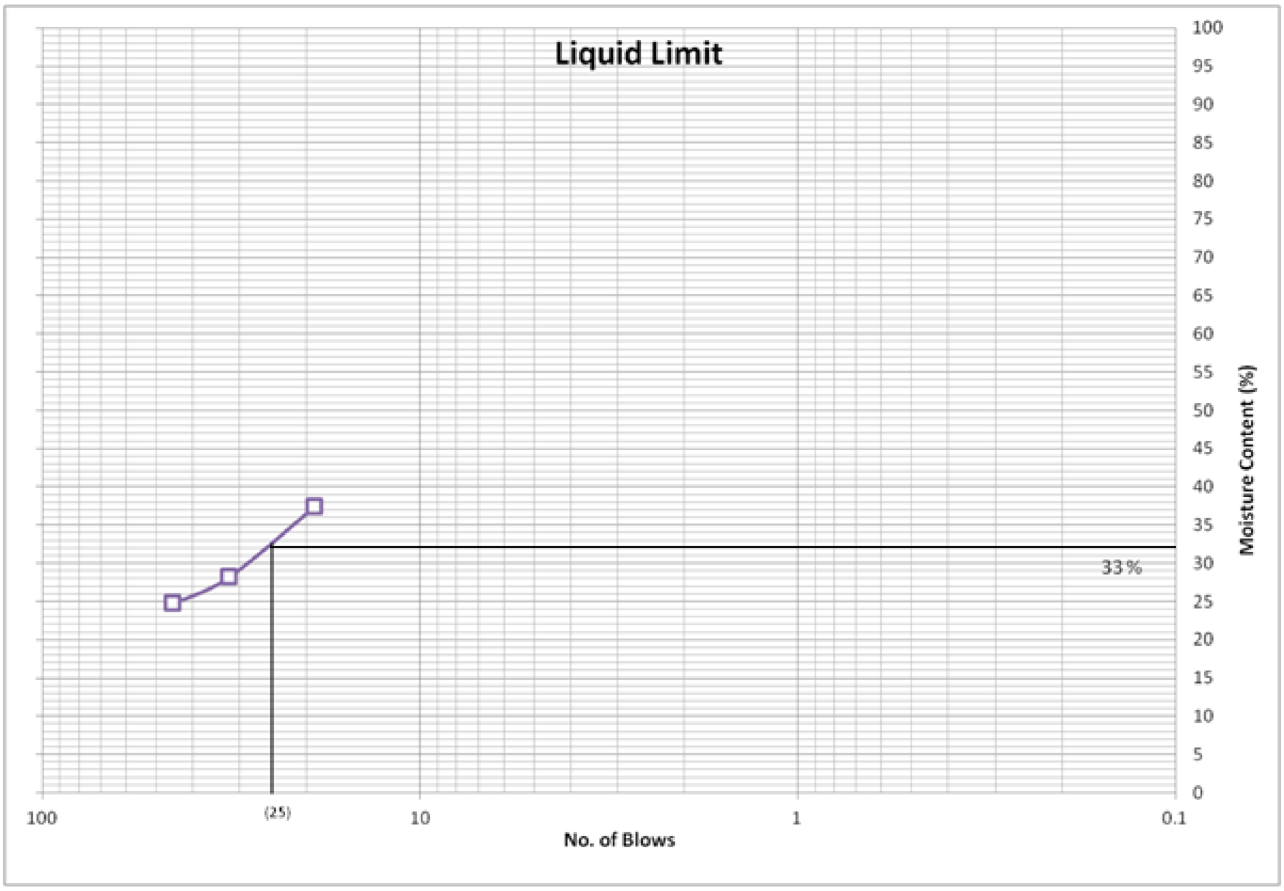


Fig 3. Liquid Limit with 10% KCl

Liquid limit of the soil sample with 10% KCl comes out to be 33% as seen from fig 3.

There is a reduction of 3% as compared to the soil sample with 5% KCl.

