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Utilization Of GGBS For Eco-Friendly Stabilization Of Black Cotton Soils

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Abstract: Black cotton soil, known for its high swelling and shrinkage characteristics, often causes severe damage to pavements and foundations due to volume changes with moisture variation. This study investigates the use of Ground Granulated Blast Furnace Slag (GGBS) — an industrial by-product — for the sustainable stabilization of black cotton soil. Various laboratory tests such as Atterberg limits, were performed to assess improvements in soil behavior. The results revealed that the addition of GGBS significantly reduced the liquid limit and plasticity index, indicating lower expansiveness, while enhancing the soil's strength and stability. Utilizing GGBS not only improves the geotechnical properties of black cotton soil but also supports eco-friendly and cost-effective construction practices by repurposing industrial waste. Thus, GGBS serves as an efficient and sustainable alternative to conventional stabilizers for black cotton soil.

Index Terms **- Black cotton soil, Ground Granulated Blast Furnace Slag (GGBS), eco-friendly.**

I. INTRODUCTION

Soil is a fundamental material in civil engineering, and its stability directly affects the performance and safety of structures. Expansive soils, such as black cotton soil, pose significant challenges due to high swelling and shrinkage caused by montmorillonite clay minerals. These volumetric changes can lead to cracks in pavements, foundations, and other structures, making stabilization essential before construction.

Traditional stabilizers like lime and cement improve soil properties but are associated with high costs and environmental concerns. As a sustainable alternative, industrial by-products such as Ground Granulated Blast Furnace Slag (GGBS) have gained attention. GGBS, a by-product of iron production, exhibits cementitious properties and reacts with clay minerals to enhance soil strength and reduce plasticity. Its use not only improves soil performance but also promotes waste utilization and environmental sustainability.

This study aims to evaluate the effects of GGBS on black cotton soil, determine changes in Atterberg limits, identify the optimum GGBS content, and encourage sustainable practices in geotechnical engineering.

II. LITERATURE REVIEW

Ground Granulated Blast Furnace Slag (GGBS) is widely reported as an effective and eco-friendly stabilizer for Black Cotton Soil, significantly improving engineering properties by reducing plasticity and swelling while increasing strength parameters such as UCS and CBR. Studies show that adding 10–20% GGBS, often activated with small amounts of lime, leads to the formation of cementitious gels (C–S–H and C–A–S–H) that densify the soil matrix and enhance durability (Darsi et al., 2021; Noolu et al., 2021). Microstructural investigations confirm improved bonding and reduced pore spaces, resulting in better load-bearing capacity (Malgotra, 2023). Several experimental works (Vastrad, 2018; IRJET, 2019) also highlight

that GGBS stabilization offers a lower-carbon, sustainable alternative to cement-only methods, making it suitable for pavement subgrades and foundation layers in expansive soil regions.

III. MATERIAL

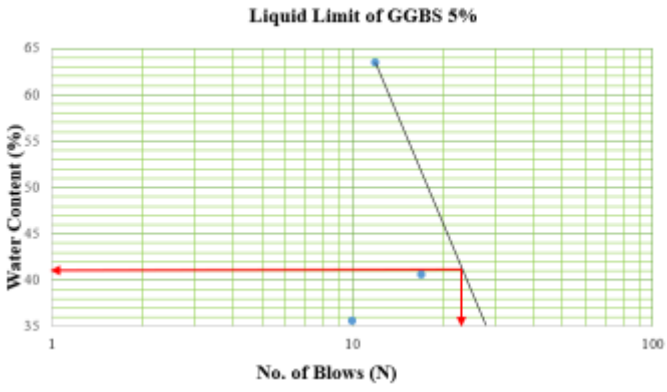
GGBS: A fine by-product of the steel industry containing calcium, silica, and alumina. It forms cementitious compounds that improve soil strength and reduce plasticity, making it a sustainable stabilizer.
Black Cotton Soil: Expansive clay soil from the Nagpur region, rich in montmorillonite, showing high swelling, shrinkage, and plasticity. It is weak in its natural state and requires stabilization for engineering use.

