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STABILIZATION OF SOFT SOIL USING INDUSTRIAL WASTE

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ABSTRACT

Improving the engineering properties of soil like its strength and bearing capacity is called as stabilization of soil. Soil stabilization also decreases permeability and structure base settlement. To endure various loads of the structure or pavement, the subgrade soil has to be strong enough to carry these loads without failure. If the subgrade soil is not good enough to sustain the loads, it should be stabilised to make it more suitable for construction. Ground-granulated blast-furnace slag (GGBS or GGBFS) is created by quenching molten iron slag (a derivative of iron and steel production) in water or steam, generating a glassy, granular product that is then dried and finely ground. Ground-granulated blast furnace slag is highly cementitious and contains a high concentration of calcium silicate hydrates (CSH), a strength-enhancing compound that improves the strength, durability, and appearance of the concrete.

In this study, a soil sample was mixed with 3%, 6%, 9%, and 12% GGBS by weight, and experiments were carried out, with the results comparison with control sample with 0% GGBS. Atterberg limits, Standard proctor test, unconfined compression test (UCS), and California bearing ratio are amongst the tests performed (CBR).

The obtained results revealed that unconfined compressive strength increased as GGBS increased from 0% to 12%. With regard to the California bearing ratio test, the value has increased as GGBS increased from 0% to 12%.

While performing the UCS test, it was discovered that the compression strength improved from 1.19 percent at 0% GGBS to 2.27 % at 9% GGBS and then decreased to 1.24 % at 12% GGBS. The optimal percentage of GGBS with the highest CBR value is 9 percent.

KEYWORDS: Soil stabilization, waste reduction, California bearing ratio (CBR), unconfined compressive strength (UCS), Atterberg limits

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1. INTRODUCTION

The stability of the soil is critical for the stability and safety of the structure. This stability is determined by the engineering properties of the soil, specifically its strength and bearing capacity. These geotechnical properties are critical in determining whether soil can be used as we wish. If the soil is less stable, its properties must change for it to be useful to us. Stabilization is responsible for this shift. Soil stabilisation as a process entails a variety of methods for achieving desirable engineering properties in soil. Soil stabilisation improves both the strength and durability of the soil. These are expressed quantitatively as compressive strength, shear strength, and bearing strength. Soil stabilisation focuses on improving soil strength and resistance to water softening by bonding soil particles together, water proofing the particles, or a combination of the two. To ensure that soil stabilisation is cost-effective and based on functional criteria, first determine the inadequate properties of the soil and then select the best possible soil stabilisation technique. Soil stabilisation has been around for a while, and there are various methods of soil stabilisation in use. The method of using cement with soil to stabilise the soil has been used in the past and is well validated, but due to the high cost of cement, it has become less recognised in recent times. Another reason for its decreased use in recent years is the negative environmental effects of its production. This has resulted in the need for other options. These alternatives must be both inexpensive and have a lower environmental impact than cement production.

The alternatives to cement as stabilizing agents can be the industrial wastes. These are the by-products of industries. Industrial wastes are at times preferred over cement because they are cheaper compared to cement and production of cement produces other by products

that are harmful to our environment. One such industrial waste is ground granulated blast furnace slag (GGBS). GGBS is a by-product of iron and steel making obtained by quenching molten iron slag from a blast furnace in water or steam.

1.1. Mechanical Stabilization

Granular stabilization is another term for mechanical stabilization. The fundamental principles at work are proportion and compaction. This technique involves the mixing of various types of soils with varying gradients. This is done in order to create a compacted soil mass.

1.2 Chemical Stabilization

The desired soil properties are achieved using this technique by adding chemically active materials to the soil. Lime, cement, bitumen, fly ash, and other soil stabilizers are examples.

Clayey soils have been stabilized using this technique. Lime improves strength and stiffness while also reducing swelling and shrinking. Its action in soil is dependent on pozzolanic materials. It is composed of clay minerals and amorphous compounds, and its absence renders lime stabilization ineffective. The process of using cement with soil to stabilise the soil has been used in the past and is well validated, but due to the high cost of cement, it has become less recognised in recent times. Another reason for its decreased use in recent years is the negative environmental effects of its production. Fly ash is a waste of coal-fired power and steam plants. It is a widely used chemical stabiliser that is based on the pozzolana reaction and aids in the filling of voids in mixtures. It works best with coarse-grained particles. GGBS is obtained from blast furnace slag, a by-product of the manufacture of iron. It mainly consists of silicate and aluminosilicate of melted calcium that periodically needed to be removed from the blast furnace. The composition of GGBS depends on the raw material used in the manufacture of iron while the physical properties depend upon the cooling process used to cool down molten material.

