Scientific Journal of Impact Factor (SJIF): 5.71

e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 5, Issue 04, April -2018

PERFORMANCE EVALUATION OF RED SOIL STABILIZED WITH GROUND GRANULATED BLAST-FURNACE SLAG AND SUGARCANE BAGASSE ASH

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ABSTRACT: *The soil is the foundation material which supports loads of the overlying structure. Red soil covers a large part of the land in India. These soils are found in areas with low rainfall, but they are not capable of retaining moisture. In this study, Ground Granulated Blast-furnace Slag (G.G.B.S.) and Sugarcane Bagasse Ash (S.C.B.A.) are used to stabilize the red soil. To make this goal experimental study test was carried in three-phase such as in the first phase, the physical properties of soil such as grain size distribution, Atterberg limits, Standard Proctor test, California Bearing Ratio, Unconfined Compression Test are determined. In the second phase, various test investigations were performed on red soil using 1%, 3%, 5% and 7% of Ground Granulated Blast-furnace Slag and optimum dosage of Granulated Blast-furnace Slag were determined and in the last phase, the soil was treated with an optimum dosage of Ground Granulated Blast-furnace Slag and 1%, 3%, and 5% Sugarcane Bagasse Ash and Standard Proctor test, California Bearing Ratio, Unconfined Compression test are determined.*

KEYWORDS: *ground granulated blast-furnace slag, sugar-cane Bagasse ash, standard Proctor test, California Bearing Ratio (CBR), Unconfined Compression test (UCT).*

I. INTRODUCTION

Soil stabilization is the alteration of soils to improve their physical properties. Stabilization can increase the shear strength of a soil and/or control the shrink-swell properties of a soil, thus improving the load-bearing capacity of a sub-grade to support pavements and foundations. Sub-soils that is not suitable for construction such as roadways, parking areas, site development projects, airports and many other situations can be stabilized. Stabilization can be used to treat soils varying from expansive Clay to granular materials and a wide range of sub-grade materials. Good qualities of subgrade soils are preferable to a durable road that is not always available for highway construction. The highway engineer designing a road pavement may be faced by weak or unsuitable sub grades. In this case, the following methods to overcome this problem can be considered. In-situ materials are subjected to improvement by normal compaction methods and then design for the modified properties. Then, import the suitable materials from the nearest convenient source and replace the site materials. Finally, improve the properties of the existing materials by incorporating some other materials; these processes are known as “soil stabilization". The most appropriate method will usually be determined by economic considerations, for example, it may be cheaper to stabilize a soil using relatively expensive additives than excavating and dispose of unsuitable materials and place suitable to fill.

Ground Granulated Blast-furnace Slag is produced as an industrial waste in millions of tons in steel industries in India and all over the world. Previously this has led to a large amount of disposable waste. Most of the slag produced was dumped in pits nearby the plants causing a serious threat to nearby flora and fauna. By using slag in soil stabilization, we can find an ecologically safe and economically viable method of industrial slag disposal. Some of the wastes like fly ash & blast furnace slag has / had pozzolanic properties and are being used in the construction industry along with cement or lime as activators. In the process of soil stabilization, the utilization of local materials is chosen so that cost of construction may be minimized to the minimum extent.

Sugar-Cane Bagasse Ash (S C B A) which is a waste material from the sugar industry can be used as a stabilizer in modifying the properties of the soil. These materials can be utilized in various civil engineering works. Bagasse ash is a residue obtained by the burning of bagasse in sugar producing factories. It is the cellular fibrous waste product obtained after the extraction of the sugar juice from cane mills. They are used as biofuels and in the manufacturing of pulp, paper products and building materials. For every 10-tons of sugarcane crushed, a sugar factory produces nearly 3-tons of wet bagasse. When this bagasse is burnt, the resultant ash is bagasse ash. Bagasse ash is a pozzolanic material which is very rich in the oxides of silica, aluminium and also calcium. Pozzolans usually require the presence of water to combine with calcium hydroxide to form stable calcium silicate, which has cementitious properties.

1.1. Objective

The main objectives of the study include the following:

1. To study the behaviour of strength gain in red soil using Ground Granulated Blast-furnace Slag stabilization.
2. To determine physical and mechanical properties of red soil stabilized with Ground Granulated Blast-furnace Slag and Sugar-Cane Bagasse Ash.
3. Analysis and interpretation of the result.

