Durability Enhancement Of GGBFS Stabilized Soil Using Calcium Oxide

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Abstract- *Use of GGBFS with soil was found to be effective for stabilization. The durability of GGBFS stabilized soil is less due to weak bonding between GGBFS and soil. Therefore, it is essential to meet the durability conditions for the long-term use of stabilized soil as subgrade when it is subjected to repeated wet and dry climatic conditions. This study carries out the use of oxides of calcium to determine the durability of soil with and without GGBFS.*

Keywords- Durability,Drying-wetting cycle test, Unconfined compressive strength.

I. INTRODUCTION

In the field of geotechnical engineering, construction of structures on soft soil or ground area is a great challenge.Due to low shear strength and high compressibility of this soil ,many engineering problems in the form of slope instability, bearing capacity failure or excessive settlement could occur either during or after the construction phase soils with high percentage of clay content have very high strength. Consistency or firmness of soft s clayey oil can be increased by adding various additives like slag ,lime, flyash etc.

Addition of GGBFS to clayey soil gives strength to the soil whereas the durability of mixture upon wetting and drying is less. Calcium Oxide (CaO) was found to be effective to improve the strength of soft soil. The present study includes the effect of CaO in treated and untreated soil with GGBFS to compare the increase in durability of stabilized soil.

II. MATERIALS

Materials used for the study are: soil ,GGBFS and Calcium Oxide.

2.1.Soil:

Soil was collected from Kazhakuttom, Thiruvananthapuram, Kerala, India. The properties of soil were tested and tabulated in Table -1. Based on Indian Standard Classification System (ISCS), the soil is classified as Clay of intermediate compressibility (CI). Unconfined compression test was conducted to confirm the soil is soft.

Table 1. Properties of 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/m^2)	38.24

2.2. Ground Granulated Blast Furnace Slag (GGBFS)

GGBFS is an industrial by-product material produced from manufacture of iron. It mainly consists of lime, alumina, and silicate. During the production of GGBFS, 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 2.

2.3 Quicklime (CaO)

Laboratory reagent grade Calcium Oxide (CaO) was used as the binding agent. Distilled water was used in preparing the test specimens and for curing. It was collected from Central Scientific Supplies Co. Ltd, Trivandrum. Properties of CaO is tabulated and shown in Table 3.

Table 3. Properties of CaO

PROPERTIES	CaO
Physical Appearance	Dry Powder
Colour	White
Molar Mass (g/mol)	56.08
Density (g/cm^3)	3.3

Table 2. 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

III. METHODOLOGY

3.1 Tests Conducted

Various tests were conducted to determine the durability of GGBFS stabilized soil using oxides of calcium.4 mixes were selected upon which durability tests was conducted. The samples were cured for few days.

Following tests were conducted:

a)Standard proctor test (IS: 2720 (Part 7)-1983)
b) Unconfined compression test (IS: 2720 (Part 10) -1983)
c) Drying wetting cycle test (ASTM D4843 - 88(2016)

3.2 Selected Mix

1. MIX 1: It comprises of soil only.Standard Proctor Compaction test was conducted to determine optimum moisture content and maximum dry density of soil. Specimen were prepared for conducting unconfined compression tests at optimummoisture content.

2. MIX 2: It comprises of soil and GGBFS.GGBFS was added to soil at varying percentage (5%,10%,15% and 20%).Standard Proctor Compaction test was conducted to determine optimum moisture content and maximum dry density of each mixture.Unconfined compression tests at optimum moisture content wasconducted for each percentage. Specimen with maximum UCS was selected as mix 2.

3.MIX 3: It comprises of Soil and CaO. CaO was added to soil at varying percentage (2%,4%,6% and 8%).Standard Proctor Compaction test was conducted to determine optimum moisture content and maximum dry density of each mixture.Unconfined compression tests at optimum moisture content was conducted for each percentage. Specimen with maximum UCS was selected as mix 3.

4. MIX 4. It comprises of soil, GGBFS and CaO.CaO was added to mix 2 at varying percentage (2%,4%,6% and 8%).Standard Proctor Compaction test was conducted to determine optimum moisture content and maximum dry density of each mixture.Unconfined compression tests at optimum moisture content was conducted for each percentage. Specimen with maximum UCS was selected as mix 4

3.3 Durability Test (Wetting and Drying Test)

Drying- wetting cycle test was done for determining the durability of selected mixes. Specimens were allowed to cure for 7 days. 5 Specimens of height 7.5 cm and 3.8 cm diameter from each mix was prepared for conducting durability test. For drying process, each specimen is covered laterally with plastic film. Place all the specimens in an oven for a temperature of 60°C for 23 hours. Take all specimen out of oven and allow 1-hour equilibrium. For wetting process.Immerse the specimens in distilled water and maintained for 23 hours. Take all specimen out of immersion chamber and allow 1-hour equilibrium. The specimens are unwrapped and unconfined compression tests on one specimen of each mix. Then the procedures mentioned above were repeated for 3, 5, and 7 cycles.

IV. RESULTS AND DISCUSSION

4.1. Unconfined Compression Test

The UCS values of soil with different percentages of GGBFS is given in Table 4 and the variation of UCS is given in Fig 1.

