Improvement of clayey soil characteristics by using silica Fume and GGBS

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Abstract: The Construction of foundation, road embankments and pavements on problematic soft soil is a difficult task for civil engineers. Now a day's civil engineers are forced to construct structures at available sites without considering the type of soil. 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. 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. This investigation focused on the use of industrial waste or materials like Ground Granulated Blast furnace Slag (GGBS) and silica fume as stabilizing agent.

Keywords: Silica Fume, GGBS, Soil Stabilization, Unconfined Compressive strength, CBR Value.

1.1 INTRODUCTION

Due to rapid growth of urbanization and industrialization, minimization of industrial waste is serious problem in present days and Due to increase population, loose soil is very necessary for stabilization of soft soil at which hat buildings and roads are stabilized in this soil. In this soil, Geotechnical properties of soft soil are not sufficient likes low bearing capacity, low shear strength, more moisture content, Due to variation moisture content, and the volume of soil is also variated at which swelling and shrinkage action are generated. For soil modification we have to add certain amount of additive to the soil for improving their properties but these additions finally proves to be more expensive. Whereas in case of soil stabilization some inferior materials or some industrial or agricultural wastes can be used in place of cement or lime with the soil to improve its quality. This will result in cost effective construction. Moreover, due to rapid industrialization throughout the country the productions of huge quantity of waste materials create not only the environmental problems but also disposal hazards. Safe disposal of these materials is of prime concern and this situation can be addressed by the bulk utilization of these materials mainly in the field of civil engineering applications. Many waste materials are used to modify the characteristics of soft soils. Traditionally the soils are stabilized by lime, cement, etc. In recent year the uses of waste materials like fly ash, plastic, rice-husk ash, slag, etc. for soil stabilization is gaining importance. Here, in this project soil stabilization has been done with the help of silica fume and Ground Granulated Blast Furnace Slag (GGBS or GGBFS) which is obtained by quenching molten iron slag from a blast furnace in water or steam.

1.2 LITERATURE REVIEW ON GGBS AND SILICA FUME

Sufyan Ansari et al studied on the effects of GGBS in the properties of soil. The main objectives of this paper were to investigate the effect of GGBS on the engineering property (optimum moisture content and maximum dry density, plastic limit, liquid limit, compaction, unconfined compressive strength, triaxial and California bearing ratio test) of the soil and determine the engineering properties of the stabilized. GGBS are added from 0% to 40% by dry weight of soil, first of all check the all soil property at 0 % (no GGBS) and then compare after addition of GGBS from 10% to 40%. On the basis of Standard Proctor test & Unconfined Compressive Strength test the optimum percentage of GGBS is 10%. Investigations showed that generally the engineering properties which improved with the addition of GGBS. The California bearing ratio of soil increases as the percentage of GGBS replaced in increase.

NANDA H.S et al studied on the effect of ground granulated blast furnace sag on the geotechnical properties of lime treated Lithomargic soil. In this study experimental investigations are made to evaluate the unconfined strength including compaction characteristics of Lithomargic soil (shedi soil) stabilized with ground Granulated Blast furnace Slag (GGBS) and lime. The percentage of slag added to the shedi soil, as percentage of dry soil mass, varied from 10 to 50%. The results obtained illustrate that 30% addition of slag by weight gives optimum unconfined compressive strength after 90 days of curing. Further investigations are done by adding lime to the soil-GGBS mix (at optimum GGBS content) in the range of 1 to 6% of total mass of shedi soil for different curing periods. It was found that inclusion of lime can significantly enhance the UCS values of stabilized shedi soil.

Sougat Manda et al studied on the Stabilization of Soil using Ground Granulated Blast Furnace Slag and Fly Ash**.** The aim of the present investigation is to assess the usefulness of industrial waste i.e GGBS and Fly ash as a soil admixture and focused to improve the engineering properties of soil to make it capable for the subgrade construction of road, moreover to minimize the dumping problems of GGBS and Fly ash in open places. The outcome of this investigation intends to minimize the cost of construction as conventional materials such as cement, lime etc. used in stabilization of soil are becoming expensive. The present investigation deals with the behavioral aspect of soil when mixed with GGBS and Fly ash.

