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Study on Roof Tiles Using Modified Black Cotton Soil

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Abstract— In order to optimize the cost of construction, engineers have always been on the lookout for efficient and light roofing which requires minimum maintenance and labor to install. Black cotton soil is an expansive soil which is very hard when dry, but lose its strength in wet condition. The quantity of Ground granulated blast furnace slag (GGBS) which is a by-product of iron and steel industry and fly ash is one of the major waste material from the thermal power plants has increased abundantly as a result of industrialization. These two by-products are generally deposited in the landfill causing increase in environmental pollution and disposal problems. In this study the black cotton soil was stabilised using fly ash separately and a combination of fly ash & GGBS. The optimum mix of each combination was used for the manufacturing of roofing tiles in plain roof tile pattern. The tiles were hand moulded and burned in the kiln at a temperature of 800°C - 900°C. The mechanical and physical characteristics of tiles were analysed & compared with each other.

Keywords— Black cotton soil, Fly ash, GGBS, roof tile

I. INTRODUCTION

Black soils are available in the central, western and southern states of India. They are found to occur in patches and are considered as extension of the black cotton soils observed in the adjacent Coimbatore district of Tamil Nadu. These soils are dark in colour with high clay content and less organic matter. It is calcareous have an alkalinity from neutral to moderate. Hence they exhibit the characteristic cracking during dry periods. They are usually located in gently sloping to nearly level lands. The levels of potassium and calcium are moderate and those of nitrogen and phosphorus, low. These are also known as Indian regurs.

Fly Ash is one of the major waste materials available from thermal power plants and its treatment and disposal was a problem in the early stages. Using fly ash would be beneficial for several environmental reasons, such as relieving air pollution, reducing the amount of leachate from fly ash during storage to seep through the underground water layer and saving natural resources when using fly ash as a replacement for raw materials used in cement manufacturing process.

The fly ash can be applied in geotechnical projects to enhance clay strength, increase bearing capacity, reduce swell potential of expansive clay, and maintain low permeability of the stabilized clay.

Ground granulated blast furnace slag is obtained as a by-product of iron and steel making from a blast furnace in water or steam. In order to produce a glassy, granular product that is then dried and ground into a fine powder. The main components of blast furnace slag are CaO, SiO2 and MgO. Increasing the CaO content of the slag results in an increased compressive strength. The use of GGBS decrease the risk of damages caused by alkali–silica reaction (ASR), chloride ingress is reduced, risk of reinforcement corrosion are also reduced and provides higher resistance to attacks by sulphate and other chemicals.

II. MATERIAL PROPERTIES

The details of materials required for the preparation of roof tiles are discussed below.

A. Black Cotton Soil

The soil was collected from the chittoor taluk of Palakkad district. It was dried and pulverised to be used for the experiments. The properties of black cotton soil were shown in Table I.

B. Fly Ash

Fly Ash is one of the major waste materials available from thermal power plants and its treatment and disposal was a problem. It is collected from HNL, velloore. The fly ash can be applied to enhance clay strength, increase bearing capacity, reduce swell potential of expansive clay, and maintain low permeability of the stabilized clay. It is dark grey in colour. The specific gravity of fly ash is 2.70.

C. Ground Granular Blast Furnace Slag (GGBS)

Ground granulated blast furnace slag is obtained by quenching molten iron slag (a by-product of iron and steel-making) from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder. They are off white in colour and has specific gravity of 2.85. It was collected from ASTRAA chemicals, Chennai.
III. METHODOLOGY

The effect of fly ash and GGBS on the properties of clay was determined. The mix was prepared in 1 part black cotton soil + 1 part fly ash (BF1) and 1 part black cotton soil + 2 part fly ash (BF2). The optimum mix was determined using the UCS test. From the UCS test it was found that BF2 is the optimum mix and GGBS is added accordingly i.e. 1 part of black cotton soil +1.5 part fly ash +0.5 part GGBS (BFG1), 1 part of black cotton soil +1 part fly ash + 1 part GGBS (BFG2), 1 part black cotton soil + 0.5 part fly ash + 1.5 part GGBS (BFG3). From these 3 mix ration BFG3 is found the optimum mix from UCS test. The tiles were prepared using BF2 and BFG3 ratio. The test results were shown in table II.

### TABLE II

<table>
<thead>
<tr>
<th>Ratio</th>
<th>Unconfined Compressive strength (kN/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BF1</td>
<td>0.077</td>
</tr>
<tr>
<td>BF2</td>
<td>0.082</td>
</tr>
<tr>
<td>BFG1</td>
<td>0.05</td>
</tr>
<tr>
<td>BFG2</td>
<td>0.054</td>
</tr>
<tr>
<td>BFG3</td>
<td>0.07</td>
</tr>
</tbody>
</table>

A. Casting of Clay Tiles

The tiles were hand moulded and is burnt in the kiln. Raw materials were weigh batched and manually mixed with respect to the tile preparation ratio. The mould size were selected as 150mm x 150mm x 15mm. The tiles were air dried for 10 days in order to remove all the moisture then burnt in the kiln around 900°C.

B. Testing of Specimen

Strength parameters were tested against the standard specifications given by IS 2690 (part ii):1992 (tests on Flat Terracing Tiles). The durability study of tiles were not conducted only the preliminary investigations were done.

1. Water absorption: The water absorption was determined according to IS 3495(part ii):1992. The maximum water absorption of shall not exceed 20% of the weight of tile. The water absorption of tiles are shown in fig 1 and the test result were shown in table III.

2. Permeability test: The permeability test was determined according to IS 654:1992. The test was conducted in a trough, open at the bottom, the dimensions being equal to the size of tile under test. The tile was fitted at the bottom of the trough and the space between the tile and the sides of the trough were plugged water-tight with a suitable material like wax, bitumen, etc. Water was poured into the mould so that it stands over the lowest tile surface to a height of 5 cm. The water in the trough was allowed to stand for a period of 6 hours. The bottom of the tile was carefully examined to see whether the water has seeped through the tile as shown in fig 2 and the test result were shown in table III.
3. Flexural strength test: The flexural strength test was determined according to IS 2690 (part ii):1992. The flexural strength of the tiles should not be less than 1.5N/mm². The table III shows the flexural strength result.

<table>
<thead>
<tr>
<th>Ratio</th>
<th>Water Absorption (%)</th>
<th>Permeability</th>
<th>Flexural strength (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BF2</td>
<td>19.47</td>
<td>Nil</td>
<td>0.96</td>
</tr>
<tr>
<td>BFG3</td>
<td>19.77</td>
<td>Nil</td>
<td>0.91</td>
</tr>
</tbody>
</table>

IV. CONCLUSION

- The tiles cannot be prepared from the black cotton soil alone without modification due to its high shrinkage and swelling nature.
- The test result of water absorption shows that the tiles were within the permissible limit.
- The water absorption is more for the tiles which has GGBS content.
- The permeability test shows that the tiles are impermeable.
- The clay tiles doesn’t satisfy the strength requirement of flat terracing tiles.
- The strength of clay tiles can be improved by either changing the mix ratio or by the addition of suitable additives.

REFERENCES