"STABILIZATION OF BLACK COTTON SOIL USING EGG SHELLS"

A PROJECT

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

BACHELOR OF TECHNOLOGY
IN
CIVIL ENGINEERING
Under the supervision of
Niraj Singh Parihar
(Assistant Professor)

By

Tushar Rawat (121682)

to

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY,WAKNAGHAT SOLAN – 173 234
HIMACHAL PRADESH INDIA

ABSTRACT

Nowadays, considerable attention has been paid to the utilization of alternative materials, which bear higher engineering quality than traditional materials and are financially affordable. Soil is one of the most important materials used in a variety of construction projects including earth canals and earth dams. The fact that soil may provide all the resistance characteristics necessary for a project illustrates the importance of various methods used to improve soil quality. Black cotton soils are highly clay soil grayish to blackish in color. They have high expensive characteristics. Black Cotton soils have low shrinkage limit and high optimum moisture content. It is highly sensitive to moisture changes, compressible subgrade material. These damages typically take an irreparable toll on structures, which further clarifies the importance of soil improvement. Considering millions of tons of waste produced annually across the country, which not only poses the problem of disposal but also adds to environmental contamination and health risks, utilization of such refuse and industrial wastes and their subsidiary products as alternatives to construction materials may effectively contribute to environmental preservation and minimization of their adverse effects on the environment. In the present study, eggshell powder was used as a waste, to combine with soil and the properties of clay soil were investigated in different mixture proportions. Then the properties of soils including liquid and plasticity limits as well as plasticity index, dry density, optimum moisture content and shear strength, which were already measured, were compared with those of the experimental specimens mixed with eggshell powder in different proportions. Since the introduction of egg shell improves the engineering behaviour of soils, this review work exposes those qualities and applications that make quarry egg shell powder a good replacement or admixture during soil improvement and for a more economic approach. In the present study, optimum amount of egg shells were found to be 6%.

CERTIFICATE

This is to certify that the work which is being presented in the project title **"Soil Stabalisation of Black Cotton Soil Using Egg Shells"** in partial fulfillment of the requirements for the award of the degree of Bachelor of technology and submitted in Civil Engineering Department, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by Tushar Rawat (121682) during a period from July 2015 to December 2016 under the supervision of **Niraj Singh Parihar,** Assistant Professor, Civil Engineering Department, Jaypee University of Information Technology, Waknaghat.

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

Date:

Dr. Ashok Kumar Gupta
(Professor & Head of Department)
Civil Engineering Department
JUIT Waknaghat

Niraj Singh Parihar
(Assistant Professor)
Civil Engineering Department
JUIT Waknaghat

ACKNOWLEDGEMENT

I take this opportunity as a privilege to thank all individuals without whose support and guidance selection of project in this stipulated period of time was an impossible task. First and foremost I would like to express my deepest gratitude to my project guide Mr. NIRAJ SINGH PARIHAR, Department of Civil Engineering, Jaypee University of Information Technology, Solan. His invaluable support, guidance, motivation and encouragement made project a simple task. His readiness for consultation at all times, his educative comments and inputs, his concern has been extremely helpful.

I am grateful to Dr. Ashok Kumar Gupta, Head of the Department of Civil Engineering, Jaypee University of Information Technology, Solan, for his valued suggestions and inputs during course of the project work.

I would also like to thank all professors and lecturers for their generous help in various ways for the completion of this project. I also extend my thanks to my fellow student for their friendly co-operation.

LIST OF GRAPHS

LIST OF TABLES

1. INTRODUCTION

1.1 General Introduction

Black Cotton soils are found in extensive region of Deccan trap in India. They are of variable thickness, underlain by black sticky material known as “black soil”. The soil for this study is taken from Maharashtra. The black cotton soil are of expansive nature, when comes in contact with water, it either swells or shrinks and results in moments to the structure which generally are not related to the direct effect of loading. On account of its high volumetric changes it is not suitable for construction. It swells and shrinks excessively due to presence of fine clay particles. It can also lead to differential settlement. Over the last years, environmental issues have prompted engineering to use alternatives to some constructional materials. Both earthwork researchers and engineers have paid considerable attention to using wastes in soil stabilisation and improving physical and mechanical properties of soil. This has help to remove environmental problems as well as contribute to the economy. The most common type of stabilisation are lime stabilization, cement, chemical, bitumen and salt stabilization.

In this study, the chemical stabilization using egg shells on black cotton soil are carried out. First, the classification of soil is done with the help of wet sieving, liquid limit and plastic limit tests. Then the focus is shifted on the engineering strength properties of soil .The experiment done for this purpose are unconfined compressive strength test, light compaction test and direct shear test. The values of different test corresponding to different percentage of egg shells are duly noted, plotted and explicitly interpreted. The mining of egg shells is ranging from (0 to 10) % at the interval of 2%.The eggshells are mostly made up of calcium carbonate and membrane is valuable protein. The shells obtained for this study are of boiled eggs passing through 425 micron sieve.

1.2 Significance

In geotechnical practice, there are many cases when it is necessary to improve soils as replacement is not possible all the times. In India about 51.8 million hectares of the land are not covered with black cotton soil. These are expansive in nature and pose several challenges for civil engineers worldwide. They have low shrinkage and high optimum moisture content. They are highly sensitive to moisture and mostly results in differential settlement .These damages typically take the toll on the structures, which further clarifies the significance of this study. In this work attempt has been made to use waste like egg shells (which are produced in huge amount in daily basis) to improve the working parameters of the black cotton soil, thus making it useful for the pavement design and other constructional purposes.

2. <u>LITERATURE REVIEW</u>

- **F.Z. Aissiou1, A. Nechnech1, and H. Aissiou**, 2013 had a which work consists of the presentation of the results of a laboratory study on the treatment of a clay soil in the area of the Inhabitant of Algiers by incorporation of various contents extinct lime. For that, physical and mechanical tests such as (unconfined compression test, classification tests of the grounds in 1st place and shear test) were carried out and the results obtained highlight an unquestionable and definitely better improvement of the characteristics geo techniques such as the resistance of compression, resistance of shearing (angle of friction and cohesion) etc.

- **O.O. Amu et al** in 2005 studied the effect of eggshell powder on the Stabilizing Potential of Lime on an Expansive Clay Soil. He conducted series of tests to determine the optimal quantity of lime and the optimal percentage of lime-ESP combination. The optimal quantity of lime was gradually replaced with suitable amount of eggshell powder. Results indicated that lime stabilization at 7% is better than the combination of 4% ESP + 3% lime.

- **Hossein Moayedi, Bujang B.k. Huat, Falemeh Moyadi, Afshin Asadi and Alireza Parsaie** in 2008 explained that soft clay soil can be stabilized by the adding of small percentages, by weight, of sodium silicate, thereby producing an improved construction material and enhancing many of the engineering properties of the soil. In order to explain such improvements, one of the most frequently occurring minerals in clay deposits, namely, kaolinite was subjected to a series of tests. As sodium silicate stabilization is most often used in relation to construction, the tests were chosen with this in mind. As results, addition of 5mol/L sodium silicate showed the highest unconfined compressive strength (UCS) results. However the effect of chemical molarities on UCS become less and less, with longer curing time.

- **Muthu Kumar, Tamilarasan V S**, 2014 investigates the effect of egg shells in the index and engineering properties of soil. It show that optimum usage of eggshell powder added to the soil was 3% and the delayed compaction effect leads to increase in unconfined compressive strength of soil when compared to the without delay in compaction.

3. OBJECTIVE

.

- To improve the unconfined compressive strength of the soil to significant amount.
- To improve the shear strength of soil using egg shells.
- To find out the optimum content of egg shells for mixing with black cotton soil.

4. <u>TEST PERFORMED</u>

4.1 Wet Sieving:

Objective: To find the particle size of the soil specimen using Hydrometer.

Equipments & Apparatus:

- Two 1000 cc measuring cylinder and distilled water.
- Sodium hexa-meta phosphate and sodium carbonate.
- 75 micron sieve
- Hydrometer
- Thermometer

Procedure:

- Took about 700 ml of water in one measuring cylinder. Immersed the hydrometer in the cylinder. Took the reading and determine the volume of hydrometer.
- Measured the distance between the neck and the bottom of the bulb. Record it as the height of the bulb.
- Now transferred the soil suspension to a 75 micron sieve .Used the jet stream of distilled water and wash the soil specimen.
- Did the dry sieving of soil retained on sieve and wet sieving on soil passing through it.
- Added chemicals and soil passing through the sieve and water to make the volume up to 1000 ml.
- Immersed the hydrometer and took readings corresponding to 0.5,1,2,4,8,16,30,60,120,240,480 and1440 min.
- Then the particle size distribution curve was plotted.

4.2 **Determination of specific gravity (IS 2720 (PART III)**

Objective: To determine the specific gravity of soil by pycnometer method.

Equipment & Apparatus:

- Pycnometer
- Sieve(4.75 mm)
- Vacuum pump
- Oven
- Weighing balance
- Glass rod

Preparation Sample: After receiving the soil sample it is dried in oven at a temperature of 105 to 1150C for a period of 16 to 24 hours.

Procedure:

- Pycnometer was dried and weighed with its cap(W1)
- About 200 g to 300 g of oven dried soil passing through 4.75mm sieve was poured into the pycnometer and weighed again (W2).
- Water was added to cover the soil and screwed on the cap.
- Pycnometer was shaked well and connected to the vacuum pump to remove entrapped air for about 10 to 20 minutes.
- After the air had been removed, the pycnometer was filled with water and weighed it (W3).
- Pycnometer was cleaned by washing thoroughly.
- Cleaned pycnometer was filled completely with water up to its top with cap screw on.
- Pycnometer was weighed after drying it on the outside thoroughly (W4).

4.3 Liquid Limit (IS: 2720 (PART V)-1985)

Objective: To determine the liquid limit of soil using casagrande apparatus.

Equipment & Apparatus:

Balance (0.01g accuracy)
Sieve [425 micron]
Cassagrande apparatus
Oven

Preparation Sample:

After receiving the soil sample it is dried in air or in oven (maintained at a temperature of 600C). If clods are there in soil sample then it is broken with the help of wooden mallet. The soil passing 425 micron sieve is used in this test.

Procedure:

- About 120 gm. of air dried soil from thoroughly mixed portion of material passing 425 micron IS sieve was obtained.
- Distilled water was mixed to the soil thus obtained in a mixing disc to form uniform paste. The paste should have a consistency that would require 30 to 35 drops of cup to cause closer of standard groove for sufficient length.
- A portion of the paste was placed in the cup of casagrande device and spread into portion with few strokes of spatula. It was trimmed to a depth of 1 cm at the point of maximum thickness and excess of soil is returned to the dish.
- The soil in the cup was divided by the firm strokes of the grooving tool along the diameter through the centre line of the follower so that clean sharp groove of proper dimension was formed.
- Then the cup was dropped by turning crank at the rate of two revolutions per second until two halves of the soil cake come in contact with each other for a length of about 12 mm. by flow only.
- The number of blows required to cause the groove close for about 12 mm. was recorded.
- A representative portion of soil was taken from the cup for water content determination.
- The test was repeated with different moisture contents at least 3 times for blows between 10 and 40.

4.4 Plastic Limit (IS: 2720 (PART V)-1985)

Objective: To determine the plastic limit of soil.

Equipment & Apparatus:

- Oven
- Balance (0.01 g accuracy)
- Sieve [425 micron]
- Flat glass surface for rolling

Preparation of Sample:

After receiving the soil sample it is dried in air or in oven (maintained at a temperature of 600C). If clods are there in soil sample then it is broken with the help of wooden mallet. The soil passing 425 micron sieve is used in this test.

Procedure:

- A soil sample of 20 gm. passing 425 micron IS sieve was taken.
- It was mixed with distilled water thoroughly in the evaporating dish till the soil mass becomes plastic enough to be easily moulded with fingers.
- It was allowed to season for sufficient time, to allow water to permeate throughout the soil mass. 10 gms. of the above plastic mass is to be taken and is to be rolled between fingers and glass plate with just sufficient pressure to roll the mass into a thread of uniform diameter throughout its length. The rate of rolling shall be between 60 and 90 stokes per minute.
- The rolling was continued till the thread becomes 3 mm. in diameter.
- The soil is then kneaded together to a uniform mass and rolled again.
- The process was continued until the thread crumbled with the diameter of 3 mm.
- The pieces of the crumbled thread are collected in an air tight container for moisture content determination.

Plasticity Index:

- The plasticity index was calculated as the difference between its liquid limit and plastic limit.
- Plasticity Index (Ip) = Liquid Limit (W_L) – Plastic Limit (Wp)

4.5 Light Compaction Test (IS : 2720 (PART- VII)-1980)

Objective: Determination of optimum moisture content and maximum dry density of plain and egg shells mixed black cotton soils.

Equipment& Apparatus:

- Cylindrical metal mould – 100mm dia and 1295.90 cm^3 volume and conform to IS: 10074 -1982.
- Balances
- Oven
- Container
- Sieve -4.75mm and 19mm
- Steel Straight egde
- Mixing Tools

Procedure:

- A 5kg sample of air dried soil passing through the 19mm IS test sieve was taken. The sample was mixed thoroughly with a suitable amount of water.
- The mould of 1295.90 cm^3 capacity with base plate attached was weighed to the nearest 1 gm.
- The mould was placed on a solid base, such as 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 2.6kg rammer dropped from the height of 310mm above the soil. The blows was distributed uniformly over the surface of each layer .The operator ensures that the tube of the rammer was kept clear of soil so that the rammer always falls freely.
- The extension was removed and the compacted soil was levelled off carefully to the top of the mould by means of straightedge. The mould and soil was 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 determined.
- The remainder of the soil specimen was broken up, rubbed through the 19mm IS test sieve, and then mixed with the remainder of the original sample. Suitable increments of water was added successively and mixed into the sample and the above procedure from operation was repeated for each increment of water added.
- The same procedure was repeated for different mixed proportion of black cotton soil and egg shells viz. 2, 4, 6, 8 and 10%.

4.6 Unconfined Compressive Strength (IS:2720(PART X)-1991)

Objective: To determine the unconfined compressive strength of soil

Equipment& Apparatus:

- Compression device suitable for unconfined compression test (motorised or manual).
- Sample extractor.
- Proving ring of capacity 500 N and 1000 N.
- Dial gauges with 0.01 mm least count.
- Knife.
- Split mould of 3.8 cm diameter and 7.6 cm long.

Procedure:

- The sample was carefully ejected from the linear of spine spoon sampler of standard penetration test, and then it was cut into pieces with a length approximately twice its diameter. The initial length and diameter of the sample was measured.
- The two ends of the sample was trimmed, shaped and placed on the conical bottom plate loading device.
- The load dial gauge and strain dial gauge was set to zero.
- The load was applied by raising the bottom plate of the load device.
- The load dial gauge and strain dial gauge reading was noted after every 30 seconds.
- The sample was compressed until it fails or a vertical deformation of 20%.
- The failure angle was measured.

4.7 **Direct Shear Test**:

Objective: To determine the value of internal friction angle and cohesion of the soil.

Equipment &Apparatus:

- Direct Shear Box
- Dial Gauge and Balances

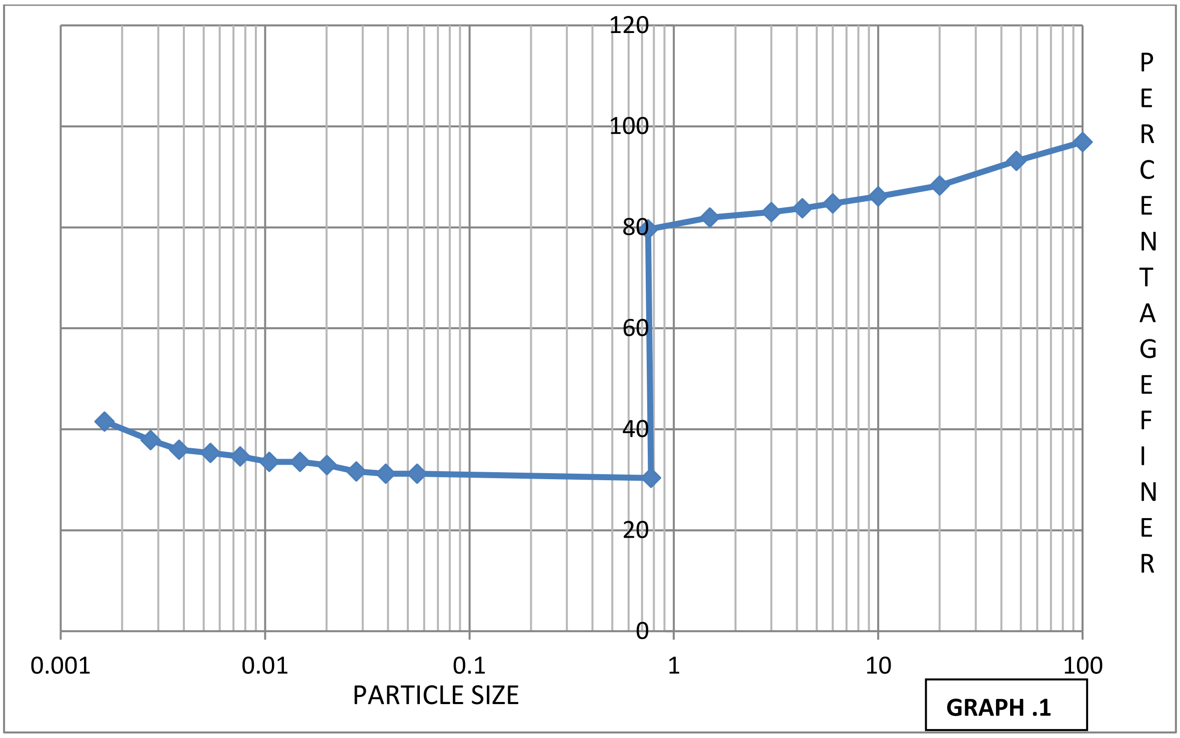
Procedure:

- Assembled the box by putting lower grating stone and then the soil, followed by upper grating plate and loading block.
- Applied the desired normal load and removed the shear pin.
- Applied the dial gauge and recorded their initial readings.
- Started the motor. Took the reading of the shear force and volume change till failure.

