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Research Article

Evaluating the Ability of Chemical Additive for Soil Stabilization

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Abstract

In India, the rapid increase in population growth coupled with an increase in vehicles posed the reduction of available land where the highway infrastructure development especially on maximum available weak or soft soil. Insecure soils make huge issues for asphalts and henceforth needs to be investigated scientifically initially in the laboratory. In this study, at first the examination of normal soil is done to assess the physical and engineering properties as indicated by Indian Standard (1498 – 1970) by coordinating exploration focus tests and to evaluate the adjustment in properties by the utilizing Nano chemical terrasil stabilizer of 0.021% percent dose to be used as a part of the asphalt configuration for the economy. A chemical named Terrasil was utilized as a stabilizer and it was utilized at fixed dosage i.e. 0.021% by dry aggregate weight of soil test according to the criteria's laid down by Zydex Industries, Vadodara. The pilot study is carried out to determine the improvement of soil properties and consequently, correct outline systems of the asphalt layers based upon the sub-grade quality are worked out as per the guidelines of IRC code and thereby comparative saving cost per km is shown.

Keywords: *Soil Stabilization, Clay soil, Terrasil, OMC-MDD, UCS, CBR.*

1. Introduction

Many civil engineering structures fail due to the failure of soil underlying the structure for e.g. construction of bridges, buildings, dam, etc. India confronts quick populace development and industrialization created the utilization of transportation office to convey business heavier vehicle loads and redundant uses of it subsequently delivering heavier focuses particularly on roads running in clayey soil zones are known for bed condition and unusual conduct for which the way of the clayey soil add to some degree. The utilization of chemical stabilization materials as an added substance to regular soil makes a positive commitment to monetary. Admission of water in rainy season weakens the roads soil base. For soil like black cotton soil, these climatic changes are responsible for its swelling and shrinkage. The addition of nano-chemical to soil in an optimum quantity can be proved beneficial to the problem. Terrasil is a nanotechnology based product. Hence an attempt is made to evaluate engineering properties of ordinary soil material with and without using Nano chemical terrasil stabilizer of 0.021% percent dose and to determine the changes in CBR value for the thickness of adaptable flexible pavement design so as to have a cost benefit to pavement engineers.

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2. Materials

The materials which are to be used in this study as follows:

2.1 Clay Soil

The Soil is collected from the Valsad city near NH-48 at 2 m depth. The experiments are conducted in NKPC-Geotechnical laboratory, Valsad, Gujarat. The soil used is the extracted waste soil, which on the visual test and by laboratory test known to be clay soil. The soil is intermediate plastic clayey soil, i.e. CI soil. The tests according to Indian Standards are performed on the soil to check the properties of untreated and treated the soil with stabilizer. The engineering properties of clay soil investigated are as shown in table 1.

Table 1 Properties of clay soil

Sr. No.	Property	Value
1	Specific Gravity	2.4
2	Liquid Limit	41.75%
3	Plastic Limit	25.28%
4	Plasticity Index	16.67%
5	Free Swell Index	60%
6	Optimum Moisture Content	17.70%
7	Maximum Dry Density	1.7360 g/cc
8	Unconfined Compressive Strength	51.66 KPa
9	California Bearing Ratio	2.38%

2.2 Terrasil

Terrasil is a nanotechnology based product produced by Zydex Industries Ltd., Gujarat. Terrasil is water soluble, ultraviolet and heat stable, reactive soil modifier. It improves the frictional value, reduces water permeability and maintains breathability of the soil layer. The composition of terrasil is shown in table 2 and the physical properties are highlighted in table 3.

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 Physical properties 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. Literature Reviews

In order to support the research activity, a careful examination of a body of technical literature pointing towards the relevance of soil stabilization is shown below:

P. Yuvaraj (Feb 2016) had found that the exploratory study on the suitability of the cockle shells as a partial replacement for in concrete. In developing countries where concrete is widely used, the high and steadily increasing cost of concrete have made construction very expensive. The high cost of conventional building materials is a major factor affecting housing delivery in the world. This has necessitated research into alternative materials of construction and analyzing tensile and compressive strength characteristics of concrete produced using sea shells as substitutes for conventional coarse aggregate with partial replacement using M20 grade concrete. The main objective is to encourage the use of these products as construction materials in the low-cost building. In this research work, experiments have been conducted with a collection of materials required and the data required for mix design are obtained by sieve analysis and specific gravity test. Sieve analysis is carried out from various fine aggregates (FA) and coarse aggregates (CA) samples and the sample which suits the requirement is selected. Specific gravity tests are carried out for fine and coarse aggregate. In this project, cement is partial replacement with lime powder of about 10%, 20%, 30%.The coarse aggregate is partial replacement with 10 %, 20%, and 30% by a sea shell. The water cement ratio is maintained for this mix design is 0.5. Results show that replacement of appropriate cockle shell content able to produce workable concrete with satisfactory strength. Integration of 20% cockle shell enhanced the strength of concrete making it be the highest as compared to any other replacement level.

