The Major Project- II

On

A Study of Soil Stabilization Using Rice Husk Ash

Submitted In Partial Fulfilment for the Award of the Degree of

MASTERS of TECHNOLOGY

IN

CIVIL ENGNEERING

With Specialization In

GEOTECHNICAL ENGINEERING

By

Amit Upadhyay

(Roll No. 2K13/GTE/02)

Under The Guidance of

Prof. A. K. Gupta

Department of Civil Engineering

Delhi Technological University, New Delhi

Department of Civil Engineering

Delhi Technological University, New Delhi

Delhi – 110042

2015

DELHI TECHNOLOGICAL UNIVERSITY, DELHI

CERTIFICATE

This is to certify that major project-II entitled "**A STUDY ON SOIL STABILIZATION USING RICE HUSK ASH"** is bona fide record of work carried out by Amit Upadhyay (Roll No. 2K13/GTE/02) under the guidance and supervision, during session 2015 in partial fulfilment of the degree of Master of Technology (Geotechnical Engineering) from Delhi Technological University New Delhi.

The work in this major project- II has not submitted for the award of any other degree to the best of my knowledge.

Prof. A. K. Gupta

Civil Engineering Department,

Delhi Technological University, Delhi

New Delhi 110042

2015

DELHI TECHNOLOGICAL UNIVERSITY, DELHI

ACKNOWLEDGEMENT

As I write this acknowledgement, I clarify that this is note of thanks and regard from my side. I am very thankful toward my project guide **DR. A. K. GUPTA**, Professor, Civil Engineering Department, Delhi Technological University New Delhi for giving me an opportunity to work guidance. I am also thankful to **Prof. A. K. SAHU,** Professor, Civil Engineering Department, Delhi Technological University New Delhi for giving guidance during the project.

I thank to Soil mechanics lab in-charge and attenders of Civil Engineering Department, Delhi Technological University New Delhi to give permission to perform various soil test.

I also thank to Heico India Ltd. Lab members Industrial area phase II Naraina New Delhi to give me permission to perform Tri-axial test in their soil laboratory.

Amit Upadhyay

M.Tech (Geotechnical Engineering)

2K13/GTE/02

DELHI TECHNOLOGICAL UNIVERSITY, DELHI

DECLARATION

I hereby declare that the work in this Project Report entitled"**A STUDY ON SOIL STABILIZATION USING RICE HUSK ASH"**is bona fide record of work carried out by me as a part of major project-II in partial fulfilment for the Master of Technology in Geotechnical Engineering.

I have not submitted the matter presented in this report for the award of any other degree.

Amit Upadhyay
M.Tech (Geotechnical Engineering)
2K13/GTE/02
Civil Engineering Department,
Delhi Technological University, Delhi
New Delhi 110042

ABSTRACT

Soil on various locations may not suitable for construction due to poor or low bearing capacity such as expansive or collapsible soil. Stabilization is a technique which introduce several years before with the purpose to make soil capable. Use wastes that will reduce construction cost as well as environmental hazards. Generally industrial wastes and agricultural wastes like fly ash and rice husk ash. . Rice husk contains silica, which highly reactive. Ash is produced by incineration process and its reactivity is controlled by thermal treatment, oxidation availability. Under these conditions it is produce ash with high specific surface area and because of this highly reactive. The main advantage of this is that it improves the properties like shear strength, stiffness modulus, and load carrying capacity of soil. Using various percentages of rice husk ash in soil and make number of samples and experiment them. It is seen that it improves shear parameter and load carrying capacity of soil. After the experiment it is seen that Rice Husk Ash is a good stabilizer it improve the shear parameter also improve the soil properties.

Keywords:

Soil, Rice husk ash, Standard proctor, direct shear, tri-axial machine, CBR test

CONTENTS

LIST OF SYMBOLS

1. RHA …………………………………………………… Rice Husk Ash
2. CBR …………………………………………………… California Bearing Ratio
3. MDD ………………………………………………….. Maximum Dry Density
4. OMC ………………………………………………….. Optimum Moisture Content
5. % ………………………………………………………. Percentage
6. Fig.…………………………………………………… Figure

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.0 INTRODUCTION

1.1GENERAL

Soil is basic material of construction. It transfer load coming from superstructure in buildings, while in case of roads it take load from the base course and sub base course but soil on various locations may not suitable for construction due to poor or low bearing capacity such as expansive or collapsible soil. Stabilization is a technique which introduce several years before with the purpose to make soil capable. Many additives like cement, lime, and other additives like fly ash, gypsum, silica fume, rice husk ash, have been used. Countries like India has produced in large quantity of industrials and agricultural wastes like fly ash or rice husk ash which has low cost value. Countries like US followed the concept of no wastes and used these materials for development of new material through value addition. Stabilization improve soil properties and it is necessary due rise of land cost and huge demand for high rice buildings. Improving properties of soil by using cost effective materials like industrial wastes fly ash or agriculture wastes like rice husk ash. These materials have cementitious property. Soil like clay, its properties like low shear strength can be improved by using stabilization technique. These material increases its strength.

1.1 **Introduction of Rice Husk Ash**

Rice husk is by product obtained from during milling of rice. This is surrounding by paddy grains. Approximately 0.23 tons of rice husk is formed every ton of rice produced. In the whole world total production of rice is 500 million tons. Out of these more than a half is produced in India and China. Rice husk used as fuel for parboiling in certain country in rice mills and to power steam engines. The residual obtained after burning is called rice husk ash which is waste and contribute environmental pollution.

This waste is recycled to produce other materials. Rice husk is mainly composed of two part one is organic matter and other one is inorganic matter. Organic matter is 70% to 80% of total rice husk by weight. Organic and inorganic part varies considerably depending upon temperature, geological distribution and practices of agriculture.

Table 1.1: World Production Rate for Rice Paddy and Rice Husk(Million Metric Tons), (Hwang & Chandra, 2009)

COUNTRY	RICE PADDY (million metric ton)	RICE HUSK (million metric ton)
Bangladesh	27	5.4
Brazil	9	1.8
Burma	13	2.6
China	180	36
India	110	22
Indonesia	45	9
Japan	13	2.6
Korea	9	1.8
Philippines	9	1.8
Taiwan	14	1.8
Thailand	20	4
US	7	1.4
Vietnam	18	3.6
others	26	5.2
Total	500	100

1.3Reactivity of Rice Husk Ash

Rice husk contains silica, which highly reactive. Ash is produced by incineration process and its reactivity is controlled by thermal treatment, oxidation availability. Under these conditions it is produce ash with high specific surface area and because of this highly reactive.

1.4 Disposal of Rice Husk Ash

It is important issue to dispose rice husk ash in countries like India which has produce large amount of rice. It has long time to decompose and also has low nutritional value, not appropriate for compositing or used as manure. If it not properly disposed it causes environmental issues or impact on environment the production is 500 million tons of rice. One is it is used as a fuel kiln. It kiln used to produce bricks and clay product which is used in daily life. After kiln fired using rice husk, nearly 20% of it remain in the ash form. Disposal of ash is big problem. In present investigations made to utilised rice husk ash for geotechnical purpose after mixing with soil.

1.5 Uses of Rice Husk Ash

A stabilizer – The rice husk ash appears an inert material with silica in crystal form by structure of particles, it is unlikely that it reacts with lime and form calcium silicate. It is also unlikely reactive as fly ash. So it would give satisfactory result while using as stabilized material.

Lightweight fill – Ash appear to be suitable light weight fill and not present very much difficulties in compaction. It has very high angle of internal friction that means it is more stable.

Other uses – RHA of low compacted is used in concrete of light weight. It is also used in water supply as a final filter. Un-burnt rice husk also used as primary filter

1.6 Effect of Temperature on Burning of Rice Husk Ash

Rice husk contain very high percentage of silica. If it is burnt under control temperature it gives highly reactive silica. It is seen that at low temperatures ash contain amorphous silica. It is used as filler in paper, paint, rubber, fertilizer, and insecticides. It is purity high surface area and small particle size can be used as catalyst or an adsorbent in chemical synthesis. In order to prepare this amorphous silica you must have purity from rice husk, either it is thermal treated or treated with chemicals at maintained temperature. Carbonization temperature is preferably held less than 973 $^{\circ}$K to avoid any transformation of amorphous to crystalline.

CHAPTER 2

LITERATURE REVIEW

REVIEW OF LITERATURE:

Many scholarshave used different proportion of Rice Husk Ash for their experiments and research that are available. Geotechnical projects are generally designed on the basic of ASTM and AASTHO standards. These are based on controlled condition but on the field these condition are different, so that premature failure occurs. In situ conditions, examine soil behaviour very carefully to actual condition as possible. RHA which is used for experiment and burnt under controlled temperature taken from N K Enterprises Singhania house, Main Road, Jharsuguda, ORISSA. Analyse the results which comes from use of RHA on soil before use as construction material. Use of Fly Ash and Rice Husk Ash with soil is cost effective process. Use of Rice Husk Ash reduces the disposing of wastes.

The outcome of various researchers who have worked using RHA with different types of soil from time to time are given as a literature review in the following paragraphs.

Rao et.al (2012) conductedstudy on improving the properties of expansive soil with help of ferric chloride and RHA. RHA, a waste pozzolanic material is tried with ferric chloride and used in expansive soil in order to improve its strength and other properties. In these studies various experiment like atterberg limit, proctor test, permeability, and swelling test is conducted. In his experiment he used RHA passing from 425µ sieve and it is well burnt and variation from 0% to 16% of dry unit weight of soil. It is seen that decreases in liquid limit by 26% with the addition of 8% RHA and 1% Ferric chloride and swelling pressure reduced by 50% and increased UCS value 57% after 28 days curing.

Rao et.al (2012) carried out an experimental study on expansive soil stabilization with lime, gypsum and Rice Husk Ash. Sample like expansive soil + RHA+ lime or expansive soil + RHA + gypsum mixtures are used for testing. It is seen that liquid limit decreased by 26% when sample of soil + 20% RHA + 5% lime and swelling pressure reduced by 88%. UCS increased when soil sample of soil + 20% RHA + 5% lime + 3% gypsum after 28 days curing. It is also seen that CBR value increased 1350% when 20% RHA +5% lime + 3% gypsum are used in soil.

Grytan et.al (2012) conducted studies on geotechnical properties of soil in stabilizing by using RHA and conducted various experiment for workability, strength, compressibility and compaction characteristic. Various test such as UCS, compressive strength, direct shear and consolidation test conducted for different composition of RHA and original soil was performed. Due to addition of RHA swelling index and compressibility is reduced. At 10% of RHA UCS and direct shear strength is optimised.

Subbarao et al., (2011) conducted study on Industrial Wastes in soil. It enhanced the geotechnical properties of soil replaced with wastes having pozzolanic properties like RHA and Fly Ash. 2%, 4%, and 6% RHA of soil weight is used in soil sample. Using 4 % RHA and Fly Ash is not giving much improvement in soil hence accelerator like lime is used with RHA and Fly Ash is used and optimum result is obtained.

Akshaya et al. (2010) conducted study on effect of RHA and marble dust on expansive soil. This study represents the test results of marble dust on strength and durability of soil with optimum percentage of RHA. It is found the 10% RHA is optimum based on UCS. Marble dust is found 30% by weight of dry soil is optimum, at and increment of 5% in compaction, UCS test, soaked CBR test. The UCS and CBR of expansive soil increased 20% with addition of marble and RHA. If further increased marble dust it impact negative effect on properties. Maximum dry density and optimum dry density increases with increases of marble dust percentage. For best stabilization is found on optimum proportion of soil RHA and Marble dust 70:10:20.

Zemke Nick (2009) conducted study on RHA. After the research and testing sample, he concluded that RHA is one of substitution of Portland cement up to 30%. It decreases cost of project and also disposes of rice husk ash product. It is one of the options in south East-Asia where rice production is prevalent.

BrooksRobert M. **(2009)** carried out study on stabilization of soil with RHA and Fly Ash as a construction material. Various test with different percentage of RHA and Fly Ash and strength test were conducted. From the experiment it is seen that 12% RHA and 25% Fly Ash was recommended for strengthening of soil for sub grade.

Roy T. K. (2009) was working on possibility of utilization RHA by mixing with local alluvial soil with small % of lime for make soil suitable for subgrade material for roads and also wants to reduces in cost of construction. It provides one of solution of disposing Ash. To check the properties of mixed soil in increasing order of RHA 0% 10% 20% 30% by dry weight of soil is used and increases lime content 1% to 3% with the variation of lime. It is seen that decreases the max dry density with increases RHA percentage from 0% to 30% these value increases gradually with increases lime percentage 0% to 3%. CBR value maximum with RHA 20% further increase in RHA reduction in CBR value without lime. Addition of lime and RHA simultaneously increases CBR value with increases its percentage in soaked and un-soaked condition.

Aihassan Musa (2008) in his report, he focused on the permeability of soil treated with RHA and lime. His experiment on laterite soil also known as CH soil as per AASTHO and as per unified soil classification system, with 4% lime and 6% RHA for maximum value of UCS for stabilization. It is seen that permeability of soil is increased with the curing days. It is also seen that 4% to 6% RHA with 6% lime give max strength and reduced permeability.

Aihassan Musa (2008) conducted experiment RHA and cement with soil. Using 2% to 8% cement by weight of soil for compaction, CBR, UCS characteristic. It is seen that increases OMC with decrement in dry density. Also improvement in CBR and UCS with increases RHA. Maximum UCS is obtained on 6% to 8% RHA.

Aihassan Musa (2008) carried out studied of RHA for stabilization of lateritic soil. With the variation of RHA from 2% to 12% of soil weight its stabilization process is conducted. It is seen that increase RHA percentage increase in OMC but decrement in MDD. It is also seen that CBR and UCS values are increased with increment in RHA values.

Nair G. Deepa (2008) carried out experiment on a structural investigation of RHA and investigating its pozzolanic activity. In his experiment, he conducted chemical analysis, X-Ray diffraction and microscopic analysis and seen that highest amount of silica present in RHA when burning at a temperature of 500^{o}C – 700^{o}C. RHA is one of the material which is used as pozzolanic cement additive.

Ramakrishna A. N. and Kumar Pradeep (2008) carried out studied on soil properties with mixture of RHA and cement in soil at various proportions. On his experiment it is seen that with addition of RHA-cement in soil its dry density decreases and OMC increases, UCS and CBR values also increases.

Jha J.N. and Gill K. S. (2006) carried out number of experiment like compaction, strength, CBR test and durability tests on soil mixture in which lime and RHA are present. UCS value determined after 7, 14, 56 day curing and With RHA its strength 1.77 times when lime 7% as compare to without RHA and lime content 5%, 6%. By adding RHA CBR value also increases due to pozzolanic action between silica and lime with the increase content of RHA.

Basha E. A. (2004) conducted test for stabilization of residual soil using Rice Husk Ash and cement which are used for evaluation of properties of soil such as compaction, compaction, and X-ray diffraction. On the basis of experiment he concluded both cement and RHA reduces plasticity of soil. Also it decreases dry density and increases OMC. For optimum result 6% to 8% of cement and 10% to 15 % rice husk ash is used.

Rahman M. A.(2003) carried out study on geotechnical properties of soil by using various percentage of RHA in cohesive and cohesion-less soil. He conducted various test likeAtterberg limits, dry density OMC, CBR etc. for various percentage of RHA. It is seen that CBR, OMC and cohesion increases with increases in RHA for both types of soils.

Muntohar, Setyo Agus (2002) conducted test on soil with the mixture of uncontrolled burning of Rice Husk for the improvement of soil. He varied the RHA in 7.5%, 10%, 12.5% proportion and lime varies in 2, 4, 6 & 10% proportion. It is seen that lime and RHA combination decreases the swelling pressure and increases bearing capacity of soil.

Johari Mehat (1993) carried out experimental studies of RHA effect on the soil properties like compaction, strength and durability of lateritic soil which is used for sub grade for road work. It is seen that various proportion of cement and RHwith the soil influences compaction characteristic, soaked and un-soaked CBR value, tensile strength and durability. Durability characteristic is achieved and recommended.

Dutta R. K. and Das Kalyan (1977) of C.B.R.I. Roorkee established that if soil contains more than 20% clay and mixed with RHA in proportion of 1:1 by weight than it is seen that it gives highly reactive pozzolona. This material mixed with lime and sand and used in mortar, plaster and foundation.

CHAPTER 3

MATERIAL USED

3.0 INTRODUCTION

Soil testing is part of design and analysis of soil engineering. Evaluation of soilsample and determination of properties of soil in field condition is essential part of geo-technical engineering. It play important role in irrigation, highway, structure and hydraulics engineering.

