Stabilization on Expansive soil using sea shell powder and Rubber powder

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Abstract. BCS, type of expansive soil which is responsible for the volumetric changes with the change in the moisture content due to the excessive presence of montmorillonite. The stabilization of soil is the process of enhancing the properties of expansive soil and makes it stable to withstand the load acting on it. The stabilization is done by controlled compaction and addition of different types of stabilizers and admixtures. Hence this stabilization is done by various admixtures like cement, fly ash, bagasse, coir fibre, granite dust, rubber powder, sea shell powder etc. This paper represents the study of rubber powder and sea shell powder as different admixture to refine BCS properties. The unconfined compressive strength of BCS is found by adding sea shell powder and rubber powder as admixture, here this paper presents the results of an attempt that is performed.

1. Introduction

1.1 Black Cotton Soil (BCS)
Expansive soil are also known as black cotton soil. Expansive soil are mainly concentrated in the region of central India and Deccan plateau, cotton is more efficiently grown in this type of soil. The prime factor for the development of BCS is due to the climatic conditions along with parent rock.

1.2 Soil stabilization
Improvement of the sub base to the load capacity to the support of pavements and foundation is performed by stabilization in engineering properties. The improvement in soil strength and resistance is increased by soil stabilization by water bonding method of the particles together. The basic and normal stabilization forms are drainage and compaction (if water enters out of wet soil, it gets more grounded). The different procedure is by expanding degree of molecule measure and further improvement can be accomplished by adding folios to weak soils. Soil adjustment can be cultivated by few techniques. Each and every one of these strategies comes into two general classifications in particular

- The Mechanical stabilization.
- The Chemical stabilization.
1.3. Mechanical stabilization
By altering the physical nature of the native soil particles, through incorporating different physical properties like barriers and nailing or by induced compaction and vibration technique, stabilization can be achieved.

1.4. Chemical stabilization
The soil stabilization essentially relies primarily upon synthetic responses accordingly soil minerals (pozzolanic materials) and stabilizer (cementitious material) to accomplish the ideal quality.

1.5. Stabilization by using different types of admixture is as follows.
Lime, cement, fly ash, bituminous, rice husk, thermal, electrical, geo textile, recycled products, fabrics, waste products.

2. Materials and methodology
In the present work, some of the tests were carried out by adding Sea Shell Powder (SS) and rubber powder as an admixture by varying its %.

2.1. Materials used
- Black Cotton Soil.
- Sea Shell Powder.
- Rubber Powder.

2.1.1. Black cotton soil (BCS)

![Figure 1. Black cotton soil.](image)

They exhibit high swelling of soil under rainy season and shrink under dry condition. The sample (Figure 1) was collected in the place near Koppal district, Bannikoppa village, Karnataka. The following results under various test at 2m depth. The soil was pulverized to pass through micron sieve of IS -425, air dried and oven dried @ 110°C before testing. General properties are shown in Table 1.

2.1.2. Sea shell powder
Shell powder Seashells are the exoskeletons of mollusks, for example, snails, shellfishes, clams and numerous others. The shell powder is the buildup powder that is made by powdering of the normally accessible hard shells which is the exoskeleton of Mollusks. Studies uncover that lime stabilization is one of the conventional and monetary procedures and shows a superior improvement. Such shells have various layers and are composed mostly of calcium carbonate with only a small quantity of protein. The sea shells were finely grained and the sea shell powder passed through IS 150 Micron sieve and retained on IS 75 Micron Sieve. The sea shells are cleaned and dried and are heated at 100°C to 250° shown in Figure 2. General important properties and chemical composition of sea shell powder are shown in Table 2, 3 respectively.
Table 1. Properties of Black Cotton Soil.

| Sr. No | Property                          | Value  |
|--------|-----------------------------------|--------|
| 1      | Specific gravity (G)              | 2.68   |
| 2      | Particle size distribution        |        |
|        | Gravel                           | 0.53   |
|        | Clay                             | 54.57  |
|        | Silt                             | 20.02  |
|        | Sand                             | 24.89  |
|        | Cu                               | 10     |
|        | Cc                               | 1.5    |
| 3      | Free Swell Index (%)              | 37     |
| 4      | Liquid Limit (%)                 | 74.2   |
| 5      | Plastic Limit (%)                | 37.57  |
| 6      | Plasticity Index (%)             | 36.63  |
| 7      | Shrinkage Limit (%)              | 12     |
| 8      | OMC(%)                           | 27     |
| 9      | Maximum dry density(kN/m³)       | 13.11  |
| 10     | Unconfined Compressive Strength(qu, kN/m²) | 158.06 |

Table 2. Properties of Sea Shell Powder

| Sr. No | Properties                     | Value  |
|--------|--------------------------------|--------|
| 1      | Specific gravity               | 2.45   |
| 2      | Liquid Limit (%)               | 42     |
| 3      | Plastic Limit                  | Non-Plastic |
| 4      | Optimum Moisture Content       | 18.28  |
| 5      | Maximum Dry Density            | 14.2   |

Figure 2. Sea Shell Powder.

