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A Study on Stabilization of Expansive Soil with Ground Granulated Blast Furnace Slag and Flash

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Abstract: *Soil stabilization is one of most important for the construction which is widely used in connection with pavements and structures because it improves the engineering properties of soil. Utilization of industrial waste materials in the improvement of soils is a cost efficient and environmental friendly method. Stabilization of the expansive soil is studied by using flyash and Ground Granulated Blast Furnace. In the present investigation is to evaluate the compaction, CBR and unconfined compressive strength of stabilized black cotton soil using flyash and Ground Granulated Blast Furnace with different percentages. The geotechnical properties like compaction parameters has increased enabling increase California Bearing Ratio in both soaked and unsoaked conditions which indicates that improved in strength. From these results, it was found that optimum GGBS is 5 % and 5% flyash gives the maximum increment in the CBR and UCS values compared with all the other combinations.*

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I. Introduction

Expansive soils popularly known as black cotton soils, because of their suitability for growing cotton, cover almost 20% of the geographical land available in India. These deposits, because of the specific physical and chemical makeup, are undergoing volume changes with seasonal variations (Snethen et al., 1975; Chen, 1988). Civil Engineers face many difficulties when construction activities are to be done in expansive soils such as Black Cotton Soil because of their unconventional behaviour. Soils, which exhibit a peculiar alternate swell-shrink behavior due to moisture fluctuations, are known as expansive soils. Stabilization is a method of processing available materials for the production of low-cost road design and construction, the emphasis is definitely placed upon the effective utilization of waste by products like flyash, GGBS with a view to decreasing the construction cost. Sharma and Sivapullaiah (2011), study the effectiveness of binder viz., Flyash or Ground Granulated Blast furnace slag (GGBS) were mixed with the expansive soil along with a small amount of lime to increase soil pH and enable pozzolanic reactions. Based on the findings, both Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) decreased with the addition of GGBS to the BC soil which isdue to predominant effects of reduced clay content and increased frictional resisting. Unconfined compressive strength (UCS) of the Flyash-GGBS mixture increases with the increase in the GGBS content. The reduction in strength in the Flyash-GGBS mixtures is overcome by addition of lime. Kiran B. Biradar et al., (2014), were studied the performance of crusher dust, flyash and steel slag mixing with different percentages blending in soil and from the results decrease in consistency limits, soil has exhibited lower void ratios with the addition of Quarry dust and Steel slag,improvement in compaction characteristics increase in maximum dry density and decrease in OMC with steel slag & quarry dust and an opposite trend with flyash. Both Unsoaked and soaked CBR has been improved with admixtures and the improvement is more pronounced in soaked performance over Unsoaked. Performance ratio improved for UCS with the addition of admixtures. 1.18, 1.27 and 1.09 times improvement is observed with addition of Quarry dust, Steel slag and flyash respectively. Dayalan (2016) studied the different amount of flyash and GGBS are mixed separately, i.e., 5%, 10%, 15% and 20% by dry weight of soil and conducted various physical and strength performance tests like specific gravity, Atterberg limits, standard proctor test and CBR tests. From the results, it was found that optimum value of flyash is 15% and GGBS is 20% for stabilization of given soil based on CBR value, and with the increases of flyash and GGBS percentage, OMC goes on decreasing while maximum dry density goes on increasing, hence compact ability of soil increases and making the soil more dense and hard. The CBR value increases with increase in amount of flyash and attained maximum value at 15%and again decreases. The same trend is also observed in GGBS in which the maximum CBR value (8.6%) is attained at 15% of GGBS. In this investigation, different

laboratory experiments like Compaction CBR and UCS tests were conducted by varying percentages of 0 %, 2.5 %, 5 %, 7.5 % of Ground Granulated Blast Furnace Slag and 2.5 %, 5% and 7.5 % Flyash were blended to the expansive soil and from test results it is found that there is an improvement in geotechnical properties. Testing is conducted with a view to find the optimum percentages Ground Granulated Blast Furnace Slag and Flyash.

