Effect of Stabilization Using Flyash and GGBS in Soil Characteristics

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ABSTRACT

Expansive soils are a worldwide problem that poses several challenges for civil engineers. They are considered a potential natural hazard, which can cause extensive damage to structures if not adequately treated. Such soils swell when given an access to water and shrink when they dry out. Utilization of industrial waste materials in the improvement of soils is a cost efficient and environmental friendly method. Stabilisation of the soil is studied by using flyash and ground granulated blast furnace slag. This paper includes the evaluation of soil properties like unconfined compressive strength test and California bearing ratio test. The soil sample was collected from Palur, Tamil Nadu and addition to that, different percentages of flyash (5, 10%, 15% and 20%) and GGBS (15%, 20%, 25%) was added to find the variation in its original strength. Based on these results CBR test was performed with the optimum flyash, optimum GGBS and combination of optimum flyash with varying GGBS percentages (15%, 20%, and 25%). From these results, it was found that optimum GGBS (20%) gives the maximum increment in the CBR value compared with all the other combinations.

***Keywords*: California bearing ratio test, Clay Soil, fly ash, ground granulated blast furnace slag, soils, unconfined compressive strength test**

I. INTRODUCTION

In developing countries like India, the biggest handicap is to provide a complete network of road system in the limited furnaces available to build road by conventional method. Therefore there is a need to go for suitable method of low cost road construction followed by a process of stage development of the roads, to meet the growing needs of road traffic. The construction can be considerably decreased by selecting local materials including local soils for the construction of the lower layers of the pavement such as the sub-base course and subgrade soil. If the stability of the local soil is not adequate for supporting the wheel loads, the properties are improved by soil stabilization techniques (Pankaj.R.Modak et al. 2012). The soil stabilization means the improvement of stability or bearing power of the soil by the use of controlled compaction, proportioning and/or the addition of suitable admixture or stabilizer. It can be used to treat a wide range of sub-grade materials from expansive clay to granular materials (Krishna Gudi et al. 2013).

The greatest challenge before the processing and manufacturing industries is disposal of the residual waste products. Waste products which are generally toxic, ignitable, corrosive or reactive pose serious health and environmental consequences. Thus disposal of industrial waste is a measure issue of the present generation. This measure issue requires an affective, economic and environment friend method to combat the disposal of the residual industrial waste products. One of the common and feasible ways to utilize these waste products is to go for construction of roads, highways and embankments. If these materials can be suitably utilized in construction of roads, highways and embankments then the pollution problem caused by the industrial wastes can be greatly reduced. Huge amount of soil is used in the construction of roads and highways but sufficient amount of soil of required quality is not available easily. These industrial wastes which are used as a substitute for natural soil in the construction not only solve the problems of disposal and environmental pollution but also help to preserve the natural soil. Bidula Bose (2012) studied the geo-engineering properties of the virgin soil and flyash treated soil and it was found that there was 55% increment in the CBR value when compared with the virgin soil. Erdal Cokca (2008) studied the effect of ground granulated blast furnace slag (GGBS) and GBS-cement with a view to decrease the construction cost and It was found that there was 62% decrement in the swelling potential with GGBS treated soil from the virgin soil. Anil K.S & P.V.Sivapullaiah (2011) studied the effectiveness of flyash with ground granulated blast furnace slag in the soil and it was found that the UCS of flyash- GGBS mixture increases with the increase in the GGBS content. And also it was observed that the strength increases with the curing period.

II. MATERIALS USED

The soil sample for this study was collected from Athipattu, Thiruvallur distric, Tamil Nadu in India. It was collected from a depth of 40m below the natural ground level by open excavation. The soil was dried and pulverized to perform the various experimental studies.

Flyash is fine, glass powder recovered from the gases of burning coal during the production of electricity. These micron-sized earth elements consist primarily of silica, alumina and iron. When mixed with water, the flyash forms a cementitious compound with properties very similar to that of Portland cement. The flyash used in the experimental studies was collected from Ennore thermal power plant which is in the Chennai district of Tamil Nadu, India.

Blast furnace slag is produced as a by-product during the manufacture of iron in a blast furnace. Molten blast furnace slag has a temperature of 1300-1600°C and is chilled very rapidly to prevent crystallization. The granulated material thus produced is known as granulated blast furnace slag. Blast furnace slag has a glassy, disordered, crystalline structure which can be seen by microscopic examination which is responsible for producing a cementing effect. The GGBS used in this study was collected from Visakhapatnam in Andhra Pradesh, India.