2.1.3. Rubber powder
For the improvement of engineering properties of the problem crumb rubber powder, clay was preferred as an additive and its properties are shown in table 4 and table 5. Disintegrate rubber is the term normally preferred to reuse rubber from the Truck scrap tires. During the reusing procedure steel and fluff is evacuate leaving tire rubber with a granular consistency. kept handling with a granular and/or wafer factory perhaps with the guide of mechanical methods, diminish the size of the molecule further Right now rubber is frequently utilized as an added substance in bituminous solid blend. As of now India is confronting a gigantic rubber waste removal. To address the above concerns Crumb Rubber Powder is utilized as an added substance to improve the building properties of dark cotton soil. The Crumb Rubber Powder which is utilized in the examination are of 1.18mm down size
(IS strainer) (Figure 3). In the present examination, Crumb Rubber Powder is utilized as an added substance in the preliminary investigation to get wanted engineering properties.

### Table 3. Chemical composition of Sea Shell Powder.

| Sr. no | Oxide   | %   |
|--------|---------|-----|
| 1      | SiO₂    | 1.60|
| 2      | Al₂O₃   | 0.92|
| 3      | CaO     | 51.56|
| 4      | MgO     | 1.43|
| 5      | Na₂O    | 0.08|
| 6      | K₂O     | 0.06|
| 7      | H₂O     | 0.31|
| 8      | LOI     | 41.84|

### Table 4. Properties of rubber powder

| Sr. No | Properties          | Values |
|--------|---------------------|--------|
| 1      | Specific gravity    | 0.92   |
| 2      | Water absorption    | 2 %    |
| 3      | Dry density (kN/m³) | 12.54  |
| 4      | Moisture content (%)| 19.65  |

**Figure 3. Crumb Rubber Powder**

### Table 5. Chemical Properties of Rubber powder

| Sl. No | Material/Element | Mass % |
|--------|------------------|--------|
| 1      | Rubber           | 54     |
| 2      | Carbon black     | 29     |
| 3      | Sulphur          | 1      |
| 4      | Textile          | 2      |
| 5      | Oxidize zinc     | 1      |
| 6      | Additives        | 13     |

### 3. Methodology

The expansive soil was admixture with Sea shell powder of varying % of 6 %, 8, 10, 12, 14 and rubber powder of 2, 3, 4, 5 and 6 % also and admixed with BC soil. The specific gravity was also conducted as per IS 2720-1980, for expansive soil sea shell powder. Grain size analysis was conducted as per IS 2720 (Part 4)-1985 for expansive soil. Atterberg’s limits were conducted as per IS 2720(Part 5) 1985 and IS 2720 (Part 6) 1972, for expansive soil independently and by adding admixtures of sea shell powder (6, 8, 10, 12 and 14 %), rubber powder (2, 3, 4, 5 and 6 %).
3.1. Compaction test
The OMC and MDD of expansive soil alone and admixed with sea shell powder and rubber powder are determined by Mini Compactor test, having an internal diameter of 3.81cm and 10 cm height and 4.61cm external diameter. It has a sample mould assembly with a removable collar of 3.50 Height and a detachable base plate. Height of fall is 10cm, with hammer weight of 1kg with 36 blows/layer. The compaction test were done to determine OMC and MDD with varying % (6, 8, 10, 12 and 14%) of sea shell powder and (2, 3, 4, 5 and 6%) of rubber powder.

3.2. Unconfined strength of soil in compression
The Unconfined strength of soil in compression examines are conducted on cylindrical specimens having height of 76mm and 38mm. The test was conducted as per IS 2720 part 10. Soil passing 4.75mm is used for preparation of moulds. Exact amount of soil is taken with respect to MDD of soil obtained through compaction and mixed thoroughly with water which is calculated from OMC and specimen is prepared. The sample is prepared by varying % (6, 8, 10, 12 and 14%) of sea shell powder separately and the test was carried out of different curing periods. Again the samples are prepared by varying % (2, 3, 4, 5 and 6%) of rubber powder separately and the test was carried out for different curing periods. The samples with optimum dosage of sea shell powder and rubber powder are prepared by mixing thoroughly desired amount of expansive soil then it is mixed thoroughly to obtain uniform moisture and then specimen is prepared. The required amount of water was calculated and added. After preparation of moulds, are wrapped with air tight bad and kept for curing in desiccators for 0 and 3 days. All the specimens are prepared with OMC and MDD as obtained by mini compaction (Figure 4).

