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An Experimental Study on Stabilization of Red Soil by G.G.B.S and Jute Fibre

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ABSTRACT

Stabilisation is a broad sense for the various methods employed and modifying the properties of a soil to improve its engineering performance and used for a variety of engineering works. In today"s day soil stabilisation is the major problem for civil engineers, either for construction of road and also for increasing the strength or stability of soil and reduces the construction cost. In this thesis the soil are stabilised by ground granulated blast furnace slag (GGBS) and this material is obtained from the blast furnace of cement plant, which is the byproduct of iron (from ACC plant, sindri). It is generally obtained in three shaped one is air cooled, foamed shaped and another is in granulated shaped. The use of by-product materials for stabilisation has environmental and economic benefits. Ground granulated blast furnace slag (GGBS) material is used in the current work to stabilise soil (clay). The main objectives of this research were to investigate the effect of GGBS on the engineering property (optimum moisture content and maximum dry density, plastic limit, liquid limit, compaction, unconfined compressive strength, triaxial and California bearing ratio test) of the soil and determine the engineering properties of the stabilised. Granulated shaped blast furnace slag is most suitable for increasing the strength of the soil and for this we check the following property of soil. GGBS are added from 0% to 25% by dry weight of soil, first of all check the all soil property at 0 % (no GGBS) and then compare after addition of GGBS from 5% to 25%. The investigations showed that generally the engineering properties which improved with the addition of GGBS. The addition of GGBS resulted in a dramatic improvement within the test ranges covered in the programme. The maximum dry density increased and the optimum moisture content decreased with increasing GGBS content and at 25% we got the maximum value of dry density.

Keywords: Red soil, Ground Granulated Blast Furnance Slag(GGBS), Jute Fibre.

I. INTRODUCTION

Stabilization of soil in a broader sense is the modification of the properties of a soil is improving its engineering performance. Soil stabilization is broadly used in connection with road, pavement and foundation construction. It improves the engineering properties of the soil in terms of volume stability, strength, and durability. Soil stabilization occurs over a longer time period of curing. The effects of blast furnace slag stabilization are usually measured after 0days, 3days, 7days, 15days, 28days or longer. A soil that is treated with blast furnace slag is modified and its properties are changed which may lead to stabilization. When sufficient amount of blast furnace slag is added to the soil, stabilization occurs. Stabilization is different than modification as strength increases. Over a long time period, the strength increases up to the addition of 10% of blast furnace slag. Red soil is generally, is derived from weathering of ancient metamorphic rocks of the ancient Deccan plateau. It is red colour due to the abundance of iron in it. When iron content is suitably lower, the colour will be yellow or brown colour. Red soil is usually that group of soil that develops in warm temperature and is generally abundant in moist climate where deciduous or mixed forests are present. They generally have a thin organic and inorganic mineral layer overlaying a yellowish brown layer resting on the alluvial deposits. Red soil is available in many states of

India. Red soil is generally found in Odisha, Tamil Nadu, Karnataka, Maharashtra, Chhattisgarh, Birnbaum (West Bengal), Mirzapur, Jhansi, Haripur (Uttar Pradesh), Udaipur, Durgapur, Batswana and Bhilwara districts (Rajasthan), Chotanagpur plateau of Jharkhand, AndhraPradesh. Blast furnace slag is use to make iron operate on temperatures capable of 2000°C and are feed with a carefully to inhibited mixture of limestone, iron ore, and coke. The iron ore transfer to iron which sink to the base of the furnace. Blast furnace slag is a by-product material generate [by thermal power plants from combustion of iron, iron ore, iron scrap, and fluxes (limestone or dolomite) are charged into a blast furnace along with coke for fuel. The coke is combusted.

II. METHODS AND MATERIAL

METHODS

Red soil was collected and it was subjected to air dried to carry the whole study. The whole study was carried in 3 phases.

In phase 1, preliminary tests like Specific gravity, Liquid limit, Plastic limit, differential free swell were conducted on existed soil.
In phase 2, Compaction characteristics of Red soil along with different percentages of G.G.B.S and JUTE fibre were studied. OMC and MDD were calculated through proctor test.Maximum values are obtained for the proportion having 10% GGBS.
In phase 3, at 10% GGBS, Jute Fibre was added by 0%, 0.25%, 0.50%, 0.75%, and 1% in random inclusion manner. Total 6 samples were prepared and those are presented in Table – 1. Several tests like, Modified Compaction, CBR, UCS and Consolidation were carried on these samples.

