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Effect of Terrasil on Geotechnical Properties of Expansive Soil Mixed With Lime

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Abstract: ***Expansive soil is considered as the problematic soil for most of construction activities because of its expansive behaviour. Thus this type of soil needs to be treated prior to any construction activities. There are many way to solve this problematic behaviour of expansive soil. Soil stabilization is one of the technique to improve the geotechnical behaviour of expansive soil. This paper presents the effect of Terrasil on the geotechnical properties of black cotton soil treated with lime. The present study is aimed at determining the geotechnical behaviour of black cotton soil-lime mixture with variation of a nano-chemical called Terrasil. The Terrasil content was varied from 0.05 to 0.09 % by the weight of dry soil, while the lime is used as a base stabilizer in quantity equals to 2% by weight of dry soil. The results indicated that the unconfined compressive strength (UCC) and CBR values of black cotton soil can be increased by the addition of terrasil and lime. The increase in unconfined compressive strength and CBR values was highest with 0.07 % terrasil. Thus the behaviour of black cotton soil in response to construction activities can be improved with the addition of terrasil as a stabilizer.***
Keywords-Expansive Soil, Soil Stabilization, Lime, Terrasil.

I. INTRODUCTION

Civil engineering structures like dams, embankments, roads and buildings which are constructed on expansive soils results in a failure due to highly expansive behaviour of expansive soils. The major reason behind failure of structure on expansive soil is its expansive behaviour which is due the presence of mineral called montmorillonite. Soil having montmorillonite minerals has high water content capacity and swells significantly when it gets wet. In India expansive soils are also known as Black Cotton Soils as cotton is cultivated in majority of the areas where this black soil is found. It covers around 16.6% of total land area of India. The construction of structures on Black Cotton Soil has always been a big challenge to any geotechnical engineers. Many researchers have worked to improve or stabilize its expansive behaviour with various admixtures. *Rintu Johnson (2015):* studied the stabilization of Black Cotton soil treated with cement and terrasil and found that the soil + 4% cement mixture added with 0.07% terrasil is the best soil combination which is exhibiting the higher UCC strength and CBR value. The UCC strength of soil-cement mixture added with 0.07% terrasil is improved about 613% higher than the strength of clay soil. The maximum CBR strength reported was 15.6% and is about 8 times the CBR strength of clay soil. *Nandan A. Patel (2015):* investigated performance of CL soil treated with 0.041% terrasil in his work. Based on the tests he observed that the treated soaked CBR values are increased which is because soil treated with 0.041% terrasil renders improved density values by reducing the void ratios conducted in the laboratory. *B M Lekha and S Goutham (2013):*conducted experimental investigation on black cotton soil and soil treated terrasil. It was observed that UCS strength increases with increase in dosage of stabilizer and curing period. It is also observed that, dosage i.e. 1.2% terrasil shows good increment, but further increase of dosage results in a marginal improvement of strength. also the CBR values increase with the increase in percentage of stabilizer .

Terrasil is a nano-chemical and is emerging as a new material for the stabilization of soil. In the present work black cotton soil was chemically stabilized by using a commercially available nano-chemical named as terrasil along with lime (used as base admixture). Experimental investigation has been carried out with 0.05, 0.07 and 0.09% variation of terrasil on black cotton soil mixed with lime (=2% by the weight of dry soil) and are tests for CBR values and UCC values at different curing periods (i.e. 0days, 14days, 21days).

II. MATERIALS

A. Black cotton soil

Soil used in this experimental work is Black Cotton soil collected from site near Sagda Railway station, Sagda, Jabalpur, (M.P.). Coordinates of this site are: 23˚8’30”N and 79˚51’53” E. Geotechnical properties of black cotton soil are given in Table- 1

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Table-1: Geotechnical properties of Black Cotton soil.

S.NO.	PROPERTIES	VALUES
1.	SOIL CLASSIFICATION	CH
2.	SPECIFIC GRAVITY	2.45
3.	LIQUID LIMIT	61.34 %
4.	PLASTIC LIMIT	25.50 %
5.	PLASTICITY INDEX	35.83 %
6.	DFS	70 %
7.	OPTIMUM MOISTURE CONTENT	16.10 %
8.	MAXIMUM DRY DENSITY (g/cc)	1.82
9.	CBR	2.37 %
10.	UCC (KN/m^2)	133.34

B. Lime

Lime used in this investigation was purchased from local market.

C. Terrasil

Terrasil is nanotechnology based product produced by Zydex Industries Ltd., Gujarat. Terrasil is water soluble, ultra violet and heat stable, reactive soil modifier. It improves the frictional value, reduces water permeability and maintains breathability of the soil layer. It is available in concentrated liquid form and is to be mixed with water in specified proportion before mixing with the soil.