Plastic Limit Test (No KCl)

Wt. Of Empty container (gm)	Wt of Container & Soil(gm)	Wt. of Container & Dry Soil(gm)	Wt. of Water (gm)	Wt. of dry Soil(gm)	Moisture Content (%)
19.8	27.2	25.25	1.75	7.4	23.7
17.7	31.4	28.06	3.34	13.7	24.4

Tab 4.5 Plastic Limit without KCl

Plastic Limit of the soil without KCl comes out to be 24% as seen from table 4.5

Plastic Limit Test (5% KCl)

Wt. Of Empty container (gm)	Wt of Container & Soil(gm)	Wt. of Container & Dry Soil(gm)	Wt. of Water (gm)	Wt. of dry Soil(gm)	Moisture Content (%)
21.2	29.4	27.6	1.81	8.2	22.1
20.7	28.5	26.6	1.83	7.8	23.3

Tab 4.6 Plastic Limit without KCl

Plastic Limit of the soil with 5% KCl comes out to be 22.7% as seen from table 4.6

There has been a reduction of 1.3% in the plastic limit upon addition of 5% KCl solution to the soil.

Plastic Limit Test (10% KCl)

Wt. Of Empty container (gm)	Wt of Container & Soil(gm)	Wt. of Container & Dry Soil(gm)	Wt. of Water (gm)	Wt. of dry Soil(gm)	Moisture Content (%)
21.2	29.4	27.6	1.81	8.2	22.1
20.7	28.5	26.6	1.83	7.8	23.3

Tab 4.7 Plastic limit with 10% KCL

Plastic Limit of the soil with 10% KCl comes out to be 22.5% as seen from table 4.7

There has been a reduction of 1.5% in the plastic limit upon addition of 10% KCl solution to the soil

PROCTOR COMPACTION TEST (No KCl)

Determination No.					
Weight of the mould + base in gm	5525	5525	5526	5527	5525
Weight of the mould + base + soil compacted in gm	7134	7432	7544	7567	7467
Weight of soil after compaction	1609	1907	2018	1997	1951
Weight of moisture container gm	18.6	19.7	19.4	19.8	19.3
Weight of moisture container + wet soil in gm	40.1	35.4	36.6	44.3	52.1
Weight of moisture container + dry soil in gm	37.20	34.90	33.90	40.4	46.8
Volume of mould cm^3	1000	1000	1000	1000	1000
Bulk Density (γ_t)(gm/cc) =W/V	1.609	1.907	2.018	1.997	1.951
Water Content (%) w =	15.60	17.19	17.68	18.93	19.27
Dry Density (γ_d)(gm/cc) =	1.39	1.62	1.71	1.67	1.63

Tab 4.8 Proctor Compaction test without KCl

A graph between dry density and moisture content is plotted to find out the optimum moisture content of the soil and the maximum dry density of the soil.