Figure 4. Mini-Compaction
4. Results and discussions

**Table 6.** Results of tests conducted in the present study

| Sr. no | Program | Compaction test | UCS (kN/m²) |
|--------|---------|-----------------|-------------|
|        |         | $\gamma_d$ (Km/m³) | $\omega$ (%) | Un-cured  | 3 Day |
| 1      | Expansive soil | 13.9 | 27 | 158.06 | 157.59 |
| 2      | ES+6 % SS | 11.9 | 19.4 | 138.24 | 131.76 |
| 3      | ES+8 % SS | 12.55 | 17.2 | 175.68 | 156.47 |
| 4      | ES+10 % SS | 15.25 | 20.2 | 234.37 | 183.92 |
| 5      | ES+12% SS | 15.79 | 19.3 | 258.9 | 237.10 |
| 6      | ES+14% SS | 15.76 | 17.4 | 216.44 | 182.59 |
| 7      | ES+2% CRP | 11.38 | 30.82 | 223.95 | 226.61 |
| 8      | ES+3% CRP | 12.03 | 33.7 | 202.62 | 199.95 |
| 9      | ES+4% CRP | 12.36 | 34.76 | 239.94 | 221.28 |
| 10     | ES+5% CRP | 13.52 | 36.89 | 271.94 | 250.61 |
| 11     | ES+6% CRP | 11.03 | 38.62 | 245.28 | 189.29 |
| 12     | ES+12% SS+ 2% CRP | 15.01 | 22.2 | 183.96 | 201.43 |
| 13     | ES+12% SS+ 3% CRP | 16.05 | 21.79 | 220.23 | 257.84 |
| 14     | ES+12% SS+ 4% CRP | 17.25 | 20.37 | 255.15 | 279.33 |
| 15     | ES+12% SS+ 5% CRP | 18.32 | 19.87 | 279.32 | 297.61 |
| 16     | ES+12% SS+ 6% CRP | 16.29 | 22.47 | 236.35 | 183.98 |
4.1. Variation of compaction of soil characteristics on different % of sea shell powder.

The compaction test was conducted on the BCS mixed with Sea shell powder of varying % to obtain the optimum sea shell powder content for the soil which is taken in this study.

![Figure 6. Differential of OMC and MDD for different % of sea shell powder.](image)

4.2. Variation of compaction soil characteristics on various level of rubber powder and ideal sea shell powder.

![Figure 7. Differential OMC and MDD for ideal sea shell powder and distinctive % of rubber powder.](image)

Compaction test was directed with various rate (2, 3, 4, 5 and 6 %) of disintegrated rubber powder and ideal sea shell powder. Compaction curve is consequently acquired for expansive soil with various level of rubber powder. Figure 7 Shows that there was an expansion in dry unit weight and abatement in the moisture content with ideal % of sea shell powder and differing level of rubber powder. Impact of expansive soil with rubber powder is controlled by including rubber powder at various rate.

Consequently right now is seen that there is a significant increment in the dry density when the level of added soil to rubber powder expanded from 2 to 5 % in light of the fact that the dry density of soil is expanded up to 5 % and afterward it is diminished. Thus the rubber powder of 5 % is considered as the ideal rubber powder content from the thought of expanded dry density of the expansive soil.
4.3. Impact of Sea shell powder upon unconfined compressive strength of BCS.

Unconfined strength of soil in compression test is led broadly for expansive soil by treating with various level of sea shell powder. In the present examination the test is finished by blending the BCS with 12 % ideal Sea shell powder relieved for a time of Un-Cured and 3 day so as to decide the effect of curing on unconfined compressive soil strength of soil. Stress versus strain chart is plotted to decide the unconfined compressive strength of the BCS.

Figure 8. Stress-Strain attributes of BCS for various % of Sea Shell Powder for Un-Cured.

Figure 9. Stress-Strain Attributes of BCS for various % of sea shell powder for 3 Days of curing.

Figure 8 and 9 shows the graphical representation of the unconfined strength of soil in compression of the soil when mixed with sea shell powder (6, 8, 10, 12 and 14 %) for a curing period of Un Cured and 3 days respectively. Optimum Sea shell powder content taken in this study is 12 % which increase the strength of BCS, beyond which the strength of the treated soil decreases at different curing periods. The strength gained for other proportions are less when compared to obtained %. Hence here 12 % of sea shell powder is considered as optimum for BCS.

