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EFFECT OF CEMENT AND SODIUM HYDROXIDE ON THE GEOTECHNICAL PROPERTIES OF GROUND GRANULATED BLAST FURNACE SLAG TREATED LITHOMARGIC SOIL

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Abstract – *Lithomargic soil is most commonly available soil throughout west coast of India. The Lithomargic soil strata are existing at shallow depths below natural ground level and are whitish, yellowish or pinkish in colour. These are classified as silty sand or sandy silt and are considered to be very sensitive soil of low strength when it is wet or saturated. In this study experimental investigations are made to evaluate the unconfined compressive strength including compaction characteristics of Lithomargic soil stabilized with ground Granulated Blast Furnace Slag (GGBS), cement and sodium hydroxide. The percentage of slag added to the soil, as percentage of dry soil mass was 0 to 30%. The results obtained illustrate that 30%addition of slag by weight gives optimum unconfined compressive strength after 30 days of curing. Further investigation is done by adding cement in the range of 2% - 6% of Lithomargic soil to the optimum GGBS – soil mix. The variation in strength is also studied for different curing period. The investigation is further carried out by adding 1% sodium hydroxide to the above cement-soil-GGBS mix and for different curing periods. Strength for addition of 4% cement to the optimum GGBS – Soil mix and increase the strength up to 14 Folds compare to Lithomargic soil alone. However, the replacements of 1% of cement by 1% of sodium hydroxide in the above mix enhance strength further by 18 folds with respect to strength of Lithomargic* soil alone.

***Key Words*: Soil Stabilization, Lithomargic soil, GGBS, Cement, Sodium hydroxide. Unconfined compressive strength.**

1. INTRODUCTION

Infrastructural facilities like highways, bridges, railway lines, flyovers and runways pass through different types of soil deposits. Many times, it becomes inevitable to provide the infrastructures over weak soil and hence the cost of construction increases for providing additional safety against failure of structure. One such deposit is identified along western coast of India which is called 'Lithomargic clay'. Lateritic type of deposits comprising of a hard-lateritic crust and a layer of lithomargic clay under it is common along coastal belt of Karnataka, Goa and Maharashtra states of India. Hydrated alumina and kaolinite are the main components of lithomargic soil. This soil exists between lateritic layer and hard rock and is present at a depth of 1-3 meters below the top lateritic outcrop. Lithomargic clay is a dispersive soil when dry and loses its strength in the vicinity of water and may get washed away if not protected from rain water and raising level of under- ground water from ground water Table during monsoon. Thus, the base layer below the super structure or substructure of important infrastructure may create cavities; top layer slides, causes subsidence and leads to failure of structure. Hence improvement of the geotechnical and engineering properties of lithomargic soil by mechanical or chemical stabilization is very much essential. Chemical stabilization now a day is considered to be effective and economical for certain types of soil. Use of pozzolonic materials such as cement, sodium hydroxide and other additives for chemical stabilization is well established in case of much type of weak soils. During stabilization of soil, strength gain is observed to be due to the formation of new chemical compounds of improved properties by the reaction between ingredients of soil and the stabilizers in the presence of water. Quantity of water available for soil- stabilizer reaction is most important for some type of stabilizers and additives. An effective compound which contributes for the improvement of strength and other properties of original soil will be formed only if sufficient quantity of water is available for complete reaction. Normally both light and heavy compaction of soil is being done to achieve 95% compaction at site. Water added to achieve this may be on the dry side of optimum dry density value or wet side of it. If the water added to soil is less than optimum moisture content and is corresponding to dry of optimum value, quantity of water required for complete reaction between soil and ingredients may be less and this results in the formation of insufficient reactive compounds which impart lesser strength to soil mix. However, some type of ingredients of low potential reaction may require sufficient water for complete formation of compounds of higher strength values. This may be possible if the compaction of stabilized soil could be carried out with moulding water content corresponding to wet of optimum side only. Therefore, it becomes necessary to find the suitable moulding water content to be adopted while compacting the treated soil to obtain maximum strength after prolonged curing. In the present work it is intended to study the effective utilization of GGBS activated by cement and sodium hydroxide for the stabilization of lithomargic soil of western coastal belt of India. Also study on the effect of moulding water content in the process of stabilization of lithomargic soil by these stabilizers and additives forms the important part of investigation.