III. METHODS OF TESTING

The laboratory tests carried out on the natural soil include Sieve analysis, Atterberg limits, Specific gravity, Free swell test, Standard Proctor test, Unconfined Compressive strength test and California Bearing Ratio test.

Unconfined compressive strength test (UCS)

The shearing strength is commonly investigated by means of compression tests in which an axial load is applied to the specimen and increased until failure occurs. The unconfined compressive strength is the load per unit area at which and unconfined cylindrical specimen of soil will fail in a simple compression test. If the unit axial compression force per unit area has not reached a maximum value up to 20 percent axial strain, unconfined compressive strength shall be considered the value obtained at 20 percent axial strength. This test was conducted as per IS 2720 (Part10): 1973.

California Bearing Ratio test (CBR)

The California bearing ratio is a penetration test for evaluation of the mechanical strength of road sub-grades and base-courses. The test is performed by measuring the pressure required to penetrate a soil sample with a plunger of standard area. The measured pressure is then divided by the pressure required to achieve an equal penetration on a standard crushed rock material. It is the ratio of force per unit area required to penetrate a soil mass with standard circular piston at the rate of 1.25 mm/min. to that required for the corresponding penetration of a standard material. This test was performed as per IS 2720(Part 16): 1979.

IV. RESULTS AND DISCUSSIONS

The physical properties of the soil used in this study before the addition of stabilizers are shown in Table 1.From this, it can be said that the soil is clay of intermediate compressibility.

Table 1: Physical properties of the soil

Test	Parameters		Symbol	Description
Sieve Analysis	Sand		S	14.66%
	Silt & Clay		M & C	85.34%
Atterberg Limits	Liquid Limit		W_L	74%
	Plastic Limit		W_P	22.7%
	Shrinkage Limit		W_S	5.06%
	Plasticity Index	$I_P = W_L - W_P$	I_P	51.3%
		A-line Equation*		39.42%
Classification of soil				CH
Specific Gravity			G	2.15
Free swell test				53.85%
Standard proctor test			γd max	1.44
			OMC	26.13%
UCC	UCS value		q_u	0.65
CBR	CBR value			1.63%

For performing the UCC test the soils were prepared by adding the optimum moisture content obtained by conducting the Standard Proctor test. The admixtures were added at varying percentages of Flyash (5%, 10%, 15% & 20%) and GGBS (15%, 20% & 25%) for 7, 14 & 21days of curing. The variation in the strength can be observed in Figure 1 and 2 with varying percentages of flyash alone and GGBS alone respectively for 7days curing. The UCS value for different percentages of flyash and GGBS are given in Table 2.

Table 2: UCS value for different percentages of flyash and GGBS

SAMPLE	ADDITIVE (%)		7 Days curing (kg/cm^2)	14 Days curing (kg/cm^2)	21 Days curing (kg/cm^2)
Soil sample	Flyash	5	0.87	0.95	1.04
		10	0.98	1.02	1.14
		15	0.89	0.91	1.08
		20	0.88	0.89	1.04
	GGBS	15	1.55	1.76	1.96
		20	1.81	2.34	2.48
		25	1.73	2.26	2.34

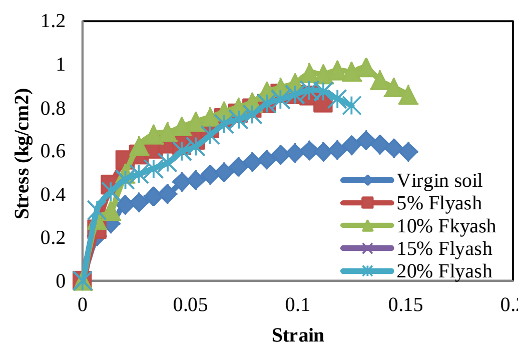

Figure 1: UCS value for different percentages of flyash by curing for 7days

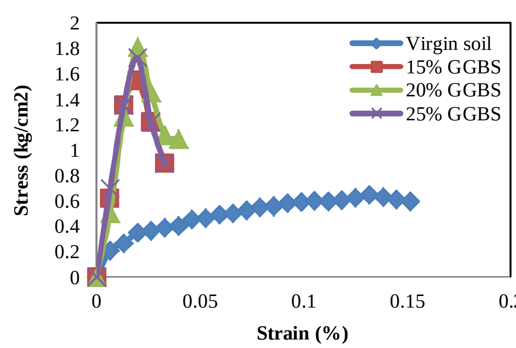

Figure 2: UCS value for different percentages of GGBS by curing for 7days

Similarly the variation in the strength was determined for 14days as well as for 21days and is shown in Figure 3, 4, 5 & 6.