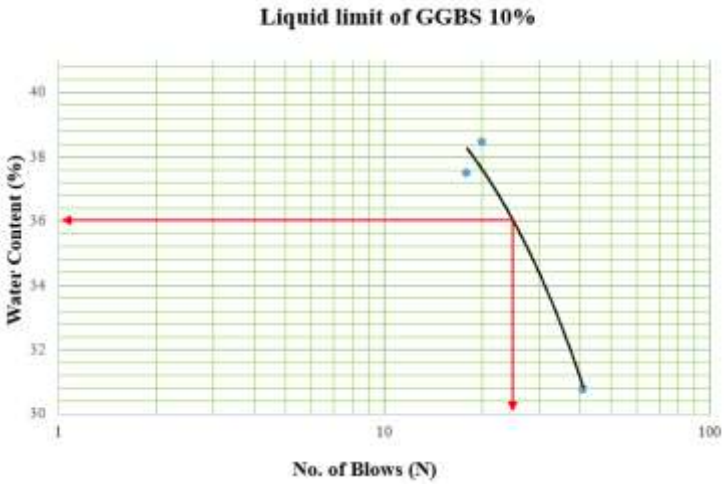
IV. RESULTS AND DISCUSSION

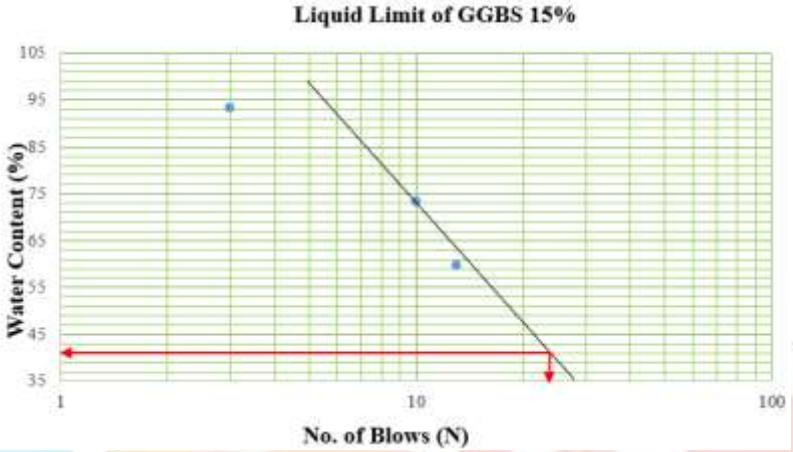
The index properties of the Black Cotton Soil were determined through standard laboratory tests to understand its behavior and suitability for stabilization. The tests included Atterberg Limits (Liquid Limit, Plastic Limit, and Plasticity Index) to evaluate plasticity and swelling characteristics, along with Specific Gravity to assess the soil's composition and density. The expansive Black Cotton Soil used in this study was collected from the Nagpur region of Maharashtra, and its natural water content, specific gravity, and consistency limits were systematically measured in the laboratory. The detailed results are presented below.

UNTREATED SOIL:

Sr.No	Experiment Names	Results
1	Water content of soil	29.55%
2	Specific gravity of soil	2.68
3	Liquid Limit of soil	47%
4	Plastic Limit of soil	25.38
5	Plasticity Index	21.26%







Parameter	Untreated Soil	Soil + 5% GGBS	Soil + 10% GGBS	Soil + 20% GGBS
Liquid Limit (LL)	47%	41%	36%	39%
Plastic Limit (PL)	25.38%	32.11%	33.33%	37.77%
Plasticity Index (PI)	21.38%	8.8%	2.67%	1.22%

V. CONCLUSION

GGBS stabilization of black cotton soil leads to several significant improvements in its engineering behavior. The laboratory investigations show that the addition of GGBS effectively reduces the liquid limit and plasticity index, thereby decreasing the soil's expansiveness. The unconfined compressive strength increases noticeably, enhancing the soil's overall load-bearing capacity. The swelling potential is also greatly minimized, which contributes to improved stability for construction applications. Since GGBS is an industrial by-product, its use in soil stabilization is both eco-friendly and sustainable. Overall, GGBS-treated soil demonstrates superior engineering properties, making it highly suitable for foundations, subgrade preparation, and pavement works.

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