CERTIFICATE

This is to certify that Vibha Mishra and Kamini Pandey have satisfactorily carried out brief and elaborative literature investigations or surveys and completed the project work entitled "Soil Stabilization by Addition of Egg Shell Powder". The work is being submitted as a part of the partial fulfilment of B.Tech in Civil Engineering**.**

Dr. Rakesh Kumar	Dr. P K Agrawal
(Project Guide)	(HOD, Civil Dept.)

DECLARATION

This is an undertaking to declare that the report for this project work entitled "**Soil Stabilization by Addition of Egg Shell Powder**" is self-proclaimed work of the authors based on their own studies carried out under the supervision of Dr. Rakesh Kumar.

We declare that to the best of our knowledge and belief, the report fulfils the ordinal requirements of the project report of the institution MAULANA AZAD NATIONAL INSTITUTE OF TECHNOLOGY, BHOPAL and is up to the desired standard for the purpose of which is submitted for.

- **VIBHA MISHRA** **211111248**
- **KAMINI PANDEY** **211111236**

ACKNOWLEDGEMENT

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We would like to express our profound gratitude towards Dr. S.P.S. Rajput, Assistant Professor, Project Coordinator for his periodic suggestions and motivation.

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We are also thankful to all other faculty members and staff members, MANIT Bhopal for their precious help and guidance which proved to be of immense worth. We would also like to thank our classmates and friends for their suggestions and helpful discussions.

Last but not the least, our heartiest thanks to our parents for their blessings and all those who have directly or indirectly helped us during the entire duration of our project.

TABLE OF CONTENTS

ABSTRACT

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.

Soil stabilization is the process of improving the engineering properties of soil and thus making it more stable. It is required when the soil available for construction is not suitable for the intended purpose. It can be done by the use of controlled compaction, proportioning and the addition of suitable different types of admixtures and stabilizers. Soil stabilization is very necessary for various construction works like road pavement and foundation because it improves the engineering properties of BC Soil. The objective of this work is to estimate the effect of Eggshell Powder on some geotechnical properties of black cotton soil; in order to determine the suitability of Eggshell powder for use as a modifier or stabilizer in the treatment of black cotton soil for roadwork. This work represents a study of the Eggshell powder as the admixture or stabilizer in improving some Engineering Properties of Black Cotton (BC) soils. This experimental program evaluates the effect of the Eggshell powder on some basic engineering properties of BC soil such as Unconfined compression test, Compaction, and California Bearing Ratio (CBR) of BC Soil.

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 was found to be 6%.

INTRODUCTION

- ## 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 MANIT, BHOPAL, MADHYA PRADESH. The black cotton soil is 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 stabilization 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 stabilizations are lime stabilization, cement, chemical, bitumen and salt stabilization.

In this study, the chemical stabilization using egg shell powder 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.

- **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.

- **OBJECTIVES**

I. To study the physical properties of Black Cotton soil.
II. To study the influence of egg shell powder and cement on strength behavior in terms of CBR for BC soil.
III. To determine strength parameters of soil with different percentages of eggshell powder and cement by conducting Unconfined Compression test (UCC).

LITERATURE REVIEW

- **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 shows 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.

TESTS PERFORMED

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.

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 of 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).

3. Liquid Limit (IS: 2720 (PART V)-1985)

Objective: To determine the liquid limit of soil using Casagrande's Apparatus.

Equipment & Apparatus:

- Balance (0.01g accuracy)
- Sieve [425 micron]
- Casagrande's 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's 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 center 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. 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 molded with fingers.
- It was allowed to season for sufficient time, to allow water to permeate throughout the soil mass. 10 g 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 (I_p) = Liquid Limit (W_L) – Plastic Limit (W_p)

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 diameter and 1295.90 cubic cm 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 cm3 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 were 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 were 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 were 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%.

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 (motorized 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 were trimmed, shaped and placed on the conical bottom plate loading device.
- The load dial gauge and strain dial gauge were 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 were noted after every 30 seconds.
- The sample was compressed until it fails or a vertical deformation of 20%.
- The failure angle was measured.

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.

8. California Bearing Ratio Test

Objective: CBR is the ratio expressed in percentage of force per unit area required to penetrate a soil mass with a standard circular plunger of 50 mm diameter at the rate of 1.25 mm/min to that required for corresponding penetration in a standard material. The ratio is usually determined for penetration of 2.5 and 5 mm. When the ratio at 5 mm is consistently higher than that at 2.5 mm, the ratio at 5 mm is used.

Apparatus and Equipment:

- CBR Test Apparatus
- CBR Mould with Base Plate, Stay Rod and Wing Nut
- Cylindrical mould
- Collar
- Spacer Disc
- Weights

Procedure:

Preparation Of Test Specimen:

1. Remolded specimens are prepared in the laboratory by compaction. The material used in the remolded specimen shall pass 19 mm I.S. sieve. Allowance for large material shall be made by replacing it by an equal amount of material which passes a 19mm I.S. Sieve but is retained on 4.75 mm sieve.

2. The dry density for a remolding shall be either the field density or the value of the maximum dry density estimated by the compaction test (Heavy Compaction Test as per IS 2720 (Part-8) - 1983, for Railway Formation). The water content used for compaction shall be the optimum water content or the field moisture as the case may be.

3. Dynamic Compaction: A representative sample of the soil weighing approximately 4.5 kg or more for fine grained soil and 5.5 kg or more for granular soil shall be taken and mixed thoroughly with water. If the soil is to be compacted to the maximum dry density at the optimum moisture content, the exact mass of the soil required shall be taken and the necessary quantity of water added so that the water content of the soil sample is equal to the determined optimum moisture content.

4. Fix the extension collar and the base plate to the mould. Insert the spacer disc over the base. Place the filter paper on the top of the spacer disc.

5. Apply Lubricating Oil to the inner side of the mould. Compact the mix soil in the mould using heavy compaction, i.e., compact the soil in 5 layers with 55 blows to each layer by the 4.89 kg rammer.

6. Remove the extension collar and trim the compacted soil carefully at the level of top of mould, by means of a straight edge. Any holes developed on the surface of the compacted soil by removal of the coarse material, shall be patched with the smaller size material. Remove the perforated base plate, Spacer disc and filter paper and record the mass of the mould and compacted soil specimen. Place a disc of coarse filter paper on the perforated base plate, invert the mould and compacted soil and clamp the perforated base plate to the mould with the compacted soil in contact with the filter paper.

7. Place a filter paper over the specimen and place perforated plate on the compacted soil specimen in the mould. Put annular weights to produce a surcharge equal to weight of base material and pavement, to the nearest 2.5 kg.

8. Immerse the mould assembly and weights in a tank of water and soak it for 96 hours. Mount the tripod for expansion measuring device on the edge of the mould and record initial dial gauge reading. Note down the readings every day against time of reading. A constant water level shall be maintained in the tank throughout the period.

