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Experimental Study on the use of Nano Chemical and Cement in the modification of Subgrade

Roshni S, Dr. S. P. Jeyapriya

Abstract— Weak soils are most likely to cause damage to all structures including road pavements. Stabilization of soil is done to avoid these damages and improve strength. It also helps in improving the compaction characteristics of soil. In this work, chemical stabilization of black cotton soil was done to improve the subgrade. Soaked CBR test was conducted on soil treated with nano chemical Terrasil with Cement as binder. The percentage addition of Terrasil was varied from 0.03%, 0.05%, 0.07% and 0.09% inorder to find the optimum content of the nano chemical. With optimum percentage of Terrasil and with varying percentage of cement such as 1%, 2%, 3%, and 4% on soil, CBR test was conducted.The maximum CBR value is obtained at a combination of 0.07% Terrasil and 3% Cement. CBR percentage was increased by 3.6 times when compared to soil without stabilizer. SEM and EDAX analysis was done to know the morphology and chemical composition in the unstabilized and stabilized soil sample.

Index Terms— Cement , EDAX , Nano chemical, SEM, Soaked CBR, Stabilization, Terrasil

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1 INTRODUCTION

The Roads are a vital component in nation building and one of the most effective modes to establish socio-economic and political network. The Soil stabilization is the alteration of any inherent property of a soil to improve its engineering performance. Improvement of stability or bearing power, density, and shear parameter reduces compressibility, permeability, swelling and shrinkage property. Different methods can be used to treat and improve the geotechnical properties of the problematic soils by treating it in situ. These methods include densifying treatments, pore water pressure reduction techniques, the bonding of soil particles and use of reinforcing elements. Nano chemicals are nanotechnology based products which can provide solutions to moisture and bonding issues in pavements. Addition of nano particles as an external factor to soil will result in soil manipulation at atomic or molecular level and it influences the strength, permeability indices and resistance properties of soil. Nanotechnology is a reformed mode which can address the rising concern of poor quality roads.

The main objective of the present work is to evaluate the potential use of nano chemical solution in improving the various properties of cement treated clay soil. The plasticity characteristics, compaction and strength characteristics of clayey soils were studied with the addition of 0.03%, 0.05% 0.07%, and 0.09% of Terrasil to find the optimum content. With optimum percentage of Terrasil and with varying percentage of cement such as 1%, 2%, 3%, and 4% on soil, CBR test was conducted. A significant change in the plasticity nature, maximum dry density and optimum moisture content is obtained when the soil sample was treated with Terrasil and Cement. The results were compared and reported. SEM and EDAX analysis was done to know the morphology and chemical composition in the unstabilized and stabilized soil sample.

2 MATERIALS

2.1 Soil

The soil was collected for Testing program from GCT College, Coimbatore located at 1101’4.4142” N latitude and 76056’21.2622” E longitude. Sample collected was oven dried, pulverized and basic properties were determined.

2.2 Terrasil

Terrasil is nanotechnology based 100 percent organo silane, water dissolvable, bright and warmth steady, receptive soil modifier to waterproof soil subgrade [1]. 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. The chemical composition of Terrasil [1] is given in Table.1.

TABLE 1
CHEMICAL COMPOSITION OF TERRASIL

Chemical Compound	Values in %
Hydroxyl alkyl - alkoxy - alkyl silyl	65- 70%
Benzyl alcohol (C_7H_8O)	25-27%
Ethylene glycol ($C_2H_6O_2$)	3- 5%

2.3 Ordinary Portland Cement (OPC)

Portland bond is a multi-mineral compound made up of oxides of calcium, silica, alumina andiron. At the point when cement is blended with water, solidifying mixes of calcium-silicate-hydrate (CS-H) and calcium-aluminate- hydrate (C-A-H) are shaped and over

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abundance calcium hydroxide is discharged. Some calcium is along these lines accessible to respond with the soil molecule right on time in the change process when the water is included, and extra calcium gets to be accessible later as it structures amid concrete hydration. The hydrates help to balance out flocculated earth particles through cementation. The hydration responses and quality increments happen generally between 24 hours and 28 day.

3 Results And Discussions

The results obtained from the various tests on untreated soil and soil stabilized with additives. The results obtained are discussed below.

3.1 Properties of Soil

The various properties of soil [7], [8] namely natural moisture content, specific gravity, Free Swell Index, Atterberg's limits, grain size distribution, optimum moisture content, maximum dry density and California Bearing Ratio obtained are summarized in Table 2.