3.1 MATERIALS AND TESTING PROCEDURE

It is plan to study strength and compaction properties of soil using various percentage of Rice Husk Ash. The aim of the study is to investigate the effects of various proportions of RHA i.e. 0%, 5%, 8%, &11%on the following parameters:

1. Direct shear of different proportion of mixes.
2. CBR test of different proportion of mixes.
3. Tri-axial test of different proportion of soil.

3.1.1 SOIL SAMPLES

Locally available soil (DTU library) was obtained and air-dried. It was hand sorted to remove any pebbles and vegetative matter. The soil was then sieved through 4.75mm to eliminate gravel fraction. The soil was then oven dried for 24 hours before it was mixed with RHA.

<u>Following tests has been performed on soil</u>

- Determination of Specific Gravity
- Determination of Liquid Limit

- Grain Size Analysis
- Proctor Compaction Test
- California Bearing Ratio
- Direct Shear test
- Tri-axial Test

1)DETERMINATION OF SPECIFIC GRAVITY

The Specific Gravity of soil was found out by density bottle method is 2.55

Table 3.1 Specific Gravity Test of DTU soil

Empty weight	W_1 (gm)	694.19	694.19	694.19
Empty weight + dry soil	W_2 (gm)	894.06	944.06	994.06
Empty weight + drysoil +water	W_3 (gm)	1686.44	1749.33	1746.57
Empty weight + water	W_4 (gm)	1565.1	1565.1	1565.1
Specific Gravity	**S.G.**	2.54	2.58	2.53

$$S.G = \frac{\mathbf{W2-W1}}{(\mathbf{W2-W1})-(\mathbf{W3-W4})}$$

AVERAGE SPECIFIC GRAVITY = 2.55

2) DETERMINATION OF LIQUID LIMIT

- Liquid Limit of DTU Soil is 23%

Table 3.2 Flow Value of DTU Soil

Water Content (%)	No. of Blows
12	60
16	43
21	29
26	21
30	15

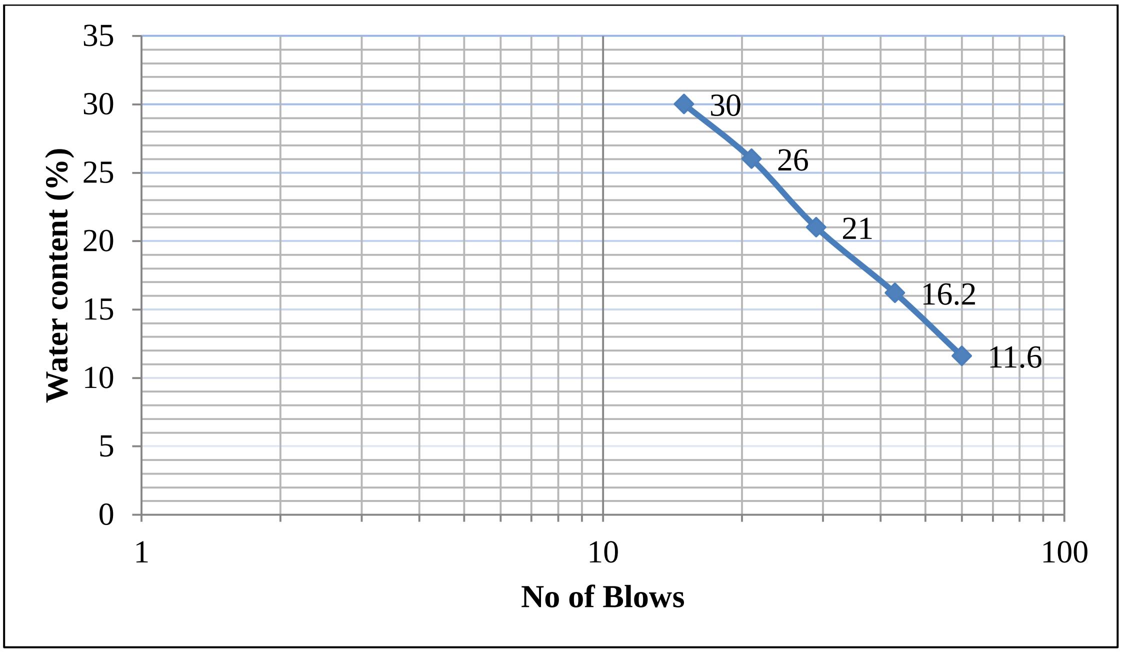

Fig. 3.1 FlowCurve

3) GRAIN SIZE ANALYSIS

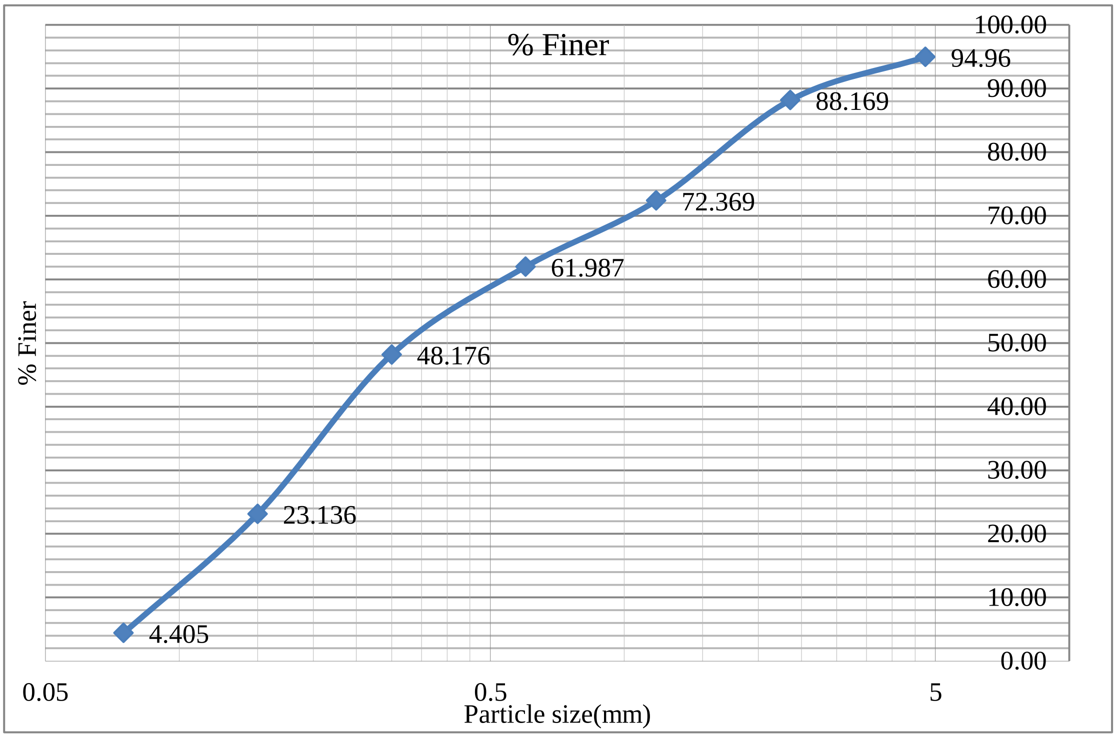

Fig. 3.2 Grain Size Analysis of DTU Soil

- Classification as per Indian Standard Code (IS 2720:1985 part 4)
- Sand with appreciable amount of fines Silty Sand (SM)

Table 3.3 Grain Size Analysis Values

S. no.	**Sieve size (mm)**	**Mass of soil retained (gm.)**	**Percentage on each sieve Retained Mass of soil/Wt. *100**	**Cumulative % retained**	**% finer, 100-cumulative retained**
1	4.75	50.31	5.031	5.031	94.96
2	2.36	68.00	6.8	11.831	88.169
3	1.18	158.00	15.8	27.631	72.369
4	.600	103.32	10.38	38.013	61.987
5	.300	138.11	13.81	51.824	48.176
6	.150	250.40	25.04	76.864	23.136
7	0.075	187.31	18.73	95.595	4.405
8	Pan	44.05	4.405	100	-

4) PROCTOR COMPACTION TEST

Maximum Dry Density (kN/m³)	18.21(kN/m³)
Optimum Moisture Content (%)	11%

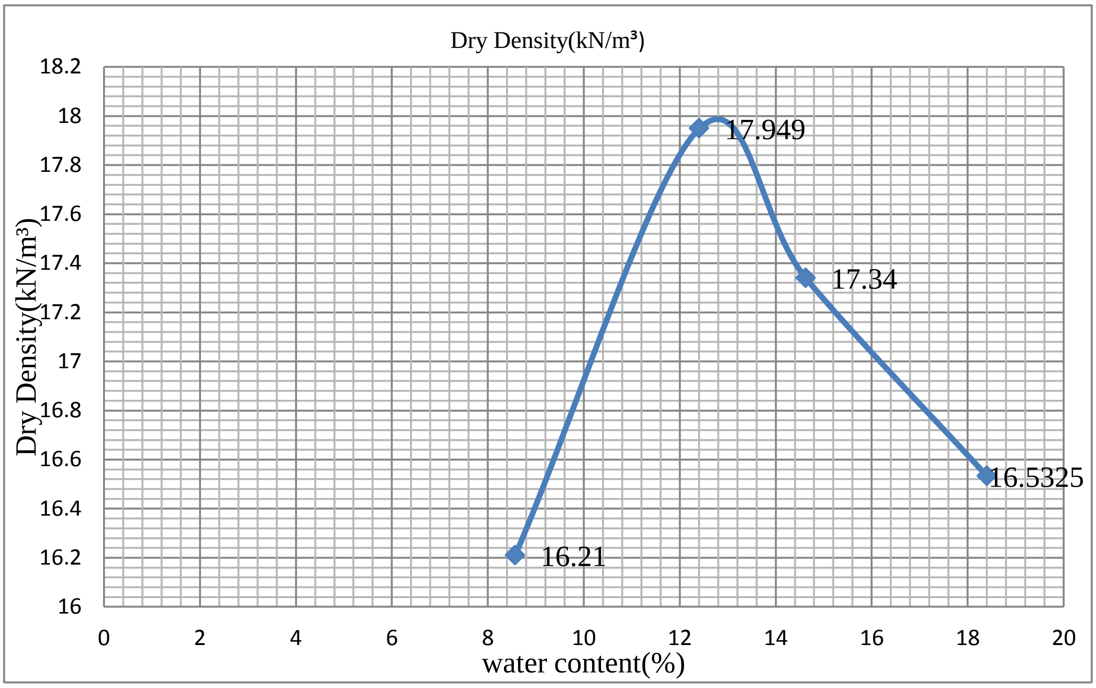

Fig. 3.3 Compaction Curve of Standard Proctor Test

5) <u>CALIFORLIA BEARING RATIO</u>

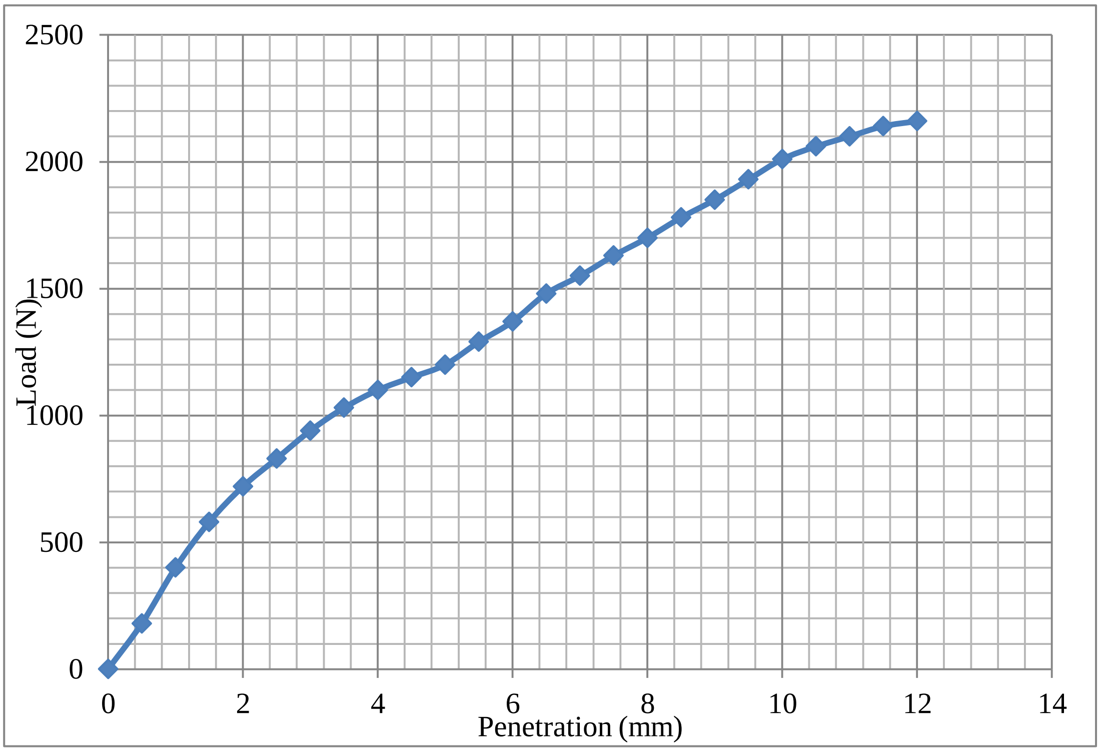

Fig.3.4 California Bearing Ratio on DTU Soil (Sample 1)

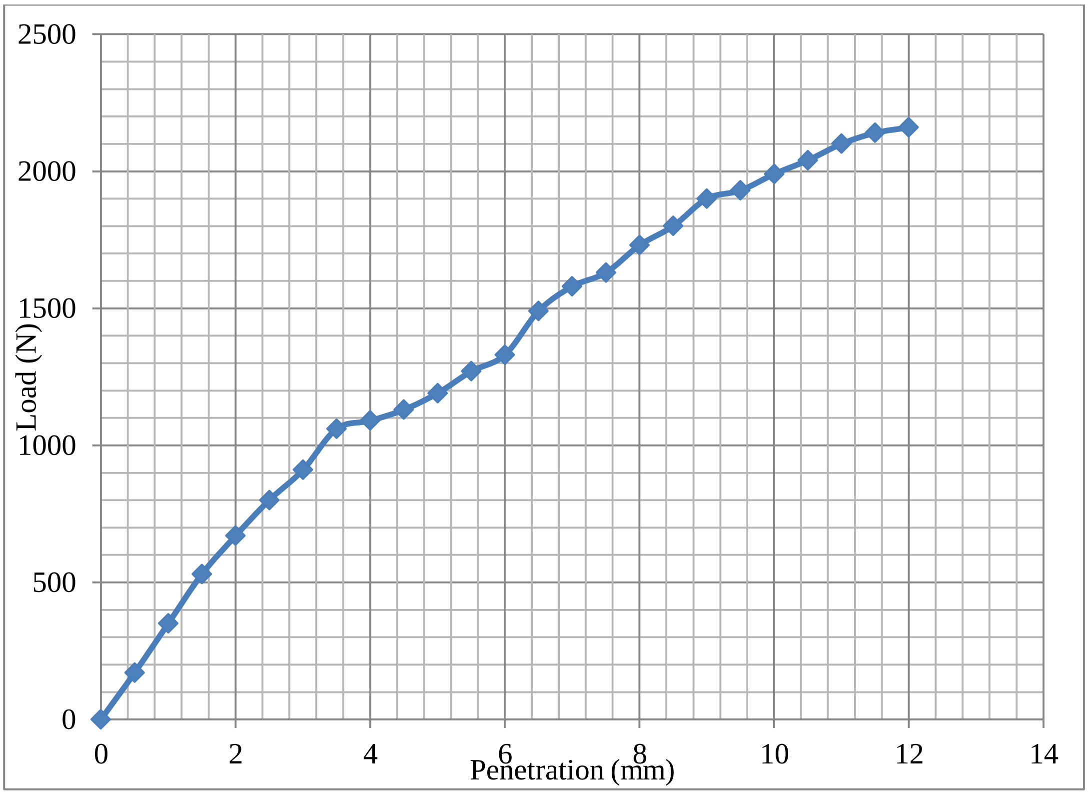

Fig. 3.5 California Bearing Ratio on DTU Soil (Sample 2)

Table 3.4 California Bearing Ratio values (sample 1)

S.NO.	PENETRATION OF PISTON(mm)	Load taken by sample(N)	Standard load (N)	CBR value
1	2.5	830	13700	6.05%
2	5	1200	20550	5.83%

Table 3.5 California Bearing Ratio values (sample 2)

S.NO.	PENETRATION OF PISTON(mm)	Load taken by sample (N)	Standard load (N)	CBR value
1	2.5	810	13700	5.91%
2	5	1190	20550	5.79%

