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Advance Way to Upgrade Pavement Subgrade Layer by Chemical Stabilization

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Abstract :- There are numerous soil stabilization techniques for improving the strength of the in-situ soil especially in road construction, and one of the techniques is using chemical additive. Chemical improvement is a time saving method that enables subgrade or sub-base layer and otherwise unsatisfactory materials in-situ to obtain higher density and strength, obviating the need for costly excavation and replacement with borrow material. This paper presents some results of the preliminary stages of research program carried out to explicate the mechanism and behavior between the liquid chemical and the engineering properties of three natural residual soils at laboratory scale. Liquid-formed chemical was selected in this research due to scarcity of such findings instead of the prevalent solid chemical additive such as lime, cement or fly ash. The focus on this research is on the improvement of engineering properties of two natural residual soils and mixed with different proportions of liquid chemical. Series of laboratory test on engineering properties, such as Modified Proctor Test, Consistency limits, moisture-density relationship (compaction) and California Bearing Ratio was undertaken to evaluate the effectiveness and performances of this chemical as soil stabilizing agent.

Keywords: - **Atterberg limit, CBR, Chemical Stabilization, Terrasil, Modified proctor test**

I. INTRODUCTION

Over the past few decades several factors have led to an increase in the number of people migrating to large cities. Consequently these large cities are getting over populated and quite expectedly necessity of business, residential construction has increased the civil engineering projects located in areas with unsuitable soil is one of the most common problems in many parts of the world. The unsuitable soil (Black cotton Soil) can be stabilized by performing soil stabilization. In India black soil is the most problematic soil when it comes to construction. In rainy season black cotton soil swells and become sticky. Whereas in summers the moisture present in the soil evaporates and soil shrinks resulting in the crack of approximate 10 to 15 cm wide and up to 1 meter deep. The percentage covered by black cotton soil in geotechnical areas of India is 16.6%, which says huge amount of soil in India needs stabilization. Mechanical, chemical, electrical, thermal and other methods are in practice to improve the engineering properties of soil.

In developing countries like India the biggest handicap to provide a complete network of road system is the limited finances available to build road by the conventional methods. Therefore there is a need for low cost road construction to meet the growing needs of the road traffic. The construction cost can be considerably decreased by selecting local materials including local soils for the construction of the lower layers of the pavement such as the embankment and sub-base course. If the stability of the local soil is not adequate for supporting wheel loads, the properties are improved by soil stabilization techniques. Thus the principle of soil stabilized road construction involves the effective utilization of local soils and other suitable stabilizing agents.

II. MATERIAL AND METHODOLOGY

Types of Soil

➢ **Black cotton soil**

In this study, the soil under scrutiny was gathered from the vicinity of Flora Institute Of Technology, Khopi, Pune. At first, so as to distinguish the wide soil sorts in the field with no research facility testing, a visual characterization is done, which demonstrates that soil under scrutiny is brown in shading, further examination is completed with water to make a paste and rubbed in middle of fingers leaves a stain which is not watched for residues. When it is wet it doesn't get to be dry soon. In like way, display swelling and shrinkage and are described by a typical shrinkage pattern. The soil has an expansive surface zone because of level and lengthened molecule shapes that stick together when wet, avoiding typical waste procedures. When it is wet it doesn't get to be dry soon. In like way,

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when completely dry, it is not soon wetted and shrinks causing breaks.

➢ **Red soil**

Red soil is derived from weathering of ancient metamorphic rock of the Deccan plateau. Red soil is any of a group of soil that grow in a humid temperature, moist climate under deciduous and mix forests and that have raw mineral. Thin organic layers overlying a yellowish brown leached deposit resting on an alluvial. Their colour is mostly ferric oxides occurring a slight coatings on the soil particle through the iron oxide arise as hematite as hydrous ferric oxide, the colour is red and when it happen in the hydrate system as limonite the soil become to be yellow colour. Generally the surface soils are red while the horizon under gets yellowish colour.