M.V. Sravan, H.B. Nagaraj (June 2015) had found that time related physical properties of a natural soil treated with Terrazyme has discovered that liquid limit reduces with time, while plastic limit increased with ageing. The reduced plasticity index indicates that the soil is volumetrically stable and becoming less compressible. UCS of soil treated with different percentages of Terrazyme at ageing periods were evaluated, and optimum percentage for the soil arrived. The addition of Terrazyme has increased the UCS of the soil. UCS of soil with/without an optimum percentage of Terrazyme along with combinations of cement and lime with time were evaluated. The admixtures-soil combination which yielded the best UCC strength was selected for the preparation of CSEBs. Blocks prepared with Terrazyme had the higher wet compressive strength and lower water absorption than other blocks. After two months, the wet compressive strength of blocks prepared with Terrazyme was found 30% to 50% higher than the blocks without Terrazyme, bringing out the beneficial effect of Terrazyme.

Swathy M Muraleedharan, Niranjana K (March 2015) had found that the results of experiments conducted on clay of high plasticity treated with an organic, non-toxic, eco-friendly bio-enzyme stabilizer (TerraZyme) to improve the engineering and index properties of soils. The effect of the enzyme on the soil in terms of Plasticity Index, Compaction, Unconfined Compressive Strength (UCS), and California Bearing Ratio (CBR) are studied. The dosage of bio-enzyme added to the soil was 0ml, 0.1ml, 0.2ml, 0.3ml and 0.4ml per kg soil. It has been observed that the enzyme-treated soil showed significant improvement in index and engineering properties of soil.

Aderinola O.S. ,Owolabi T.A (March 2014) had describe that an array of remarkable improvements over each percentage at which cement was kept constant (i.e. at 5% and 10% of the dry weight of soil), and Renolith varied (i.e. at 2.5%, 5%, 7.5%, and 10% of the weight of cement respectively). There was a consistent peak of strength observed at the value of Renolith at 5% of the weight of cement used; though the stronger result was arrived at with higher percentage of cement (at 10% of the dry weight of soil). However, the poorest of the stabilized samples displayed interesting results from the tests in that it's strength indices increased by 7% in Maximum Dry Density; 1,863% in Unsoaked California Bearing Ratio and 200% in Unconfined Compressive Strength after 28 days.

Dr. K.V. Manoj Krishna and Dr. H.N. Ramesh (Sept. 2012) had found that the black cotton soil with 3% calcium chloride shows higher maximum dry density and minimum optimum moisture content. Black cotton soil with 3% calcium chloride shows 17 folds increase in strength on compared with soil alone at 30 days curing. Black cotton soil treated with 3% calcium chloride shows higher shear strength parameters and safe bearing capacity of the soil is increases by 12 to 15 folds on compared with soil alone. Black cotton soil treated with 3% calcium chloride shows 1:2.5 as optimum embankment slope which gives the highest factor of safety on compared with soil alone.

Nandan A. Patel, Prof.C. B. Mishra, Mr. Vasu V. Pancholi (2015) is found that the responsibility of the road authorities to use the local material and correct the soil properties using additives enhancing the strength of soil and make the road-durable. The examination was completed to focus first soil engineering properties (with and without stabilizer), standard compaction; four days soaked California Bearing Ratio (CBR), permeability test and cyclic loading test according to codal procurement. A concoction named Terrasil was utilized as a stabilizer and it was utilized for altered measurement i.e. 0.041% by dry aggregate weight of soil test according to the convention of Zydex Industries, Vadodara. Test outcome demonstrates that designing properties got modified and CBR on stabilized clayey samples increased considerably, which reflects the lower thickness in correlation with natural characteristic soil properties. Additionally, the expense is diminishing which advantages the road builders, engineers, policy makers and pavement designers as well.