6) <u>DIRECT SHEAR TEST</u>

$\tau = c + \sigma \tan\phi$

$c = 9.291 kN/m^2$ $\phi = 29^{o}$

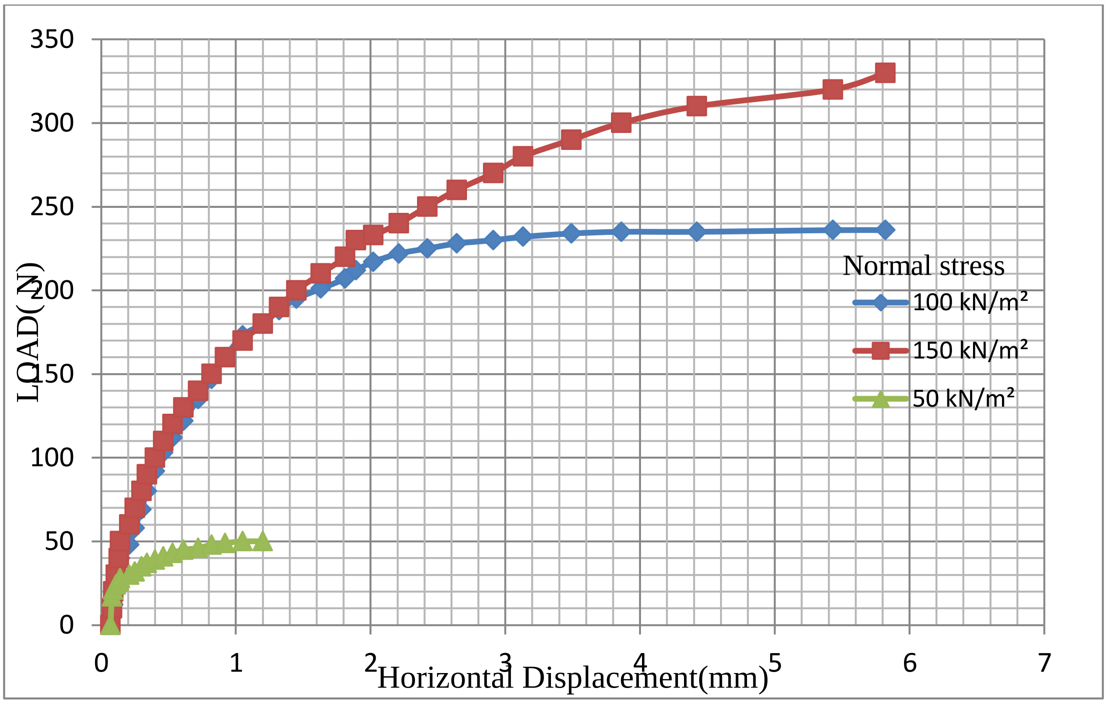

Fig. 3.6 Load Displacement Curve of Direct Shear Test

7) Tri-axial Test (Unconsolidated Undrained)

$\sigma_1 = \sigma_3 \tan^2(45^o+\phi/2) + 2c\tan(45^o+\phi/2)$

$c = 10.98 kN/m^2 \phi = 25.35^o$

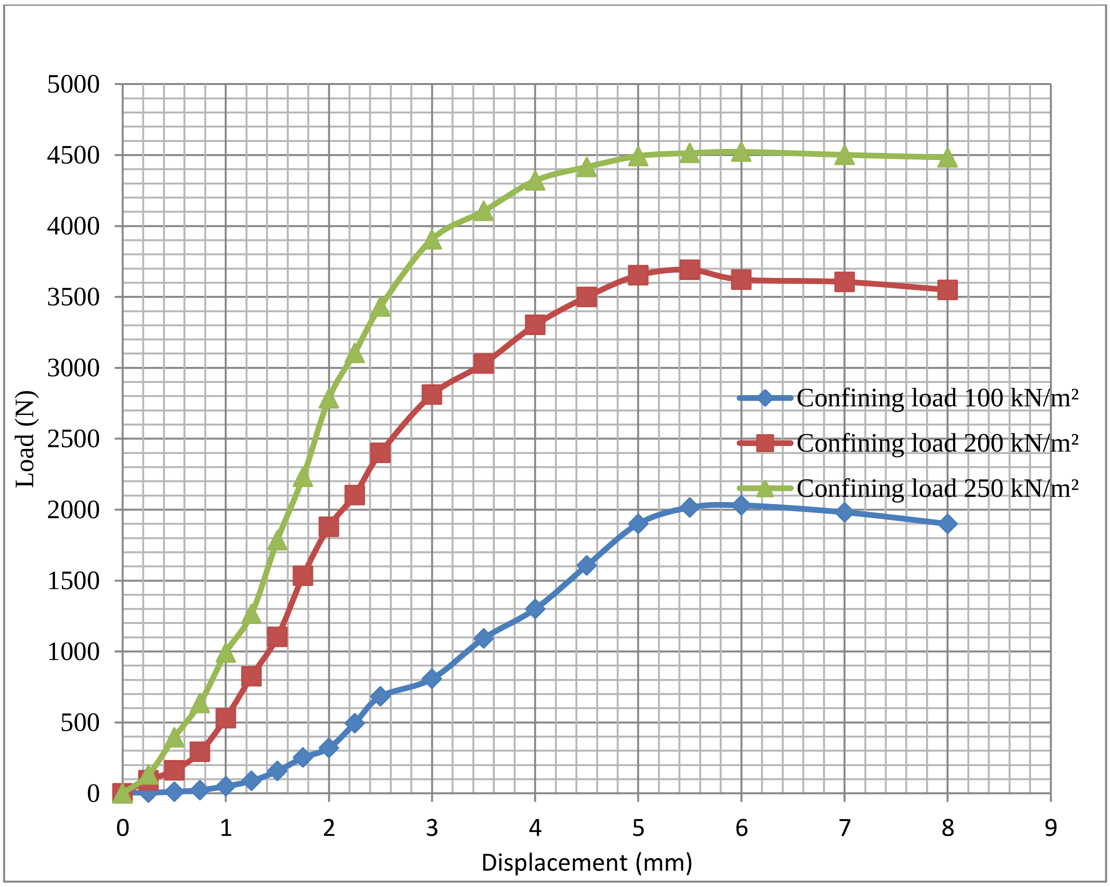

Fig. 3.7 Load Displacement Curve of Tri-axial Test

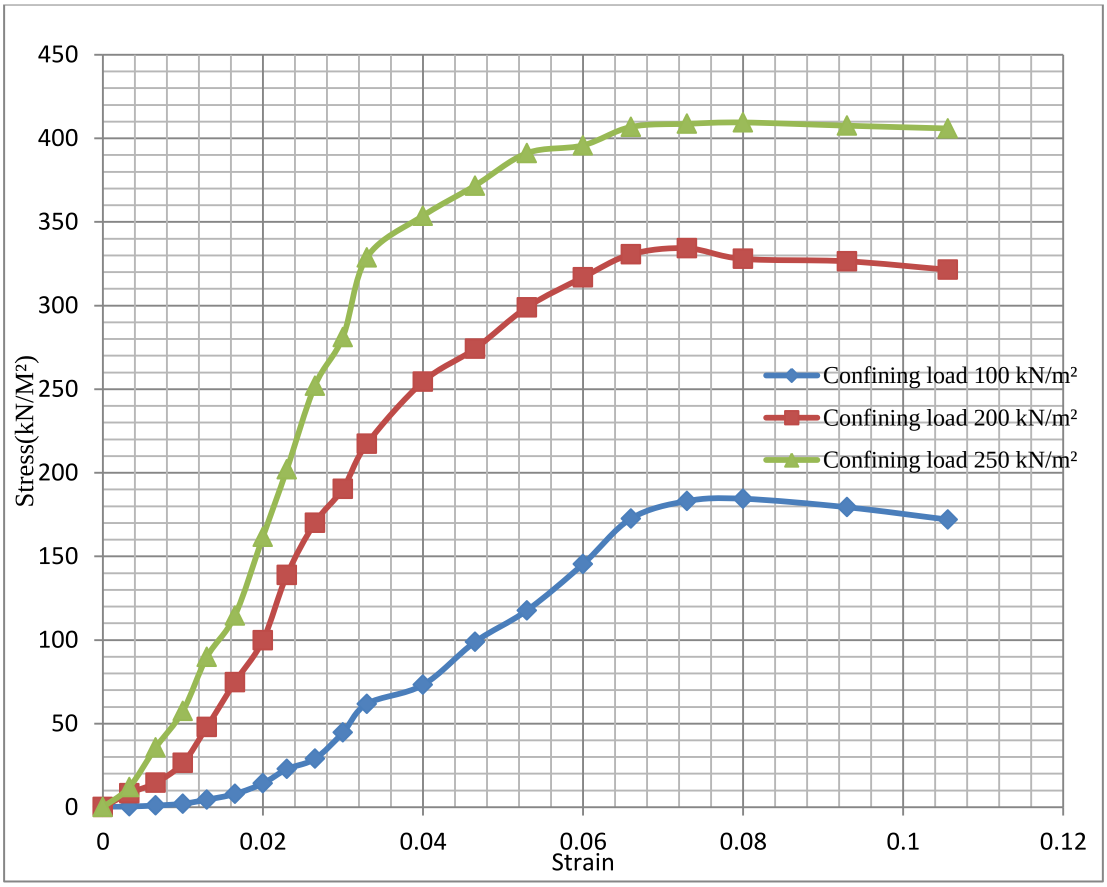

Fig. 3.8 Stress Strain Curve of Tri-axial Test

Table 3.6 Physical properties of soil

S. No.	**Parameters**	**Results**
1. ‘	Light compaction test i) MDD (kN/m^3) ii) OMC **(%)**	18.21 11%(approx.)
2.	Liquid limit **(%)**	24
3.	Specific gravity	2.55
4.	Permeability	18 x 10^{-4}cm/s
5.	CBR	6.054
6.	Indian Soil Classification	SM
7.	Direct Shear Result	c= 9.291kN/M^2 ϕ= 29^o
8.	Tri-axial Result	c=10.98kN/m^{2}ϕ=25^o

3.1.2Properties of RHA

Table 3.7 Chemical properties of RHA provided by N.K.ENTERPRISES, ORRISA

S.NO.	COMPONENT	PERCENTAGE OF RHA
1.	Silica (Sio_2)	89.39
2.	Alumina (Al_2O_3)	2.57
3.	Iron Oxide (Fe_2O_3)	1.53
4.	Lime (CaO)	0.89
5.	Magnesia Oxide (MgO)	0.74
6.	Potassium (K_2O)	2.95
7.	Other Oxide	1.93

Table 3.8 Analysis of grain size of RHA

Sieve Size	%age Passing	Test Method
12.5	100	IS: 2720 (PART IV)
10	100	
4.75	100	
2	100	
.6	100	
.425	100	
.3	100	
.150	100	
.075	43.6	

Table 3.9 Physical property of RHA

S.NO.	PROPERTY	VALUES
1.	Specific Gravity	2.01
2.	Grain Size a).Gravel Fraction b).Sand Fraction c).Silt and Clay	 0.00 56.4 43.6

3.1.3 WATER

Tap water was used throughout the study.

3.2 MIX PROPORTIONS

Soil, RHA and cement are to be mixed thoroughly to have uniform mixture by hand mixing using different proportions of RHA. These are mixed in proportions given below in the table:

Sample	**Name of Proportion**	**SOIL : RHA**
Sample 1	Soil: RHA	100:0
Sample 2	Soil: RHA	95:5
Sample 3	Soil: RHA	92:08
Sample 4	Soil: RHA	89:11

Chapter 4

Experimental Programme

4.0 INTRODUCTION

In this chapter, description of methodology and experimental programme has been given. Description of tests has been stated. Details on proportion of RHA in soil are given.

4.1 TEST CARRIED OUT FOR INVESTIGATION

Following test carries out on soil with various %age of RHA

- **PROCTOR COMPACTION TEST**
- **CALIFORNIA BEARING RATIO**
- **DIRECT SHEAR TEST**
- **TRI-AXIAL TEST**

4.2 METHODOLOGY

Proctor Compaction Test

- This test is carried out on soil to determine maximum dry density and optimum moisture content of soil.
- Effect of addition of RHA has been observed on change in valueof maximum dry density and optimum moisture content.

California Bearing Ratio Test

- CBR test are performed according to IS2720 PART 16.
- According to IRC 37: 2012, the CBR results depend on a various factor and wide variation in values can be expected.
- In current investigation, improvement of CBR value of soil has been achieved by adding various percentage of RHA.
- Test is carried out on optimum moisture content.

Direct Shear Test

- Test carried out on optimum moisture content and MDD.
- Test performed as per IS 2720-part 13-1972.
- In this investigation, change in the value of internal friction angle and value of cohesion on use of various percentage of RHA.

Tri-axial Test

- Test performed as per is 2720 part-11-1993.
- Test is unconsolidated un-drained Test.
- Test carried out on optimum moisture content and MDD.
- In this investigation, change in the value of internal friction angle and value of cohesion on use of various percentage of RHA.

Chapter 5

Results and Discussion

5.0 INTRODUCTION

In this chapter various results have been shown of various tests that have been performed.

Test are performed at CIVIL ENGINEERING DEPARTMENT, DTU, NEW DELHI and Tri-Axial test performed at laboratory of HEICO INDIA LTD., NARAINA INDUSTRIAL AREA PHASE II, NEW DELHI.

5.1 COMPACTION TEST

The results of compaction tests are presented in the form of graphs and one table . A curve is drawn between the moisture content and dry density to obtain the maximum dry density (MDD) and optimum moisture content (OMC).