From the experimental results, conclusions have been obtained that some properties of modified soil has improved. The unconfined compressive strength, unsoaked CBR and soaked CBR of modified soil is increased with respect to natural soil sample

Chhaya et al did a study on Effect of Silica Fume on Engineering Properties of Black Cotton Soil. It was indicated in the result the CBR had a significant increment and same as UCS.With increase in silica fume from 0% to 20% there was a decrease in differential free swell of the clay from 50% to 7%. There was a decrease in Proctor compaction results with increment in MDD and OMC. It was thus concluded that the silica fume posed the potential of stabilizing expansive soils. They also conducted a research on effect of Silica Fume on Index Properties of Black Cotton Soil also and found that the Liquid limit increased from 54% to 57% while PL decreased from 27.07% to 26.29% when there was an increment in Silica fume content from 5% to 20%. Plasticity Index was noticed to have increased from 26.93% to 30.71% and an increase in shrinkage limit from 7.55% - 12.70%, respectively. Differential Free Swell was observed to have decreased from 25% to 7%. Silica fume was thus recommended for use in modification of soil.

1.3 MATERIAL USED

Following materials are used in this study:

SOIL

Soft soil for the study has been collected from Mohri Village, Near to Shahabad, Kurukshetra, Haryana.

Figure 1: Soil Sample

GRAND GRANULATED BLAST SLAG

GGBS 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.

Figure 2: GGBS

SILICA FUME

Silica fume, also referred to as micro silica or condensed silica fume, is a byproduct material that is used as a pozzolan. This byproduct is a result of the reduction of high-purity quartz with coal in an electric arc furnace in the manufacture of silicon or ferrosilicon alloy.

Figure 3: Silica Fume

1.4 EXPERIMENTAL METHDOLOGY

The experimental setup and the test procedure have been planned in a particular way that accounts all the aspects that are related, such as relative proportions are mixed at calculated values of O.M.C. These tests were conducted for the soil with 12 % GGBS and 0%, 6%, 12%, 18%, 24 % and 30 % Silica Fume addition respectively.

Table 1: Mix Proportions

Sr. No	Sample Type	Details of additive added with the soil		
		Soil (%)	GGBS (%) by weight of soil	Silica Fume (%) by weight of soil
1.	S1	100	0	0
2.	S2	94	0	6
3.	S3	88	0	12
4.	S4	82	0	18
5.	S5	76	0	24
6.	S6	70	0	30
7.	S7	82	12	6
8.	S8	76	12	12
9.	S9	70	12	18
10.	S10	64	12	24
11.	S11	58	12	30

1.5 STANDARD PROCTOR TEST

This test is used to determine the optimum moisture content (OMC) and Maximum dry density (MDD) of the soil.

Table 2: Maximum Dry Density and Optimum moisture Content

Sr. No	Mix	OMC (%)	MDD (gm/cc)
1	S1 (Soil)	18.83	1.95
2.	S2 (Soil + 0 % GGBS + 6 % Silica Fume)	21.27	1.85
3.	S3 (Soil + 0 % GGBS + 12 % Silica Fume)	22.01	1.82
4.	S4 (Soil + 0 % GGBS + 18 % Silica Fume)	22.75	1.79
5.	S5 (Soil + 0 % GGBS + 24 % Silica Fume)	23.70	1.70
6.	S6 (Soil + 0 % GGBS + 30 % Silica Fume)	27.08	1.64
7.	S2 (Soil + 12 % GGBS + 6 % Silica Fume)	28.25	1.57
8.	S3 (Soil + 12 % GGBS + 12 % Silica Fume)	24.86	1.68
9.	S4 (Soil + 12 % GGBS + 18 % Silica Fume)	27.72	1.57
10.	S5 (Soil + 12 % GGBS + 24 % Silica Fume)	28.88	1.42
11.	S6 (Soil + 12 % GGBS + 30 % Silica Fume)	24.91	1.61

1.6 UNCONFINED COMPRESSIVE STRENGTH

The most important property for a weak soil deposit is its compressive strength which gives a measure of the load it can take before it fails. The test was carried out after the specimen was moist cured for 7 and 28 days.

