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EXPERIMENTAL STUDY ON INDEX PROPERTIES OF BLACK COTTON SOIL STABILIZED WITH TERRASIL

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Abstract: *India has rich deposits of Black Cotton soil about 16.6 per cent of total geographical area of the country (i.e. 5.46 lakh sq km). Black Cotton soils are expansive clayey soils associated with many problems like volume shrinkage, swelling, low CBR value, etc. For soil like black cotton soil the climatic changes are responsible for its swelling and shrinkage. They exhibit high swelling and shrinking when exposed to changes in moisture content and hence have been found to be most troublesome from engineering consideration. A great varieties of ground improvement techniques such as soil stabilization and reinforcement are employed to improve mechanical behaviour of soil, thereby enhancing the reliability of construction. In the present experimental work, the behaviour of Black Cotton soil with and without stabilization was studied. A nano-chemical named Terrasil (in varying dosages viz. : 0.03%, 0.05%, 0.07%, 0.09% by weight of dry soil.) and Lime (fixed at 2% by weight of dry soil added with all variation of terrasil) was used as stabilizers and the behaviour of soil to various laboratory test was examined. Test results shows that liquid limit, plasticity index and DFS of expansive soil decreased with increase in terrasil percentage and optimum quantity of terrasil was found as 0.07% by weight of dry soil which is even more effective when lime (=2% by weight of dry soil) is added with soil.*

Keywords-**Expansive Soil, Soil Stabilization, Lime, Nano-chemical, Terrasil.**

1. INTRODUCTION

Black cotton soil is spread in various part of world including India and has highly expansive nature due to the presence of montmorillonite clay mineral. The presence of montmorillonite in Black Cotton soil imparts high moisture content, low shrinkage limit & high optimum moisture content to it, thus these soil get very hard when dry but lose strength completely when gets wet. Soil stabilization is the alteration of properties of a soil to improve its response to engineering problems, like improvement in bearing capacity, stability, shear strength, swelling characteristics, shrinkage property. There are various forms of soil stabilization, commonly the conventional soil stabilization are achieved by chemical and mechanical stabilization techniques. The additives used for stabilization are termed as stabilizers. Many stabilizers such as fly ash, bitumen, lime, cement, and various chemicals are used for stabilization.

A number of researchers have worked in improving the properties of soil for various engineering application which are practical and economical. B M Lekha and S Goutham (2013):conducted experimental investigation on black cotton soil and soil treated with nano chemical called terrasil. It was found that with addition of chemical the consistency limit got improved, the LL got increased and also there is decrease in PI values. The best result were obtained for dosage 1.2% terrasil by weight of soil. Also permeability of soil is found to be nil for treated soil thus making soil impermeable completely. *Rintu Johnson (2015):* studied the stabilization of Black Cotton soil with using terrasil and found that with increase in dosage of terrasil added into the clay soil up to 0.07% weight of soil causes the plasticity index reduces from 41% to 18%. Also there is drastic decrease in permeability due to increased dosage of terrasil into the soil. *Nandan A. Patel (2015):* investigated performance of CL soil and CL soil treated with 0.041% terrasil in his work. Based on the tests conducted in the laboratory, he found that the liquid limit and plastic limit of the soils decrease with the addition of 0.041% terrasil in soil. FSI value of treated soil reduces because the film of adsorbed water is greatly reduced for treated soil and the surface area reduces, resulting in decreased swelling capacity.

Terrasil is a nano-chemical and is emerging as a new material for the stabilization of soil. In the present work terrasil and lime are used as admixtures. Experimental work has been carried out with 0.03, 0.05, 0.07 and 0.09% of terrasil with lime as base additive (=2% by weight of dry soil) and are tests for Liquid limit, Plastic limit, Plasticity Index and DFS test.

2. MATERIALS

2.1 BLACK COTTON SOIL

Soil used in this experimental work is Black Cotton soil and is 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

Table-1: 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	25.51%
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

2.2 Lime

Lime used in this investigation was purchased from local market.