5. RESULT

1. Wet Sieving:

Particle size distribution curve has been plotted in graph-1.The value for this graph is given in Table1 and Table2. Particle size is on x axis in log terms and percentage finer on y axis. The specific gravity of soil



2. Specific Gravity Test:

W1 = Wt. of bottle = 449gm

W2 = Wt. of bottle + dry soil = 549gm

W3 = Wt. of bottle+ soil+ water =1227gm

W4 = Wt. of bottle +water =1169 gm.

Specific Gravity =(W2-W1)/(W2-W1)-(W3-W4)= 2.38

This low value of specific gravity infers that the black cotton soil that is used for study is having organic content in it.

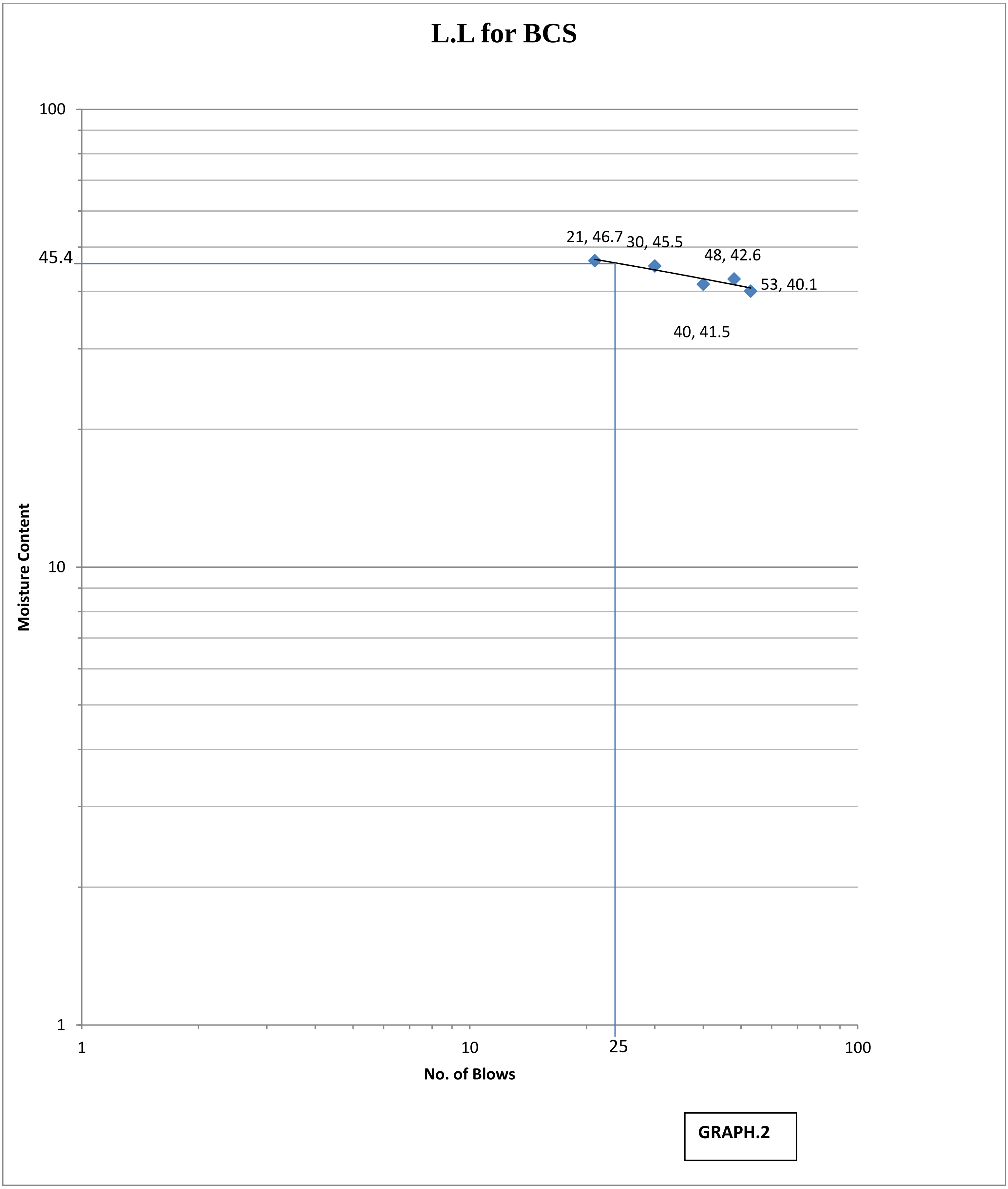
3. **<u>Liquid limit test</u>**: A ‘flow curve’ has been plotted on semi-logarithmic graph representing water content in arithmetic scale and the number of drops on logarithmic scale.

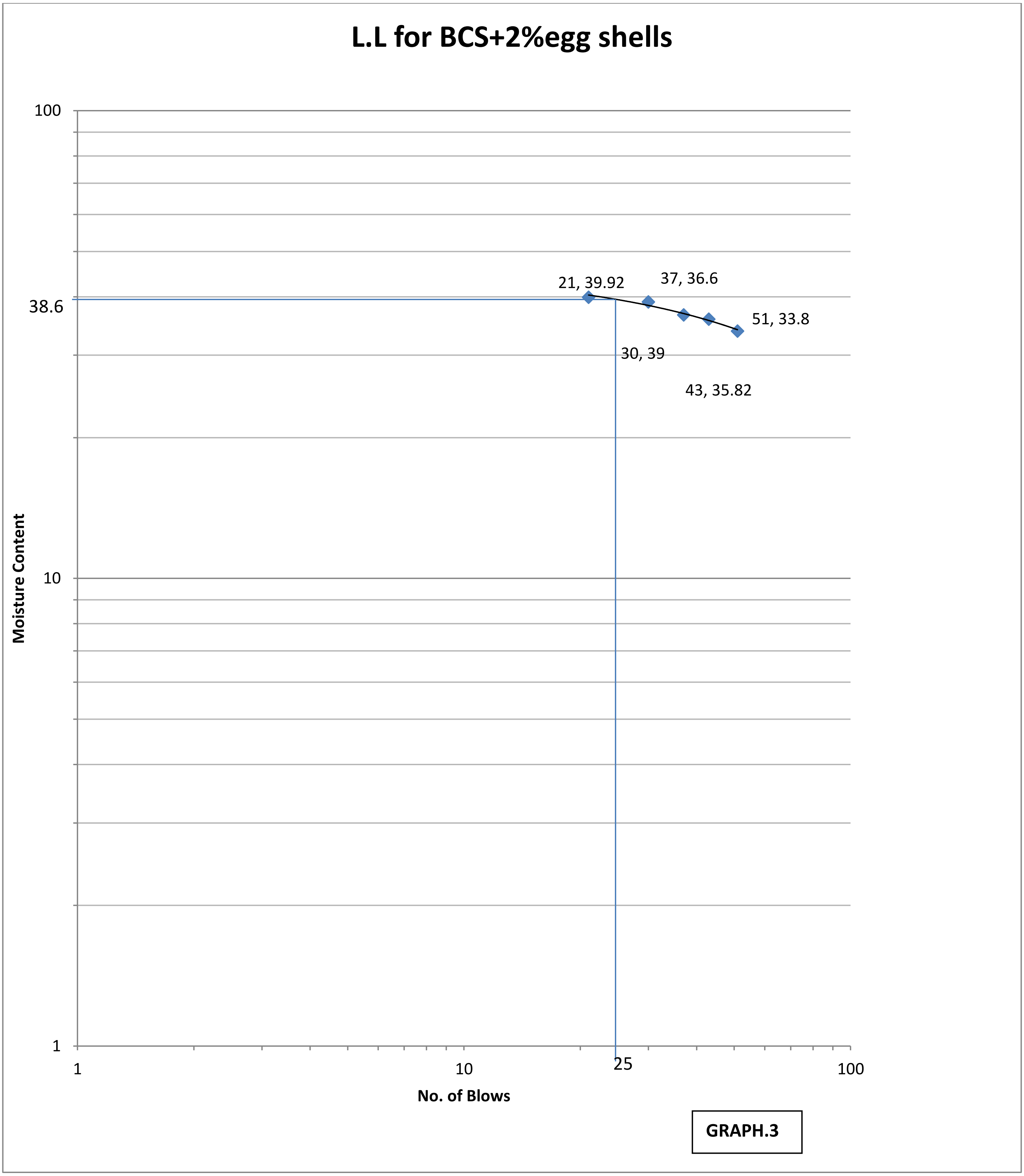
   The flow curve is a straight line drawn as nearly as possible through four points. The moisture content corresponding to 25 blows as read from curve is the liquid limit of that soil.

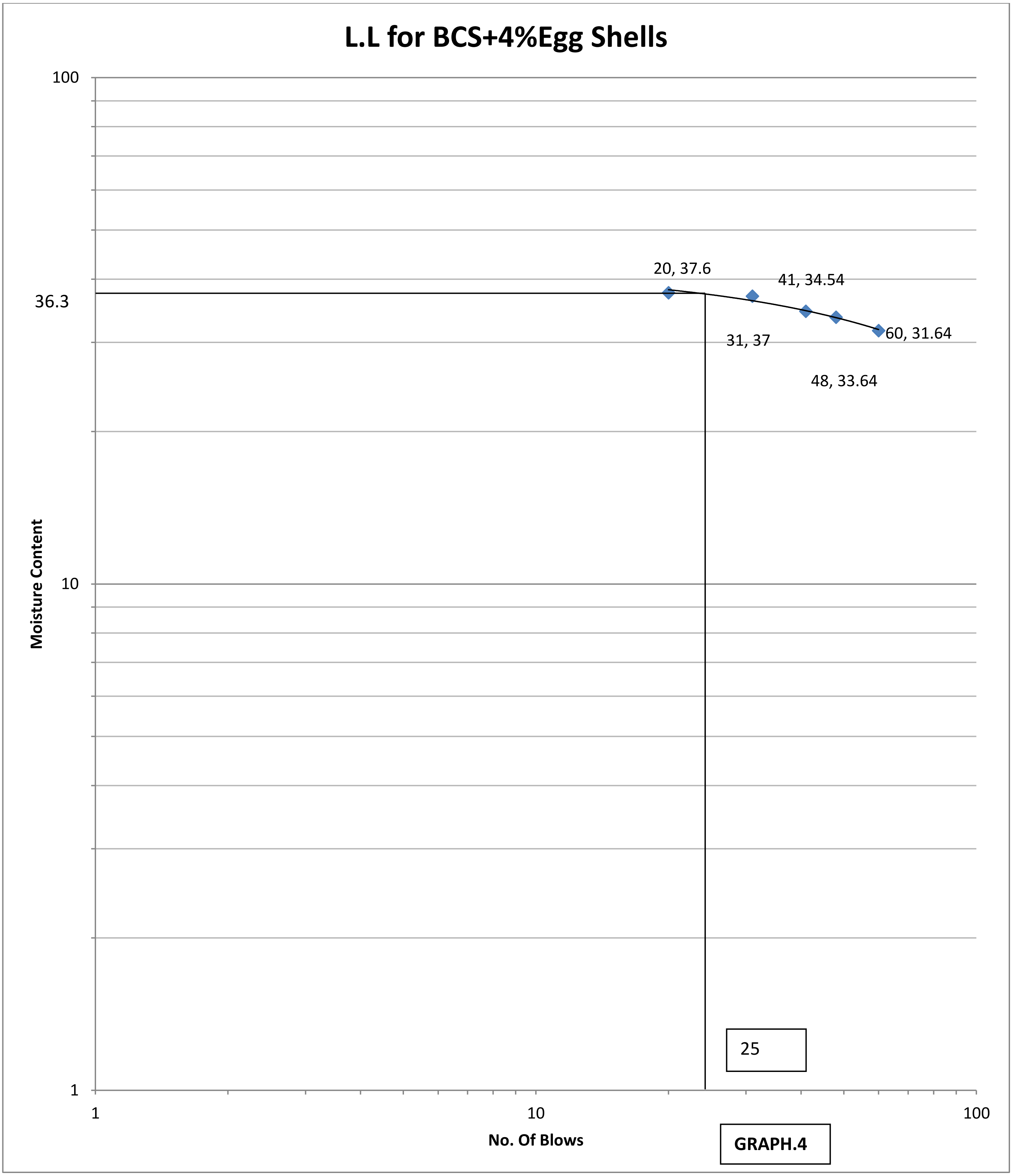
   The graph showing the variation with numbers of blows are plotted in graphs 2, 3, 4, 5, 6 and 7. The values corresponding to graphs are shown in table3, 4, 5, 6, 7 and 8.

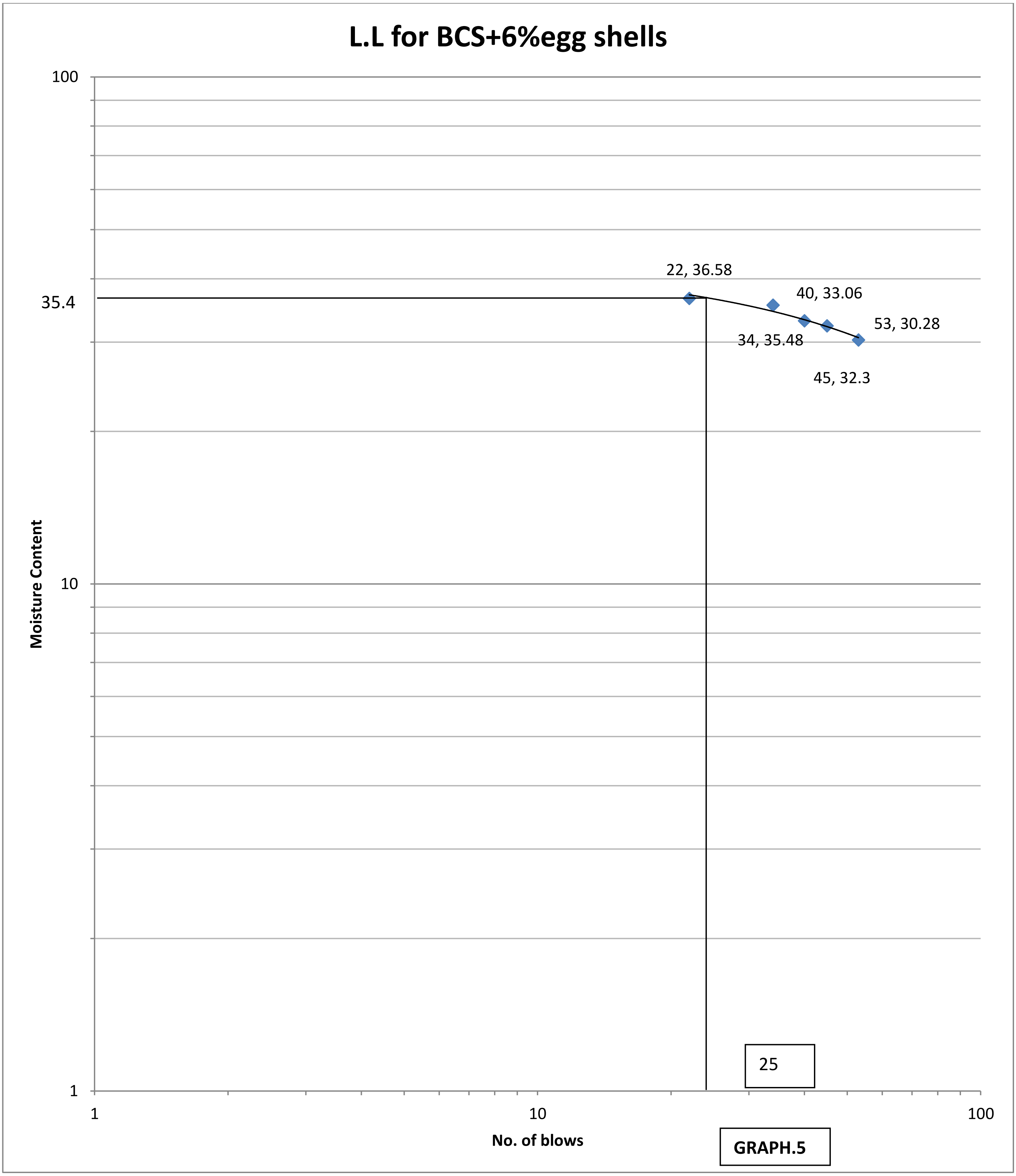
   The liquid limit of black cotton soil is observed to be 45.4% without the addition of egg shells and the value changes to 38.6%, 36.3%, 35.3 %, 34.7% and 33.9% with the addition of 2%, 4%, 6%, 8% and 10% egg shells respectively.