Table 1 : Types of Samples Prepared & Tested

Notation	Sample
G0-J0	Red soil
G10-J0	RS+10%GGBS
G10-J 0.25	RS+10% GGBS+0.25 JUTE
G10-J 0.50	RS+10% GGBS+0.50 JUTE
G10-J 0.75	RS+10% GGBS+0.75 JUTE
G10-J 1.00	RS+10% GGBS+1.0 JUTE

Several Tests were conducted on these samples and the testing methods carried were explained in following section.

LABORATORY TESTS CONDUCTED

In order to determine the effect of GGBS and Jute Fibre in Red Soil, different tests were conducted on the samples and the testing procedure followed are explained in below sections.

A. Index Properties

Liquid Limit, Plastic Limit, Specific Gravity, and Differential Free Swell (DFS) tests were carried on collected soil by following IS standard procedures. IS: 2720 - Part 5 (1985) was used to determine the Liquid and Plastic limits. By using these and plasticity chart, the type of soil was classified. Pycnometer method described in IS: 2720 – Part 3 (1980) was used to determine the Specific gravity. DFS was measured as per IS 2720 – Part 11 (1977).

B. Compaction Characteristics

The Compaction Characteristics of soil samples with different percentages of GGBS and Jute Fibre were determined by using Modified (Heavy) Compaction method as per IS: 2720 – Part 8 (1983). By using this test, the relationship between the OMC and MDD for different samples was evaluated.

C. California Bearing Ratio (CBR)

The standard procedure mentioned in IS: 2720 – Part 16 (1979) was followed to determine the CBR value. The CBR test was conducted on Red Soil with different percentages of GGBS and Jute fibre in both Unsoaked and Soaked conditions. In order to calculate the soaked CBR, sample was immersed in water for 96hrs.

D. Unconfined Compressive Strength (UCS)

UCS Test was carried on cylindrical soil samples with different percentages of GGBS and Jute Fibre. Split mould was used to prepare the sample, and test was conducted on samples as per IS: 2720 – Part 10

(1991). UCS was calculated on samples at 0, 3, 7, 14, 28 days curing periods.

E. Consolidation Characteristics

Consolidation Characteristics of soil samples were determined as per IS: 2720 – Part 15 (1986). The pressure applied on consolidometer assembly are 0.1, 0.2, 0.4, 0.8, 1.6 kg/cm^2. From this test, Coefficient of Compressibility (a_v), Compression Index (c_c) and Coefficient of Volume Change (m_v) were calculated and their variation with different percentages of GGBS and Jute fibre in Red soil was analyzed.

The above mentioned tests were carried on different types of soil samples (as mentioned in Table – 1) and their test results were presented in below section.

MATERIALS

Different types of materials used in this study are Red Soil, Jute Fibre, GGBS and their details along with properties are explained in below sections.

A. Red soil

Red soil also called as red earth contains kaolinite type clay along with silt & fine sand. It has got its red color due to the presence of considerable quantities of iron oxide. It is less clayey and siltier in nature, and has low humus content. This soil is acidic in nature and is not able to retain moisture. The content of nutrients like nitrogen, phosphorous and lime is very small. Stabilization of soil using cement or lime is well established. Our aim here is to study the effect on engineering properties of soil and its stabilization by using blast furnace slag (an industrial waste). In this study, experimental investigations are done to know the effect of ground granulated blast furnace slag on Red soil along with small percentages of jute fibre.

Table-2: properties of Red soil

S.no	Property/Parameter	For Red soil
1	Specific Gravity	2.625
2	Grain size analysis	
	% of gravel	0.2
	% of sand particles	51
	% of silt size particles	30.8
	% of clay size particles	18 3
3	Atterberg‟s	
	Liquid limit %	29.5
	Plastic limit %	
	Shrinkage limit %	22.78 4
4	Plasticity index	40.1 5
5	Soil classification	SW
6	Free swell	11%
7	Compaction Characteristics	
	Max. dry density (kN / m3)	18.35
	Optimum Moisture content (OMC) in%	14.6

B. Jute Fibre

Jute is a vegetable fibre. It is very cheap to produce, and its production levels are similar to that of cotton. It is a bast fibre, like hemp, and flax. Coarse fabrics made of jute are called hessian, or burlap in America. Like all natural fibres, Jute is biodegradable."Jute" is the name of the plant or fibre that is used to make burlap, Hessian or gunny cloth.

