

Soil Stabilization using Ground Granulated Blast Furnace Slag

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ABSTRACT: Nowadays, soil has become one of the most important material in various fields of construction say for pavement construction, embankment etc. As there is scarcity of good quality of soil, many different methods were introduced to improve the strength of soil. Soil Stabilization is one of the method which is utilized for strength improvement and modifying the properties of soil and it is carried out using various additives or industrial wastes. In this research, we have carried out the stabilization method by adding Ground Granulated Blast Furnace Slag (GGBS) to the soil. GGBS is obtained from the blast furnace of cement plant, which is the byproduct of iron and also a environmental friendly material and has economic benefits. The main objective of this study is to examine the effects of addition of GGBS in different proportions i.e. 0, 5, 10 and 15% to the soil. This study briefly describes the engineering properties of soil such as optimum moisture content, maximum dry density, liquid limit, plastic limit, UCS and CBR after addition of GGBS. From the result, it was discovered that the optimum value of GGBS is 15% for stabilization of given soil based on CBR value.

KEYWORDS: Black cotton soil, GGBS, stabilization of soil, CBR value, Unconfined compression test.

ABBREVIATIONS:

1. **GGBS:** Ground Granulated Blast Furnace Slag
2. **BCS:** Black Cotton Soil
3. **LL:** Liquid Limit
4. **PL:** Plastic Limit
5. **FSI:** Free Swell Index
6. **OMC:** Optimum Moisture Content
7. **MDD:** Maximum Dry Density
8. **CBR:** California Bearing Ratio Test
9. **UCS:** Unconfined Compression Test
10. **IS:** Indian Standard

I. INTRODUCTION

Expansive clay called black cotton soil is found in several parts of India. It covers approximate 20% of the total area of India (about 5.4 lakh sq.kms). These soil is found in states like Madhya Pradesh, Gujarat, Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu.

Nowadays, expansive soil are highly problematic soil because of volume change behavior under its moisture condition. It shrinks and swell with decrease and increase in water content respectively. It is proved itself as a source of economical loss. So, appropriate remedial measures are to be considered before construction in the areas having this type of expansive soil.

Soil stabilization is the alteration process for improving engineering properties of soil. Improvement includes increasing the bearing capacity, tensile strength and overall performance of in-situ subsoil to support pavement and foundation. This technology has increased the number of additives used for soil stabilization purpose.

There are various methods of soil stabilization such as,

1. Mechanical method of Soil Stabilization
2. Physical method of Soil Stabilization
3. Chemical alteration of Soil Stabilization
4. Additive method of Soil Stabilization
5. Agriculture and domestic waste method of Soil Stabilization



In this research work, we have used chemical stabilization. In this, soil stabilization depends on chemical reaction between stabilizer and soil mineral. It is done to reduce permeability of soil, increase shear strength and enhance bearing capacity by using chloride, sodium silicate, cement, lime, fly ash, GGBS, bitumen etc.

In this study, Ground Granulated Blast Furnace Slag (GGBS) is used as a chemical agent to improve the engineering properties of soil. GGBS is the by product of steel industry. GGBS is mixed with the soil using hand mixing in different proportion such as 5%, 10%, 15% and compared the modified soil properties with natural soil (0% GGBS).

II. OBJECTIVE

- To determine the basic properties of soil which affect the design and safety of structure and improve the strength of subbases.
- To improve certain mechanical properties of soils, such as swelling or shrinkage, plasticity etc.
- To facilitate compaction and increase load bearing capacity.
- To increase the shear strength (UCS) of soil.

III. MATERIALS

SOIL: Black Cotton Soil

The soil used in this project is a black cotton soil and it is collected from Vagra, Dist-Bharuch, Gujarat. The black cotton soil was collected by method of disturbed sampling after removing the top soil layer at 150mm depth and transported to the laboratory. The soil was air dried and sieved with IS sieve 425 micron as required for laboratory test. The index and engineering properties of the black cotton soil were determined as per IS codes.