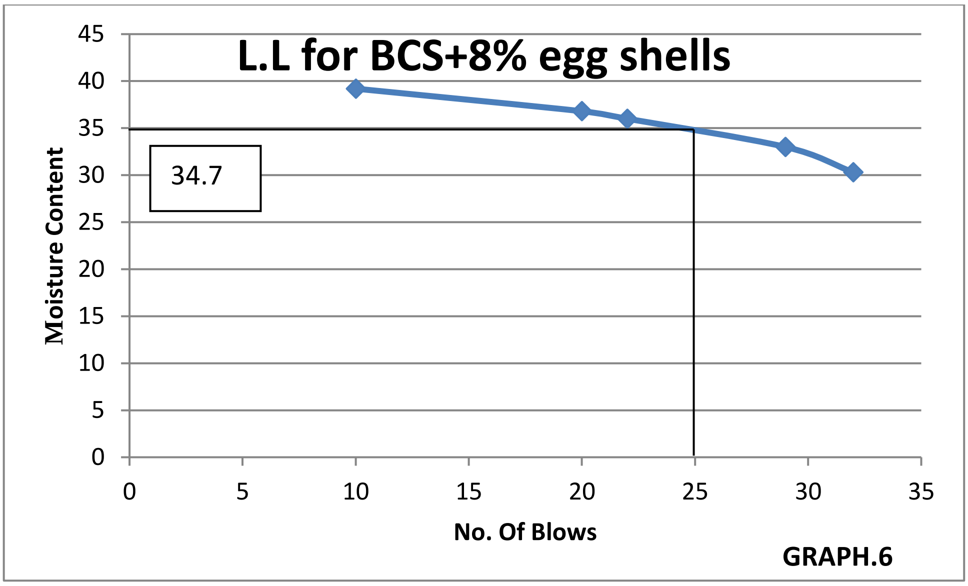
   This implies that the value of liquid limit is slowly changing from the medium degree of expansion (35-50) towards the low degree of expansion (20-35) according to the IS 1498- 1970.

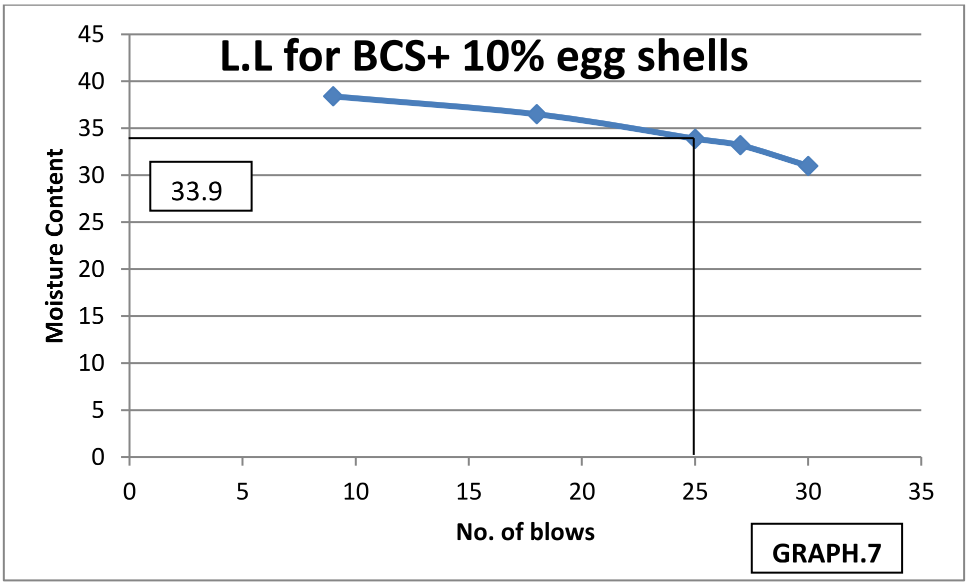

L.L for BCS
100
45.4
10
1
Moisture Content
21, 46.7
30, 45.5
48, 42.6
53, 40.1
40, 41.5
1
10
25
100
No. of Blows
GRAPH.2


L.L for BCS+2%egg shells
100
38.6
10
1
Moisture Content
21, 39.92
37, 36.6
51, 33.8
30, 39
43, 35.82
1
10
25
100
No. of Blows
GRAPH.3


L.L for BCS+4%Egg Shells
100
36.3
10
1
Moisture Content
20, 37.6
41, 34.54
31, 37
60, 31.64
48, 33.64
25
1
10
100
No. Of Blows
GRAPH.4


L.L for BCS+6%egg shells
100
35.4
10
1
Moisture Content
22, 36.58
40, 33.06
53, 30.28
34, 35.48
45, 32.3
25
1
10
100
No. of blows
GRAPH.5

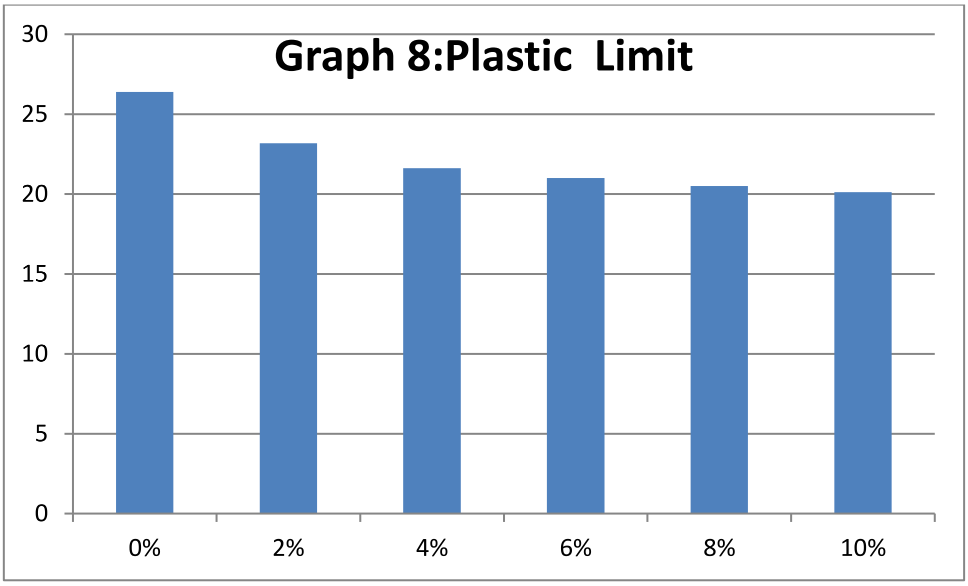

L.L for BCS+8% egg shells
Moisture Content
No. Of Blows
34.7
0
5
10
15
20
25
30
35
40
45
0
5
10
15
20
25
30
35
GRAPH.6


L.L for BCS+ 10% egg shells
Moisture Content
No. of blows
33.9
0
5
10
15
20
25
30
35
40
45
0
5
10
15
20
25
30
35
GRAPH.7

4. <u>Plastic Limit Test</u>: Compare the diameter of thread at intervals with the rod. When the diameter reduces to 3 mm, note the surface of the thread for cracks.

The average plastic limit of black cotton soil was 26.4% without the addition of egg shells and the value changes to 23.16%, 21.6%, 21%, 20.5 and 20.1 with the addition of 2%, 4%, 6%, 8% and 10% egg shells. The values for the test are shown in table 9, 10, 11, 12, 13 and 14.

This implies that the value of plastic limit is also slowly decreasing and hence there is a decrease in the degree of expansion.



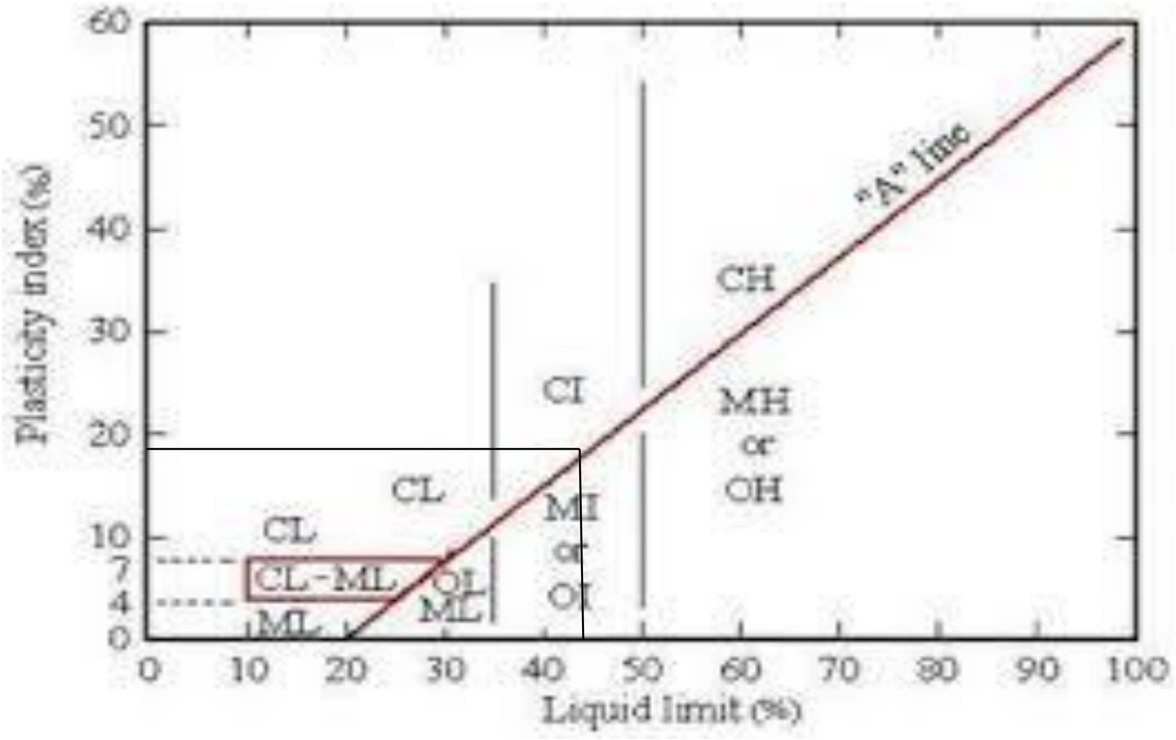
Soil Classification:

On the basis of results from the above experiments, soil was classified as follows:-

Plasticity Index

Plasticity Index (Ip) = Liquid Limit (W_L) – Plastic Limit (Wp)

Ip = 45.4%-26.4% = 18.6% without egg shells



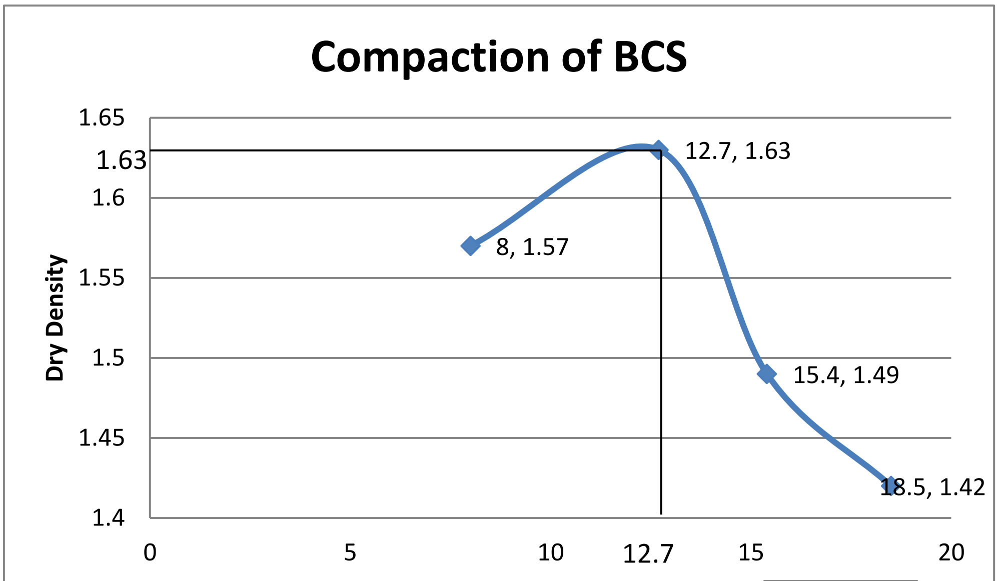
Casagrande's Plasticity Chart

- The soil was found to be CI according to the plasticity chart that is the soil is clayey of medium compressibility.

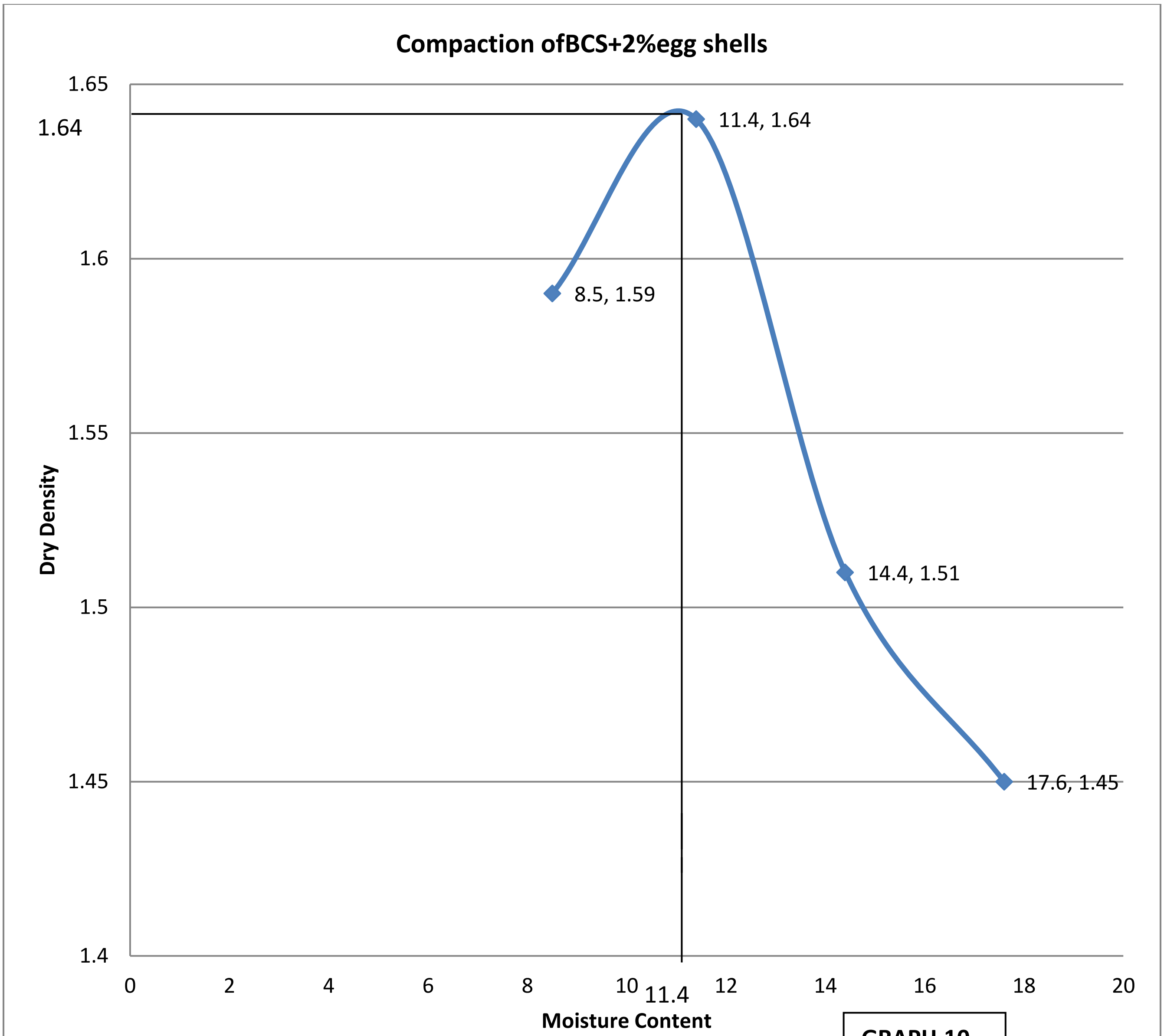
.