9. At the end of soaking period, note down the final reading of the dial gauge and take the mould out of water tank.

10. Remove the perforated plate and the top filter paper. Weigh the soaked soil sample and record the weight.

Procedure For Penetration Test

1. Place the mould assembly with test specimen on the lower plate of penetration testing machine. To prevent upheaval of soil into the hole of the surcharge weights, 2.5 kg annular weight shall be placed on the soil surface prior to seating the penetration plunger after which the remainder of the surcharge weights shall be placed.
2. Seat the penetration piston at the center of the specimen with the smallest possible load, but in no case in excess of 4 kg so that full contact of the piston on the sample is established.
3. Set the load and deformation gauges to read zero. Apply the load on the piston so that the penetration rate is about 1.25 mm/min.
4. Record the load readings at penetrations of 0.5, 1.0, 1.5, 2.0, 2.5, 4.0, 5.0, 7.5, 10 and 12.5 mm.
5. Raise the plunger and detach the mould from the loading equipment. Take about 20 to 50 g of soil from the top 30 mm layer and determine the moisture content.

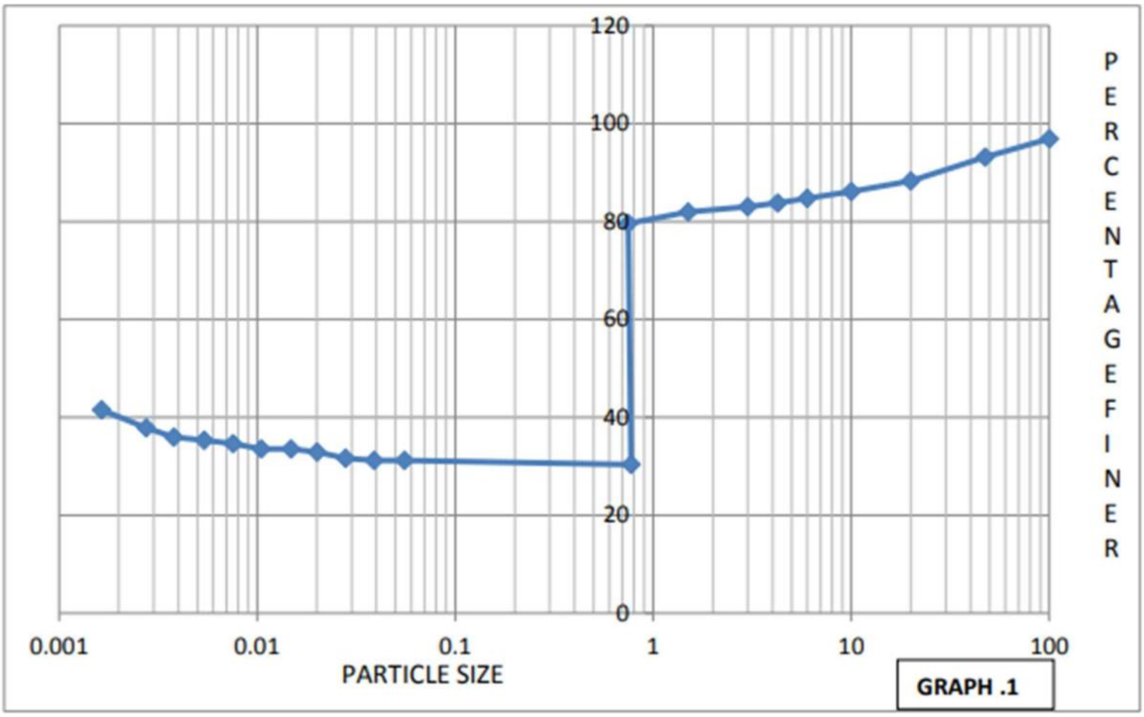
RESULTS (RAW SOIL)

S. No.	Properties	Observations (%age values)
1.	Specific Gravity, G	2.38
2.	Liquid Limit, LL	45.4
3.	Plasticity Limit	26.4
4.	Maximum Dry Density, MDD	15
5.	Optimum Moisture Content	23.5
6.	%age Fines	<95%
7.	Unconfined Compressive Strength, UCS	191.7 Kn/m2
8.	**California Bearing Ratio, CBR**	
	Soaked at 2.5mm Penetration	1.49
	Unsoaked at 2.5mm Penetration	5.1
	Soaked at 5mm Penetration	1.09
	Unsoaked at 5mm Penetration	4.47
9.	Plasticity Index/Soil Classification	18.6/CI Type

RESULTS (Modified Soil)

WET SIEVING

Particle size distribution curve has been plotted in graph-1. Particle size is on x axis in log terms and percentage finer on y axis.



SPECIFIC GRAVITY

W_1 = Wt. of bottle = 449gm

W_2 = Wt. of bottle + dry soil = 549gm

W_3 = Wt. of bottle+ soil+ water =1227gm

W_4 = Wt. of bottle +water =1169 gm.

Specific Gravity =$(W_2-W_1)/(W_2-W_1)-(W_3-W_4)$ = 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.