➢ **River sand**

Sand is natural occurring granular material composed of finely divided rock & mineral particles. It is defined by size, being finer than gravel & coarser than silt. Sand can also refer toward textural class of soil or soil type that is a soil containing more than 85% sand size particles (by mass).
The composition of sand varies, depending on the local rock sources and conditions, but the most common constituent of sand in inland continental settings and non-tropical coastal settings is silica (silicon dioxide, or SiO_2), usually in the form of quartz. The second most common type of sand is calcium carbonate, for example aragonite, which has mostly been created, over the past half billion years, by various forms of life, like coral and shellfish. It is, for example, the primary form of sand apparent in areas where reefs have dominated the ecosystem for millions of years like the Caribbean.

Tests on Soil

Test to know the engineering properties of soil can be carried out on site as well laboratory. On-site test are as follows:

1. Standard Penetration Test.
2. Cone Penetration Test, etc.

Laboratory test are as follows:

1. Atterberg Limits Test.
2. California Bearing Ratio.
3. Direct Shear Test.
4. Expansion Index Test.
5. Soil Compaction Test.
6. Unconfined Compression Test etc.

Type of Chemical

➢ **Terrasil**

Terrasil is nanotechnology based 100 percent organo silane, water dissolvable, bright and warmth steady, receptive soil modifier to waterproof soil subgrade. The Characteristics of Terrasil is such that it wipes out narrow ascent and water entrance from top, decreases water penetrability of soil bases (10-5 cm/s to 10-7 cm/s) while keeping up 100% vapor porousness, diminishes expansively and free swell, keeps up dry CBR under wet conditions, holds quality of road bases and expands imperviousness to deformation by keeping up frictional values between residue and controls disintegration of soils . TERRASIL is anything but difficult to utilize and safe to handle item that renders treated soils very water repellant. Terrasil conveys demonstrated results with a wide range of soils and doesn't modify their appearance. Terrasil is a think that blends with water. Once connected, it attempts to bond with the soil's silica and oxygen atoms. This implanted synthetic response makes the treated soil 98% water safe. The holding procedure starts inside of 3 hours of the beginning application till the procedure is finished (72 hrs.), Terrasil turns into a changeless piece of every soil particle and won't separate or filter into groundwater .

Table 1 Chemical composition of terrasil.

Chemical Compound	Value in Range(%)
Hydroxyalkyl-alkoxy-alkylsilyl	65-70%
Benzyl Alcohol	25-27%
Ethylene Glycol	3-5%

III. LABORATORY WORK AND RESULT

Performed various laboratory test on soil i.e Red and Black cotton soil to find out their basic properties such as liquid limit, plastic limit, specific gravity, modified proctor & CBR tests. And soil stabilization by using conventional stabilization for both red and black cotton soil by using natural river sand(10%) & chemical stabilization for both red & black cotton soil by using Terrasil(0.041%) from Zydex Industries.

A. Conventional Method Engineering Properties

In conventional method 10% of natural river sand is used as an additives to the soil i.e. both red and black cotton soil by weight of soil. All the test such as liquid limit, plastic limit, specific gravity, modified proctor & C.B.R test were performed on respective soils.

Red soil
Liquid limit

Table 2 LL of Red soil with 10% sand.

No	I	II	III
No. Of blows	24	25.5	28
Container no	1	2	3
Mass of container + wet soil(g)	25	33	27
Mass of container + dry soil(g)	22.5	28.5	24
Mass of water (g)	2.5	4.5	3
Mass of container (g)(W_1)	16	16	16
Mass of oven dry soil (g)(W_2)	6.5	12.5	8
Water content (%)	38.46	36	37.5

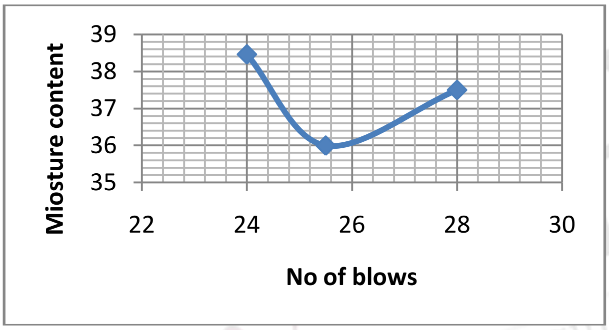

Fig. 1 Flow curve for Red Soil with 10% sand.