Table-2**:** Composition of Terrasil chemical

Chemical compound	Value in range, %
Hydroxyalkyl-alkoxy-alkylsil	65 – 70 %
Benzyl alcohol	25 – 27 %
Ethylene glycol	3 – 5 %

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Table-3: Properties of Terrasil chemical

Property	Description
Appearance	Pale yellow liquid
Density	1.01g/ml
Viscosity at 25ºC	20-100 cP
Solubility	Forms water clear solution
Flash Point	$>80^0$C
Freezing point	5^0C

III. EXPERIMENTAL INVESTIGATION

A. Lime treated clay soil

The lime treated clay soil was prepared after mixing the 2% lime by weight of dry soil into the clay soil. Further, various laboratory tests like consistency limits, UCC strength, and CBR tests were conducted on soil-lime mixtures to examine the effect of cement on improvement of geotechnical properties of clay soil and the results are tabulated in Table 4.

Table 4: Test result on soil treated with 2% Lime

S.NO.	Property	Value
1	Consistency limits	
	Liquid Limit (%)	55.31
	Plasticity Index (%)	19.98
2.	DFS (%)	65
3.	OMC (%)	14.90
4.	MDD (g/cc)	1.84
5.	Unconfined compression strength, (KN/m^2)	139.86
6.	CBR value (Soaked) (%)	7.85

B. Methodology

A series of laboratory tests were conducted on soil-lime(=2% by the weight of dry soil) mixture with different proportion of terrasil i.e. 0.05%, 0.07%, 0.09% by weight of dry soil. The following tests were conducted on soil mixed with Lime (=2% by weight of dry soil) and terrasil as per relevant IS codes of practice:

California bearing ratio (CBR) Test (soaked CBR, with curing period as 0,14 & 21 days)

Unconfined Compression Strength (UCC) Test (with curing period as 0,14 & 21 days)

C. Mix prepration

Following mix has been prepared with different percentage of Terrasil.

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Soil Sample + 2% Lime + 0.05% Terrasil (CLT1)
Soil Sample + 2% Lime + 0.07% Terrasil (CLT2)
Soil Sample + 2% Lime + 0.09% Terrasil (CLT3)

IV. RESULTS AND DISCUSSION

Test results are summarized in Table-5 and Table-6. The result of Unconfined Compression strength (UCC) test on various dosages of terrasil added to soil-lime mixture at different curing periods (i.e. 0 days, 14 days, 21 days) is tabulated in Table-5. Variation of Soaked CBR values of sample prepared with mixture of soil, lime and terrasil at diffrent curing times (i.e. 0 days, 14 days, 21 days) are tabulated in Table-6.

A. Unconfined compression strength

To obtain the compressive strength values of each chemical treated lime-soil mixture, various UCC tests were performed on prepared samples (soil+2% lime+terrasil %). The samples were tested for different curing periods, 0, 14 and 21 days in order to examine the effect of curing on strength properties. For each chemical treated soil-lime mixture, three similar UCC specimens were prepared and tested to report the average value of UCC strength

Table 5**:** UCC Strength of Terrasil treated lime mixed soils at different curing periods

Sample Type	UCC Strength (KN/m^2) at different curing time		
	0 days	14 days	21 days
CLT1	143.03	256.32	310.26
CLT2	144.56	269.63	334.65
CLT3	143.89	260.12	318.05

The effect of Terrasil quantities and curing time on UCC strength of lime mixed soil is illustrated in fig 1. Irrespective of all dosages, the maximum strength acheived is at 21 days of curing. The UCC strength is much more in the case of soil mixed with 0.07% Terrasil chemical irrespective of all curing times. It indicates the optimum dosage of Terrasil chemical added to the lime mixed soil is 0.07% which leads to maximum UCC strength.