5. Light compaction test

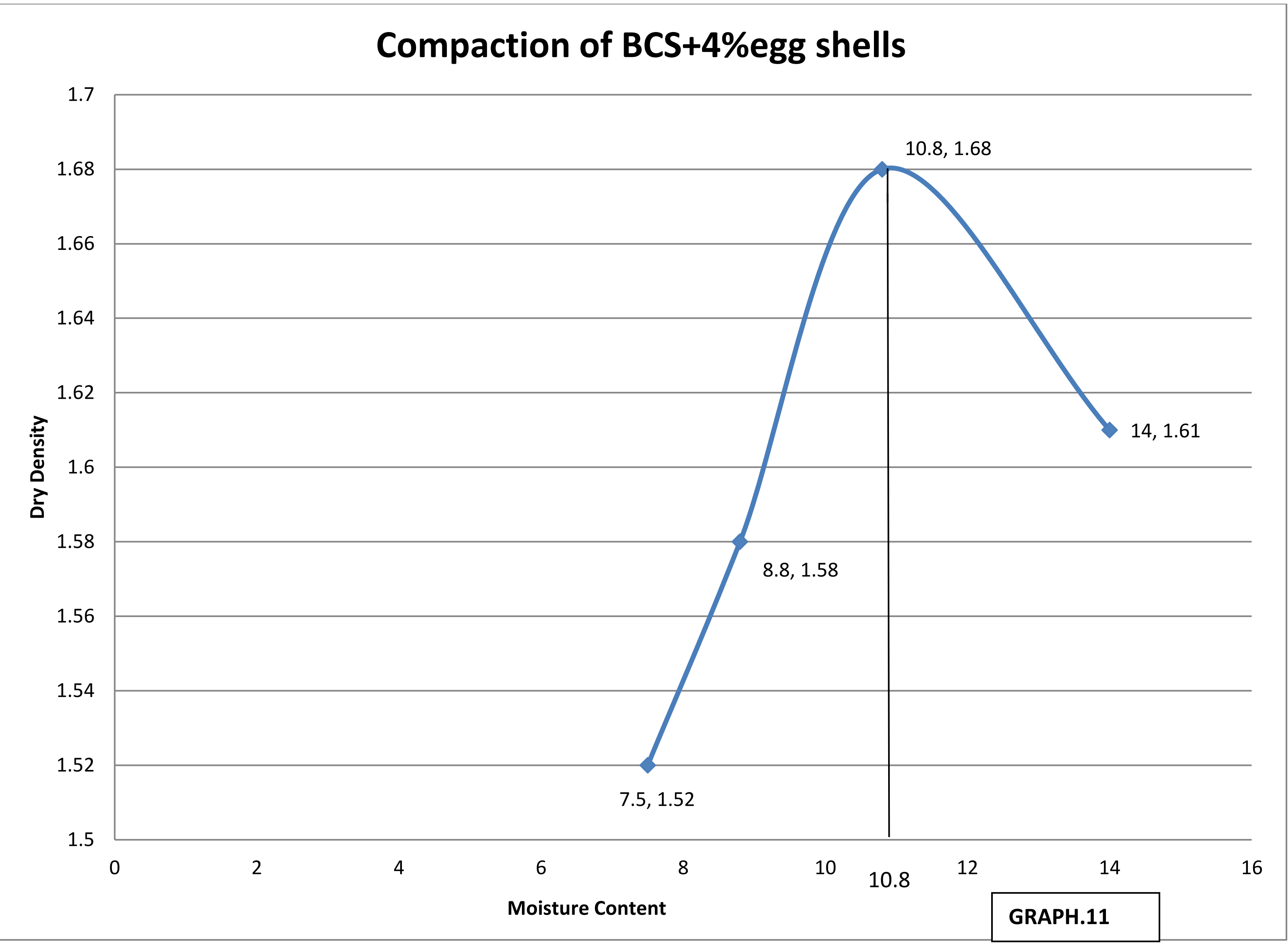
From the light compaction test, we obtain the maximum dry density and the optimum moisture content and the graphs were plotted. The values corresponding to graphs are shown in table 21, 22, 23, 24, 25 and 26.

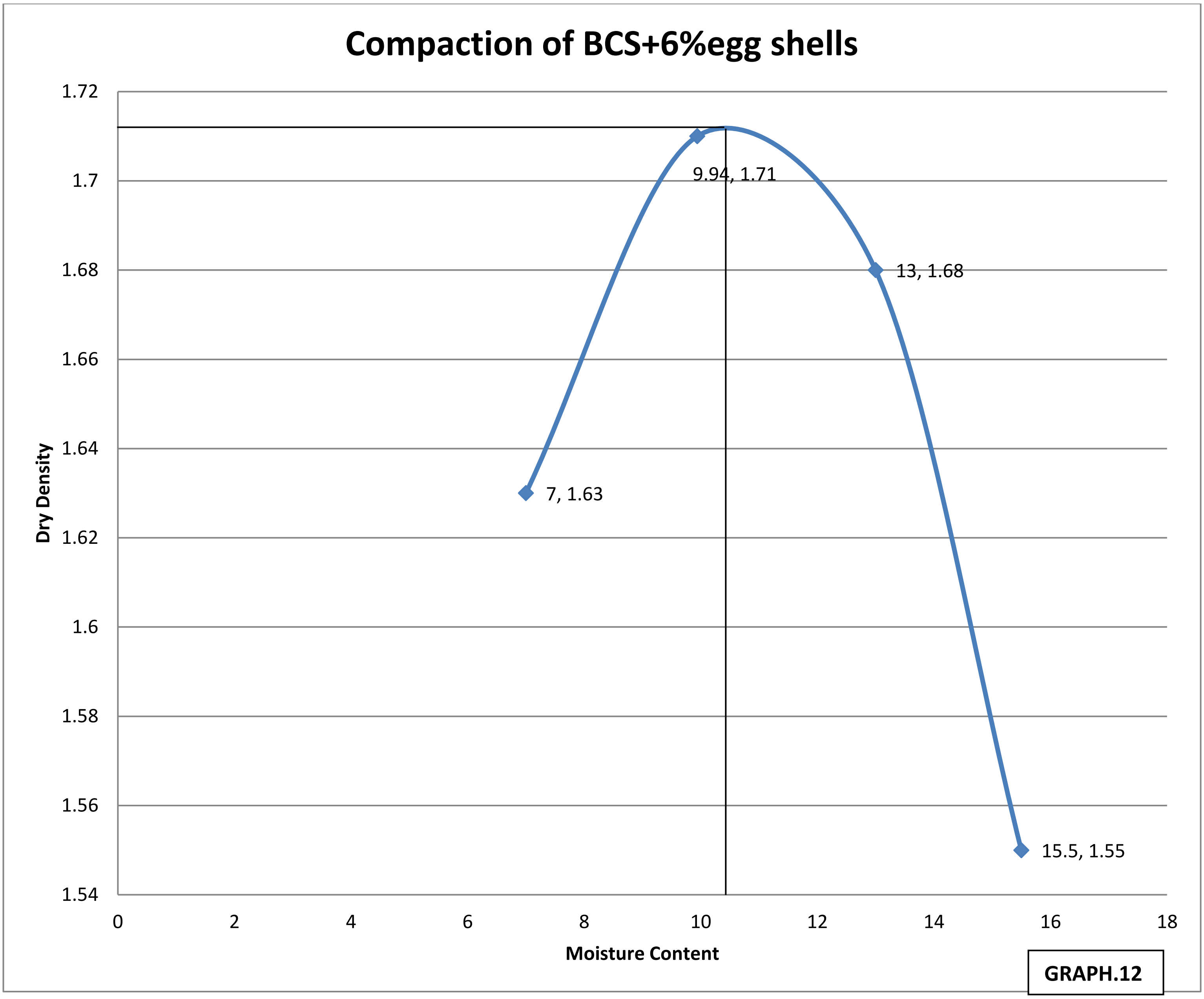


GRAPH.9


Compaction ofBCS+2%egg shells
Dry Density
Moisture Content
1.65
1.64
1.6
1.55
1.5
1.45
1.4
0
2
4
6
8
10
11.4
12
14
16
18
20
8.5, 1.59
11.4, 1.64
14.4, 1.51
17.6, 1.45

GRAPH.10

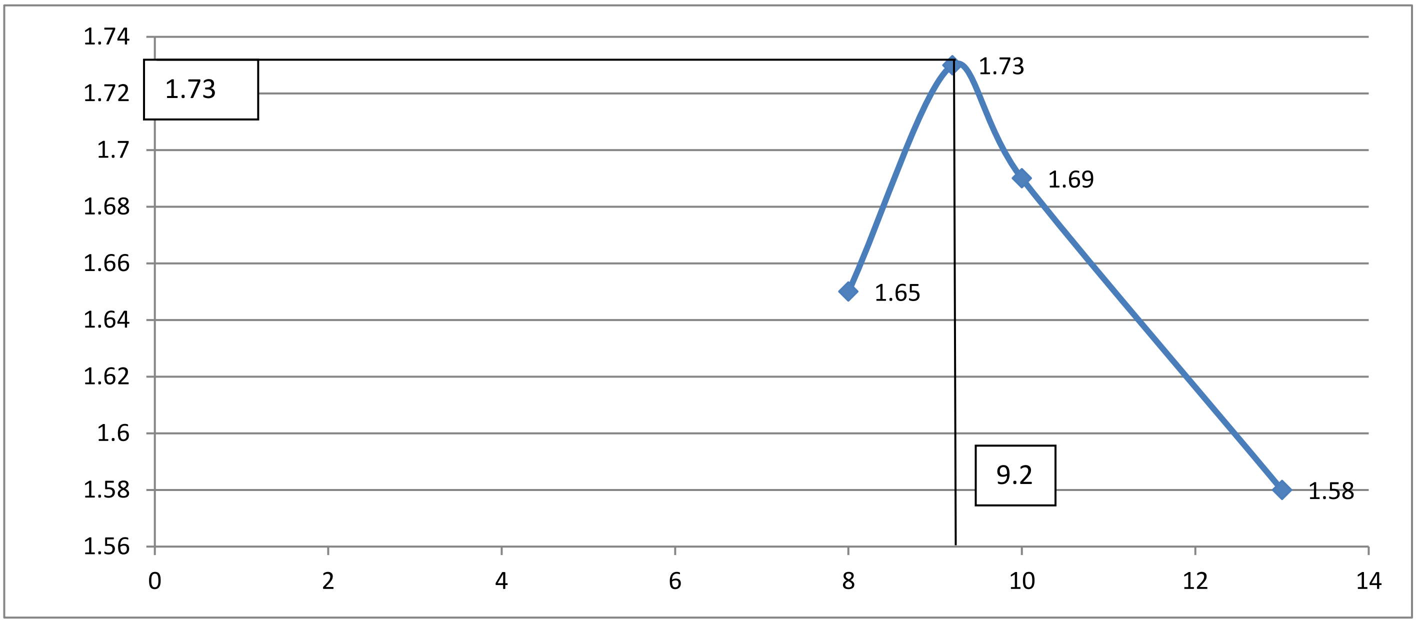

Compaction of BCS+4%egg shells
Dry Density
Moisture Content
1.7
1.68
1.66
1.64
1.62
1.6
1.58
1.56
1.54
1.52
1.5
0
2
4
6
8
10
12
14
16
10.8, 1.68
14, 1.61
8.8, 1.58
7.5, 1.52
10.8
GRAPH.11



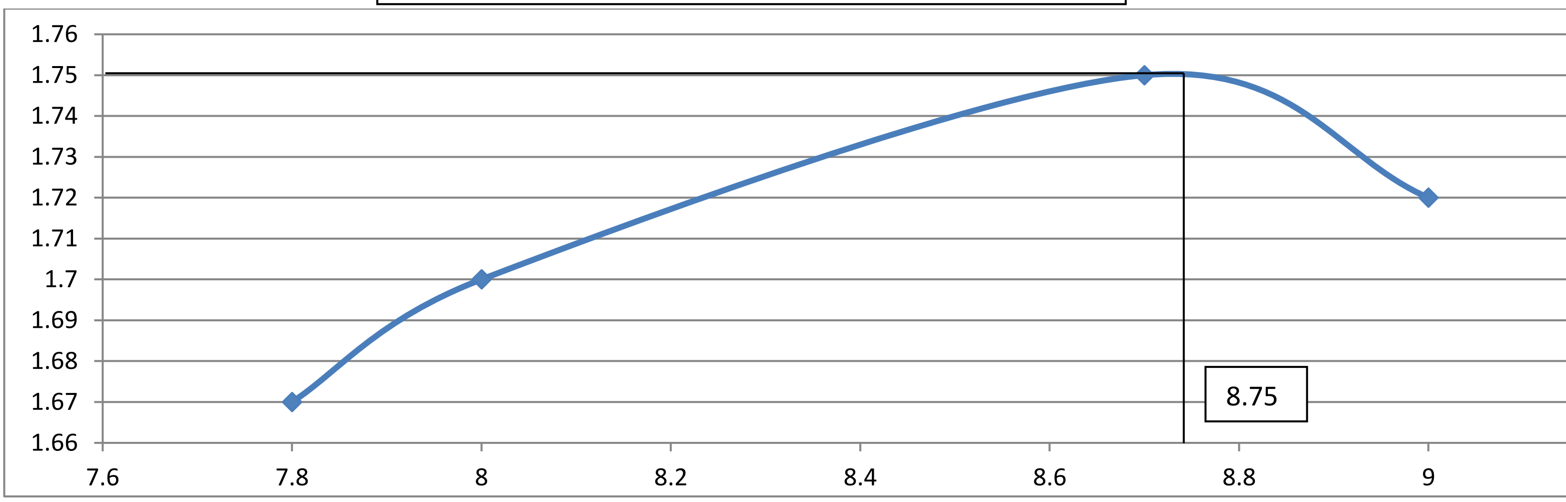
Compaction of BCS+6%egg shells
Dry Density
1.72
1.7
1.68
1.66
1.64
1.62
1.6
1.58
1.56
1.54
0
2
4
6
8
10
12
14
16
18
Moisture Content
9.94, 1.71
13, 1.68
7, 1.63
15.5, 1.55
GRAPH.12

.