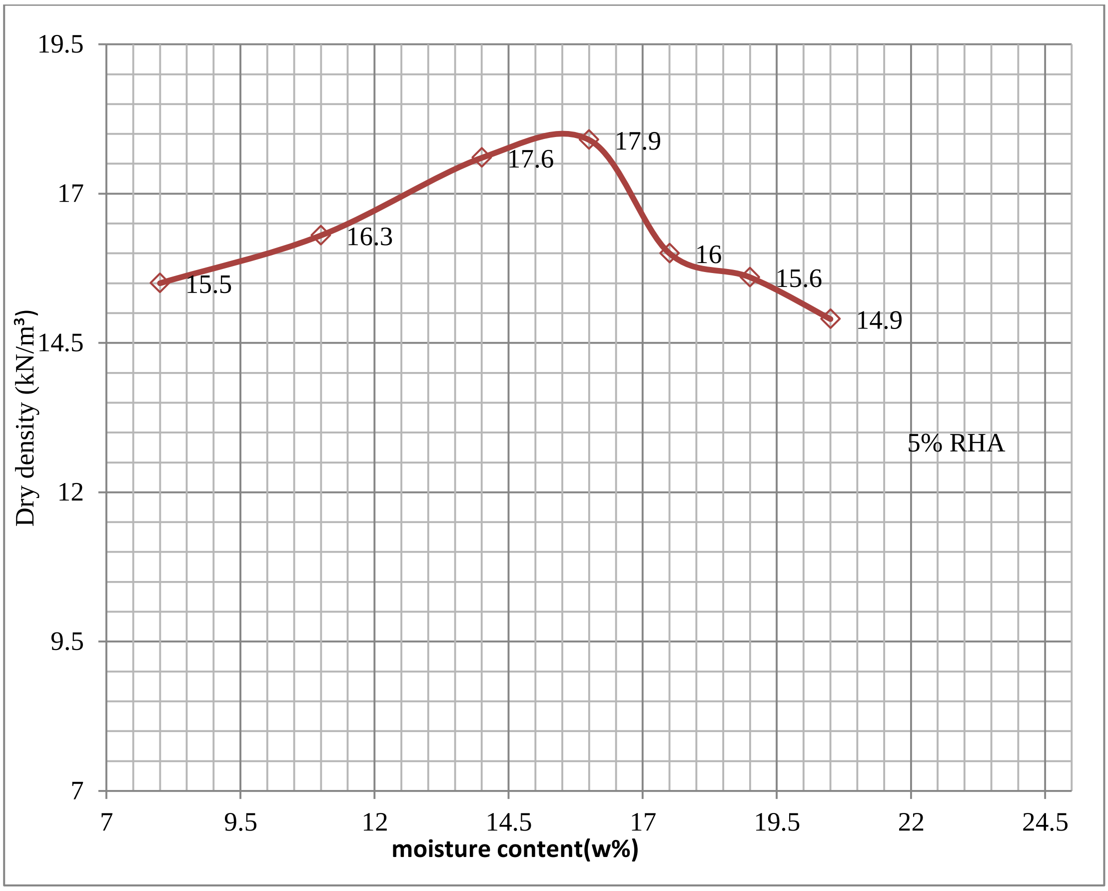

Fig. 5.1 Graph Shows Moisture- Density Relationships at 5% RHA

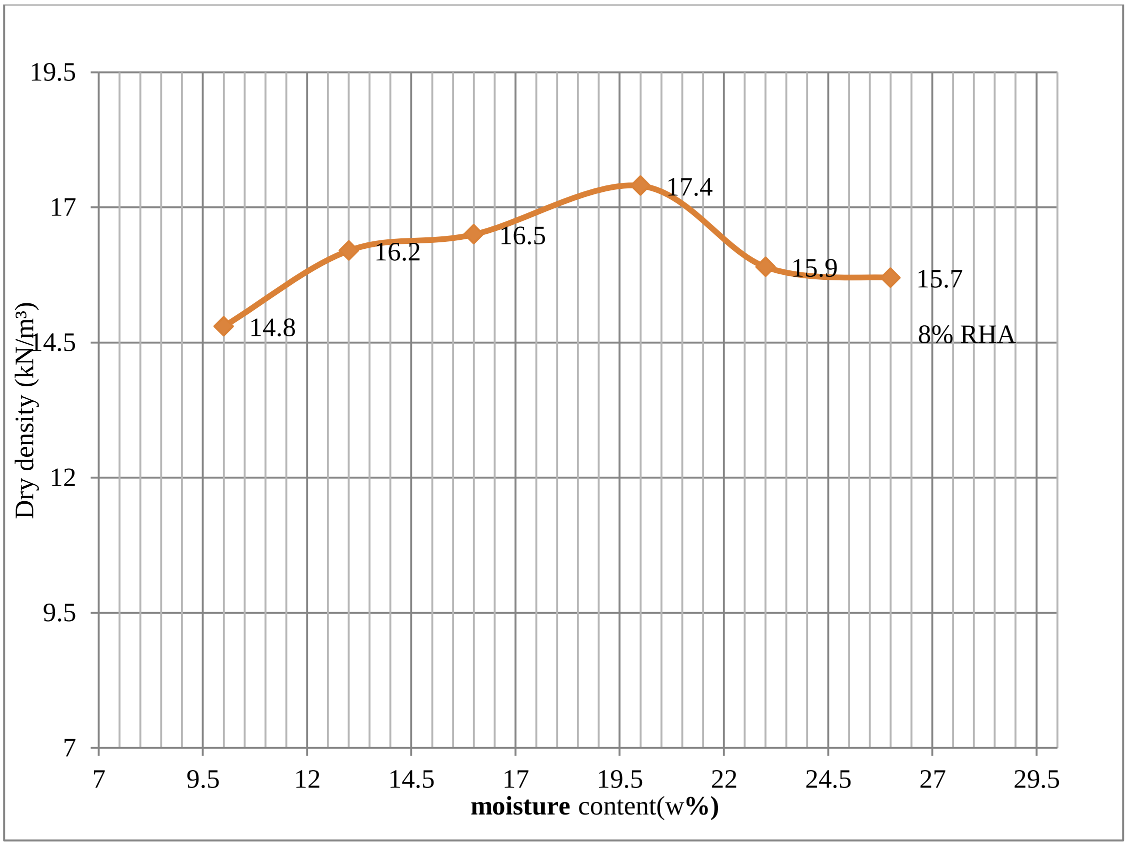

Fig.5.2 Graph Shows Moisture- Density Relationship at 8% RHA

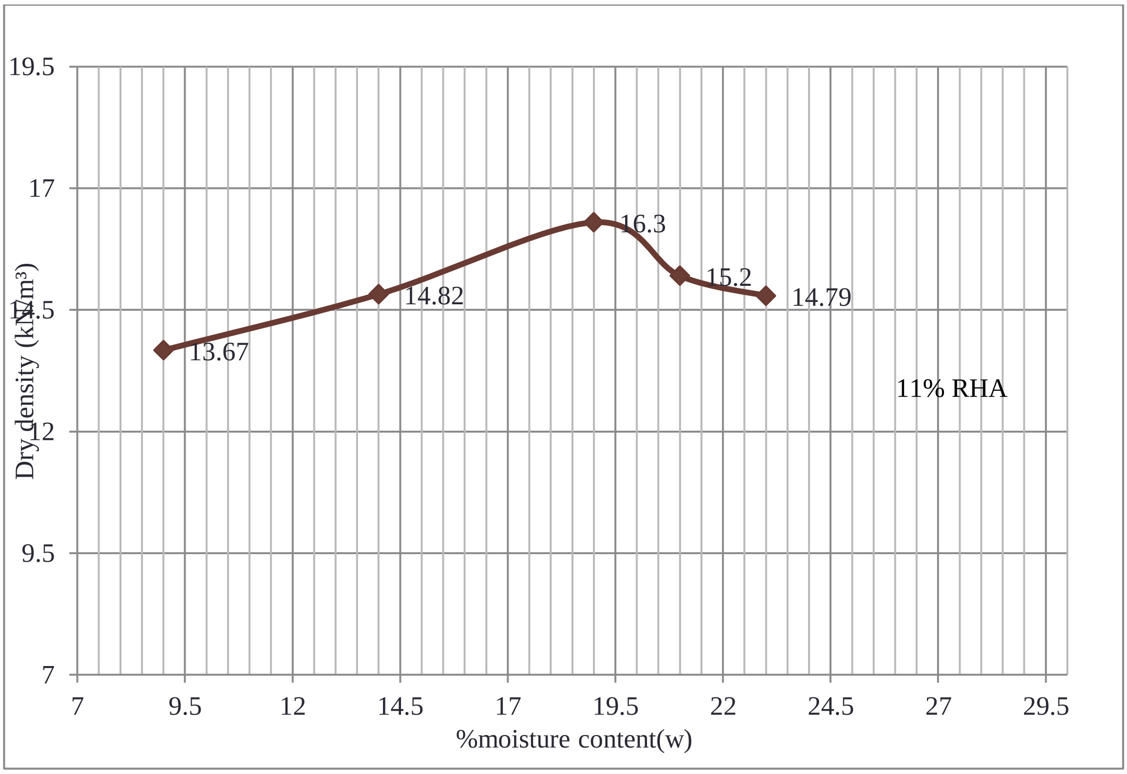

Fig.5.3 Graph Shows Moisture- Density Relationship at 11% RHA

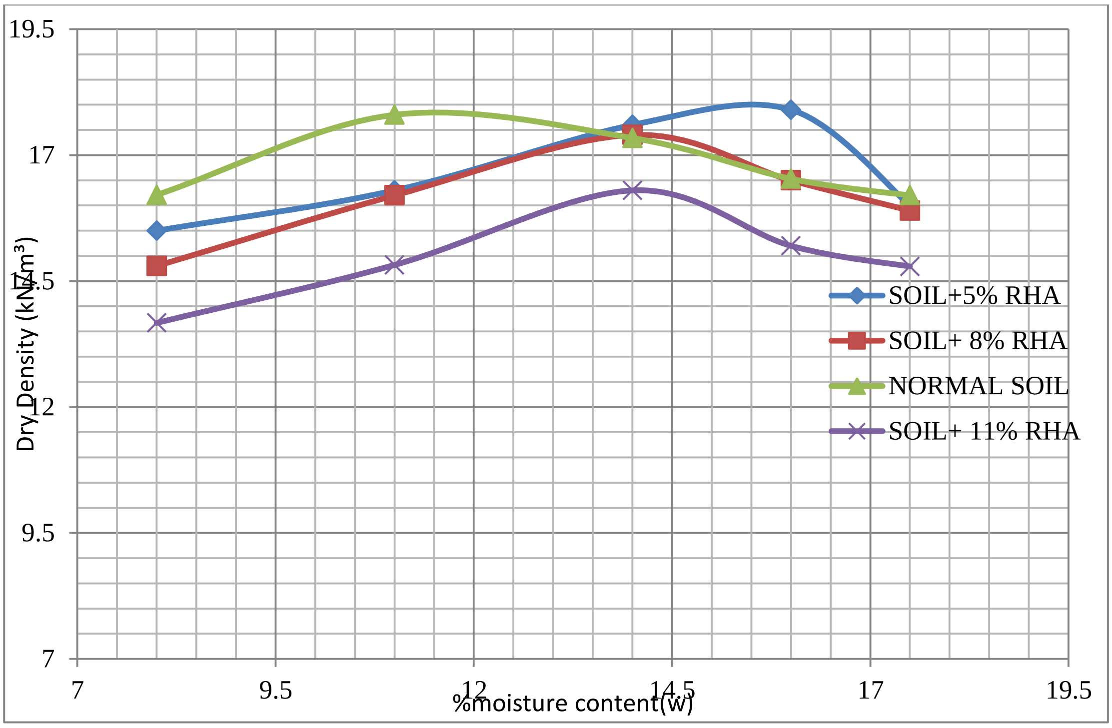

Fig. 5.4 Graph Shows Moisture- Density Relationship at Different Percentage of RHA

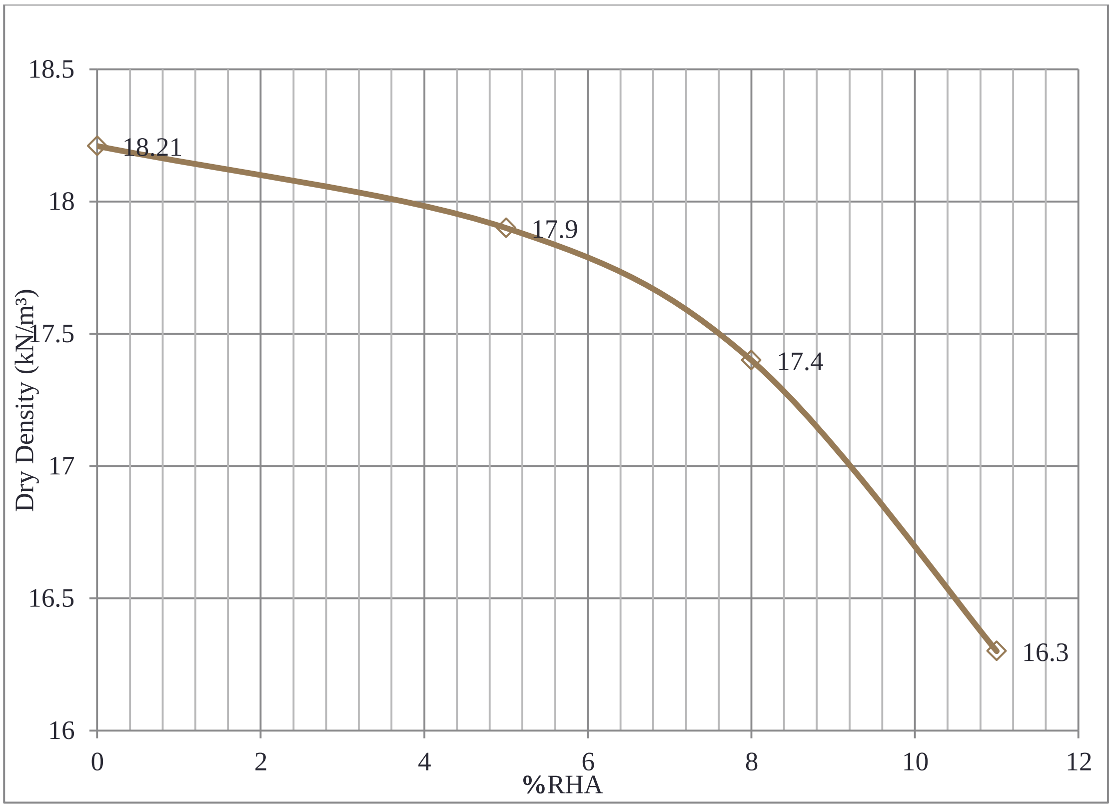

Fig. 5.5 Graph Shows Dry Density- RHA Relationship

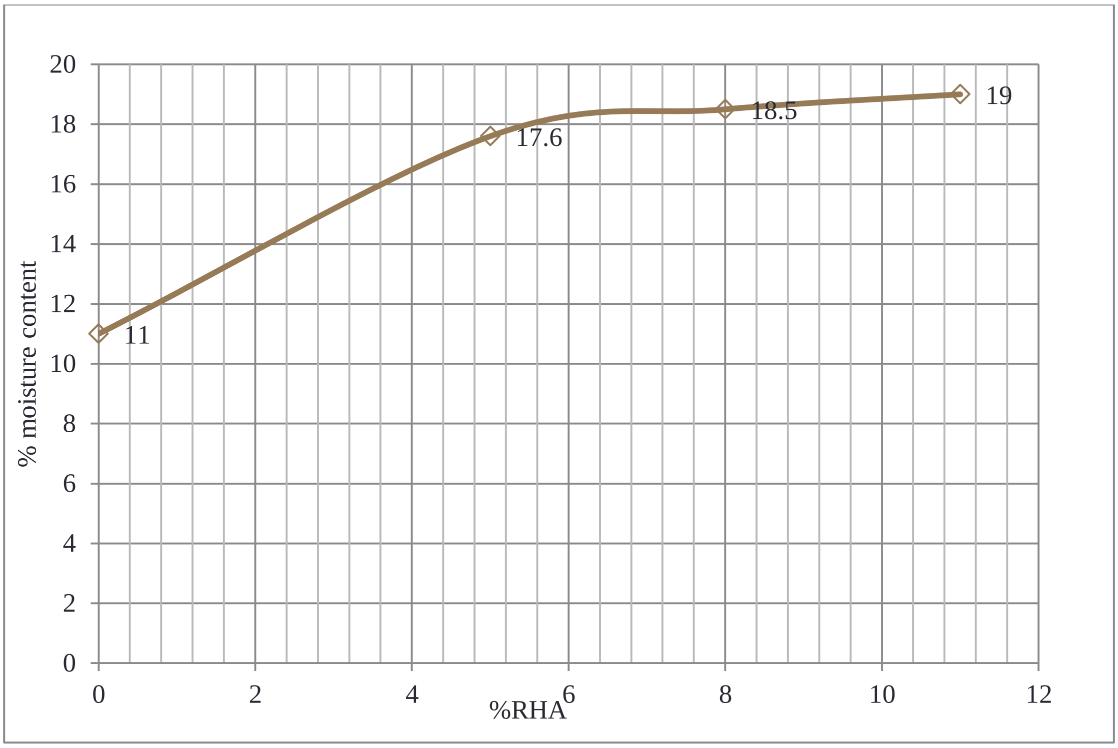

Fig. 5.6 Graph Shows Optimum Moisture Content - RHA Relationship

Table 5.1 Shows OMC Dry Density Variation with %RHA

S.No	% RHA	OPTIMUM MOISTURE CONTENT(%)	MAXIMUM DRY DENSITY(kN/m³)
1	0	11	18.21
2	5	17.6	17.9
3	8	18.5	17.4
4	11	19	16.3

5.2 CALIFORNIA BEARING RATIO

The results of the CBR presented in the form of graphs and table. Curves are drawn between load (N) and penetration (mm).