<u>Liquid Limit:- 38.5</u>
Plastic limit

Table 3 PL of Red soil with 10% sand.

No	I	II	III
CONTAINER NO	1	2	3
Wt of container	16.5	16.5	16.5
Wt of cont+ wet of soil	23.5	22	22.6
Wt of cont. + dry soil	21	20.5	20
Wt of water	2.5	1.5	2.6
Wt of dry soil	7	6	6.5
Water content	35	25	40

<u>Plastic Limit:-33.33</u>
Specific gravity [IS: 2720 (Part-III/SEC-I)]

Table 4 Specific Gravity Test for Red soil with 10% sand.

Determination	I	II	III
Density bottle no	1 (250gm)	2 (350 gm)	3 (300 gm)
Mass of density bottle	681	681	681
Mass of density bottle + dry soil	932	1032	982
Mass of density bottle + soil + water	1653	1684	1668
Mass of bottle +water	1506	1506	1506
Specific gravity	2.41	2.02	2

<u>Average Specific Gravity=2.14</u>
Modified proctor test (Heavy Compaction)

Table 5 Proctor Test for Red soil with 10% sand.

Determinatio n no	I	II	III	IV	V
Wt of mould + compacted soil	513 6	909 6	1056 0	1012 0	9560
Wt of mould	554 6	554 6	5546	5546	5546
Volume of mould	225 0	225 0	2250	2250	2250
Wt of compacted soil	256 7	355 0	5014	4574	4014
bulk density	1.4	1.57	1.80	2.032	1.78 4
Dry density	1.29	1.42	1.56	1.722	1.48
Percentage of water use	6	10	15	18	20

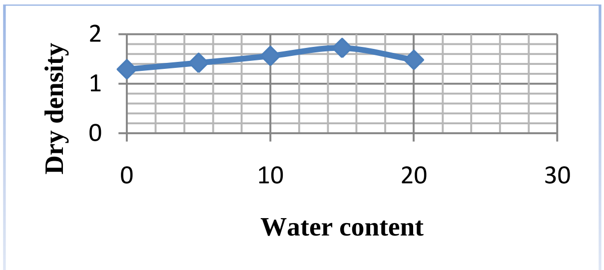

Fig. 2 Compaction Curve for Red soil with 10% sand.

<u>OMC: - 15% and MDD:- 1.7125 g/cm^3</u>
CBR

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Table 6 Standard load used in C.B.R test.

Penetration	Unit std. Load (kgf/cm2)	Total std. Load (kgf)
2.5mm	70	1370
5mm	105	2055
7.5mm	134	2630
10mm	162	3180
12.5mm	183	3600

Table 7 C.B.R test of red soil with 10% sand.

Soil type	Penetration	CBR	
		Native	10% sand
Red soil	@ 2.5 mm	6.5	8.37
	@ 5.0 mm	7.99	9.47

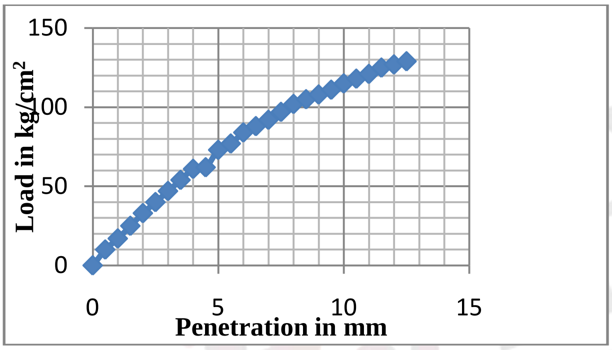

Fig. 3 Load Penetration Curve for C.B.R test of Red soil with 10% Sand

Black cotton soil
Liquid limit

Table 9 LL B.C soil with 10% sand.