Table 3: Unconfined Compressive strength

Sr. No	Mix	UNCONFINED COMPRESSIVE STRENGTH (KN/m^2)	
		7 Days Curing	28 Days Curing
1	S1 (Soil)	135.27	139.50
2.	S2 (Soil + 0 % GGBS + 6 % Silica Fume)	150.07	213.47
3.	S3 (Soil + 0 % GGBS + 12 % Silica Fume)	160.63	227.21
4.	S4 (Soil + 0 % GGBS + 18 % Silica Fume)	173.32	231.44
5.	S5 (Soil + 0 % GGBS + 24 % Silica Fume)	177.54	236.72
6.	S6 (Soil + 0 % GGBS + 30 % Silica Fume)	184.94	258.92
7.	S2 (Soil + 12 % GGBS + 6 % Silica Fume)	171.20	213.47
8.	S3 (Soil + 12 % GGBS + 12 % Silica Fume)	181.77	258.92
9.	S4 (Soil + 12 % GGBS + 18 % Silica Fume)	194.45	268.43
10.	S5 (Soil + 12 % GGBS + 24 % Silica Fume)	162.75	183.88
11.	S6 (Soil + 12 % GGBS + 30 % Silica Fume)	182.83	265.26

1.7 EFFECT ON CBR

California bearing ratio 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 a required extent, for the corresponding penetration of a standard material.

Table 4: CBR Variation for both soaked and unsoaked

Sr. No	Mix	Unsoaked	Soaked
1	S1 (Soil)	2.67	4.06
2.	S2 (Soil + 0 % GGBS + 6 % Silica Fume)	4.61	5.84
3.	S3 (Soil + 0 % GGBS + 12 % Silica Fume)	4.89	6.06
4.	S4 (Soil + 0 % GGBS + 18 % Silica Fume)	5.35	6.27
5.	S5 (Soil + 0 % GGBS + 24 % Silica Fume)	5.56	6.63
6.	S6 (Soil + 0 % GGBS + 30 % Silica Fume)	5.84	6.98
7.	S2 (Soil + 12 % GGBS + 6 % Silica Fume)	6.98	7.74
8.	S3 (Soil + 12 % GGBS + 12 % Silica Fume)	7.70	9.02
9.	S4 (Soil + 12 % GGBS + 18 % Silica Fume)	8.38	8.77
10.	S5 (Soil + 12 % GGBS + 24 % Silica Fume)	8.05	8.57
11.	S6 (Soil + 12 % GGBS + 30 % Silica Fume)	7.73	8.41

CONCLUSION

After doing various literature studies and experimental studies, following conclusions are drawn:

1. The maximum CBR value is achieved at a replacement of 30 % silica fume with 0 % GGBS.
2. The maximum CBR value is achieved at a replacement of 12 % silica fume with 12 % GGBS.
3. The maximum Unconfined Compressive strength value is achieved at a replacement of 30 % silica fume with 0 % GGBS.
4. The maximum Unconfined Compressive strength is achieved at a replacement of 18 % silica fume with 12 % GGBS.
5. The liquid limit increases by using silica fume and GGBS in soil.
6. The Plastic limit increases by using silica fume and GGBS in soil.

7. When the period of curing increases, the strength of soil with the above mentioned combination will improve.
8. Main cause for these results is the predominant effects of reduced clay content and increase in the resistance to friction respectively. Hence compactability of soil increases and making the soil more dense and hard.

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