International Journal of Engineering, Management, Humanities and Social Sciences Paradigms (IJEMHS)
Volume 30, Issue 02, Quarter 02 (April to June 2018)
ISSN (Online): 2347-601X
www.ijemhs.com

# STABILIZATION OF BLACK COTTON SOIL WITH STONE DUST AND FIBERS

**SUCHISMITA SATPATHY**
Aryan Institute of Engineering & Technology, Bhubaneswar

**ABSTRACT:** A trial examination is done to concentrate on the impact of stone residue and Polypropylene filaments on designing and strength properties of the Black Cotton Soils. The properties of settled soil like compaction attributes, unconfined compressive strength and California bearing proportion were assessed and their varieties with content of stone residue and filaments are assessed. Expansion of either Optimum level of stone residue (3%) and Optimum Percentage of strands (0.6%) or Optimum level of its blend to the Black Cotton Soil has further developed the strength qualities of sub grade.

## 1. INTRODUCTION

Foundations in expansive soils, popularly known as black cotton soils in this country, undergo alternate swelling and shrinkage upon wetting and drying due to seasonal moisture fluctuations. Usually, moisture and water vapor migrates from the high temperature zones around the building. The difference in water contents between the interior and the exterior zones of the building causes uplift of the interior portion and results in mound – shaped heave of the floor of the building. This induces hogging moments, which are more detrimental to the safety of the structure than sagging moments. Severe cracking might result in the walls of the structure as a consequence. In India, about one-fifth of the land area, mostly in and around the Deccan plateau, is covered with these soils. The pockets include the states of Andhra Pradesh, Madhya Pradesh, Uttar Pradesh, Rajasthan, Gujarat, Maharashtra, Karnataka and Tamilnadu. Design of problem-free and economical foundations in these soils continues to pose challenge to civil engineers.

### Soil Stabilization

The term soil stabilization means the improvement of the stability or bearing power of a poor soil by the use of controlled compaction; proportioning and the addition of suitable admixtures or stabilizers. Soil stabilization deals with mechanical, physico-chemical and chemical methods to make the stabilized soil serve its purpose. The stabilization process, essentially involve excavation of the in-situ soil, treatment to the in-situ soil and compacting the treated soil. As the stabilization process involve excavation of the in-situ soil, this technique is ideal for improvement of soil in shallow depths such as pavements.

Methods of stabilization may be grouped under two main types: (a) modification or improvement of a soil property of the existing soil without using any admixture and (b) modification of the properties with the help of admixture. The examples of the first type are compaction and drainage, which improve the inherent shear strength of soil. The examples of the second type are stabilization with admixtures like cement, lime, bitumen, fly ash and chemicals. Deep soil deposits are stabilized by electrical methods, grouting, freezing etc. The use of lime, cement and bitumen has become common as stabilizing agents. The soil chosen for the purpose of the present study is a Black Cotton soil and the stabilizers used are Stone Dust and polypropylene Fibers.

### Polypropylene Fibers

In recent years the uses of fibers in various fields have gained much importance. Several researches on soil reinforced fibers have been reported some amongst are shown below. The research on fiber-reinforced soils demonstrated that this material might be a practical and cost

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effective technique for reinforcement of subgrade soils in flexible pavements. In comparison with systematically reinforced soils, randomly distributed fiber reinforced soils exhibit some advantages. Randomly distributed fibers offer strength isotropy and limited potential plane of weakness that can develop parallel to oriented reinforcement (Nagrale Prashant P., Chandra Satish & Viladkar M.N). Fibers are used to evaluate a methodology for preventing crack developments in clays due to desiccation by the use of short polymeric fibers. The inclusion of randomly distributed, discrete tensile reinforcement elements in compacted clay offers a potential solution to the problem of sloughing instability of levees. Such elements are available as short polypropylene fibers. An investigation was conducted and from the results obtained, there is potential for the use of fiber reinforcing in clays as it is increasing the strength of the clay by reducing desiccation cracking. It is suggested that the reinforcing fiber concept might be improved if longer fibers with a different texture or surface coating were used (REMR Technical Note GT-SE-1.8, 1998). Fibers are also used as reinforcement for water contaminant soil liners.

## 2. EXPERIMENTAL STUDY

### Test Materials

*Black Cotton Soil*

The soil used in the present study was collected from Shanker Pally, Medak District, Andhra Pradesh. The Properties of the Black Cotton soils are given in Table 2.