(GRAPH.13): Compaction Of BCS With 8% egg shells

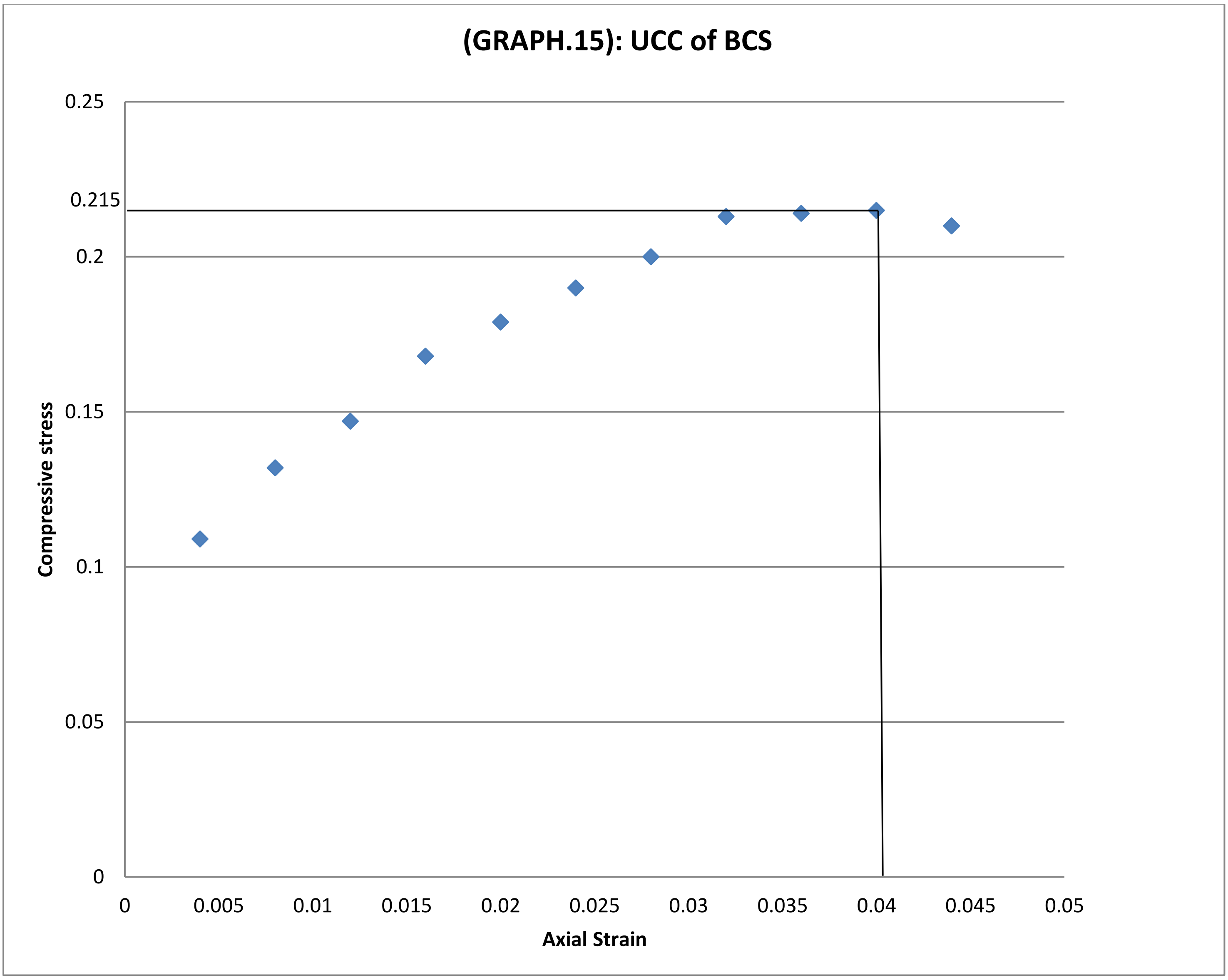


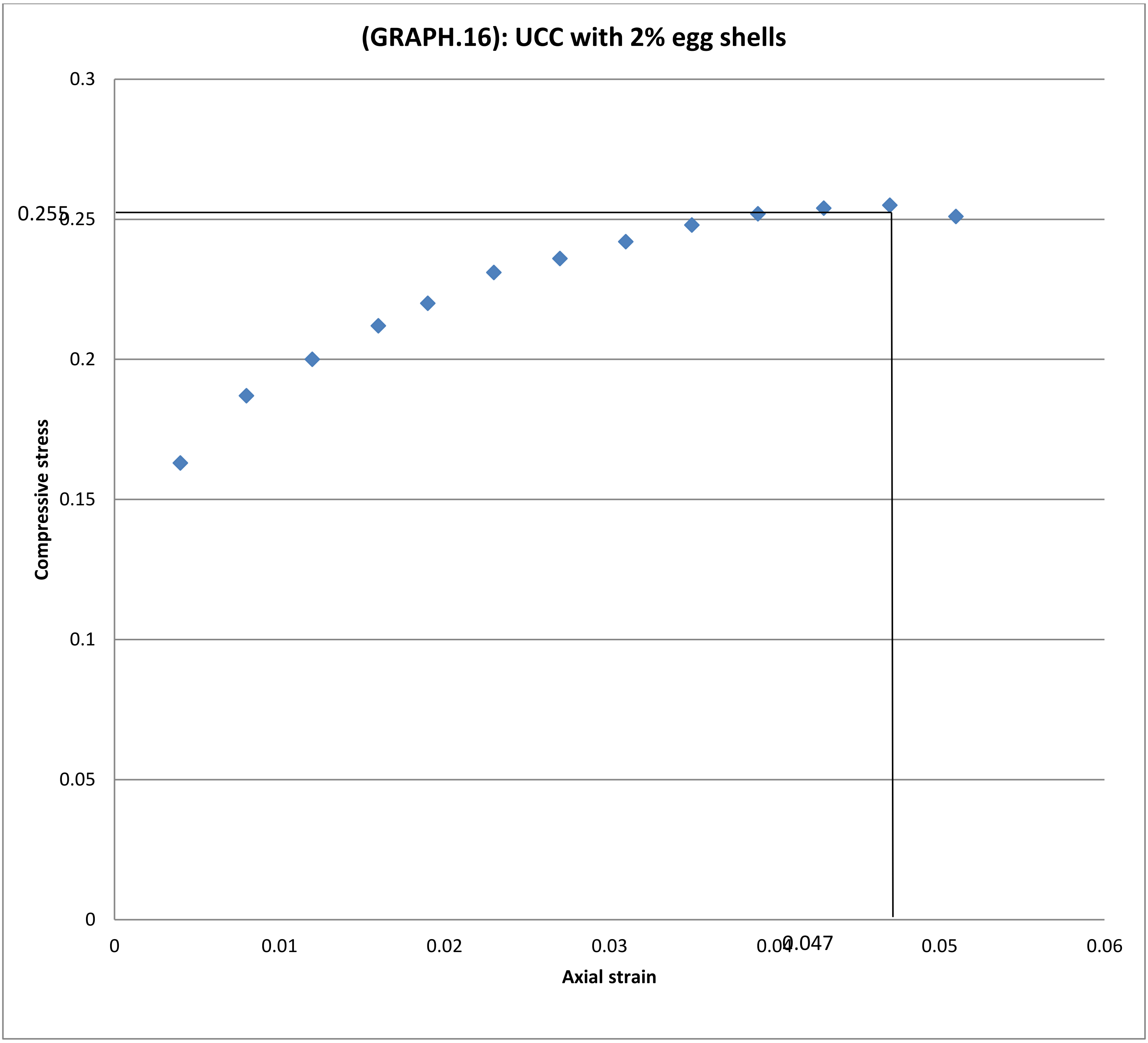
(GRAPH.14): Compaction Of BCS+10% egg shells

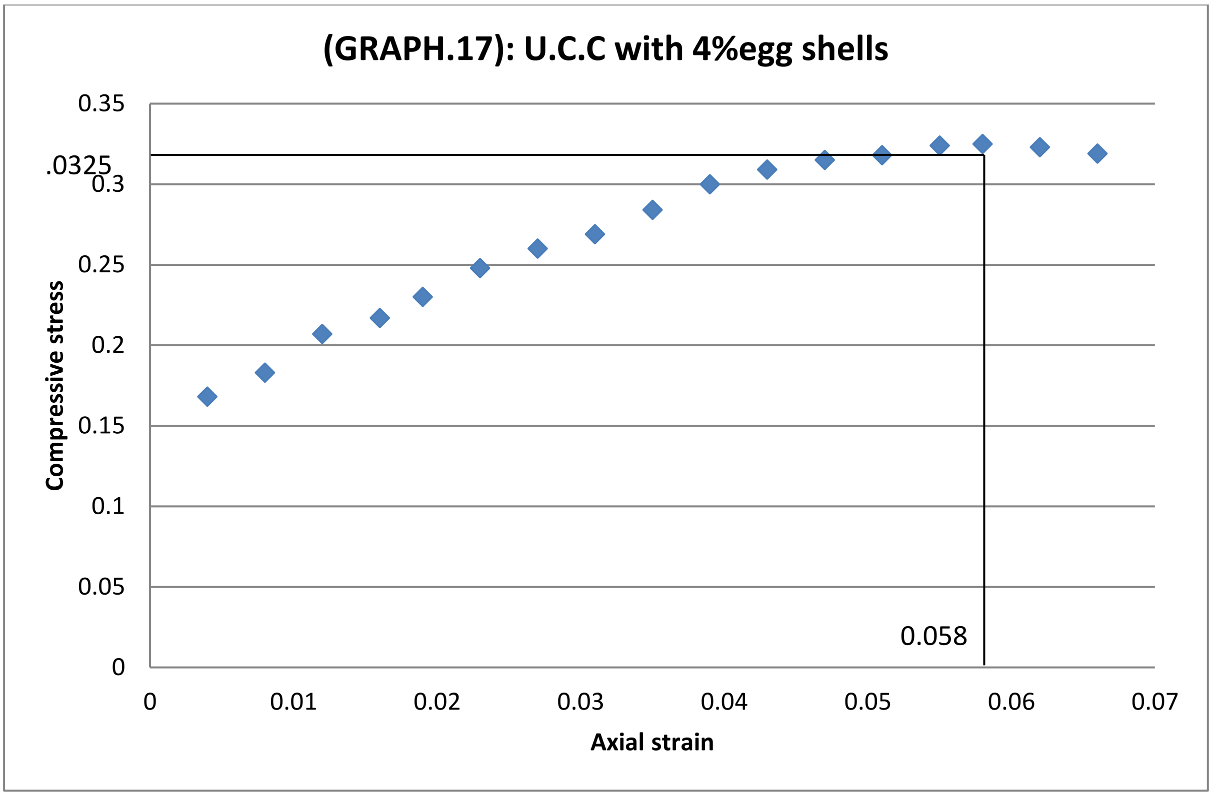


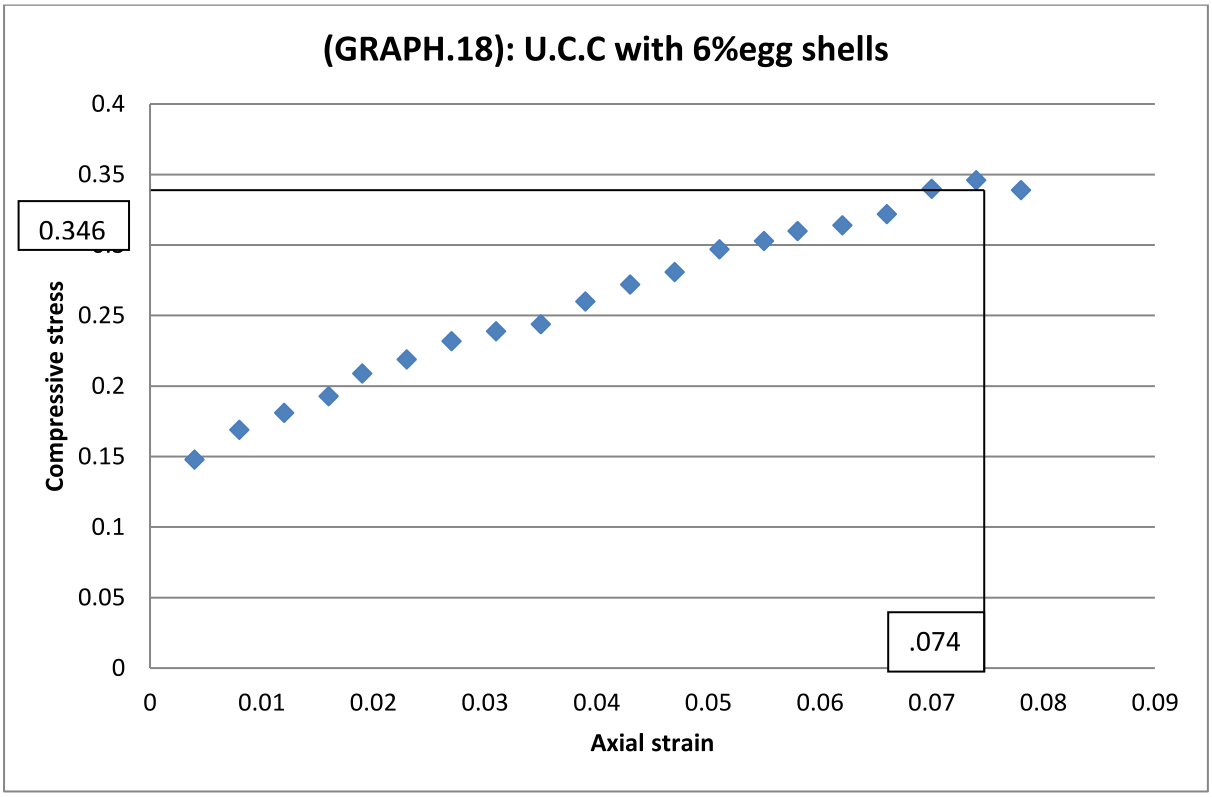
- The maximum dry density increases from 1.63 to 1.64, 1.68, 1.71, 1.73 &1.75 with the addition of 2%, 4%, 6%, 8%and 10% egg shells respectively.
- The optimum moisture content decreases from 12.7% to 11.4%, 10.8%, 9.94%, 9.2%& 8.75%/ with the addition of 2%, 4%, 6%, 8% and 10% egg shells respectively.

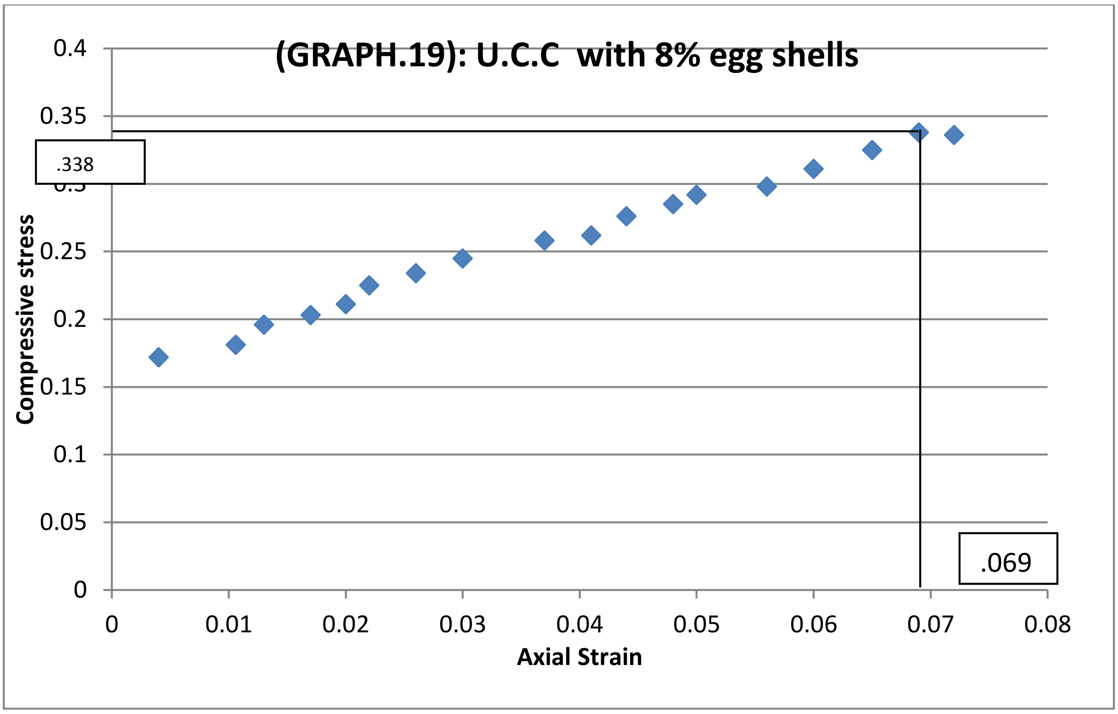
5. **Unconfined Compressive Strength**

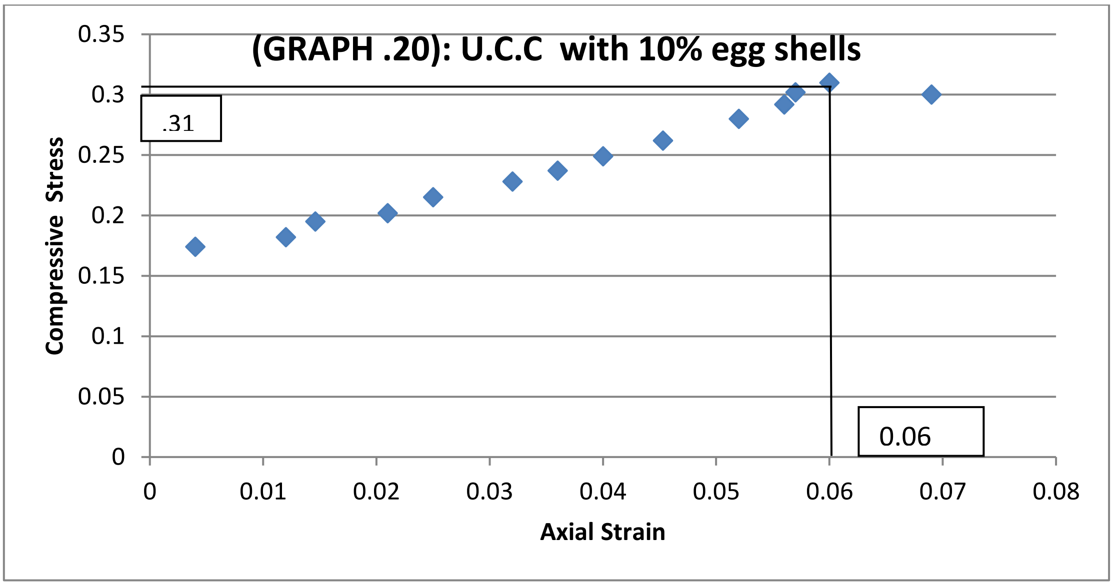



(GRAPH.16): UCC with 2% egg shells
Compressive stress
0.3
0.255
0.25
0.2
0.15
0.1
0.05
0
0
0.01
0.02
0.03
0.04
0.047
0.05
0.06
Axial strain


(GRAPH.17): U.C.C with 4%egg shells
Compressive stress
Axial strain
.0325
0.058
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07


(GRAPH.18): U.C.C with 6%egg shells
Compressive stress
Axial strain
0.346
.074
0
0.05
0.1
0.15
0.2
0.25
0.35
0.4
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09

