# STRENGTHENING OF BLACK COTTON SOIL USING EGG SHELL POWDER AND COCONUT SHELL POWDER

**MALLIKARJUN YAMMY KOTRESH[1], SHARANAKUMAR[2]**

*[1]Bheemanna Khandre Institute of Technology, Bhalki, Bidar District, India*
*[2]Professor, Bheemanna Khandre Institute of Technology, Bhalki, Bidar District, India*

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***Abstract*** — Strengthening of clayey soil is very necessary and much important process during any construction practices, since clayey soil is well known for its dramatic nature according to the seasonal variation and causes huge problems in construction practices, Thus in the present investigation work Egg shell powder (ESP) and Coconut shell powder (CSP) are used as strengthening materials for clayey soils, since Egg shells are waste material and non-bio degradable and abundantly available material when compared to other stabilizing materials and also it resembles similar properties of lime and Coconut shells are obtained in large quantities, environmental and agriculture waste having good property in binding, which is used as a second strengthening material. Initially the Index and Engineering properties of original soil sample is determined by varying percentage of ESP say 2%, 4%, 6%, 8%, 10%, 12% and 14% by weight of soil mass from which 4% replacement of ESP obtained as optimum value which gives MDD and less OMC thus by keeping 4% replacement of ESP as constant, Again CSP is varied in different percentages say 0.25%, 0.5%, 0.75% 1%, 2%, 3% 6% 9%. In which, the combination of 4% ESP+0.5% CSP gives better results in OMC,MDD, UCS values. Thus by using above two admixtures the strength properties of soil can be greaterly increased up to certain extent.

***Index Terms*— BC Soil, Egg Shell Powder, Coconut Shell Powder, OMC, MDD, UCS**

## I. INTRODUCTION

A Civil Engineer often to face problematic soils such as expansive or clayey soils, These soils are usually Dark Black to Dark Brown in color, due to the presence of three major mineral compositions like **Kiolinite, Montomoronalite and Illite,** where Kiolinite is the mineral which is more stable and are not susceptible to any natural conditions, but the mineral Montomoronalite is less stable, due to this the soil exhibits dramatic nature in an extreme stages of an consistency from very hard to very soft when saturated. The mineral Illite falls in between these properties, when the soils having mineral Montomoronalite is in more percentages causes a severe problems in all Civil Engineering Construction practices.

In order to overcome with such problems one as to look for strengthening this type of soils by using different methods of stabilization like, Physical, Chemical, Bio-chemical, Electrolytic, Granular, Geosynthetics and many more, the method of stabilization is chosen in such a manner that, the stabilizing material is more economical, easily available, nature friendly and easy to process.

Chicken Egg is Protiencious material which is consumed daily as a food in India and all over the world. After consuming the edible part the remaining non edible part say, Egg Shell's is directly disposed on ground surface or to the any landfills, since Egg shell are non-biodegradable material and even it also attracts insects due to its constituent when it directly disposed on ground surfaces as a waste material. In turn it causes harmful infection and disturbs the natural environment which is not a human friendly aspect, and also effects human health as a secondary or tertiary reason for the cause of disease.

The Chicken Egg Shell mainly consists of **95-97%** of calcium carbonate **($CaCO_3$)** as constituent material, which is strengthening by a protein matrix. Due to its similar composition like Lime stone, the waste chicken eggs shells can also be effectively used as strengthening material, in the process of strengthening, the clayey soils which usually absorbs water by its nature and compositions, in turn it may increase the strength properties of clayey soils.

Coconuts are generally consumed in day to day life in India and all over the world. Coconut shells are organic in nature and belong to the palm tree family. Coconut is not only used for food purpose but its non edible part says, its hard shell is used in different industries, domestically and commercially due to its versatility in various parts. CSP is used as substitute material in manufacturing of Glues, Resin's or Phenol Formaldehyde. Since coconut shell is having high potential material due to its high strength and modulus properties. By the idea of gaining strength, utilizing this CSP as a strengthening material due to its fibrous nature and high water absorbing capacity by its virtue.

This absorbs natural water content of clayey soil which in turn leads to increasing the strength property of clayey soils.