Table 5.2 Show CBR Variations with %RHA

S.No.	%RHA	CBR VALUE SAMPLE 1	CBR VALUE SAMPLE 2
1	DTU SOIL (0%RHA)	6.058	5.91
2	5%RHA	8.97	8.54
3	8%RHA	10.58	10.36
4	11%RHA	11.75	11.31

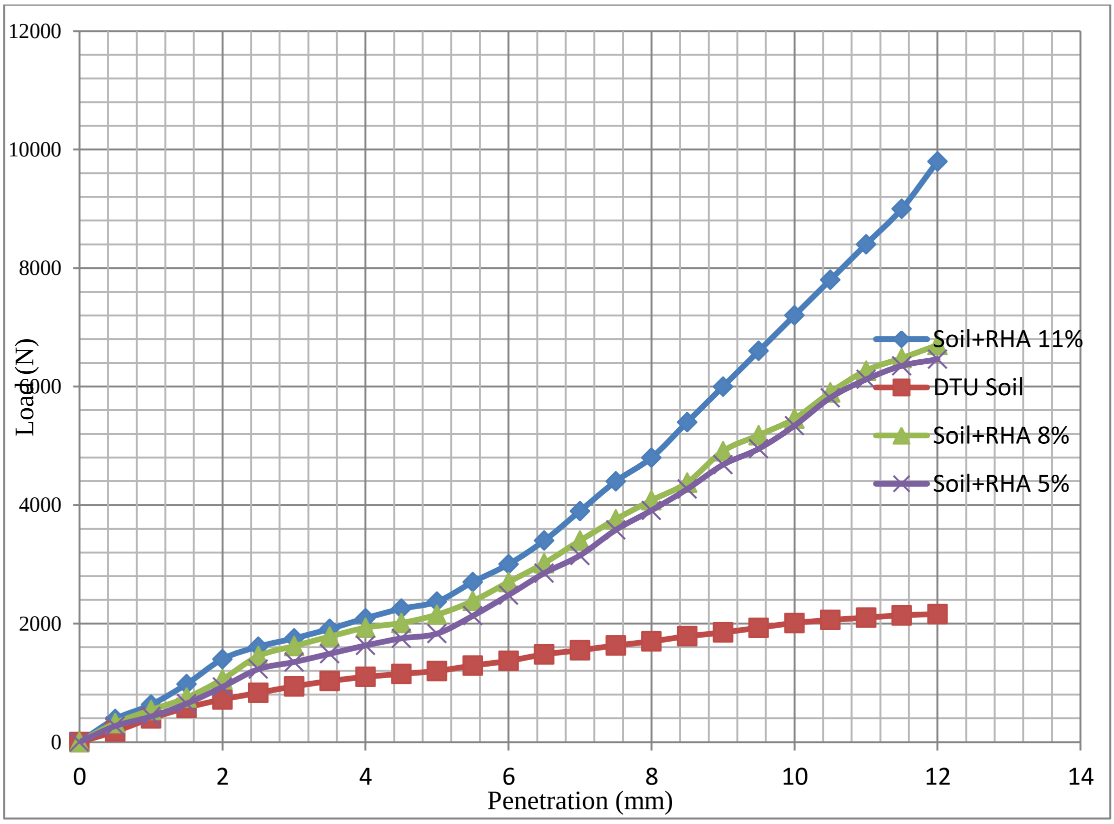

Fig. 5.7 California Bearing Ratio Curves of Sample 1

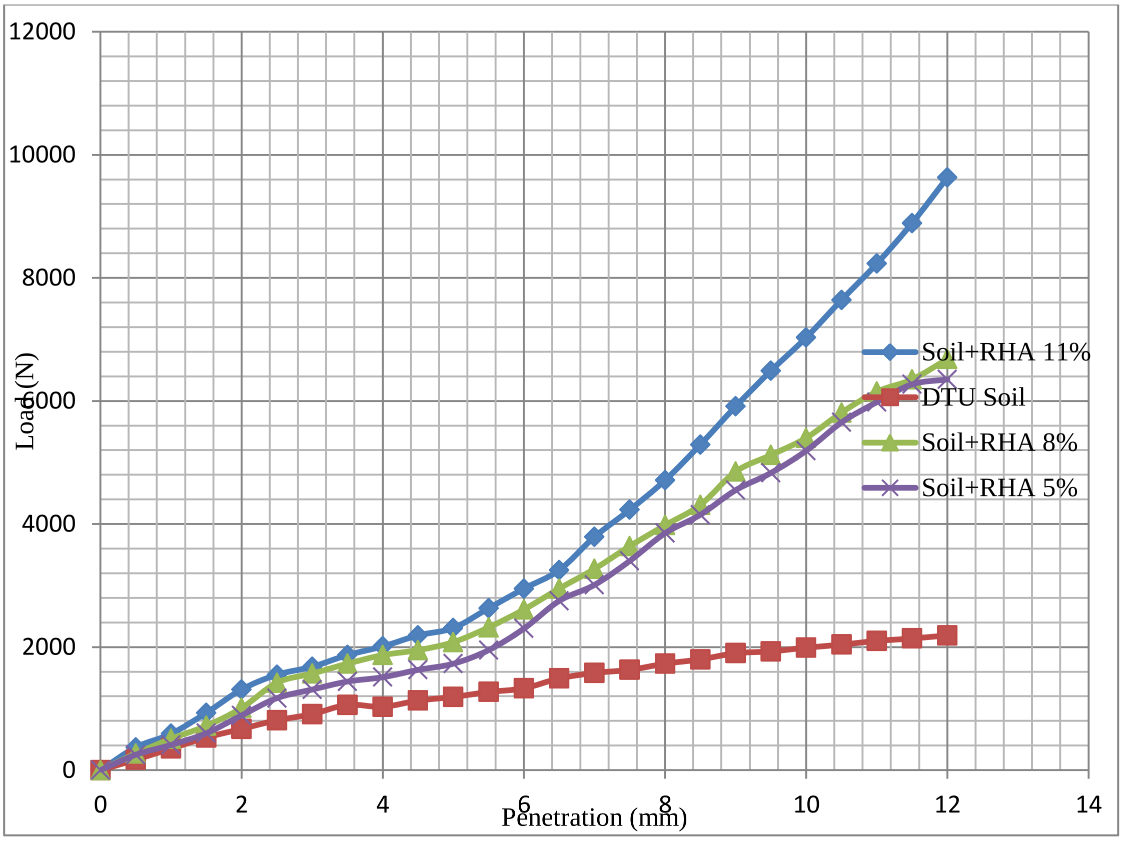

Fig. 5.8 California Bearing Ratio Curves of Sample 2

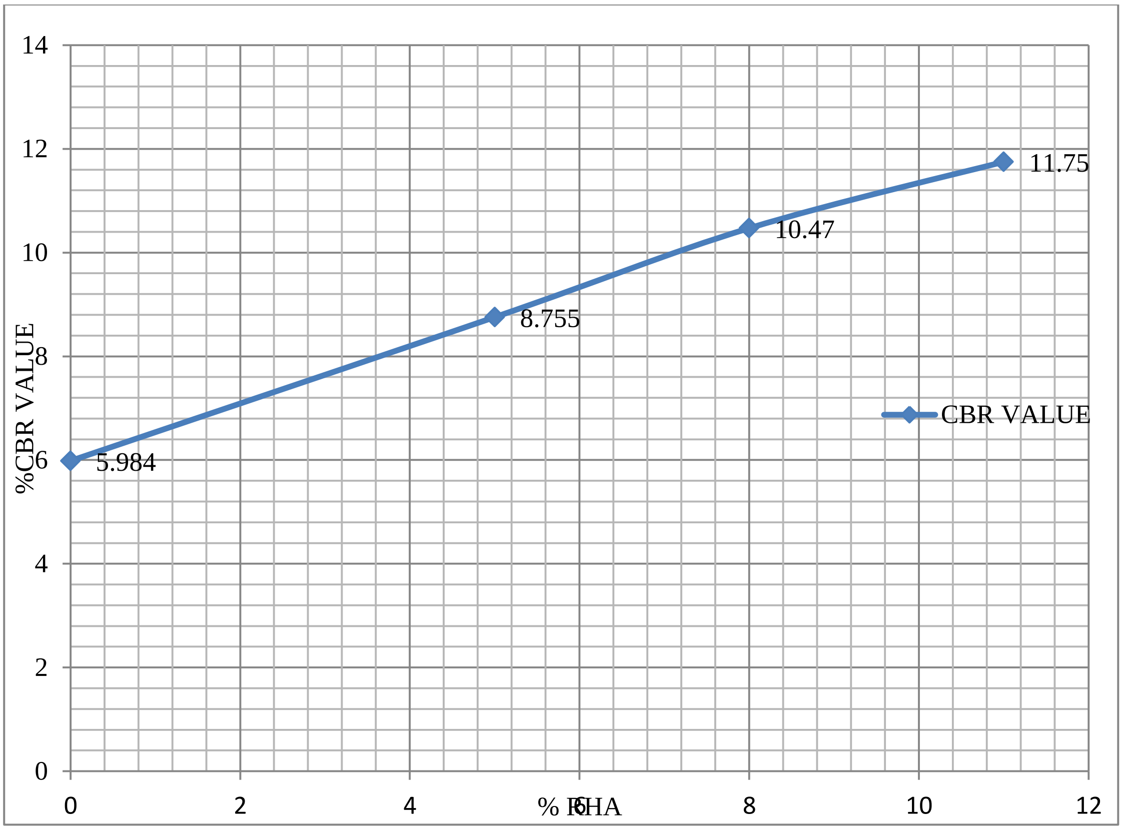

Fig. 5.9 Curves between Avg. CBR Value and %RHA

5.3 DIRECT SHEAR TEST

Results are in the form of graphs and tables. Curves are drawn between load and deformation.

Table 5.2 Shows Angle of friction and Cohesion Variation with %RHA of Direct Shear

S.No.	%RHA	ANGLE OF FRICTION(°)	COHESSION(kN/m²)
1	DTU Soil (0%RHA)	29	9.21
2	5%RHA	27.57	19.44
3	8%RHA	24.24	22.11
4	11%RHA	23.53	25.22

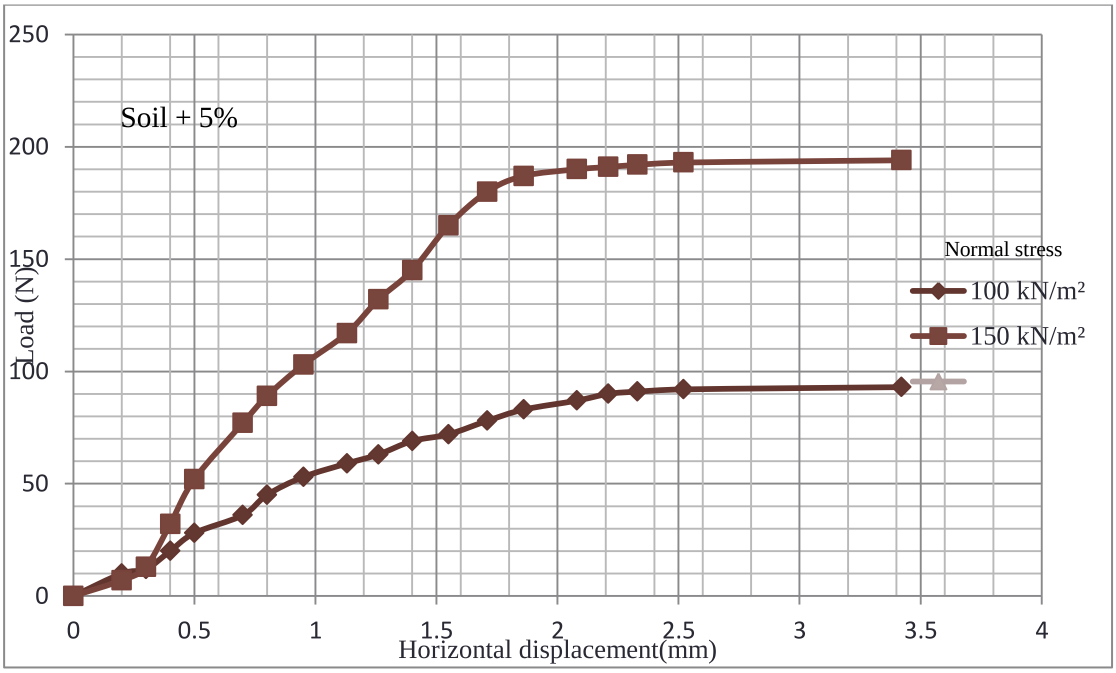

Fig 5.10Curves between Load -Horizontal Displacement of 5% RHA of Direct Shear

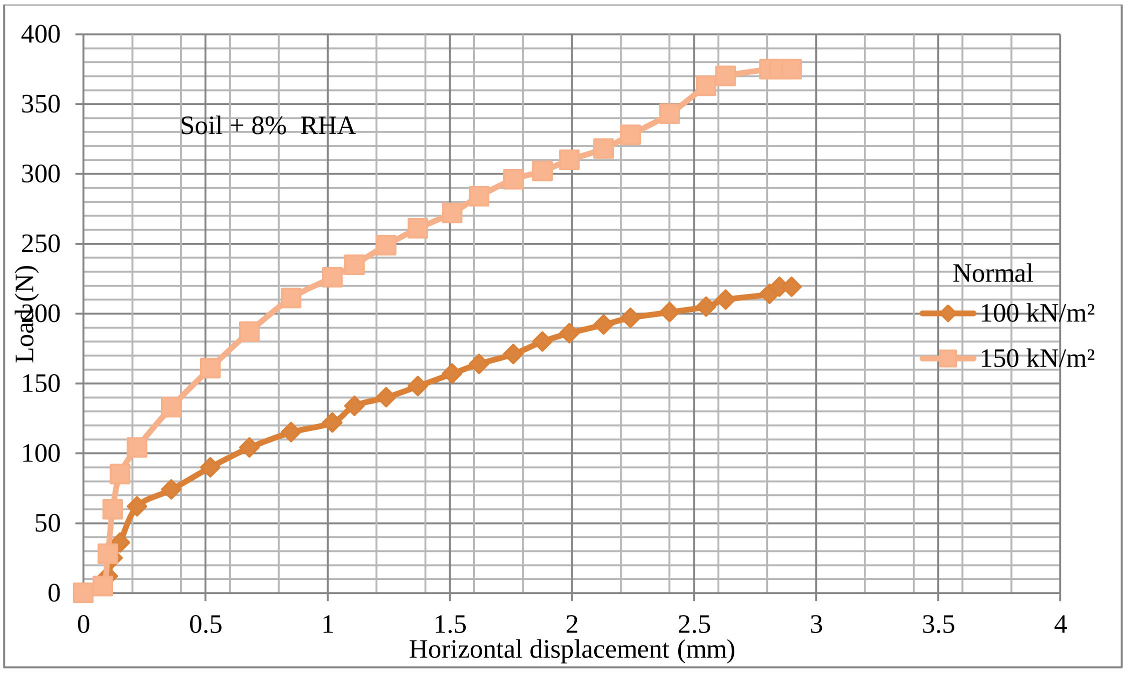

Fig. 5.11Curve between Load -Horizontal Displacement of 8% RHA of Direct Shear

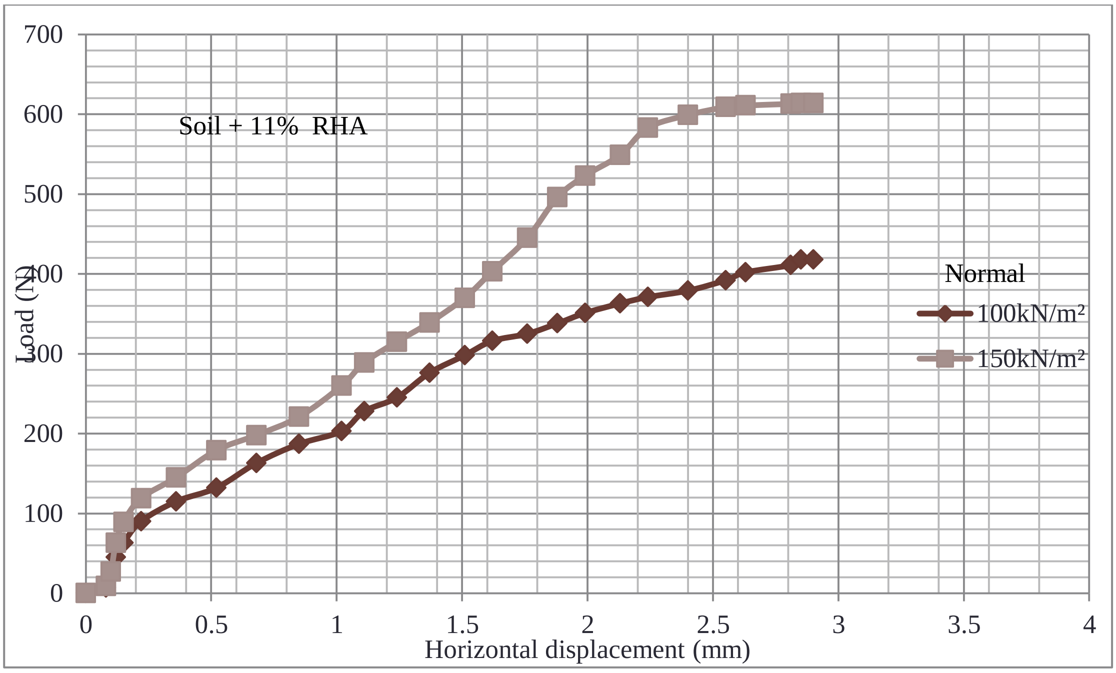

Fig. 5.12 Curve between Load -Horizontal Displacement of 11% RHA of Direct Shear

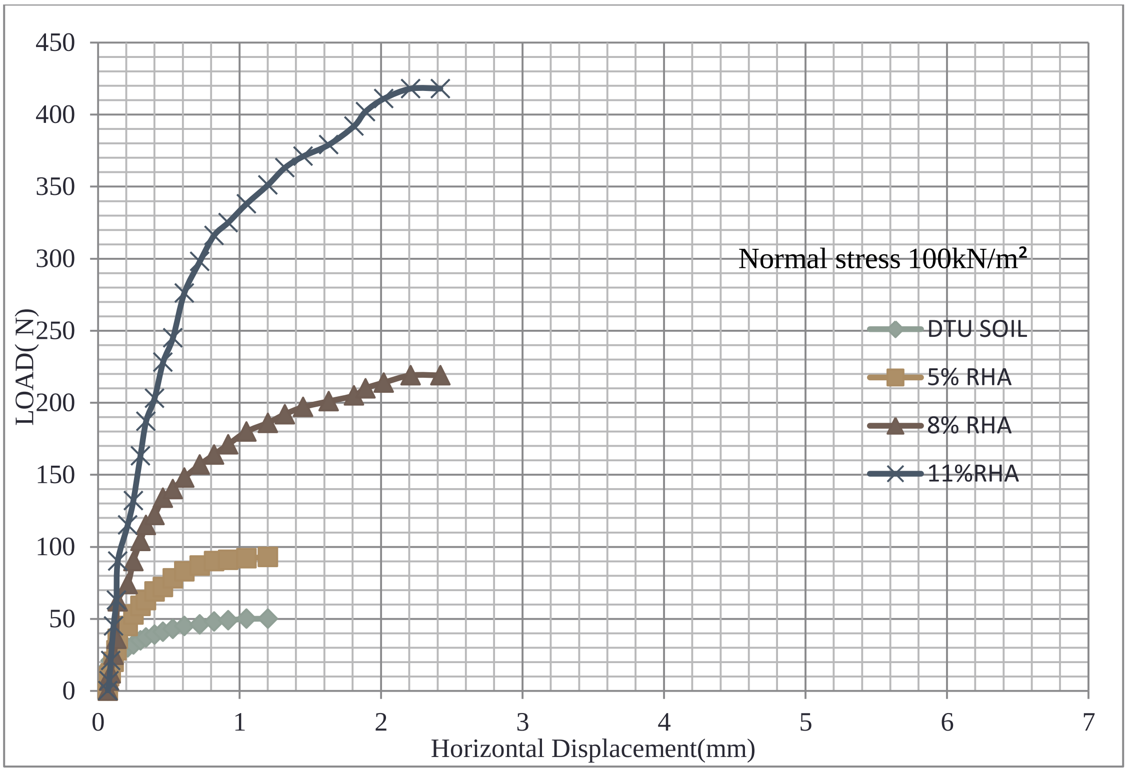

Fig. 5.13 Direct Shear Curve Between Load -Horizontal Displacement of Different % of RHA of Direct Shearat Normal Stress 100kN/m²

