Experimental Studies on Soil Stabilized with GGBS for Varying Percentages of Waste Plastic Fiber

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Abstract - *Stabilization is a broad sense for the various methods employed and modifying the properties of soil to improve its engineering performance and used for variety of engineering works. In this paper, the soil is stabilized with GGBS and WPF. GGBS is obtained from the blast furnace of cement plant, which is a by-product of iron (Jindal steel work, Bengaluru). GGBS is generally a three shaped one is air cooled, foamed shaped and granulated shaped. The use of by-product materials for stabilization has environmental and economic benefits. An experimental study is carried out to investigate the strength properties of soil stabilized with GGBS for varying percentages of WPF have been discussed. The main objective of this study is to carry out the laboratory tests on soil stabilized with GGBS and WPF to find out Atterberg limits, shear strength and compression strength. Tests like liquid limit, plastic limit, specific gravity test, UCS, CBR, DST have been conducted. Aspect ratio of WPF in 2mm by 10 mm is randomly placed over the soil sample. From the study it was observed that there is a significant improvement in strength by adding GGBS in varying percentages like 5%, 10%, 15%, 20%, 25% and 30% and GGBS - WPF in varying percentages like 5% - 1%, 10% - 1.5%, 15% - 2%, 20% - 2.5%, 25% - 3% and 30% - 3.5%. From the standard compaction test, for Addition of GGBS for varying proportions tend to decrease in OMC from 28.12% to 17.94% with increase in MDD from 1.59% to 1.70% and similarly for GGBS -WPF with varying proportions tend to decrease in OMC from 26.42% to 11.11% with increase in MDD from 1.56% to 1.82%. And from CBR test, for Addition of GGBS with varying proportions it was found that there is increase in CBR value from 1.28% to 3.96% and similarly for GGBS - WPF in varying proportions it was found that there is increase in CBR value from 2.87% to 5.87%. similarly, from UCS test, for Addition of GGBS in varying proportions it was found that there is an increment in shear strength of the soil from 0.0595N/mm^2 to 0.1214N/mm^2. And similarly, for Addition of GGBS-WPF in varying proportions it was found that there is an increment in shear strength of the soil from 0.053N/mm^2 to 0.111N/mm^2. Based on the results of DST, for Addition of GGBS in varying proportions, it was found that there is increment in shear strength of the soil from 0.0081 N/mm^2 to 0.0186 N/mm^2 for 0.5kg of applied load, 0.0083 N/mm^2 to 0.0190 N/mm^2 for 1kg of applied load and 0.0085 N/mm^2 to 0.0193 N/mm^2 for 1.5kg of applied load. And similarly for Addition of GGBS-WPF in varying proportions, it was found that there is increment in shear strength of the soil from 0.009 N/mm^2 to 0.0223 N/mm^2 for 0.5kg of applied load, 0.0092 N/mm^2 to 0.0227 N/mm^2 for 1kg of applied load and 0.0094 N/mm^2 to 0.0231 N/mm^2 for 1.5kg of applied load. From overall test results we found that there is increase in shear stress, compressive strength for different proportions of the WPF.*

***Key Words*: OMC (Optimum Moisture Content), MDD (Maximum Dry Density) CBR (California bearing ratio), DST (Direct shear test), UCS (unconfined compression test), WPF (Waste plastic fibers), GGBS (Ground Granulated Blast Furnace Slag).**

1. INTRODUCTION

Innovative methods of soil stabilization are in great demand all over the world. Soil stabilization is any process which improves the physical properties of soil such as increasing shear strength, bearing capacity etc. which can be done by use of controlled compaction or addition of admixtures like cement, lime and waste materials like flyash, GGBS, rice husk etc. the cost of introducing these additives has also increased in recent years which opened the door widely for the development of other kinds of soil additives such as plastics, bamboo etc. this new technique of soil stabilization can be effectively used to meet the challenges of society to reduce the quantities of waste materials. GGBS have pozzolanic properties and are being used in the construction industry along with cement or lime as activators. Around 110 million tonnes of flyash gets accumulated every year at the thermal power stations in India. Internationally flyash is considered as a by-product which can be used for many applications. Fly ash mission was initiated in 1994 to promote gainful and environment friendly utilization of the material. One of the areas identified for its bulk utilization was in construction of roads and embankments. The cost of any road pavement project includes initial costs and subsequent maintenance costs. The initial costs include many items such as land, accommodation works, bridges and subways, drainage, pavement construction. The type and thickness of the pavement construction determine a large percentage of the initial cost of any road project. Therefore, the development and use of methods to decrease the cost of pavement construction is very beneficial.