II. METHODOLOGY

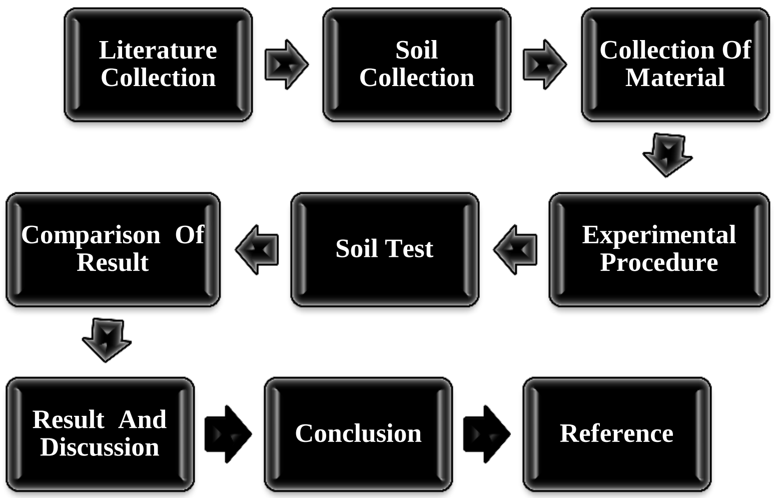

Fig 1.Flow chart showing methodology of present study

The soil sample collected is oven dried, pulverized and stored in airtight containers. The index and engineering properties of soil were determined initially, which include particle size distribution, Atterberg limits, proctor test, unconfined compressive test and CBR test.

After determining the properties, the soil is replaced with different percentages (1%, 3%, 5%, and 7%) of ground granulated blast furnace slag and performed proctor test, CBR test, unconfined compressive test. The soil sample was collected from Anna Nagar, Tamil Nadu and in addition to that; different percentages of sugarcane bagasse ash (1%, 3% and 5%) with an optimum dosage of ground granulated blast furnace slag were added to find the variation in its original strength.

III. MATERIALS USED FOR THE EXPERIMENT

3.1. Red Soil

Red soil is a type of soil that develops in a warm, temperate, moist climate under deciduous or mixed forest, having thin organic and organic-mineral layers overlying a yellowish-brown leached layer resting on an alluvial red layer. Red soils are generally derived from crystalline rock. They are usually poor growing soils, low in nutrients and humus and difficult to cultivate because of its low water holding capacity. Red soils denote the third largest soil group of India covering an area of about 3.5 lakhs sq. km (10.6% of India's area) over the Peninsula from TamilNadu.The texture of red soils varies from sand to clay, the majority being loam. Their other characteristics include porous and friable structure, the absence of lime, kankar and free carbonates, and a small number of soluble salts.

3.2. Ground Granulated Blast Furnace Slag

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. Two major uses of GGBS are in the production of quality-improved slag cement, namely Portland Blast furnace cement (PBFC) and high-slag blast-furnace cement (HSBFC), with GGBS content ranging typically from 30 to 70%; and in the production of ready-mixed or site-batched durable concrete. Concrete made with GGBS cement sets more slowly than concrete made with ordinary Portland cement, depending on the amount of GGBS in the cementitious material, but also continues to gain strength over a longer period in production conditions. This results in the lower heat of hydration and lower temperature rises, and makes avoiding cold joints easier, but may also affect construction schedules where the quick setting is required.

Use of GGBS significantly reduces the risk of damages caused by alkali-silica reaction (ASR), provides higher resistance to chloride ingress — reducing the risk of reinforcement corrosion and provides higher resistance to attacks by sulfate and other chemicals.

3.3. Sugarcane Bagasse Ash

Bagasse is the fibrous matter that remains after sugarcane or sorghum stalks are crushed to extract their juice. It is dry pulpy residue left after the extraction of juice from sugarcane. Bagasse is used as a biofuel and in the manufacture of pulp and building materials. Bagasse can also be very useful to generate electricity. Dry bagasse is burnt to produce steam. The steam is used to rotate turbines to produce power.