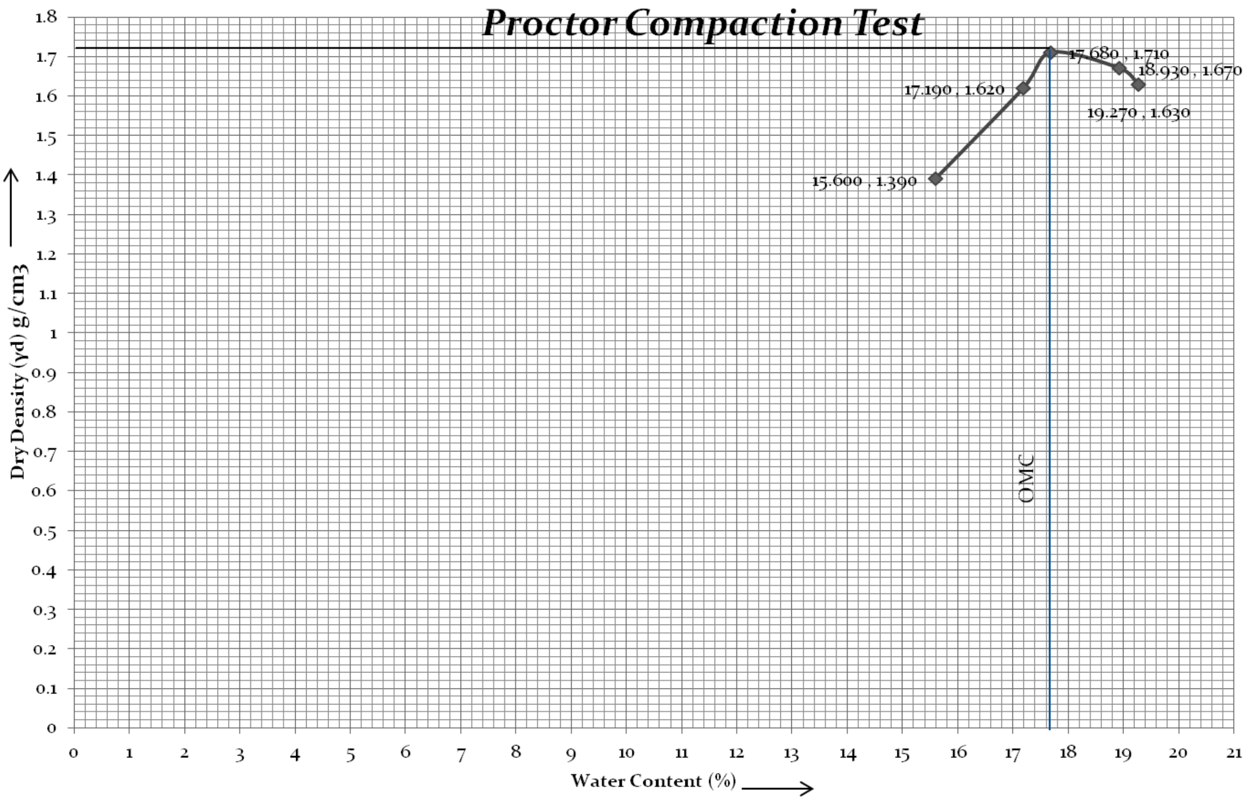


Fig 4 Graph for Proctor Compaction Test without KCl

From the graph (Fig 4) is it evident that the Optimum moisture content of the soil is 17.680% while the dry density of the soil is 1.710 g/cc.

PROCTOR COMPACTION TEST (5% KCl)

Determination No.					
Weight of the mould + base in gm	5525	5524	5525	5526	5525
Weight of the mould + base + soil compacted in gm	7331	7421	7489	7390	7310
Weight of soil after compaction	1806	1896	1964	1865	1785
Weight of moisture container gm	19.8	19.8	20.1	19.3	20.4
Weight of moisture container + wet soil in gm	37.1	38.5	38.9	38.1	40.4
Weight of moisture container + dry soil in gm	35.09	36.2	36.1	35.2	37.1
Volume of mould cm^3	1000	1000	1000	1000	1000
Bulk Density (γ_t)(gm/cc) =W/V	1.806	1.896	1.964	1.865	1.785
Water Content (%) w =	13.14	14.02	17.50	18.23	19.76
Dry Density (γ_d)(gm/cc) =	1.59	1.66	1.68	1.57	1.49

Tab 4.8 Proctor Compaction test with 5% KCl

A graph between dry density and moisture content is plotted to find out the optimum moisture content of the soil and the maximum dry density of the soil.

