Effect of GGBFS on Geotechnical Properties of Clayey Soil

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Abstract - *Now a days, a large acre of land is occupied by industrial waste. It not only creates land problem but also creates environmental problems. In order to utilize the industrial waste, an attempt is made to stabilize the red soil by adding ground granulated blast furnace slag. In this project, the soil is stabilized by ground granulated blast furnace slag (GGBFS), which is the byproduct of iron and the soil is treated with quicklime.*

Tests was conducted to evaluate the effect of addition of 0%, 5%, 10%, 15%, 20% blast furnace slag in order to stabilize the soil. The particular UCS samples were cured for 3, 7, 15 days. Based on the analyses of experimental results, UCS value is maximum with addition of 10% of blast furnace slag afterwards the UCS value decreases with further addition in blast furnace slag. The optimum dosage of slag was found to be as 10%. Soil was mixed with varying percentages of CaO (2%,4%,6%,8%) and the optimum dosage was found to be 6%. This study aims to find the influence of GGBFS on various geotechnical properties of soil.

***Keywords**: ground granulated blast furnace slag, quicklime, stabilization*

1.INTRODUCTION

Stabilization of soil in a broader sense is the modification of the properties of a soil is improving its engineering performance. It improves the engineering properties of the soil in terms of volume stability, strength, and durability. Soil stabilization occurs over a longer time period of curing. A soil that is treated with blast furnace slag and quicklime is modified and its properties are changed which may lead to stabilization. The blast furnace slag is considered as a waste disposal which can be used in the construction material like road, pavement, railway ballast, landfills etc.

In this project, the soil is stabilized by ground granulated blast furnace slag (GGBFS), which is the byproduct of iron and the soil is treated with metal oxides such as quicklime.

GGBFS has a good binding property and hence stabilizes the soil. Metal oxides have the capacity to form insoluble compounds when react with heavy materials and clays are capable to reduce contaminant transport.

1.1EXPERIMENTAL STUDIES

A. Materials

a) Red soil:

The soil used in this study is red soil which was collected from Kazhakuttom. The properties of soil were tested and tabulated in Table 1. Based on IS Classification System, the soil was classified as clay of intermediate compressibility (CI).

b) Quicklime (CaO)

The used lime for this study is quicklime (CaO). It was collected from Central Scientific Supplies Co. Ltd, Trivandrum. Properties of quicklime is tabulated and shown in Table 2.

c) Ground Granulated Blast Furnace Slag (GGBFS)

GGBFS is a by-product material produced from manufacture of iron. It mainly consists of lime, alumina, and silicate. There is similarity between GGBFS and ordinary Portland cement in oxides types but not the percentage.

During the production of GGFBS, its cementitious characteristics increases because molten slag chills rapidly after leaving the furnace. The rapid chilling leads to decrease in the crystallization and transforms the molten slag into a glassy material. The additive was collected from Astra Chemicals, Chennai. The chemical composition of GGBFS is given in Table 3.

B. Methodology

GGBFS was mixed with soil at varying proportions of 5%,10%,15% and 20% to find the optimum amount for stabilization. The soil was also mixed with quicklime at different proportions of 2%,4%6% and 8% to find the optimum amount. Various laboratory tests such as Atterberg limits, compaction test and unconfined compression tests were conducted to ascertain the effect of lime and GGBFS on soil properties. The specimens for UCC was cured for a period of 0,3,7 and 14 days.