2. OBJECTIVES

1. Determine the best GGBS percentage for soil stabilization.
2. To assess the effects of GGBS percentage on soft soil geotechnical properties such as California Bearing Ratio and unconfined compressive strength.
3. To assess the effects on maximum dry density and optimum moisture content.

3. MATERIAL & METHODOLOGY

3.1Soil

The soft soil was collected from Ichgam rural road, Budgam district Jammu and Kashmir at a depth of 0.35 m for this study.

Fig 1: Soil sample

3.2 Ground granulated blast furnace slag

GGBS was purchased online via India mart sourced from Dalton mines Delhi.

Fig 2: GGBS sample

3.3 Methodology

The various physical properties of the soil like Specific Gravity, Grain size distribution,Consistency, Optimum moisture content (OMC), Maximum dry density (MDD), Unconfined compressive strength (UCS) and California Bearing Ratio (CBR) values were found out in laboratory.

Table 1: Properties of soft soil

Soil properties	Description
Liquid limit	69.14
Plastic limit	21.57
Plasticity index	47.56
Optimum moisture content	14.3
Maximum dry density	1.71
CBR value (soaked)	2.04
CBR value (unsoaked)	5.9
Specific gravity	2.46
Shear strength	0.59

After that we mixed the GGBS with the different proportion (such as 3%, 6%, 9% and 12% of dry weight of soil) and found out the physical properties of GGBS mixed soil compare the observations that obtained.

Table 2: Combinations of additive with soil

S no	Soil (%)	GGBS (%)
1	97	3
2	94	6
3	91	9
4	88	12

4. RESULTS AND DISCUSSION

4.1 Effect of Specific gravity

For virgin soil, the specific gravity is 2.46. As we raise the value of the GGBS percentage, the value grows. The value rises to 2.49 for a 3% increase in GGBS and rises to 2.57 for a 12% increase in GGBS, representing a 4.84 percent increase.

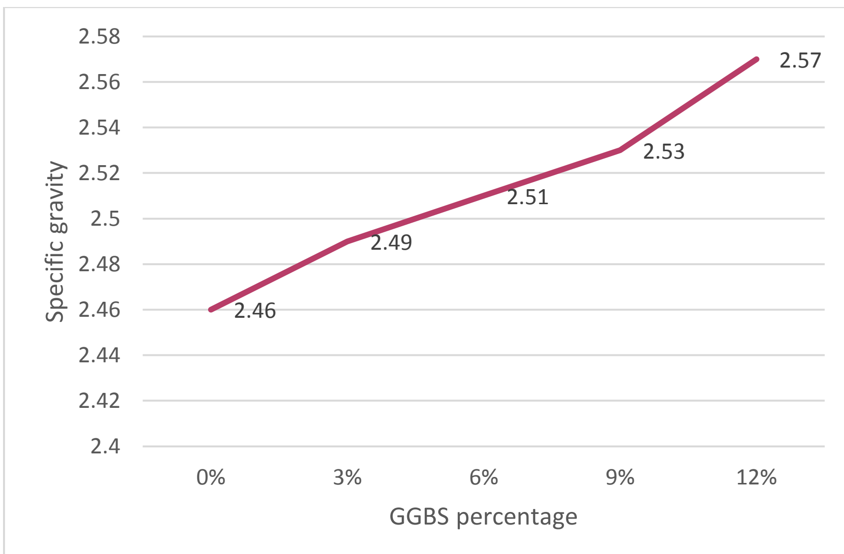

Fig 3: Specific gravity vs GGBS percentage Graph

4.2 Effect of compaction properties

Maximum dry density (MDD) and optimum moisture content (OMC) of all trial mixtures were determined in the laboratory in accordance with IS: 2720 (Part 8) - 1983. A standard proctor test was performed to determine the correlation between dry density and moisture content. The testing was conducted out with 3%, 6%, 9%, and 12%. GGBS percentages mixed with soil to test the impacts on optimum moisture content and maximum dry density.