IV. RESULTS AND DISCUSSION

4.1. Index and engineering properties of red soil

NAME OF TEST	TEST RESULT
Liquid limit	51%
Plastic limit	22.81%
Plasticity index	35.19%
Modified Proctor test	OMC-17%
	Max dry density-1.7g/cc
CBR Ratio for un-soaked Condition	8.9 %
Unconfined compressive strength	0.082Kg/mm²

4.2. Testing Of Samples To Find The Optimum Dosage Of GGBS

4.2.1. Standard Proctor Test

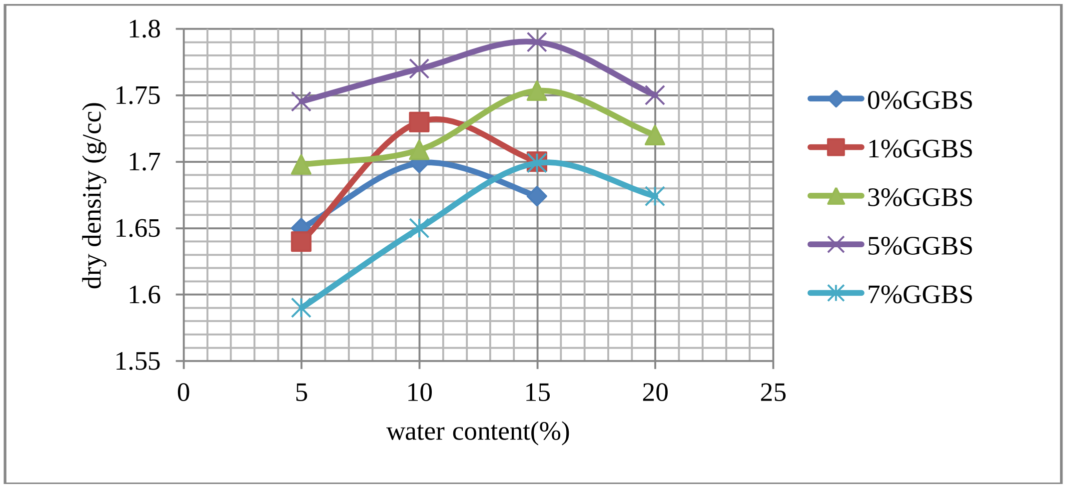

Fig 2 Graphical representation of Proctor Test

Variation of OMC and MDD with a percentage increase in GGBS

% of GGBS	Max. dry density (g/cc)	Optimum moisture Content (%)
0	1.7	17
1	1.73	17.5
3	1.75	18.1
5	1.79	18.7
7	1.69	18.8

From the test results it is clear that the OMC and MDD increases up to 5% and then decreases with increase in percentage GGBS

