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Effect of Random Inclusion of Plastic Fibres on Strength Behaviour of Ground Granulated Blast Furnace Slag Treated Black Cotton Soil

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ABSTRACT: Soil stabilization is most important for the construction which is widely used in connection with road pavement and foundation construction because it improves the engineering properties of soil such as strength. Utilization of industrial waste materials in the improvement of soils is a cost efficient and environment friendly method. Stabilization of the expansive soil is studied by using Ground Granulated Blast Furnace Slag (GGBS) and Plastic Fibres. The present investigation is to evaluate the compaction and CBR values of stabilized black cotton soil using GGBS and plastic fibre mixes. The geotechnical properties like compaction parameters and California Bearing Ratio increase which indicates the improvement in strength. From these results, it was found that optimum percentage of GGBS is 15% and of plastic fibres is 1% which gives the maximum increment in the CBR value compared with all the other combinations.

KEYWORDS: - Compaction, California Bearing Ratio, Expansive Soil, GGBS, Plastic Fibres.

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I. INTRODUCTION

Soil is the major and most commonly used material in the filled of civil engineering. Safe and Economic disposal of industrial wastes and development of economically feasible ground improvement techniques are among the important challenges being faced by the engineering community. Soil stabilization is required to increase the bearing capacity of foundation soils. However, the main use of stabilization is to improve the natural soils for the construction of highways and airfields. Stabilization 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. Soil stabilization has become the major issue in construction engineering and the researches regarding the effectiveness of using industrial wastes as a stabilizer are rapidly increasing. Laboratory experiments by blending different percentages of GGBS and Polypropylene Fibres in black cotton soil and from the test results ,strength of BC soil increased with addition of GGBS up to 40% for the curing periods of 7and 28 days and further addition of GGBS decreased the strength of Soil , addition of 40% GGBS to the BC soil reduced the swell percent from 25 % to 12.1 % and further additions of GGBS to the BC soil do not have significant reduction in swell percentage. Strength of BC soil blended with 40 % of GGBS increased with addition of 0.75 % of Polypropylene fibers for the curing periods of 7 and 28 days and further addition of polypropylene fibers decreased the strength of soil 40 % GGBS mixture blended with polypropylene fibers, addition of 0.75 % Polypropylene fibers to the GGBS blended BC soil reduced the swell percent from 25 % to 2.5 %. Further additions of polypropylene fibers to the GGBS blended BC soil do not have significant reduction in swell percentage [1]. Sugarcane straw ash and polypropylene fibres blending in expansive soil at varying percentages to stabilize the soil. Various geotechnical laboratory tests like compaction, Unconfined Compression Test and California Bearing Test were carried by varying the percentage of sugarcane straw ash (10%, 15%, 20% and 25%) and polypropylene fibres (0.5%, 1.0% and 1.5%) respectively. It is found that 20 % increase in the percentage of sugarcane straw ash and 1% polypropylene fibres increases the UCS and CBR values. Hence 20% of sugarcane straw ash and 1% of fibres had shown promising influence on the strength characteristics of soil, thereby giving a two-fold advantage in improving poor soil and also solving a problem of waste disposal[2] .Laboratory tests on Flyash and GGBS and from test results , with the increases of flyash and GGBS percentage, optimum moisture content goes on decreasing while maximum dry density goes on increasing, hence compact ability of soil increases and making the soil more dense and hard. OMC of 14.8% is reached at 10% of flyash and of 13.7% is reached at 10% of GGBS. CBR value increase with increase in amount of flyash and attained maximum value at 15% and again decreases and same trend is also observed in