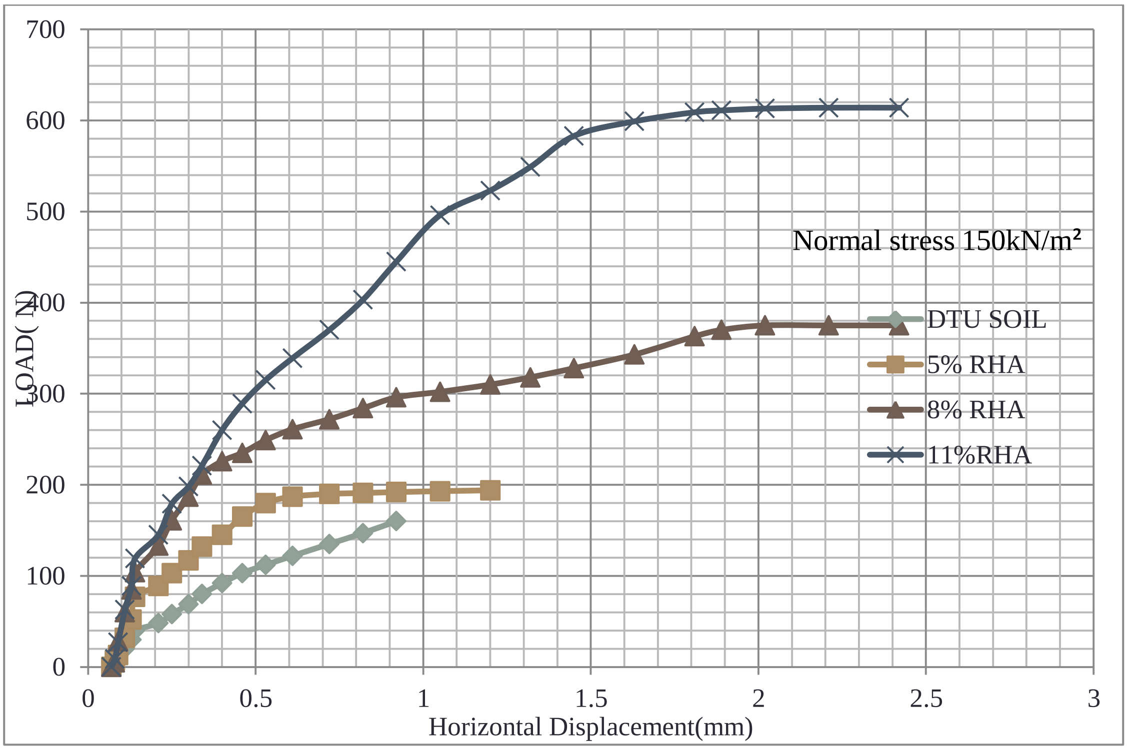

Fig. 5.14Curve Between Load -Horizontal Displacement of Different % of RHA of Direct Shearat Normal Stress 150 kN/m²

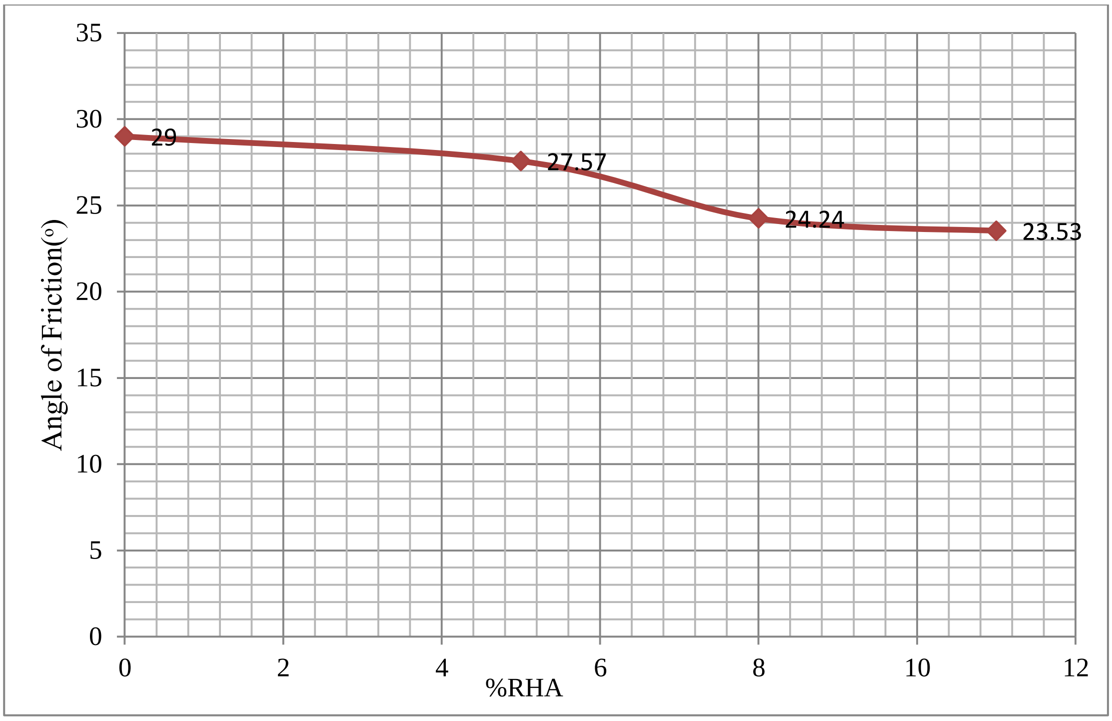

Fig. 5.15Curve between Angle of Friction and % of RHA of Direct Shear

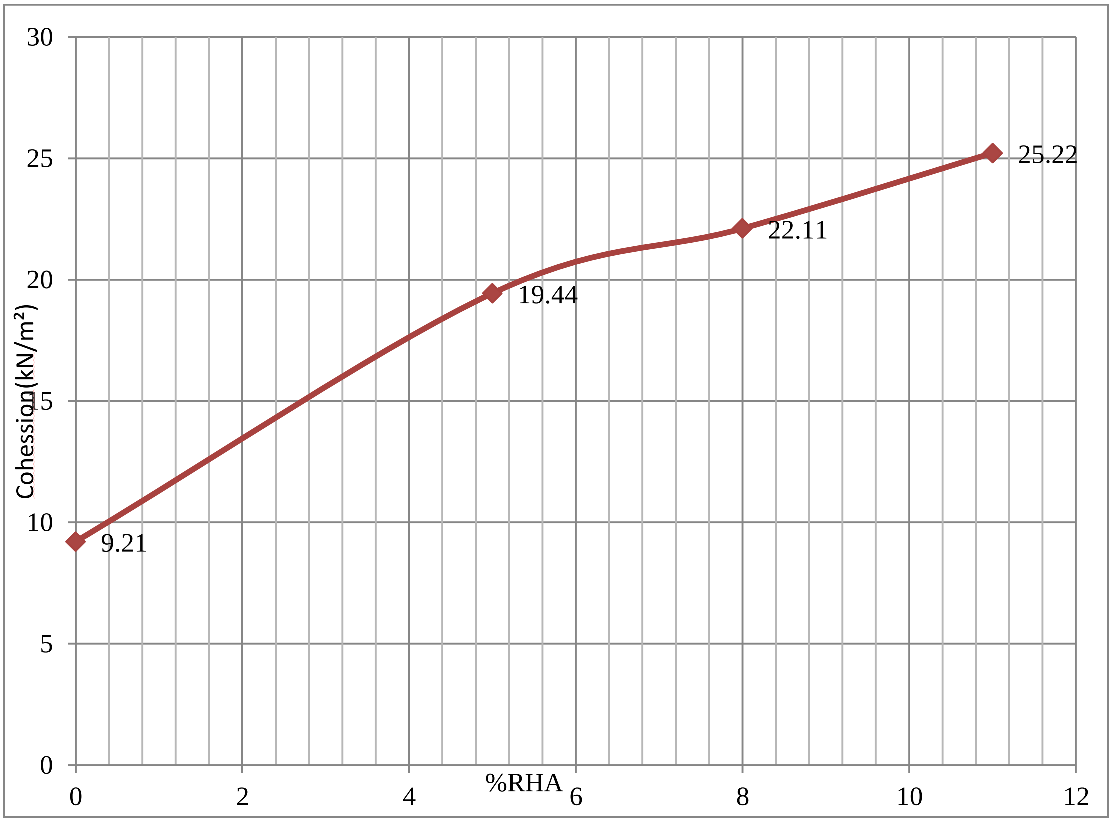

Fig. 5.16Curve between Cohesion and % of RHA of Direct Shear

5.4 TRI-AXIAL TEST

Results are in the form of graphs and tables. Curves are drawn between load and deformation and Stress-Strain.

Table 5.3 Shows Angle of friction and Cohesion Variation with %RHA of Tri-axial test

S.No.	%RHA	ANGLE OF FRICTION(°)	COHESSION(kN/m²)
1	DTU Soil (0%RHA)	26	11.27
2	5%RHA	17.57	29.62
3	8%RHA	13.24	30.79
4	11%RHA	12.56	31.24