4.2.2. California Bearing Ratio Test

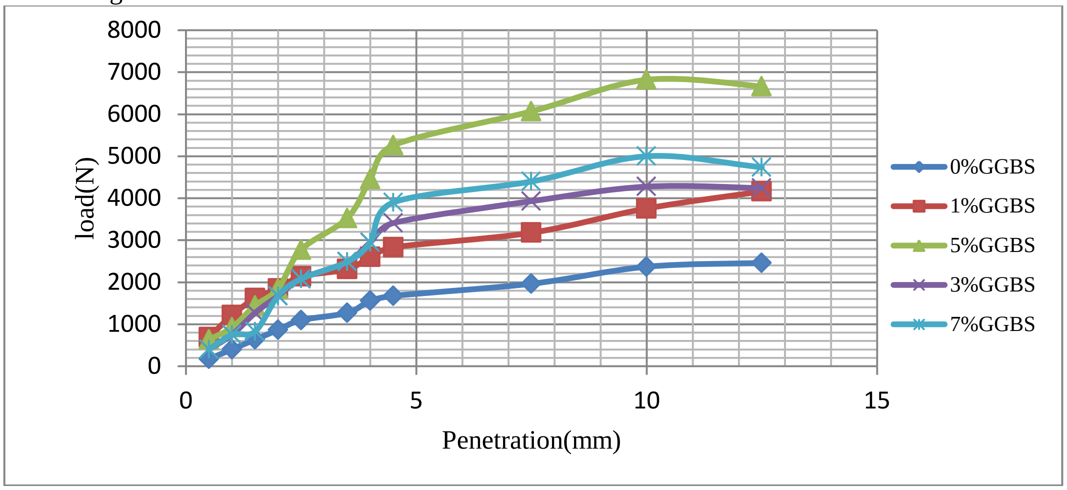

Fig 3 Graphical representation of CBR test

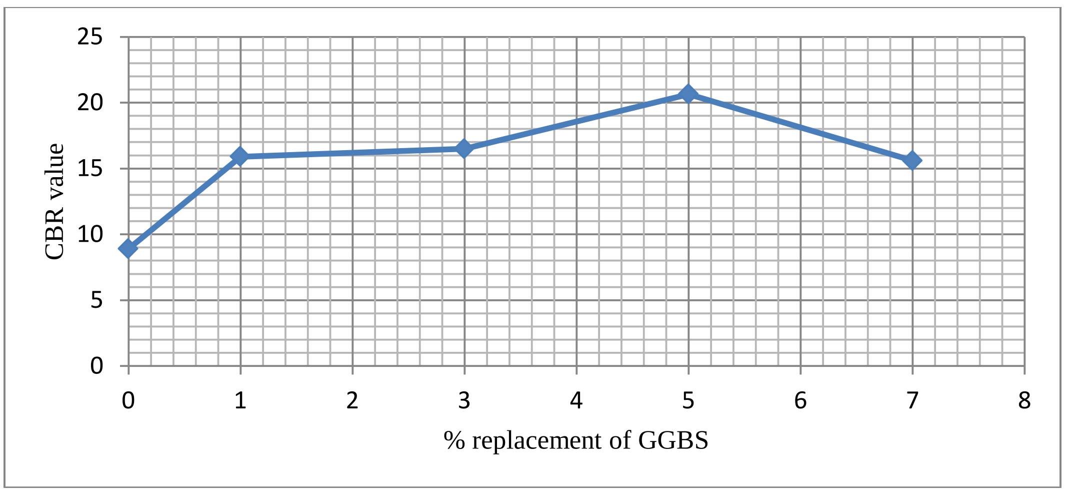

Fig 4 Graphical representation of Variation of CBR value with % increase in GGBS

CBR value increased with increase in percentage replacement of GGBS up to 5% and then the value decreases. The value of CBR has increased 2.3 times than the pure soil.