*Stone Dust*

The stone dust used in the present study was collected from Geo-Technical Laboratory, JNTU Campus, Kukatpally, Hyderabad.

*Fibers*

Polypropylene fibers from Sanghi filaments, Hyderabad, have been used in the investigation. The properties of fibers are given in Table 1.

Table 1: Physical Property of Polypropylene Fibers

| *Property* | *Value* |
|---|---|
| Tensile strength | 553–759 Mpa |
| Young’s modulus | 3450 Mpa |
| Specific gravity | 0.9 |
| Melting Point | 160–170 °C |
| U V Resistance | Poor |
| Acid Resistance | Very good |
| Alkali Resistance | Good |
| Dispersion | Good |

Table 2: Properties of the Black Cotton Soils

| | |
|---|---|
| *Grain Size Distribution* | |
| Gravel (%) | 0 |
| Sand (%) | 10 |
| Silt (%) | 60 |
| Clay (%) | 30 |
| *Engineering Properties* | |
| Specific Gravity | 2.71 |
| Optimum moisture content, (%) | 24 |
| Maximum dry density, (gm/cc) | 1.495 |
| Liquid Limit (%) | 66 |
| Plastic Limit (%) | 23.8 |
| Plasticity index (%) | 42.2 |
| **Free swelling index (%)** | **100** |
| California Bearing Ratio (CBR) | 1.85 |
| Unconfined compressive strength (kg/cm$^2$) | 5.847 |

## 3. RESULS AND DISCUSSIONS

### Effect of Stone Dust with Black Cotton Soil

Figure 1 shows the variation of the dry density with % stone dust. With increase in percentage of stone dust the dry density increases significantly. The increase of the MDD is from 1.465, 1.475, 1.482, 1.531, 1.537, and 1.536 to the stone dust of 0%, 1%, 2%, 3%, 4%, and 5% respectively. The effect is clearly seen in the Figure 2. Figure 2 shows the variation of CBR with stone dust. For the stone dust of 0%, 1%, 2%, 3%, 4%, and 5% the CBR values are 1.02, 2.5, 2.7, 2.91, 2.49, and 2.08. It is shown in Figure 2 that the resistance to penetration of plunger is found increasing up to certain point with increase in stone dust percentage and then decrease. It is found that there is constant increase in strength with increase in percentage of stone dust up to 3% and further increase in percentage of stone dust decreases the strength. Figure 3 shows the variation of unconfined compressive strength with stone dust. The unconfined compressive strength (UCC) has also same trend acquired in CBR. The optimum percentage of stone dust is 3%. For the stone dust of 0%, 1%, 2%, 3%, 4%, and 5% the UCC values are 5.847, 7.34, 7.63, 9.36, 8.7, and 6.34. The experimental values ate given in Table 3 for different percentages of stone dust.

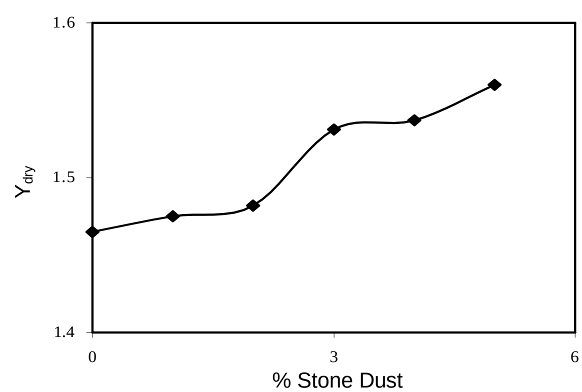


Fig. 1: Variation of Dry Density with Stone Dust

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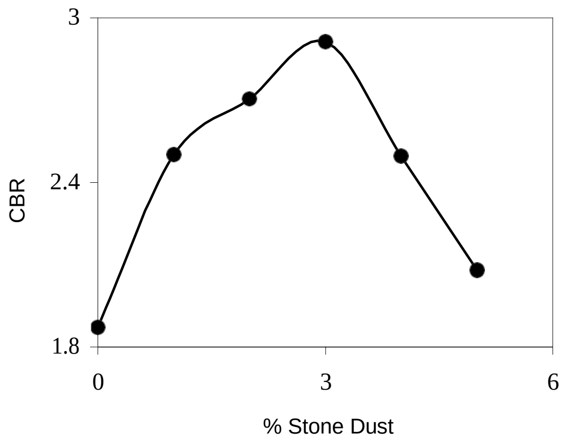