II. Material and Methods

The materials used for the stabilization of expansive soil are Ground Granulated Blast Furnace (GGBS) and Flyash(FA) and the properties and availability are mentioned below.

Black Cotton Soil: Natural black cotton soil was obtained from Amalapuram, East Godavari district, Andhra Pradesh. The soil is dark grey toblack in color with light clay content. The obtained soil was air dried, pulverized manually and soil passing through 4.75 mm IS sieve was used as shown in the Figure 1.The physical properties of black cotton soil are presented in Table 1.

Ground Granulated Blast Furnace Slag: (GGBS): Quenching, (i.e., sudden cooling with water or air) of hot slag may result into formation of vitrified slag (Figure 2). The GGBS is a result of use of water during quenching process. This waste material is easily available and also cost efficient. It has a cementations property which acts as binding material for the soil. In general, the presence of sufficient quantity of CaO results in enhanced slag basicity and compressive strength. The GGBS used in this project work is collected from Rashtriya Ispat Nigam Limited, Visakhapatnam. The chemical compositions of GGBS Cao=30%–38%; Sio2 =30%–40%; Al_2O_3 = 15%–22%; MgO = 8%–11%; FeO = 5% (max) and MnO = 2% (max) and the physical properties are presented in Table 1.

Flyash: Flyash was collected from Vijayawada Thermal Power Station (VTPS), Vijayawada as shown in the Fig.2. The physical properties of flyash are Specific Gravity =2.32, Sand = 6%, Fines = 94%, Optimum Moisture Content (%) = 25.4 and Maximum Dry Density (kN/m^3) =11.67.The chemical properties are Silica (SiO_2)= 56.60, Magnesium (MgO)= 1.17, Calcium (CaO) = 12.14, Iron (Fe_2O_3) = 8.14, Titanium (TiO_2) = 1.61, Sodium (Na_2O) = 1.00, Sulphur (SO_3) = 2.22, Potassium (K_2O) = 0.90 and Alumina (Al_2O_3) = 16.22 respectively.

Fig. 1 Expansive Soil

Fig. 2 Ground Granulated Blast Furnace Slag

Fig.3 Flash

III. Laboratory Experimentation

Laboratory tests were conducted for finding the index and other important properties of the soils used during the study. Compaction, CBR and Unconfined Compressive Strength tests were conducted by using different percentages of GGBS and Flyash mixed with black cotton soil materials for finding optimum percentages.

Compaction Properties: Optimum moisture content and maximum dry density for black cotton soil blending with different percentages of GGBS and Flyash were mixed with a view to determine optimum percentages by conducting IS heavy compaction test as per IS: 2720 (Part VIII).

California Bearing Ratio (CBR) Tests: Samples were prepared for CBR test using expansive soil material mixing with different percentages of waste materials GGBS and Flyash with a view to determine optimum percentages. The unsoaked and soaked CBR tests were conducted in the laboratory for all the samples as per IS Code (IS: 2720 (Part-16)-1979) as shown in the Fig. 4.

Unconfined Compression Strength Test: The unconfined compression strength tests were conducted in the laboratory as per IS Code (IS: 2720, Part X (1991). Unconfined compressive strength is one of the most widely referenced properties of stabilized soils. For strength testing, specimens are generally tested at their maximum dry density and optimum moisture content. The load frame of compression testing machine apparatus was used for conducting the unconfined compressive strength test. The strain rate was kept as 1.2 mm/min in all the experiments. The proving ring of capacity 2 kN was used fortesting specimens as shown in the Fig. 5.

Fig.4 California Bearing Ratio Test Apparatus

Fig.5 Unconfined Compressive Testing Machine

IV. Results and Discussions

Various tests were conducted in the laboratory as per I S Code provisions and the test results are furnished
below with a view to determine the optimum percentages.