4.2.3.Testing of soil for Unconfined Compression test

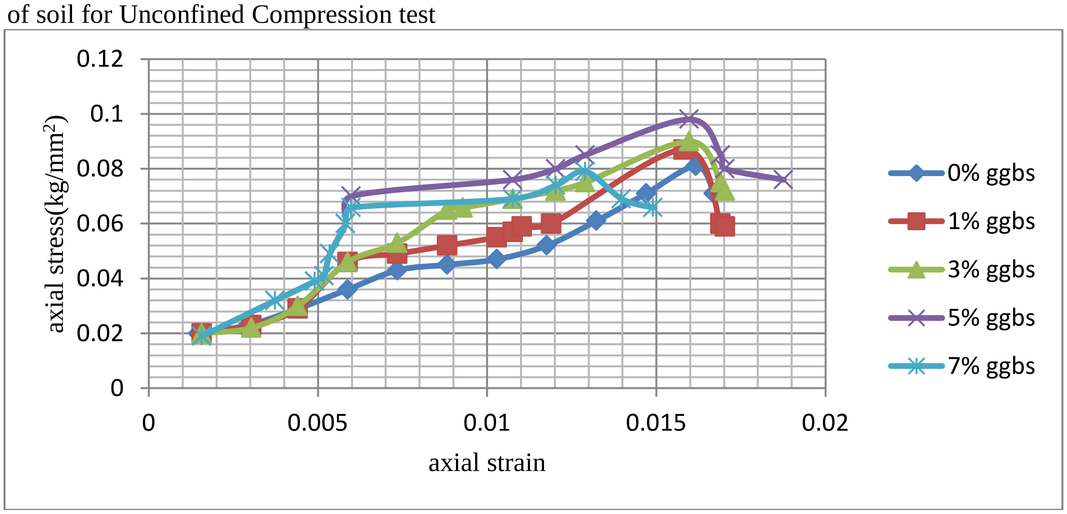

Fig 5 Graphical representation of unconfined compression test

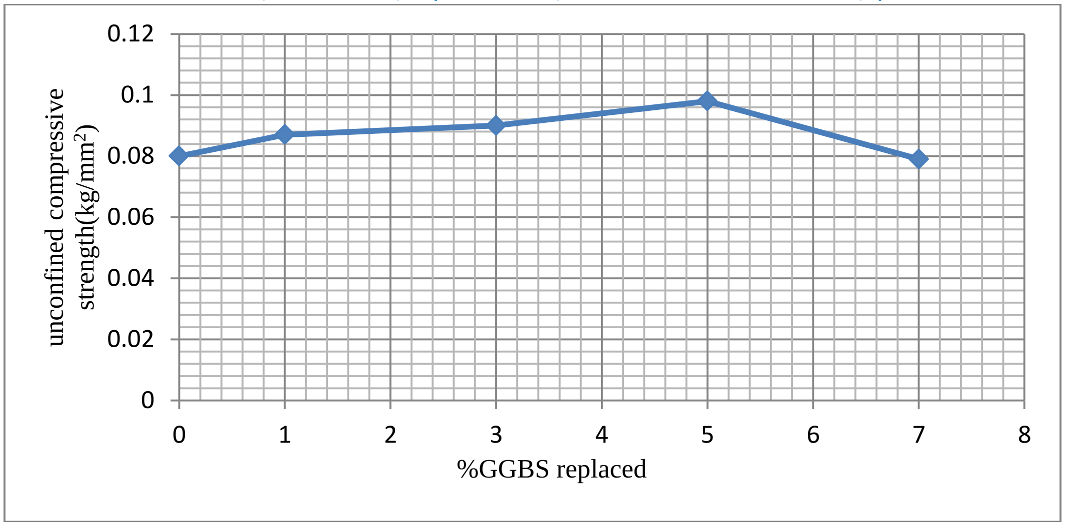

Fig 6 Variation unconfined compressive strength value with % increase in GGBS

The unconfined compressive strength increase with increase in percentage up to 5% replacement of GGBS and then the value gradually decreases. The maximum value is obtained as 0.098 Kg/mm² for 5% GGBS.

4.3. Determination of strength behavior of soil at an optimum dosage of GGBS and varying % of SCBA

4.3.1.Proctor Test

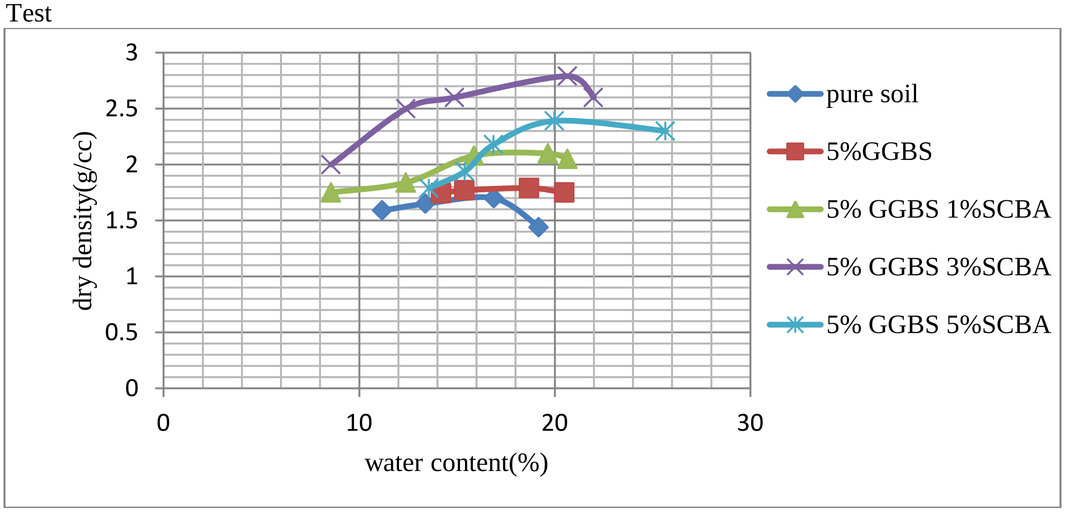

Fig 7. Proctor Test for optimum dosage of GGBS and varying percentages of SCBA

Variation of OMC and MDD with percentage increase in GGBS

5%GGBS:% SCBA	Max. dry density (g/cc)	Optimum moisture Content (%)
0:0	1.7	17
5:1	2.1	19.67
5:3	2.79	20.67
5:5	2.39	20.07

From the test results, the OMC and MDD are maximum at 5%GGBS and 3%SCBA and then the value decreases.

