*International Journal of Civil and Structural Engineering*
*Volume 3 : Issue 3* *[ISSN 2372-3971]*
*Publication Date : 30 December, 2016*

# *Suitability of Nano-Chemical Stabilizer in Black Cotton Soil*

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***Abstract*— Construction and subsequent maintenance of pavements in good condition has become quite problematic During monsoon season the natural subgrade soils become soft and pose serious problem ,To the movement of vehicular traffic, Instead of cutting out and replacing the unstable soil, soil adjustment is the only alternative as it saves lot of time and millions of money too. Soil adjustment can be defined as the change of the soil properties by synthetic or physical means keeping in mind the end goal to improve the designing nature of the soil. This paper presents the result of comprehensive laboratory investigation over behaviour of stabilised black cotton soil using Terrasil and Zycobond as nano- chemical based stabiliser. The soil is stabilised in different proportions and combination of Terrasil and Zycobond.**

***Keywords*— *Terrasil, Zycobond, clay soil, UCS, CBR***

## I. Introduction

The origin of expansive soil is related to a complex combination of conditions and processes that result in the formation of clay mineral having a particular chemical makeup which, when in contact with water, will expand. The degree of expansion of clay soils depends upon the type of clay mineral predominantly present in the soil mass. The presence of montmorillonite minerals in these soils imparts them high swelling –shrinkage properties. These soils are very hard when dry, but lose strength completely when wet. Long term performance of pavement structures depends on the stability of the underlying soils. Engineering design of these constructed facilities relies on the assumption that each layer in the pavement has the minimum specified structural quality to support and distribute the super imposed loads. These layers must be able to resist excessive permanent deformation, resist shear and avoid excessive deflection that may result in fatigue cracking in overlaying layers. The local earth material available at the site do not always meet the requirement and may require improvements to their engineering properties in order to transform these inexpensive earth materials into effective construction materials. Stabilization is usual practice for these problematic soils as replacing part or whole foundation material with good quality material is uneconomical.

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Sources in the road transport and highways ministry of India recently issued a circular which states that at least 10% of any project cost should be spent on new technology and materials, which already have been approved by the Indian Roads Congress(IRC) such as RBI grade 81, zydex nanotechnology (1). The motive is to popularize the trend that will help to build greener roads, and economical also. These new solutions are developed that can give all season pot- hole free roads, ensuring faster transportation of people and minimizing the risk of accident.

The overall objective of the research presented in this paper is to investigate the performance of nano-chemical like Terrasil and Zycobond for stabilization of subgrade soil. The main purpose of stabilization of subgrade soil is to improve the performance of a material by increasing its strength, stiffness and durability. The technique is specially recommended for developing countries where their roads, be it rural or urban are mostly unpaved or thin surfaced.

In addition, it may provide a greater resistance to the ingress of water. There are many types of stabilizer that can be used, each with their own pros and cons. The strength of stabilized material will often continue to increase for a period of several years from the time it is constructed.

### *A. Nano-chemicals*

Nano-chemicals are the nanotechnology based chemicals which are related with the production and the reactions of nano-particles and their compounds. These are materials that are manufactured at a scale that is 10 thousand times smaller than the size of human hair. at this level, quantum effects can be significant , and also new ways of carrying out chemical reactions become possible. In this project two different nano-chemicals; Terrasil and Zycobond are used as soil stabiliser agent.

#### *1)* Terrasil

Terrasil is emerging as a new material for the stabilization of soil. It is a commercially available chemical 2stabilizer which is used in the present investigation. It is available in concentrated liquid form and is to be mixed with water in specified proportion before mixing with the soil. Terrasil is nanotechnology based 100 percent organosilane, water soluble, ultraviolet and heat stable, reactive soil modifier to waterproof soil subgrade. It reacts with water loving silanol groups6 of sand, silt, clay and aggregates to convert it to highly stable water repellent alkyl siloxane bonds and forms a breathable in-situ membrane. It resolves the critical sub-surface issues. It is water soluble, chemically reactive and non-leachable and works well with all silicate containing materials. It can be applied to almost all types of soil. Terrasil being a Nano modification keeps the pores open to allow vapours to escape while2 preventing water to come in. Nano-chemicals can be identified as environmental friendly since they conserve limiting resources like aggregates and bitumen. They also allow the use of in-situ

soils minimizing use of fuel for transporting good soils over long distance.

