ENHANCEMENT OF SOIL SUBGRADE PROPERTIES USING TERRASIL AND ZYCOBOND WITH WASTE FOUNDRY SAND

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ABSREACT - *Blackcotton soil deposits can be found throughout India. When exposed to changes in moisture content, blackcotton soils exhibit significant swelling and shrinkage, making them particularly challenging from an engineering perspective. To improve the mechanical behaviour of soil and increase the dependability of construction, many different ground improvement techniques, such as soil stabilization and reinforcement are used. In this study, an effort was made to enhance the strength properties of blackcotton soil treated with Terrasil and Zycobond in varying dosages of 0.06%, 0.08%, 0.1%, and 0.12% by dry weight of soil with an optimal content of Waste Foundry Sand (30%) was used as stabilizers, and the behaviour of soil to various laboratory tests was examined. The test results demonstrate that blackcotton soil stabilized with 0.1% by dry weight of terrasil and zycobond yield significant strength in terms of maximum dry density, CBR, and UCC, as well as a reduction in the Freeswell index.*

Key Words: Blackcotton soil, Waste Foundry soil, Terrasil and Zycobond, CBR, UCS

1.0 INTRODUCTION

Pavement requires high-quality materials with sufficient strength and durability qualities. The largest obstacle to providing a full road network in a developing nation like India is the lack of available funding to build roads using conventional methods; as a result, it is necessary to investigate feasible low-cost construction methods.One way to address the rising demand for road construction is to employ locally accessible materials that have undergone appropriate treatment. The goal of developing innovative construction and soil stabilising methods is to reduce the thickness of the pavement on inferior subgrade. In these situations, natural soils are treated with various compounds to enhance their engineering qualities. Research is underway to see if waste material could be used as a partial substitute in an effort to use refuse in huge quantities. By blending the waste materials with the soil, it is potential to alter the soil varied qualities and improve weak soil.

2.0 MATERIALS

Black cotton soil is highly clayed soil that ranges in colour from grey to black. They contain a highly expanding clay mineral called montmorillonite. It is quite sensitive to variations in moisture. It collected from Gulbarga district.

Ferrous and non-ferrous metal casting both produce waste foundry sand as a by-product. High-grade silica is used. It can be put to use in many of the same applications as manufactured or natural sand. Waste foundry sand from Saravana foundries in Bangalore is gathered for experiments.

Terrasil and Zycobond is a nanotechnology based product manufactured by Zydex industries Ltd. Terrasil is a water soluble, heat stable and relative soil modifier. It also reduces water permeability and maintains breathability of the soil layer. Zycobond acts as a bonding agent, it enhances quality of soil layer, controls soil disintegration, quick drying of soil layers, reduces undulations and low maintenance costs. It is available in concentrated liquid form and it is to be mixed with water in specified proportion before mixing with the soil.

3.0 OBJECTIVE OF THE PRESENT STUDY

- To determine the properties of Black cotton soil
- To access the influence of varying dosage of waste foundry sand (10%, 20% and 30% by dry weight of soil) on strength characteristics.
- To find out optimum dosage of waste foundry sand to achieve maximum strength.
- To access the effect of varying dosage of terrasil and zycobond (0.06%, 0.08%, 0.1% and 0.12% by dry weight of soil) on the strength properties.
- To find out the optimum dosage of terrasil and zycobond with addition of waste foundry sand to achieve maximum strength of soil.

4.0 LITERATURE REVIEW

Researchers T. Raghavendra et al. (2018)[(1)] conducted a study with the aim of evaluating the strength of stabilised soil during a curing time. They tested soil with varying chemical dosages for stabilisation. According to their test results, a nanochemical dosage of 1 kg/m^2 has the strongest effect. With an increase in nanochemical dosage, the freeswell index falls.

The change in soil qualities of untreated soil is the study's main focus, according to Nandan A. Patel et al. (2015)[(2)]. The study shows the change in thickness due to reactivity of soil treated with 0.041% terrasil is about 25% smaller than the thickness obtained for blackcotton soil, despite the test results showing a marginal drop in Atterberg's limits, Permeability, and CBR increased. The benefit associated with 0.041% terrasil is sustainable from an economic standpoint.

