SOIL STABILIZATION USING TERRASIL AND GGBS FOR PAVEMENT SUBGRADE MATERIAL

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Abstract - *When the amount of moisture in the soil fluctuates, expansive soil has a tendency to expand and contract, losing its ability to sustain the structure above it and eventually collapse. It can be prevented by increasing and stabilizing the soil's characteristics. Today, nanomaterials have a bigger impact on our daily life. A crucial element in the design of both flexible and rigid pavement constructions is the subgrade soil. High moisture susceptibility and subgrade settlement, which result in the subgrade losing strength, are the main reasons for pavement failure. The pavements built on these types of soil typically deteriorate over time. In order to operate vehicles more efficiently and effectively, which calls for decent roadways, appropriate geometric design, and pavement condition maintenance, the population is growing. Without a question, road transportation is the backbone of the country and its development is of utmost importance. The soil stabilization method aids in obtaining the necessary qualities of a soil for the construction of pavement. Lack of strength is one of the main causes of pavement failure. By varying the proportions of additive materials in the sub-grade, strength can be improved. Using laboratory testing, the ideal concentrations of GGBS and Terrasil were discovered to be 15% and 0.6% respectively. Finally, the experimental results of prepared soil combinations were ana- lysed to obtain plasticity, UCS, CBR and compaction parameters. Addition of optimum percentage of GGBS and Terrasil reduced the plastic behaviour of soil and increased the UCS, CBR and compaction characteristics.*

***Key Words*: Compaction test, CBR, UCS, Terrasil, GGBS**

1. INTRODUCTION

The majority of India has black cotton soil. The hue of black cotton soils is caused by basalt residual deposits. They are very clayey soils with a color spectrum from gray to black. In order to enhance the geotechnical properties of weak soils, such as compressibility, strength, permeability, and durability, stabilizing agents (binder materials) are applied to them. Soil stabilization has begun to change recently as a result of the rising demand for fuel, raw materials, and infrastructure. It is becoming more widely used and economically advantageous as a method of soil improvement as better research, materials, and equipment become available. The subgrade, an essential component of the pavement system, is crucial in creating a solid, long-lasting surface. Highways with lower CBR values require thicker pavements to accommodate design traffic, which increases the cost of the pavement's composition. Numerous methods for subgrade stabilization have been created by various researches to address this soil-related issue.

2. Literature Review

Olaniyan et al. (2017) In this work, the geotechnical properties of weak laterites stabilized utilizing nanochemicals (Terrasil and Zycobond) are investigated. The laterites were stabilized at 5, 10, and 15%, respectively, using weight-based measurements of terrasils and zycobonds. Geotechnical tests were conducted on both stabilized and unstabilized samples, including CBR, MDD, OMC and Particle Size Analysis.

Raghavendra et al. (2018)

In this study, Terrasil and Zycobond were utilized at doses of 0.6 kg/m3, 0.8 kg/m3, 1 kg/m3, and 1.2 kg/m3, respectively. Cement is consistently utilized as 3% of the soil's volume. After curing for 7, 21, and 28 days, a test for unconfined compressive strength is conducted.At the following ratios: 0.6kg/m3, 0.8kg/m3, 1kg/m3, and 1.2kg/m3, terrasil and zycobond are compared using the free swell index.

Olaniyan O.S et al. (2018)

Weight-based measurements of terrasils and zycobonds were used to stabilize the laterites at 5, 10, and 15%, respectively. According to a particle size distribution examination, Samples A and B had 76.6% and 66.5%, respectively, of their samples passing filter No. 200. For Terrasil stabilized samples A, the LL, PI, MDD, and OMC range from (36 -52)%, (8 -32)%, (1.73 - 2.34)g/cm3, and (7.20 - 10.8)%. (36 - 58)%, (15-34)%, (1.8 - 2.63)g/cm3, and (10.5 - 14.0)% are the values for Sample B, respectively. Zycobond Stabilized samples A range from (11.5 - 24.0%), (45 - 50%), (14 - 30%), and (2.21 - 1.92)g/cm3. The values for Sample B range from (37 to 56%)%, (11-38%%), (1.79 to 2.09)g/cm3, and (9.6 to 12.4%%)%. For samples stabilized with Terrasil, the average CBR (soaked and unsoaked) ranges from (5–6)%, (13–17%)%, and (4–6)%, (20–25%)%. For samples A and B, the CBR ranges from (5–7)%, (20–29%)%, and (3–14%)%, (22–55%)%, respectively. This study demonstrated that 15% was the ideal amount of nanochemicals to provide the best compressive strength. Weak lateritic soil's geotechnical qualities were improved using nanochemicals (Terrasil and Zycobond).

