

# Stabilization of Expansive soil using Terrasil and Micro silica fume: A Review

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**Abstract**— Soil Stabilization is the phenomenon which deals with modifying the properties of soil to improve its performance. Stabilization is being used for a variety of engineering works either in its natural form or in a processed form. Eventually all structures rest on soil foundation where the main objective is to increase the strength or stability of soil and to reduce the construction cost. The performance of terrasil and micro silica fume stabilized soil was evaluated using physical and strength performance tests namely; Atterberg's limit, specific gravity, compaction test, unconfined compressive test, California bearing ratio (CBR) and direct shear test. These test were conducted in order to evaluate the improvement in the strength characteristics of the soil. After performing direct shear test, there was an improvement in angle of friction ( $\Phi$ ). As the percentage of terrasil and micro silica fume increased,  $\Phi$  increased. As bearing capacity is dependent on C and  $\Phi$ , it was also observed that there is an increase in bearing capacity of the soil.

**Keywords**— Stabilization, Terrasil, micro silica fume, expansive soil, atterberg's limit, moisture content

## I. INTRODUCTION

Many civil engineering structures fail due to failure of soil underlying the structure for e.g. construction of buildings, dam, bridges, etc. Out of these one of the major problem which country faces is failure of transportation system. An efficient transport system is a pre-requisite for sustained economic development. In country like India which is rich in monsoons, moisture becomes a huge problem to roads. 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. Addition of nano chemical to soil in an optimum quantity can be proved beneficial to the problem discussed above.

Soil stabilization technique, used to modify the properties of poor quality soils available at the site, to make them meet the desired requirements of design/ construction. The commonly used materials are fast depleting and hence search for new materials and improved techniques to process the local materials have gained. Since the nature and properties of the soils vary widely, a suitable stabilization technique has to be used to deal with a particular situation or requirement.

It is a well-known fact that a construction is as strong as its foundations are. Now a days the constructions sites with good soils for foundations are fewer and fewer. One of the most difficult issues on sites, especially in road construction is the presence of highly cohesive soils, soils that are easily affected by the change of the water content. Swelling clay soils present a problematic challenge for civil and geotechnical engineers all over the world. Aspects that need identification when dealing with expansive soils include: soil properties, water conditions, water content variations temporal and spatial, (generated by trees and the seasonal change), and the stiffness of foundations and associated structures built on active shrink/swell soils. Stabilization procedures are available in order to reduce or completely eliminate the swelling potential of expansive clays. The problematic soil is removed and replaced by a good quality material or treated using mechanical and chemical stabilization. Different procedures can be used to improve the geotechnical characteristics of problematic soils by treating in situ. One of the solutions for soil stabilization is treatment with mineral binders. The solution has been proven to be effective of various types of cohesive soils. Terrasil and micro silica fume is used to stabilisation for expansive soil.

## II. COMPOSTION OF MICRO SILICA FUME

In this study, micro silica fume–lime, additive mixture was used to modify the freezing–thawing properties of granular oils. Micro silica fume are waste materials and they are extensively used in geotechnical engineering applications due to their pozzolanic reactivity. These materials have low unit weight, low compressibility, and high pozzolanic reactivity. The pozzolanic reactivity depends on their reactive silica, free lime, carbon and iron content, fineness flame temperature in furnace, and particle size distribution. The performance of stabilized samples with these additive mixtures was evaluated to develop them as alternative construction materials with high freezing–thawing durability for road constructions and earthwork applications.