The purpose of Ajay Kumar et al. (2017)[3] is to investigate how blackcotton soil behaves both with and without stabilisation. According to their findings, the ideal amount of terrasil is discovered to be 0.07% weight of dry soil and is more effective when lime is added at a rate of 2%. At 0.07% of terrasil, the liquid limit, plastic limit, and differential freeswell index start to fall and then gradually increase.

The goal of Nandan A. Patel (2015)[4] is to examine Terrasil and Zycobond impact the soil index proportion of untreated soil. According to their test results, the soil's liquid limit improved, the plastic limit dropped, the Freeswell index decreased, and the soaked CBR also improved. From an economic standpoint, improving soil qualities with the use of terrasil (0.041%) and zycobond (0.020%) is feasible.

Manali D. Patel et al (2020)[5]'s intent is to determine the foundry sand mix in order to ascertain the proportionate quantity added for greater strength. Maximum dry density and optimum moisture content both rise with the addition of WFS. The test results indicate that 20% of the soil's weight should be the recommended dosage of foundry sand.

In their study, Kuldeep Grower (2019)[6], they used marble dust and foundry sand in dosages ranging from 13% to 22% to stabilise the soil. It is clear from the experimental results that foundry sand stabilises soil more effectively than marble dust. Because foundry sand has a high silica content, it can better bond with soil particles, enhancing the soil's bearing ability.

Selvaraj A et al(2018)[7] .'s objective is to investigate how Blackcotton soil behaves both with and without stabilisation. According to the test results, terrasil dose increases cause Atterberge limits to decrease. With an increase in dosage, the swelled index also dropped. The optimal content of terrasil is set at 1.0% by dry weight of soil for the soaking CBR, increased maximum dry density and soil.

5.0 METHODOLOGY

In this study, an effort has been made to enhance the strength properties of soil from black cotton that has been treated with Nanochemicals. Three steps make up the experimental process. On Blackcotton soil the following tests were performed in the first stage: Wet sieve analysis, Atterberg's limit test (LL and PL), Modified Proctor Compaction test, California Bearing Ratio test (CBR), and Unconfined Compression test. Blackcotton soil treated with Waste Foundry Sand of 10%, 20%, and 30% by dry weight of soil, Freeswell Index Test, Modified Proctor Compaction Test, California Bearing Ratio Test (CBR), and Unconfined Compression Test were conducted in the Second Stage. Based on strength characteristics, the stabilized samples were evaluated to determine the ideal dosage of waste foundry sand. In third stage Blackcotton soil treated with Terrasil and Zycobond of 0.06%, 0.08%, 0.1%, and 0.12% by dry weight of soil with the ideal dose of Waste foundry sand, the Freeswell index test, Modified Proctor Compaction test, California Bearing Ratio test (CBR) and Unconfined Compression test were performed. Based on strength characteristics, the stabilised samples were evaluated to determine the impact of varied Terrasil and Zycobond dosages.

5.1 FREESWELL INDEX TEST

The soil sample that passed through a 425 µm sieve was used for the test. Two samples, each weighing 10gm, were then obtained and placed in separate 100ml cylinders. Up to 100 ml of distilled water was placed in one cylinder, and up to 100 ml of kerosene oil was placed in the other. For 24 hours, the two cylinders were allowed to reach equilibrium. Following that, the ultimate volumes of both containers were noted. The lowest dosage was determined to be ideal.

5.2 COMPACTION TEST

The maximum dry density and ideal moisture content of the soil combination were determined using the Modified Proctor Compaction Test, which was carried out in accordance with IS2720 Part-8 (reaffirmed 1995). Increases in MDD and decreases in OMC are caused by an increase in compacting energy per unit volume. IS heavy compaction is performed.

5.3 CALIFORNIA BEARING RATIO TEST

Tests were conducted in accordance with IS2720 (Part-16) (reaffirmed 1997), and samples were prepared in various arrangements. After being mixed with the ideal amount of water, samples were compacted to MDD. Heavy compaction hammers were used to compact the CBR samples. Further research is being considered on four days of soaked CBR at 2.5mm penetration.