Effect of GGBS and Flyash on Compaction: From the compaction test results the maximum dry density values are increases from 15.51 kN/m^3, 16.18 kN/m^3, 16.59 kN/m^3 and 16.23 kN/m^3 and optimum moisture content values are decreases from 26.53%, 24%, 21.33%, and 20.83%respectively when the soil is mixed with 0 %, 2.5 %, 5 % and 7.5 % of GGBS as shown in the Fig. 6. The optimum percentage of GGBS is 5 %. The decrease in optimum moisture content is attributed to the factthat additional water held within the flocs resulting from flocculation. From Fig.7 it is observed that, the OMC values are decreasing from 20.27 %, 18.12 % and 17.13 and the MDD values are varied from 16.68kN/m^3, 17.02 kN/m^3 and 16.83 68kN/m^3 respectively due to the addition of 2.5%, 5% and 7.5% flyash blended with the expansive soil and 5 % optimum percentage of flyash.

Effect of GGBS and Flyash on California Bearing Ratio (CBR): Unsoaked and Soaked CBR tests were conducted for expansive soil mixed with different percentages of GGBS and Flyash and the results were presented in the Figs. 8 & 9. It is observed from that expansive soil mixed with different percentages of GGBS the unsoaked and soaked CBR values are 2.33.2.792,3.52 and 3.26 and1.447,1.675,1.932 and 1.827 respectively at 0%, 2.5 %, 5 % and 7.7 % blending of GGBS as shown in the Fig.8. From the above Figure the optimum percentage of GGBS is 5%. The optimum sample mix of expansive soil and 5% GGBS, different percentages of flyash 2.5 %, 5 % and 7.5 % respectively blending in the above mix and the unsoaked CBR values are 4.278,5.19 and 4.853, unsoaked CBR values are 2.364,2.941 and 2.589 for flyash blended with the expansive soil and 5 % optimum percentage of GGBS as shown in the Fig.9. From the above Figure the optimum percentage of Flyash is also 5%.

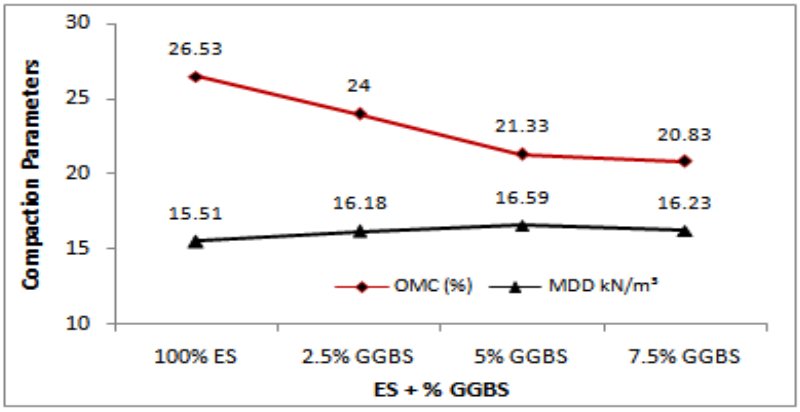

Fig.6 Variation of Compaction Parameters of Expansive Soil Treated with Different % of Ground Granulated Blast Furnace Slag

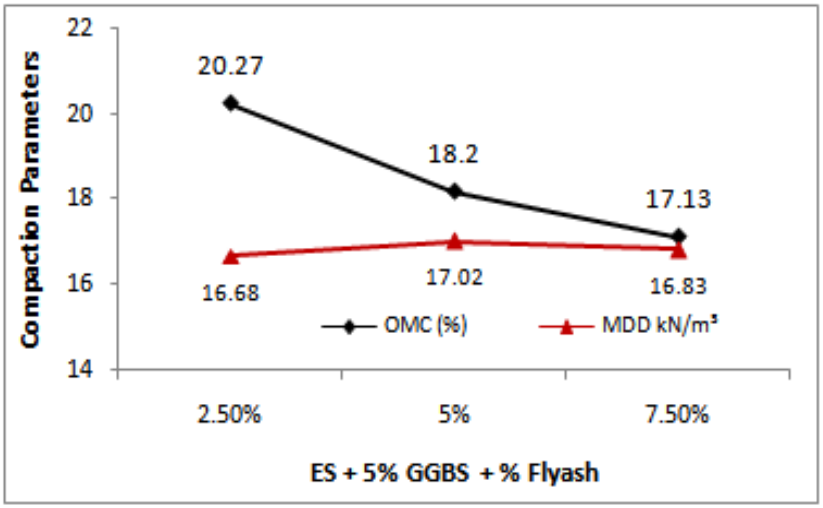

Fig. 7 Variation of Compaction Parameters of Expansive Soil Treated with 5% of Ground Granulated Blast Furnace Slag and Different % of Flyash