2. MATERIALS AND METHODS

2.1 Material Used

Ingredients used for the stabilization of Lithomargic soil are GGBS, cement and sodium hydroxide the properties and availability are mentioned below.

2.1.1 Lithomargic soil.

Lithomargic soil was collected from a depth of 1-1.50m below natural ground level near national high way side of Bhatkal, Karnataka, India. The soil was air dried for 6 days pulverized manually and sieved through 425 microns before used for experimental investigation. The soil is classified as silty sand of MI group as per Indian Standard Classification System.

2.1.2. Ground Granulated Blast Furnace Slag.

Ground granulated blast furnace slag (GGBS) was procured from Jindal Steels, Bellary. The material may be classified as low compressible inorganic silt(ML).

2.1.3. Cement.

Commercially available OPC 43 Grade cement is used.

2.1.4. Sodium hydroxide.

Chemicals used in the present study are sodium hydroxide (NaOH) which are commercially available in the chemical store.

2.2. Methodology Adopted.

2.2.1. Compaction characteristics.

Mini compaction tests proposed by Sreedharan and Shivapullaiah were used to determine the compaction characteristics of the Lithomargic soil and GGBS mix.

2.2.2. Unconfined Compression Strength.

To ascertain the compressive strength of the stabilized soil unconfined compressive strength test was carried out as per standard procedure mentioned in IS:2720(part 10)-1995, for Lithomargic soil treated with varying of percentage of GGBS. Further, UCCS test specimens were prepare by adding cement to soil- GGBS (optimum) mix, in the range of 2-6% and adding 1% of sodium hydroxide to find the optimum percentage of cement which gives maximum value of UCCS. The test samples were prepared for their maximum dry density and optimum moisture content adopting static compaction. Initially after preparing a set of three specimens before curing of stabilized mix, samples were tested to know the immediate strength. The specimens were moist cured for various curing periods keeping the specimens in desiccators to maintain the water content of samples. To prevent loss of moisture water was sprinkled at regular intervals.

3. RESULTS AND DISCUSSION

3.1 Effect of GGBS on the Compaction Characteristics.

The compaction characteristics of GGBS stabilized Lithomargic soil and Cement-Lithomargic soil mix for different proportions of ingredients are shown in Table 1. At lower % of GGBS in Lithomargic soil, Maximum Dry Density (MDD) is marginally less than that of Lithomargic soil. The increase in MDD is due to the partial replacement of soil particle in a given volume by angular shaped GGBS and partial filling of voids by GGBS, which prevent soil particles coming closer, resulting in voids. Further addition of GGBS to Lithomargic soil increases the maximum density of the stabilized soil. The increase of MDD with the increase of the percentage of GGBS is mainly due to higher specific gravity of the GGBS compared to that of Lithomargic soil.

3.2 Effect of GGBS on Strength of Lithomargic soil.

A series of strength tests were carried out for different proportions of GGBS at different curing periods. Table.2 and Table.3 and shows the variation of UCCS values for different proportions of GGBS-soil mixture and for various curing periods. Strength gain for all percentage of GGBS is marginal for immediate testing. This is due to the reason that the GGBS has a low reactive potential. Strength of GGBS stabilized soil increases with increase in GGBS percentage up to 30% for curing period of 30 days. Further increase in GGBS results in decrease in UCCS value of the stabilized mix. Therefore 30% of GGBS is considered to be optimum percentage for the stabilization of Lithomargic soil treated with GGBS. Addition of 2-6% cement to the optimum GGBS mix shows increase in strength of soil mix and strength further increases with curing periods. UCCS Value was observed to be maximum for soil-optimum GGBS mix treated with 4% cement and is 1560.612 kN/m^2 for 30 days curing as shown in Table.2. It is 14 folds more than the strength of Lithomargic soil. The result for 1% replacement of cement by 1% of sodium hydroxide for the above combination and proportions after 30 days of curing gives a significant increase in UCCS values which is found to be 1894.589 kN/m^2. as shown in Table.3.