Padmavathi et al. (2019) By connecting the soil particles together to form a durable product, soil stabilization procedures aim to strengthen the base soil's strength and stability to fulfill the needs of a specific application as well as boost resistance to softening when soaked or submerged. This study demonstrates the utilization of admixtures of nanomaterials to improve the strength properties of a c-/ soil (SC) with 31 percentage fines and a plasticity index value of about 15% under both OMC and SMC conditions. These materials include Terrasil, Zycobond, and cement. When Terrasil was added to the base soil, the product became watertight, and when used both separately as additives and in conjunction with cement, Zycobond and Terrasil considerably increased the product's strength qualities.

Tripathi et al. (2020)

Stabilizers including Terrasil, Recron 3-S fiber, and silica fume are used in this study to enhance the soil's engineering properties. In order to enhance the sub-grade properties of locally accessible soil, this inquiry will assess the impacts of various concentrations of Terrasil, Recron 3-S fiber, and Silica fume used separately and in combination as stabilizers. Our main focus has been on raising the soil's CBR because doing so helps from an economic perspective, it is preferable to lower the pavement's thickness.

Mathew et al. (2022) When the amount of moisture in the soil fluctuates, expansive soil has a tendency to expand and contract, losing its ability to sustain the structure above it and eventually collapse. It can be prevented by increasing and stabilizing the soil's characteristics. Today, nanomaterials have a bigger impact on our daily life. The goal of the project is to treat Kuttanad soil using nanocompound (Terrasil) as the major addition and GGBS as the secondary additive in order to improve its engineering capabilities. Kuttanad soil's geotechnical characteristics were first identified. Using laboratory testing, the ideal concentrations of GGBS and terrasil were discovered to be 9% and 0.03%, respectively. Finally, the plasticity, UCS, Triaxial, and compaction characteristics were determined by analyzing the trial results of created soil combinations. The soil's plastic behavior was decreased and the UCS and compaction characteristics were raised with the addition of the right amount of GGBS and terrasil. To find out how the treated and untreated soil behaved in terms of settling and FOS, a PLAXIS 2D analysis was conducted on both types of soil. According to the results, treated soil's settling behavior was reduced by 86%, and FOS increased from 1.03 to 2.29.

Datta et al. (2023)

The amounts of terrasil and coir fiber utilized in this investigation were 0.5% terrasil, 0.5%, 1.0%, 1.5%, and 2.0% coir fiber, respectively. Clay subgrade soil can be stabilized, strengthened, and have a higher CBR value by adding 0.5% Terrasil and 1.5% coir fiber, per analysis or test findings. The UCS confidence interval increases from 26.566 kpa to 27.209 kpa with the combined application of soil+0.5%Terrasil+1.5%coir fiber in the untreated soil.

3. Materials

3.1 SOIL

Source of soil

The soil used is intermediate compressibility clayey soil, according to IS classification. The table below lists the soil characteristics:

Table no. 1 Properties of soil used in the study

S.NO.	PROPERTIES	RESULTS
1.	Liquid Limit	36 %
2.	Plastic Limit	21.5 %
3.	Plasticity Index	14.5 %
4.	Optimum Moisture	13.1 %
5.	Maximum Dry	15.46 kN/m³
6.	Specific Gravity	2.58
7.	CBR (%) (soaked)	3.2 %
8.	CBR (%)	4.41 %
	U.C.S	140.2 kN/m²
10.	Indian Soil	CI

3.2 GROUND GRANULATED BLAST FURNACE SLAG

A courier was used to deliver the ground-granulated blast furnace slag from Delhi.