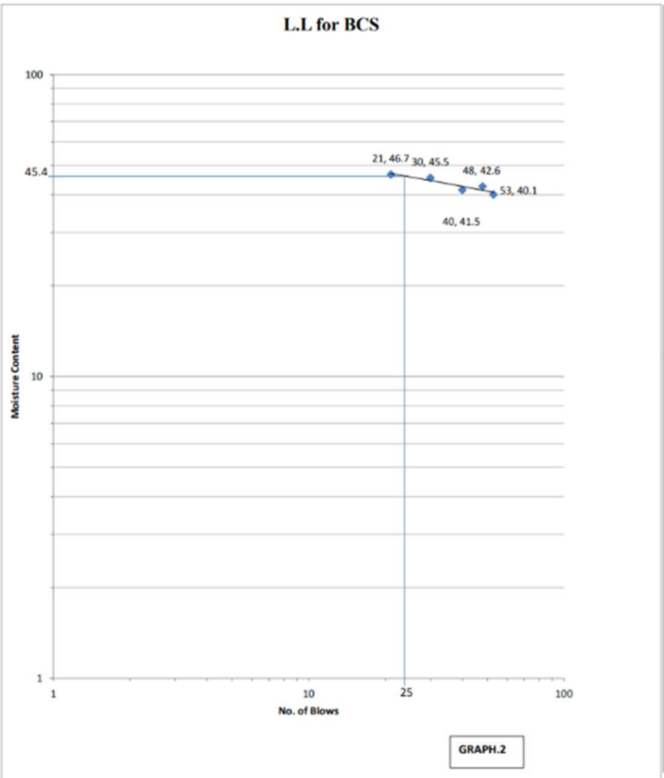
LIQUID LIMIT

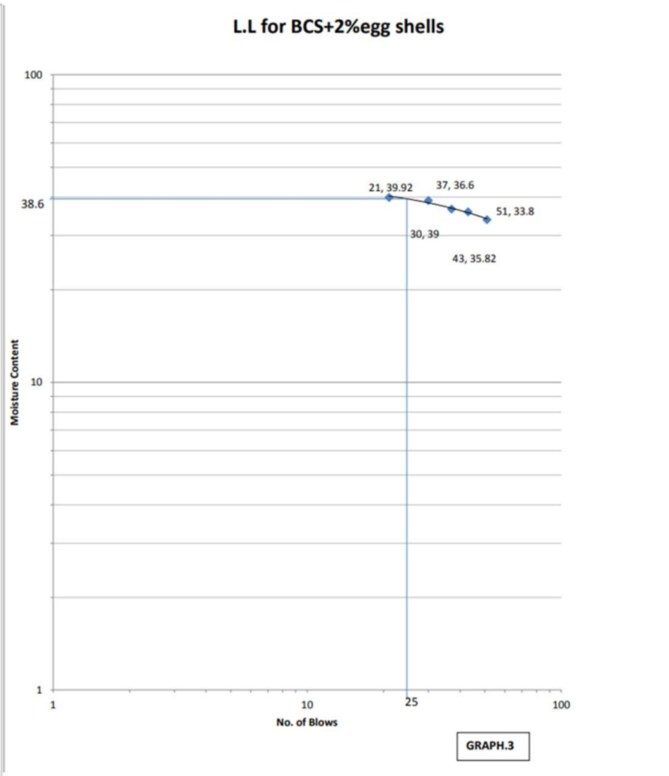
A ‘flow curve’ has been plotted on semi-logarithmic graph representing water content in arithmetic scale and the number of drops on logarithmic scale. The flow curve is a straight line drawn as nearly as possible through four points.

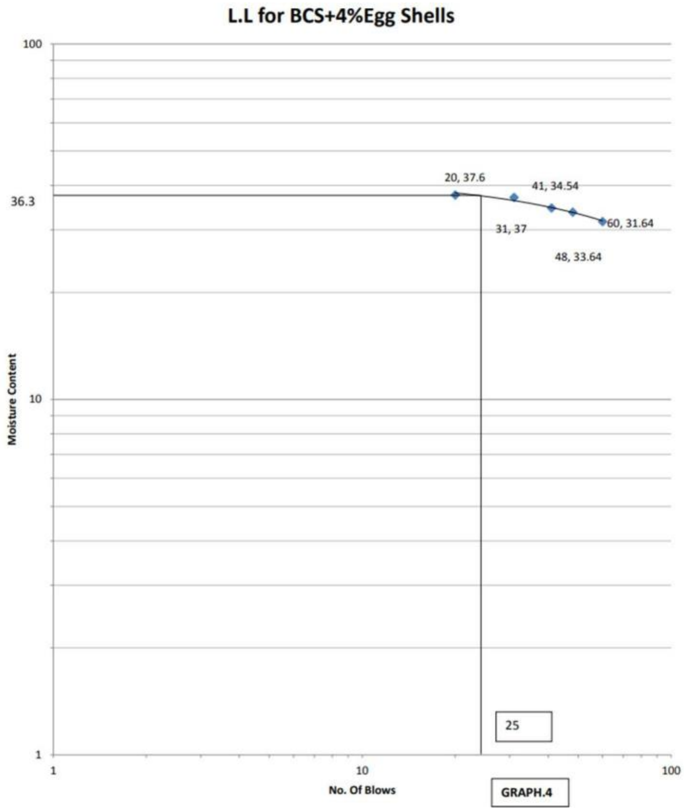
The moisture content corresponding to 25 blows as read from curve is the liquid limit of that soil. The graph showing the variation with numbers of blows are plotted in graphs 2, 3, 4, 5, 6 and 7.

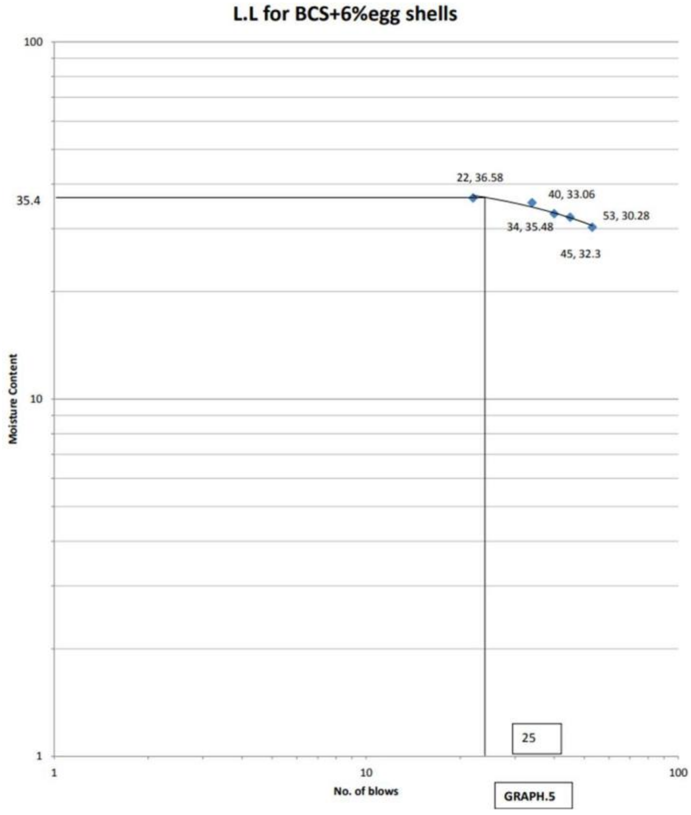
The liquid limit of black cotton soil is observed to be 45.4% without the addition of egg shells and the value changes to 38.6%, 36.3%, 35.3 %, 34.7% and 33.9% with the addition of 2%, 4%, 6%, 8% and 10% egg shells respectively.

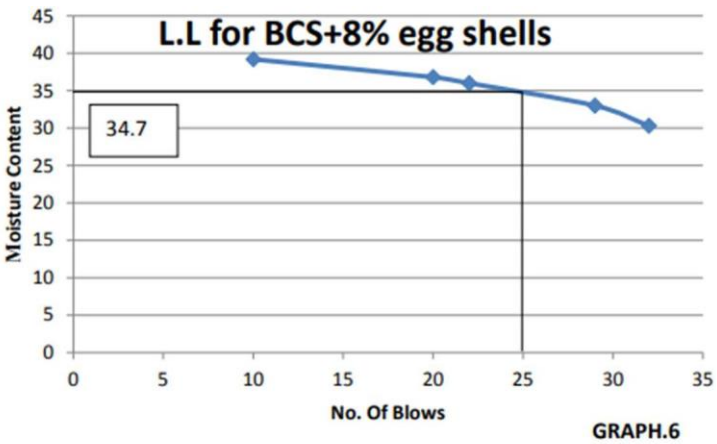
This implies that the value of liquid limit is slowly changing from the medium degree of expansion (35-50) towards the low degree of expansion (20-35) according to the IS 1498-1970.