Table 1: Properties of Soil

Properties	Values
Colour	Black
Free Swell Index(%)	144.44
Liquid Limit(%)	59.26
Plastic Limit(%)	30.98
Plasticity Index(%)	28.28
Shrinkage Limit(%)	11.07
Specific Gravity	2.55
O.M.C (%)	17.98
M.D.D. (gm/cc)	1.55
C.B.R. (Unsoaked)(%)	4.55
U.C.S. Test (kg/cm ²)	0.45

GGBS: Ground Granulated Blast Furnace Slag

GGBS is obtained by quenching molten iron slag from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder. It has a cementitious property. GGBS which is used in this investigation was collected from Technocrete Elements LLP, Surat.

Table 2: Properties of GGBS

Properties	Values
Colour	Off-White
Specific Gravity	2.75
Liquid Limit(%)	34.5
Plastic Limit(%)	Non Plastic
Plasticity Index(%)	Non Plastic
Shrinkage Limit(%)	33



IV. EXPERIMENTS

1. Free Swell Index Test [IS: 2720-40 (1977)]

To determine the swelling characteristics of the expansive soil, differential free swell test is carried out. This test helps to find out swelling potential of the soil. The test is performed as per IS: 2720 (Part-40) – 1977.

2. Specific Gravity Test [IS: 2720-3(1980)]

Specific gravity used in finding out void ratio, porosity and degree of saturation of soil. From the specific gravity, we can find whether soil is suitable for construction material or not. If specific gravity of soil is high then its value of strength will also be high.

3. Atterberg’s Limit [IS: 2720-5 (1985)]

Fine grained cohesive soil can classify by knowing liquid limit and plastic limit. From liquid and plastic limit, flow index, toughness index and plasticity index can be found out which gives idea about plasticity, cohesiveness, compressibility, shear strength and permeability of cohesive soil.

1. Liquid Limit
2. Plastic Limit
3. Shrinkage Limit

4. Standard Proctor Test [IS: 2720-7(1980)]

To determine the optimum moisture content and maximum dry density of soil, we used standard and modified proctor test. By compaction, soil gets densified due to decreased in air voids. The degree of compaction of soil is measured in terms of dry density and it is mainly depends on moisture content, compaction energy and type of soil.

5. California Bearing Ration Test [IS: 2720-16 (1987)]

CBR test was developed by California division of highway as a method of classifying soil sub grade and base course material for flexible pavement and also in designing base course for air field pavement. It is defined as the ratio of load corresponding to chosen penetration to standard load for same penetration and expressed in percentage. It may be conducted on undisturbed or re-moulded specimen in laboratory.

6. Unconfined Compression Test [IS: 2720-10 (1991)]

To determine the compressive strength of cohesive soil sample in an unconfined compression state is a object of this experiment. In this test, no confining pressure is applied. The unconfined compressive strength is given by dividing the failure load by area of cross section of the sample at failure. This is a quickest test to determine parameter like cohesion and shear strength of cohesive soil.

V. RESULT AND DISCUSSION

In this, the results of natural black cotton soil is compared with the soil mixed with GGBS. Table below shows variation of different parameters of soil like liquid limit, plastic limit, optimum moisture content, maximum dry density, CBR, UCS and free swell index.

% GGBS	0	5	10	15
LL (%)	59.26	50.41	53.99	54.13
PL (%)	30.98	25.87	22.04	21.45
OMC (%)	17.98	24.89	23.39	18.77
MDD (gm/cc)	1.55	1.54	1.56	1.61
CBR (%)	4.45	5.04	5.83	9.99
UCS (kg/cm ²)	0.45	0.95	1.02	0.64
FSI (%)	144.44	55.55	66.66	55.55