N0	I	II	III
No. Of blows	21	26	31
Container no	1	2	3
Mass of container + wet soil(g)	26	27.5	27
Mass of container + dry soil(g)	22.5	23.5	23
Mass of water (g)	3.5	4	4
Mass of container (g)(W_1)	16.5	16.5	16.5
Mass of oven dry soil (g)(W_2)	6	6	6.5
Water content (%)	58.3	61.63	66.66

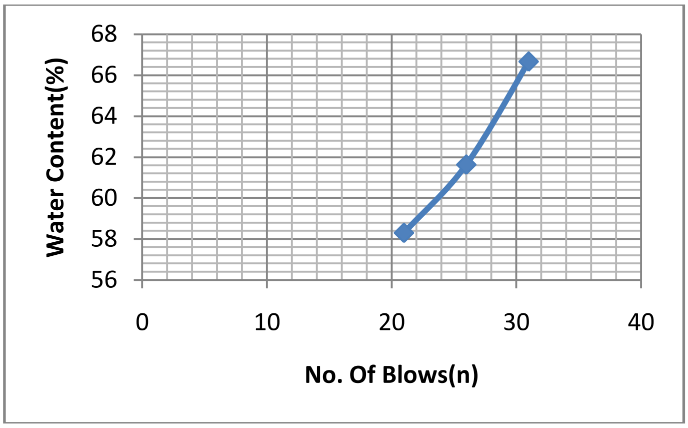

Fig. 4 Flow curve for B.C soil with 10% sand.

Liquid Limit:-60.9
Plastic limit

Table 8 PL for B.C soil with 10% sand.

NO	I	II	III
CONTAINER NO	1	2	3
Wt of container	16.5	16.5	16.5
Wt of cont+ wet of soil	24.5	23.5	23
Wt of cont. + dry soil	23	22	21.5
Wt of water	1.5	1.5	1.5
Wt of dry soil	8	7	7.5
Water content	18.75	21.14	20

Plastic Limit:- 19.96
Specific gravity [IS: 2720 (Part-III/SEC-I)]

Table 9 Specific gravity test for B.C soil with 10% sand.

Determination	I	II	III
Density bottle no	1	2	3
Mass of density bottle	681	681	681
Mass of density bottle + dry soil	932	1033	980
Mass of density bottle + soil + water	1640	1714	1677
Mass of bottle +water	1506	1506	1506
Specific gravity	2.14	2.44	2.33

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Average Specific Gravity:-2.30

Modified proctor test(Heavy Compaction)

Table 10 Proctor Test for B.C soil with 10% of Sand.

Determination no	I	II	III	IV
Wt of mould + compacted soil	8966	9331	9790	9565
Wt of mould	5546	5546	5546	5546
Volume of mould	2250	2250	2250	2250
Wt of compacted soil	3420	3785	4244	5546
bulk density	1.52	1.68	1.88	1.78
Dry density	1.43	1.55	1.70	1.56
Percentage of water use	6	8	10	13

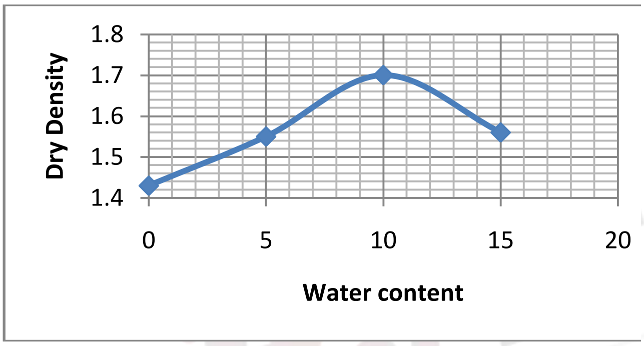

Fig. 5 Compaction Curve for B.C soil with 10% Sand.

OMC:- 10.125% and MDD:- 1.7 g/cm^3

CBR

Table11 Standard load used in C.B.R test.