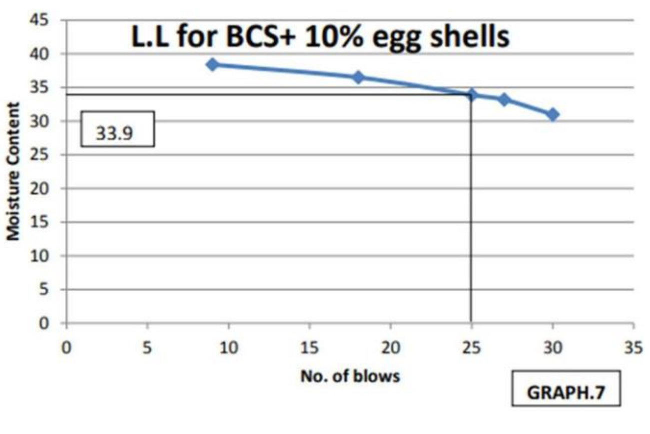





L.L for BCS+4%Egg Shells
Moisture Content
No. Of Blows
36.3
20, 37.6
41, 34.54
31, 37
60, 31.64
48, 33.64
25
GRAPH.4


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


L.L for BCS+8% egg shells
Moisture Content
No. Of Blows
34.7
GRAPH.6

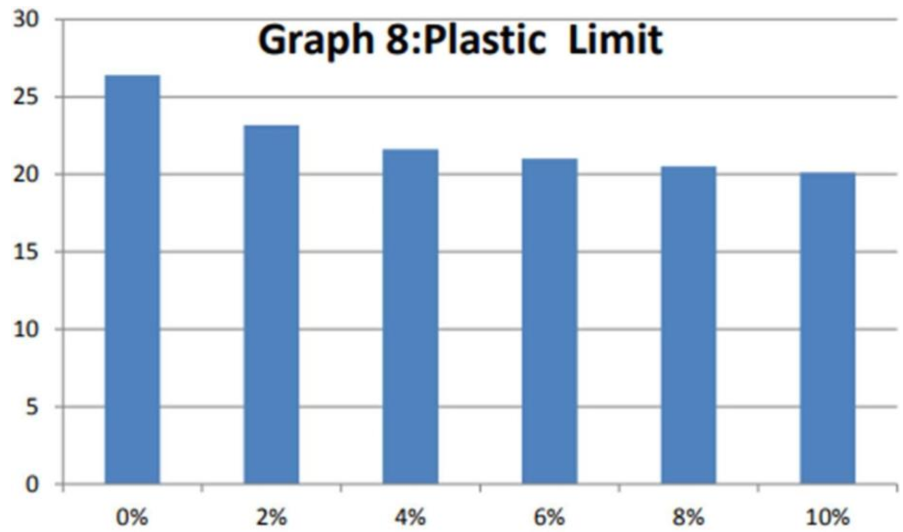

L.L for BCS+ 10% egg shells
Moisture Content
No. of blows
33.9
GRAPH.7

PLASTIC LIMIT

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.

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

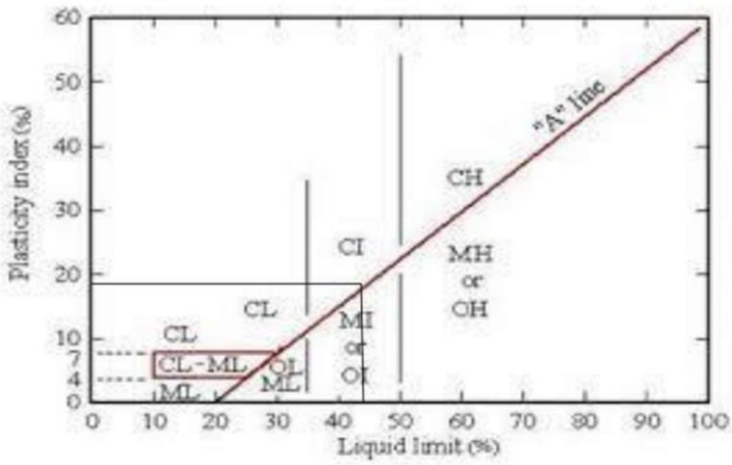


SOIL CLASSIFICATION & PLASTICITY INDEX

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

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

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

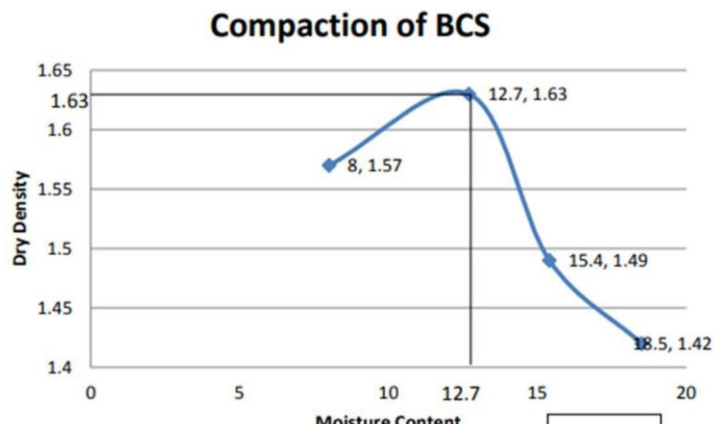


Casagrande's Plasticity Chart

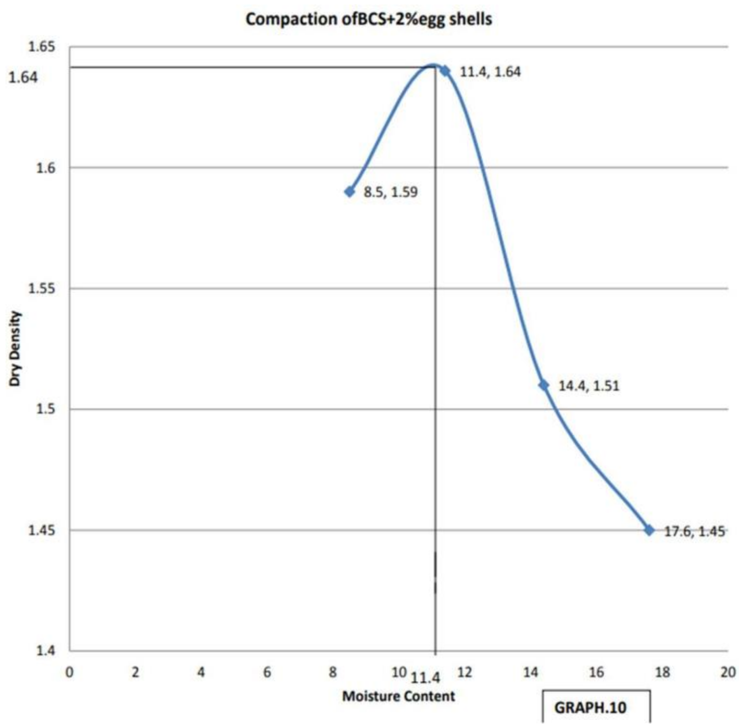
• The soil was found to be CI according to the plasticity chart that is the soil is clayey of medium compressibility.