TABLE 2
Properties of soil

Sl.No	PROPERTIES	VALUES
1	Natural Moisture Content (%)	11.11%
2	Specific Gravity	2.76
3	Sieve Analysis % of Gravel % of Sand % of Clay % of Silt	 0.37% 31.79% 47.68% 20.15%
4	Differential Free Swell	70%
5	Liquid Limit (W_L) Plastic Limit (W_P) Shrinkage Limit (W_S) Plasticity Index (I_P)	55% 27.4% 14% 27.6%
6	Soil Classification	CH
7	Optimum Moisture Content Maximum Dry Density	15.9% 1.59 g/cc
8	Soaked CBR	1.75%

3.1.1 Atterberg's Limits Test

Liquid limit, Plastic limit and Plasticity Index of soil treated with varying dosages of Terrasil and Cement are shown in Table 3

TABLE 3
Atterberg's Limits test for varying dosage of Terrasil and Cement

DOSAGE (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)
Virgin soil	55	27.4	27.6
0.03% Terrasil	58	30.8	27.2
0.05%Terrasil	62.5	35.6	26.9
0.07% Terrasil	64	37.6	26.4
0.09% Terrasil	57.5	31.2	26.8
0.07% Terrasil & 1% Cement	65	38.8	26.2
0.07% Terrasil & 2% Cement	67	41.2	25.8
0.07% Terrasil & 3% Cement	72.5	47	25.5
0.07% Terrasil & 4% Cement	68	42	26

3.1.2 Standard Proctor's Compaction Test

The optimum moisture content and Maximum dry density of soil with varying dosages of Terrasil and cement are tabulated in Table 4

TABLE 4
OMC and MDD values of soil treated with Terrasil and Cement

DOSAGE (%)	OMC (%)	MDD (g/cc)
Virgin soil	15.9	1.59
0.03% Terrasil	15	1.64
0.05% Terrasil	14.4	1.68
0.07% Terrasil	11.9	1.7
0.09% Terrasil	12.1	1.69
0.07% Terrasil + 1% Cement	11.1	1.71
0.07% Terrasil + 2% Cement	10.5	1.75
0.07% Terrasil + 3% Cement	9.4	1.78
0.07% Terrasil + 4% Cement	10	1.77

The maximum Dry Density was obtained at a dosage of 0.07% Terrasil and 3% cement. Optimum moisture content has been decreased and tendency of crack is decreased with the decrease in OMC. Compaction characteristics has been improved maximum at a dosage of 0.07% Terrasil and 3% Cement.

3.1.3 California Bearing Ratio Test

The CBR values are tabulated in the Table 5

Table 5
SOAKED CBR VALUES OF SOIL TREATED WITH TERRASIL AND CEMENT

DOSAGE	CBR (%)
Virgin soil	1.75
0.03% Terrasil	2.1
0.05% Terrasil	3.85
0.07% Terrasil	5.25
0.09% Terrasil	4.20
0.07% Terrasil + 1 % Cement	5.6
0.07% Terrasil + 2 % Cement	5.78
0.07% Terrasil + 3 % Cement	6.3
0.07% Terrasil + 4 % Cement	5.43

The maximum CBR obtained is 6.3% at 0.07% Terrasil and 3% Cement. The optimum dosage of Terrasil was found to be 0.07% and Cement is 3%.

3.2 SEM and EDAX Analysis

The SEM (Scanning Electron Microscopy) and EDAX were done to identify the nano sized particle and chemical components present in the soil samples respectively.

The soil sample passing through 75 micron sieve of 50 grams are taken and given for test [6].

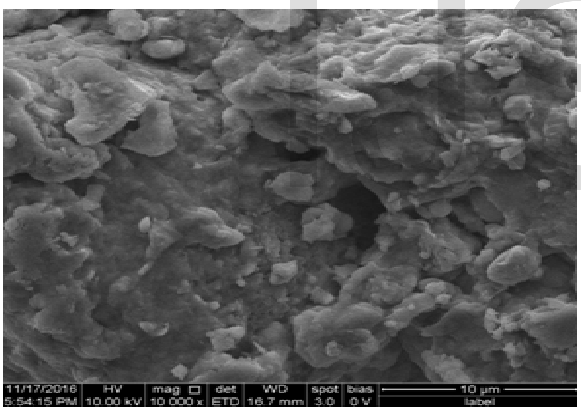

Fig.1 SEM Analysis (Virgin soil, 10µm)