2.3 Terrasil

Terrasil is a nano-chemical and is a nanotechnology based product manufactured by Zydex Industries Ltd., Gujarat, India. Terrasil is water soluble, ultra violet and heat stable, reactive soil modifier it also 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 compound	Value in range, %
Hydroxyalkyl-alkoxy-alkylsil	65 – 70 %
Benzyl alcohol	25 – 27 %
Ethylene glycol	3 – 5 %

Table-3: Technical specifications of Terrasil

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^{0}C

3. METHODOLOGY

A series of laboratory tests were conducted on black cotton soil mixed with different proportion of terrasil i.e. 0.03%, 0.05%, 0.07%, 0.09% by weight of dry soil, then in next stage in addition to variation of terrasil (%), lime is also added about 2% by weight of dry soil. The following tests were conducted on black cotton soil, soil mixed with terrasil, and on combination of soil+terrasil+lime as per relevant IS codes of practice:

- Liquid limit
- Plastic limit
- Plasticity index
- Differential free swell (DFS) Test

4. MIX PREPRATION

STAGE I: Following mix has been prepared by mixing soil with different percentage of Terrasil.

- Soil Sample + 0.00% Terrasil (CT0)
- Soil Sample + 0.03% Terrasil (CT1)
- Soil Sample + 0.05% Terrasil (CT2)
- Soil Sample + 0.07% Terrasil (CT3)
- Soil Sample + 0.09% Terrasil (CT4)

STAGE II: Following mix has been prepared by mixing soil with different percentage of Terrasil and fixed quantity of Lime i.e. 2% by weight of dry soil.

- Soil Sample + 2% Lime + 0.00% Terrasil (CLT0)
- Soil Sample + 2% Lime + 0.03% Terrasil (CLT1)
- Soil Sample + 2% Lime + 0.05% Terrasil (CLT2)
- Soil Sample + 2% Lime + 0.07% Terrasil (CLT3)
- Soil Sample + 2% Lime + 0.09% Terrasil (CLT4)

5. RESULTS AND DISCUSSION

Test results are summarized in Table-4 and Table-5. Variation of LL, PI and DFS of Black Cotton Soil mixed with different proportion of terrasil (i.e. Stage-I) are shown in figure-1 to figure-3 and variation of LL, PI and DFS for stage II are shown in the figure-4 to figure-6. The plasticity index of soil decreases with increase in terrasil content up to 0.07% after that further increase in terrasil content there is slight increase in plasticity index. Thus the optimum quantity of terrasil found to be 0.07% in both stages (i.e. Stage I and Stage II) for maximum effect on liquid limit and plasticity index, also the DFS values decreases gradually with increase in terrasil content up to 0.07% of terrasil and gets slightly increased after it.

Table-4 :Test results on Black Cotton Soil with variation of Terrasil (%)

S.NO.	SAMPLE TYPE	LL (%)	PI(%)	DFS (%)
1	CT0	61.34	35.83	70
2	CT1	60.70	34.20	66.67
3	CT2	59.68	30.83	54.54
4	CT3	58.96	27.90	45.45
5	CT4	58.17	30.19	50

Table-5 : Test results of Lime mixed Soil with variation of Terrasil (%)

S.NO.	SAMPLE TYPE	LL (%)	PI(%)	DFS (%)
1	CLT0	55.31	19.98	65
2	CLT1	60.81	27.91	50
3	CLT2	59.07	25.74	45
4	CLT3	56.46	19.76	30
5	CLT4	53.89	21.58	36.36