LIGHT COMPACTION TEST

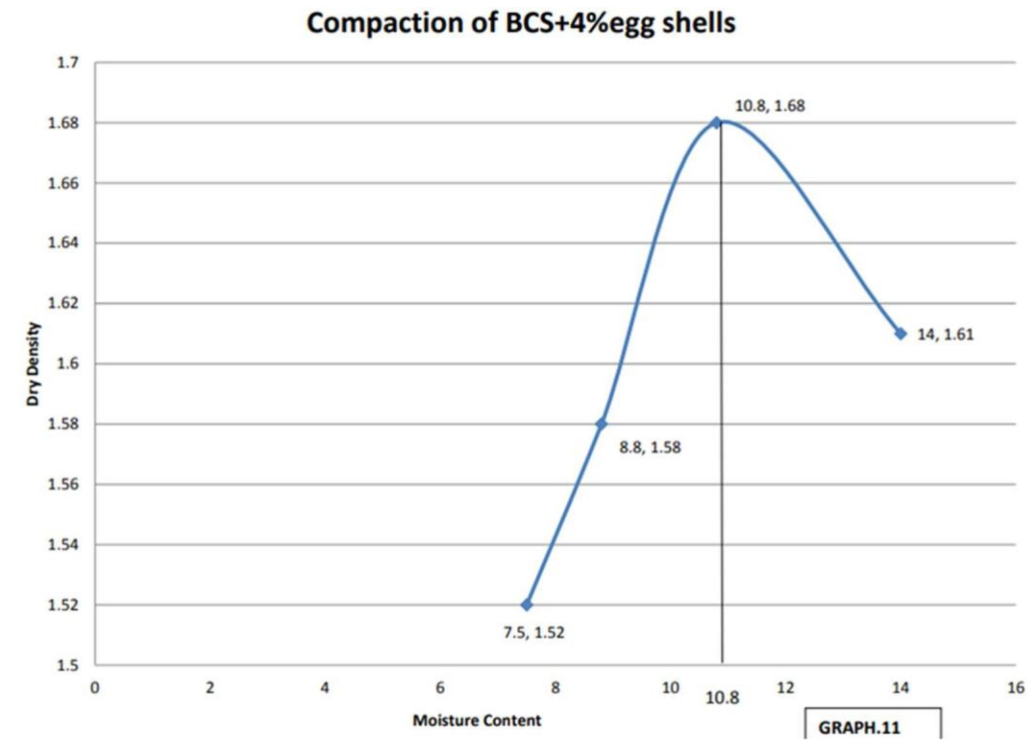
From the light compaction test, we obtain the maximum dry density and the optimum moisture content and the graphs were plotted.