## II. MATERIALS AND METHODOLOGY

### 2.1 Materials:

In the present work, we used three major materials namely, Black cotton soil as strength gaining material, Egg Shell Powder **(ESP)** and Coconut Shell Powder **(CSP)** as strengthening materials.

**2.1.1 Black cotton soil (BC):**The soil is collected from Sadhguru Vidyalaya's, open field. This has a coordinates **18° 0504″ North and 77°2184″ East,** of Bhalki town, Bidar district, Karnataka State, India. This soil is collected from an open excavation method at an average depth of **4.5 feet-5feet** below the original ground surface.

**Table 2.1.1 (a) Physical Properties of Black cotton Soil**

| Sl No | Properties | Black cotton soil |
|---|---|---|
| 1 | Specific Gravity | 2.63 |
| 2 | Plastic Limit (%) | 45.50 |
| 3 | Liquid Limit (%) | 73.30 |
| 4 | Shrinkage Limit (%) | 19.39 |
| 5 | Plasticity Index | 23.725 |
| 6 | I S Soil Classification | CH |
| 7 | MDD, (g/cc) | 1.615 |
| 8 | Optimum Moisture Content (%) | 20.27 |
| 9 | Free Swell Index (%) | 40 |
| 10 | Natural Water Content (%) | 14.10 |
| 11 | Wet Sieve Analysis (%) | 78 ( clay+silt) |
| 12 | Color | Dark Black in Color |
| 13 | Odour | Odorless |
| 14 | Category | Clay of High Plasticity |
| 15 | Unconfined Compressive Strength (Kpa) | 139.11 |
| 16 | Direct Shear | C=21.51 Kpa and Φ=70.86 |
| 17 | California Bearing Ratio (CBR) | 2.5mm=1.63<br>5.0mm=1.32 |

### 2.1.2 Egg shell powder (ESP):

The Egg shells are collected from different Bakeries and Restaurants of Bhalki town and these Egg shells are properly washed in water and allowed it for drying (sun drying) in order to remove the impurities and bad odour coming from the Egg shells, after complete drying these Egg shells are powdered using mechanical means say (Mixer), later on these fractions are sieved through **425μ** Indian Standard **(IS)** Sieve to make it as a fine powder. The physical and chemical properties of **ESP** are listed below,

**Table 2.1.2.(a): The Physical a properties of Egg shell powder**

| Physical Properties | Egg Shell Powder |
|---|---|
| pH | 8.2 |
| Flammability | Non-flammable |
| Freezing Point | None |
| Odour | Odorless |
| Storage | Dry storage |
| Shelf life | 12 Months |
| Specific Gravity | 1.256 |
| Moisture Content | 1.093 |
| Particle Density | 1.025(g/m3) |
| Porosity % | 23.9 BET |
| Bulk Density | 0.9 (g/m3) |

**Table 2.1.2.(b): The Chemical a properties of Egg shell powder**

| Chemical Name | % by Mass |
|---|---|
| Cao | 50.9 |
| $Al_2O_3$ | 0.08 |
| $SiO_2$ | 0.04 |
| $Fe_2O_3$ | 0.02 |
| MgO | 0.01 |
| $P_2O5$ | 0.20 |
| $Na_2O$ | 0.23 |
| Sro | 0.14 |
| $SO_3$ | 0.001 |
| NiO | 0.59 |
| CI | 0.06 |

**Fig 2.1.2 (a): Egg Shell Powder**

### 2.1.3 Coconut shell powder (CSP):

Coconut shells are collected from different restaurants and temples of Bhalki town and these shells are kept for sun drying for few days, then these coconut shells are crumbled using rammer until it gets into powder form and later on this powder is passed through **425μ** Indian Standard **(IS)** sieve to make it as fine powder.

| Chemical Composition | Range in Percentage (%) |
|---|---|
| Pentosam | 29.6% |
| Lignin | 27.3% |
| Moisture | 26.2% |
| Cellulose | 8.02% |
| Uronic Anhydrides | 4.61% |
| Solvent Extractives | 3.39% |

**Table 2.1.3 (a) Chemical Properties of Coconut Shell Powder**

**Fig 2.1.3 (a): Coconut Shell Powder**

### 2.2 Methodology:

This Experimental work mainly involves in determining the optimum percentages of Egg Shell Powder **(ESP)** and Coconut Shell powder **(CSP)** that can be used effectively in soil in order to achieve a greater strength than the original soil sample.