2. Materials used for study

2.1 Waste Plastic fiber

Figure 1; Plastic fibers are similar to the roots of trees and vegetation which provide an excellent ingredient to improve the soils and the stability of the natural slopes. Disposal of plastic waste is a serious issue in India. New technologies have been developed to minimize their adverse effect on the environment. Figure 1; showing the plastic fiber with an aspect ratio of 2:10 is randomly placed over the soil mass and GGBS then mixed thoroughly with varying percentages of GGBS so that a fairly homogeneous mixture is obtained and then the required water was added then it is stabilized to improve the strength parameters. The WPF adopted in the present study by varying percentages like 1%, 1.5%, 2%, 2.5%, 3% and 3.5% respectively.

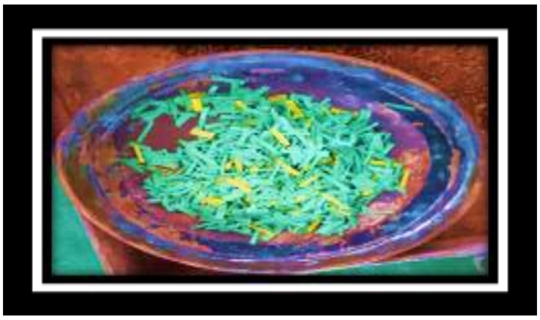

Fig-1: Waste plastic fiber

2.2 Soil sample

The Soil sample shown in Figure 2 is obtained from M S Ramaiah campus. Bigger size lumps were removed and the soil retained on 4.75mm sieve is collected. Then it was oven dried for 24 hours at 105°c to 110°c.

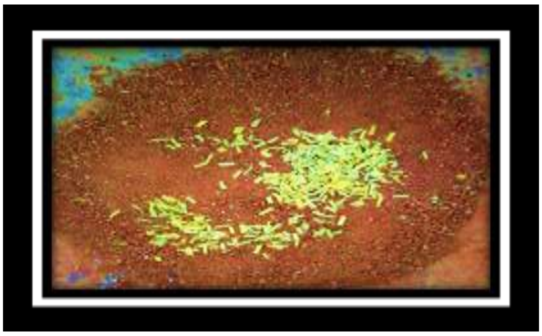

Fig-2: Soil Sample with WPF

2.3 GGBS

Ground Granulated Blast Furnace Slag is a by-product from the blast-furnace used to make iron. These operate at a temperature of about 1,500 degree centigrade and are fed with a carefully controlled mixtures of iron-ore, coke and limestone. The iron ore is reduced to iron and the remaining materials from a slag that floats on top of the iron. This slag is periodically tapped off as a molten liquid and if it is to be used for the manufacture of GGBS it has to be rapidly quenched with large volume of water or steam, dried and ground into fine powder. The GGBS shown in Figure 2. is procured from the Jindal Steel Work Cement Limited (JSW) Bengaluru. GGBS adopted in the present study for varying percentages like 5%, 10%, 15%, 20%, 25% and 30% respectively.

Fig 3: Ground Granulated Blast Furnace Slag

3.0 Methodology

All the laboratory tests conducted for stabilized soil as per IS standards. Laboratory tests such as Atterberg's limit, standard compaction, CBR, Unconfined compressive strength test and Direct shear test were carried out on soil sample. The present study focuses on evaluating the physical properties, compaction characteristics and strength behaviour. Experimental investigations have been carried out on 5% to 30% varying percentages of Soil-GGBS and 5%- 1% to 30%- 3.5% varying percentages of Soil-GGBS-WPF. The specific gravity of the soil sample was determined according to the Indian Standards, IS: 2720 (Part-3) (1980). The grain size analysis of the soil was determined in accordance with IS: 2720 (Part-4) (1985). For determination of Atterberg's limits IS: 2720 (Part-5) (1985). To determine the compaction characteristics of the soil IS: 2720 (Part-7) (1980) has been used. Unconfined compressive strength (UCS) testing has been carried out on the soil in accordance with the IS: 4332 (Part-5) (1970). California bearing ratio test was conducted according to IS: 2720 (Part-16). Direct Shear test was conducted according to IS: 2720 (part 13) (1986).