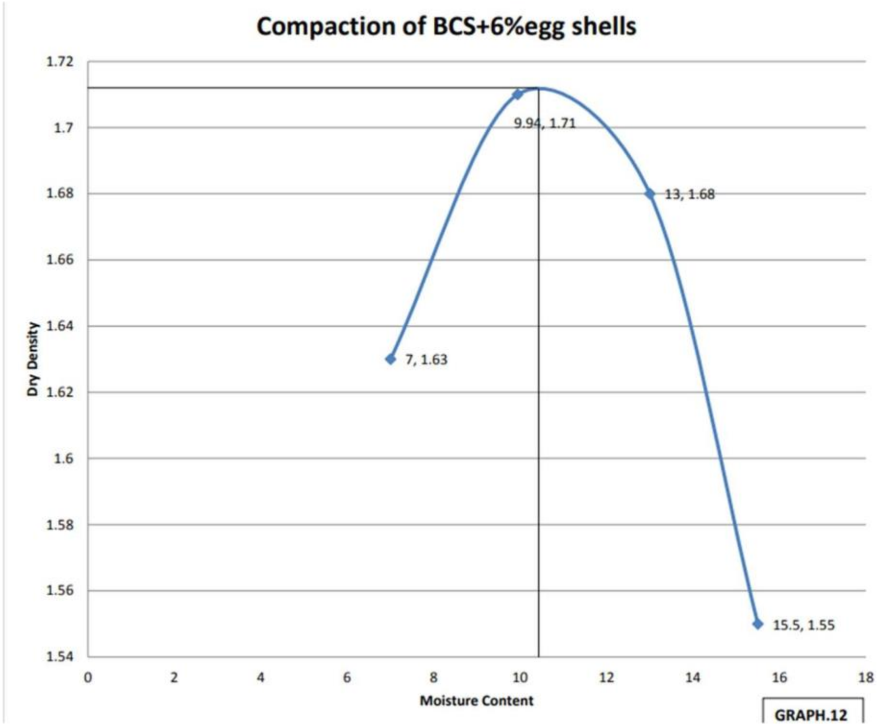


GRAPH.9

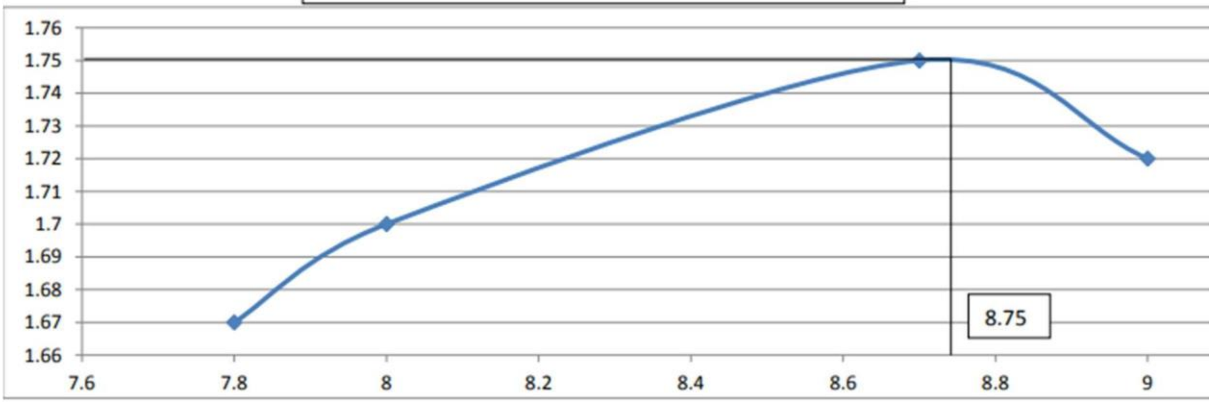


GRAPH.10

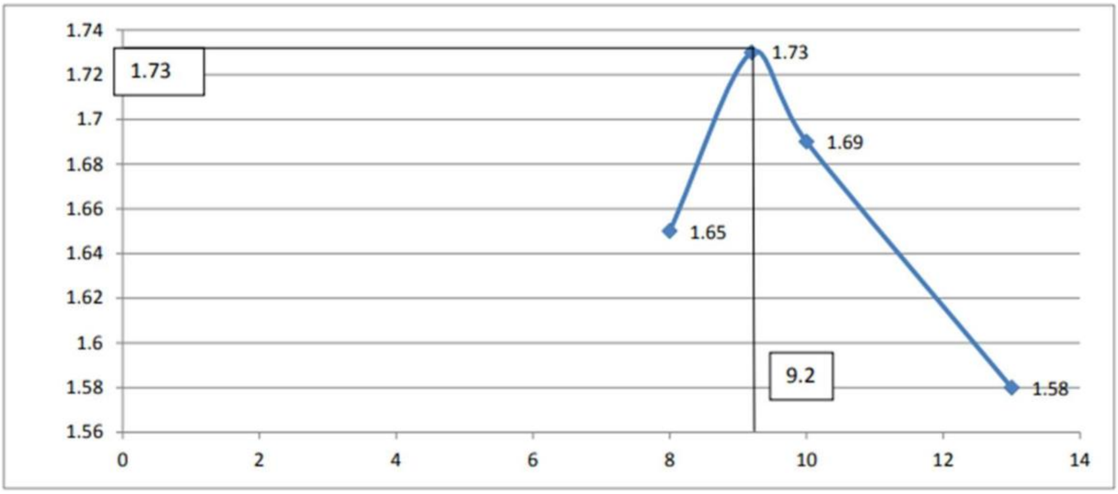

Compaction of BCS+4%egg shells
Dry Density
1.7
1.68
1.66
1.64
1.62
1.6
1.58
1.56
1.54
1.52
1.5
0
2
4
6
8
10
12
14
16
10.8
Moisture Content
10.8, 1.68
14, 1.61
8.8, 1.58
7.5, 1.52
GRAPH.11


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



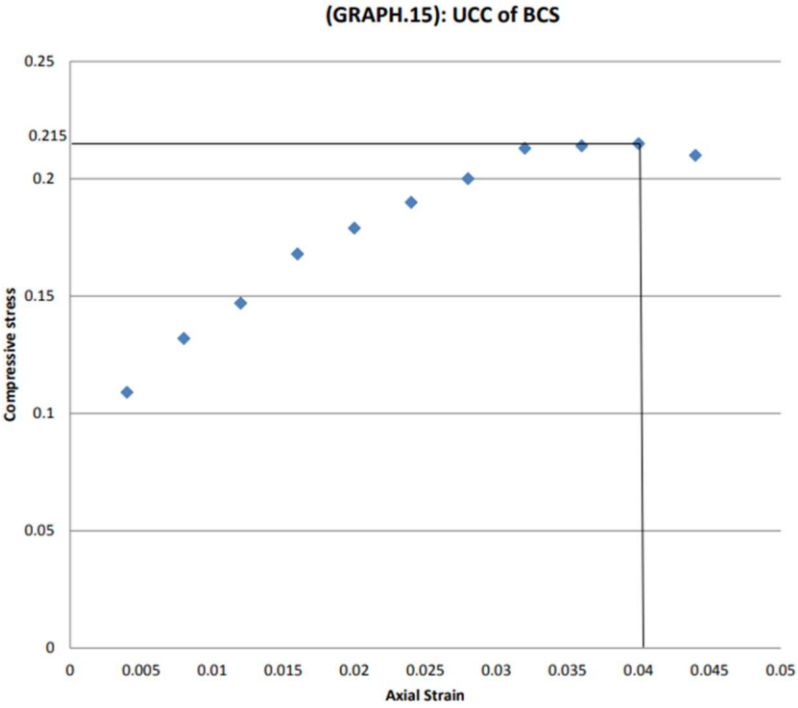
(GRAPH.13): Compaction Of BCS With 8% egg shells

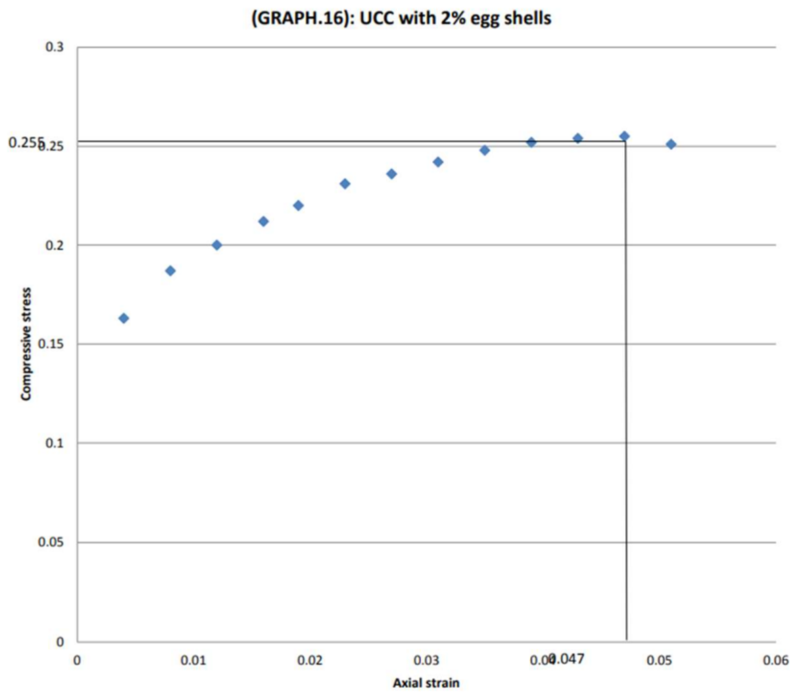


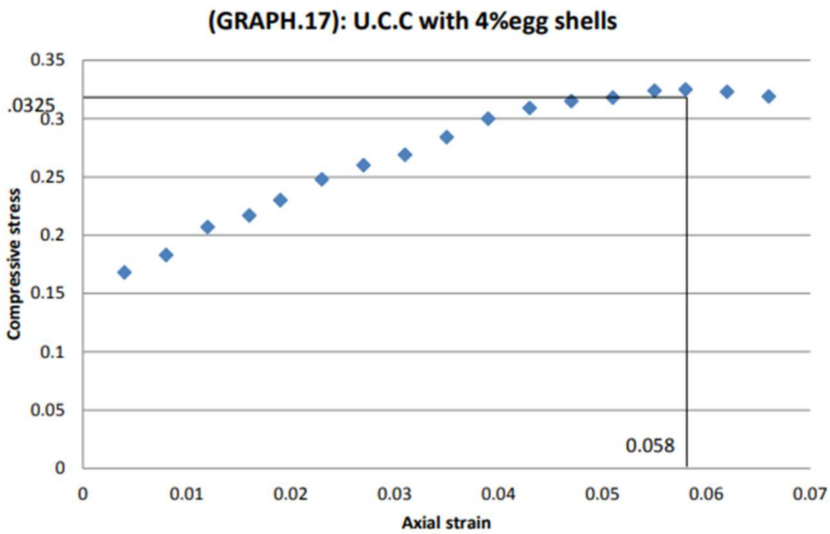
- The maximum dry density increases from 1.63 to 1.64, 1.68, 1.71, 1.73 &1.75 with the addition of 2%, 4%, 6%, 8%and 10% egg shells respectively.
- The optimum moisture content decreases from 12.7% to 11.4%, 10.8%, 9.94%, 9.2%& 8.75% with the addition of 2%, 4%, 6%, 8% and 10% egg shells respectively.