GGBS in which the maximum CBR value (8.6 %) is attained at 15% of GGBS. It is concluded that the optimum value for flyash is 15% and GGBS is 20% respectively. Based on the results of this study, it appears that the selected soil can be effectively stabilized with the addition of flyash at 15 % or 20% GGBS by dry weight of soil. Flyash- GGBS mixtures are suitable for use in rural roads, embankments and it be used as provide fill materials of comparable strength [3]. Two industrial wastes GGBS and Calcium Carbide Residue in the stability of soil. From the experimental results permeability of the soil has reduced, Unconfined Compressive Strength has increased and increases CBR in both soaked and unsoaked conditions. With the increase of% of GGBS, liquid limit, plastic limit and plasticity index decreases, hence the soil sample becomes less plastic and less compressible [4]. Various laboratory tests Plastic Limit, Liquid Limit, Free swell index, Specific gravity test, Proctor compaction test and unconfined compressive strength to determine the effect of Ground Granulated Blast Furnace slag on black cotton soil and red soil. From the test results liquid limit, plastic limit and free swell index decreased with addition of GGBS and slight increase in specific gravity of both type of soil. MDD and OMC decreases with addition of GGBS up to 20-30% and then it increases with further addition of GGBS. UCS strength increased from 230.1KPa for 100% black soil (0% GGBS) to 443.3 for 70% black soil (30%GGBS) and from 263.5KPa for 100% Red soil (0%GGBS) to 429.7KPa for 70% Red soil (30%GGBS). So we have concluded that 30% is the optimum dosage of GGBS in soil[5]. Effectiveness of binder viz., Flyash or Ground Granulated Blast furnace slag were mixed with the expansive soil along with a small amount of lime to increase soil pH and enable pozzolanic reactions. Based on the findings, both Optimum Moisture Content and Maximum Dry Density decreased with the addition of GGBS to the BC soil which is due to predominant effects of reduced clay content and increased frictional resisting. Unconfined compressive strength of the Flyash-GGBS mixture increases with the increase in the GGBS content. The reduction nin strength in the Flyash-GGBS mixtures is overcome by addition of lime [6]. An experimental study is conducted to find the effect of ground granulated blast furnace slag and plastic fibres on mechanical properties of black cotton soil. In the initial the basic properties of black cotton soil were found out. The first phase of the work includes effect of GGBS on compaction and CBR characteristics of black cotton soil with a view to determine optimum percentage of GGBS%. The next phase focuses reinforcement material plastic fibres blending in optimum mix of expansive soil and GGBS and conducted compaction & CBR tests with a view to determine the effect of plastic fibres. The results indicated that with addition of GGBS to black cotton soil the maximum dry density increased and optimum moisture content decreased and CBR values increased addition of plastic fibres to mixture of black cotton soil and optimum dosage of GGBS.

II. MATERIALS USED

The materials used for the stabilization of Expansive soil are GGBS and plastic fibres this study. The properties and availability are mentioned below.

2.1 Black Cotton Soil: Natural black cotton soil was obtained from Godilanka, Amalapuram, East Godavari district, Andhra Pradesh. The soil is dark grey to black in color with light clay content. The obtained soil was air dried, pulverized manually and soil passing through 4.75 mm IS sieve was used as shown in the Fig. 1. The physical properties of black cotton soil are furnished in Table.I.

Table I: Physical Properties of Expansive Soil

Property	Symbol	Value
Liquid Limit (%)	W_L	85.66
Plastic Limit (%)	W_P	36.06
Plasticity Index (%)	I_P	49.60
Soil Classification	--	CH
Specific Gravity	G	2.66
Free Swell (%)	FS	140
Optimum Moisture Content (%)	OMC	29.17
Maximum Dry Density (g/cc)	MDD	1.428
CBR(%)	--	1.345
Natural Moisture Content (%)	w	11.14

2.2 Ground Granulated Blast Furnace Slag (GGBS): Quenching, (i.e., sudden cooling with water or air) of hot slag may result into formation of vitrified slag (Figure 2). The GGBS is a result of use of water during quenching process. This waste material is easily available and also cost efficient. It has a cementitious property which acts as binding material for the soil. In general, the presence of sufficient quantity of CaO results in enhanced slag biscuity and compressive strength. The GGBS used in this project work is collected from Rashtriya Ispat Nigam Limited, Visakhapatnam. The chemical compositions of GGBS Cao=30%–38%; Sio_2 =

30%–40%; $Al2O_3$ = 15%–22%; MgO = 8%–11%; FeO = 5% (max) and MnO = 2% (max) and the physical properties are presented in Table.II.

Fig .1Black Cotton Soil

Fig. 2: Ground Granulated Blast Furnace Slag

Fig.3: Plastic Fibres

Table II: Properties of Ground Granulated Blast Furnace Slag (GGBS)

Name of the Experiment	Properties
Free Swell Index (%)	0
Specific Gravity	2.52
Grain Size Analysis	
% of Gravel	0.1
% of Sand	1.8
% of Silt	97.3
% of Clay	0.8
Compaction	
Optimum Moisture Content (%)	13
Maximum Dry Density (kN/m^3)	11.56

2.3 Plastic Fibres: Plastic fibres were obtained from waste plastic cover as shown in the Fig.3. The average thickness of 2 mm.Therefore a growing need to find alternative uses of reclaimed plastic bag waste to lengthen the usage time of the plastic material and thereby save the degrading environment.