5.4 UNCONFINED COMPRESSIVE STRENGTH TEST

Test carried out in accordance with IS2720 (part 10) Static compaction was used to prepare cylindrical test specimens. The sample was tested for various curing periods 0, 7, 14, and 28 days in order to examine the effect of curing strength attributes.

Table -1: Physical properties of Black cotton soil

Soil type	Blackcotton soil
Particle size distribution	
Gravel, %	0

Sand, %	23.72
Silt and Clay %	76.28
Atterberg's limit	
Liquid limit, %	76.3
Plastic limit, %	36
Plasticity index, %	40.3
Modified compaction results	
Maximum dry density, gm/cc	1.482
Optimum moisture content, %	28.0
California bearing ratio	
Unsoaked CBR, %	5.58
Soaked CBR, %	1.397
Unconfined compressive strength, kg/cm²	1.570

6.0 RESULTS OF WASTE FOUNDRY SAND TREATED BLACKCOTTON SOIL

Table -2: Results of Freeswell index test

Description	Free swell index	Free swell ratio
BC soil + 4% cement + 10% WFS	61.90	1.619
BC soil + 4% cement + 20% WFS	45.45	1.455
BC soil + 4% cement + 30% WFS	36.36	1.364

Table -2: Results of Modified compaction test

WFS	MDD g/cc	OMC %
10%	1.77	30.8
20%	1.83	25
30%	1.922	31

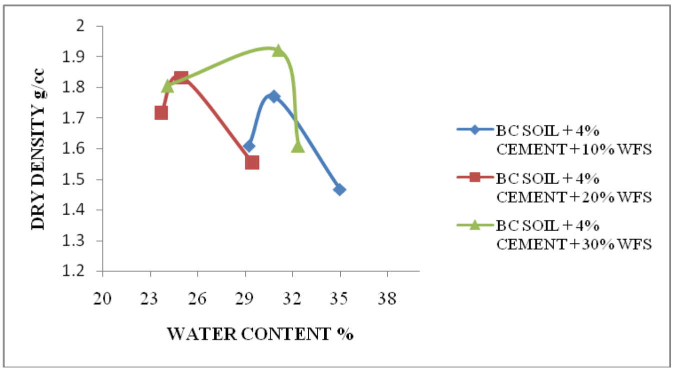

Fig.1 Variation in Compaction curves of Black cotton soil treated with percentage of Waste foundry sand

Table -3: Results of CBR

WFS	Unsoaked CBR	Soaked CBR
10	8.38	5.123
20	10.71	5.587
30	12.57	6.518

Table-4: Results of UCC

WFS	Unconfined compressive strength, kg/cm²			
	0 days	7 days	14 days	28 days
0	1.748	1.79	1.879	1.95
10	1.864	1.92	2.193	2.417
20	2.066	2.365	2.79	3.05
30	2.479	2.55	2.811	3.567

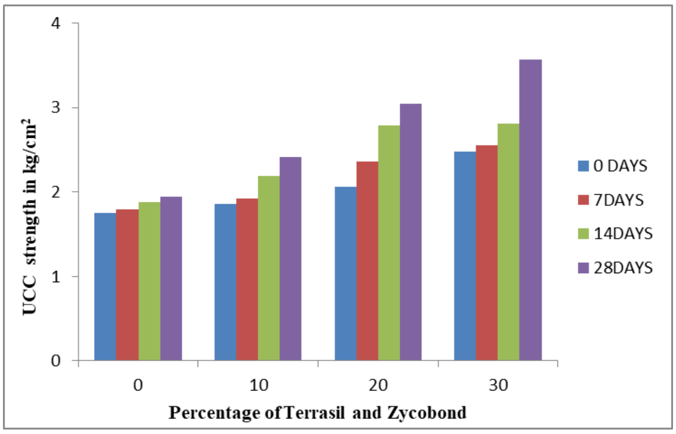

Fig.2 Variation in UCC of Blackcotton soil treated with percentage of WFS

7.0 RESULTS OF TERRASIL AND ZYCOBOND

TREATED BLACKCOTTON SOIL

Table-5: Results of Freeswell index test

Description	FSI	FSR
BC soil + 4% C + 30% WFS + 0.06% of T & Z	40	1.40
BC soil + 4% C + 30% WFS + 0.08% of T & Z	36.36	1.364
BC soil + 4% C + 30% WFS + 0.1% of T & Z	20	1.20
BC soil + 4% C+ 30% WFS + 0.12% of T & Z	25	1.25