The tests which were conducted here are,

1. Compaction Test
2. Unconfined Compressive Strength Test (UCS)

Firstly, the above tests are conducted for normal soil (BC) without additives and the results are taken.

Then the same tests which we are conducted for soil (BC) are conducted for the soil (BC) with the addition of ESP by the percentage replacement of ESP i.e. 2%, 4%, 6% and 8% by the weight of soil mass taken. The results which are obtained by these tests are noted down

Later on, by keeping that optimum percentage of Egg shell powder **(ESP)** as constant with respect to the weight of the original soil, the Coconut shell powder **(CSP)** is varied in different percentages say **0.25%, 0.5%, 0.75%,1%, 2%, 3%, 6%, 9**%, by weight of the soil mass again the same tests were conducted.

The results which are obtained by these tests are noted down and the results are compared with the results of Normal Soil (BC).

## III. RESULTS AND DISCUSSIONS

### 3.1 OMC and MDD:

OMC and MDD are main parameters of Compaction; here we conducted Standard Proctor Test for determination of OMC and MDD.

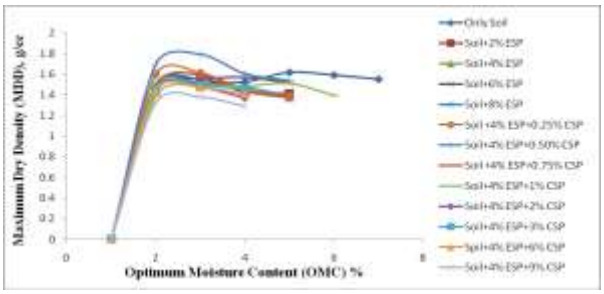


**Fig 3.1: Showing results of Soil replaced with different percentages of ESP and CSP and their combinations in MDD and OMC**

**Table 3.1: Overall results of Soil replaced with different percentages of ESP and CSP and their combinations of MDD and OMC**

| Sl No | Description | MDD (g/cc) | OMC, (%) |
|---|---|---|---|
| 1 | **Soil** | 1.615 | 20.27 |
| 2 | **Soil+ 2% ESP** | 1.553 | 28.32 |
| 3 | **Soil+ 4% ESP** | 1.721 | 16.4 |
| 4 | **Soil+ 6% ESP** | 1.570 | 26.52 |
| 5 | **Soil+ 8% ESP** | 1.512 | 27.97 |
| 6 | **Soil + 4% ESP+0.25% CSP** | 1.611 | 23.18 |
| 7 | **Soil + 4% ESP+0.50% CSP** | 1.793 | 22.05 |
| 8 | **Soil + 4% ESP+0.75% CSP** | 1.592 | 25.97 |
| 9 | **Soil + 4% ESP+1% CSP** | 1.511 | 35.02 |
| 10 | **Soil + 4% ESP+2% CSP** | 1.473 | 31.62 |
| 11 | **Soil + 4% ESP+3% CSP** | 1.489 | 32.01 |
| 12 | **Soil + 4% ESP+6% CSP** | 1.471 | 27.51 |
| 13 | **Soil + 4% ESP+9% CSP** | 1.377 | 32.88 |

The **Table 3.1 and the Fig 3.1** shows the overall results of Compaction Test conducted for Soil, Soil replaced with ESP by the weight of soil mass and the soil replaced with ESP and CSP by the weight of soil mass. The results which we obtained are, for the **replacement of 4% ESP with the soil** we get the result that the **MDD value is 1.721g/cc and OMC value is 16.40% and for the replacement of 4% ESP + 0.5% CSP result obtained that the MDD value is 1.793g/cc and OMC Value is 22.05%**. From the overall results we concluded that the MDD value increases after the addition of admixture thus, the admixture is suitable for stabilization.