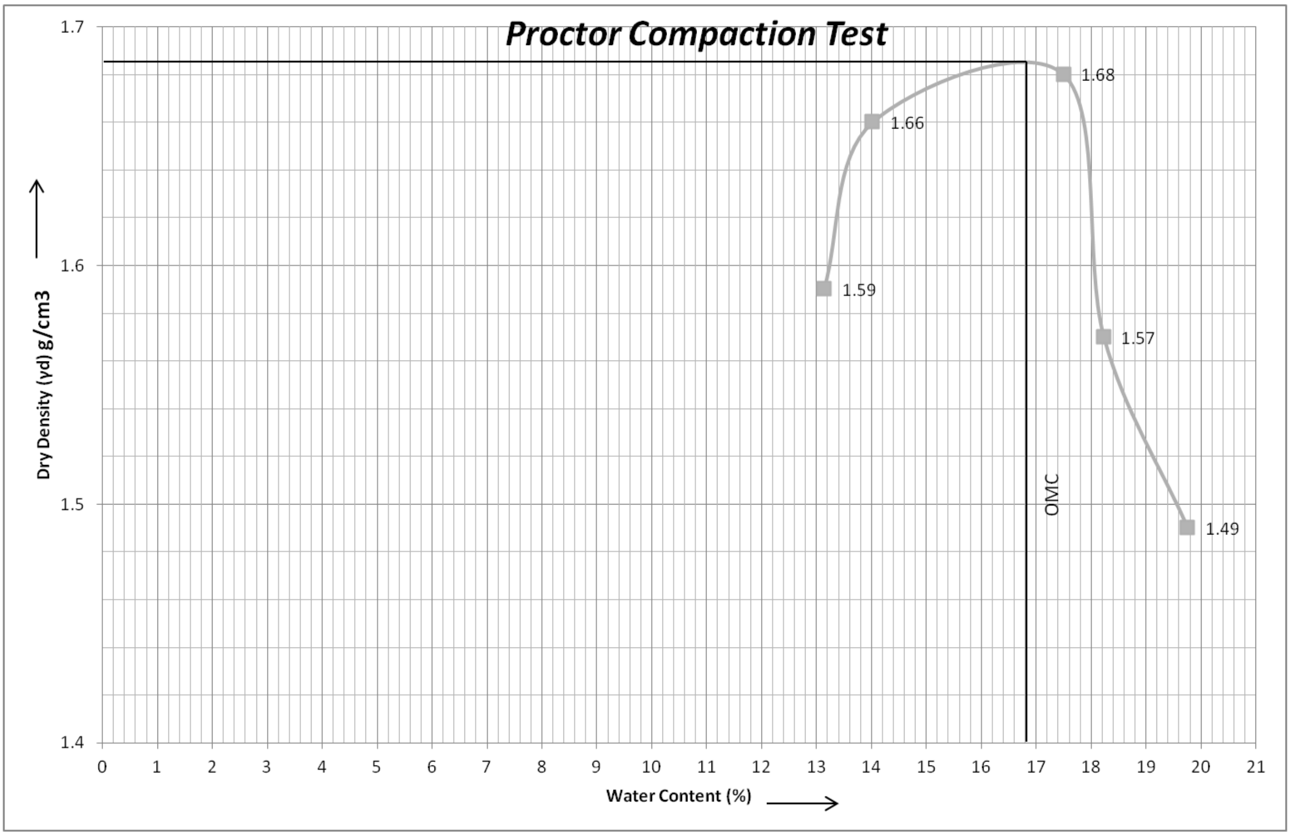


Fig 5 Graph for Proctor Compaction Test with 5% KCl

From the graph is it evident that the Optimum moisture content of the soil is 16.80% while the dry density of the soil is 1.685 g/cc. there has been a reduction in both the optimum moisture content and maximum dry density of the soil as compared to the previous case. The OMC reduced by 0.88% while the dry density reduced by .025% upon addition of 5% KCl solution to the soil.

UNCONFINED COMPRESSIVE STRENGTH (No KCl)

Length of Sample = 7.2cms (L)

Diameter of sample = 3.6cms (D)