4.3.2. CBR test

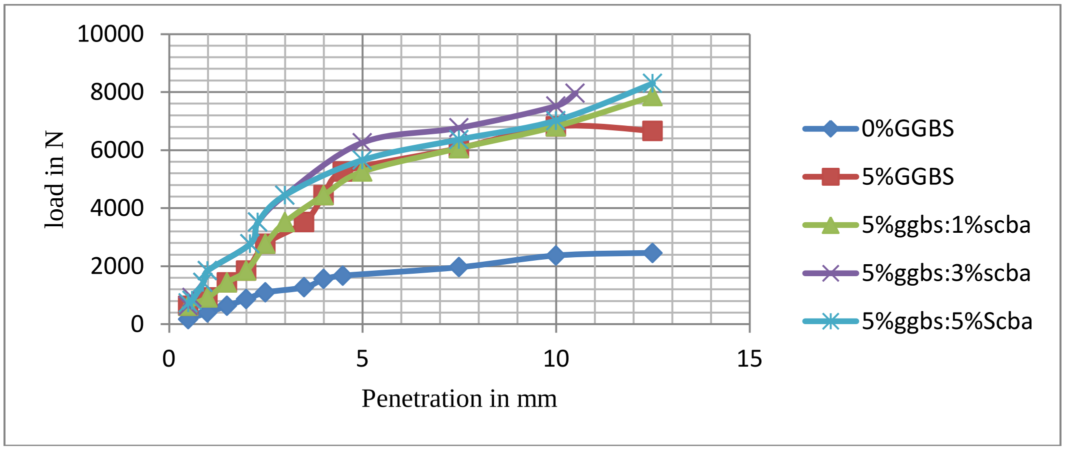

Fig 8. CBR test for optimum dosage of GGBS and varying percentages of SCB

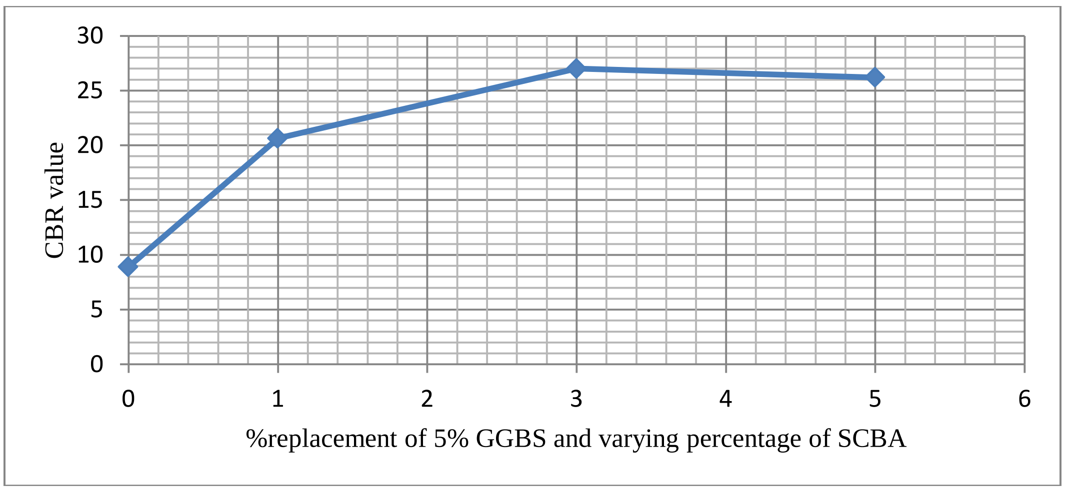

Fig 9. CBR value for an optimum dosage of GGBS and varying percentages of SCBA

CBR value increased with increase in percentage replacement of SCBA up to 3% and then the value decreases.