Figure 10 shows the variation of unconfined strength of soil in compression expansive soil ad mixed with sea shell powder (6, 8, 10, 12 and 14 %) for different curing periods. Compared to Un-Cured and 3 days curing period. Addition of sea shell powder, increases the bonding soil between clay particles there by it increases the cohesive strength of the soil.
Figure 10. Unconfined strength of soil in compression of expansive soil admixed with Sea shell powder for different curing period.

Table 7. Unconfined compressive strength of BCS treated with sea shell powder for different %

| % of Sea shell Powder | Un Cured | 3 Days Curing |
|-----------------------|----------|---------------|
| 0                     | 158.06   | 157.59        |
| 6                     | 138.24   | 131.76        |
| 8                     | 175.68   | 156.47        |
| 10                    | 234.37   | 183.92        |
| 12                    | 258.90   | 237.10        |
| 14                    | 216.44   | 182.59        |

The above Table 7. Shows the unconfined strength of soil in compression of soil treated with different % of Sea shell powder at different curing period. Here the maximum strength is observed at 12 % of Sea shell powder that is 237.10 kN/m².

4.4 Effect of Rubber powder on unconfined strength of soil in compression of BCS.

Unconfined strength of soil in compression test is conducted for expansive soil by treating with 5 % Rubber powder. In the present study, the experiment is conducted by mixing the BCS with varying rubber powder (2, 3, 4 and 5 %) cured for a period of Un-Cured and 3 days in order to determine the effect of curing on unconfined compressive strength of soil. Stress versus strain graph is plotted to determine the unconfined compressive strength of the BCS.

Figure 8, 9, 11 and 12 shows the graphical representation of the unconfined soil compressive strength of the soil when mixed with rubber powder (2, 3, 4, 5 and 6 %) for a curing period of 0, 3, 7 and 14 days respectively. Optimum Rubber powder content taken in this study is 5 % which increase the strength of BCS, beyond which the strength decreases at different curing periods. The strength gained for other proportions are less when compared to obtained %. Hence here 5 % of rubber powder is considered as optimum for BCS.

Figure 11. Stress-Strain characteristics of BCS for various % of rubber powder for Un-Cured.
Figure 12. Stress-Strain characteristics of BCS for various % of rubber powder for 3 days of curing.

Figure 13. Unconfined strength of soil in compression of expansive soil admixed with rubber powder for different curing period.

Figure 12 shows the variation of unconfined strength of soil in compression expansive soil mixed with rubber powder (2, 3, 4, 5 and 6 %) with different curing periods. Compared to Un-Cured and 3 days curing period, the strength is continuously increases. In addition of rubber powder, increase the bonding between clay particles there by it increases the cohesive strength of soil.

The above Table 8 shows the unconfined strength of soil in compression of soil treated as in with different % of rubber powder at different curing period. Here the maximum strength is observed at 5 % of Crumb rubber powder that is 250.61kN/m².

| % of Rubber powder | Un-Cured | 3 Day Curing |
|--------------------|---------|-------------|
| 2                  | 223.95  | 226.61      |
| 3                  | 202.62  | 199.95      |
| 4                  | 239.94  | 221.28      |
| 5                  | 271.94  | 250.61      |
| 6                  | 245.28  | 189.29      |

The above table 8 shows the unconfined strength of soil in compression of soil treated as in with different % of rubber powder at different curing period. Here the maximum strength is observed at 5 % of Crumb rubber powder that is 250.61kN/m².

5. Conclusion

- BCS treated with shell powder demonstrated higher estimation of MDD and Unconfined Compressive strength for 12 %. From this we presume that the 12 % as ideal rate for shell powder.
- By including 12 % of ideal shell powder content the quality of the strength is expanded by 6 % for a relieving time of 3 days.
- The test outcomes demonstrate that the unconfined compressive strength for shell powder treated with BCS expanded radically with the curing period (up to 12 %) and afterward it diminishes for 14 % of shell powder.
- The compaction test consequences of BCS treated with shell powder and rubber powder yield higher estimation of rubber for the mix of 12 % shell powder and 5 % of rubber powder.
• The blend of 12 % of sea shell powder and 5 % rubber powder demonstrated higher unconfined compressive strength contrasted with other mix.
• The expansion of 12 % of sea shell powder and 5 % of crumb powder expands the compressive strength by 14 % for a curing time of 3 days.
• The test outcomes demonstrate that the unconfined compressive strength of BCS treated with optimum % of sea shell powder and 5 % of rubber powder expanded radically with the curing time.
• The results consistently showed higher values for its unconfined compressive strength tests when compacted at its MDD and OMC for all %s of sea shell powder and rubber powder.
• The treatment of BCS with sea shell powder and rubber powder has a significant effect on its consistency limits.
• The engineering properties of BCS treated with optimum % of sea shell powder are improved owing to the increase in the MDD and unconfined compressive strength.

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