An Experimental Study on Expansive Soil Stabilized with GGBS

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Abstract: In developing countries like India, due to the remarkable development in road infrastructure, Soil stabilization has become the major issue in construction activity. Stabilization is not only a method of altering or modifying of one or more soil properties to improve the engineering characteristics and performance of a soil, but also processing available materials for the production of low-cost design and construction.

Expansive soils are known for their low plasticity and low shear strength. These soils present significant geotechnical and structural engineering challenges all over the world, with costs associated with expansive behavior estimated to run in to several billions annually. Expansive soils are the soils that experience significant volume change associated with changes in water content which means they are volumetrically unstable due to seasonal moisture variation. Their strength decreases and compressibility increases tremendously on wetting. By keeping the above problem in view, the cohesive natured clayey soil was chosen and checked for compaction properties along with other general soil characteristics by varying the content of ground granulated blast furnace slag, which is waste by-product released during the processing of iron and steel metals.

From the present study, it deduced that there is a significant decrease in compressibility characteristics of the clay with the increase in ggbs content. Ultimately, the composite soil which is stabilized with ggbs content proves to be
good construction material for complex civil engineering structures such as embankment, earthen dams and runways. The usage of ggbs for soil stabilization is not only economical, but also beneficial to the environment by putting an industrial waste to good use.

Keywords – Soil Stabilization, Expansive Soil, Ground Granulated Blast Furnace Slag (GGBS), Strength Properties.

I. INTRODUCTION

A land based structure of any type is only as strong as its foundation. For that reason, soil is a critical element influencing the success of a construction project. Soil is either a part of the foundation or one of the raw materials used in the construction process. Therefore, understanding the engineering properties of soil is crucial to obtain strength and economic permanence. Most recently, soil stabilization has once again become a popular trend as global demand for raw materials, fuel and infrastructure has increased.

Soil stabilization is the process of maximizing the suitability of soil for a given construction purpose. Soil stabilizers can be used to treat the upper several inches of soil or aggregate surfaces of low-volume roads when the strength or other properties of the in-situ soil do not meet the desired or required levels for anticipated traffic. Soil can be either modified or stabilized by many methods, including chemical, mechanical, thermal, and electrical. Modification is generally short term and includes benefits such as improvement in workability (expediting construction and saving time and money). Stabilization generally results in a longer term strength gain.

Since expansive soils have a tendency to change their volume to a large extent, they cause heavy distress to engineering constructions. The lightweight structures are severely affected due to high swelling pressure exerted by these soils. Such type of large scale distress, due to expansive shrinking nature of expansive soil, can be prevented by either obstructing the soil movement and reducing the swelling pressure of soil or making the structure sufficiently resistant to damage from soil movement. Although mechanical compaction, dewatering and earth reinforcement have been found to improve the strength of the soils, other methods like stabilization using admixtures are more advantageous. The different admixtures available are lime, cement, fly ash, blast furnace slag, etc. The present stabilization, now-a-days, is gaining more importance because of its abundant availability and environmental concerns related to its production.

Scope and Importance of the Study:

The experimental study is concerned with the selection of approximate type of soil to achieve a very high degree of compaction and to expose the compaction properties of clay. The clayey soils are difficult to compact in the initial stage of compaction, but as the moisture content increases the compaction becomes quite easy. The results of the study can provide thoughts for applying clay soil in various applications of soil stabilization process.

The study involves the usage of Ground granulated Blast Furnace Slag (GGBS) for the stabilization of clay soil, which is well mixed in different proportions as 5%, 10%, 15%, 20% and 25%. From the mixture, the effectiveness of the stabilizer will be determined by conducting CBR, Unconfined Compression and Proctor Tests.

Soils that can be found every day in construction area have different characteristics and gives major effects to the construction. The soils that are not safe for construction should be treated to achieve the specification. An appropriate treatment method for the soil should be selected by considering the type, cost and duration of the construction. The usage of GGBS as stabilizer is an increasing significant approach to treat the problematic soils.