4.0 Results and Discussion

Various laboratory tests have been conducted on Soil sample as per IS codes:

The objective of present study is to investigate the liquid limit, Plastic limit, plasticity index, compaction characteristics, UCS, CBR and Shear strength characteristics of soil by the addition of Soil-GGBS for varying percentages like 5%, 10%, 15%, 20%, 25% and 30% and addition of Soil-GGBS-WPF for varying percentages like 5% - 1%, 10% - 1.5%, 15% - 2%, 20% - 2.5%, 25% - 3% and 30% - 3.5% respectively. Addition of Soil-GGBS tends to decrease in OMC with increase in MDD from 5% to 30% as shown in the Table-II. CBR value is increased from 5% to 30% by addition of GGBS as shown in the Table-II. Compressive strength of soil increased with addition of GGBS from 5% to 30% as shown in the Table-II. Similarly Shear Strength of the soil is increased from 5% to 30% as shown in the Table-III. Addition of Soil-GGBS-WPF tends to decrease in OMC within increase MDD from 5%-1% to 30%-3.5% as shown in the Table-IV. CBR value is increased from 5%-1% to 25%-3% and there is slight decrease in CBR value at 30% - 3.5% by addition of GGBS-WPF as shown in the Table-IV. Compressive strength of soil increased with addition of GGBS-WPF from 5%-1% to 30%-3.5% as shown in the Table-IV. Similarly Shear Strength of the soil is increased from 5%-1% to 30%-3.5% as shown in the Table-V. The graphical representation of results is shown from Chart 1 to Chart 13. And from Table I to Table V shows the results of experiment conducted on different percentages of stabilizer.

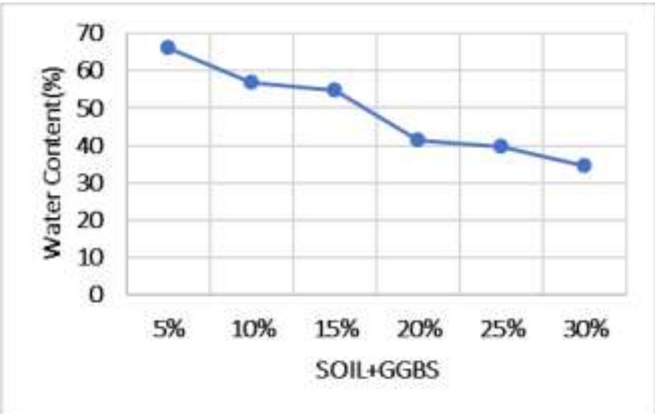

Chart 1: Graphical Representation of Liquid Limit for varying percentages of Soil+GGBS

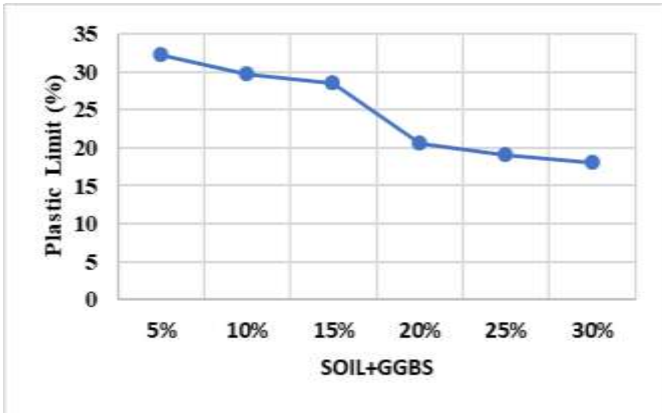

Chart 2: Graphical Representation of Plastic Limit for Varying percentages of Soil+GGBS

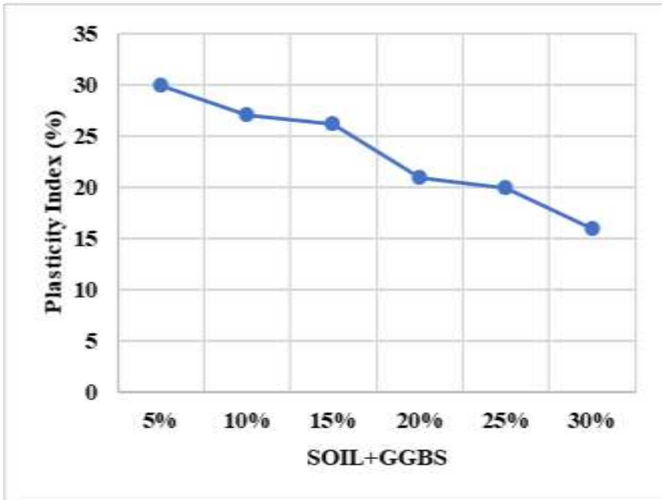

Chart 3: Graphical Representation of Plasticity Index for Varying percentages of Soil+GGBS