Table 1: Compaction characteristics of stabilized Lithomargic soil with GGBS and cement

Mixture	Maximum Dry Density (kN/m³)	Optimum Moisture Content
Lithomargic soil alone	15.60	20
Ls + 30% GGBS	15.75	23
LS + 30% GGBS+ 2% CEMENT	14.82	30
LS + 30% GGBS+ 3% CEMENT	14.85	32
LS + 30% GGBS+ 4% CEMENT	15.35	32
LS + 30% GGBS+ 6% CEMENT	15.60	32

Table 2: Compressive strength (UCCS) of Lithomargic soil + GGBS and Cement (2-6%) mixture for different days of curing

Mixture	Unconfined Compressive Strength (kN / m²)		
	Curing Periods		
	0 days	7 days	30 days
Lithomargic soil (L S) alone	108	108	108
LS + 30% GGBS	160.69	235.93	330.16
LS + 30% GGBS + 2% Cement	146.17	519.79	1126.168
LS + 30% GGBS + 3% Cement	97.98	486.67	1194.196
LS + 30% GGBS + 4% Cement	97.2	738.68	1560.612
LS + 30% GGBS + 6% Cement	127.44	1020.96	2731.682

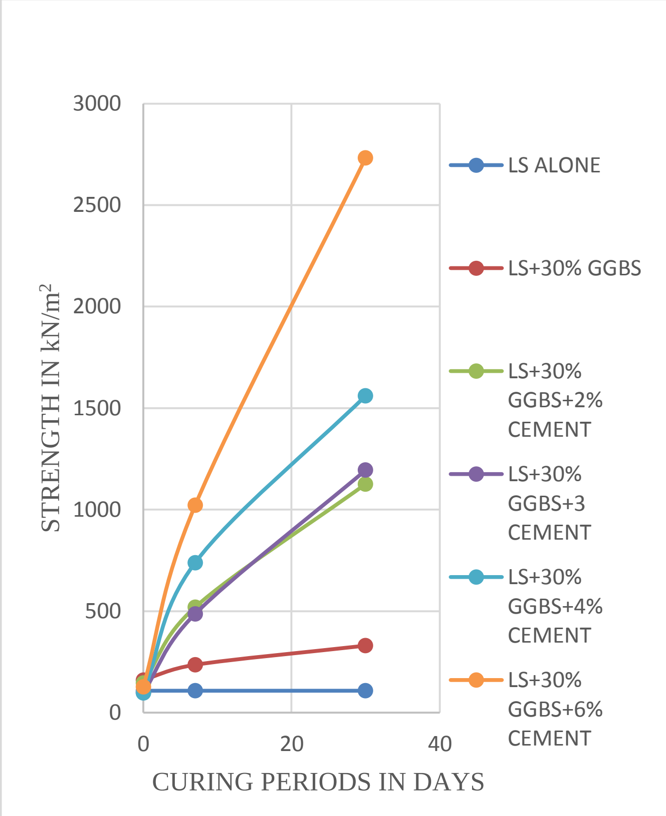

Chart-1: Variation of UCCS values for Soil+GGBS+Cement mix for different curing periods.

Table 3: Strength (UCS) of soil, GGBS, cement and sodium hydroxide mixture for different curing periods.