Fig. 2: Variation of CBR with Stone Dust

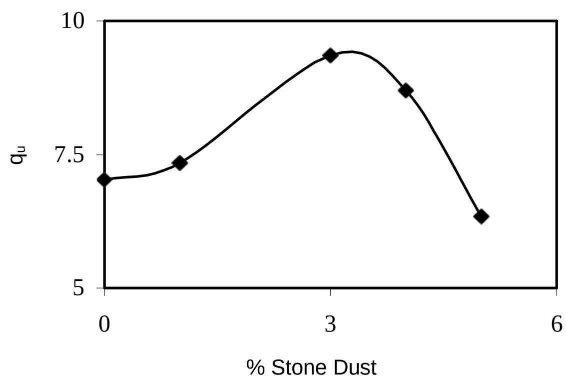

Fig. 3: Variation of UCC with Stone Dust

Table 3: Effect of Stone Dust with Black Cotton Soil

| *% SD* | *O.M.C %* | $\gamma_d$ *gm/cc* | $q_u$ *kg/cm*$^2$ | *c kg/cm*$^2$ | *C.B.R* |
|---|---|---|---|---|---|
| 0 | 24 | 1.495 | 5.847 | 2.92 | 1.02 |
| 1 | 21.6 | 1.475 | 7.34 | 3.67 | 2.5 |
| 2 | 22.8 | 1.482 | 7.63 | 3.81 | 2.70 |
| 3 | 23 | 1.531 | 9.36 | 4.68 | 2.91 |
| 4 | 22.3 | 1.537 | 8.703 | 4.35 | 2.49 |
| 5 | 16.5 | 1.56 | 6.34 | 3.17 | 2.08 |

**Effect of Polypropleyene Fibers with Black Cotton Soil**

Figures 4 to 6 shows the effect of fibers with black cotton soil. It is found that there is constant decrease in MDD, Figure 4 shows variation of dry density with fibers. The MDD decrease from 1.495, 1.466, 1.43, 1.39 and 1.36 for the fibers of 0% 0.3%, 0.6%, 0.9% and 1.2%. Figure 5 shows the variation CBR with percentage of fibers. There is an increase in CBR value up to 0.9% percent of fibers and at 1.2% of fibers a decrease in CBR is noted. The CBR values are 1.02, 1.66, 2.35, 2.77, and 2.49 for the fibers of 0% 0.3%, 0.6%, 0.9% and 1.2%. Figure 6 shows the variation of UCC with percentage of fiber. There is strength increase with increase in percentage of fibers up to 0.6% and then the strength decreases with further increase in percentage of fibers. The values of UCC are 5.85, 6.28, 6.8, 5.95, and 4.88 for the fibers of 0% 0.3%, 0.6%, 0.9% and 1.2% respectively.