| Sl.No | Description | Compressive Strength (Kpa) | Cohesion (Kpa) |
|---|---|---|---|
| 1 | **Soil** | 138.27 | 69.14 |
| 2 | **Soil+ 2% ESP** | 393.24 | 196.62 |
| 3 | **Soil+ 4% ESP** | 1054.21 | 527.01 |
| 4 | **Soil+ 6% ESP** | 639.70 | 319.85 |
| 5 | **Soil + 4% ESP+0.25% CSP** | 809.96 | 404.93 |
| 6 | **Soil + 4% ESP+0.50% CSP** | 1240.63 | 620.32 |
| 7 | **Soil + 4% ESP+0.75% CSP** | 746.32 | 373.16 |
| 8 | **Soil + 4% ESP+1% CSP** | 1060.95 | 530.30 |
| 9 | **Soil + 4% ESP+2% CSP** | 306.83 | 153.42 |
| 10 | **Soil + 4% ESP+3% CSP** | 336.43 | 168.21 |
| 11 | **Soil + 4% ESP+6% CSP** | 414.37 | 207.18 |
| 12 | **Soil + 4% ESP+9% CSP** | 302.89 | 151.44 |

**3.2 Unconfined Compressive Strength (UCS):**

The Unconfined compressive strength test, were conducted for Soil, soil replaced with the different percentages of ESP and also for the combination of Soil, ESP and CSP.

**Table 3.2 Overall results of Soil replaced with different percentages of ESP and CSP and their combinations of UCS test.**

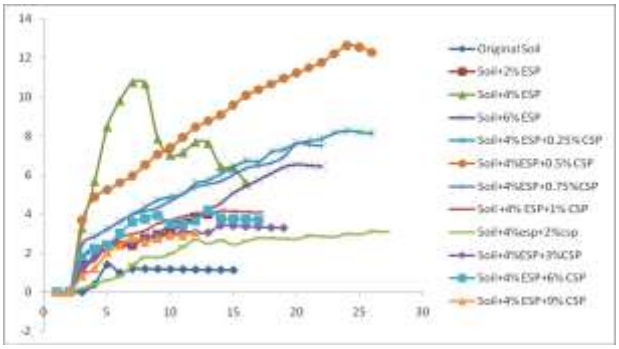


**Fig 3.2: Showing results of Soil replaced with different percentages of ESP and CSP and their combinations in UCS test**

The **Table 3.2 and the Fig 3.2** shows the overall results of UCS tests conducted for Soil, Soil replaced with ESP by the weight of soil mass and the combination of ESP and CSP with Soil. The results which we obtained are, for the **replacement of 4% ESP with the soil** we get the value of compressive strength as **1054.21kPa** and for the **SOIL + 4% ESP + 0.5% CSP** we get the value of compressive strength is **1240kPa**. By knowing the results we concluded that compressive strength value of soil increases after the addition of admixtures for the certain extent.

## IV. CONCLUSIONS

Series of Experimental works are carried out in order to determine the effectiveness of ESP and CSP as an admixture in strengthening of Soil, since these admixtures are very cheap, easily available in huge quantity and less processing cost, and also ESP resembles a property of Lime stone whose having a great water absorbing capacity by its nature and composition and also CSP exhibits a property of good binding material when compared to other admixtures by its mineral composition that is why it is used as binding material in many industries. Thus the combination of above these two admixtures gives a better results in strengthening of Soil even though the soil need such property in strengthening. The following Conclusions were obtained from present experimental work;

The MDD value increased by **6.56%,** when compared to original soil sample replaced with **4% ESP** and OMC value decreased up to **19.09%,** for the soil and at the same ESP percentage.

The value of **MDD** and **OMC** increased by **11.02% and 8.78%** when compared to original soil sample, for the combination **of Soil +4% ESP +0.50% CSP** the reason here is CSP requires more water for binding purpose by its virtue.

The UCS value increased by **662.43%** for Compressive strength and **662.24%** for Cohesion, when compared to original soil sample, when the soil is replaced with **4% ESP.**

due to decrease in water content and increases in compaction phenomenon

When soil is replaced with Optimum percent of ESP and in different percentage of CSP the value of Compressive strength and C increased by **797.25%** and **797.19%** , for the Combination of **Soil +4% ESP +0.50% CSP.** Due to the greater binding property of CSP when it combines with soil.

Thus by observing all the results, obtained from the different tests it can be concluded that the ESP and CSP can be effectively used in strengthening of Soil Up to certain limit

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