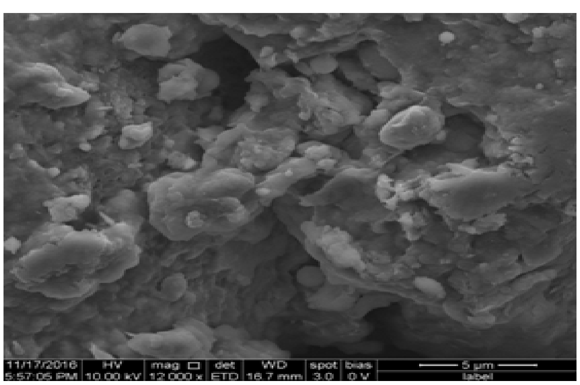

Fig.2 SEM Analysis(Virgin soil, 5µm)

TABLE 6
EDAX ANALYSIS ,VIRGIN SOIL

Acquisition Date:11/17/2016 7:07:02 PM
HV:10.0kV Puls th.:1.47kcps

```
El AN  Series   unn. C norm. C Atom. C
Error (1 Sigma)

                 [wt.%]   [wt.%]   [at.%]
[wt.%]

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O  8  K-series  31.37   56.43   68.87
4.38

Si 14 K-series  16.40   29.50   20.51
0.74

Al 13 K-series   4.82    8.67    6.27
0.27

Mg 12 K-series   3.01    5.41    4.34
0.20

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        Total:  55.60  100.00  100.00
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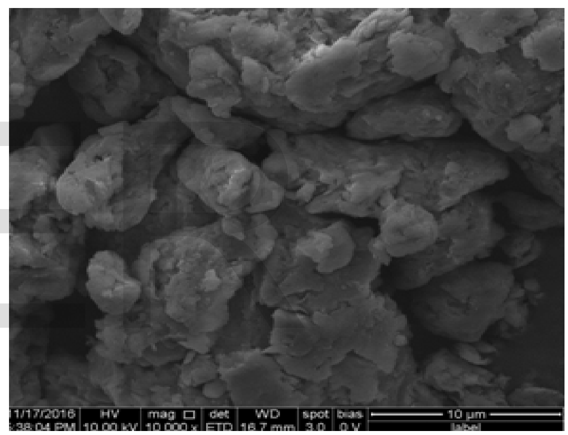

Fig.3 SEM Analysis(Treated Soil, 10µm)

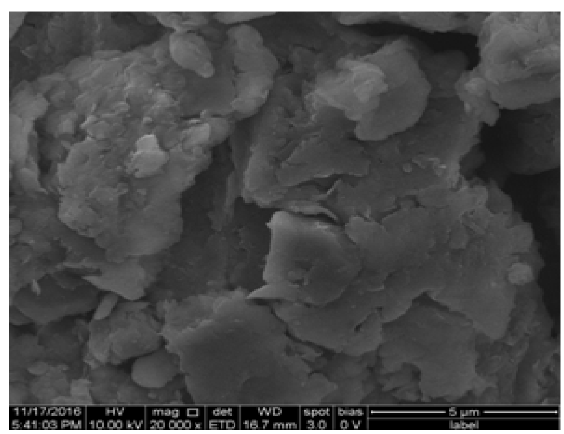

Fig.4 SEM Analysis(Treated Soil, 5µm)

TABLE 7
EDAX ANALYSIS, TREATED SOIL

Acquisition Date:11/17/2016 6:48:18 PM
HV:10.0kV Puls th.:1.41kcps

El	AN	Series	unn. C [wt.%]	norm. C [wt.%]	Atom. C [at.%]	Error (1 Sigma) [wt.%]
O	8	K-series	32.92	53.20	62.26	4.87
Si	14	K-series	18.38	29.71	19.80	0.84
Al	13	K-series	5.13	8.29	5.75	0.29
C	6	K-series	4.24	6.86	10.69	1.37
Mg	12	K-series	1.20	1.95	1.50	0.11
		Total:	61.88	100.00	100.00	

The scanning electron microscopy was used to understand the morphology of the untreated and stabilized soil samples.

SEM micrograph of the untreated clay soil is shown in Fig.1 and Fig.2. SEM micrographs of the stabilized soils are shown in Fig.3 and Fig.4. From images it can be analysed that untreated soil sample contains more void spaces when compared to that of cement and Terrasil treated samples. In the stabilized soil samples particles are bound together and is seen that particles are more closely packed.

Energy Dispersive Analysis of X-rays (EDAX) [6]provides the quantitative analysis of elements present in the sample. EDAX analysis of untreated soil and treated soil with 0.07% Terrasil and 3% Cement are shown in Table.6 and Table.7 It has been clearly noticed that in both samples major chemical components present are Silica, Aluminium, and Oxygen.

3.3 Pavement Design

The design of flexible pavement is carried out as per IRC: 37 2001[9],[10]. The design of pavement is done with CBR of plain black cotton soil sample and with improved CBR value obtained by this study. This explains the variation in the thickness of the flexible pavement with increase in CBR value.

Input Data:
i) Two - lane single carriage way
ii) Initial traffic volume =1200cv/day
iii)Traffic growth rate per annum = 7.5%
iv) Design life =15 yrs
v) Vehicle Damage Factor =3.5
vi) Distribution Factor =0.75
vii) CBR value of untreated soil = 1.75%
viii) CBR value of optimum content of Terrasil & Cement = 6.3%

Design Calculation:
Cumulative number of standard axles to be catered for design

$N = (365\{(1+r)n-1\} \times D \times A \times F)/r$ ……………………………(1)

Where
N – Cumulative number of standard axles to be catered for design interms of million standard axles – msa
A – Initial traffic
D – Lane distribution factor
F – Vehicle damage factor, VDF
N – Design life in years
r – Annual growth rate of commercial vehicles
N = 30 msa
For CBR value of 1.75% and N = 30msa, Referring IRC: 37-2001 Plate 1
Total Thickness of the pavement =900 mm
For 0.07% Terrasil + 3% cement subgrade CBR = 6.3%