III. LABORATORY EXPERIMENTATION

Various tests were carried out in the laboratory for finding the index and other important properties of the black cotton soil used during the study. Index Properties, Compaction, and soaked CBR tests were conducted by using different percentages of GGBS and Plastic Fibres mixed with black cotton soil materials for finding optimum percentages.

3.1 Index Properties: Standard procedures recommended in the respective I.S. Codes of practice [IS:2720 (Part-5)-1985; IS:2720 (Part-6)-1972], were followed while finding the Index properties viz. Liquid Limit and Plastic Limit of the samples tried in this investigation.

3.2 Compaction Properties: Optimum Moisture Content and Maximum Dry Density of Black Cotton Soil with different percentages of GGBS and plastic fibre mixes were determined according to IS Heavy compaction test IS: 2720(Part VIII).

3.3 California Bearing Ratio (CBR) Tests: Different samples were prepared for CBR test using expansive soil material mixing with different percentages of GGBS and Plastic fibres with a view to determine optimum Percentages. The CBR tests were conducted in the laboratory for all the samples as per IS Code (IS: 2720 (Part-16)-1979).

IV. RESULTS AND DISCUSSIONS

Laboratory tests were conducted for finding the index and other important properties of the soils used during the study. Compaction and CBR tests were conducted by using different percentages of GGBS and plastic fibres mixed with expansive soil materials for finding optimum percentages.

4.1 Effect of GGBS on Index Properties: Liquid limit values were reduced from 86.53,73,68.88,63.54,58.26 AND 53.5,the plastic limit values are also decreasing from 36.05%,33.25%,31.25%,30.24%,29.14% and 27.48% respectively by adding 0 %, 10%, 15% ,20%,25% and 30 % of Ground Granulated Blast Furnace Slag respectively when blended with the expansive soil as shown in the Fig. 4. Effect of Ground Granulated Blast Furnace Slag decreases the liquid limit and plastic limit of soil and the soil becomes more workable because of decrease in plastic properties of soil and due to formation of cementing material.

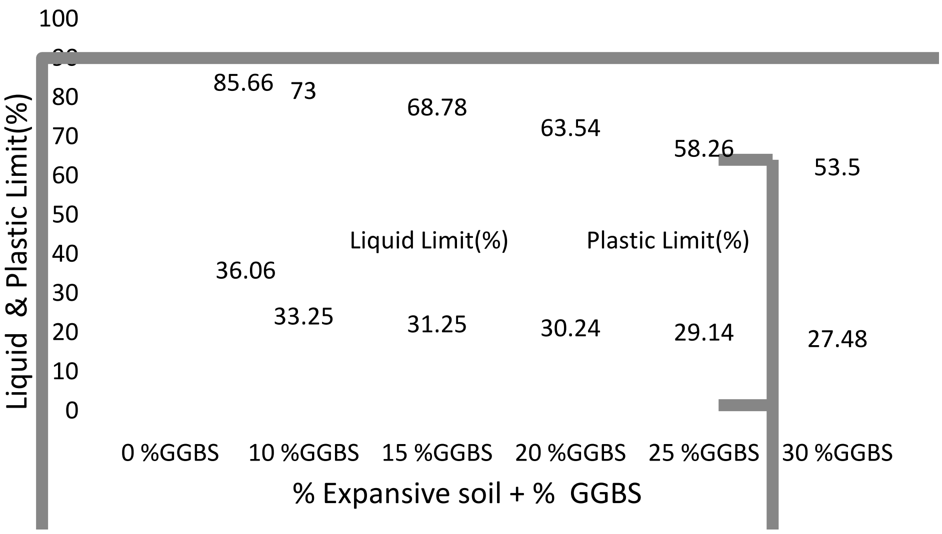

Fig.4 Variation of Liquid Limit and Plastic Limit Values of Expansive Soil Treated with Different % of GGBS