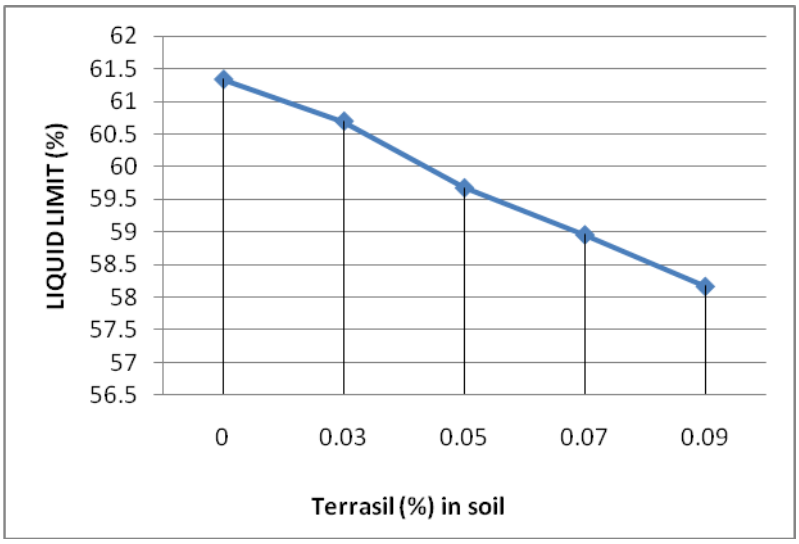

Fig 1: Variation of Liquid Limit with Terrasil (%) in Soil

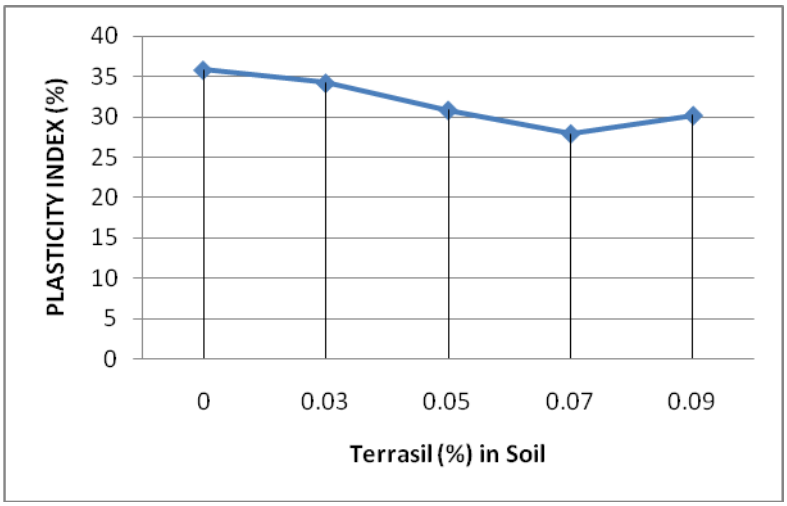

Fig 2: Variation of Plasticity Index with Terrasil (%) in Soil

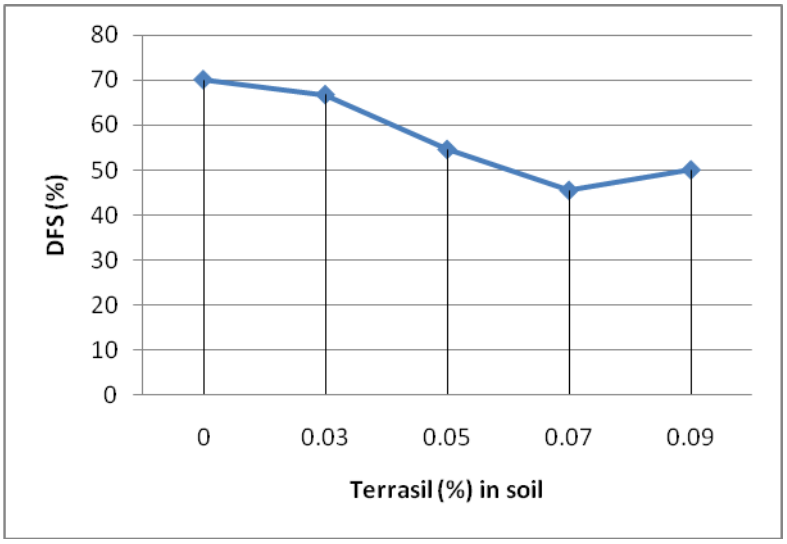

Fig 3: Variation of DFS value with Terrasil (%) in Soil

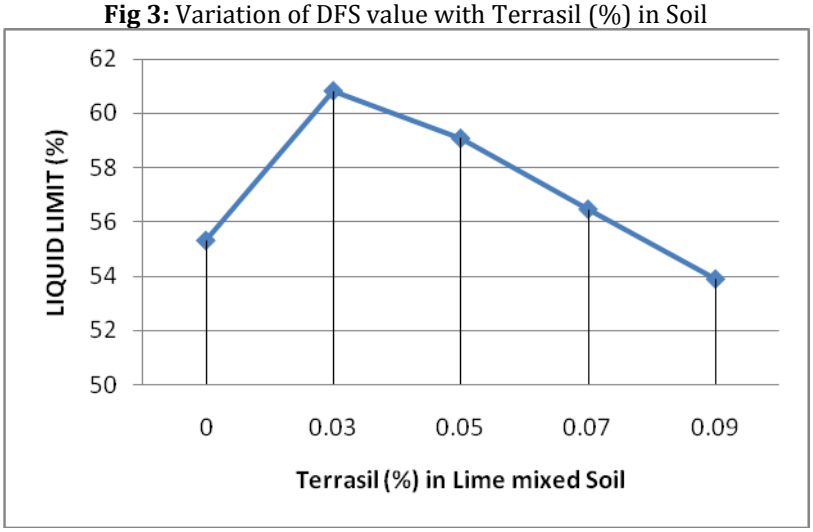

Fig 4: Variation of Liquid Limit with Terrasil (%) in Lime mixed Soil

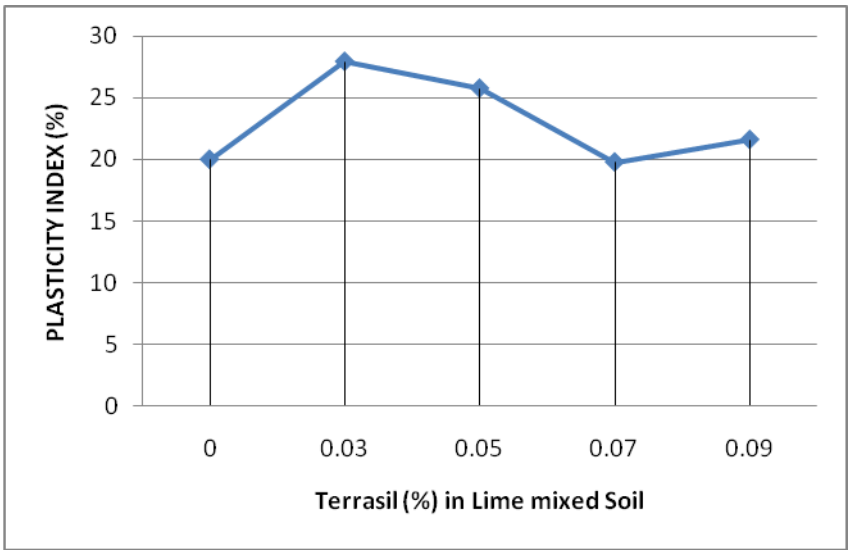

Fig 5: Variation of Plasticity Index with Terrasil (%) in Lime mixed Soil.

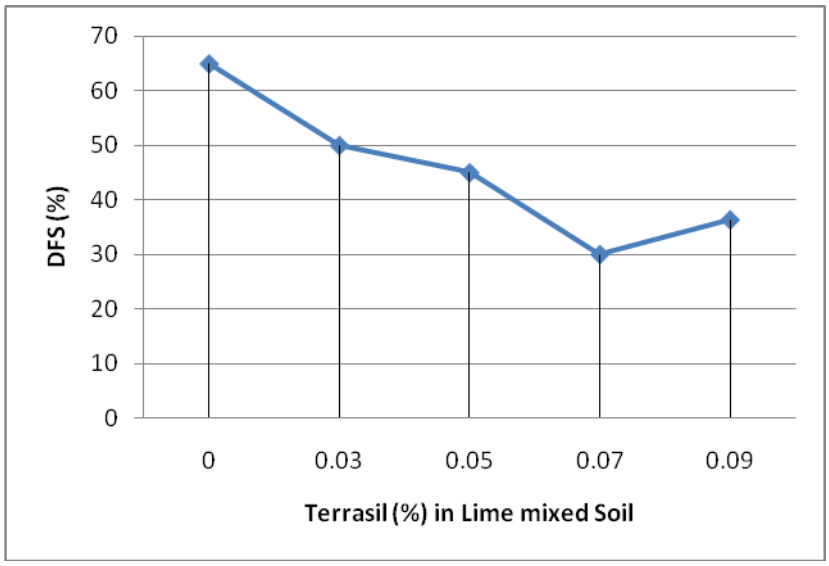

Fig 6: Variation of DFS value with Terrasil (%) in Lime mixed Soil

6. CONCLUSIONS

From the results of investigation following conclusions can be drawn.

- Liquid limit of soil decreases from 61.34% to 58.17% with increase in terrasil (%) in Stage-I, also with addition of 2% of lime with terrasil (%) i.e. in stage-II the Liquid Limit of soil get decreased from 61.34% to 53.89%.

- Plasticity index of soil decreases from 35.83% to 27.90% with increases in terrasil content up to 0.07% and after that with increase in terrasil content in stage-I slight increment is observed. Also when terrasil (%) added with 2% lime (i.e. stage-II) the Plasticity Index of soil get decreased from 35.83% to minimum 19.76% at 0.07% dosage of terrasil. There after slight increase in Plasticity Index is found with addition of terrasil.

- Differential free swell value decreases from 70% to 45.45% with increasing terrasil content only upto0.07% and then slightly get increased in stage-I. Also when terrasil(%) added with lime (i.e. stage II) the DFS value of soil decreases from 70% to minimum 30% at an optimum dosage of 0.07% terrasil.

Above results indicates that the optimum quantity of terrasil (%) required for reducing liquid limit and plasticity index of soil is 0.07% of weight of dry soil and is more effective with addition of lime (=2% by weight of dry soil).

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