Objectives of the Study:

The basic objectives of our present study are as follows:

- Improving the bearing capacity of the soil on addition of GGBS.
- Variation of Strength of the soil at different water contents.
- Effect of GGBS on CBR value of the soil.
- Effect of GGBS on Compressive Strength of the soil.

II. LITERATURE REVIEW

The necessity of improving the engineering properties of soil has been considered as old as construction has existed. Many of the ancient Chinese, Romans and Incas buildings and road ways which exist till today utilized different techniques of soil stabilization. The use of lime as a building material dates back 5,000 years when lime and clay were mixed and compacted to form bricks used in the construction of the pyramids of Shensi in Tibet. About 2,000 years ago the Romans used lime to improve the quality of their roads. The Romans also made mixtures of lime and volcanic ash called "pozzolana" in which the principles of today's cement can be seen. John Smeaton built the Eddy stone lighthouse in 1756 using a mixture of blue lime and pozzolanic clay without being aware that he had discovered the basic principle of cement manufacture. This enabled Joseph Aspdin to patent the process, which he called "Portland cement" in 1824.

The modern era of soil stabilization began in the United States during 1960's and 1970's when shortages of aggregates and petroleum resources forced engineers to consider alternatives of road construction instead of soil replacement. Since 1930, tests have been carried out in the United States with lime stabilization but success was achieved only ten years thereafter. The use of cement stabilization is over 65 years old with methods and materials proven and well established. Non-traditional stabilization products have been in development since the 1960's with many research papers and projects written on the subject. However, despite the multitude of information available the acceptance of these stabilization products is to be proven through time.

Blast furnace slag have a long history of being utilized as industrial by- products, going back almost 100 years in the United States. BFS is composed of the non -metallic components removed from iron ore during processing in a blast furnace. It consists essentially of silicates and alumina-silicates of calcium and other bases. BFS have unique physical and chemical properties that make them particularly well suited to a variety of uses in construction and civil engineering projects.

Ten million tons of blast furnace slag is produced in India annually as a by-product of Iron and Steel Industry. Blast furnace slag is composed of silicates and alumina silicates of lime and other bases. It is a latent hydraulic product which can be activated with anyone like lime, alkalies or Portland cement.

METHODOLOGY

Expansive Soil

The Clay that has been used in this study was a typical BC soil collected from Odalarevu near Amalapuam, East Godavari District. The soil used for the investigation was dried, pulverized and then sieved through 4.75mm size sieve. The properties of black cotton soil experimented, based on relevant I.S. code provisions are given in the Table 1 below.

Table 1 Physical properties of Clayey Soil

Laboratory Experimentation	Value
Specific gravity	2.46
Compaction Parameters	
Maximum Dry Density(g/cc)	1.66
O.M.C. (%)	20
Atterberg's limits	
Liquid limit (%)	27.1
Plastic limit (%)	16.4
Plasticity index(%)	10.7
IS classification	CL
Differential Free Swell (%)	105
CBR- Unsoaked	4.2
Soaked	3.49

Ground Granulated Blast Furnace Slag(GGBS)

The stabilizer – ground granulated blast furnace slag (*GGBS)* was used in this experimental study was obtained from Vizag Steel Plant, Visakhapatnam.

Physical Properties of GGBS

Property/Parameter	***Value***
Colour	*Grey*
Size (mm)	*0.003*
pH Value	*8.4*
Atterberg's Limit ***a) Liquid Limit (%)***	*26* *Non -*
Specific Gravity	*2.81*
Compaction Characteristics a)Max. Dry Density (g/cc) *b)Optimum Moisture Content [OMC] (%)*	*1.38* [illegible]

MIXING RATIOS

The values adopted in the present study for the percentage of slag are 0%, 5%, 10%, 15%, 20% and 25% and are as follows:

A) 0% GGBS + 100% SOIL

B) 5% GGBS + 95 % SOIL

C) 10% GGBS + 90% SOIL

D) 15% GGBS + 85% SOIL

E) 20% GGBS + 80% SOIL

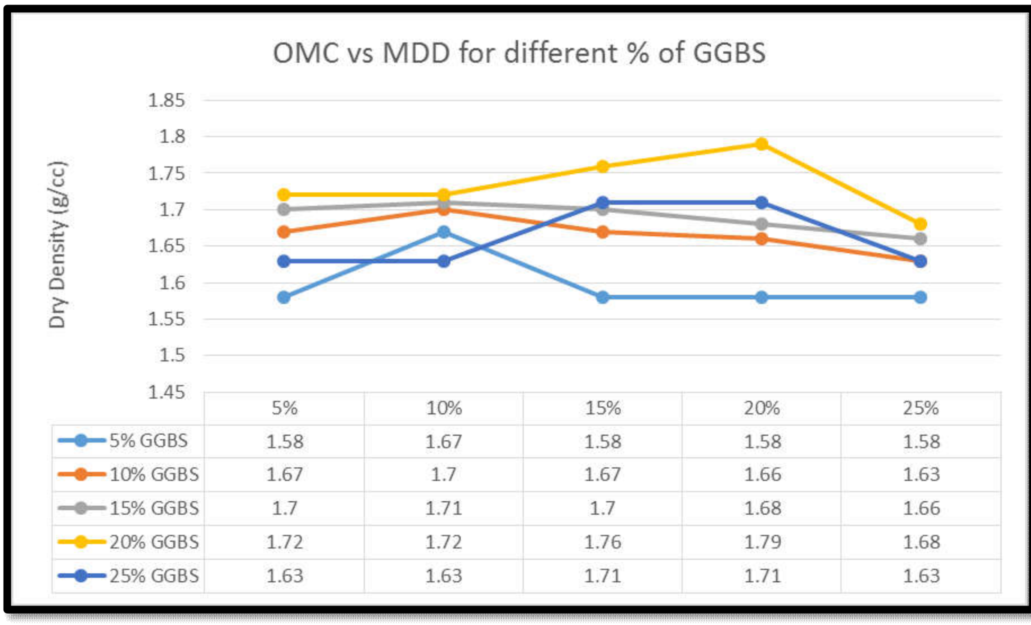
F) 25% GGBS + 75% SOIL

G) 25% GGBS + 75% SOIL

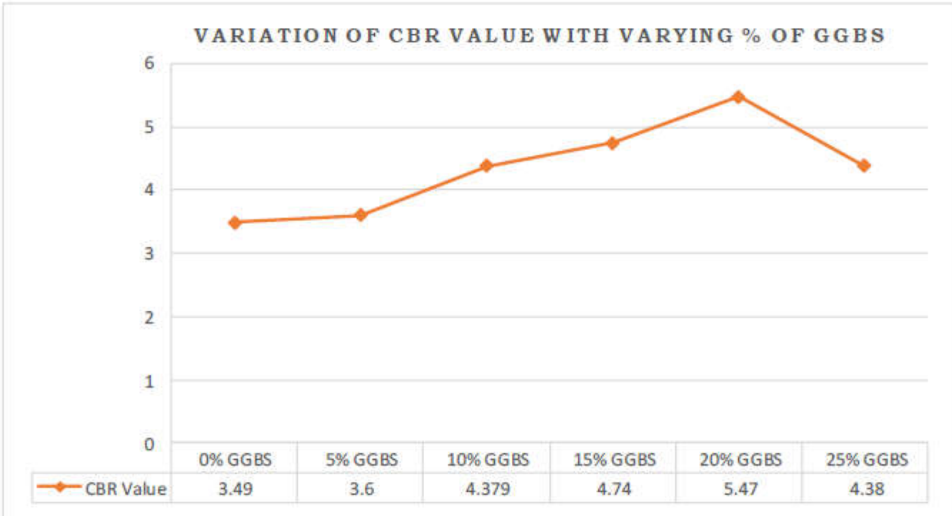
RESULTS AND DISCUSSIONS

Properties of Expansive soil with GGBS:

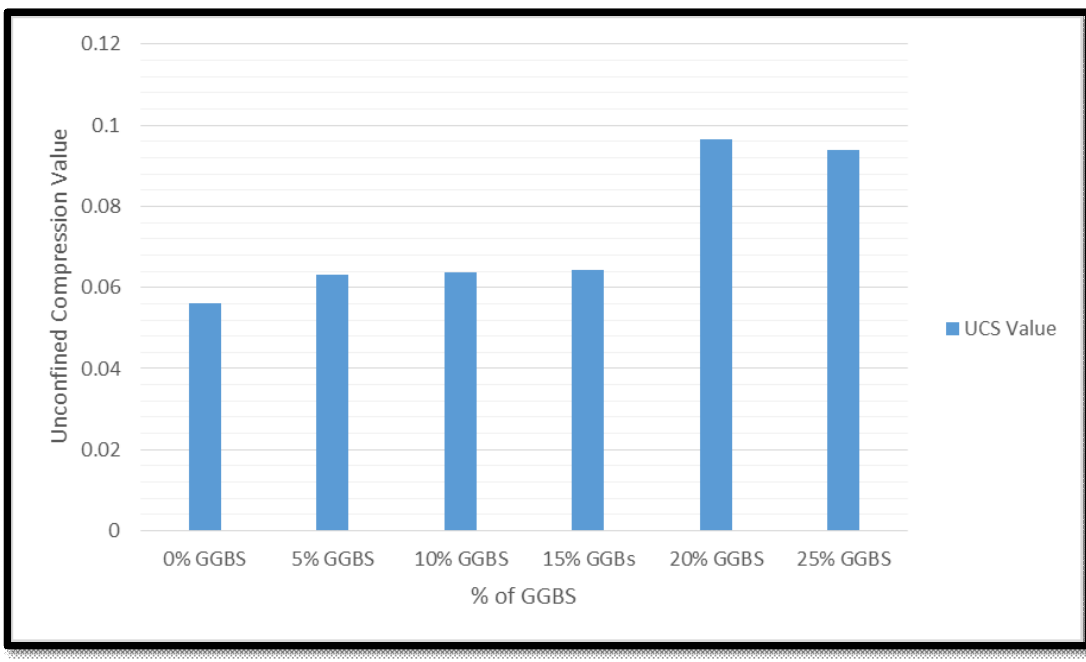
ES+GGBS(%)	OMC(%)	MDD(g/cc)	CBR(%)		UCC(MPa)
			UNSOAKED	SOAKED	
100+0	20	1.66	5.21	3.49	0.0562
95+5	19	1.72	6.01	3.6	0.0631
90+10	18.6	1.722	5.92	4.379	0.0637
85+15	20	1.76	6.23	4.74	0.0643
80+20	20	1.79	7.14	5.47	0.0965
75+25	20	1.79	5.88	4.38	0.0938



Variation of OMC vs. MDD for different % of GGBS



Variation of CBR for different % of GGBS



Variation of UCS Value with varying % of GGBS

CONCLUSIONS

- It is observed that with the increase in water content, the dry density also increases up to 10% moisture content and with further increase in water content the dry density decreases gradually.

- The increase of the maximum dry unit weight with the increase of the percentage of GGBS is mainly due to the higher specific gravity of the fine GGBS compared with expansive soil and the immediate formation of cemented products by hydration which increases the density of soil.

- It can also be observed that the optimum moisture content was decreased with further increase in GGBS content.

- The lowest dry density was observed to be about 1.58 g/cc for 95% soil and 5% GGBS mixture and highest dry density was about 1.79g/cc. for 80% soil and 20% GGBS mixture.

- It can also be observed that the CBR Value of the soil was increased gradually up to 20% GGBS content and gets decreased with further increase in GGBS content.

- On comparing the results from UCS test of the soil sample, it is found that the values of unconfined compressive strength shows a net increment of 41.7% from 0.0562 MPa to 0.0965 MPa (illustrated in figure- 5.14).

- Overall it can be concluded that reinforced soil can be considered to be good ground improvement technique especially in engineering projects on expansive soils.

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