Properties of Jute Fibre:

1.Jute fibre is 100% bio-degradable and recyclable and thus environmentally friendly.
2.Jute is a natural fibre with golden and silky shine and hence called The Golden Fibre.
3.Jute is the cheapest vegetable fibre procured from the bast or skin of the plant's stem.
4.It is the second most important vegetable fibre after cotton, in terms of usage, global consumption, production, and availability.
5.It has high tensile strength, low extensibility, and ensures better breathability of fabrics. Therefore, jute is very suitable in agricultural commodity bulk packaging.

Figure 1. Jute Fibre

C. Ground Granulated Blast Furnance Slag (GGBS)

Ground-granulated blast-furnace slag (**GGBS** or GGBFS) 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. The blast furnace slag is considered as a waste disposal which can be used in the construction material like pavement, road, landfills, railway ballast, etc. Different types of slag produce depending on the method used to cool the molten slag. The blast furnace slag (BFS) is immerse the sulphur as of the charge comprises about 20% of iron product. There are different forms of slag produced depending on the methods used to cool the molten slag

The product involved air cooled blast furnace slag are

- Air cooled blast furnace slag(ACBFS)
- Expanded or foamed blast furnace slag(EBFS)
- Pelletized blast furnace slag(PBFS)
- Granulated blast furnace slag(GBFS)

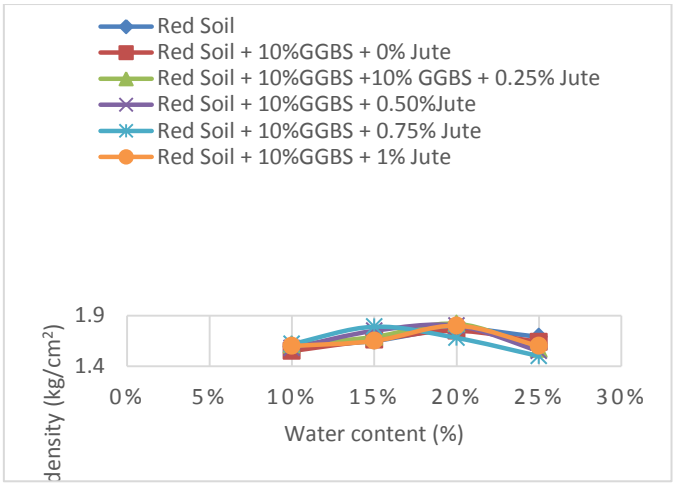
III. RESULTS AND DISCUSSION

A. Index Properties

The basic index properties of collected soil are, Liquid Limit is 37.5%, Plastic Limit is 15.87% and Plasticity Index is 21.63%. Based on these, the soil was classified as CH (Clay with High Plasticity). Specific gravity obtained is 2.46. And Differential Free Swell is 50%. From DFS, the soil was classified as High Expansive Soil.

B. Compaction Characterstics

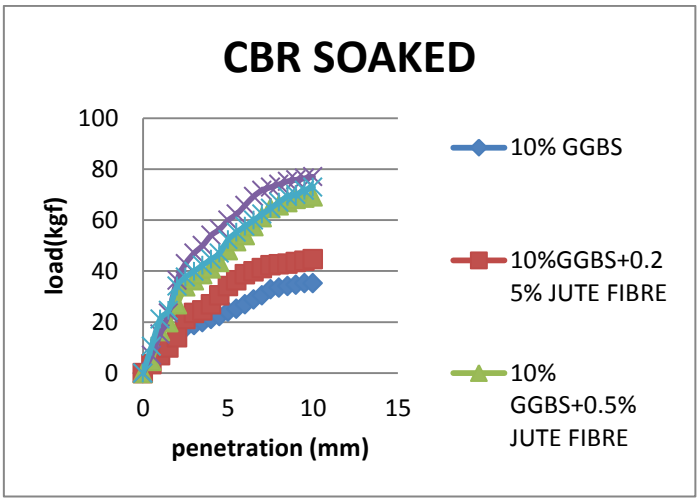
The MDD and OMC obtained for untreated soil are 20% and 1.50g/cc. OMC was increased with the addition of Jute Fibre. The variation of OMC and MDD with different percentages of GGBS and Jute Fibre was shown in Graph– 1.