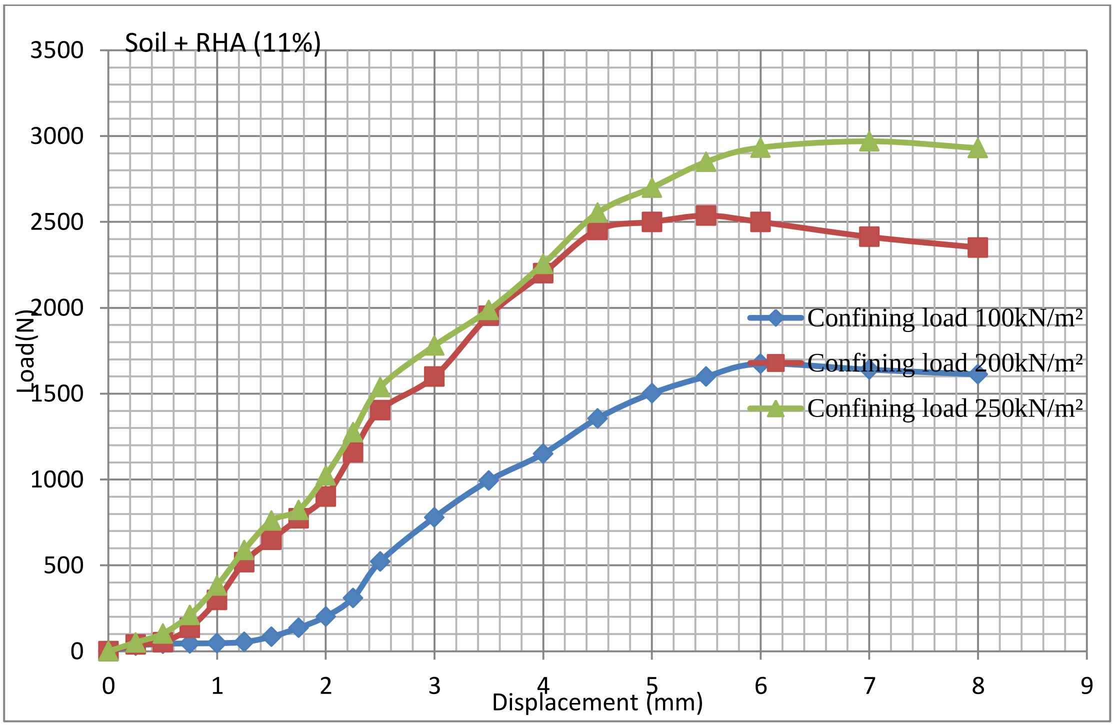

Fig. 5.17 Curve between Load-Horizontal Displacement at11%RHA of Tri-axial Test

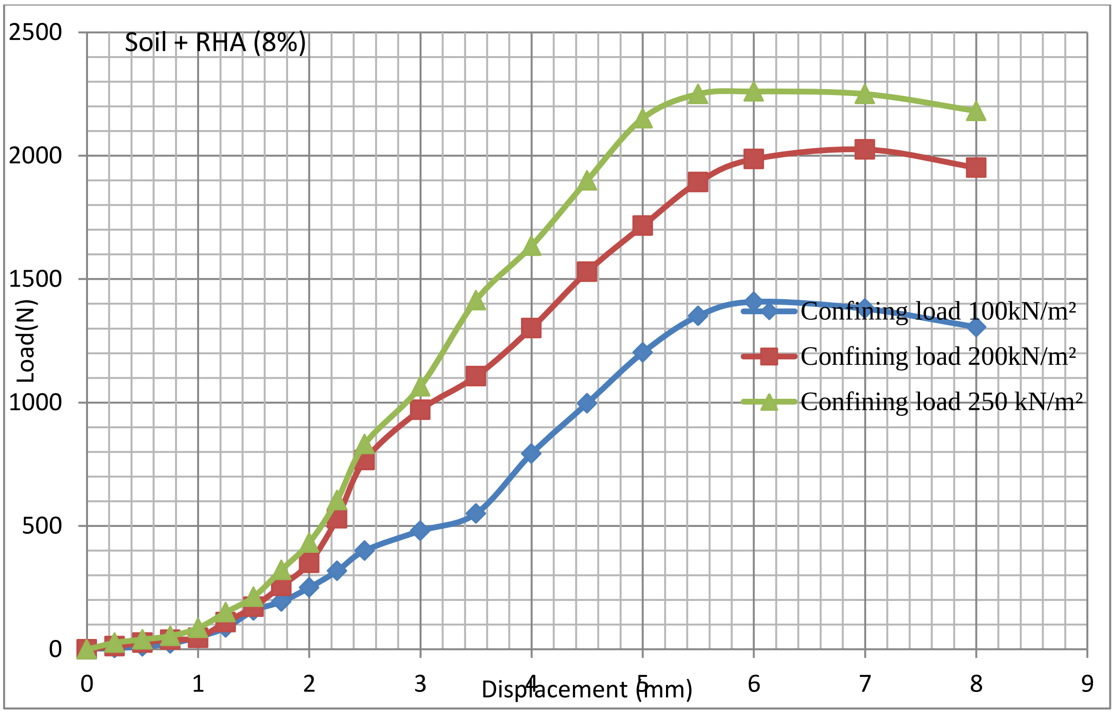

Fig. 5.18 Curve between Load-Horizontal Displacement at8%RHA of Tri-axial Test

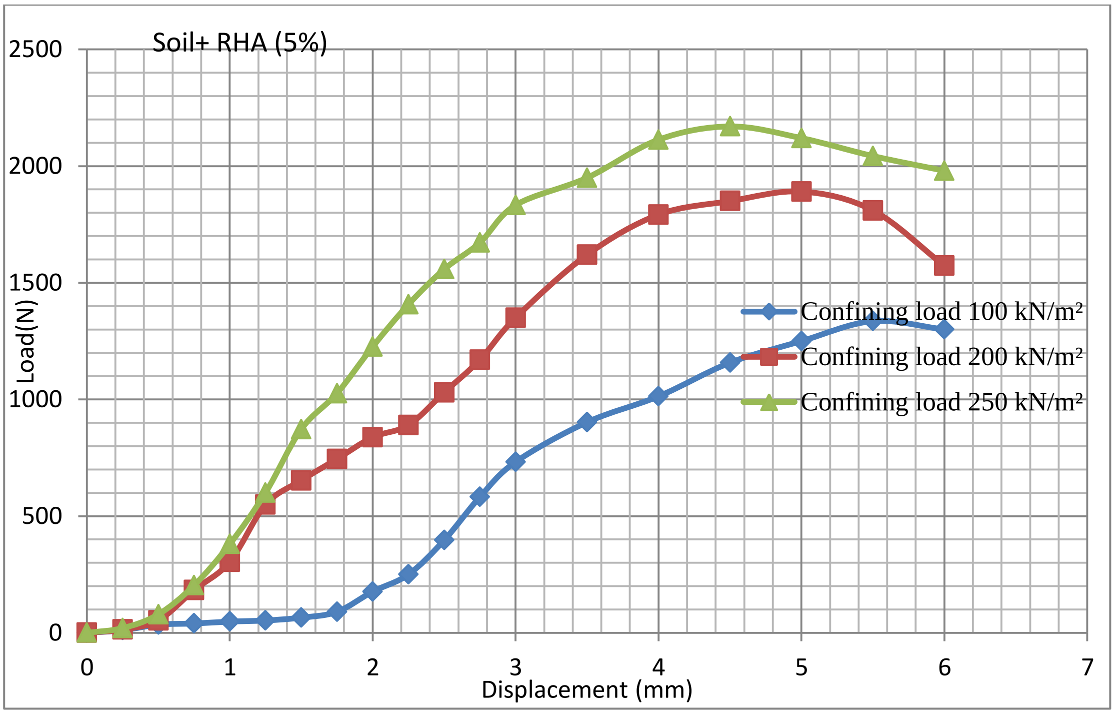

Fig. 5.19 Curve between Load-Horizontal Displacement at5%RHA of Tri-axial Test

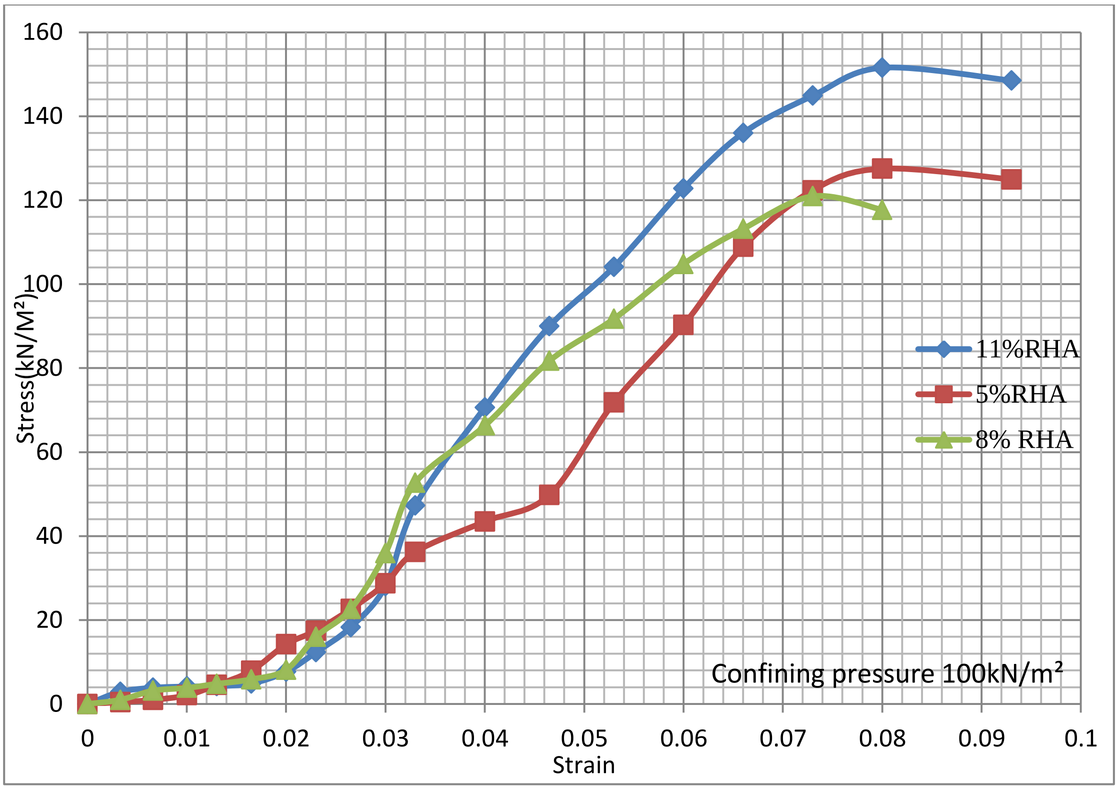

Fig. 5.20 Curve between Stress-Strain at different % of RHA of Tri-axial Test on Confining Pressure 100kN/m²

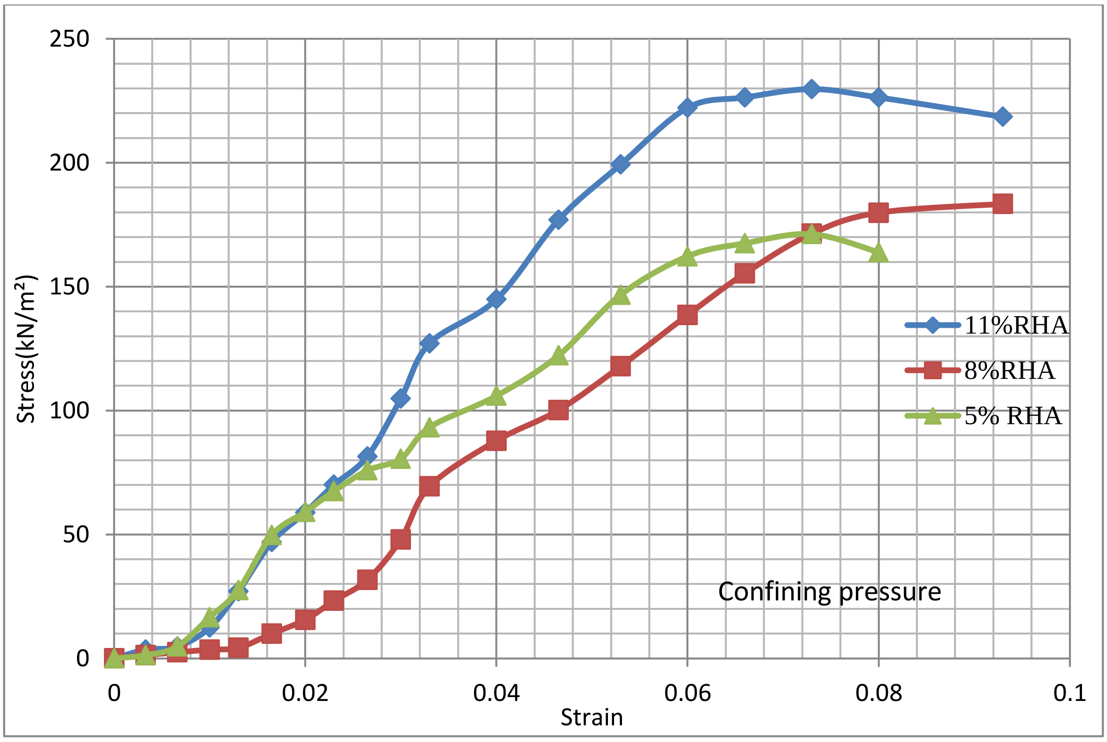

Fig. 5.21 Curve between Stress-Strain at different % of RHA of Tri-axial Test on Confining Pressure 200kN/m²

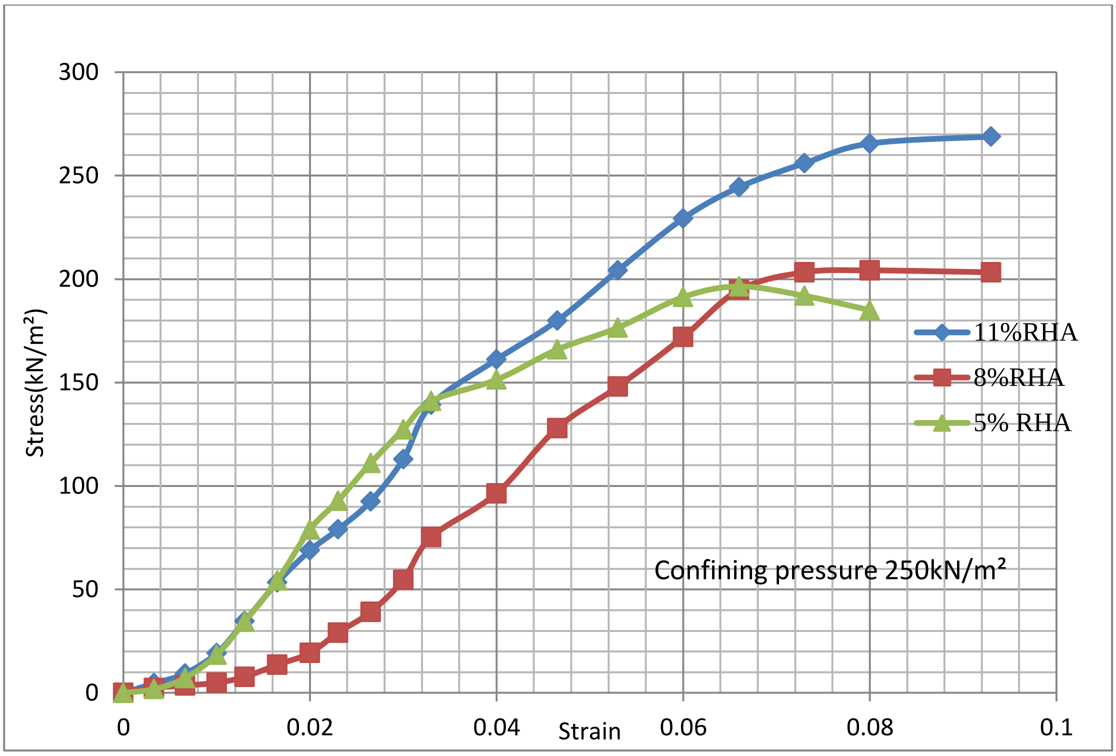

Fig. 5.22 Curve between Stress-Strain at different %RHA on Confining Pressure 250kN/m²