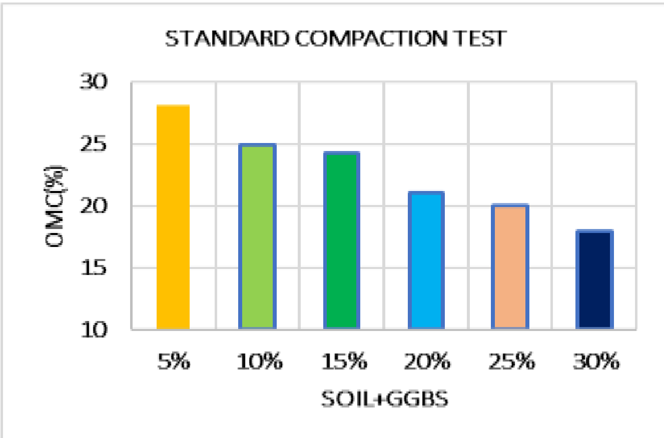

Chart 4: Graphical Representation of OMC for Varying percentages of Soil+GGBS

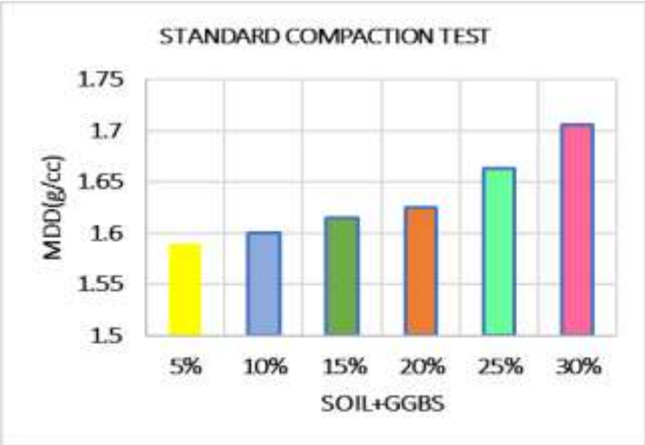

Chart 5: Graphical Representation of MDD for Varying percentages of Soil+GGBS

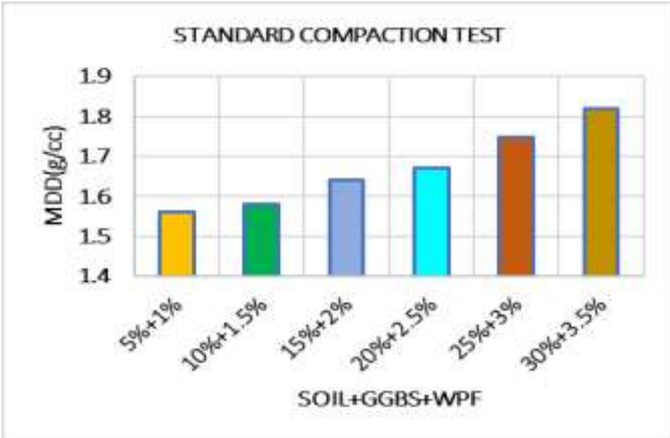

Chart 8: Graphical Representation of MDD for Varying percentages of Soil+GGBS+WPF