A stress versus strain graph is plotted for this test

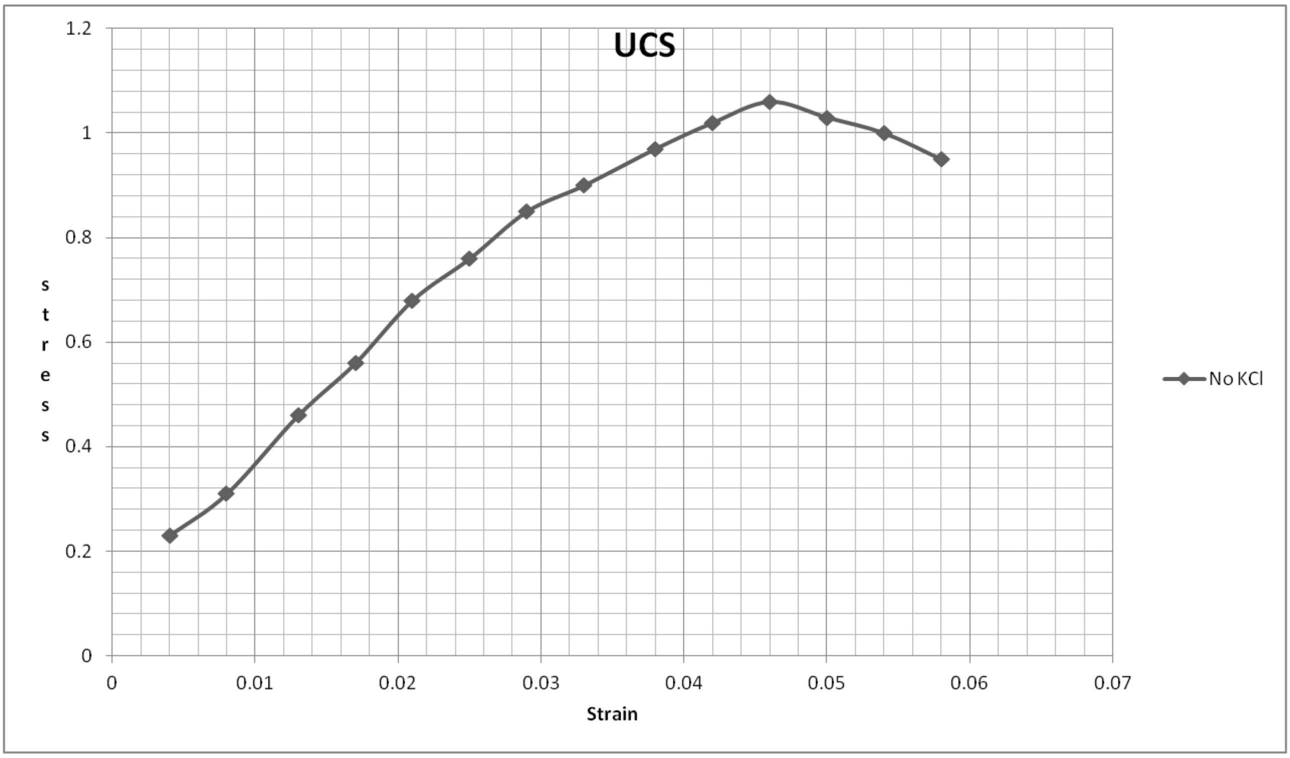


Fig 6 Graph for Unconfined compressive strength without KCl

The unconfined compressive strength of the sample is 1.06 Kg/cm^2 as evident from fig 6.

<u>UNCONFINED COMPRESSIVE STRENGTH (5% KCl)</u>

Length of Sample = 7.2cms (L)

Diameter of sample = 3.6cms (D)