Table 1. Properties of Red Soil

SL NO	PROPERTIES	VALUES
1.	Specific Gravity	2.62
2.	Liquid Limit (%)	43.1
3.	Plastic Limit (%)	20.87
4.	Plasticity Index (%)	22.23
5.	Shrinkage limit (%)	12.75
6.	IS Classification	CI
7.	Clay (%)	57
8.	Silt (%)	24
9.	Sand (%)	19
10.	Optimum Moisture Content (%)	18.6
11.	Maximum Dry Density (g/cc)	1.84
12.	UCC (kN/m²)	57.2

Table 2. Properties of Quicklime

PROPERTIES	CaO
Physical Appearance	Dry Powder
Colour	White
Molar Mass (g/mol)	56.08
Density (g/cm³)	3.3

Table 3. Chemical Composition of GGBFS

S.NO	CHARACTERISTICS	VALUES
1	Fineness (M / Kg)	390
2	Specific Gravity	2.85
3	Particle Size (Cumulative %)	97.10
4	Insoluble Residue	0.49
5	Magnesia. Content (%)	7.73
6	Sulphide Sulphur (%)	0.50
7	Sulphite Content (%)	0.38
8	Loss on Ignition (%)	0.26
9	Manganese Content (%)	0.12
10	Chloride content (%)	0.009
11	Glass Content (%)	91
12	Moisture Content (%)	0.10

3. RESULTS AND DISCUSSION

1. Soil mixed with different percentage of GGBFS:

A. Effect on Atterberg Limit

The test for Plastic and Liquid limit was carried out in accordance with IS: 2720 (Part 5)-1985.

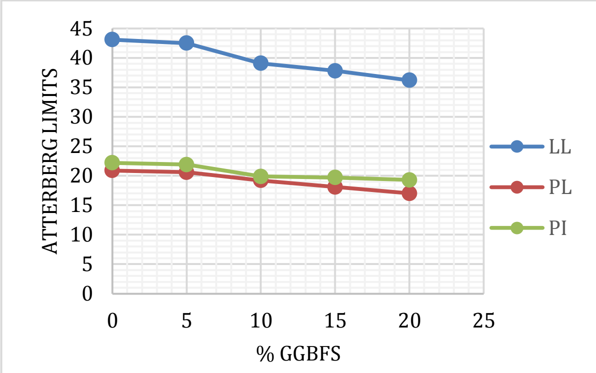

Fig 1. Variation of Atterberg limit for varying GGBFS percentage

From the graph, it was observed that the Atterberg limit decreased with increase in percentage of GGBFS.

B. Effect on Compaction Characteristics

Proctor compaction test was carried out to determine the water content-dry density relation as per IS: 2720 (Part VII)-1980.

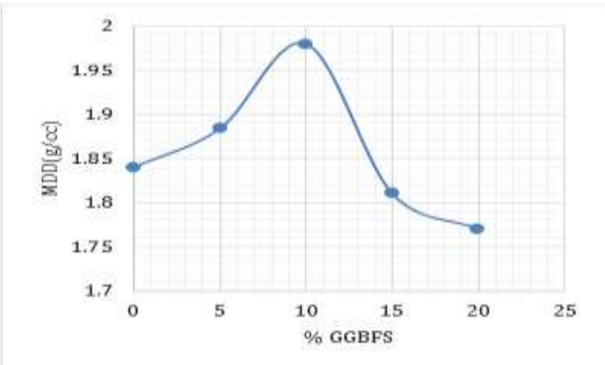

Fig 2. Variation of maximum dry density for varying GGBFS percentage

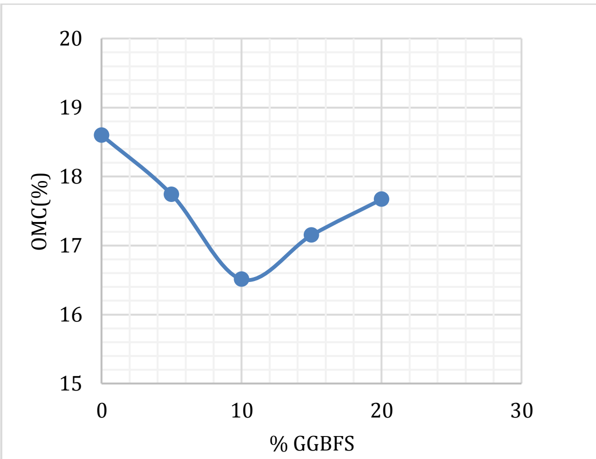

Fig 3. Variation of optimum moisture content for varying GGBFS percentage

From fig 2 and 3, it was observed that MDD increases and OMC decreases to a certain percentage and then decreases with increasing percentage of GGBFS. The increase in MDD can be due to the replacement of GGBFS particles in the mixture which have higher specific gravity of 2.85 as compared to soil.