Total thickness of the pavement = 650mm
Reduction in pavement thickness =250 mm

4 CONCLUSION

The black cotton soil is identified as Clay of High Compressibility (CH) and has low Soaked CBR value of 1.75%. As the CBR less than 2 %, an additional capping layer of 150mm is required while flexible pavement layers are laid which leads to increase in the cost of the project. Hence the soil is required to be stabilized before laying the pavement layers. Treatment with stabilizers showed an increase in MDD and decrease in OMC with increase in the percentage of stabilizers up to optimum content. Atterberg's limits tests showed a little decrease in the plasticity index of stabilized soil with increase in stabilizers up to optimum content. The optimum dosage of Terrasil was found to be 0.07%. CBR value is maximum at 0.07% Terrasil and 3% cement dosage. The maximum value of CBR obtained is 6.3% which is 3.6 times greater than the CBR value of plain soil. From SEM images it can be analysed that untreated soil sample contains more void spaces when compared to that of Terrasil and Cement treated samples. In the stabilized soil samples particles are bound together and is seen that particles are more closely packed. EDAX analysis of untreated soil and treated soil provides the quantitative analysis of elements present in the samples. Major chemical components presents are Silicon, Aluminium, Oxygen etc,. It is observed from the pavement design that there is a reduction of thickness of 250 mm is seen while comparing the plain soil and the stabilized soil which leads to the cost reduction.

REFERENCES

[1] Chaudhari Riddhi, Tabiyar Suman, Bholanda Heena, Chaudhari Shivani, C. B. Mishra, (2016), 'Mitigating the Quality of Expansive Soil Utilizing Terrasil as an Additive', *IJRSI,* Volume III, Issue V ISSN 2321 – 2705 , pp 161 – 165

[2] Goutham Sarang, Lekha B M, A U Ravi Shankar, (2015), 'Aggregate and Bitumen Modified with Chemicals for Stone Matrix Asphalt Mixtures', *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE),* pp 14 – 20

[3] Nandan A. Patel, Prof.C. B. Mishra, Mr. Vasu V. Pancholi, (2015), 'Scientifically Surveying the Usage of Chemical for Soil Stabilization', *International Journal of Research in Advent Technology*, Vol.3, No.6, E-ISSN: 2321-9637.

[4] Syed Shoaib Ahmed, Sudeep Roy, Anurag Singh, (2015) 'Mitigating flash flood after - effects by stabilization of soil - based construction platform using nanotechnology, 'Terrasil' , *The International Daily Journal,*38(174), pp 52 – 58.

[5] Seyedi Gelsefidi Seyed Alireza, Mirkazemi Seyed Mohammad, Baziar Mohammad Hasan, (2016), 'Application of Nano material to Stabilize a Weak Soil', *International Conference on Case Histories n Geotechnical Engineering* pp 1 - 8

[6] Yasaman Dehghan Banadaky, Hamed Niroumand, Khairul Anuar Kassim, (2014), 'A review on various Nano imaging systems in Geotechnical engineering', *EJGE* Vol. 19 , pp 17433 - 17441

[7] IS: 1498. (1970), Classification and Identification of Soils for General Engineering Purposes.

[8] IS: 2720 (Part – v), (1970), Determination of Liquid and Plastic limits. *Indian Standard Method for soils part v*.

[9] IRC 37 – 2001 Guideline for design of flexible pavement.

[10] Khanna S.K., and Justo, C.E.G., (1993), "Highway Engineering", New Chand and Bros, 7th edition, New Delhi.