Penetration	**Unit std. Load (kgf/cm2)**	**Total std. Load (kgf)**
2.5mm	70	1370
5mm	105	2055
7.5mm	134	2630
10mm	162	3180
12.5mm	183	3600

Table 12 C.B.R Test for B.C Soil with 10% sand.

Soil type	**Penetration**	**CBR**	
		Native	**10% Sand**
Black cotton soil	@ 2.5 mm	1.64	2.05
	@ 5.0 mm	1.42	1.8

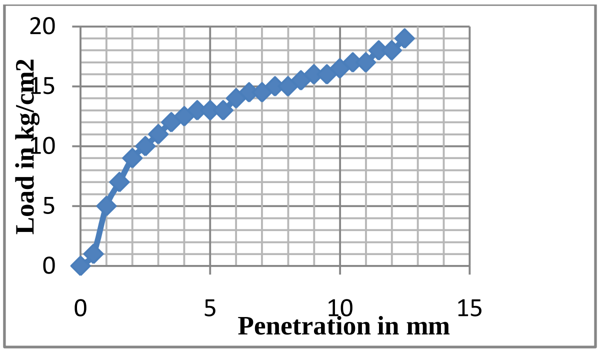

Fig. 6 Load Penetration Curve for C.B.R Test of B.C soil with 10% sand.

B. Chemical Method Engineering Properties

In chemical method 0.041% of Terrasil is used as an additive to the red & black cotton soil by weight of soil. All the test such as liquid limit, plastic limit, specific gravity, modified proctor & C.B.R test were performed on respective soils.

Red soil

Liquid limit

Table 13 LL Red soil With 0.041% Terrasil.

N0	I	II	III
No. Of blows	25	28	23
Container no	1	2	3
Mass of container + wet soil(g)	26	28	30
Mass of container + dry soil(g)	25	26.5	29
Mass of water (g)	1	1.5	1
Mass of container (g)(W_1)	16.5	16.5	16.5
Mass of oven dry soil (g)(W_2)	8.5	10	12.5
Water content (%)	11.76	15	8

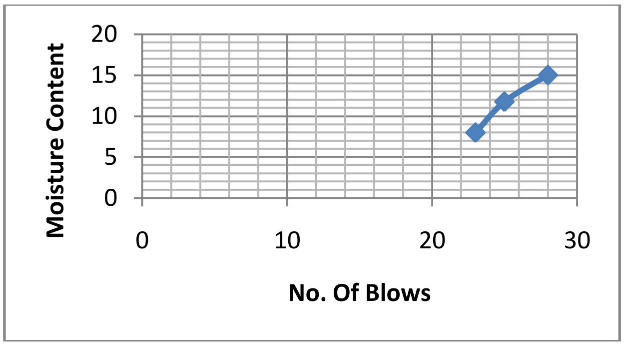

Fig. 7 Flow curve for Red Soil with 0.041% Terrasil.

Liquid Limit:-11.7
Plastic limit

Table 14 Plastic Limit of Red Soil with 0.041% Terrasil.

NO	I	II	III
CONTAINER NO	1	2	3
Wt of container	16.5	16.5	16.5
Wt of cont+ wet of soil	33.5	32.5	31.2
Wt of cont. + dry soil	30	29.5	28
Wt of water	3.5	3	3.2
Wt of dry soil	13.5	13	11.5
Water content	25.9	23.07	27.8

Plastic Limit:-25.59
Modified proctor test (Heavy Compaction)

Table 15 Proctor Test Compaction Test of Red soil with 0.041% Terrasil

Determination no	I	II	III	IV	V
Wt of mould + compacted soil	7707	8446	9458	8458	5671
Wt of mould	5546	5546	5546	5546	5546
Volume of mould	2250	2250	2250	2250	2250
Wt of compacted soil	2161	2900	3912	3125	2912
bulk density	0.96	1.28	1.73	1.38	1.29
Dry density	0.91	1.16	1.50	1.16	1.075
Percentage of water use	6	10	15	18	20