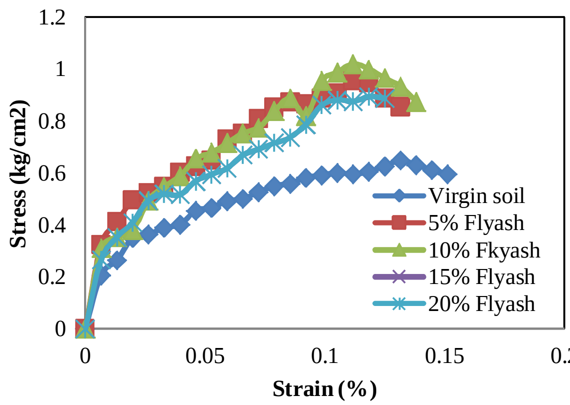

Figure 3: UCS value for different percentages of flyash by curing for 14days

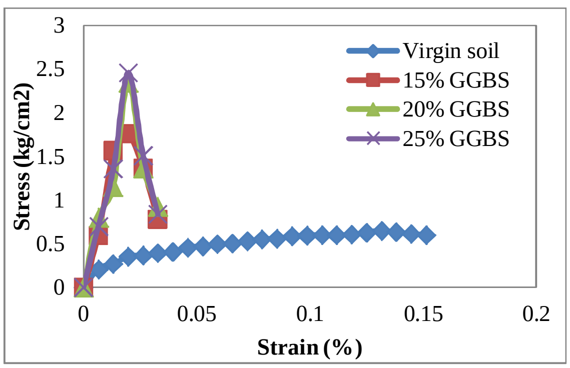

Figure 4: UCS value for different percentages of GGBS by curing for 14days

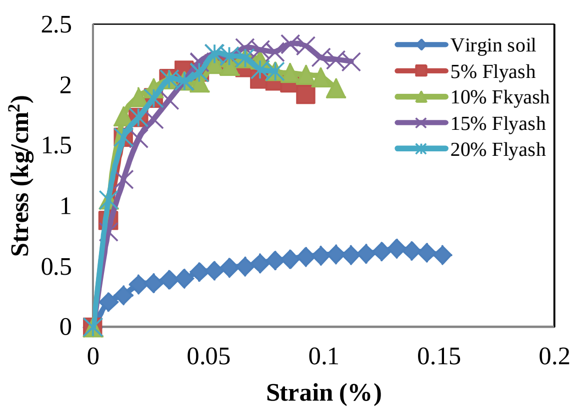

Figure 5: UCS value for different percentages of flyash by curing for 21days

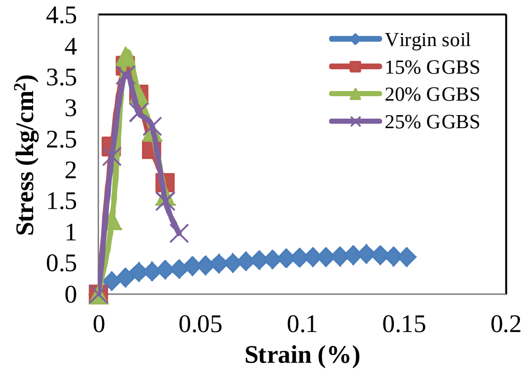

Figure 6: UCS value for different percentages of GGBS by curing for 21days

From the UCC test the optimum Flyash and optimum GGBS percentages were determined as 15% and 20%, respectively.

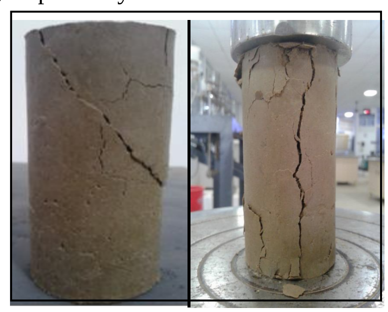

Figure 7: Failure pattern in Flyash alone & GGBS alone treated soil sample

Based on the above results, samples were prepared for CBR test i.e., with optimum Flyash (15%), optimum GGBS (20%) and combination of optimum Flyash with varying GGBS percentages (15%, 20% & 25%) and were tested after curing for 4, 7 & 10days. For the CBR test a graph will be plotted for penetration Vs loads. The 4 days curing results are shown in Figure 8. The CBR values of these are shown in Table 3 and 4.