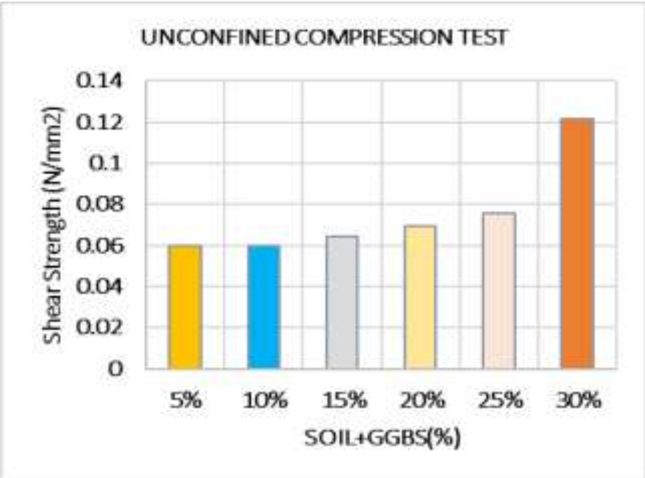

Chart 6: Graphical Representation of UCS for Varying percentages of Soil+GGBS

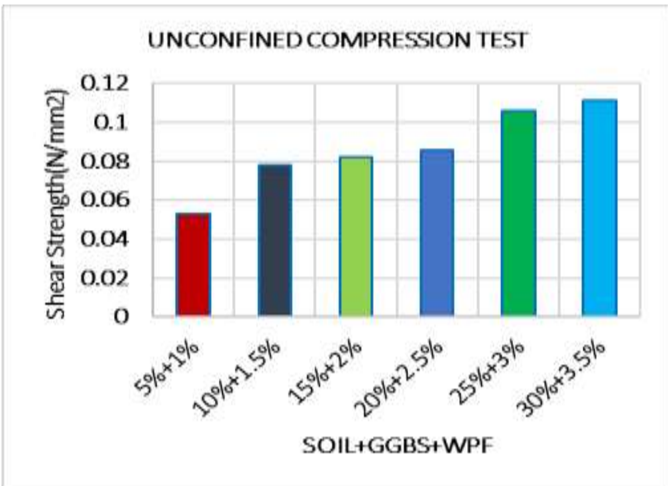

Chart 9: Graphical Representation of UCS for Varying percentages of Soil+GGBS+WPF

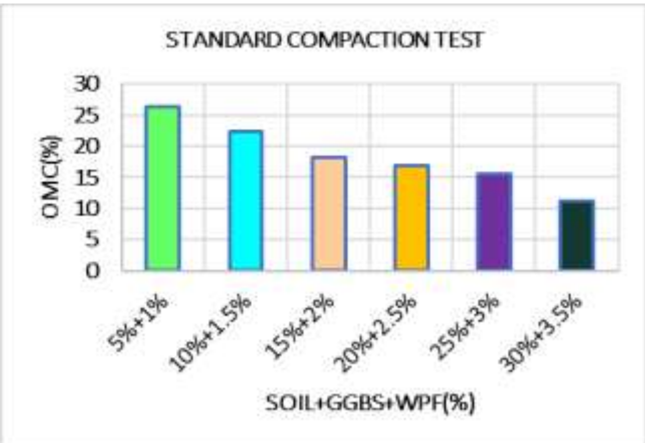

Chart 7: Graphical Representation of OMC for Varying percentages of Soil+GGBS+WPF