A stress versus strain graph is plotted for this test

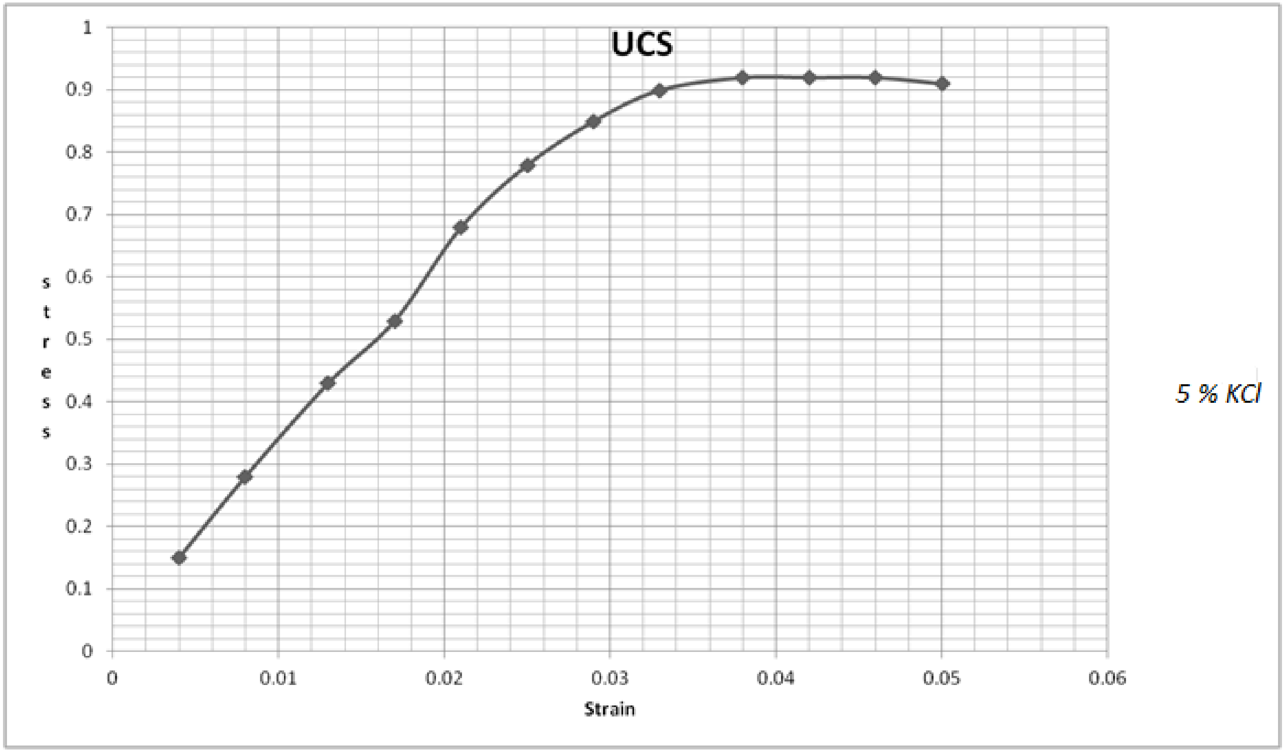


Fig 7 Graph for Unconfined compressive strength with 5% KCl as evident from fig 7

The unconfined compressive strength of the sample is 0.92 Kg/cm^2. There has been a reduction in the strength of the soil by 0.14 kg/cm^2 upon addition of 5% KCl solution to the soil.

UNCONFINED COMPRESSIVE STRENGTH (10% KCl)

Length of Sample = 7.2cms (L)

Diameter of sample = 3.6cms (D)