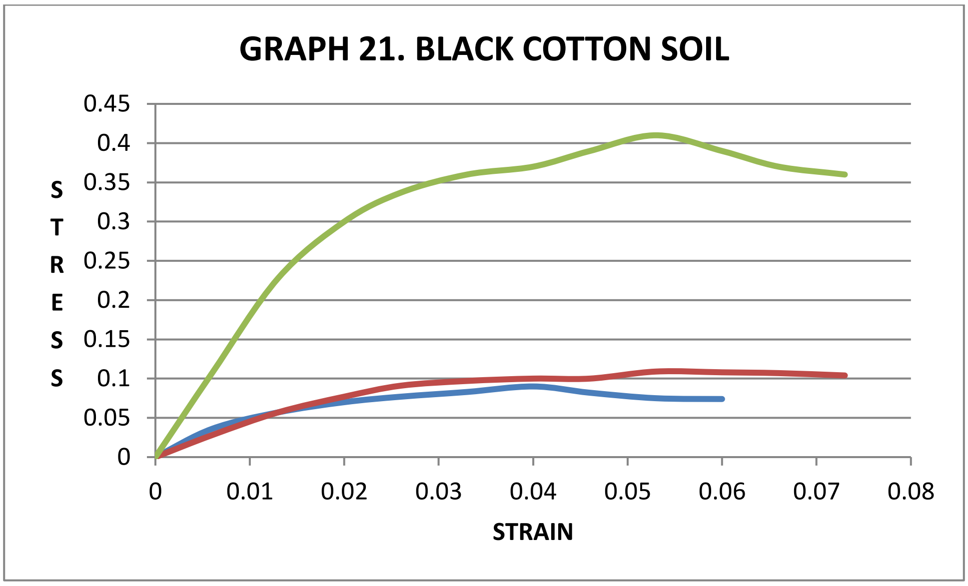


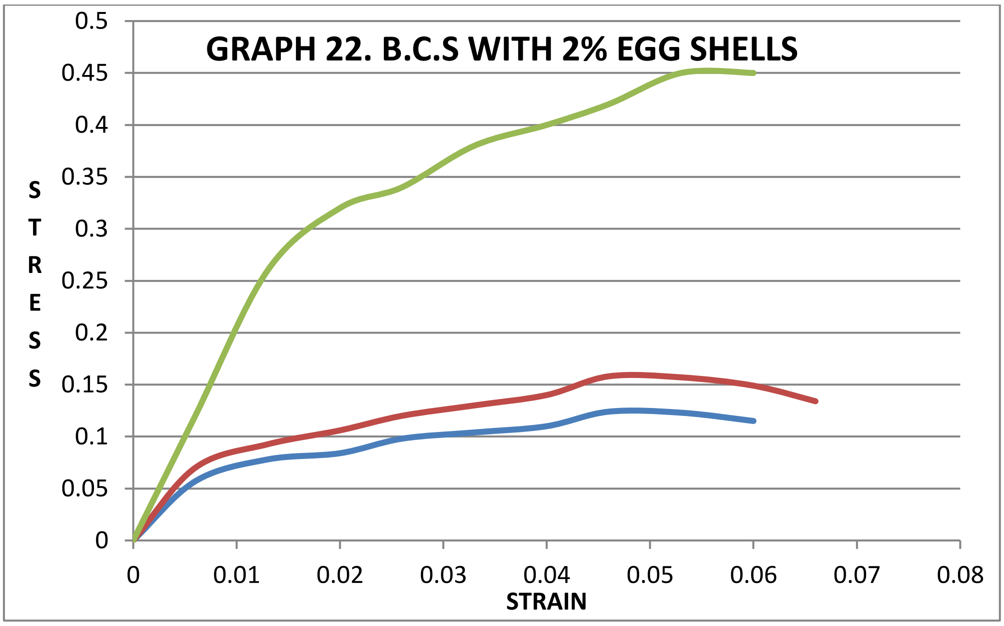


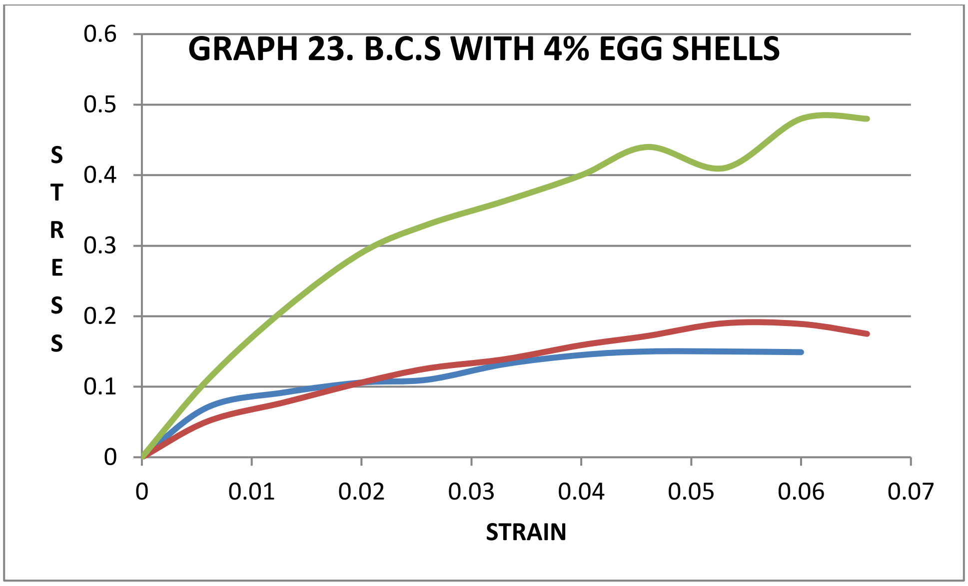
- The unconfined compression strength of soil increases on addition of egg shells by 2%, 4%, 6% but shows a dip in the value on addition of 8% and 10% egg shells.
- The trend which soil show is 0.215, 0.255, 0.325, 0.346, 0.336 and .31 on only soil, addition of 2%, 4%, 6%, 8% and10% respectively.
- The increase in UCS of soil after addition of 6% egg shells was nearly 80%.
- The values corresponding to graphs are shown in table15, 16, 17, 18, 19 and20.

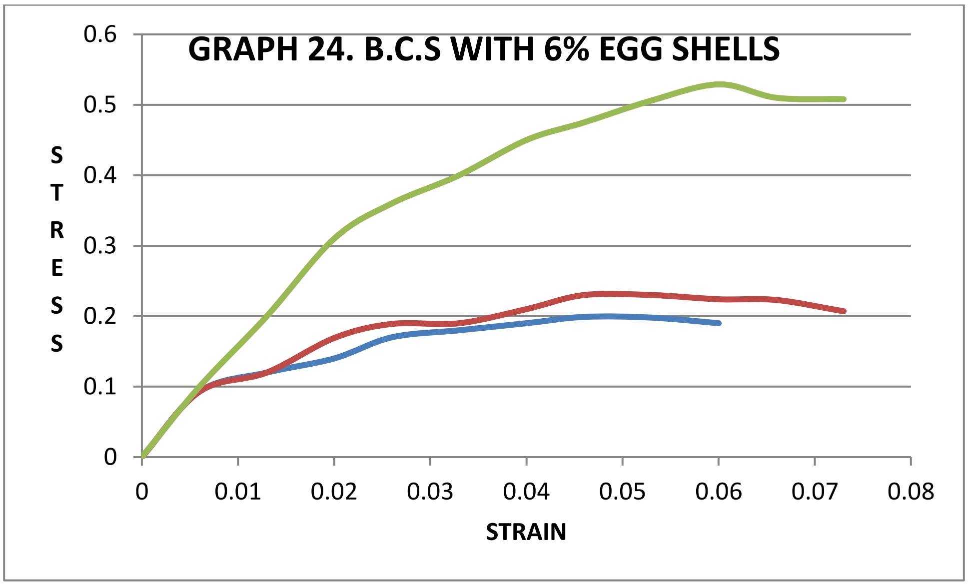
6. <u>DIRECT SHEAR TEST</u>: The graph has been plotted for shear test with strain on X axis and stress on Y axis Cohesion of soil is predicted by virtue of this test.

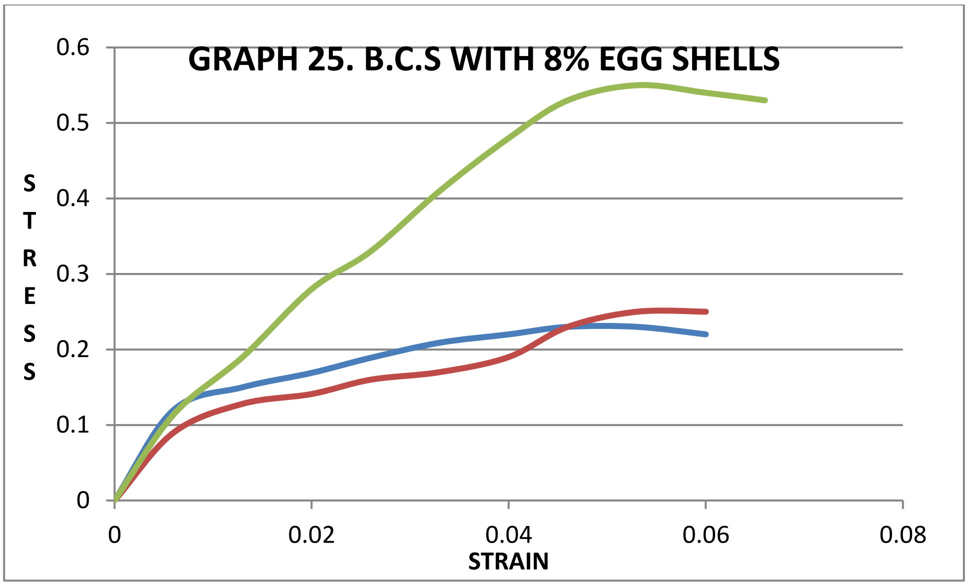
The green, red and blue lines are values of stress and strain corresponding to 0.5, 1and 2 Kg/cm^2.

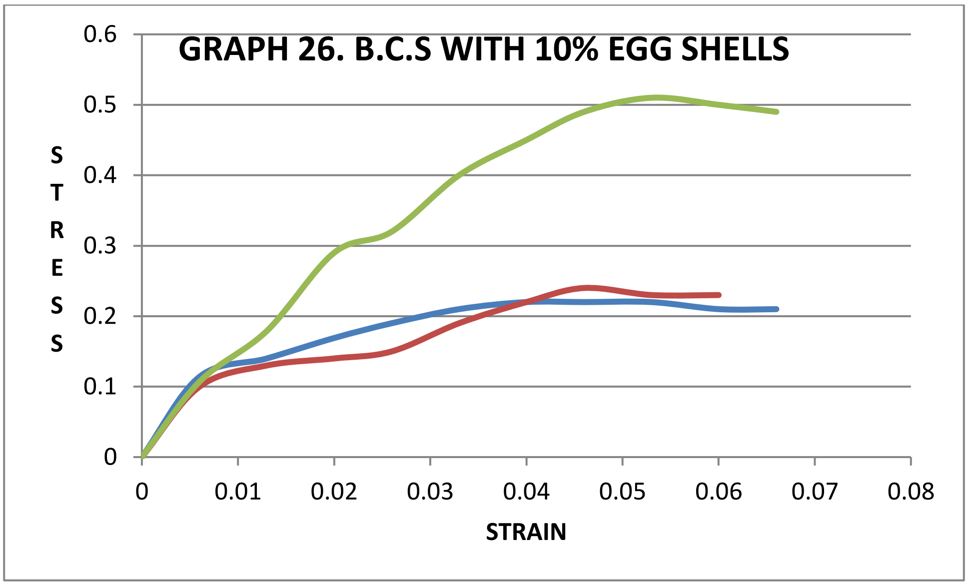


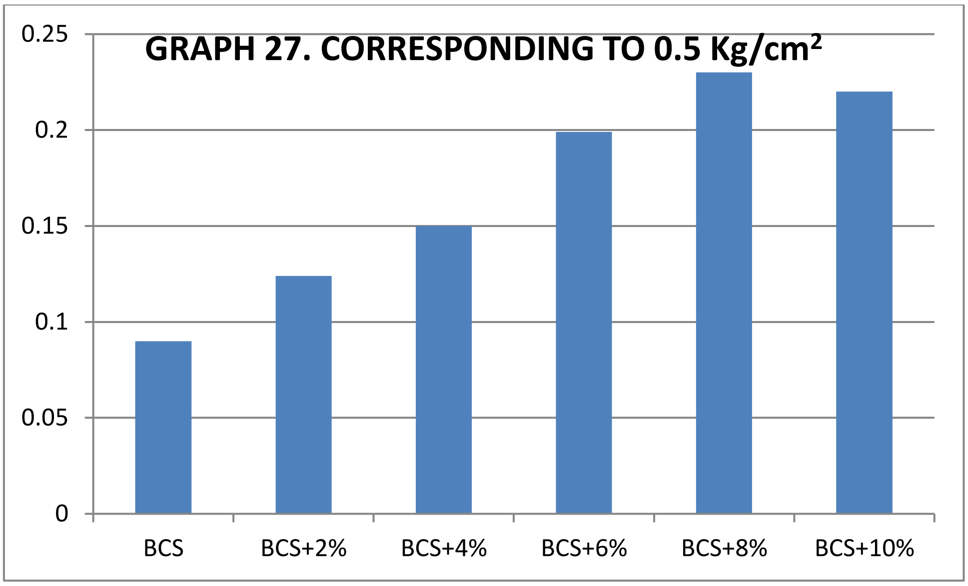



GRAPH 23. B.C.S WITH 4% EGG SHELLS
STRESS
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
STRAIN

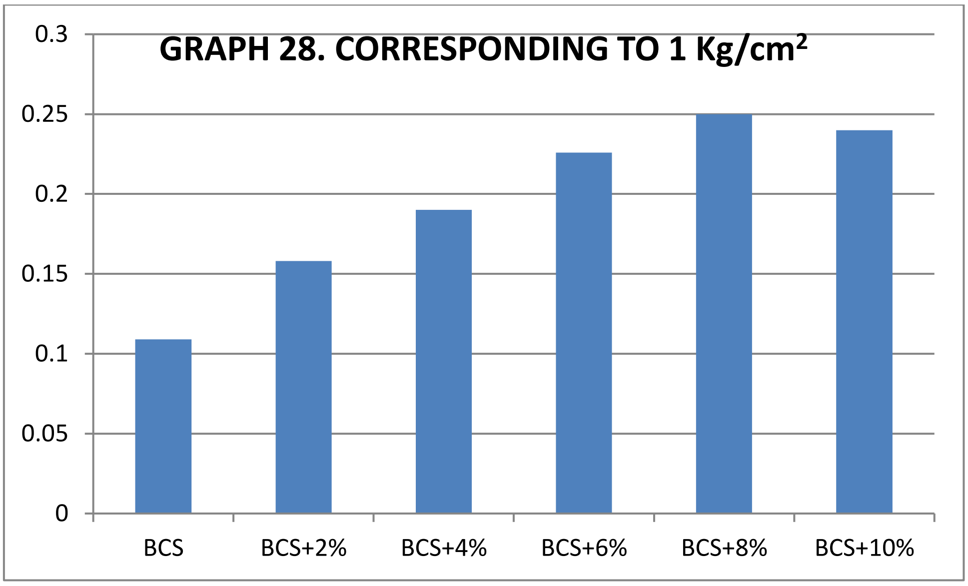

GRAPH 24. B.C.S WITH 6% EGG SHELLS
STRESS
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
STRAIN


GRAPH 25. B.C.S WITH 8% EGG SHELLS
STRESS
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.02
0.04
0.06
0.08
STRAIN

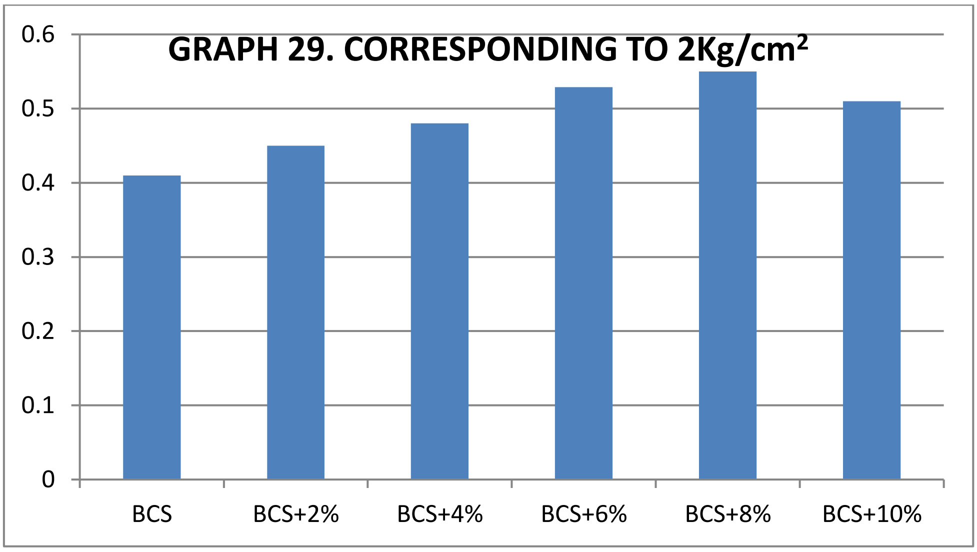

GRAPH 26. B.C.S WITH 10% EGG SHELLS
STRESS
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
STRAIN



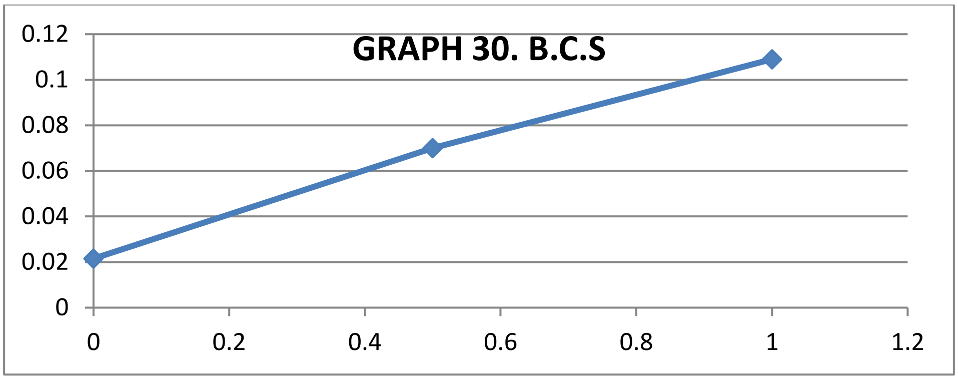
GRAPH 27. CORRESPONDING TO 0.5 Kg/cm2
0.25
0.2
0.15
0.1
0.05
0
BCS
BCS+2%
BCS+4%
BCS+6%
BCS+8%
BCS+10%