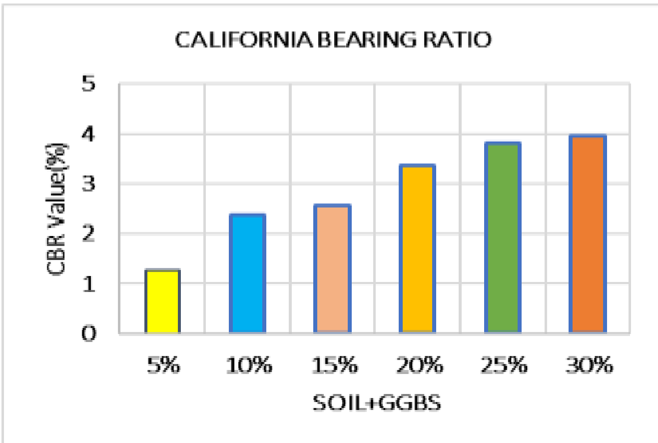

Chart 10: Graphical Representation of CBR for Varying percentages of Soil+GGBS

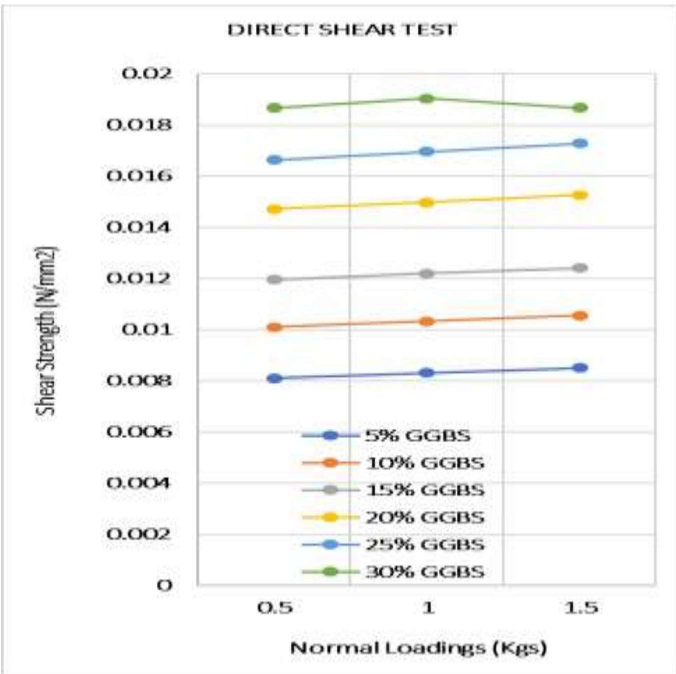

Chart 11: Graphical Representation of DST for Varying percentages of Soil+GGBS

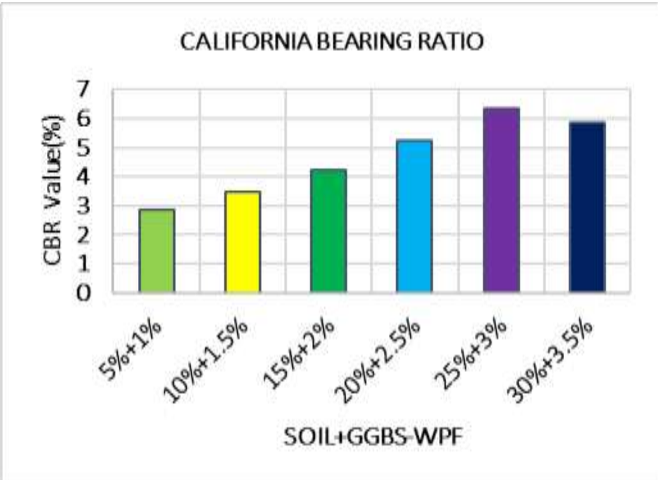

Chart 12: Graphical Representation of CBR for Varying percentages of Soil+GGBS+WPF

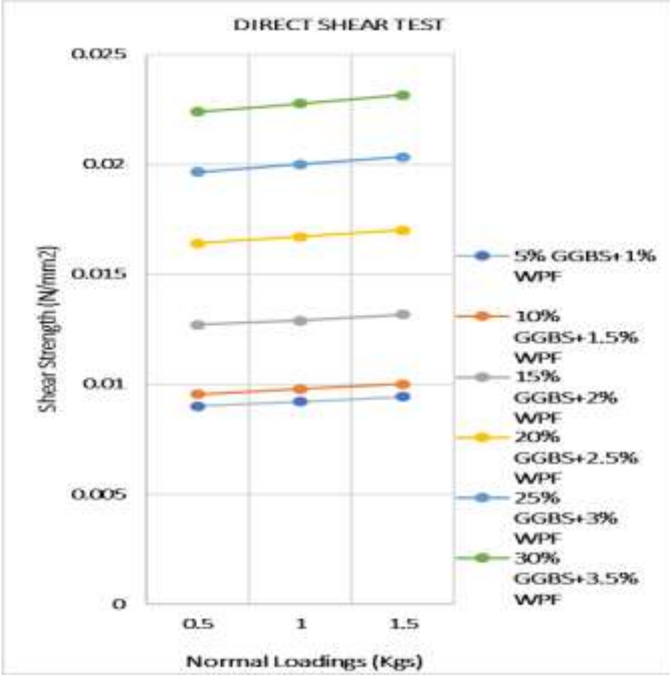

Chart 13: Graphical Representation of DST for Varying percentages of Soil+GGBS+WPF

Table I: Results of Atterberg Limits for varying percentages of SOIL+GGBS

GGBS	W_L	W_P	I_P
5%	66.2	32.28	29.92
10%	56.8	29.67	27.12
15%	54.7	28.55	26.14
20%	41.54	20.61	20.92
25%	39.80	19.06	19.93
30%	34.60	18.07	15.92

Where;

