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# Compaction behaviour of black cotton soil using GGBS and Ordinary Portland Cement

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**Abstract** *The gain in the strength or bearing ability of the poor soil by the action of compaction, and the inclusion of suitable admixtures is termed as soil stabilization. Soil stabilization is a substitute method for improving the properties of black cotton soil which is also considered as problematic soil. The properties of soil can be improved by blending the admixtures or without blending the admixture with the cohesive soil. There are several industrial wastes among them a popular and huge quantified waste material is ground granulated blast furnace slag which creates the hazardous to the environment. In this paper the stabilization of black cotton soil is attempt by using ground granulated blast furnace slag with small percentage of ordinary Portland cement is used for improving the mechanical properties of the soil by means of compaction. The experimental studies are made to study the effects of optimum quantity of ground granulated blast furnace slag (25%) and varying proportions of Ordinary Portland cement (0%, 0.3%, 0.6%, 0.9% and 1.2%) on Maximum dry density(MDD) and Optimum moisture content(OMC) when used with black cotton soil.*

***Key Words***: **Black cotton soil, GGBS, OPC, OMC, MDD etc.**

## I. INTRODUCTION

India is a country of large dimensions with different climates and geological conditions. Due to different geological conditions, it is having different verities of soil from one place to another. One among them is black cotton soil, which is also known as the problematic soil. The black cotton soils are weak soils which are which exhibit the high swell and shrinkage characteristics when they exposed changes in moisture content and create trouble for construction of engineering projects. Black cotton soils are one of the major soil deposits of our country which covers around 20% of the land. These soils are having problems like contraction, expansions, less bearing capacity and they are less stable when compared with red soil. The black cotton soil covers larger area of land and up to 3.7m deep, it is necessary to treat it and enhance the properties of it by means of stabilization for using such soils for the construction purpose. Stabilization of such soils can be done by using additives, admixtures, by products from the industries or by using the concept of reinforcement. GGBS is one of the by products from steel and steel making industries which is produces in large quantity. It is used in optimum dosage (25%) in combination with small percentage of ordinary Portland cement (0.3%, 0.6%, 0.9% and 1.2%).

### 1.1 SOIL STABILIZATION

The gain in the strength or bearing ability of the poor soil by the action of compaction, and the inclusion of suitable admixtures is termed as soil stabilization. It deals with the physic chemical, mechanical and chemical methods to make the soil to perform the duties of its purpose. The soil stabilization is deals with the in situ excavation, treatment then compaction of the same. As the stabilization process deals with excavation of the in-situ soil, the stabilization is found to be perfect for improvement in shallow depths such as pavements.

Stabilization of low quality soil can be done in two ways.

a) Without blending the admixtures.

b) By blending the admixtures with loose soils.

Compaction and drainage, which enhance the inherent shear strength of soil is the example of type one.

Stabilization with admixtures like cement, lime, GGBS, Silica fume, Fly ash and other chemicals are example of type second.

Electrical methods, grouting and freezing techniques are used for stabilization of deep soils. The utilization of lime and bitumen stabilizing agents are of common type. For this study, black cotton soil is chosen with GGBS as stabilizer blended with small percentages of ordinary Portland cement.

## II. EXPERIMENTAL DETAILS

### *A. Materials:*

**1. Black cotton soil:** The black cotton soil used for this study is collected from a construction site in Irani Galli Chidri road, Bidar from an open excavation at a depth of

2.5 m below the natural ground level. The soil used for this study was light black in color.

The physical properties of soil are tabulated in table.

**Table -1:** properties of B.C. soil

| SL.N0 | Property | value |
|---|---|---|
| 1 | Specific gravity | 2.52 |
| 2 | Liquid limit | 70% |
| 3 | Plastic limit | 33% |
| 4 | Plasticity index | 37% |
| 5 | Unconfined Compressive Strength (kg/cm2) | 1.06 |
| 6 | MDD (g/cc) | 1.43 |
| 7 | OMC (%) | 32.2 |
| 8 | IS soil classification | CH |
| 9 | Free swell index | 40 |

**2. Ground Granulated Blast Furnace Slag:** The GGBS used for this experimental study has cement properties, which makes the partial replacement of additives. The GGBS is purchased from JSW cement ltd. Bellary district in Karnataka state.