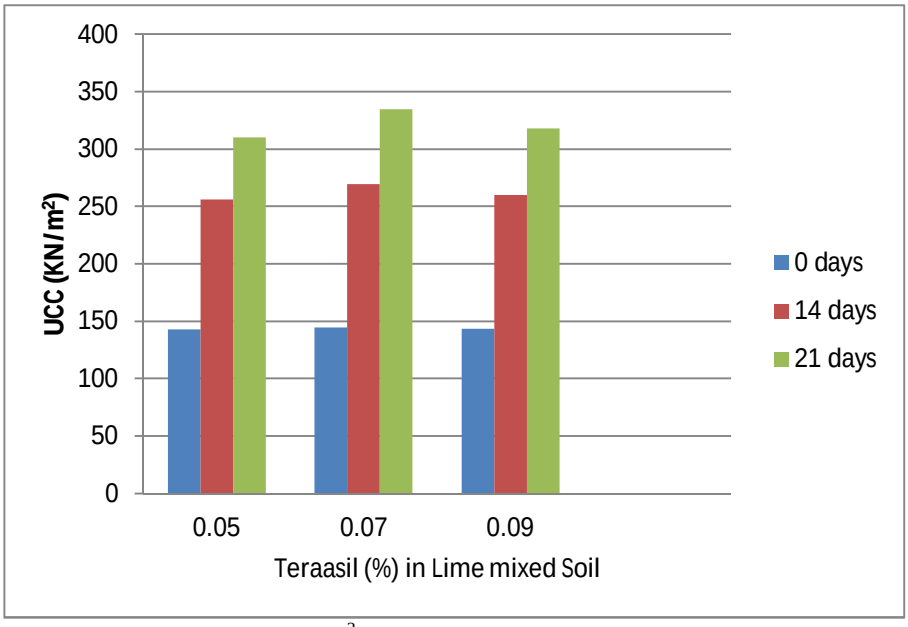

Fig 1: Variation of UCC (KN/m^2) values with Terrasil (%) at different curing period

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B. California Bearing Ratio

Three combinations of samples were prepared after adding the Terrasil chemical in the dosages of 0.05%, 0.07% and 0.09% in to the clay soil mixed with lime (i.e. 2% by weight of dry soil). The CBR chemical treated samples were compacted at maximum dry density after mixing the chemical with controlled optimum water content. The sample was compacted by using heavy compaction hammer. The samples were tested at the different curing times of 0 days, 14 days and 21 days in order to examine the effect of curing on CBR value. All prepared samples were tested for CBR after soaking them for a soak period of 4 days.

Table 6: CBR Strength of Terrasil treated lime mixed soils at different curing periods

Sample Type	CBR Strength (%) at different curing time		
	0 days	14 days	21 days
CLT1	9.18	14.17	16.73
CLT2	11.70	21.32	23.43
CLT3	9.93	19.40	21.22

The effect of Terrasil chemical dosages on CBR strength of soil at different curing times is illustrated in the fig. 2. It is clearly noted that the strength values are maximum at 21 days of curing. The maximum strength was reported to 23.43% corresponding to optimum dosage of 0.07 % Terrasil chemical added to the soil-lime mixture.

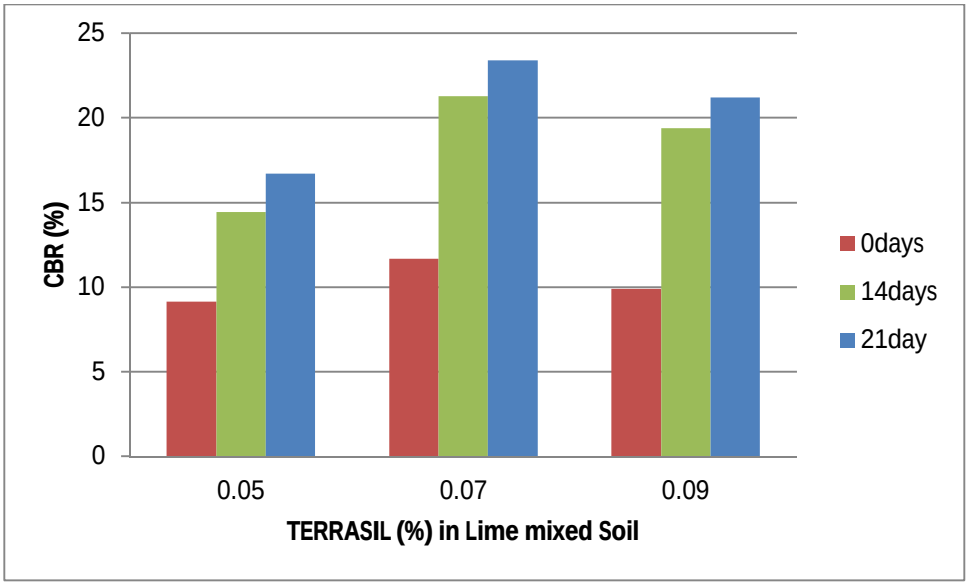

Fig 2: Variation of CBR values with Terrasil (%) at different curing period

V. CONCLUSIONS

Based on experimental investigations some major conclusions can be drawn with regards to the effect of Terrasil and Lime (as a base additive) on UCC and CBR strength of black cotton soil.

The maximum dry density of untreated soil was found to be 1.82 g/cc at an optimum moisture content of 16.10% and got improved to 1.84 g/cc at optimum moisture content of 14.90% when 2% lime by the weight of dry soil is mixed with soil.

The untreated soil has UCC strength about 133.43 KN/$m^2$and the soaked CBR of untreated soil was found to be 2.37% .

The soil treated with lime i.e. 2% by the weight of dry soil found to have UCC value about 139.86 KN/$m^2$and the soaked CBR vale of same was found to be 7.85%.