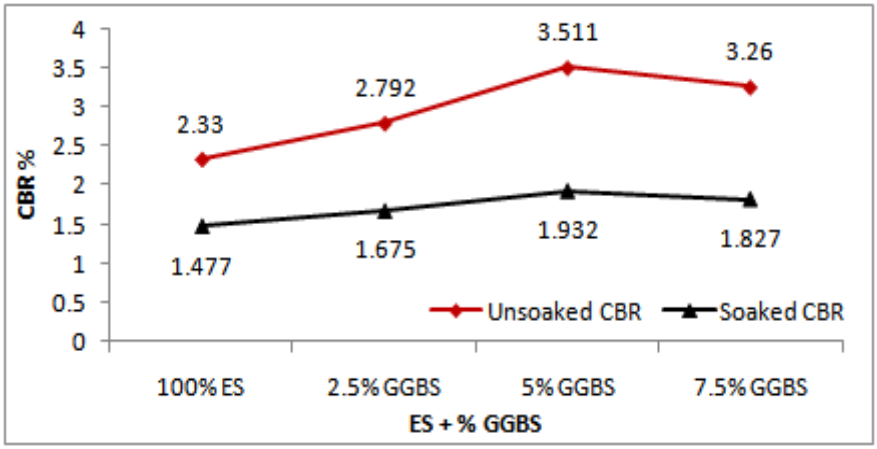

Fig.8 Variation of CBR Values of Expansive Soil Treated with 5% of Ground Granulated Blast Furnace Slag and Different % of Flyash

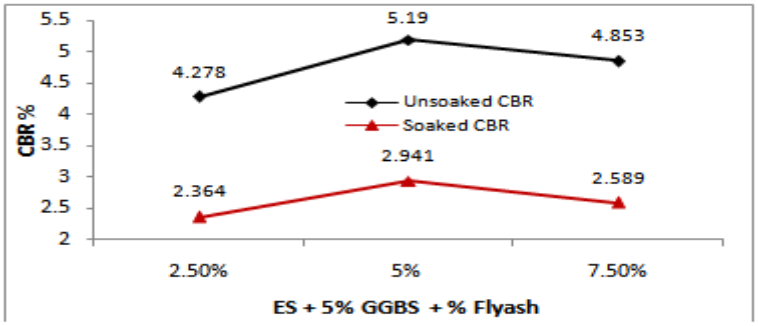

Fig.9 Variation of CBR values of Expansive Soil Treated with Different % of Ground Granulated Blast Furnace Slag

Effect of GGBS and Flyash on Unconfined Compressive Strength (UCS): Effect of GGBS and Flyash on Unconfined Compressive Strength (UCS): Unconfined compressive test at OMC is conducted as per IS: 2720 (part-X) -1991. Unconfined compressive strength test was conducted at different curing periods at a strain rate of 1.25 mm/min. Specimens of 38 mm diameter and 76 mm height were prepared at OMC for different percentages of GGBS 2.5%, 5%, and 7.5% blended in black cotton soil and cured for 1, 3, 7, 14, 21 and 28 days and the unconfined compressive strength values are 149kPa, 153 kPa, 161 kPa, 167 kPa, 170 kPa and 175 kPa respectively at 5% of Ground Granulated Blast Furnace Slag(GGBS) as shown in the Fig.10.After finding the optimum percentage of GGBS , different percentages of Flyash 2.5%, 5%, and 7.5% blended in black cotton soil and cured for 1, 3, 7, 14, 21 and 28 days and the unconfined compressive strength values are 168kPa,179 kPa,192 kPa,197 kPa,204 kPa and 213 kPa respectively at 5% Flyash as shown in the Fig.11.From the above test results the optimum percentages of GGBS and Flyash are 5% and 5% respectively.