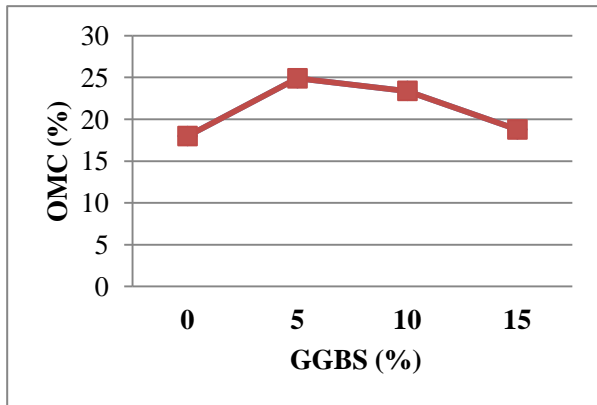


Fig.1: Variation of OMC with increasing % of GGBS

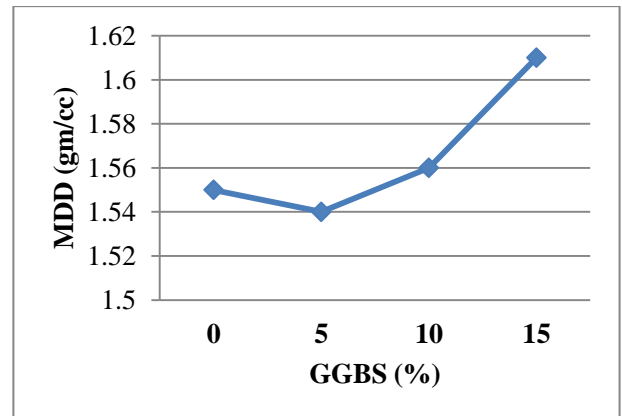


Fig.2: Variation of MDD with increasing % of GGBS

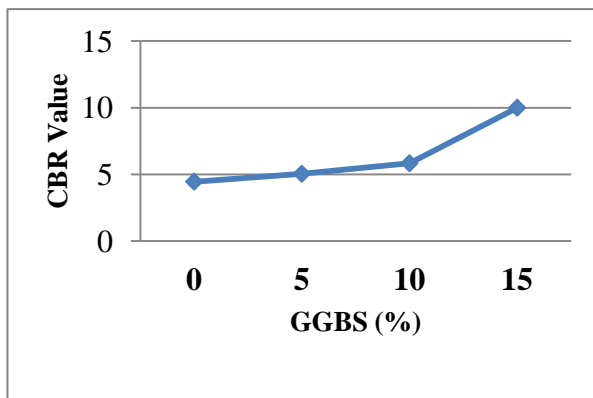


Fig.3: Variation of CBR value with increasing % of GGBS

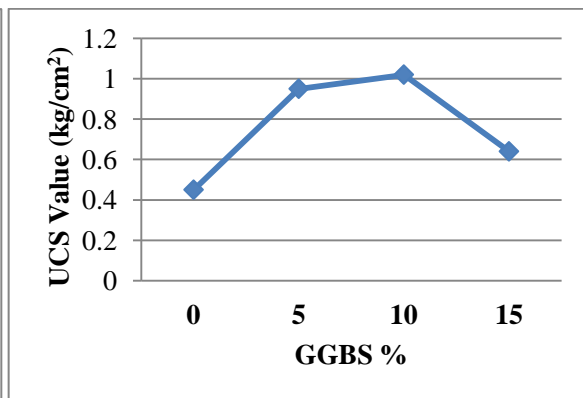


Fig.4: Variation of UCS value with increasing % of GGBS

VI. CONCLUSION

- GGBS is a waste byproduct which is abundantly produced from iron factories, as it has high specific gravity of 2.78, it is used as stabilizing material.
- Using GGBS is an economical and gainful utilization since there is scarcity of good quality soil for pavement and embankment fill.
- With the increase in percentage of GGBS from 0 to 15%, the optimum moisture content decreases from 24.89 % to 18.77 % whereas maximum dry density goes on increasing from 1.54 gm/cc to 1.61 gm/cc, hence compactibility of soil increases and making the soil more dense and hard.
- With addition of varying percentage of GGBS, the CBR value was found maximum at 15%.
- With addition of increasing percentage of GGBS, the maximum compressive strength was found at 10 % which was high from remaining percentage of GGBS as well as strength of BC at 0%.

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