4. Experimental outcomes

4.1 Sample Preparation and tests

The soil sample is collected from the site and dried out in direct sunlight; the clods are busted to get the uniform sample. The busted wooden material, small aggregates, organic matters are shifted carefully from soil samples. The sample is kept in the oven for drying to use in a test at temperature 150^{0}C for 24 hours. Basic properties of soil are determined. The weight of soil sample taken for a test is replaced by Nano chemical terrasil stabilizer of 0.021% percent dose. The soil stabilized with terrasil and the strength parameters like OMC-MDD, CBR and UCC were determined. By getting out on each result of all these blends the comparison of the best suitable additive mix will be carried out.

4.2 Results of OMC and MDD for Clay soil stabilized with Terrasil

The OMC and MDD of the soil samples for 0.021% of terrasil stabilizer were determined by performing the Standard proctor test. The dry density was resolute and plotted against the corresponding water content to ascertain OMC and MDD. The 0.021% of Terrasil is tabulated in table 4.

Table 4 OMC-MDD of the Samples

% Replacement	Clay Soil + Terrasil	
	OMC (%)	MDD (g/cc)
0	17.70	1.7360
0.021	15.42	1.7401

4.3 Results of California Bearing Ratio (CBR) test for Clay soil stabilized with Terrasil

The CBR test is carried out as per the IS code 2720 part 16, 1987 on the soil containing 0.021% of Terrasil (fig 1) and the 4-day outcome is as shown in table 5.

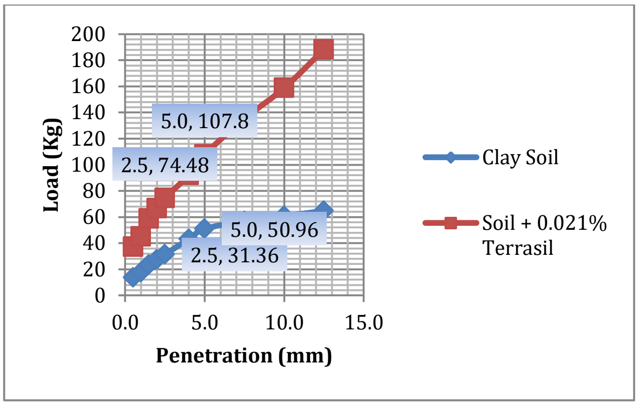

Fig. 1 Penetration Vs Load

Table 5 CBR Value

CBR Value at St. Penetration 2.5 mm and St. load 1370 Kg		
Sample	CL Soil	Soil + Terrasil (0.021%)
Load at 2.5 mm	31.36	78.48
CBR Value	2.29	5.44
CBR Value at St. Penetration 5 mm and St. load 2055 Kg		
Sample	CL Soil	Soil + Terrasil (0.021%)
Load at 5 mm	50.96	107.8
CBR Value	2.38	5.25

4.4 Results of Unconfined Compressive Strength (UCS) test of Clay soil stabilized with Terrasil

The samples were tested as per the IS code 2720 part 10 1991 by using 0.021% of terrasil of the soil. At 0.021% replacement of soil with additive coming out to be 60.79 KPa (fig. 2).

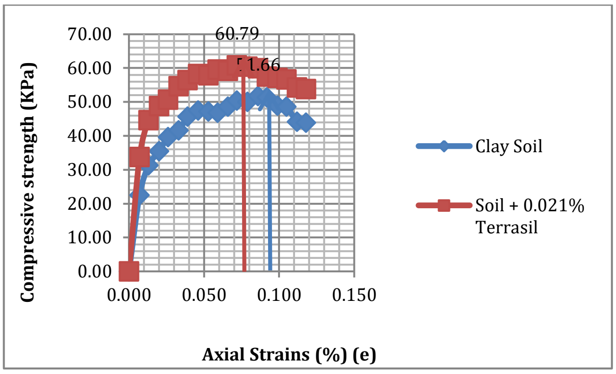

Fig. 2 Stress vs Strain for Clay soil + Terrasil

4.5 Thickness Design of Flexible Pavement as per IRC: 37 – 2012

Data

- National Highway (6 Lane)
- Design Traffic (A) = 1000 CVPD
- Lane Distribution Factor (D) = 60 percent (Three Lane Dual Carriageway Road)
- Vehicle Damage Factor (F) = 4.5 (Plain Terrain)
- Design Life (n) = 15 years
- Annual Growth Rate (r) = 7.5 percent (Assumed)
- Width = 10.5 + 10.5 m (Considering only single side, i.e. 10.5 m)
- Design Soak CBR = 2.38% (obtained)