Mixture	Unconfined Compressive Strength (kN / m²)		
	Curing Periods		
	0 days	7 days	30 days
Lithomargic soil (L S) alone	108	108	108
LS + 30% GGBS + 2% Cement +1% NaOH	124.91	1462.63	1715.505
LS + 30% GGBS + 3% Cement +1% NaOH	107.43	1202.0	1894.589
LS + 30% GGBS + 4% Cement +1% NaOH	88.48	1258.15	1747.443
LS + 30% GGBS + 6% Cement +1% NaOH	68.74	2019.1	2128.662

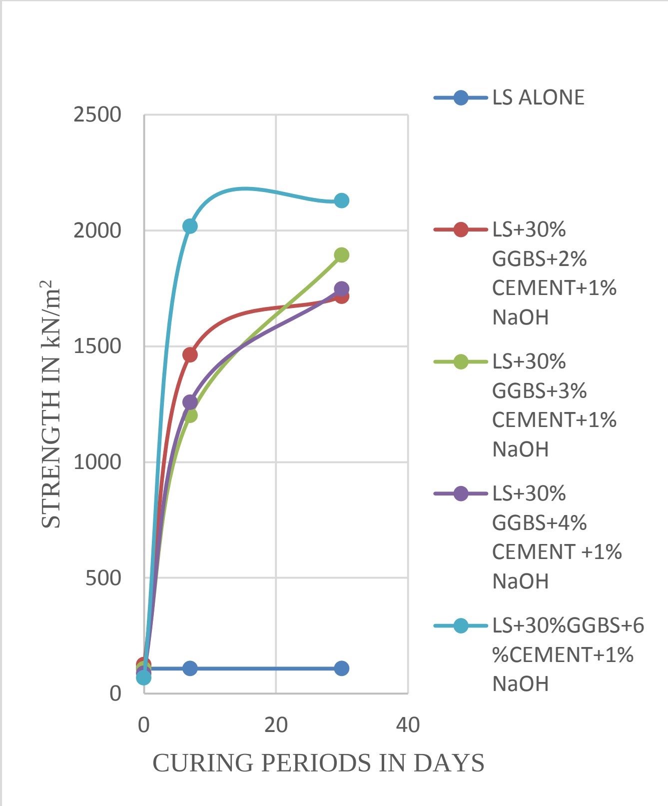

Chart-2: Variation of UCCS values for Soil+ GGBS +Cement+ NaOH mix for different curing periods.

4. CONCLUSIONS

Soil stabilization using GGBS is found to be advantageous means for improving the engineering properties of Lithomargic soil. Addition of small quantity of cement to optimum GGBS soil mixture further enhances the strength of stabilized Lithomargic soil. Based on present experimental investigation following conclusions can be drawn.

1. Ground Granulated Blast Furnace Slag is a highly pozzolonic material having slow reactive potential. This industrial waste certainly can be used for stabilization of Lithomargic soil. This does not show increase in strength immediately after mixing with soil. However, cured stabilized soil shows increase in strength. Considering curing period of 30 days, 30% of GGBS is found to be optimum percentage for stabilization of Lithomargic soil.
2. The unconfined compressive strength of Lithomargic soil and GGBS mixtures increases with increase in GGBS percentage and curing. 30% of GGBS is found to be optimum, which gives the strength of 330.16 kN/m^2 after 30 days of curing.
3. Addition of 4% of cement to 30% GGBS soil mixture predominantly increases the strength UCCS value is 1560.612 kN/m^2. From the present study, it has been concluded that GGBS and cement can be effectively used in the stabilization of Lithomargic soils.
4. Lithomargic soil- optimum GGBS mixture treated with 3% cement and 1% sodium hydroxide moulded at wet of optimum condition and cured for 30 days gives the unconfined compressive strength of 1894.59kN/m^2
5. Increase of GGBS content in the soil increases the maximum dry density of stabilized soil, but optimum moisture content decreases. This is due to the effect of replacement of soil by GGBS of higher specific gravity.

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