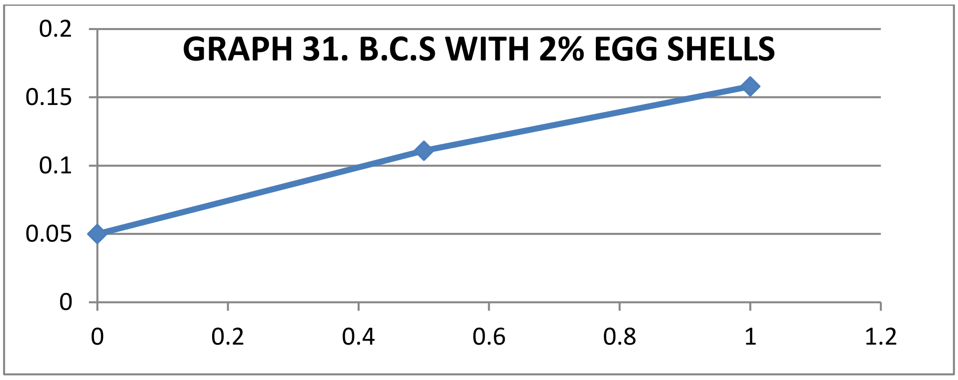


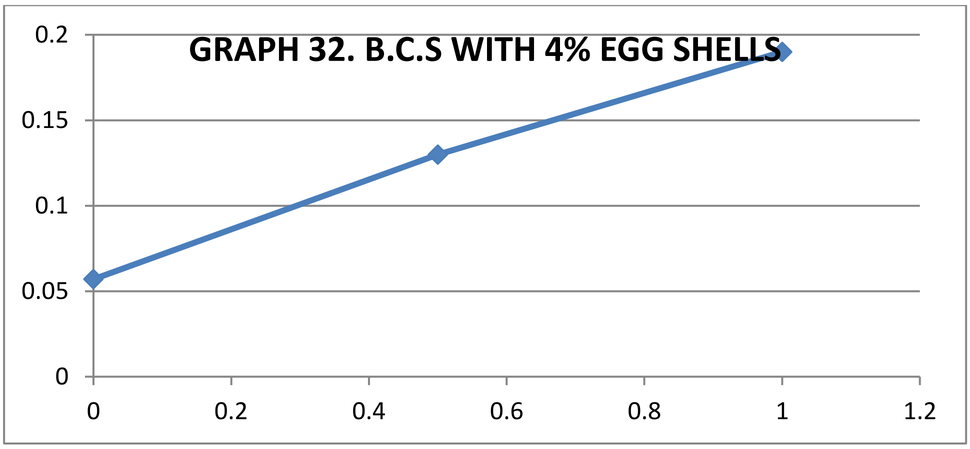
GRAPH 28. CORRESPONDING TO 1 Kg/cm2
0.3
0.25
0.2
0.15
0.1
0.05
0
BCS
BCS+2%
BCS+4%
BCS+6%
BCS+8%
BCS+10%

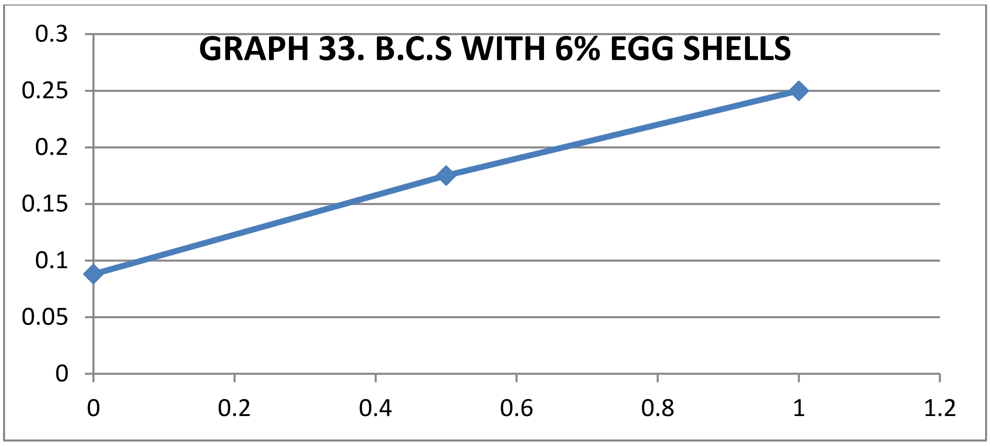


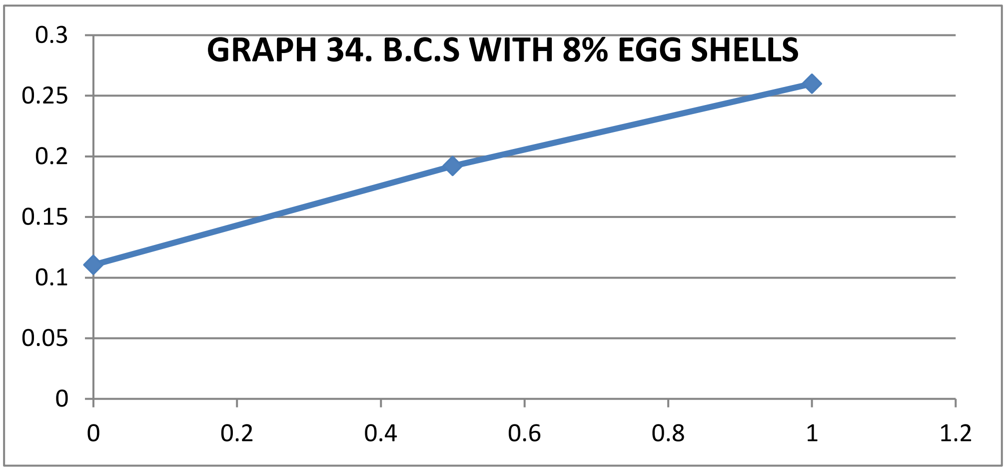
GRAPH 29. CORRESPONDING TO 2Kg/cm2
0.6
0.5
0.4
0.3
0.2
0.1
0
BCS
BCS+2%
BCS+4%
BCS+6%
BCS+8%
BCS+10%

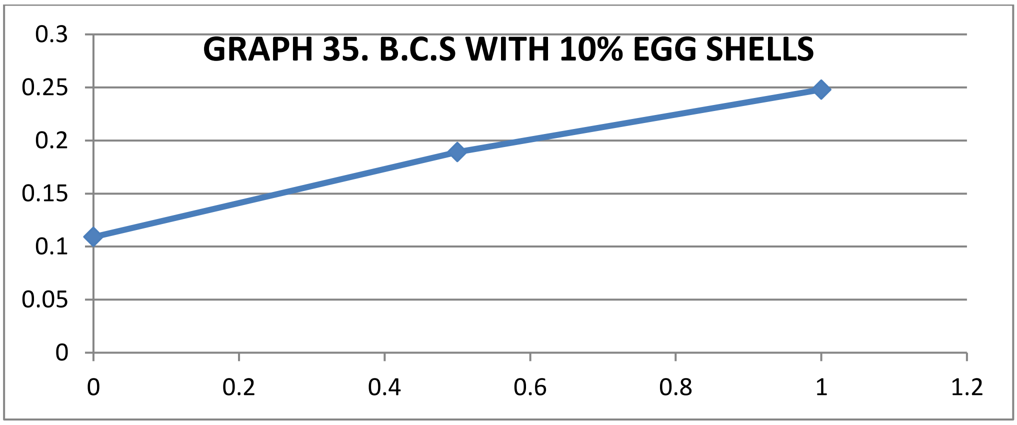

GRAPH 30. B.C.S
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.2
0.4
0.6
0.8
1
1.2


GRAPH 31. B.C.S WITH 2% EGG SHELLS
0.2
0.15
0.1
0.05
0
0
0.2
0.4
0.6
0.8
1
1.2


GRAPH 32. B.C.S WITH 4% EGG SHELLS
0.2
0.15
0.1
0.05
0
0
0.2
0.4
0.6
0.8
1
1.2







The cohesion for Black cotton soil is showing an increasing trend up to addition of 8% egg shells. It shows a dip in cohesion as well as in strength at 10%egg shells.

The values of cohesion corresponding to 2, 4, 6, 8 &10% egg shells are 0.0215, 0.047, 0.057 .088, 0.1105 & 0.105, respectively. The values corresponding to graphs are shown in table 27, 28, 29, 30, 31 and 32.

6. CONCLUSIONS

- The Liquid Limit and Plastic Limit of BCS decreased due to addition of Egg Shells. Hence, it can be noted that the Plasticity characteristics of the Black Cotton Soil reduce.
- The Optimum Moisture Content of Black Cotton Soil decreased and Maximum Dry Density increased with increase in Egg Shell content.
- The increase in UCS of soil after addition of Egg Shells was nearly 80%.
- The shear strength is also showing increment on addition of egg shells.
- Overall the soil properties were changing from the medium degree of expansion to low degree expansion with increment in strength also up to 6% egg shells.

7. REFERENCES

- IS 2720 Part- III/ Section2, 1997, “Methods of Tests for soils” (Specific Gravity), BIS, New Delhi.
- IS 2720 Part- IV, 1995, “Methods of Tests for soils” (Grain Size Analysis), BIS, New Delhi.
- IS 2720 Part- V, 1995, “Methods of Tests for soils” (Atterberg Limits), BIS, New Delhi
- IS 2720 Part- VIII, 1997, “Methods of Tests for soils” (Proctor’s Compaction Test), BIS, New Delhi.
- IS 2720 Part- X, 1991, “Methods of Tests for soils” (Direct Shear), BIS, New Delhi.
- “Soil mechanics and foundational engineering” by Dr. K.R Arora.

A. APPENDEX

A.1 Wet Sieve Analysis:

- Sample Taken= 500gm

For soil retaining on 75µ sieve (135.5 gm):

TABLE.1				
IS Sieve	Wt. retained(gm)	% Wt. retained	Cumulative %	% Finer
10mm	15.5	3.1%	3.1%	96.9%
4.75mm	18.6	3.72%	6.82%	93.18%
2mm	24.9	4.9%	11.72%	88.28%
1mm	10.9	2.18%	13.9%	86.1%
600µ	6.8	1.36%	15.26%	84.74%
425µ	4.7	.94%	16.2%	83.8%
300µ	8	.165%	16.96%	83.04%
150µ	9.7	1.94%	18.9%	81.91%
75µ	7.8	1.5%	20.4%	79.6%

For soil passing through 75µ sieve(364.5gm):

- a(specific gravity of solids correction factor) = 1.038
- W.B(hydrometer sample weight) = 50
- G_s(specific gravity of soil particles) =2.38
- G_w(specific gravity of water)=.9974
- Fluid Viscosity(V) (22 C)=.00958
- V_h=12ml
- A_j=38.46cm^2

TABLE.2					
Time Elapsed(T) (min)	Hydrometer reading(H_0)	H_1	$H=H_1+(H_0-(V_h/2A_j))$	$P.S=((30*V*H)/(980*(G_{s-}G_w)*T))^{1/2}$	%Finer =(H*a*100)/(W.B)
.5	1.020	2.8	14.14	.0774	30.34
1	1.019	3.2	14.54	.0555	31.20
2	1.019	3.2	14.54	.039	31.20
4	1.018	3.4	14.74	.028	31.63
8	1.016	4	15.34	.0201	32.91
15	1.015	4.3	15.64	.0148	33.56
30	1.015	4.3	15.64	.0105	33.56
60	1.013	4.8	16.14	.00755	34.63
120	1.012	5.1	16.44	.0054	35.28
240	1.011	5.4	16.74	.0038	35.92
480	1.008	6.3	17.64	.00275	37.85
1440	1.002	8	19.34	.00164	41.5

6.2 Liquid Limit

6.2.1 On soil without egg shells

TABLE.3					
Serial no.	1	2	3	4	5
Weight Of Container	28.6	27.6	25.8	27	28.1
Weight of container + Wet Soil	57.1	45.9	48.2	42.2	50.7
Weight Of Container + Dry Soil	48.9	40.4	42.1	38	43.4
Weight of Water	8.2	5.5	6.1	4.2	7.3
Weight Of Dry Soil	20.4	12.5	14.3	9.1	17.5
Moisture Content (%)	40.1	45.5	42.6	46.7	41.5
No. of blows	53	30	48	21	40

6.2.2 On soil with 2% egg shells

TABLE.4					
Serial no.	1	2	3	4	5
Wt. Of container	28.8	27.6	25.8	27.2	28.3
Wt. of container+ wet soil	59.9	50.35	44.7	40.86	55.17
Wt. of container+ Dry soil	52	44.35	39.4	36.96	47.97
Weight of water	7.9	6	5.3	3.9	7.2
Weight of Dry soil	23.37	16.75	13.6	9.76	19.67
Moisture content (%)	33.8	35.82	39	39.92	36.6
No. of blows	51	43	30	21	37

6.2.3 On soil with 4% egg shells

TABLE.5					
Serial no.	1	2	3	4	5
Wt. Of container	28.9	27.4	25.9	27.3	28.2
Wt. of container+ wet soil	60.1	52.1	44.78	68.4	53.3
Wt. of container+ Dry soil	52.6	45.9	39.68	64.1	46.4
Weight of water	7.5	6.2	5.1	3.5	6.9
Weight of Dry soil	23.7	18.4	13.78	9.30	18.2
Moisture content (%)	31.64	33.64	37	37.6	34.54
No. of blows	60	48	31	20	41

6.2.4 On soil with 6% egg shells

TABLE.6					
Serial no.	1	2	3	4	5
Wt. of container	29	27.5	25.7	27.5	28.4
Wt. of container+ wet soil	59.11	50.98	45.93	40.94	55.76
Wt. of container+ Dry soil	52.11	45.18	40.63	37.34	48.96
Weight of water	7	5.8	5.3	3.6	6.8
Weight of Dry soil	23.11	17.68	14.93	9.84	20.56
Moisture content (%)	30.28	32.3	33.48	36.58	33.06
No. of blows	53	45	34	22	40

6.2.5 On soil with 8% egg shells

TABLE.7					
Serial no.	1	2	3	4	5
Wt. of container	28.2	27.1	27.3	27.4	28.9
Wt. of container+ wet soil	45.1	44	44.4	46.7	49.4
Wt. of container+ Dry soil	41.2	39.8	39.9	41.5	43.6
Weight of water	3.9	4.2	4.5	5.2	5.8
Weight of Dry soil	13	12.7	12.6	14.1	14.7
Moisture content (%)	30.3	33	36	36.8	39.2
No. of blows	32	29	22	20	10

6.2.6 On soil with 10% egg shells

TABLE.8					
Serial no.	1	2	3	4	5
Wt. of container	27.3	28.1	28.3	28.5	28.8
Wt. of container+ wet soil	51	52.5	51.3	52.7	53.7
Wt. of container+ Dry soil	45.2	46.4	45.5	46	46.8
Weight of water	5.8	6.1	5.8	6.7	6.9
Weight of Dry soil	17.9	18.3	17.2	18.5	18
Moisture content (%)	31	33.2	33.9	36.5	38.4
No. of blows	30	27	25	18	9

6.3 Plastic limit

6.3.1 On soil without egg shells

TABLE.9		
Mass of container + wet soil	42.7	41.3
Mass of container + dry soil	37.5	36.5
Mass of water	5.2	4.8
Mass of container	18.1	18.1
Mass of dry soil	19.4	18.4
Plastic Limit (%)	26.8	26.08

6.3.2 On soil with 2% egg shells

TABLE.10		
Mass of container + wet soil	45.5	44.7
Mass of container + dry soil	40.5	39.9
Mass of water	5	4.8
Mass of container	17.9	18.1
Mass of dry soil	22.6	21.8
Plastic Limit (%)	23.42	22.9

6.3.3 On soil with 4% egg shells

TABLE.11		
Mass of container + wet soil	46.6	45.6
Mass of container + dry soil	41.5	40.9
Mass of water	5.1	4.7
Mass of container	18.2	18
Mass of dry soil	23.3	22.9
Plastic Limit (%)	21.86	21.34

6.3.4 On soil with 6% egg shells

TABLE.12		
Mass of container + wet soil	47.5	47.05
Mass of container + dry soil	42.3	42.05
Mass of water	5.2	5
Mass of container	17.9	17.9
Mass of dry soil	24.4	24.15
Plastic Limit (%)	21.3	20.7

6.3.5 On soil with 8% egg shells

TABLE.13		
Mass of container + wet soil	49.3	48.3
Mass of container + dry soil	43.9	43.2
Mass of water	5.4	5.1
Mass of container	18.1	18
Mass of dry soil	25.8	25.2
Plastic Limit (%)	20.87	20.19

6.3.6 On soil with 10% egg shells

TABLE.14		
Mass of container + wet soil	49.42	47.83
Mass of container + dry soil	44.12	42.83
Mass of water	5.3	5
Mass of container	17.8	17.93
Mass of dry soil	26.32	24.9
Plastic Limit (%)	20.13	20.07