Table -6: Results of Modified compaction test

Terrasil and Zycobond	MDD g/cc	OMC %
0.06 %	1.78	17.5
0.08 %	1.82	16.3
0.1 %	1.84	16.2
0.12 %	1.827	15.6

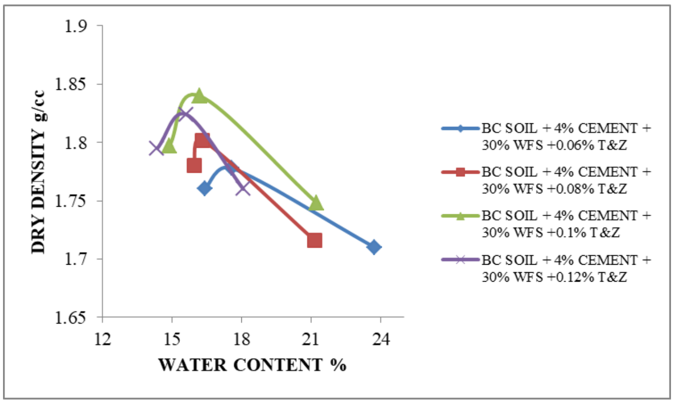

Fig.3 Variation in Compaction curves of Black cotton soil treated with Terrasil and zycobond

Table -7: Results of CBR

Terrasil & Zycobond	Unsoaked CBR	Soaked CBR
0.06 %	10.709	6.989
0.08 %	12.57	8.840
0.1 %	13.969	9.778
0.12 %	13.50	8.850

Table-8: Results of UCC

Terrasil & Zycobond	Unconfined compressive strength, kg/cm²			
	0 days	7 days	14 days	28 days
0	1.748	1.79	1.879	1.95
10	1.864	1.92	2.193	2.417
20	2.066	2.365	2.79	3.05
30	2.479	2.55	2.811	3.567

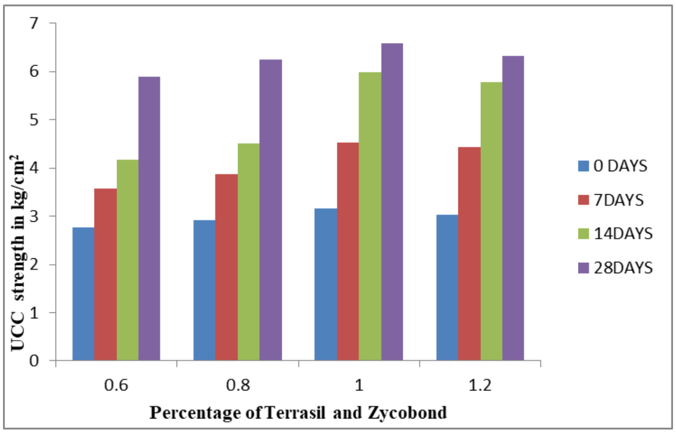

Fig.4 Variation in UCC of Blackcotton soil treated with Terrasil and Zycobond

8.0 CONCLUSIONS

From the results of investigation following conclusions can be drawn

- Freeswell index decreases from 40% to 20% with increase in dosage of Terrasil and Zycobond along with optimum content of Waste foundry sand.
- Maximum Dry Density is achieved at 0.1% of terrasil and zycobond is 1.84g/cc and Optimum Moisture Content of 16.2%.
- Higher Soaked CBR and UCS can be achieved with a combination of 0.1% terrasil and zycobond with 30% waste foundry sand and 4% cement.
- The Crust thickness of Stabilized blackcotton soil with Optimum content of terrasil and zycobond decreases when compare to crust thickness of silty soil.
- Blackcotton soil stabilized with terrasil and zycobond (0.1%) with Waste foundry sand of 30% and 4% of cement yield substantial strength.

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