**Table 2:** chemical properties of GGBS

| Composition | Percentage |
|---|---|
| Magnesia content (%) | 7.72 |
| Sulphide sulphur (%) | 0.51 |
| Sulphide content (%) | 0.27 |
| Chloride content (%) | 0.009 |
| Glass content (%) | 92 |
| Moisture content (%) | 0.10 |

**Table 3**: physical properties of GGBS

| Description | Properties |
|---|---|
| Fineness(M2/Kg) | 375 |
| Specific gravity | 2.88 |
| 45 micron (residue)(%) | 7.20 |

**3. Ordinary Portland cement:** cement is a binder, a substance used for construction that sets, hardens and adheres to other material, binding them together. The cement used for this study which is purchased from a local supplier in Bhalki, dist Bidar.

***B. Preparation of sample:***

The various basic properties of chosen soil were found out as per IS codes. Now, the soil is treated with varying percentages of ordinary Portland cement (0.3%, 0.6%, 0.9% & 1.2%) for this treated soil sample the OMC and MDD values were found out as per IS codes. The B.C. soil is then blended with 25% of GGBS, the OMC and MDD values were found out of the same as per IS codes. In further sample preparation, the cement fractions of 0.3%, 0.6%, 0.9% & 1.2% were added with B.C. SOIL+25%GGBS. The OMC & MDD values were found out from the compaction curves as per IS codes.

***C. Experimental work:***

Basic physical properties of black cotton soil were found out as per Indian standards codes. OMC and MDD were found out for various blending proportions discussed above.

## III. RESULT AND DISCUSSIONS

***A. OMC and MDD results***

Table 4: Describing OMC and MDD test results for the soil treated with GGBS and varying percentage of OPC.

| SL NO. | Description | OMC (%) | MDD (g/cc) |
|---|---|---|---|
| 1 | B.C. SOIL+0.3% OPC | 31.9 | 1.438 |
| 2 | B.C. SOIL+0.6% OPC | 31.7 | 1.439 |
| 3 | B.C. SOIL+0.9% OPC | 31.25 | 1.445 |
| 4 | B.C. SOIL+1.2% OPC | 30.4 | 1.450 |
| 5 | B.C. SOIL+25%GGBS | 27% | 1.569 |
| 6 | B.C. SOIL+25%GGBS+ 0.3%OPC | 26.5 | 1.580 |
| 7 | B.C. SOIL+25%GGBS+ 0.6%OPC | 25.8 | 1.589 |
| 8 | B.C. SOIL+25%GGBS+ 0.9%OPC | 24.5 | 1.596 |
| 9 | B.C. SOIL+25%GGBS+ 1.2%OPC | 24.0 | 1.604 |

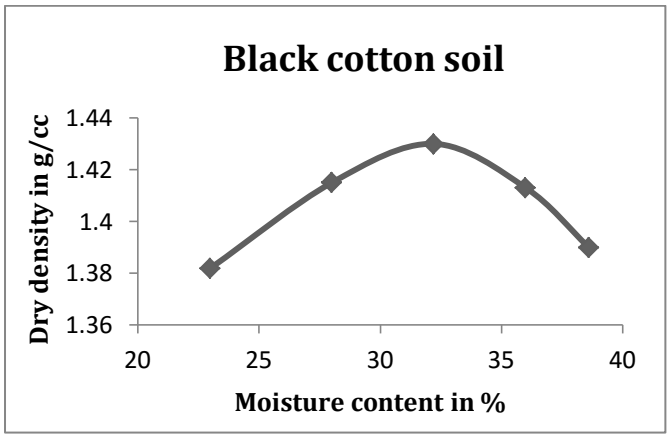


**Fig-1:** Compaction curve for black cotton soil

MDD and OMC values for the untreated black cotton soil are 1.430 g/cc & 32.3% respectively

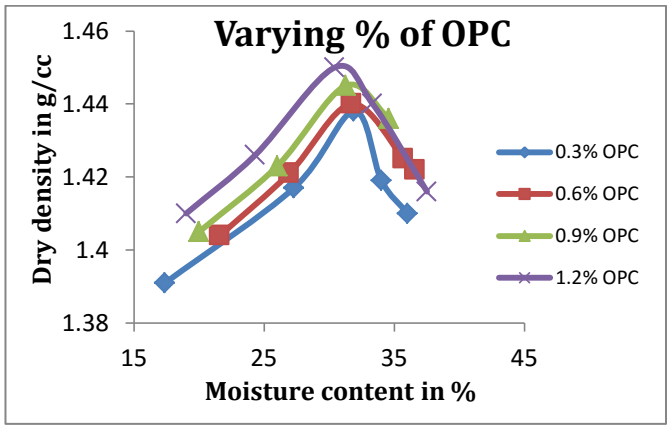


**Fig-2**: Compaction curve for soil treated with varying percentage of cement

From the above curve it can be clearly seen that as the percentage of cement increases from 0.3% to 1.2%, the maximum dry density also gets increases from 1.438g/cc to 1.450g/cc and the optimum moisture content decreases from 31.9% to 30.4% due to the process of hydration.