### 2) Zycobond

It is acrylic co-polymer dispersion for bonding soil particles and imparting resistance to soil erosion and dust controls. It is mixed with Terrasil solution and 8sprayed on compacted soils. Present study is conducted on black cotton soil which intermediate compressible clay(CI) found in Jhalawar Kota region of India. Soil properties of this region are characterized by high swelling and shrinkage associated with climate change in moisture content, low bearing strength etc. Soil samples collected from this region was tested in the laboratory for the investigation of various engineering properties.

TABLE I. PROPERTIES OF TERRASIL AND ZYCOBOND

| **Terrasil** | | **Zycobond** | |
|---|---|---|---|
| ***Property*** | ***Description*** | ***Property*** | ***Description*** |
| Appearance | Pale yellow liquid | Appearance | White liquid |
| Solid Content | 68-70% | Chemical Type | Acrylic Co-polymer |
| Viscosity at 25oC | 100-500cps | Physical State | Liquid |
| Specific Gravity | 1.01 (gm/ml) | Specific Gravity | Dispersible in water |
| Solubility | Forms water clear solution | Solubility | 1.01-1.02 g/ml |
| Flash Point | >80oC | PH Value | Approx. 6.5-8 |
| Terrasil : Water (Water proofing) | 1 kg: 400 litres | Chemical Stability | Stable under normal temp. |

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TABLE II. PROPERTIES OF BC SOIL

| **S. No.** | **Properties** | **Value** |
|---|---|---|
| 1 | Specific Gravity | 2.4 |
| 2 | Natural Moisture Content (%) | 10.25% |
| 3 | Atterberg's Limits | |
| | Liquid Limit (%) | 40.38 |
| | Plastic Limit (%) | 25.76 |
| | Plasticity Index (%) | 14.62 |
| 4 | Free Swell Index | 41.59 |
| 5 | Modified Proctor Test | |
| | Optimum Moisture Content (%) | 19.56 |
| | Maximum Dry Density (kn/m3) | 1.641 |
| 6 | IS Soil Classification | CI |
| 7 | California Bearing Ratio (%) | |
| | Soaked at MDD | 3.08 |
| 8 | Unconfined Compressive Strength (MPa) | 0.345 |

## II. DESIGN OF STABILIZED SOIL MIXTURES AND COMBINATION

To stabilise given soils with Terrasil, initially it was mixed with water in required proportion to prepare Terrasil solution. Similarly for Terrasil and Zycobond solution, Terrasil is mixed first and then Zycobond is added. As these chemicals are in concentrated liquid form whose specific gravity is almost equal to water, no more calculations needed while mixing this solution as a percentage of dry soil to prepare sample.

For combinations which consist of cement, initially predetermined quantity of cement was added in oven dry soils then Terrasil solution is mixed with soil cement blend. All the test specimens were prepared with static compaction method at optimum moisture content determined by standard proctor test.

- To ensure whether Terrasil chemical reacted properly or not, a drop of water placed over top dry surface of CBR mould not get absorbed at least for 20 minutes.
- After a satisfactory completion of water drop test, this mould is kept for 4 days in soaking condition and further tested in CBR testing machine.

TABLE III. Trial mix program for various soil test

| **S. No.** | **Treatment** | **Trial Mix (in kg/m3 Chemical Added)** | | |
|---|---|---|---|---|
| | | ***Dosage-1*** | ***Dosage-2*** | ***Dosage-3*** |
| 1. | Untreated | NA | NA | NA |
| 2. | T | 0.5 | 0.75 | 1.5 |
| 3. | T+Z | 0.5 + 0.25 | 0.75 + 0.375 | 1.5 + 0.75 |
| 4. | T+C | 0.5 + 3% | 0.75 + 3% | 1.5 + 3% |

## III. Results

This paper aimed to investigate performance of nano-chemical stabiliser (Terrasil and Zycobond) so various laboratory experiments were performed on the soil. The behaviour of soil varies according to the type and the amount of stabiliser used. The amount of stabiliser required for appreciable stabilization depends on the type and characteristics of soil.