W_L- Liquid Limit

W_P - Plastic Limit

I_P - Plasticity Index

Table II: Results for varying percentages of SOIL+GGBS

GGBS	OMC (%)	MDD (g/cc)	UCS (N/mm^2)	CBR (%)
5%	28.12	1.590	0.0595	1.28
10%	25	1.600	0.06	2.37
15%	24.32	1.615	0.0645	2.57
20%	21.05	1.625	0.0695	3.36
25%	20	1.663	0.0755	3.82
30%	17.94	1.706	0.1214	3.96

Table III: Results of DST for varying percentages of SOIL+GGBS

GGBS	DST (N/mm^2)		
	0.5 Kg	**1 Kg**	**1.5 Kg**
5%	0.0081	0.0083	0.0085
10%	0.0101	0.0103	0.0105
15%	0.0119	0.0121	0.0124
20%	0.0147	0.0149	0.0152
25%	0.0166	0.0169	0.0172
30%	0.0186	0.0190	0.0193

Table IV: Results of for varying percentages of SOIL+GGBS+WPF

GGBS+WPF	OMC (%)	MDD (%)	UCS (N/mm^2)	CBR (%)
5%+1%	26.42	1.560	0.053	2.87
10%+1.5%	22.41	1.580	0.078	3.46
15%+2%	18.18	1.640	0.082	4.22
20%+2.5%	16.92	1.670	0.086	5.24
25%+3%	15.56	1.740	0.106	6.33
30%+3.5%	11.11	1.820	0.111	5.87

Table V: Results of DST for varying percentages of SOIL+GGBS+WPF

GGBS+WPF	DST (N/mm^2)		
	0.5 Kg	**1 Kg**	**1.5 Kg**
5%+1%	0.009	0.0092	0.0094
10%+1.5%	0.0095	0.0097	0.01
15%+2%	0.0127	0.0129	0.0131
20%+2.5%	0.0164	0.0167	0.017
25%+3%	0.0196	0.0199	0.0203
30%+3.5%	0.0223	0.0227	0.0231

5.0 CONCLUSION

The present experimental studies were carried out to find out the stabilization of soil by using GGBS and GGBS-WPF. The conclusion is based on best results obtained for Addition of Soil - GGBS from 5% to 30% and Addition of Soil - GGBS - WPF from 5%-1% to 30%-3.5% respectively. The following conclusions have been drawn based on the laboratory investigations carried:

- **From Standard Compaction Test**, we can observe that there is decrease in OMC with Increase in MDD from 5% to 30% addition of Soil+GGBS

- **From Standard Compaction Test**, we can observe that there is decrease in OMC with Increase in MDD from 5%+1% to 30%+3.5% addition of Soil+GGBS+WPF

- **Based on the results from UCS Test**

  We can observe that there is increase in shear strength of soil with increasing percentages of Soil+GGBS from 0.0595N/mm^2 to 0.1214 N/mm^2 and Soil+GGBS+WPF from 0.053 N/mm^2 to 0.111 N/mm^2

- **Based on the results from CBR Test**

  We can observe that there is increase in strength of Soil+GGBS+WPF when compared to Soil+GGBS and we found that maximum strength is achieved at 25% GGBS+Soil and 30% + 3.5% GGBS+WPF+Soil.

- **Based on the results from DST Test**

  We can observe that there is increase in shear strength with addition of 5% to 30% of Soil+GGBS even with same normal loading

  We can observe that there is high increase in shear strength with addition of 5%+1% to 30%+3.5% of Soil+GGBS+WPF even with same normal loading

  Various laboratory tests have been conducted on Soil sample as per IS codes:

  Based on the results of all the major tests we can observe that there is an increase in all the parameters for the selected percentages of GGBS i.e.(5%, 10%, 15%, 20%, 25%, 30%) and GGBS+WPF i.e.(5%-1%, 10%-1.5%,15%-2%, 20%-2.5%, 25%-3%, 30%-3.5%)

  As per results of our current study, from the major tests, we can observe that maximum strength is achieved at 30% GGBS+Soil and 30% GGBS+WPF+Soil found that the best possible percentage (%) of Soil+GGBS and Soil+GGBS+WPF.

6.0 REFERENCES

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BIOGRAPHY

Navneeth Kumar received a Bachelor degree in civil engineering from Sri Venkateshwara College of Engineering (SVCE), Bengaluru in 2017 and a Master Degree in Construction engineering and management from M.S. Ramaiah University of Applied Sciences (MSRUAS), Bengaluru in 2019. He is currently interested in research in the field of construction.