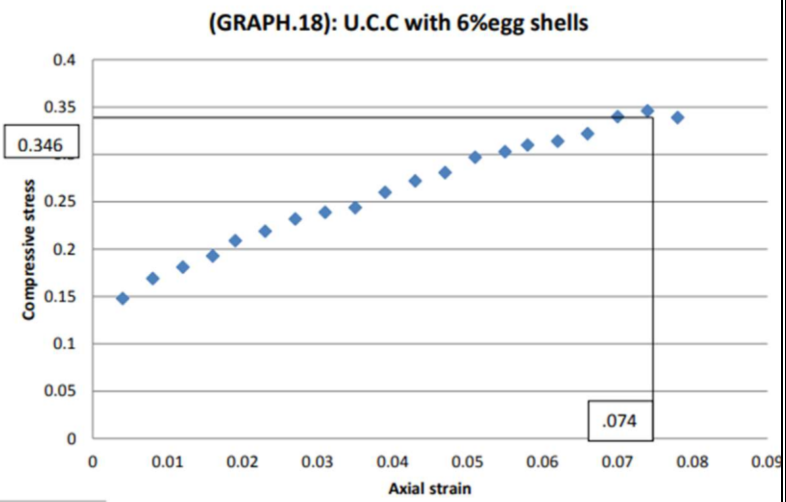
UNCONFINED COMPRESSIVE STRENGTH

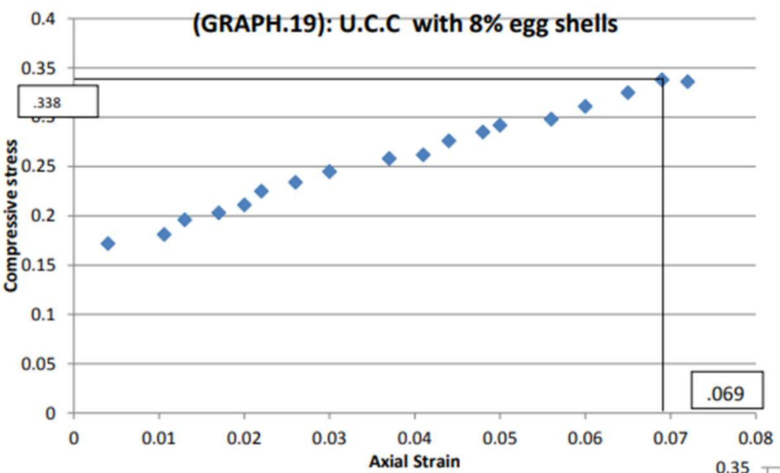
- The unconfined compression strength of soil increases on addition of egg shells by 2%, 4%, 6% but shows a dip in the value on addition of 8% and 10% egg shells.
- The trend which soil show is 0.215, 0.255, 0.325, 0.346, 0.336 and .31 on only soil, addition of 2%, 4%, 6%, 8% and10% respectively.
- The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