The unconfined compression strengths of soil-lime mixture treated with terrasil (in various %) was found to be maximum at an

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optimum dosage of 0.07% of terrasil chemical irrespective of different curing periods, and the highest value of UCC obtained was 334.65 KN/m^2 at curing time of 21 days.

The CBR strengths of soil-lime mixture treated with terrasil (in various %) was found to be maximum at an optimum dosage of 0.07% of terrasil chemical irrespective of different curing periods, and the highest value of CBR obtained was 23.43% at curing period of 21 days.

The maximum CBR strength reported was 23.43% and is about 10 times the CBR strength of virgin soil.

In conclusion, the soil + 2% lime mixture added with 0.07% terrasil is the best soil combination which is exhibiting the higher UCC strength and CBR value. The stabilized soil of soil-lime-terrsil mixture is very useful as a subgrade material due to improved CBR value to reduce the thickness of overlying base-course layers in road pavement.

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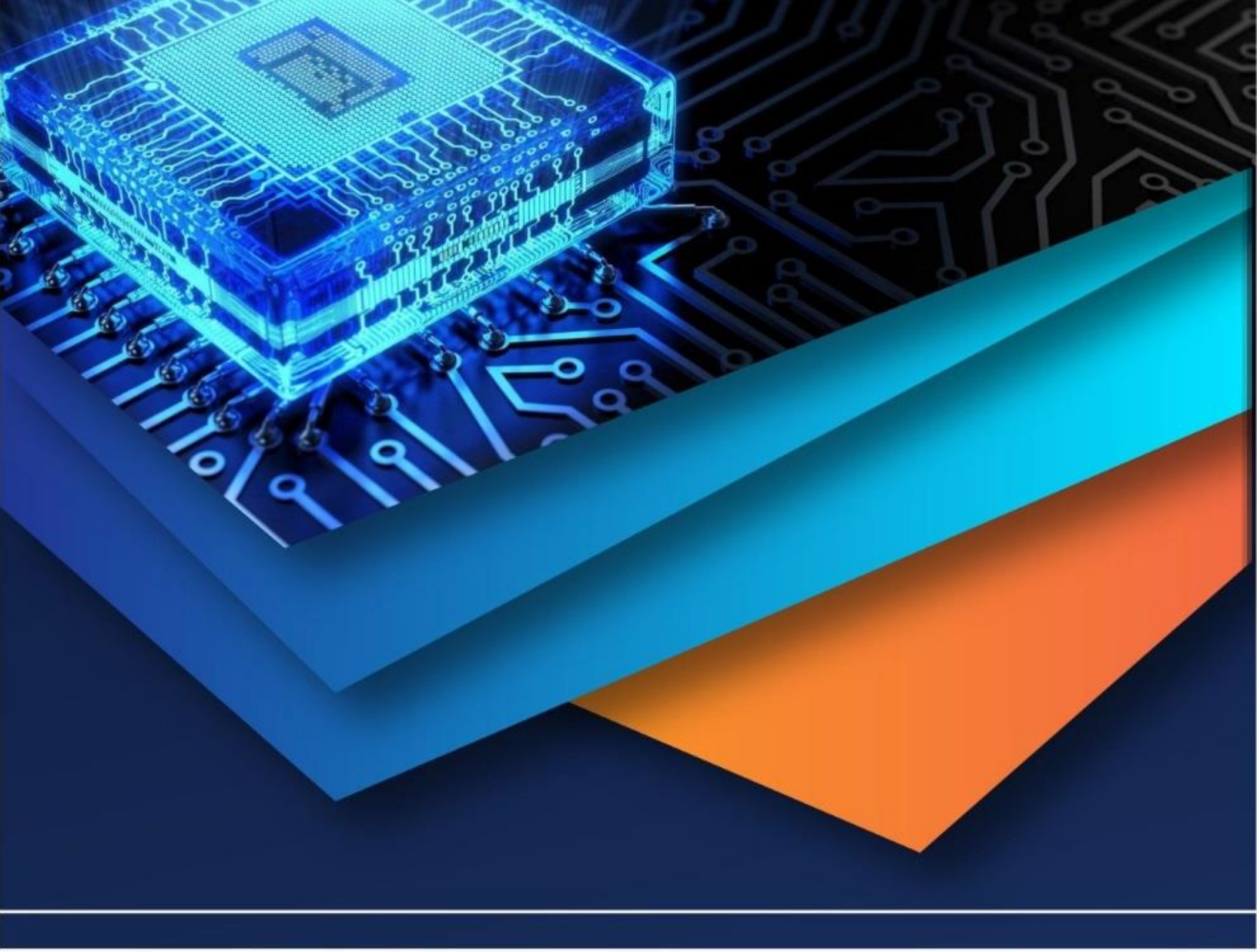

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