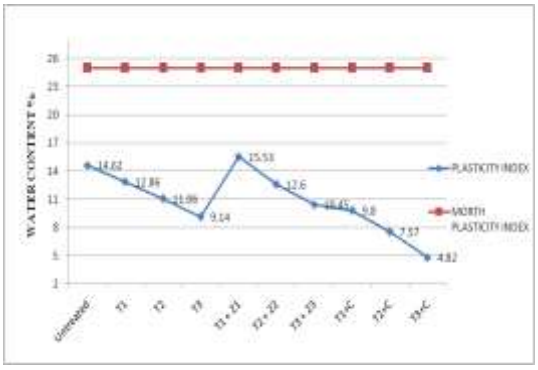


Figure 1. Variation of plasticity index on soil

TABLE IV. VARIATIONS IN COEFFICIENT OF PERMEABILITY

| Dosage | Coefficient of Permeability (cm/sec) |
|---|---|
| 0 | 5.8e10-8 |
| Terrasil (0.75 kg/m3) | 0 |

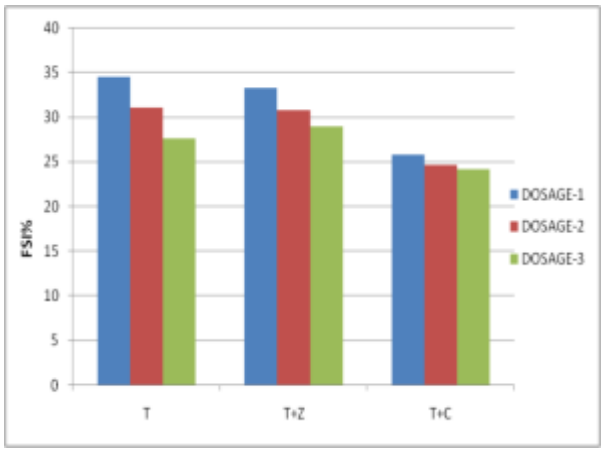


Figure 2. Variation in FSI of soil

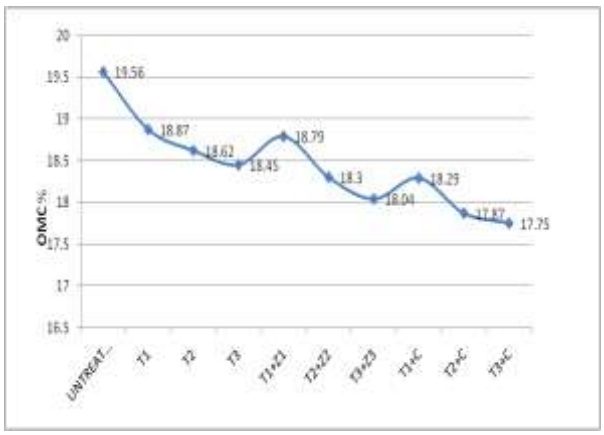


Figure 3. Variation in OMC with different treatment

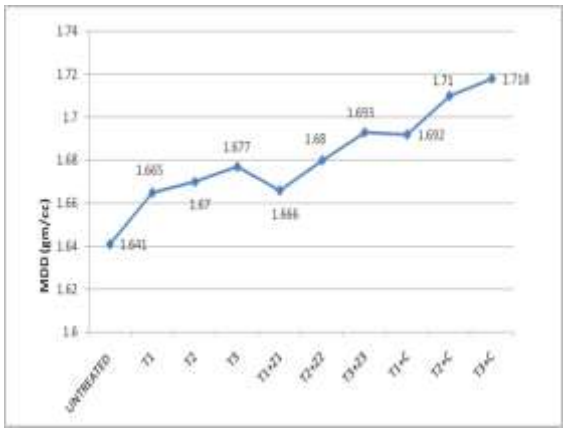


Figure 4. Variation in MDD with different treatment

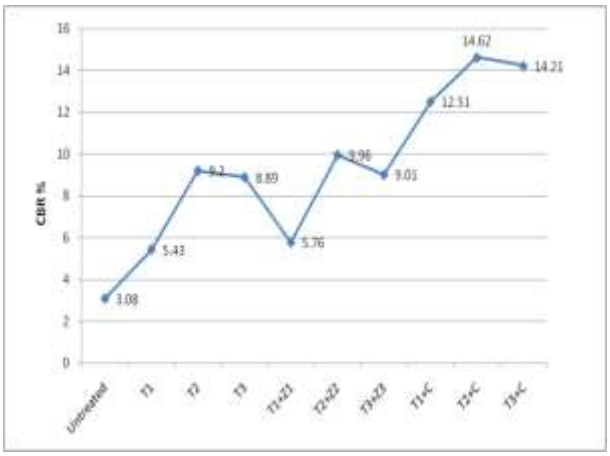


Figure 5. Variation in CBR % with different treatment on soil

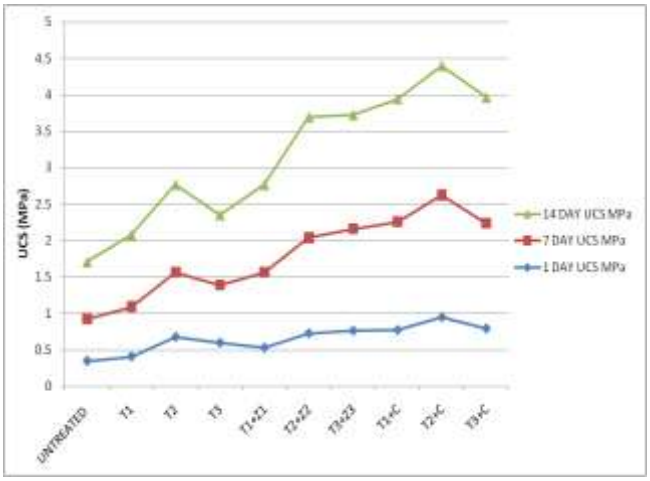


Figure 6. Variation in UCS of soil with different treatments

## IV. Discussion

- Generally stabilisation of soil enhanced the mechanical properties such as California bearing ratio and UCS as well as modulus of elasticity (E) in terms of 50% of load at failure. Although this research is based on materials obtained from Jhalawara, Kota Rajasthan, it provides useful information for the manufacture of stabilised soils using similar materials available in other parts of the world.
- The potential benefit of stabilisation was found to depend on the type of soil, the amount of stabilisers, stabilisers combinations and the age. A small fraction of cement act as a modifier in clay soil, so the combination T+C showed better mechanical characteristics in comparison with only Terrasil (T) or T+Z combination.
- Based on the laboratory experimental results and the response of soil over nano-chemical treatment it can be seen that, dosage-2 for only Terrasil and T+Z combination is found to be optimum dosage rate where it shows the best performance.
- Conducting permeability test indicate that at optimum dosage of Terrasil at which CBR is

maximum, the permeability of soil reduces to almost zero. Thus making the soil 100% waterproof and decreasing the failure of subgrade due to penetration of moisture.