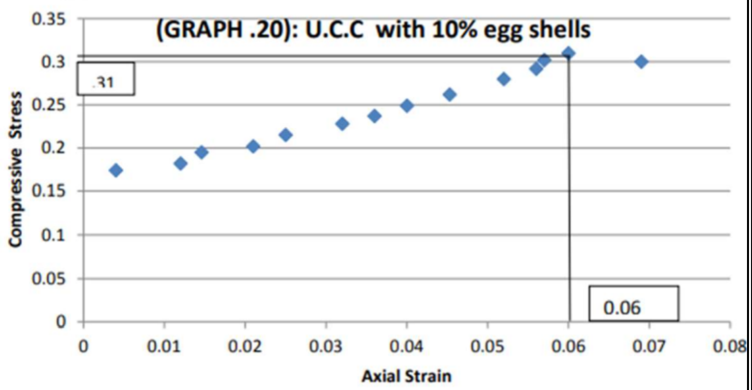





(GRAPH.17): U.C.C with 4%egg shells
Compressive stress
Axial strain
.0325
0.058


(GRAPH.18): U.C.C with 6%egg shells
Compressive stress
Axial strain
0.346
.074

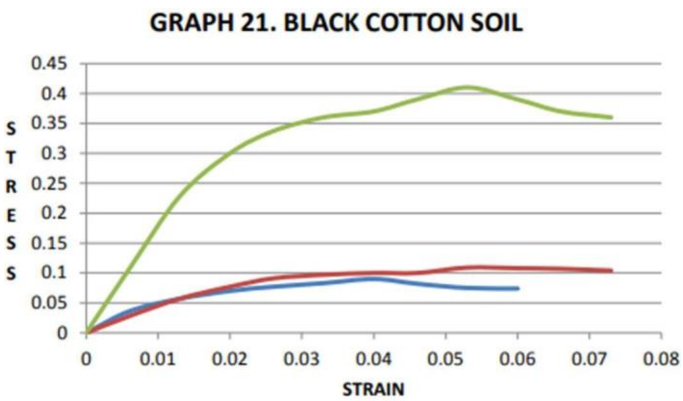

(GRAPH.19): U.C.C with 8% egg shells
Compressive stress
Axial Strain
.338
.069

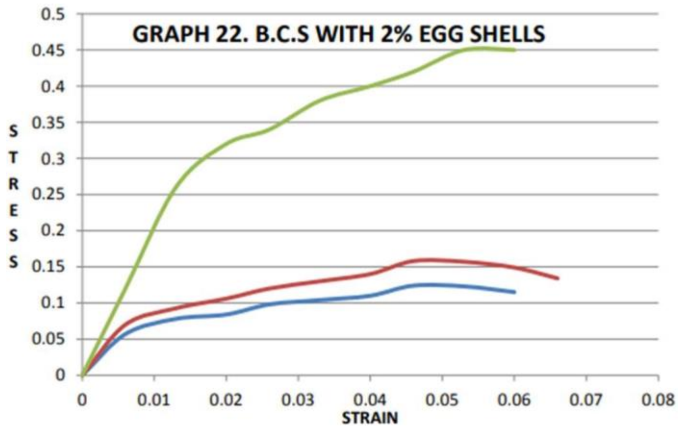

(GRAPH .20): U.C.C with 10% egg shells
Compressive Stress
Axial Strain
.31
0.06

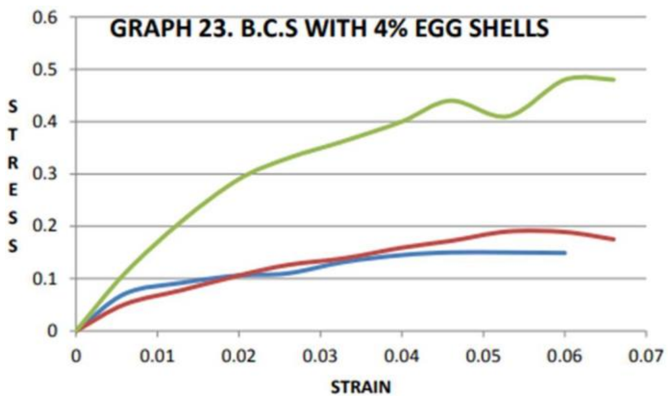
DIRECT SHEAR TEST

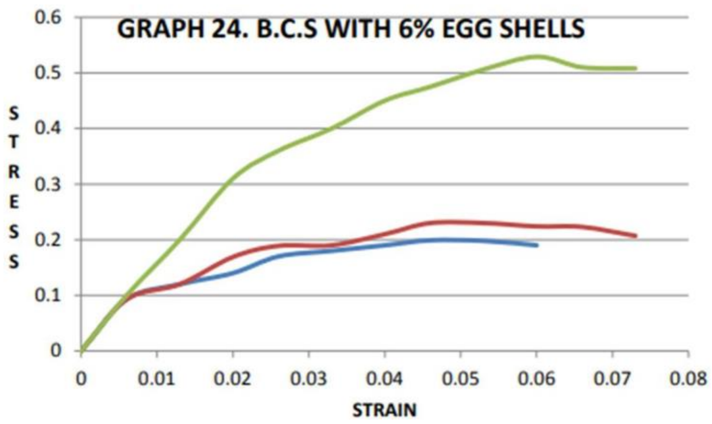
The graph has been plotted for shear test with strain on X axis and stress on Y axis Cohesion of soil is predicted by virtue of this test.

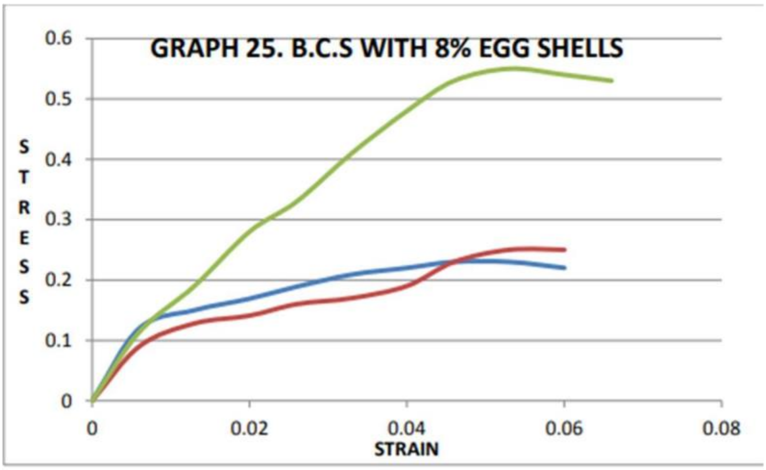
The green, red and blue lines are values of stress and strain corresponding to 0.5, 1and 2 Kg/cm2.

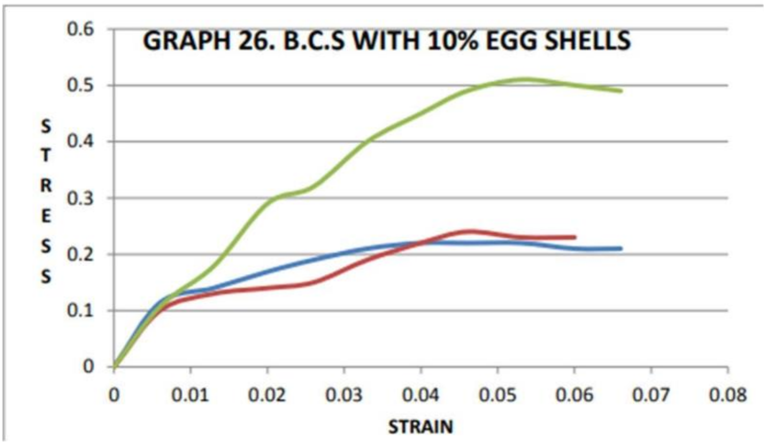












- The cohesion for Black cotton soil is showing an increasing trend up to addition of 8% egg shells. It shows a dip in cohesion as well as in strength at 10%egg shells.
- The values of cohesion corresponding to 2, 4, 6, 8 &10% egg shells are 0.0215, 0.047, 0.057 .088, 0.1105 & 0.105, respectively.

CALIFORNIA BEARING RATIO

The Unsoaked CBR value of BCS at 2.5 mm and 5 mm penetration was 5.1% and 4.47% and the soaked CBR value of BCS at 2.5 mm and 5 mm penetration was found to be 1.49% and 1.09% respectively.

After addition of Egg Shells, the unsoaked CBR value increases to 14.00% from 5.1%, whereas the soaked CBR value increases to 7.15% from 1.49%. Hence, the increase in soaked CBR value at 2.5 mm penetration is nearly 380%.

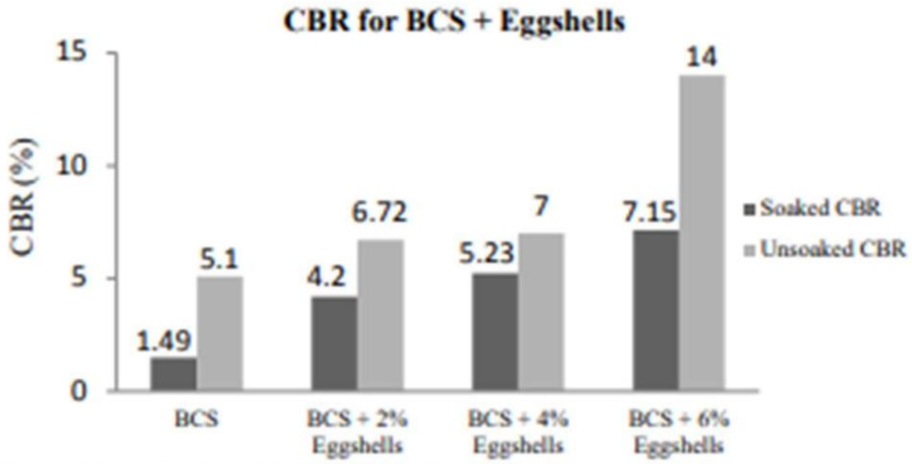


Fig. 9: Increase in CBR with Egg Shell Content

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.
- It was observed that the CBR values were increased up to 15% ESP which attains a maximum value, and also further addition decreases the CBR.
- 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.

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