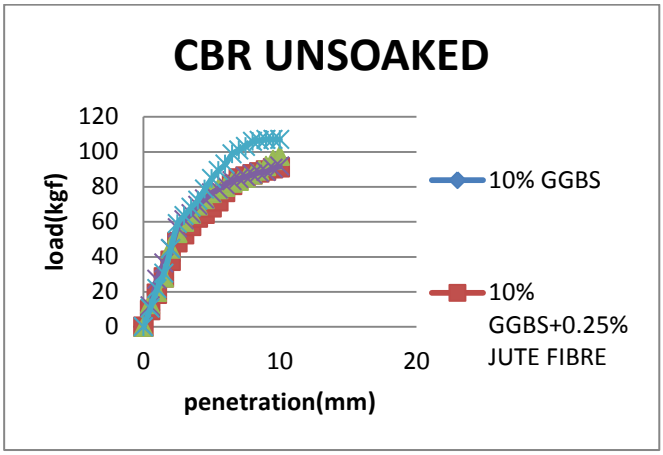
Graph -1: Compaction Curves

C. California Bearing Ratio (CBR)

The variation of Load with Penetration graphs for Red Soil along with different percentages of GGBS and Jute fibre in both Unsoaked and Soaked condition were shown in Graph – 2 and Graph – 3 respectively.



Graph -2: Load Vs Penetration graphs of Soaked CBR

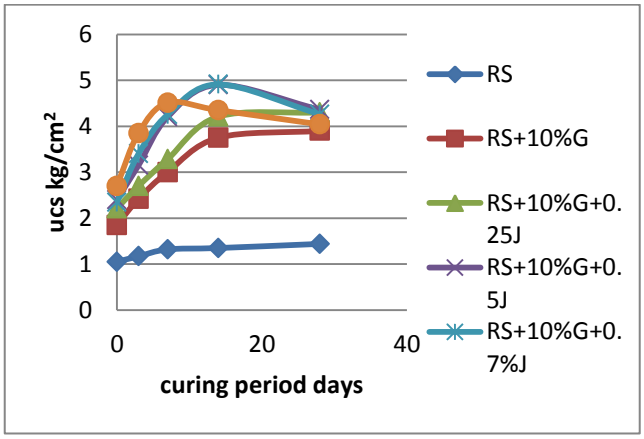


Graph -3: Load Vs Penetration graphs of Unsoaked CBR

From above graphs CBR values Increased when compared to the normal Soil in both Unsoaked and Soaked Conditions. High for the soil having 10% of GGBS and 0.75% of jute Fibre, Decreased when jute fibre percentage is increased from 0.75% to 1%

D. Unconfined Compressive Strength (UCS)

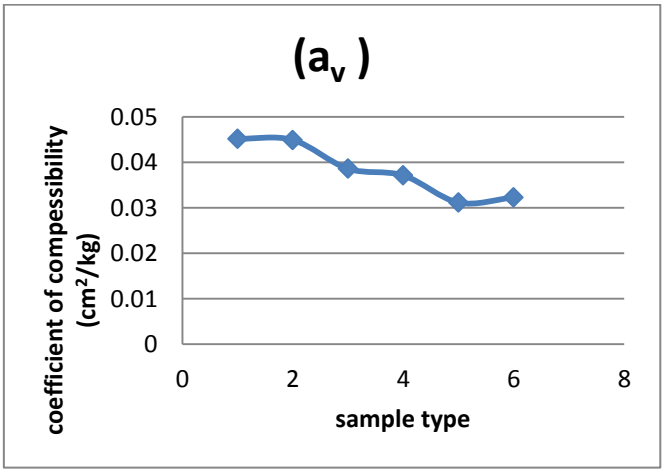
UCS at 0, 3, 7, 14, and 28 days curing periods was calculated. And the variation of UCS with Curing Days was shown in graph– 5. UCS values for all percentages were increased when compare with normal soil. Red soil with 10% of GGBS has gradual increase in UCS along with curing days. And the red soil at 10% GGBS with 0.25% and 0.5% jute fibre also have gradual increase in UCS along with curing periods. But soil with 0.75% and 1% jute fibre have strength increment earlier curing days and have decrement in later curing days. Maximum value of UCS is obtained for 0.75% jute fibre at 14days, but in 28 days curing period, for 0.5% jute fibre combination have high UCSvalue.