Design Calculations:

Cumulative no. of standard axle load,

$$N = \frac{365 \text{ x } [(1+r)^n - 1]}{r} \text{ x A x D x F}$$

$$N = \frac{365 \text{ x } [(1+0.075)^{15} - 1]}{0.075} \text{ x } 1000 \text{ x } 0.60 \text{ x } 4.5$$

$$N = 25.74 \text{ msa} = 26 \text{ msa}$$

Taking the value as 2% CBR and 26 msa traffic, thickness design is calculated as per IRC: 37 – 2012, pg.26. After interpretation of 26 msa traffic Pavement composition is shown in fig. 3.

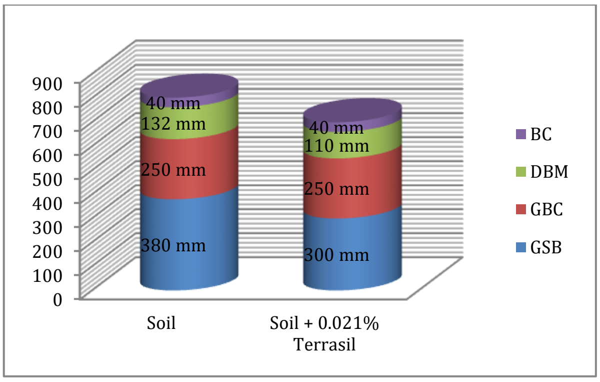

Fig. 3 Comparison of Thickness layers with and without additives

4.6 Construction Cost

Table 6 Summary of Cost Analysis (1 km) for 10.5 m width of road

Sr. No.	Materials	Cost (Rs.)
1	Clay Soil	21,258,573
2	Clay Soil + Terrasil	18,715,725

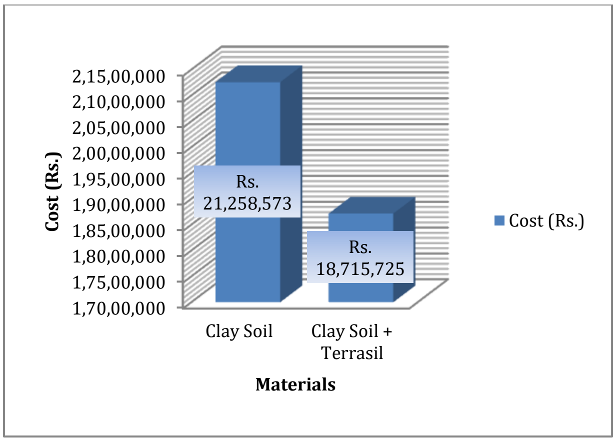

Fig. 4 Summary of Cost Analysis (1 km) for 10.5 m width of road

Conclusions

The liquid limit and plastic limit of the soils decrease with the addition of terrasil to the soil in a proper proportion. The CBR value of soil gets increased with the addition of terrasil. The effect of terrasil chemical on the improvement of CBR is much effective. The initial increase in the CBR is noted for 0.021% addition of Terrasil after which decrease is seen which is due to lower moisture content. The increase in CBR of stabilized soil noted is 2.37 times that of ordinary soil. The cost of untreated soil per km comes out to be Rs. 21,258,573 while soil treated with 0.021% of terrasil per km comes out to be Rs. 18,715,725. This indicates that the cost reduces to Rs. 2,542,848 per km when treated with Terrasil (0.021%). The highway contractors and pavement designers can avail the usage of Terrasil 0.021% with ordinary soil, as it is alluring and backings the supportable improvement in road development for the long term.

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Standard Codes

IS 1498-1970, Soil Classification

IS: 2720 (Part 2) - 1973, Determination of Water Content

IS: 2720 (Part 4) - 1985, Determination of Grain Size Analysis

IS: 2720 (Part 5) - 1985, Determination of Liquid and Plastic Limit

IS: 2720 (Part 8) - 1983, Determination of Water Content - Dry Density Relation Using Heavy Compaction

IS: 2720 (Part 16) - 1987, Laboratory Determination of CBR

IS: 2720 (Part X) - 1991, Determination of Unconfined Compressive Strength

IRC: 37 - 2012, Guidelines for the Design of Flexible Pavements