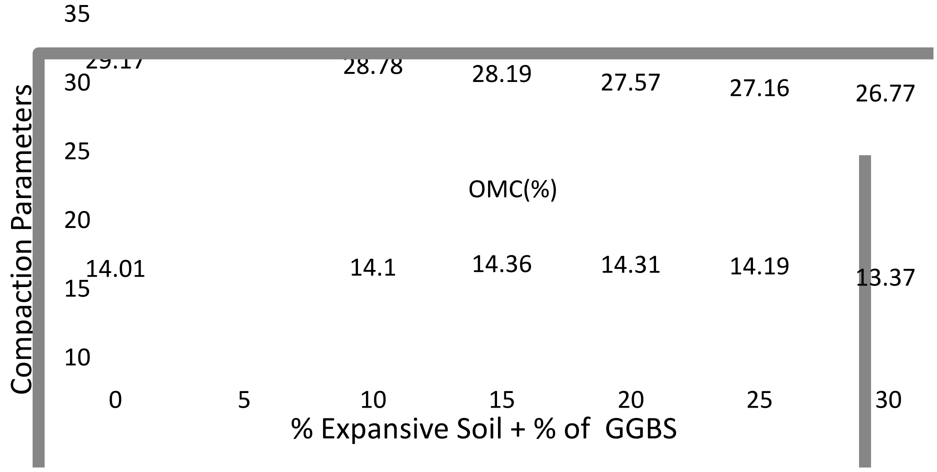

Fig.5 Variation of Compaction Parameters of Expansive Soil Treated with Different % of GGBS

4.2 Effect of Ground Granulated Blast Furnace Slag and Plastic Fibres Compaction: The OMC and MDD values are are presented below form Figs. 4 & 5. From the results the maximum dry density values are varies from 14.01kN/m^3,14.10 kN/m^3, 14.36 kN/m^3, 14.31 kN/m^3 ,14.19 kN/m^3 and 13.37 kN/m^3; optimum moisture content values are decreasing from 29.17 %, 28.78%, 28.19%, 27.57 %,27.16% and 26.77% respectively when the soil is mixed with 0 %, 10 %, 15% ,20%,25% and 30 % of Ground Granulated Blast Furnace Slag mixing in expansive soil respectively shown in the Fig.4. At 15% of GGBS attained maximum dry density. Expansive soil with 15 % optimum GGBS as soil mix, adding different % of plastic fibres 0%,0.5%,1%,1.5% and 2% the MDD & OMC values are 14.36 kN/m^3,14.53kN/m^3,14.87 kN/m^3,14.79 kN/m^3 and 14.06 kN/m$^{3;}$ 28.19%, 28.95%, 29.22%, 29.44% and 29.69 % respectively as shown in the Fig.5. From the above results 1 % plastic fibres shows maximum increase in dry density when compared to other samples tried in this investigationdue to compatibility of soil increases and making soil more dense and hard.

4.3 Effect of Ground Granulated Blast Furnace Slag and Plastic Fibres on California Bearing Ratio (CBR): Soaked CBR tests were conducted for expansive soil mixed with different percentages of GGBS and Plastic fibres and the results were presented in the Figs.7 & 8. It is observed from that expansive soil mixed with different percentages of Mill scale dust the soaked CBR values are 1.35%, 2.69%, 3.59%, 3.31%,2.25% and 1.79 % respectively at 0 %, 10%, 15%,20%,25% and 30 % blending of GGBS as shown in the Fig.7.From the above results at 15% mill scale attains maximum CBR value. Considering 15% optimum mill scale dust blending with different percentages of bamboo fibres ,the soaked CBR values are 3.59%,6.72%,8.51%,7.17% and 5.83% at 0%,0.5%,1%,1.5% and 2% blending plastic fibres respectively shown in the Fig.8. From the above the maximum CBR attained at 1% plastic fibres is 8.51% compared to other samples tried.

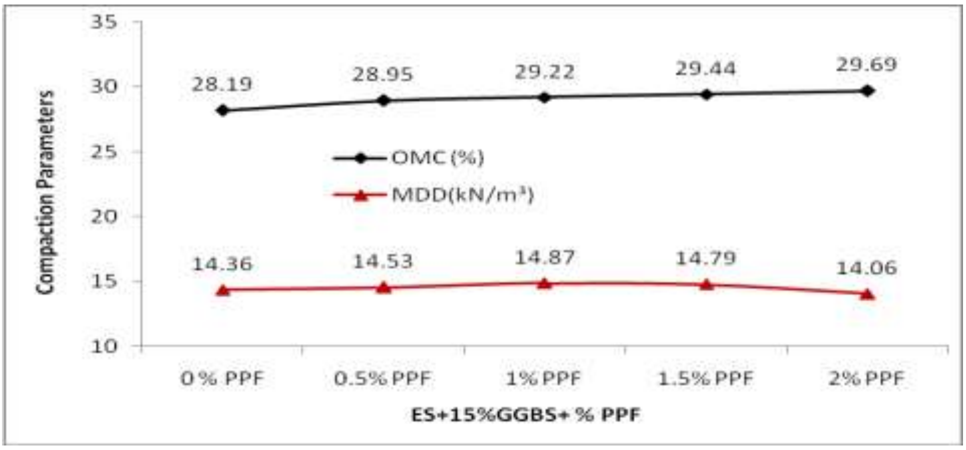

Fig. 6 Variation of Compaction Parameters of Expansive Soil with 15% GGBS and Different % of PPF