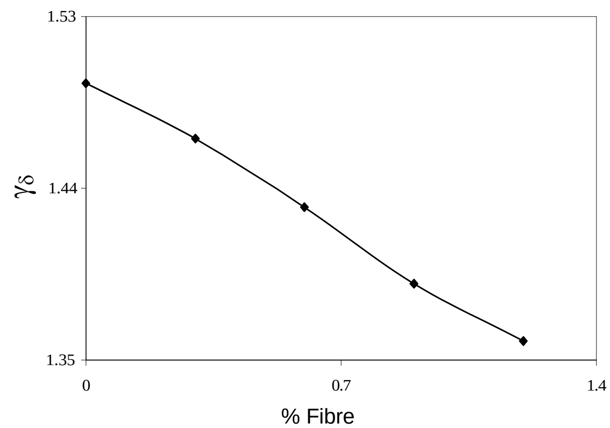

Fig. 4: Variation of UCC with % Fiber

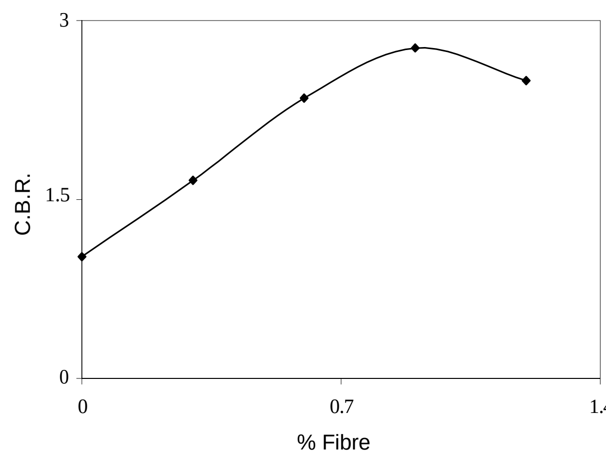

Fig. 5: Variation of CBR with % Fiber

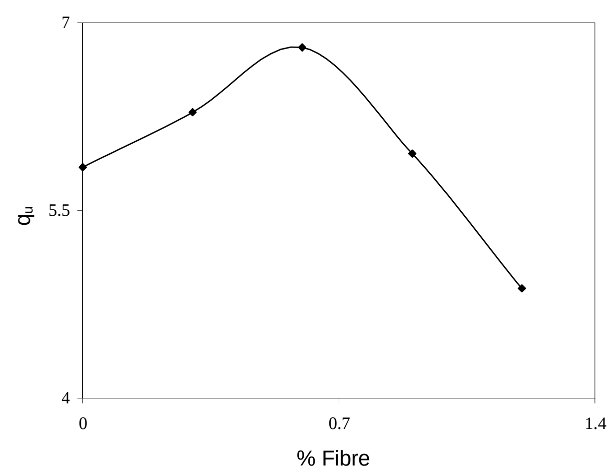

Fig. 6: Variation of UCC with % Fiber

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Table 4: Effect of Fiber with Black Cotton Soil

| *% Fiber* | *OMC %* | *$\gamma_{dry}$ gm/cc* | *$q_u$ kg/cm$^2$* | *$C_u$ kg/cm$^2$* | *CBR* |
|---|---|---|---|---|---|
| 0 | 24 | 1.495 | 5.85 | 2.92 | 1.02 |
| 0.3 | 24 | 1.466 | 6.28 | 3.14 | 1.66 |
| 0.6 | 24 | 1.43 | 6.80 | 3.40 | 2.35 |
| 0.9 | 27 | 1.39 | 5.95 | 2.98 | 2.77 |
| 1.2 | 27 | 1.36 | 4.88 | 2.44 | 2.49 |

### 3.3 Effect of Stone Dust with Polypropylene Fibers with BC Soil

In order to obtain maximum strength the soil is tested by adding 3% of stone dust and 0.6% of fibers, and the results obtained are stated as above. From the results it is found that there is increase in strength by adding optimum percentages of both stone dust and fibers. Figure 7 shows the dry density *vs* optimum moisture content for soil alone, soil with stone dust, soil with fibers and combination of soil plus stone dust plus fibers. For the combination of soil plus 3% stone dust plus 0.6% fibers the maximum dry density (MDD) and optimum moisture content (OMC) are 1.433 and 24.5. Figure 8 shows the variation of CBR with soil alone, soil with stone dust and soil with fibers and combination of soil plus stone dust plus fibers. For the combination of soil plus 3% stone dust plus 0.6% fibers the CBR value is 4.16.

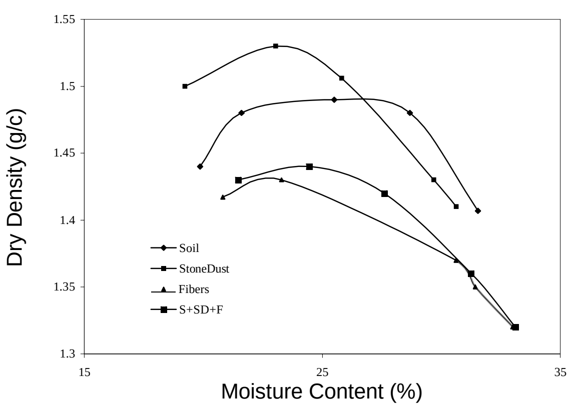


Fig. 7: Dry Density *vs* Optimum Moisture Content–Soil, Fibers, Stone Dust and its combination

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## 4. CONCLUSIONS

For soil admixed with only stone dust, the optimum combination is found to be Soil + 3% stone dust. The Soaked CBR value of this mix is found to be 2.912, which is 1.574 times more than CBR value of soil alone. For soil admixed with only fibers, the optimum combination is found to be Soil + 0.6% Fibers. The Soaked CBR value of this mix is found to be 2.35, which is 1.27 times more than CBR value of soil alone. For soil admixed with stone dust and fibers, the proportion which yielded max CBR value was found to be Soil + 3% Stone Dust + 0.6% Fibers. The Soaked CBR value of this combination was at 4.16, which is 2.25 times more than soil alone. There is increase in unconfined compressive strength with addition of stone dust and fibers and the increase in strength with addition of optimum stone dust and fibers are more compared to only stone dust and fibers.

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