PERFORMANCE ANALYSIS OF BLACK COTTON SOIL TREATED WITH CALCIUM CARBIDE RESIDUE AND STONE DUST

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INTRODUCTION

Foundations in expansive soil, generally known as black cotton soil in this country, due to seasonal moisture fluctuation, Alternate shrinkage and swelling upon wetting and drying. Frequently moisture and water vapor migrates from the high temperature zones around the building. The difference in content of water between the exterior and interior zone of the building causes uplift of the interior portion and results in mound-shaped heave of the floor of the structure than sagging moments. Severe cracks might effect in the walls of the structure as a consequence in India, about one-fifth of the land area, frequently in and around the Deccan plateau, is covered with these soil. Black cotton soil present in Madhya Pradesh,
Soil Stabilization

Soil stabilization means the improvement of the stability or bearing power of a poor soil by the use of compaction; proportioning and the addition of suitable stabilizers or admixtures. Soil stabilization includes chemical, mechanical, physico-chemical methods to make the soil stabilized. This process basically involve excavation of soil, this is an ideal technique for improving of soil in shallow depths, as in pavements. Stabilization method may be categories as two mail types: (a) improvement of soil properties of existing soil with-out using any type of admixture; and (b) improve the properties with the admixtures.

Compaction and drainage is the example of first type, which improve the intrinsic shear strength of soil. Second type of example is stabilization by admixture, such as cement, bitumen, lime, fly ash and chemicals. Deep soil deposits stabilize by grouting, electrical methods and freezing. Cement, bitumen and lime have become common as stabilizers. The black cotton soil chosen for the purpose of the study and the stabilizers are Stone Dust and CCR.

Calcium Carbide Residue (CCR) is obtained as a by-product with a major composition of calcium hydroxide and it is assumed similar to that obtained from the structure of Calcium Silicate Hydrate (CSH).

Soil stabilization is a process in which natural or manufactured additives are used to improve the properties of soil. Stabilization of clayey soil comes under chemical stabilization. Chemical additives like cement, lime, fly ash and other compounds utilized before in stabilization of clay soil for many years with various degrees of success. The chemical additives used to stabilize expansive soils have cementitious properties. Cementitious materials stabilized clayey soils and modify their properties through flocculation, cation exchange, agglomeration and pozzolanic reaction. The cement provides hydration products, which enhance the strength of the base material as well as increase the performance of the treatment and the secondary process of stabilization is pozzolanic reaction.

Stone Dust

It is a byproduct material when cutting finishing and shaping of building stones in the stone crusher plant for the stabilization of clayey soil the use of stone dust is not only as reduce the widely known environmental impacts if waste but also it attains a social responsibility, which control the use of the non-renewable resources and suggest a way for the construction industry to meet its increasing demands for material structures like building, airports, highways, tunnels are to be built, is soft and expansive and these type of soil do not have the properties which are desired for construction, so the best solution for stabilization or improve the soil. Therefore, the search for material to be used in soil stabilization is the field in which interest for researchers to resolve the problems related to the swelling of expansive clayey soil. Hence, improving the soil bearing capacity.

CCR

CCR is a byproduct from the acetylene gas production. This gas is used around the world for welding, lighting, metal cutting and to fruit ripen. The calcium carbide residue is produced by a
simple process, which is obtained from a reaction between CCR and water to formation of acetylene gas and calcium hydroxide in a slurry form of calcium carbide residue mainly consists of calcium hydroxide $\text{Ca(OH)}_2$, to improve the engineering properties of waste material by cementing agent it is an optional means of producing usable materials. High unit cost and energy intensive procedure of Portland cement are heavy force for the alternative cementitious additives. High content of natural pozzolanic materials in clayey soil, calcium hydroxide $[\text{Ca(OH)}_2]$ is a rich material can be used to produce high strength geo-material.

For the environmental and economic impact some waste rich material can be utilized collectively with natural pozzolanic material in clay to invent a cementitious material.

For clayey or expansive soil, which contain high pozzolanic material, calcium hydroxide rich material used to produce moderately high strength. Three basic reactions, which are cation exchange, aggregation and flocculation which attributed the engineering properties of rich material stabilized clay. The influences of these three are primarily responsible for the change in plasticity and shrinkage. With increasing of the time the shear strength of the stabilized soil increases gradually, due to the pozzolanic reaction.

**Experimental Program**

**Materials and Methods**

**Soil Sample**

The soil sample is a problematic silty clay collected from the Shri Govindram Seksaria Institute of Technology and Science campus in Indore, (MP.) India, at a depth of 2.8 m. This soil is inland clay, which is sensitive to changes of water content. The soil contains high fine particle. Its specific gravity is 2.62. The Liquid Limit 52.1% and Plastic Limit 25.2%. At the time of sampling the groundwater dad disappeared. The natural water content was 20%. Table 1, shows the test results of soil sample.

**Binder**

i. Calcium carbide residue: Materials used as consisted of calcium carbide residue assigned as CCR and stone dust assigned as SD. The CCR was collected from the disposal area in the dry form, as in Figure 1(b) and was sun dried for 2-3 days to reduce its high moisture content. After sun-dried, the CCR had a moisture content less than 3% and was then ground by a Los Angeles abrasion machine.

![Figure 1(a): Disposal Area in Slurry form of CCR](image)

![Figure 1(b): Disposal Area in Dry form of CCR](image)
until the particles retained on sieve No. 325 less than 10% by weight.