The OMC for 0 percent GGBS addition was 14.3 percent, and the MDD was 1.71 gm/cc. When we mixed % GGBS, the OMC reduced to 13.9 percent, a 2.79 percent decrease. The MDD remained unchanged. The addition of 6% GGBS reduced the OMC by almost 4.89 percent to 13.6 and increased the MDD by about 1.75 percent to 1.74.

With a 9 percent increase in GGBS, OMC decreased to 13.4, a 6.2 percent decrease, and MDD increased by 2.92 percent to 1.76. With a 12 percent increase in GGBS, OMC decreased to 13.3, a 6.9 percent decrease, and MDD increased by 3.5 percent to 1.77. The graphs below show the same thing.

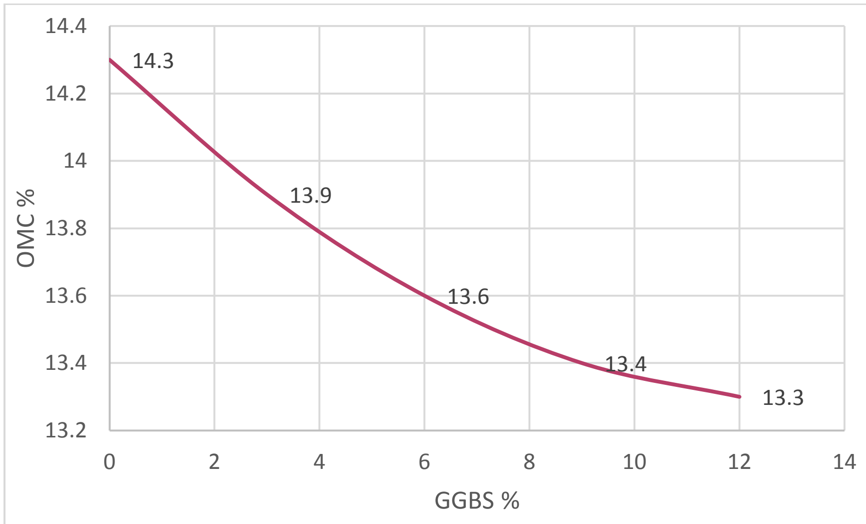

Fig 4: OMC and GGBS percentage graph

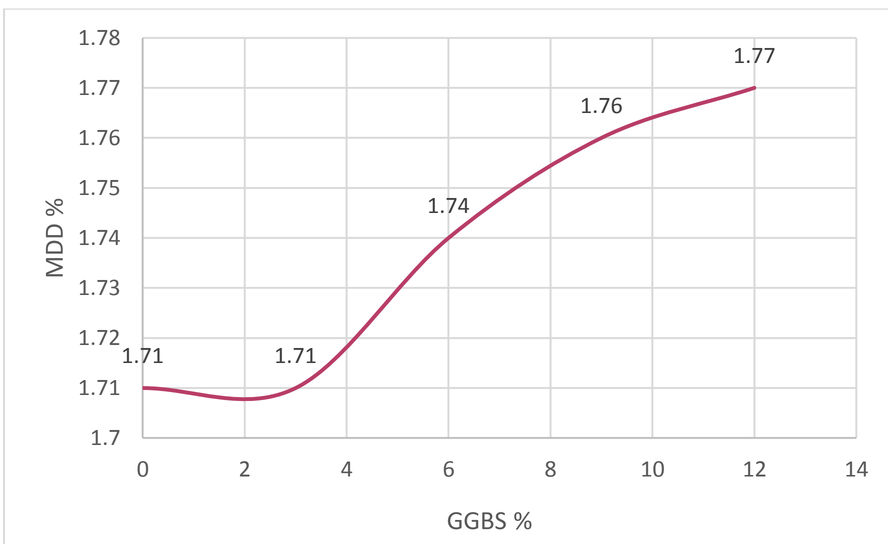

Fig 5: MDD vs GGBS percentage graph

4.3 Effect of Shear strength

Shear strength is the internal resistance to failure or deformation caused by continuous shear displacement of soil particles. Unconfined compression test was carried out to find the shear strength of soil sample. The test was carried out with 3%, 6 %, 9 % and 12 %. Percentages of GGBS mixed with soil.