Table 4.UCC strength of soil and GGBFS

Soil Mix	UCS, q_u (kPa)
Soil	57.2
Soil + 5% GGBFS	123.385
Soil + 10% GGBFS	155.648
Soil + 15% GGBFS	118.701
Soil + 20% GGBFS	88.29

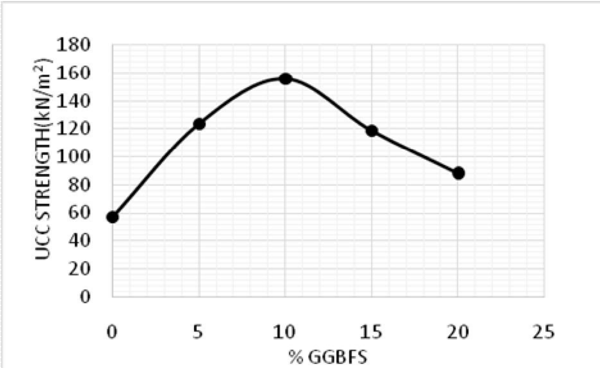

Fig 1. Variation of Unconfined compressive strength with varying percentages of GGBFS

The UCS values of soil and GGBFS stabilized soil with different percentages of CaO is given in Table 5 and the variation of UCS is given in Fig 2.

Table 5. UCC strength of soil and GGBFS stabilized soil treated with CaO

% of CaO	UCS ,q_u(kN/m^2)	
	Soil	Soil+10% GGBFS
0	57.2	155.648
2	113.04	260.31
4	202.11	371.67
6	217.6	248.51
8	170.11	209.22

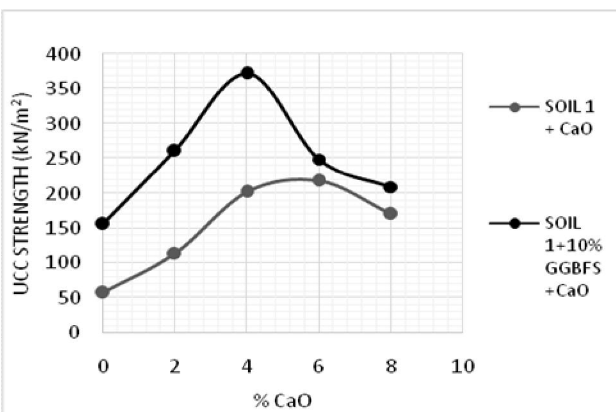

Fig 2. Variation of Unconfined compressive strength with varying percentages of CaO in soil and GGBFS stabilized soil

4.2. Mix Design

4 mixes were selected upon which durability tests was conducted. The samples were cured for 7 days. Table 6 shows the selected mixes.

Table 6. Selected mix design

MIX	COMPOSITION
Mix 1	Soil
Mix 2	Soil + 10% GGBFS
Mix 3	Soil + 6% CaO
Mix 4	Soil + 10% GGBFS + 4% CaO

4.3 Drying and Wetting Test

Drying-wetting cycle tests were conducted as per ASTM D4843 - 88(2016) on each selected mix. Table 7 shows the results of above test.

Table 7: Results of wetting- drying cycle test

Mix	UCS ,q_u(kN/m^2)					
	Number of Cycles					
	0	1	3	5	7	9
Mix 1	57.2	19.4	0	0	0	0
Mix 2	155.6	61.3	21.3	18.6	0	0
Mix 3	217.6	138.1	63.1	43.1	0	0
Mix 4	371.7	298.2	131.4	106.8	65.7	64

From the results, it was found that Mix 4 gave the maximum durability up to 9 cycles where other 3 mixes retained its strength on drying and wetting only up to 5th cycle. The consistency of the mix remains in medium.so mix 4 can be used as a durable material for subgrade.

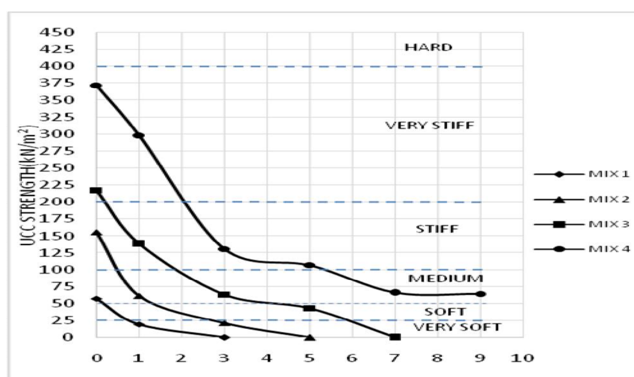

Fig 3. Effect of drying-wetting cycle on UCS of mixes

V. CONCLUSION

From the above results various conclusions can be drawn:

- GGBFS stabilized soil shows an improved increase in strength of soil.
- Ucs value of soil was very less which showed very less durability.
- UCS of GGBSF stabilized soil and CaO stabilized soil mix will become zero after 5 cycles of drying and wetting.
- Durability of mix 2 and 3 was found to be low
- Soil-GGBFS-CaOmix shows comparatively greater durability than mix 2 and 3 . Because this mix shows a strength value even after the 9th cycle of drying and wetting which isdue to the formation of cementatious.

REFERENCES

[1] Mohammed Mustapha Bessaim, AichaBessaim, HanifiMissoum, Karim Bendani (2018), "Effect of quick lime on physicochemical properties of clay soil", pg 1-4.

[2] Tatiana Olinic, Ernest Olinic (2016), "The Effect of Quicklime on Soil Stabilization", Agriculture and Agriculture Science Procedia, Vol 10, pg 444-451.

[3] Dash, S. K., and Hussain, M.(2011),"Lime stabilization of soils: reappraisal". Journal of materials in civil engineering, vl. 24, no. 6, pp. 707-714.

[4] Khushbu S. Gandhi, Shruti J. Shukla (2019), "Durability Of Commercial Waste Bagasse AshAnd Ground Granulated Blast Furnace SlagStabilized High Plastic Clay", International Journal of Recent Technology and Engineering,Vol 8(1), pp 2965-2971.