# v. Conclusions

This paper aimed to investigate performance of nano-chemical stabiliser (Terrasil and Zycobond) so various laboratory experiments were performed on the soil. The behaviour of soil varies according to the type and the amount of stabiliser used. The amount of stabiliser required for appreciable stabilization depends on the type and characteristics of soil. The overall conclusions about applicability of nano-chemical soil stabilizers in low volume road construction is given below:

1. The laboratory test results indicated that the soil type greatly influence the performance of these nano-chemical stabiliser.
2. Due to the addition of different combination of nano-chemical and cement improved CBR and UCS of clay soil. In addition it helped to reduce liquid limit, plasticity index and free swell index of expansive clay soil.
3. For soil like black cotton soil having high plasticity index and low bearing capacity, the overall performance got improved with increase in dosage rate from dosage-1 to dosage-2 and with further increase in application rate from dosage-2 to dosage-3 results in decrease in performance. Dosage-2 was observed to be optimum dosage rate.
4. It is also noted that increment in dosages rate resulted in decrement in the consistency limits. So it is clear that the chemical makes the soil stiff.
5. Permeability is found to be nil for treated soil. It makes the soil completely impermeable.
6. Fatigue analysis and triaxial tests for untreated and treated soil can be further conducted since these tests provide a better idea about the use of chemicals in soil for pavement construction.
7. This study is limited to purely clay soil whereas it can be further extended and carried out over other types of soils consist of silt, sand, alluvial soil etc. which is virgin area as far as nano-chemical stabilizer is concern.

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