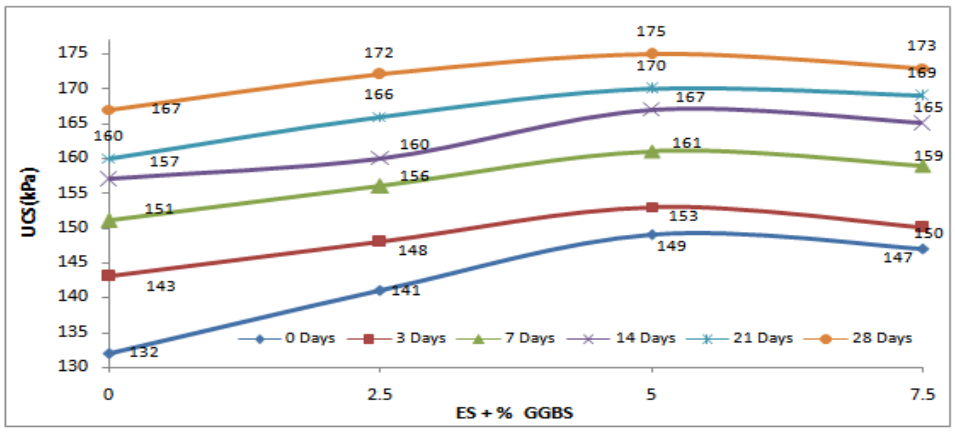

Fig.10 Variation of UCS Values of Expansive Soil Treated with Different % of Ground Granulated Blast Furnace Slag at Different Curing Periods

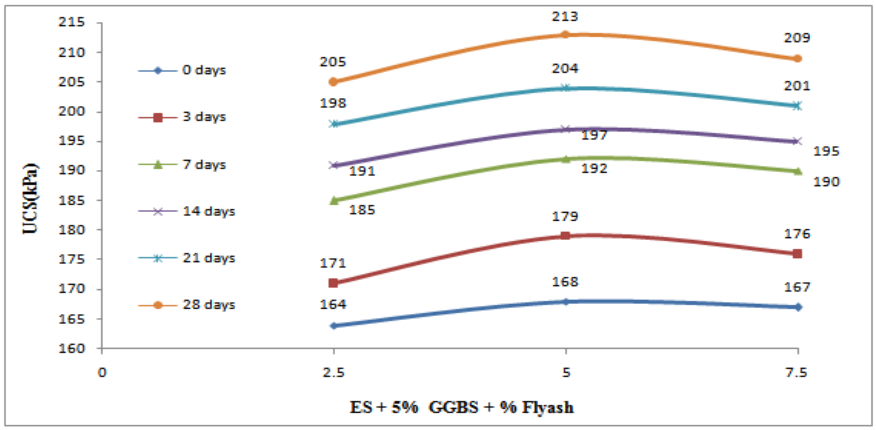

Fig.11 Variation of UCS Values of Expansive Soil Treated with 5% of Ground Granulated Blast Furnace Slag and Different % of Flyash at Different Curing Periods

V. Conclusion

The following conclusions are obtained based on the laboratory studies carried out in this investigation. The MDD value has been increased by increasing the Ground Granulated Blast Furnace Slag (GGBS) up to 5 % to the expansive soil and it starts decreasing again further adding and also both unsoaked and soaked CBR values are increased up to 5 % of GGBS and decreases further addition. The MDD value has been increased by increasing the Flyash up to 5 % to the expansive soil and 5% GGBS sample, and it starts decreasing again and also unsoaked and soaked CBR values follows the same trend. With increase of GGBS content, UCS increases in both cured and uncured soil samples. The UCS of stabilized soil (Soil-GGBS-Flyash) increases with the increase of Flyash content and curing time. The UCS values of Soil-GGBS mixture with 5% Flyash content for soil respectively at different curing periods. From this experimental study, the strength parameters have been increasing by increasing the GGBS up to 5 % and Flyash up to 5 %, respectively. Hence the optimum values of GGBS and Sodium Silicate are 5% and 5 %, respectively.

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