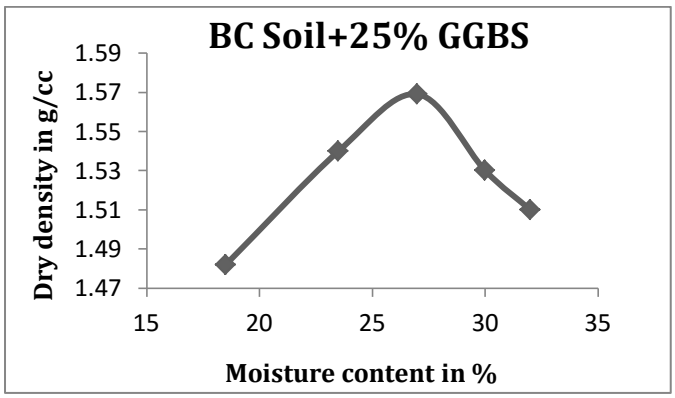


Fig-**3:** Compaction curve for soil treated with 25% GGBS

When optimum dosage of GGBS i.e. 25% is added to the black cotton soil the MDD value increase from 1.43 g/cc to 1.569 g/cc and the OMC value decreases from 32.3% to 27% when compared to untreated soil mass.

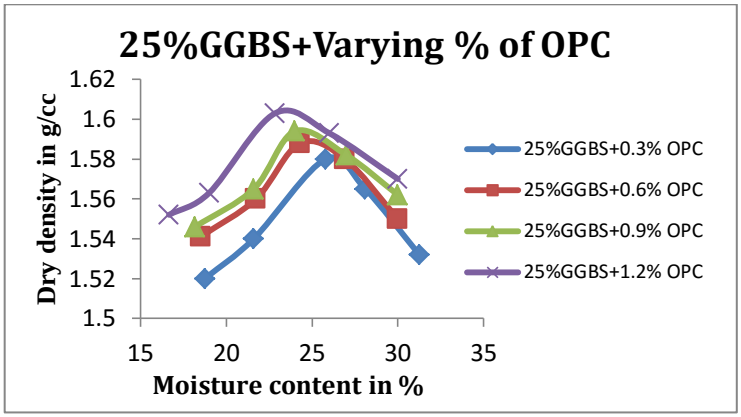


**Fig-4:** Compaction curve for soil treated with 25% of GGBS and varying % of cement

From the above curve, it can be clearly seen that as the percentage of cement increases with BC soil and GGBS, the MDD value also increases from 1.58g/cc to 1.604g/cc and the OMC reduced from 26.5% to 24% from 0.3 % to 1.2% of cement respectively.

## IV. CONCLUSION

Soil stabilization using ground granulated blast furnace slag is found to be economical for enhancing the properties of black cotton soil. These are the conclusions made after the experimental study.

1. The BC soil blended with Ordinary Portland cement shows the higher MDD results than the pure BC soil.

2. There is an increase in the MDD with increase in OPC.

3. MDD for BC soil was 1.43g/cc, which increases to 1.45g/cc when 1.2% of OPC is added. MDD increases with increase in the OPC content.

4. The OMC for BC soil was 32.3% which reduces to 30.4% when 1.2% OPC added to the soil. There is decrease in the OMC with increase in the OPC content.

5. The soil is blended with 25% GGBS which results in rapid increase in MDD value from 1.430g/cc to 1.569g/cc. And the OMC reduces from 32.3% to 27%.

6. When the soil is blended with 25%GGBS and varying percentage of OPC, the MDD value increases with increase in percentage of OPC.

7. MDD values for 25% GGBS when added with 0.3% OPC and 1.2%OPC are 1.580g/cc and 1.604g/cc respectively.

And the OMC reduces from 26.5% to 24% for soil treated with 25%GGBS with 0.3 % and 1.2% OPC respectively.

## V. SCOPE OF WORK

In present study, the compaction properties are found out by using the optimum dosage of GGBS with small percentages of cement content.

Following are recommendation for future study.

1. UCS test can be carried out for the all the trials did in this study.

2. CBR can be carried out for all the trials.

3. The strength can be increased by using higher dosage of cement and the optimum dosage of cement can be found out.

4. The same work can be carried out for enhancing the strength properties of loose sandy foundation soils and marine soils.

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