Table 3: CBR value for optimum percentages of flyash and GGBS

SAMPLE	Additive (%)	Curing period (days)		
		4	7	10
SAMPLE S-I	Flyash Optimum 15%	1.86	2.15	3.22
	GGBS Optimum 20%	10.86	11.12	12.18

Table 4: CBR for optimum flyash with varying GGBS percentages

SAMPLE	Flyash	GGBS %	Curing Period (days)		
			4	7	10
S-I	Optimum 15%	15	9.53	10.86	11.12
		20	10.06	11.65	12.71
		25	12.71	13.77	14.83

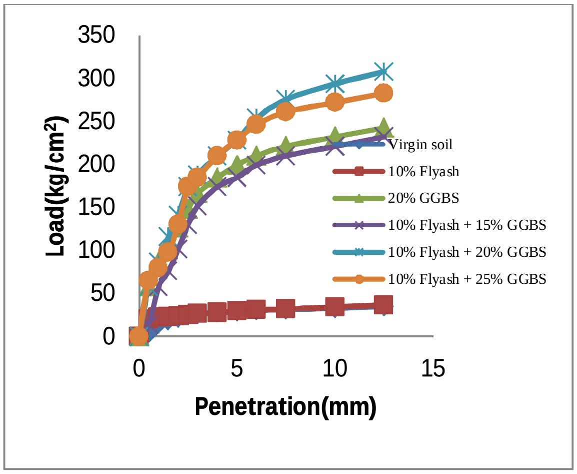

Figure 8: CBR value for different percentages after curing for 4days

Similarly, Figure 9 and 10 shows the variation in the CBR value after curing for 7 and 10days.

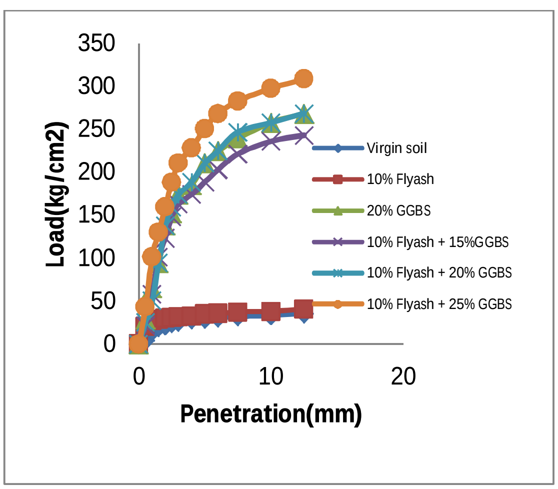

Figure 9: CBR value for different percentages after curing for 7days

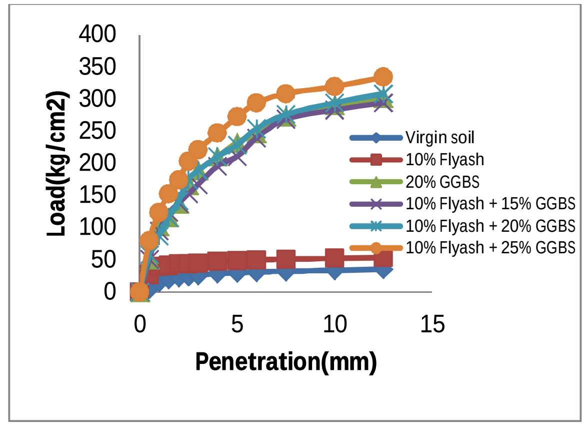

Figure 9: CBR value for different percentages after curing for 10days

V. CONCLUSION

From the results of this study, the following conclusions can be made:

- By conducting the UCC test for virgin and treated soil (5%, 10%, 15% and 20% of flyash), it was found that the soil treated with 10% of flyash gives the optimum strength when compared with the virgin soil at an increment of 42.98% for 21days of curing.
- Soil was treated with various percentages of GGBS (15%, 20% and 25%) and UCC test was performed. From the UCS value it was found that soil treated with 20% of GGBS gives the optimum strength when compared with the virgin soil with an increment of 73.79% for 21days of curing.
- Based on the UCC test results, the CBR test was performed with the optimum flyash (10%), optimum GGBS (20%) and also for combinations of optimum flyash with varying GGBS percentages (15%, 20% and 25%).
- By conducting the CBR tests, it was found that among the combinations of optimum flyash with varying GGBS percentages (15%, 20% and 25%), 10% flyash with 25% of GGBS gives an increment of 78.29% in the CBR value with curing period of 10days when compared with the CBR value of the virgin soil.

- When the period of curing increases, the strength of soil with the above mentioned combination will improve.

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