A stress versus strain graph is plotted for this test

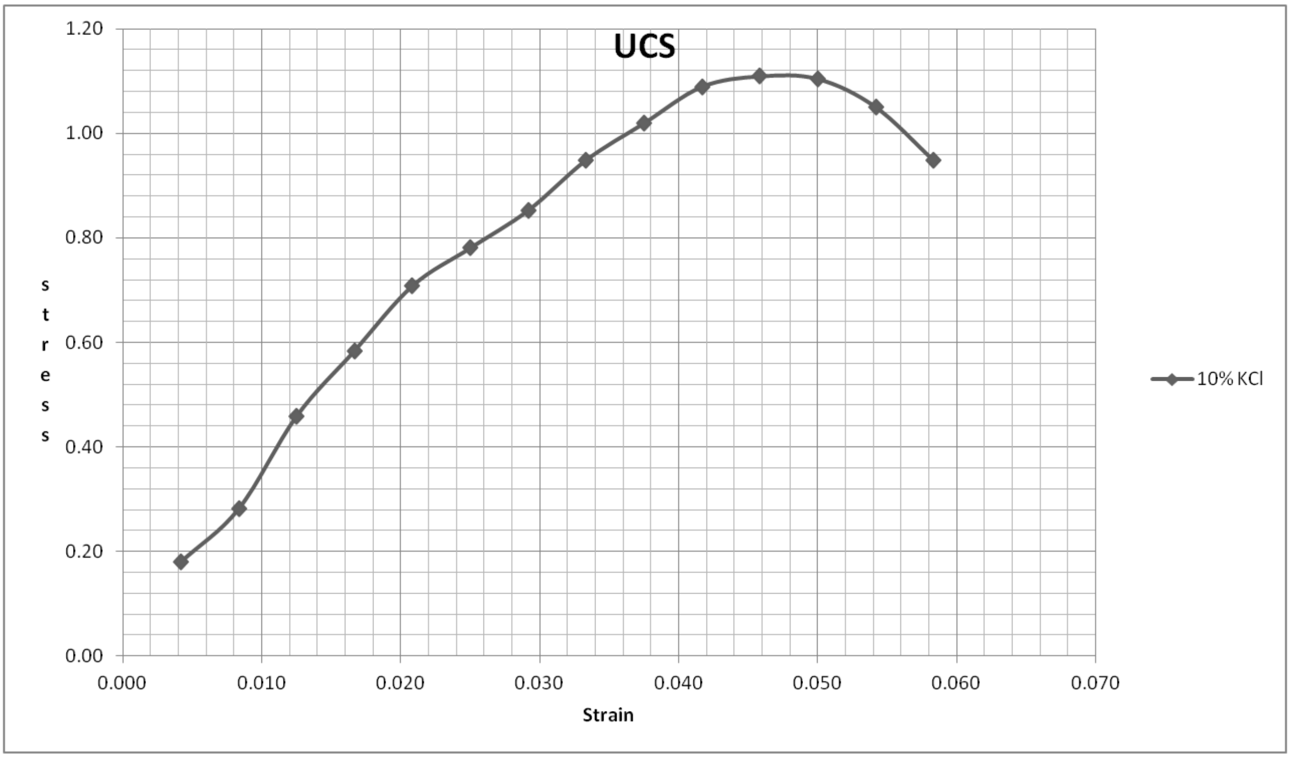


Fig 8 Graph for Unconfined compressive strength with 10% KCl as evident from fig 8

The unconfined compressive strength of the sample is 1.11 Kg/cm^2. There has been an increase in the strength of the soil by 0.05 kg/cm^2 upon addition of 10% KCl solution to the soil.

The tables and data used in calculation of the unconfined compressive strength can be seen in appendix: A.

CHAPTER 5

RESULTS AND CONCLUSION

Results

Test	No KCl	5% KCl	10% KCl
Liquid Limit	40	36	33
Plastic limit	24	22.7	22.5
OMC	17.68	16.80	-
MDD	1.710g/cc	1.685g/cc	-
UCS	1.06kg/cm^2	0.92kg/cm^2	1.11kg/cm^2

Conclusions

- The liquid limit of the soil was found to be reduced by 4% and 3% as the concentration of the potassium chloride added was increased from 0 to 5 and 10 % respectively.
- The plastic limit of the soil was found to be reduced by 1.3% and 0.2% as the concentration of the potassium chloride added was increased from 0 to 5 and 10 % respectively.
- The optimum moisture content of the soil was found to be reduced by 0.88% as 5% potassium chloride was added to the soil.
- The maximum dry density of the soil was found to be reduced by .025 g/cc as 5% potassium chloride was added to the soil.
- The unconfined compressive strength of the soil showed variation with the addition of potassium chloride as initially the strength marginally decreased by 0.14kg/ cm^2 while upon increasing the concentration to 10% from 5% the potassium the strength again increased by 0.19kg/ cm^2.