Table 2 chemical composition of Ground Granulated Blast Furnace Slag

S. No	Name of constituent	Percentage
1	SiO_2	33.67
2	$Al_2O_3 + Fe_2O_3$	19.18
3	Calcium Oxide (CaO)	36.2
4	Magnesium oxide (MgO)	8.18
5	SO_3	0.2
6	Na_2O	0.14
7	P_2O_5	0.05

3.3 TERRASIL:

Terrasil is a soil-modifying additive that is made entirely of organosilanes, is water-soluble, and is resistant to heat and ultraviolet light. Therefore, its primary function is to waterproof soils and subsoils.

It contains silanol groups, which interact with the soil's silicates to change the surface and give it long-lasting hydrophobic qualities.

By doing this, the soil will reject water molecules, making it waterproof and preventing the issues that arise from its presence.

4. EXPERIMENTAL RESULTS

4.1 STANDARD PROCTOR TEST

CLAYEY SOIL- TERRASIL AND GROUND GRANULATED BLAST FURNACE SLAG MIXES

Table no. 3: OMC and MDD results for Terrasil and GGBS mix proportions

SOIL:TL:GGBS	MDD (kN/m³)	OMC (%)
100:00:00	15.46	13.10
84.7:0.3:15	18.10	12.30
84.4:0.6:15	19.36	11.40
84.1:0.9:15	18.55	12.24

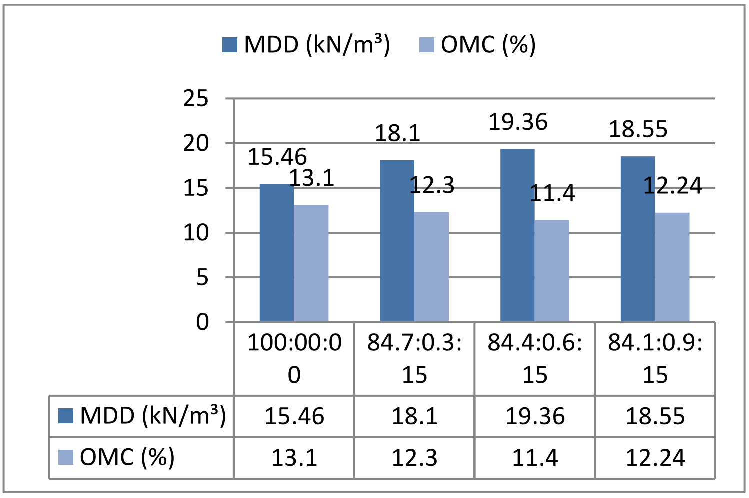

Fig:-1 Variations between MDD and OMC of GGBS and terrasil in various ratios

Table 4: Results of UCS of Terrasil and Ground Granulated Blast Furnace Slag

SOIL:TL:GGBS	Curing Period (Days)	UCS (kN/m²)
100:00:00	7	140.20
84.7:0.3:15	7	310.47
84.4:0.6:15	7	380.91

84.1:0.9:15	7	330.63

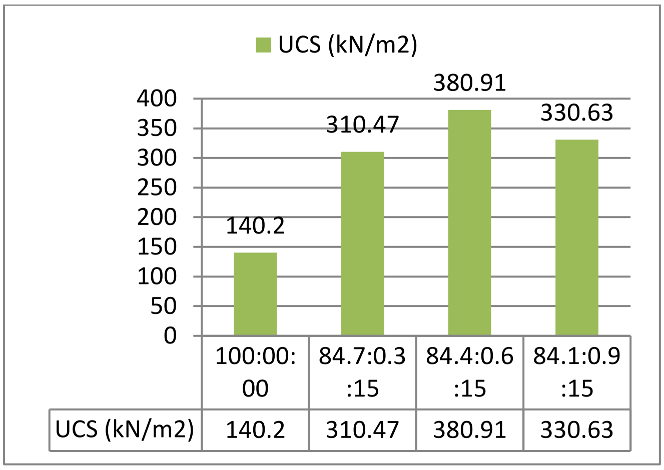

Fig:-2 UCS Graph of Terrasil and GGBS with various ratios

Table 5: Results of CBR of Terrasil and Ground Granulated Blast Furnace Slag

SOIL:TL:GGBS	CBR (%) (Soaked)	CBR (%) (Unsoaked)
100:00:00	3.20	4.41
84.7:0.3:15	5.92	9.47
84.4:0.6:15	6.87	10.30
84.1:0.9:15	6.10	9.15