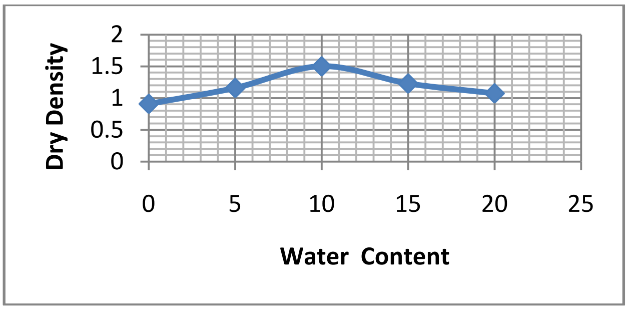

Fig. 8 Compaction Curve for Red Soil with 0.041% Terrasil.

OMC:-10.18% and MDD:-1.91g/cm^3
CBR

Table 16 Standard Load used in C.B.R Test.

Penetration	Unit std. Load (kgf/cm2)	Total std. Load (kgf)
2.5mm	70	1370
5mm	105	2055
7.5mm	134	2630
10mm	162	3180
12.5mm	183	3600

Table 17 C.B.R test of Red soil with 0.041% Terrasil.

Soil Type	Penetration	C.B.R	
		Native	0.041% Terrasil
Red Soil	@2.5 mm	1.64	2.79
	@5 mm	1.42	2.46

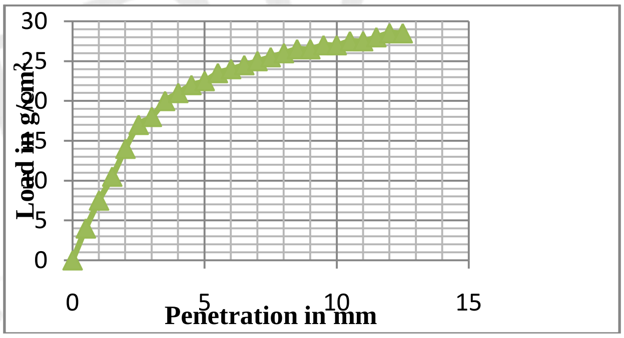

Fig. 9 Load Penetration Curve for C.B.R Test of Red soil with 0.041% Terrasil.

Black cotton soil
Liquid limit

Table 18 LL B.C Soil with 0.041% Terrasil.

N0	I	II	III
No. Of blows	25	22	28
Container no	1	2	3
Mass of container + wet soil(g)	29	32	26
Mass of container + dry soil(g)	25	26.5	23
Mass of water (g)	4	5.5	3
Mass of container (g)(W_1)	16.5	16.5	16.5
Mass of oven dry soil (g)(W_2)	8.5	10	6.5
Water content (%)	47	55	46

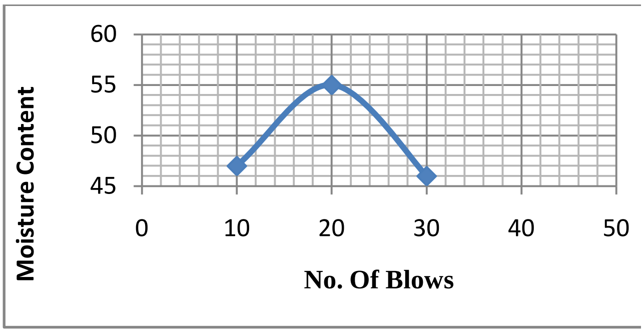

Fig. 10 Flow Curve for B.C soil with 0.041% Terrasil.

Liquid Limit:- 51.14

Plastic limit

Table 19 PL B.C soil with 0.041% Terrasil.

NO	I	II	III
CONTAINER NO	1	2	3
Wt of container	16.5	16.5	16.5
Wt of cont+ wet of soil	25	26	26.5
Wt of cont. + dry soil	23.5	24.5	24.3
Wt of water	1.5	1.5	1.5
Wt of dry soil	7	8	6.3
Water content	21.42	`18.75	23.80

Plastic Limit:-21.32

Modified proctor test(Heavy Compaction)

Table 20 Compaction Test of B.C soil with 0.041% Terrasil.