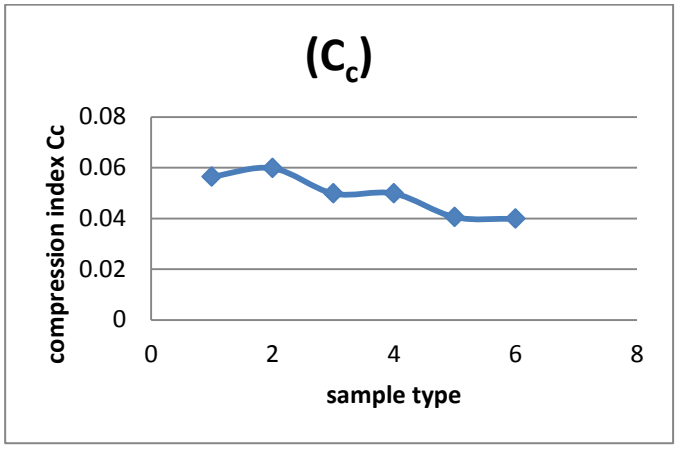
Graph-4: UCS variation at different curing periods at different % of Jute Fibre

E. Consolidation Characteristics

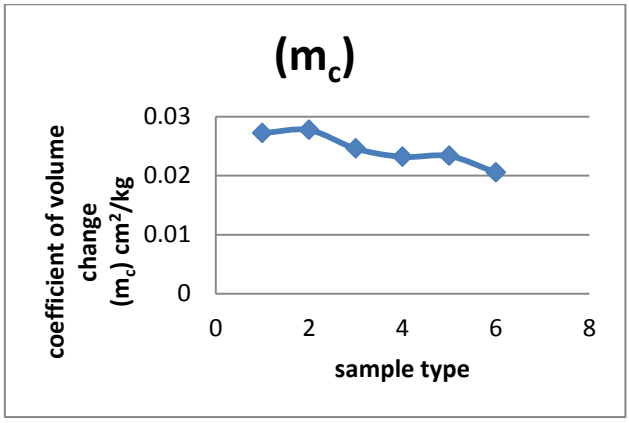
Total 3 coefficients, Coefficient of Compressibility (a_v), Compression Index (c_c) and Coefficient of Volume Change(m_v) are calculated from consolidation test and the values re resulted and their variation with different percentages of GGBS and Jute fibre are shown in Graph-5, Graph-6 and Graph-7. When comparted with Red soil, all three coefficients were decreased i.e., Consolidation characteristics were improved when GGBS and Jute Fibre were added to Red Soil.



Graph-5: Variation of Coefficient of Compressibility for different % of GGBS and Jute Fibre



Graph-6: Variation of Compression Index for different % of GGBS and Jute Fibre



Graph-7: Variation of Coefficient of Volume Change for diiferent % of GGBS and Jute Fibre

IV. CONCLUSIONS

In this, the major properties studied are OMC, MDD, CBR, UCS, and Consolidation. Based on the all investigations done all samples and when compared with normal soil, following conclusions were made.

Optimum Moisture Content: (OMC)

- Optimum moisture content (OMC) was increase with the addition of jute fibre.
- For normal soil, OMC observed at 20% and it is increased and with the addition of 0.25%, 0.5%, 0.75% and 1% jute fibre at 10% GGBS respectively
- Maximum dry density was decreased with the addition of jute fibre and GGBS
- When 5%, 10%, 15%,20% GGBS added, higher MDD observed for 10% of GGBS addition
- When jute fibre added, MDD value were decreased. But, at 0.75% jute fibre addition was increased when compared to other jute fibre additions.
- Both the Unsoaked and soaked condition of CBR were studied and Peak value was obtained at 0.75% jute fibre addition in both conditions.
- From 0 to 0.75% addition of jute fibre, CBR value was gradually increased in both unsoaked and soaked condition.
- But, CBR value was decreased after 0.75% of jute fibre addition (i.e., at 1%)
- UCS was calculated for 0, 3, 7, 14, 28 curing days.
- UCS values are gradually increased 0, 3, 7 curing days for respective addition of fibres and GGBS.
- At 14 days curing period maximum value is attained for 0.75% jute fibre addition. And But, 28 days UCS was decreased for this combination.
- At 0.75% and 1% addition of jute fibre, UCS was decreased for 28days curing period. But the values were improved when compared to normal soil.
- Gradual increment in UCS at all curing days was observed at 0.25%, 0.5% addition of jute fibre. In those, maximum value is attained for 0.5% addition.
- With overall observations of UCS, 0.5% and 0.75% addition was good, and more than that was not good.
- Coefficient of Compressibility, Compression index, Coefficient of Volume change were calculated for all samples. And observed that, there is decrement in all coefficients with addition of jute fibre and GGBS. i.e., consolidation characteristics are improved through the addition of these additives.

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