C. Effect on UCC strength

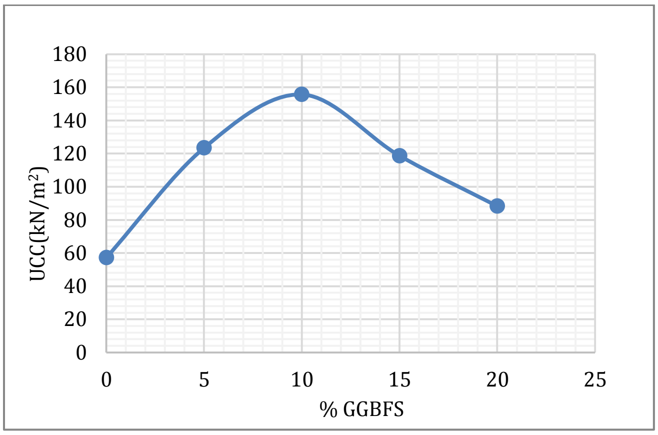

Fig 4. Variation of UCC strength for varying GGBFS percentage

From graph, UCC strength increased with increasing percentage on curing. Optimum amount of GGBFS was found to be on 10%. The increase in strength was attributed due to the formation of pozzolanic compounds.

2. Soil mixed with 10% GGBFS and quicklime.

In order to know the effect of quicklime, quicklime was added to soil+10% GGBFS at different percentage (2%,4%,6%,8%).

A. Effect on Liquid Limit

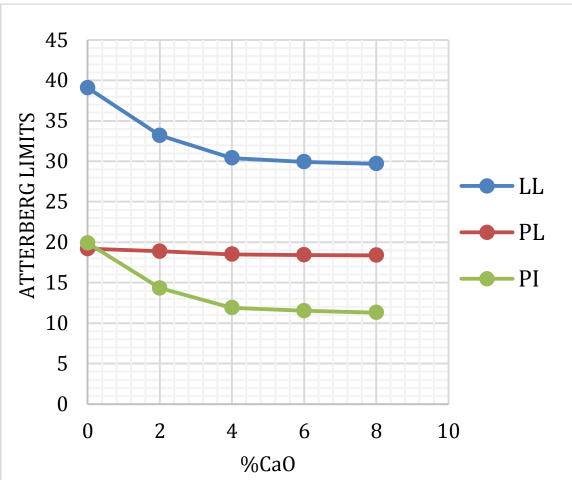

Fig 5. Variation of Liquid Limit

In mixture of soil+10%GGBFS+ quicklime, Atterberg limits decreased with increasing percentage of lime.