4.3.3.Un-Confined Compression Test

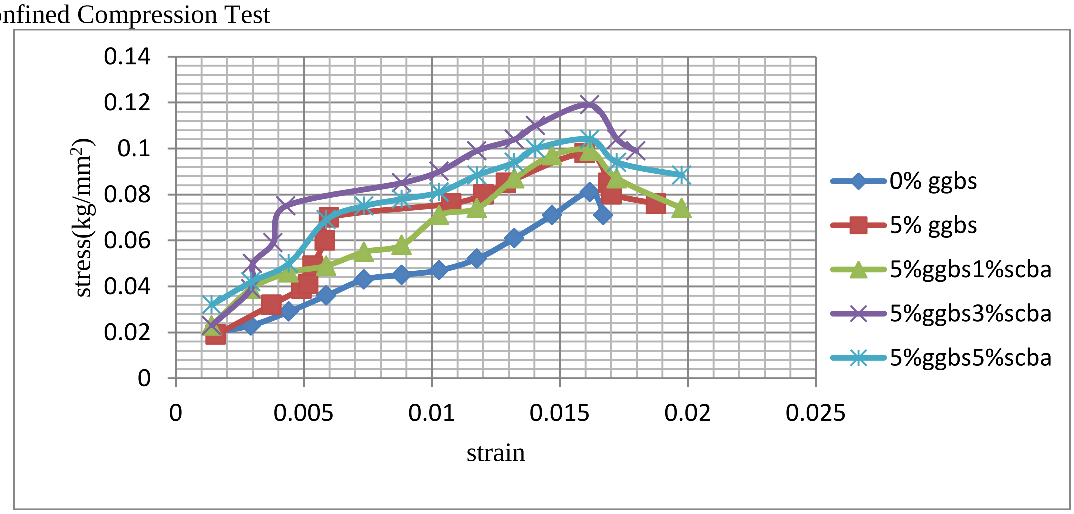

Fig 10. Un-Confined Compression Test for 5% GGBS and varying % of SCBA

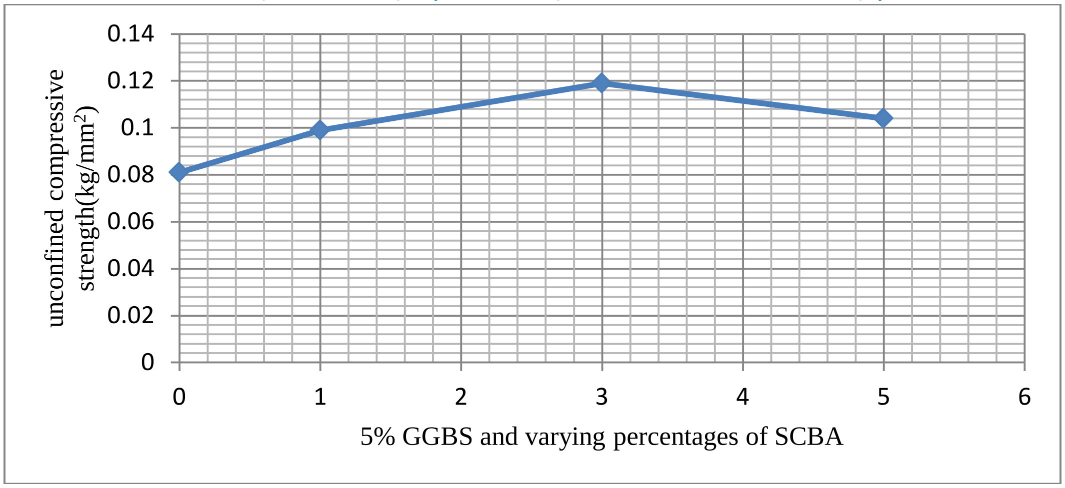

Fig 11. Variation in unconfined compressive strength with 5% GGBS and increase in SCBA

V. CONCLUSION

Based on the result obtained the following conclusions are drawn

- Ground granulated blast furnace slag is an useful biodegradable material that improves strength and stiffness of red soil. It could be utilized for stabilizing the soil for pavement, embankment constructions etc.
- The optimum moisture content of soil-GGBS mix increases with increase in percentage replacement with GGBS. But the maximum dry density of the mix first increases and then decreases with the percentage increase in the GGBS added.
- The optimum moisture content of soil- GGBS- SCBA mix increases with increase in percentage replacement with SCBA.
- The CBR ratio at 5% replacement of GGBS was found to be increased 2.3 times than raw soil.
- At 5% replacement of GGBS, compressive strength increased 1.2 times compared to pure soil specimen.
- From the combined observation of compaction test, CBR test and unconfined compression test it can be noted that replacement of 5% GGBS and 3% SCBA provide a mix having sufficient light weight and strength.
- This mix can be used for the construction of base course for roads due to its increased CBR ratio. So the total cost of the road project can be reduced.

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