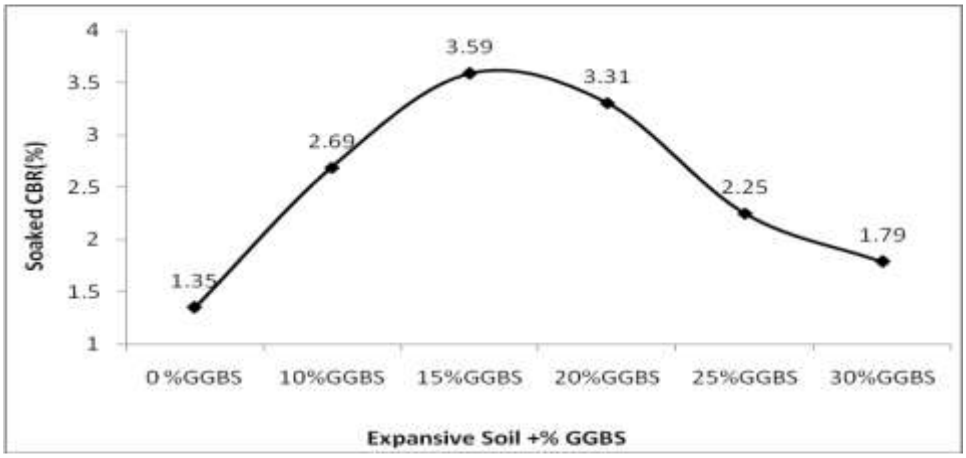

Fig.7 Variation of Soaked CBR Values of Expansive Soil Treated with Different % of GGBS

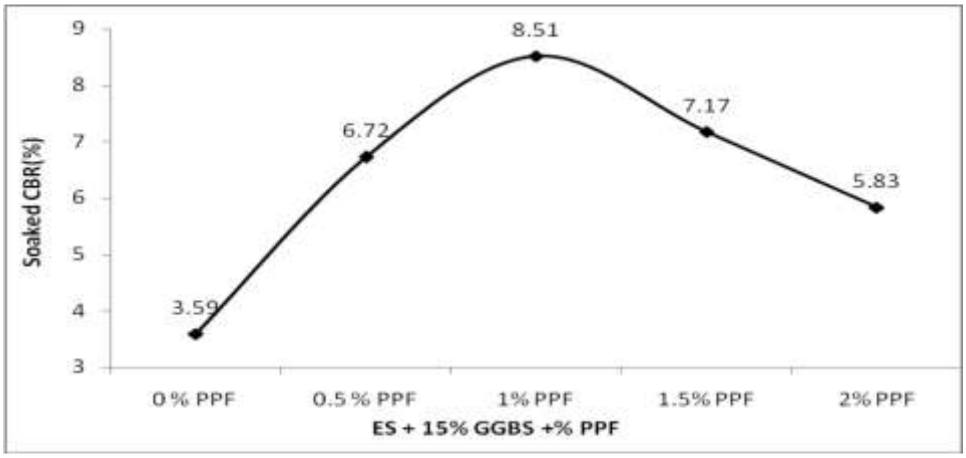

Fig.8 Variation of Soaked CBR Values of of Expansive Soil with 15% GGBS and Different % of PPF

V. CONCLUSIONS

Laboratory study evaluated the effect of GGBS and Plastic fibres on compaction and CBR properties of expansive soil. A series of tests were conducted to study the effect of GGBS and Plastic fibres on strength characteristics of black cotton soil.

- GGBS is a waste product which is produced abundantly from iron factories, as it is having high specific gravity of 2.52 is used as stabilizing material.
- Addition of 15% GGBS to BC soil the maximum dry density of expansive soil increased from 14.01 kN/m^3 to 14.36 kN/m^3 and soaked CBR values increased from 1.39% to 3.59% which is around 1.6 times more natural expansive soil.

- Addition of 15% GGBS to expansive soil with i% plastic fibres ,soil the maximum dry density of expansive soil increased from 14.01 kN/m^3 to 14.79 kN/m^3 and soaked CBR values increased from 1.39% to 8.51 % which is around 5.2 times more natural expansive soil.
- CBR value for increase in percentage of GGBS and plastic fibres that show the densification of soil takes place and more suitable for foundation.

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