B. Effect on Compaction Characteristics

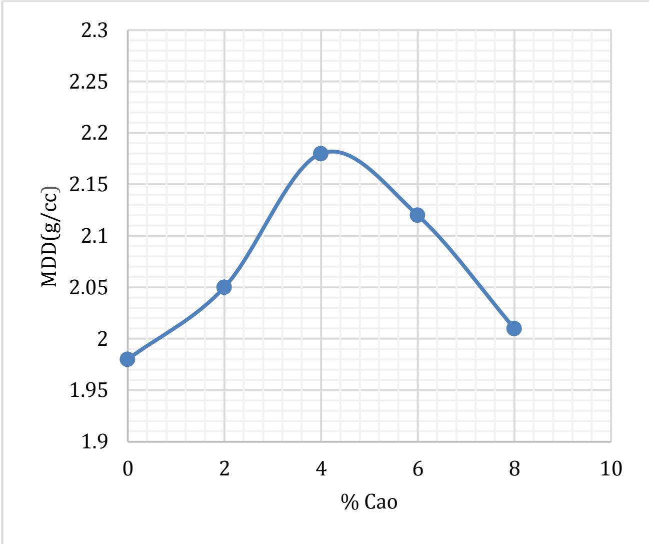

Fig 6. Variation of maximum dry density

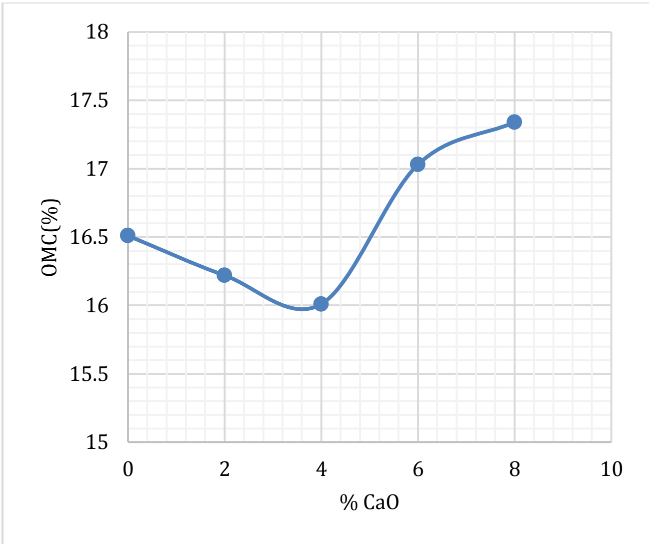

Fig 7. Variation of optimum moisture content

From the graph it was found that MDD Increases and OMC decreases to a certain percentage and then decreases with increasing percentage of GGBFS. The optimum dosage of quicklime for the mixture was found to be 4%.

C. Effect on UCC strength

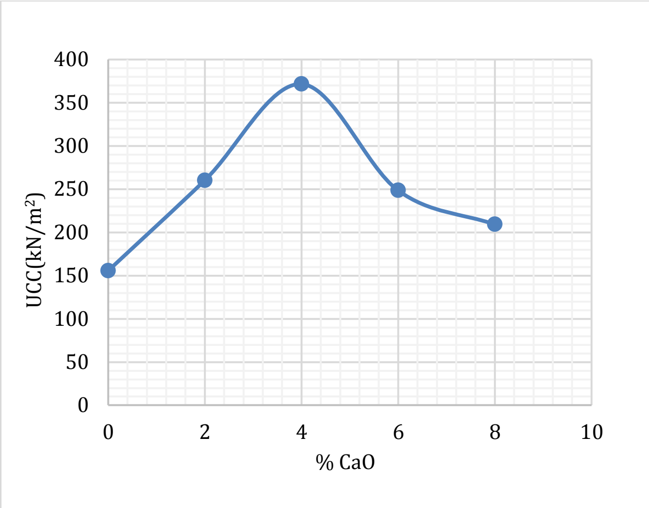

Fig 6. Variation of UCC

For soil + 10% GGBFS treated with quicklime at various percentage, the optimum dosage of quicklime was found to be 4%.

4. CONCLUSION

Based on the test performed, the following conclusion are drawn:

In mixture of soil and GGBFS,

1.Atterberg limits decreased with increase in percentage of GGBFS.

2. MDD increases and OMC decreases with increasing percentage of GGBFS to a certain limit then decreases.

3. UCC strength increased with increasing percentage on curing. Optimum amount of GGBFS was found to be on 10% and maximum strength was obtained for 7-day curing.

In mixture of soil+10%GGBFS+ quicklime

1.atterberg limits decreased with increasing percentage of lime.

2.the optimum amount of quick lime on soil + 10% GGBFS mixture was found out to be 4% for 7-day curing.
From the above conclusion, it can be concluded that a mixture of quicklime and GGBFS was found to be effective.

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