CCR is a by-product of acetylene production process and its production is described in the following equation:

$$\text{CaC}_2 + 2\text{H}_2\text{O} \rightarrow \text{C}_2\text{H}_2 + \text{Ca(OH)}_2$$

Calcium carbide residue consists mainly of calcium hydroxide, Ca(OH)$_2$ and is obtained in a slurry form. From Eq, we have 64 g of calcium carbide (CaC$_2$) which provides 26 g of acetylene gas (C$_2$H$_2$) and 74 g of CCR in terms of Ca(OH)$_2$.

The specific gravity of the CCR is 2.32. The Table 2 shows the comparison of chemical composition.

**Table 1: Properties of the Natural Expansive Soil**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Moisture Content (%)</td>
<td>20</td>
</tr>
<tr>
<td>Liquid Limit (%)</td>
<td>52.1</td>
</tr>
<tr>
<td>Plastic Limit (%)</td>
<td>25.2</td>
</tr>
<tr>
<td>Plasticity Index (%)</td>
<td>29.1</td>
</tr>
<tr>
<td>Maximum Dry Density (Mg/m$^3$)</td>
<td>1.61</td>
</tr>
<tr>
<td>Optimum Moisture Content (%)</td>
<td>18</td>
</tr>
<tr>
<td>CBR value</td>
<td>Unsoaked 5.8, Soaked 0.97</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>2.62</td>
</tr>
<tr>
<td>Color</td>
<td>Black</td>
</tr>
</tbody>
</table>

ii. Stone dust: The stone slurry was oven dried ground and sieved. Than the values of D10, D30, D$_{60}$, C$_c$ and C$_u$ were found to be 0.08, 0.19, 0.28, 1.38 and 1.54, respectively. Several tests were carried out on stone dust and the Results were found to be: liquid limit = 23%, non-plastic material specific gravity = 2.57, cohesion (C=0.08 kg/cm$^2$) and angle of internal friction. There are several studies which addressed the significance of using stone dust as a construction material and for soil stabilization in particular.

**METHODOLOGY**

All variables were taken as different percentage and the experimental variable to check its effect on the results The following procedure was followed to achieve the objectives of this research:

Preparation and testing of the research soil to identify its physical and mechanical properties. The soil was passed through a 16 mm sieve to remove coarse particles and soil was oven dried for 24 h. To find out the mechanical properties, the oven dry and grinding a series of tests, such as Standard Proctor test, unconfined compression and California Bearing Ratio (CBR) tests were carried out. All the index and mechanical tests were carried out according to the American Society of Testing and Material Standards (ASTM).

The stone slurry waste obtained from the sediment ponds of the stone cutting plants and CCR was collected from the gas production company. The CCR was oven dried for 4 h at 200°C. The CCR passed through a sieve NO. 40 (425 μm), Oven drying and sieving of stone dust. Testing the stone powder and CCR to establish their properties. Adding stone powder and CCR to the soil and conducting the required tests, such as standard proctor, unconfined compressive strength and CBR. Using the CBR values determined for the soil with and without additives to determine the thicknesses of flexible pavements from special design figures. Analysis and comparison of the results.

**TEST RESULTS**
Figure 2: Standard Proctor Test Result

Figure 3: Unsoaked CBR

Figure 4: Soaked CBR
Figure 5: 14 Days Soaked CBR

Table 2: Chemical Properties of Clay and CCR

<table>
<thead>
<tr>
<th>Chemical Composition(%)</th>
<th>Clay</th>
<th>CCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>CaO</td>
<td>26.16</td>
<td>70.79</td>
</tr>
<tr>
<td>SiO₂</td>
<td>20.11</td>
<td>6.48</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>7.54</td>
<td>2.56</td>
</tr>
<tr>
<td>Fe₂O₃</td>
<td>32.88</td>
<td>3.24</td>
</tr>
<tr>
<td>MgO</td>
<td>0.48</td>
<td>0.68</td>
</tr>
<tr>
<td>SO₃</td>
<td>4.91</td>
<td>0.66</td>
</tr>
<tr>
<td>Na₂O</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>K₂O</td>
<td>3.18</td>
<td>7.92</td>
</tr>
<tr>
<td>LOI</td>
<td>3.43</td>
<td>1.36</td>
</tr>
</tbody>
</table>

Proctor Test Results

ANALYSIS AND DISCUSSION

In this research various percentage of CCR and stone dust mixed as the CCR is a pozzolanic material so after pozzolanic reaction CBR value increased. The stone dust is another material which take part in the strength gaining process.

• Ease of Use - Mixing of stone dust with the soil is found to be more easy and effective. The workability of stone dust while mixing it with wet black cotton soil good. The procedure of mixing with the wet soil is found to be tedious and bit hard but mixing of CCR was easy.

• Eco-friendly - There is no problem of degradation in case of stone dust with the passage of time.

CONCLUSION

1. Input of CCR reduces the maximum dry density of soil. Because the specific gravity of CCR is lesser than that of the soil, as the reduction of the maximum dry unit weight an increase in optimum moisture content.

2. The stone dust increases the maximum dry density of the blended CCR-stabilized clay which indicates a packing effect and this packing effect inconsequentially improves strength development, pozzolanic reaction plays a main role on strength development as the increase of the curing time.

3. The CCR increase the chemical bonding between the clay particles. The optimum moisture content is the proper mixing state, providing the best index and engineering properties of soil.
4. At low water content it is difficult to complete the pozzolanic reaction but at higher moisture content causes the high water/stabilizer ratio (W/S), thus faster reaction.
5. The soil stabilization by the CCR and stone dust, best results when 10% of both mixed.
6. CBR value increases with curing period.

REFERENCES
14. Horpibulsuk S, Shibuya S, Fuenkajom K and