6.4 Unconfined compressive Strength

6.4.1 On soil without egg shells

TABLE.15				
(DIV*.263)	ΔL	ΔL/L	$A_f = A_o/(1-(\Delta L/L))$	$\sigma=P_f/A_f$
2.63	.5	.0026	10.76	.109
5.26	.6	.0065	10.8	.132
7.89	.89	.0106	10.856	.147
10.52	1.4	.0103	10.851	.168
13.15	1.3	.017	10.92	.179
15.78	1.7	.022	10.98	.19
18.41	2.0	.026	11.02	.20
21.04	2.2	.029	11.06	.213
23.67	2.8	.037	11.15	.214
26.3	2.9	.0386	11.17	.215
28.9	3.2	.042	11.21	.210

6.4.2 On soil with 2% egg shells

TABLE.16				
(DIV*.263)	ΔL	ΔL/L	$A_f = A_o/(1-(\Delta L/L))$	$\sigma=P_f/A_f$
2.635.26	.4	.005	10.79	.163
7.89	.59	.0078	10.82	.187
10.52	.86	.0114	10.86	.2
13.15	1.1	.016	10.91	.212
15.78	1.4	.014	10.89	.220
18.41	1.6	.022	10.98	.231
21.01	2.0	.026	11.02	.236
23.67	2.4	.032	11.09	.242
26.3	2.7	.036	11.14	.248
28.93	2.9	.039	11.17	.252
31.56	3.2	.042	11.21	.254
34.19	3.5	.046	11.25	.255
36.82	3.9	.052	11.32	.251

6.4.3 On soil with 4% egg shells

TABLE.17				
(DIV*.263)	ΔL	ΔL/L	$A_f=A_o/(1-(\Delta L/L))$	$\sigma=P_f/A_f$
2.63	.36	.004	10.78	.168
5.26	.6	.008	10.82	.183
7.89	.9	.012	10.87	.207
10.52	1.2	.016	10.91	.217
13.15	1.5	.019	10.94	.230
15.78	1.8	.023	10.99	.248
18.41	2.1	.027	11.03	.260
21.04	2.4	.031	11.08	.269
23.67	2.7	.035	11.12	.284
26.3	3	.039	11.17	.3
28.93	3.3	.043	11.22	.309
31.56	3.6	.047	11.26	.315
34.19	3.9	.051	11.31	.318
36.82	4.2	.055	11.36	.324
39.45	4.5	.058	11.4	.325
42.08	4.8	.062	11.44	.323
44.71	5.1	.066	11.49	.319

6.4.4 On soil with 6% egg shells

TABLE.18				
(DIV*.263)	ΔL	ΔL/L	$A_f = A_o/(1-(\Delta L/L))$	$\sigma=P_f/A_f$
2.63	.31	.001	10.75	.148
5.26	.48	.0064	10.8	.169
7.89	.9	.012	10.87	.181
10.52	1.1	.0147	10.9	.193
13.15	1.6	.021	10.97	.209
15.78	1.8	.024	11	.219
18.41	2.0	.026	11.02	.232
21.04	2.4	.032	11.09	.239
23.67	2.7	.036	11.14	.244
26.3	3	.04	11.18	.26
28.93	3.16	.042	11.21	.272
31.56	3.5	.049	11.29	.281
34.19	3.76	.051	11.31	.297
36.82	4.02	.053	11.34	.303
39.45	4.35	.058	11.4	.31
42.08	4.75	.063	11.46	.314
44.71	5.0	.066	11.49	.322
47.34	5.22	.0696	11.53	.34
49.97	5.66	.075	11.61	.346
52.6	5.9	.078	11.64	.339

6.4.5 On soil with 8% egg shells:

TABLE.19				
(DIV*.263)	ΔL	ΔL/L	$A_f = A_o/(1-(\Delta L/L))$	$\sigma=P_f/A_f$
2.63	.29	.0038	10.78	.172
5.26	.76	.0101	10.84	.181.
7.89	1.0	.013	10.88	.196
10.52	1.2	.016	10.9	.203
13.15	1.4	.018	10.93	.211
15.78	1.7	.022	10.98	.225
18.41	1.9	.0253	11.01	.234
21.04	2.1	.028	11.04	.245
23.67	2.6	.034	11.11	.258
26.3	3.0	.04	11.18	.262
28.93	3.1	.041	11.199	.276
31.56	3.4	.045	11.24	.285
34.19	3.7	.049	11.29	.292
36.82	4.1	.054	11.35	.298
39.45	4.4	.058	11.4	.311
42.08	4.9	.065	11.48	.325
44.71	5.2	.069	11.53	.338
47.34	5.4	.072	11.57	.336

6.4.6 On soil with 10% egg shells

TABLE.20				
(DIV*.263)	ΔL	ΔL/L	$A_f = A_o/(1-(\Delta L/L))$	$\sigma=P_f/A_f$
2.63	.26	.004	10.78	.174
5.26	.9	.012	10.87	.182
7.89	1.1	.0146	10.89	.195
10.52	1.6	.021	10.97	.202
13.15	1.9	.025	11.01	.215
15.78	2.4	.032	11.09	.228
18.41	2.7	.036	11.14	.237
21.04	3.0	.04	11.18	.249
23.67	3.4	.0453	11.24	.262
26.3	3.9	.052	11.32	.280
28.93	4.2	.056	11.37	.292
31.56	4.3	.057	11.38	.302
34.19	4.7	.06	11.42	.3
36.82	5.5	.069	11.53	.3

6.5 Light Compaction Test

6.5.1 On soil without egg shells

TABLE.21				
Determination No.	**1**	**2**	**3**	**4**
1.Mass of mould + compacted soil (kg)	6.538	6.725	6.569	6.522
2.Mass of compacted soil W_t (kg)	2.196	2.383	2.227	2.180
3.Wet density $\gamma_t = W_t/V$ (gm/cc)	1.695	1.838	1.719	1.683
4.Mass of container +wet soil (gm)	82.63	63.72	63.22	54.32
5.Mass of container + dry soil (gm)	77.85	58.59	57.77	48.65
6.Mass of water (4)-(5) (gm)	4.78	5.13	6.11	5.67
7.Mass of container (gm)	18.1	18.2	18.1	18.0
8.Mass of dry soil (5)-(7) (gm)	59.75	40.39	39.67	39.65
9.Water content=(6)/(8)*100	8%	12.7%	15.4%	18.5%
10.Dry Density $\gamma_d = \gamma_t/1+w$ (gm/cc)	1.57	1.63	1.49	1.42

6.5.2 On soil with 2% egg shells

TABLE.22				
Determination No.	**1**	**2**	**3**	**4**
1.Mass of mould + compacted soil (kg)	6.577	6.722	6.580	6.551
2.Mass of compacted soil W_t (kg)	2.235	2.380	2.238	2.209
3.Wet density $\gamma_t = W_t/V$ (gm/cc)	1.725	1.837	1.727	1.7052
4.Mass of container +wet soil (gm)	75.54	65.59	58.61	52.64
5.Mass of container + dry soil (gm)	71.04	60.73	53.51	57.44
6.Mass of water (4)-(5) (gm)	4.5	4.86	5.1	5.2
7.Mass of container (gm)	18.1	18.1	18.1	17.9
8.Mass of dry soil (5)-(7) (gm)	52.94	42.63	35.41	29.54
9.Water content=(6)/(8)*100	8.5%	11.4%	14.4%	17.6%
10.Dry Density $\gamma_d = \gamma_t/1+w$ (gm/cc)	1.59	1.64	1.51	1.45

6.5.3 On soil with 4% egg shells

TABLE.23				
Determination No.	**1**	**2**	**3**	**4**
1.Mass of mould + compacted soil (kg)	6.459	6.569	6.753	6.72
2.Mass of compacted soil W_t (kg)	2.117	2.22	2.42	2.38
3.Wet density $\gamma_t = W_t/V$ (gm/cc)	1.634	1.71	1.86	1.835
4.Mass of container +wet soil (gm)	86.61	72.53	69.5	59.53
5.Mass of container + dry soil (gm)	81.83	69.03	64.47	54.43
6.Mass of water (4)-(5) (gm)	4.78	4.5	5.03	5.1
7.Mass of container (gm)	18.1	17.9	17.9	18.2
8.Mass of dry soil (5)-(7) (gm)	63.73	51.13	46.57	36.43
9.Water content=(6)/(8)*100	7.5%	8.8%	10.8%	14%
10.Dry Density $\gamma_d = \gamma_t/1+w$ (gm/cc)	1.52	1.58	1.68	1.61

6.5.4 On soil with 6% egg shells

TABLE.24				
Determination No.	**1**	**2**	**3**	**4**
1.Mass of mould + compacted soil (kg)	6.602	6.778	6.802	6.481
2.Mass of compacted soil W_t (kg)	2.260	2.436	2.460	2.319
3.Wet density $\gamma_t = W_t/V$ (gm/cc)	1.74	1.9	1.89	1.79
4.Mass of container +wet soil (gm)	86.88	74.82	61.72	58.85
5.Mass of container + dry soil (gm)	82.38	69.71	56.69	51.65
6.Mass of water (4)-(5) (gm)	4.5	5.11	5.03	5.2
7.Mass of container (gm)	18.1	18.1	18	18.1
8.Mass of dry soil (5)-(7) (gm)	64.28	51.61	38.69	33.55
9.Water content=(6)/(8)*100	7%	9.94%	13%	15.5%
10.Dry Density $\gamma_d = \gamma_t/1+w$ (gm/cc)	1.63	1.71	1.68	1.55

6.5.5 On soil with 8% egg shells

TABLE.25				
Determination No.	**1**	**2**	**3**	**4**
1.Mass of mould + compacted soil (kg)	6.49	6.72	6.79	6.5
2.Mass of compacted soil W_t (kg)	2.29	2.42	2.39	2.30
3.Wet density $\gamma_t = W_t/V$ (gm/cc)	1.78	1.88	1.859	1.7854
4.Mass of container +wet soil (gm)	80.2	75.3	72.1	69.2
5.Mass of container + dry soil (gm)	75.5	70.1	66.8	63.85
6.Mass of water (4)-(5) (gm)	5	5.2	5.3	5.35
7.Mass of container (gm)	17.8	17.9	17.9	18.2
8.Mass of dry soil (5)-(7) (gm)	57.7	52.2	48.9	45.65
9.Water content=(6)/(8)*100	8%	9.2%	10%	13%
10.Dry Density $\gamma_d = \gamma_t/1+w$ (gm/cc)	1.65	1.73	1.69	1.58

6.5.6 On soil with 10% egg shells

TABLE.26				
Determination No.	**1**	**2**	**3**	**4**
1.Mass of mould + compacted soil (kg)	6.7	6.55	6.532	6.69
2.Mass of compacted soil W_t (kg)	2.304	2.35	2.432	2.39
3.Wet density $\gamma_t = W_t/V$ (gm/cc)	1.8	1.836	1.9	1.87
4.Mass of container +wet soil (gm)	80	78.3	81	82
5.Mass of container + dry soil (gm)	75.5	73.1	76.22	76.7
6.Mass of water (4)-(5) (gm)	4.5	5.2	4.78	5.3
7.Mass of container (gm)	18.0	18.1	17.89	17.9
8.Mass of dry soil (5)-(7) (gm)	57.5	55	58.3	58.6
9.Water content=(6)/(8)*100	7.8	8	8.7	9
10.Dry Density $\gamma_d = \gamma_t/1+w$ (gm/cc)	1.67	1.70	1.75	1.72

6.6 Direct Shear Test:

6.6.1 On soil without egg shells:

TABLE.27

Shear Strain	Corrected Area	0.5 Kg/cm²		1Kg/cm²		2Kg/cm²	
		Reading	Stress	Reading	Stress	Reading	Stress
0	3600	0	0	0	0	0	0
.006	3621.7	5	.036	4	.028	15	0.107
.013	3647.4	8	.057	8	.057	32	.228
.02	3673.46	10	.07	11	.077	43	.3
.026	3696.09	11	.077	13	.091	48	.337
.033	3722.85	12	.083	14	.097	52	.36
.04	3750	13	.09	15	.1	54	.37
.046	3773.58	12	.082	15	.1	57	.39
.053	3801.4	11	.075	116	.109	60	.41
.06	3829.78	11	.074	16	.108	58	.39
.066	3854.38			16	.107	56	.37
.073	3883.49			15	.104	55	.36

6.6.2 On soil with 2% egg shells:

TABLE.28

Shear Strain	Corrected Area	0.5 Kg/cm²		1Kg/cm²		2Kg/cm²	
		Reading	Stress	Reading	Stress	Reading	Stress
0	3600	0	0	0	0	0	0
.006	3621.7	8	.057	10	.7	18	.12
.013	3647.4	11	.078	13	.0926	37	.26
.02	3673.46	12	.084	15	.106	46	.32
.026	3696.09	14	.098	17	.12	49	.34
.033	3722.85	15	.14	19	.13	55	.38
.04	3750	16	.11	21	.14	62	.4
.046	3773.58	18	.124	23	.158	66	.42
.053	3801.4	18	.123	23	.157	66	.45
.06	3829.78	17	.115	22	.149		
.066	3854.38			20	.134		
.073	3883.49						

6.6.3 On soil with 4% egg shells:

TABLE.29							
Shear Strain	Corrected Area	0.5 Kg/cm^2		1Kg/cm^2		2Kg/cm^2	
		Reading	Stress	Reading	Stress	Reading	Stress
0	3600	0	0	0	0	0	0
.006	3621.7	10	.071	8	.057	16	.11
.013	3647.4	13	.092	11	.078	30	.21
.02	3673.46	15	.106	15	.106	42	.29
.026	3696.09	17	.11	18	.126	48	.33
.033	3722.85	19	.132	2	.139	52	0.363
.04	3750	21	.45	23	.159	58	.4
.046	3773.58	22	.15	25	.172	64	.44
.053	3801.4	22	.15	28	.19	68	.41
.06	3829.78	22	.149	28	.189	72	.48
.066	3854.38			26	.175	72	.48
.073	3883.49						

6.6.4 On soil using 6% egg shells:

TABLE.30							
Shear Strain	Corrected Area	0.5 Kg/cm^2		1Kg/cm^2		2Kg/cm^2	
		Reading	Stress	Reading	Stress	Reading	Stress
0	3600	0	0	0	0	0	0
.006	3621.7	13	.093	13	.093	14	.1
.013	3647.4	17	.12	18	.12	30	.2
.02	3673.46	20	.14	24	.169	45	.31
.026	3696.09	25	.17	27	.189	52	.36
.033	3722.85	26	.18	28	.19	58	.4
.04	3750	28	.19	31	.21	65	.45
.046	3773.58	29	.199	34	.23	69	.475
.053	3801.4	29	.198	34	.23	74	.506
.06	3829.78	28	.19	33	.224	78	.529
.066	3854.38			33	.226	76	.51
.073	3883.49			31	.207	76	.508

6.6.5 On soil using 8% egg shells:

TABLE.31							
Shear Strain	Corrected Area	0.5 Kg/cm^2		$1Kg/cm^2$		$2Kg/cm^2$	
		Reading	Stress	Reading	Stress	Reading	Stress
0	3600	0	0	0	0	0	0
.006	3621.7	17	.12	13	.09	16	.114
.013	3647.4	22	.15	18	.128	28	.19
.02	3673.46	24	.169	20	.141	40	.28
.026	3696.09	27	.189	23	.16	48	.33
.033	3722.85	30	.209	25	.17	59	.41
.04	3750	32	.22	28	.19	70	.48
.046	3773.58	34	.23	34	.23	78	.53
.053	3801.4	34	.23	38	.25	81	.55
.06	3829.78	33	.22	38	.25	80	.54
.066	3854.38					79	.53
.073	3883.49						

6.6.6 On soil using 10% egg shells:

TABLE.32							
Shear Strain	Corrected Area	0.5 Kg/cm^2		$1Kg/cm^2$		$2Kg/cm^2$	
		Reading	Stress	Reading	Stress	Reading	Stress
0	3600	0	0	0	0	0	0
.006	3621.7	16	.114	14	.1	15	.107
.013	3647.4	20	.14	18	.13	25	.179
.02	3673.46	24	.169	20	.14	42	.29
.026	3696.09	28	.19	22	.15	46	.32
.033	3722.85	31	.21	28	.19	58	.4
.04	3750	32	.22	32	.22	65	.45
.046	3773.58	33	.22	36	.24	72	.49
.053	3801.4	33	.22	35	.23	76	.51
.06	3829.78	32	.21	34	.23	75	.5
.066	3854.38	32	.21			74	.49

PHOTOGRAPHS

Egg Shells

Mixing of Egg shells With BCS

BCS with 6% egg shells

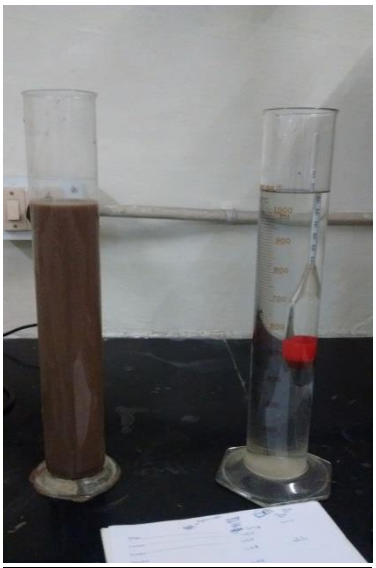
U.C.C

Light Compaction Test

UCC sample with 6% egg shells

Liquid Limit Test

Shear Test



Wet Sieving using Hydrometer