References

- Shukla.A et al. “STRENGTH AND COMPRESSIBILITY BEHAVIOUR OF BLACK COTTON SOIL STABLIZED WITH FLY ASH, JIET MADHYA PRADESH. Concluded that based on test results the expansive soil can be stabilized.
- Various Laboratory manuals on Geotechnical Engineering.
- Geotechnical Engineering Principles & Practices” by Donald P.Coduto.
- Venkara Muthaylu.P, 2012, Study of performance of chemical stabilized expansive soil.
- Ramdas.T.L, 1996, Study on strength and swelling characteristics of three expansive soils.

Scope for Future Work

In future the electrolyte used in this project can be changed. For instance in case of potassium chloride another electrolyte can be used such as calcium chloride or ferric chloride. The ions exchanged during this will be divalent and trivalent respectively thus providing different results possibly.

Also the concentrations in which these electrolytes are used can be varied thus providing a different set of results which can then be compared with the results obtained in this project.

Another aspect in this project is the soil upon which the tests are carried. In the future a different soil can be used and can be tested upon by the similar methods to obtain results which can later be compared.

APPENDIX: A

Unconfined Compressive strength without KCl

Divisions	Load(Div * 0.263)	Settlement (mm)	Strain(ΔL/L)	Failure area(A) cm2	Strength (Load/Area) kg/cm2
9	2.367	0.3	0.004	10.221	0.23
12	3.156	0.6	0.008	10.264	0.31
18	4.734	0.9	0.013	10.307	0.46
22	5.786	1.2	0.017	10.351	0.56
27	7.101	1.5	0.021	10.395	0.68
30	7.89	1.8	0.025	10.439	0.76
34	8.942	2.1	0.029	10.484	0.85
36	9.468	2.4	0.033	10.529	0.90
39	10.257	2.7	0.038	10.575	0.97
41	10.783	3	0.042	10.621	1.02
43	11.309	3.3	0.046	10.667	1.06
42	11.046	3.6	0.050	10.714	1.03
41	10.783	3.9	0.054	10.761	1.00
39	10.257	4.2	0.058	10.808	0.95

Unconfined compressive strength without KCl

Unconfined Compressive strength with 5% KCl

Divisions	Load(Div * 0.263)	Settlement (mm)	Strain(ΔL/L)	Failure area(A) cm2	Strength (Load/Area) kg/cm2
6	1.578	0.3	0.004	10.221	0.15
11	2.893	0.6	0.008	10.264	0.28
17	4.471	0.9	0.013	10.307	0.43
21	5.523	1.2	0.017	10.351	0.53
27	7.101	1.5	0.021	10.395	0.68
31	8.153	1.8	0.025	10.439	0.78
34	8.942	2.1	0.029	10.484	0.85
36	9.468	2.4	0.033	10.529	0.90
37	9.731	2.7	0.038	10.575	0.92
37	9.731	3	0.042	10.621	0.92
37	9.731	3.3	0.046	10.667	0.91
36	9.468	3.6	0.050	10.714	0.88

Unconfined compressive strength with 5% KCl

Unconfined Compressive strength with 10% KCl

Divisions	Load(Div * 0.263)	Settlement (mm)	Strain(ΔL/L)	Failure area(A) cm2	Strength (Load/Area)
7	1.841	0.3	0.004	10.221	0.18
11	2.893	0.6	0.008	10.264	0.28
18	4.734	0.9	0.013	10.307	0.46
23	6.049	1.2	0.017	10.351	0.58
28	7.364	1.5	0.021	10.395	0.71
31	8.153	1.8	0.025	10.439	0.78
34	8.942	2.1	0.029	10.484	0.85
38	9.994	2.4	0.033	10.529	0.95
41	10.783	2.7	0.038	10.575	1.02
44	11.572	3	0.042	10.621	1.09
45	11.835	3.3	0.046	10.667	1.11
45	11.835	3.6	0.050	10.714	1.10
43	11.309	3.9	0.054	10.761	1.05
39	10.257	4.2	0.058	10.808	0.95

Unconfined compressive strength with 10% KCl

APPENDIX: B

UCS apparatus in the lab at JUIT

Sample prepared from sample extractor