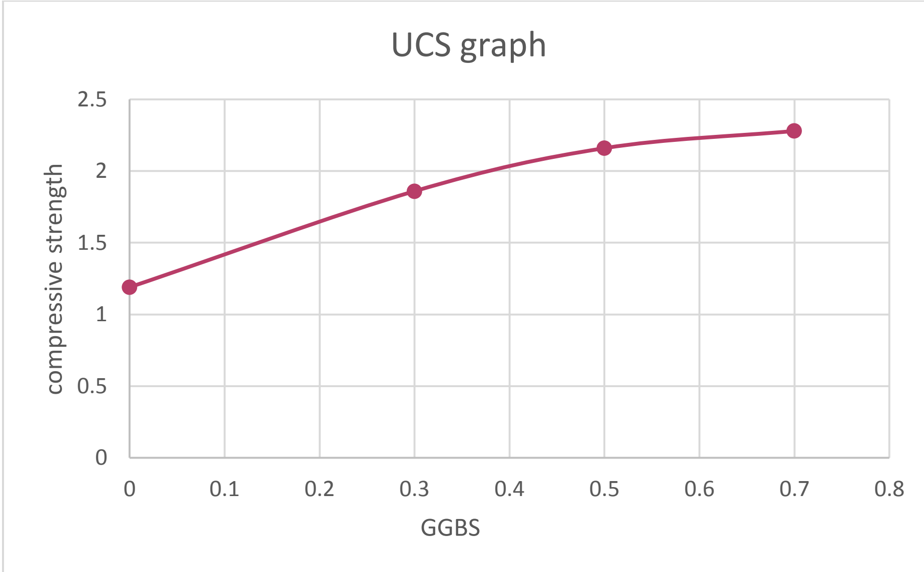

Fig 6: compression strength vs GGBS content Graph

We performed the unconfined compressive strength test, at 0%, 3%, 6 %, 9 % and 12 %. The value for compressive strength for 0 % addition of GGBS was 1.19 kg/ cm^2, when we add 3% of GGBS the compression strength becomes 2.12 kg/ cm^2 which is an increase of 78 %. The percentage of addition of GGBS is increased to 6 % and the value of compressive strength increases to about 2.56kg/ cm^2 which is an increase of 115%. When the GGBS percentage is increased to 9 percent, the compressive strength increases by 90.7 percent to 2.27 kg/ cm2. When we increase the GGBS addition to 12%, the compressive strength increases to 1.24 kg/ cm2, a 4.2 percent increase.

4.4 Effect of CBR

The analysis was performed for the following percentages of mixed GGBS: 0%, 3%, 6%, 9%, and 12%. The specimens have been compacted at their OMC and MDD from the Proctor test, and the test was run until 12.5mm of penetration was achieved. The test was performed on both soaked and unsoaked samples.