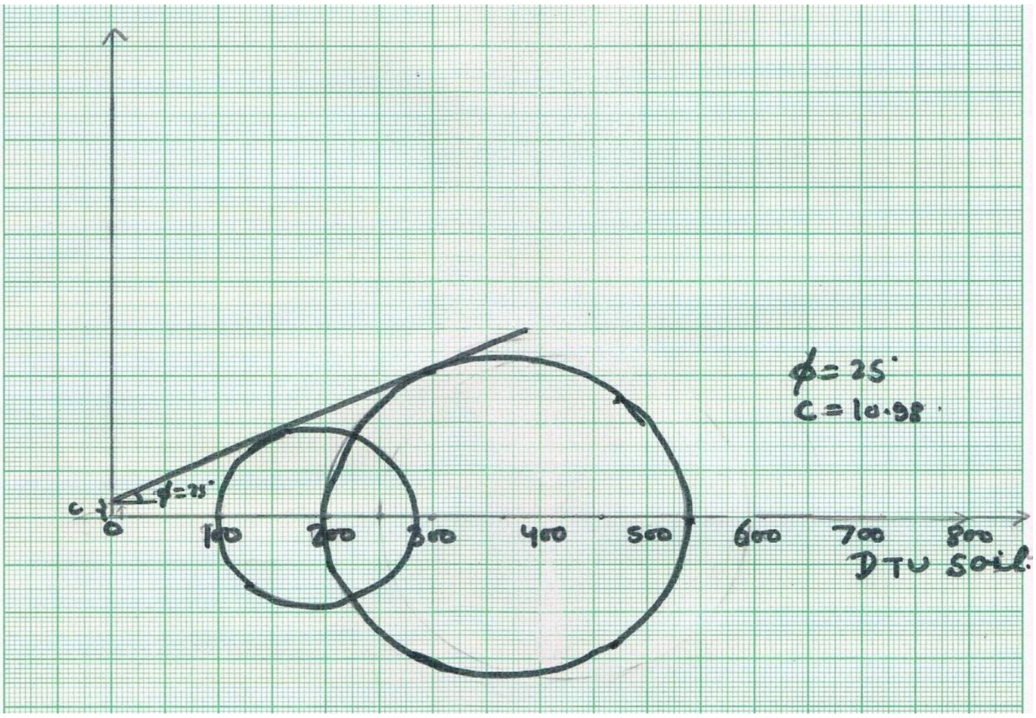

Fig 5.23 Mohr Circle of DTU Soil of Tri-axial Test

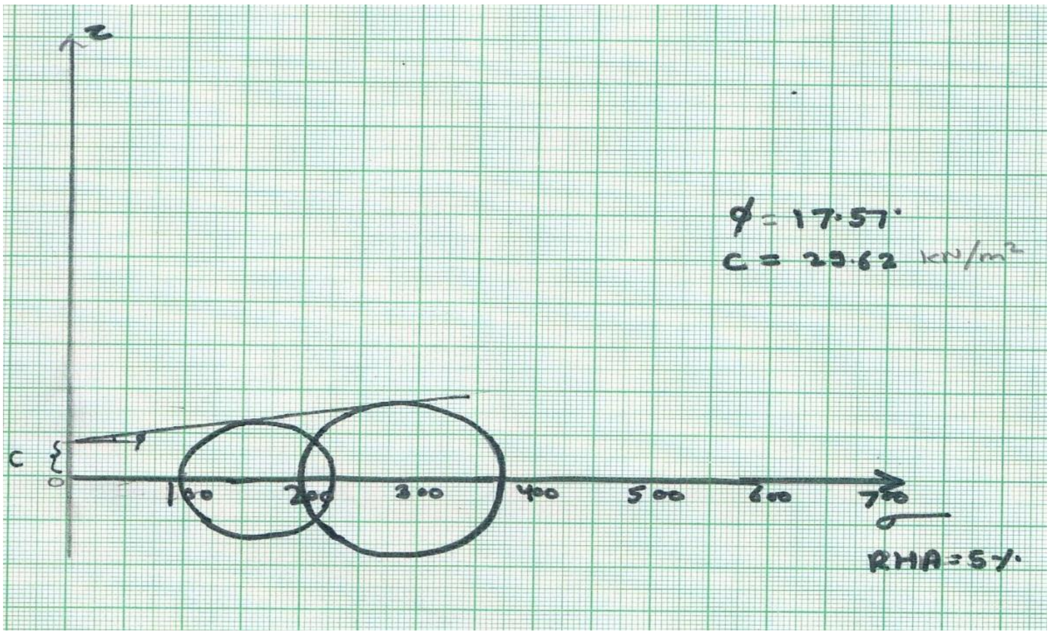

Fig 5.24 Mohr Circle of DTU Soil + 5%RHA of Tri-axial Test

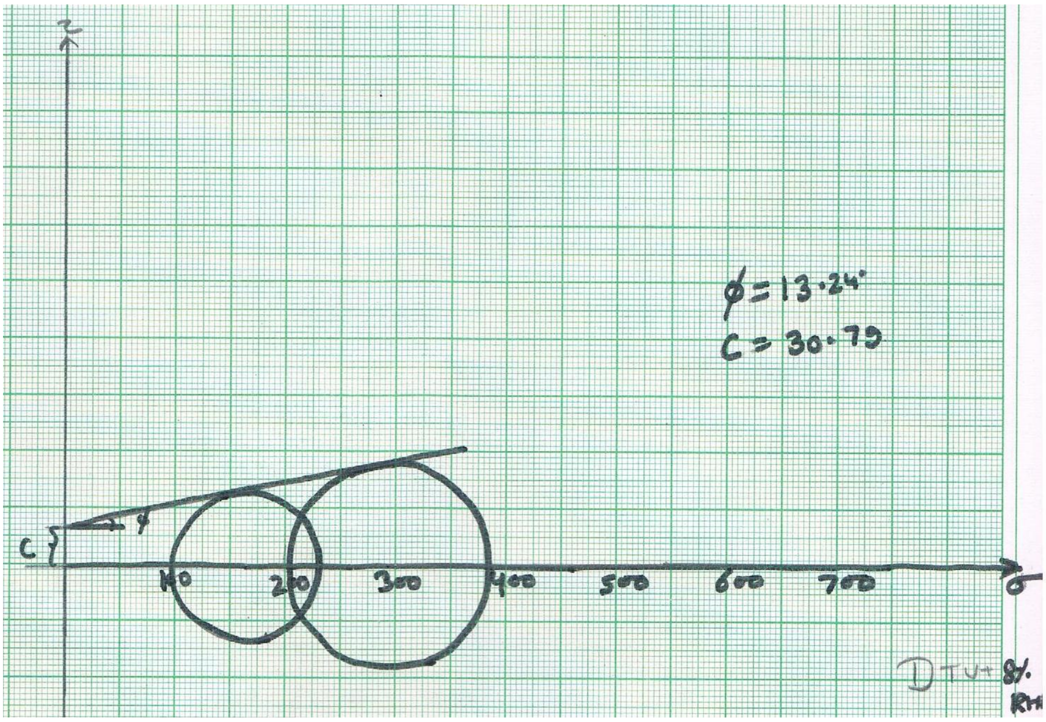

Fig 5.25 Mohr Circle of DTU Soil + 8%RHA of Tri-axial Test

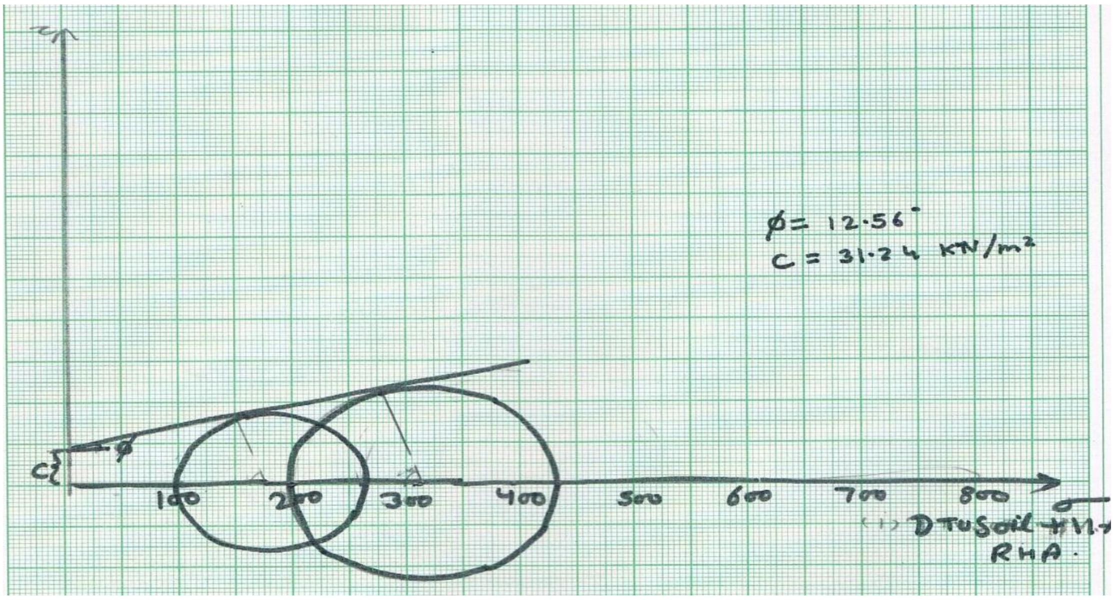

Fig 5.26 Mohr Circle of DTU Soil + 11%RHA of Tri-axial Test

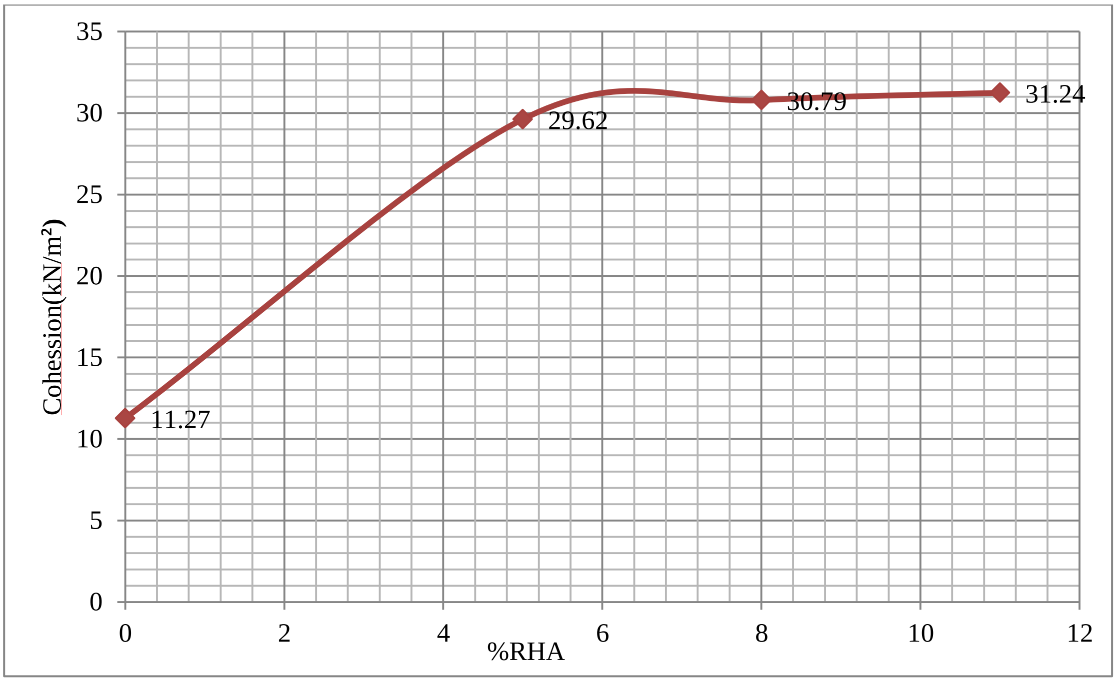

Fig. 5.27 Curve between Cohesion and % RHAof Tri-axial Test

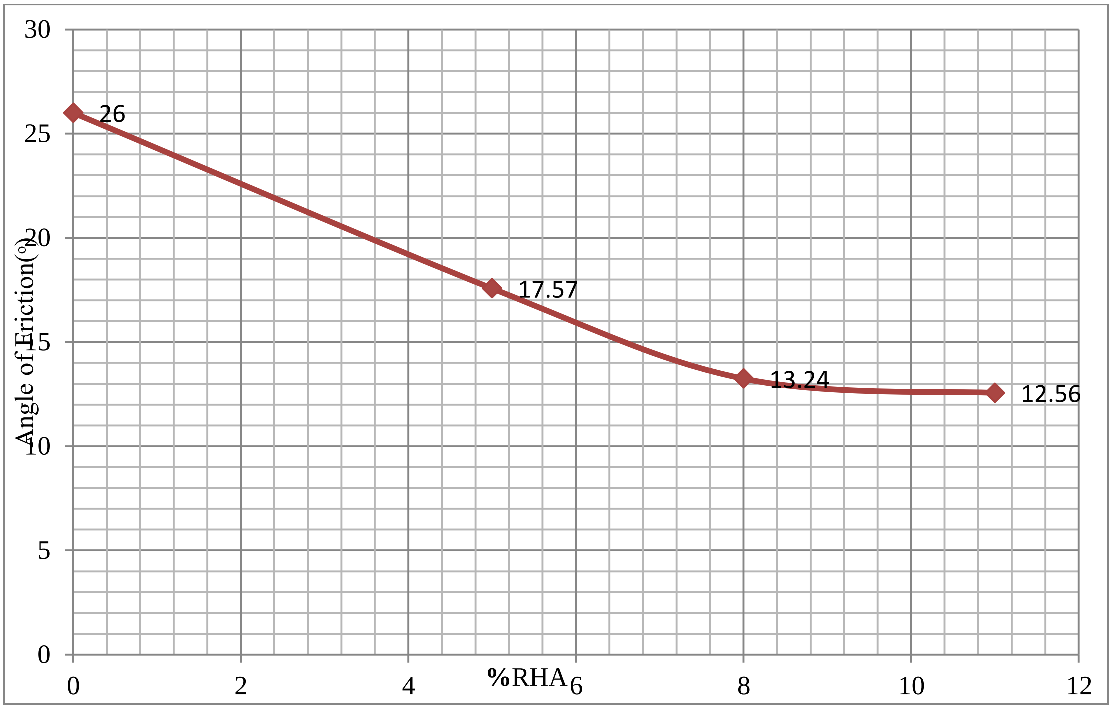

Fig. 5.28 Curve between Angle of Friction and % RHAof Tri-axial Test

5.5 DISCUSSIONS:

5.5.1 COMPACTION CHARACTERISTIC

- From the results obtained from standard proctor test on different mixes of soils: rice husk ash, Maximum dry density of DTU soil is 18.21 kN/m³ which decreases to a value of 16.3kN/m³ with addition of 11% RHA. With addition of 5%, 8% RHA, MDD decreases to a value of 17.6kN/m³, 17.4kN/m³ respectively. This shows decrease in MDD with increase the RHA content.
- Also from the results optimum moisture content of DTU soil is 11%, which increase to a value of 19% with addition of 11% RHA. With addition of 5%, 8%, RHA the value of OMC increases 17.6%, 18.5%, respectively. This shows increases in OMC with increases RHA content.
- OMC increases to max value 42.10% and MDD decreases to max value 10.48%

5.5.2 CALFORNIA BEARING RATIO

- From the results of CBR of different mixes of soil: RHA, CBR value of DTU soil is 5.984 which increases to a value of 11.52 with addition of 11% RHA. With addition of 5%, 8% RHA, CBR value increases to value of 8.755, 10.47, respectively.
- CBR value increases up-to 48.05% of initial value.

5.5.3 DIRECT SHEAR

- From the results it is seen that the value of internal friction is decreases from 29^o of DTU soil to a value of 23.53^o with addition of 11% RHA. With addition of 5%, 8% RHA value decreases to a value of 27.57^o, 24.24^o respectively. This increment due to increase in fineness and increase in internal resistance.
- Value of Cohesion of DTU Soil is $9.21kN/m^2$ which increases to a value of $25.22kN/m^2$ with addition of 11% RHA. With addition of 5%, 8% RHA increases to a value of Cohesion is $19.44kN/m^2$, $22.11\ kN/m^2$
- Value of friction angle decreases max to 18.86% but increases Cohesion to a max 64.3%.

5.5.4 TRI-AXIAL TEST

- From UU test results, it is seen that the value of internal friction is decreases from 26^o of DTU soil to a value of 12.56^o with addition of 11% RHA. With addition of 5%, 8% RHA value decreases to a value of 17.57^o, 13.24^o respectively. This increment due to increase in fineness and increase in internal resistance.
- Value of Cohesion of DTU Soil is $11.27kN/m^2$ which increases to a value of $31.24kN/m^2$ with addition of 11% RHA. With addition of 5%, 8% RHA increases to a value of Cohesion is $29.62kN/m^2$, $30.79\ kN/m^2$
- Value of friction angle decreases max to 49.07% but increases Cohesion to a max 63.92%.

CHAPTER 6

CONCLUSION AND FUTURE SCOPE

6.1 CONCLUSION

In this thesis, shear parameter, CBR value of Soil: RHA mixes has been studied. The following conclusion has been made from the results obtained from experiments

1. With increase RHA content maximum dry density decreases of soil: RHA and optimum moisture content increases. The fall in density continue with addition of 0% to 11% RHA. Similarly moisture content increases.

2. The CBR value increases with increases RHA content. It continuously increases with addition of 0% to 11% RHA.

3. From the results of direct shear, Cohesion increases with increase the RHA content while Angle of friction decreases with increase the value of RHA content. Cohesion increases continuously with addition of 0% to 11% RHA.

4.From the results of Tri-axial UU test Cohesion increases with increase the RHA content while Angle of friction decreases with increase the value of RHA content. Cohesion increases continuously with addition of 0% to 11% RHA.

6.2 SUGGESTIONS FOR FURTHER SCOPE OF STUDY

Many researches can help in improving the geotechnical properties of soil-RHA mixes, which can be useful for using waste materials as replacement of natural resources. These suggestions may prove to be boon for the best utilization of waste materials to best by further research.

1. Based on these laboratory tests further test in field should also be conducted to correlate the values of laboratory to field.

2.Strength and durability tests are required to be investigated for 28 days & 56 days of curing to know the geotechnical properties.

3. Durability on the soil- RHA mixture on the basis of freezing and thawing should be investigated.

REFERENCES

1.Khandaker M. Anwar Hossain(2011), M.ASCE Stabilized Soil Incorporating Combination Of Rice Husk Ash And Cement Kiln Dust. *Journal of the Materials in Civil Engineering @ ASCE / SEPTEMBER 2011*

2. Chai Jaturapitakkul and Boonmark Roongeung (2008) Use Of Chemically Stabilized Soil As Cusion Material Below Light Weight Structures Founded On Expensive Soil. *Journal of the Materials in Civil Engineering @ ASCE SEPTEMBER/OCTOBER 2003*

3. SabatAkshaya kumar (2010), "Effect of Marble Dust on Strength of Rice Husk Ash Stabilized Expansive Soil."*International journal of the civil and structural engineering.*

4.Aihassan, Musa & Mohammed, Alhaji, "Effects of Rice Husk Ash on Cement Stabilized Laterite."*Leonardo Electronic Journal of the Practices and Technologies ISSN 1583-1078*

5. Brooks, Robert, M., (2009), "Soil Stabilization Using Fly Ash And Rice Husk Ash". *International Journal of the Research and Reviews in Applied Sciences.*

6. G.V.Rama Subbarao (2011) "Industrial Waste in Soil Improvement."*ISRN Civil Engineering Volume (2011), Article ID 138149, 5 pages.*

7. Sarkar Gryton (2012) "Interpretation of Rice Husk Ash on Geotechnical properties of cohesive soil." *Global journal of research engineering.*

8. Rao Koteswara, (2012), "Stabilization of Soil Using RHA, Lime and Gypsum."*International Journal of the Engineering Science & Technology.*

9. Rao Koteswara, (2012), "The Effects of Ferric Chloride and RHA in the Stabilization of Expansive Soils for Pavement Subgrades." *International Journal of the Engineering Science & Technology.*

10. Zemke Nick (2009), "Rice Husk Ash" *Polytechnic State University California.*

11. Nair G Deepa (2008) "Structural Investigation Relating To Pozzolonic Activity Of RHA, *Cement And Concrete Research, Vol. - 38.*

12. Ramakrishna A.N. and Kumar Pradeep (2006) "Influence of RHA and cement on geotechnical properties of black cotton soil."*International journal of the civil structural engineering.*

13. Roy T.K. et al (2009) "Effect of lime on properties of sub grade of roads with addition of RHA."*IGC, Guntur.*

14. Mehta, P.K. (1977), "Properties of blended cements made from Rice Husk Ash". *ACT Journal. S*

15. Hwang & Chandra, (2009)“Research on Production of Rice Husk”*International Journal of the Pharmaceutical Sciences Review and Research*

16. Jha, J.N. & Gill, KS. (2006) “Effect of Rice husk ash on lime Stabilization”. *Journal of Institution of Engineers (India).*

17. Rahman, M.A., (1987), “Effects of cement —rice husk ash mixtures on geotechnical properties of lateritic soil” *Soil and Foundations.*

18. Rahman, M.A., (1987),” A comparative study of potentials of rice husk ash on cohesive and cohesion less soils.” *Journal of Environment and Building.*

19. Basha, E.A., Hashim, R., Mahmud, H.B.& Muntohar, A.S., (2004) “Stabilization of Residual soil with Rice husk ash and cement”. *Original research article Building Materialand construction.*

20. Datta, R.K., et al, (1982), “Some alternate binders Based on Rice Husk & other cheap materials”. *National seminar on science & technology and Building material, Institute of Engineers (India), Roorkee.*

21. Setyo, Muntohar, (2002), “Utilization of Uncontrolled Burnt Rice Husk Ash in Soil Improvement”. *Journal of Construction and Building Material.*

22.Megat Johari Megat Mohd Noor, Azian Abdul Aziz & RadinumarRadinSuhadi “Effects of Cement- RHA mixtures on compaction, strength and durability of Maleka series lateritic soil”.*Journal of the Applied Science and Technology.*