Determination no	I	II	III	IV
Wt of mould + compacted soil	9543	9728	9941	9812
Wt of mould	5546	5546	5546	5546
Volume of mould	2250	2250	2250	2250
Wt of compacted soil	3997	4182	4395	4266
bulk density	1.77	1.85	1.95	1.89
Dry density	1.63	1.68	1.69	1.61
Percentage of water use	8	10	15	17

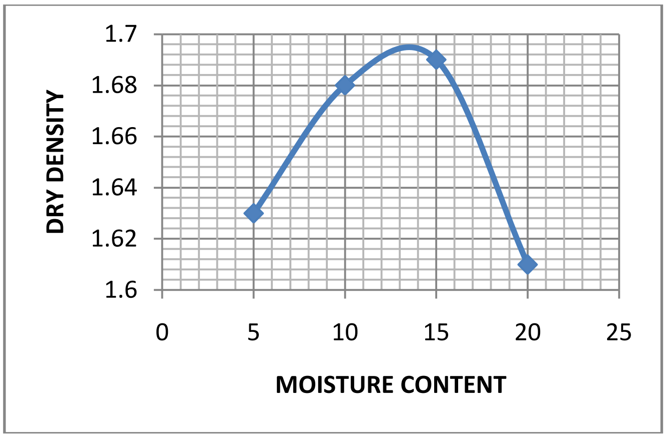

Fig. 11 Compaction Curve of B.C soil with 0.041% of Terrasil.

OMC:- 14.5 and MDD:-1.692

CBR

Table 21 Standard Load Used in C.B.R Test.

Penetration	Unit std. Load (kgf/cm2)	Total std. Load (kgf)
2.5mm	70	1370
5mm	105	2055
7.5mm	134	2630
10mm	162	3180
12.5mm	183	3600

Table 22 C.B.R test of B.C soil with 0.041% Terrasil.

Soil Type	Penetration	C.B.R	
		Native	0.041% Terrasil
Black Cotton Soil	@2.5 mm	1.64	10.641
	@5 mm	1.42	20.175

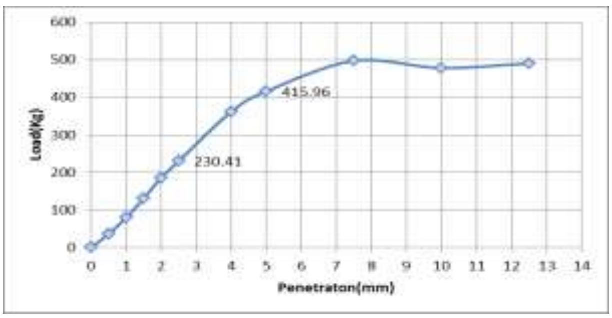

Fig. 12 Compaction Curve of B.C soil with 0.041% of Terrasil

IV. CONCLUSIONS

1. It is concluded that for Black cotton soil and Red soil the Terrasil is an effective stabilizer to improve the density and to reduce water content.
2. The Liquid limit and Plastic limit found better after adding Terrasil for native soils.
3. It clearly shows that from compaction test results there is significant change in MDD and OMC for blended soil with Terrasil compared to native soil, as we are blending Terrasil to the native soil it densifies the soil and reduces the water content to achieve maximum dry density.
4. From test results for MDD and OMC we can make out the increase in density and reduction in moisture content.
5. From test results it is concluded that Terrasil is an effective stabilizer for Black cotton soil and for Red soil.
6. From result it is clear that by adding Terrasil to the selected soils the CBR values has increased significantly.
7. From test results for CBR, it can be concluded that Terrasil is a significant stabilizer for Black cotton soil and for Red soil, if it is available in economic haulage then it proves to be effective in economic considerations.

V. ACKNOWLEDGMENT

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