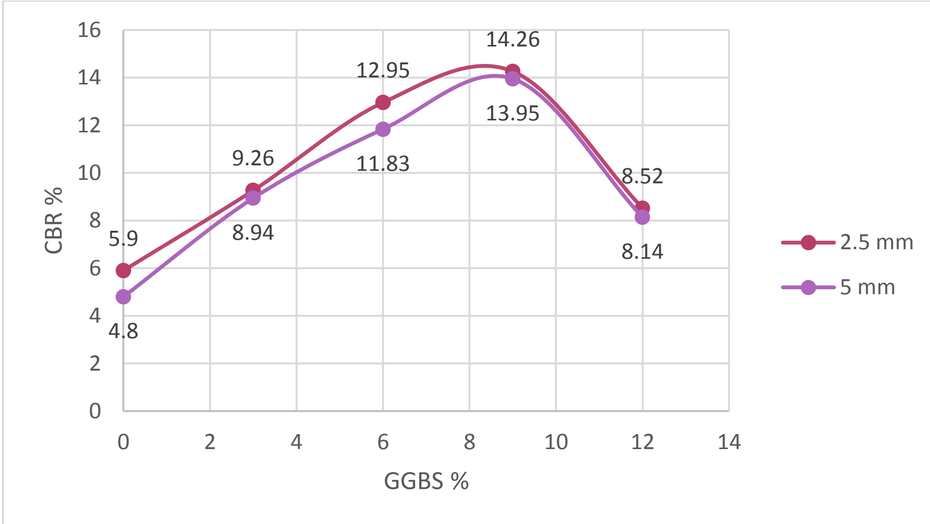

Fig 7: CBR vs. GGBS graph for unsoaked condition

We tested the California bearing ratio at 0%, 3%, 6%, 9%, and 12%. These are the values for unsoaked conditions. The value for CBR for a 0% addition of GGBS was 5.90%; when we add 3% of GGBS, the value rises to 9.26%, representing a 56.9 percent increase. The percentage of GGBS added is increased to 6%, and the value of CBR is increased to approximately 12.95, representing a 119.4 percent increase. When we increase the GGBS wastes to 9 percent, CBR rises to 14.26, representing a 141.6 percent increase. When we increase GGBS wastes to 12%, CBR rises to 8.52, representing a 44.4 percent increase.

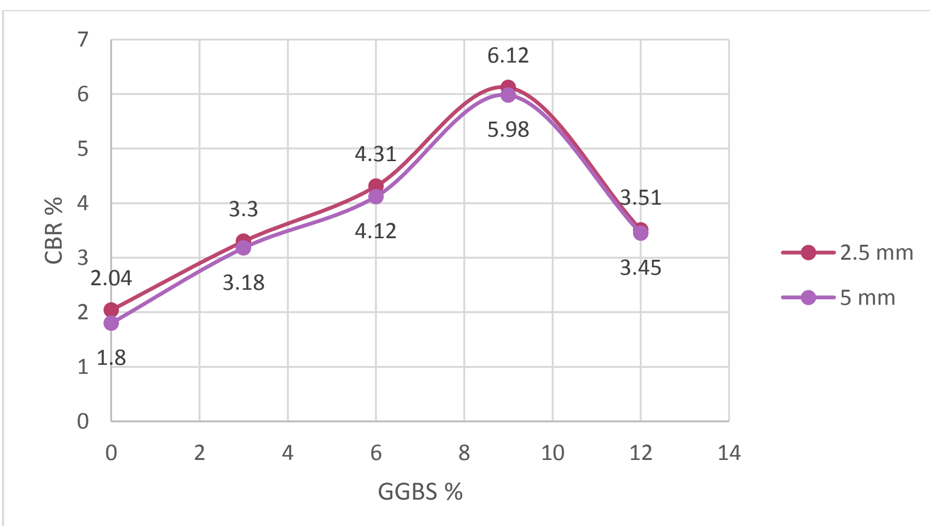

Fig 8: CBR vs. GGBS graph for soaked condition

We performed California bearing ratio test, at 0%, 3%, 6 %, 9 % and 12 %. These values are for unsoaked conditions. The value for CBR for a 0% addition of GGBS was 2.04 percent; when we add 3% of GGBS, the value rises to 5.12 percent, a 62 percent increase. The percentage of GGBS added is increased to 6%, and the value of

CBR is increased by 110 percent to approximately 4.31. When we increase the proportion of GGBS wastes to 9 percent, CBR rises to 6.12, a 199 percent increase. When we increase the proportion of GGBS wastes to 12 percent, CBR rises to 8.52, a 72 percent increase.

5. CONCLUSION

- The purpose of this study was to look into the effect of GGBS on the physical and engineering properties of soft soil. The soft soil was mixed in various proportions with GGBS (0, 3, 6, 9 & 12 present).
- The results indicate that using GGBS enhanced the soil's physical and strength properties. With the addition of GGBS to the soil, the Plasticity Index decreased, whilst also MDD and OMC increased and decreased, respectively.
- According to the UCS tests, the optimum amount of GGBS was 6 percent, which increased the strength by approximately 115 percent over soft soil.
- According to the CBR tests, the optimum amount of GGBS was 9 percent, for both the soaked and unsoaked conditions.
- Further GGBS is cheaper than cement, lime so it is cost saving, GGBS is easily available from near steel plant and use of GGBS enhances the waste management techniques.

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