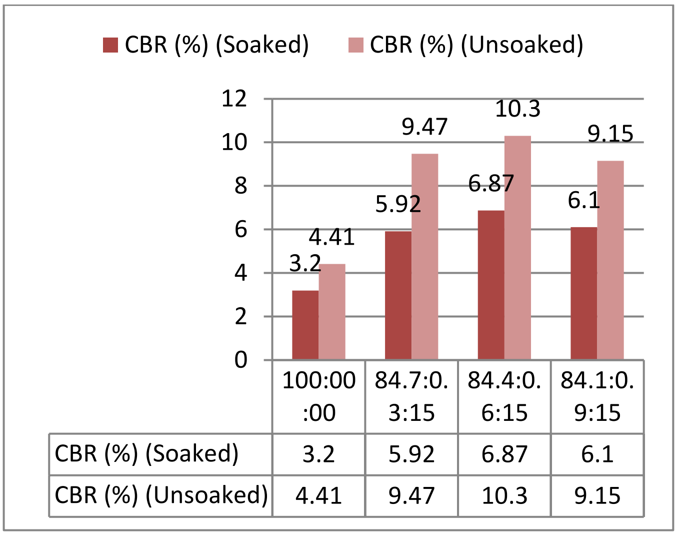

Fig:-3 CBR Graph of Coir Fiber and Terrasil with Various proportions

5 DISCUSSIONS

5.1 STANDARD PROCTOR TEST:

- This test was used to assess the soil's compaction characteristics for each dose of terrasil. For the test, three samples of soil with varying terrasil dosages of 0.5%, 1.0%, and 1.5% totaling 3kg each were collected. The outcomes of the common proctor test are displayed in Fig. 3. Peak value is 19.36kN/m3 and OMC value is lowered to 11.40% in soil that has been blended with 15% GGBS and 0.6% Terrasil.
- The graph demonstrates that the maximum dry density rises with the dosage of terrasil and GGBS up to a point when 0.6% terrasil addition and 15% GGBS are added, after which the value decreases. The optimal amounts of terrasil and GGBS addition were thus found to be 15% and 0.6%, respectively.

5.2 CBR TEST

- The wet and unsoaked values of the CBR are shown in the tables. The CBR values are raised when GGBS and Terrasil are present at concentrations of up to 15% and 0.6%, respectively. In comparison to untreated soil, the CBR value for soaked soil increases from 3.20 to 6.87%, or 2.14 times more, whereas the CBR value for unsoaked soil increased by 2.07 times, from 9.15% to 4.41%.
- Because of agglomeration, the soil is better able to withstand the stresses caused by penetration, which increases its shear resistance. Because of this, when the dosage of GGBS and Terrasil was increased, the CBR value also rose.

5.3 UCS TEST:

- According to data, when soil is combined with 0.6% Terrasil and 15% GGBS, the reinforced soil has a UCS that is 2.71 times higher than the unreinforced soil. The UCS value increased from 140.20 kN/m2 to 380.91 kN/m2 because Terrasil fills the soil's pores and functions as a water-resistive agent.
- The cause of this is that during the curing process, pozzolanic reactions occur when Terrasil and GGBS come into contact with water. It may be as a result of the chemical over time making the soil more rigid.

CHAPTER 6

CONCLUSIONS

Based on the results of the tests, the following deductions may be made:

1. Based on the results of this study, it can be concluded that GGBS is an industrial waste product that may be used to stabilize clay soil, helping to solve the problem of disposing of them in the conventional way.
2. Since adding 15% of this material to soil yields the maximum C.B.R. value, 15% of GGBS was the appropriate amount to use for this project.
3. Terrasil 0.6% with up to 15% GGBS increases the C.B.R value. It increased by 2.14 times as compared to the untreated soil.
4. For soil stability, 06% and 15% of the soil weight, respectively, of Terrasil and ground GGBS, are appropriate.
5. Unconfined compressive strength increases with an increase in Terrasil quantity and a constant amount of GGBS. Unconfined compressive strength has increased by 1.77 times when measured in comparison to untreated soil.

The soil mixes are made durable, affordable, and efficient for soil development by adding Terrasil and GGBS stabilizer if these two resources are conveniently located nearby.

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