TABLE I  
COMPOSTION OF MICRO SILICA FUME

Property	Chemical Composition(%)
Silica (SiO <sub>2</sub> )	98.84
Alumina (Al <sub>2</sub> O <sub>3</sub> )	0.04
Calcium oxide (Cao)	0.63
Iron oxide (Fe <sub>2</sub> O <sub>3</sub> )	0.03
Potassium Oxide (K <sub>2</sub> O)	0.07
Magnesium Oxide (Mgo)	0.01

III. COMPOSTION OF TERRASIL

Terrasil is water soluble, ultra violet and heat stable, reactive soil modifier. It improves the frictional value, reduces water permeability and maintains breathability of the soil layer. It is also defined as an organosilane compound which reacts with soil particles and converts them (all types of soils) from water loving to water hating particles. This makes the soil in sensitive to water and can be compacted to give better interlocking to the soil particles. It offers or forms a permanent water repellent nano layer on all types of soils, aggregates etc. This siloxane is non leachable as it chemically binds to surfaces permanently. It forms strong covalent bond structure allows the treated material to breathe i.e. It allows free flow of air through its structure and preserves thermal insulation property. Terrasil prevents damage due to capillary rise of water, cracking of soil and also resistant to ultraviolet rays. It is highly soluble in water.

TABLE 2  
COMPOSTION OF TERRASIL

Chemical compound	Value in range,%
Hydroxyalkyl alkoxyalkylsil	65-70%
Benzyl alcohol	25-27%
Ethylene glycol	3-5%
Appearance	Pale yellow liquid
Density	1.01 g/ml
Viscosity at 25° C	20-100 cP
Solubility	Forms water clear solution
Freezing point	5°C
Flash point	>80°C

IV. LITERATURE REVIEW

A number of researchers have worked in improving the properties of expansive soil for various engineering application which are practical and economical.

The following literature review describes important research results regarding use of terrasil and micro silica fume in soil improvement.

- 1) Nandan A. Patel, C. B. Mishra, D. K. Parmar, Saurabh B. Gautam -(2015) in “Subgrade Soil Stabilization using Chemical Additives” stressed that it is the obligation of the road powers to utilize the nearby material and right the soil properties utilizing added substances upgrading the quality of soil and make the road sturdy. Test result shows that engineering properties got changed and CBR on balanced out clayey examples expanded impressively, which mirrors the lower thickness in connection with regular trademark soil properties. Also the cost is decreasing which points of interest the Road developer’s engineers, strategy producers and asphalt originators too also found that the addition of Terrasil (0.041%) + zycobond (0.020%) to the soil the CBR value increased from 6.64% to 12.15% This signifies that the quality of subgrade soil is enhanced consequently expanding the load carrying limit of pavement.
- 2) Ajay Kumar Pandagre & Ashutosh Rawat-(2016) in improvement of soil properties using non chemical terrasil. Calcium chloride being hygroscopic and deliquescent is used as a water retentive additive in mechanically stabilized soil bases and surfacing. Sodium chloride is the other chemical that can be used for this purpose with a stabilizing action similar to that of calcium chloride. Sodium silicate is yet another chemical used for this purpose in combination with other chemicals such as calcium chloride, polymers, chrome lignin, alkyl chlorosilanes, siliconites, amines and quarternary ammonium salts, sodium hexametaphosphate, phosphoric acid combined with a wetting agent. Now a days nano chemicals are widely used for improving the properties of soil, some nano chemicals are terrasil, zycobond, etc.

- 3) Micro silica fume, and lime-micro silica fume have been used for stabilizing and considering their effects on the soft clay soil. A grey-colored densified micro silica fume (SF) is used. It is a pozzolanic material which has a high content of amorphous silicon dioxide and consists of very fine spherical particles. Lime reacts with soft clay to produce decreased plasticity, increased workability, and increased strength. Three percentages are used for lime (2%,4% and 6%) and three percentages are used for SF (2.5%, 5%, 10%) and the optimum percentage of SF is mixed with the percentages of lime.
- 4) “Expansive Soil Stabilization Using Bagasse Ash” in this study accentuation is offered to upgrade the nature of broad soil of Surat region, bagasse slag used as the included substance which builds the security of soil and decay the swelling of soil? The discoveries shows that Bagasse fiery debris adequately dries wet soils and gives a starting quick quality addition, which is valuable amid development in wet, temperamental ground conditions. Bagasse cinder likewise diminishes swell capability of far replacing so as to reach soils a portion of the volume beforehand held by broad mud minerals and by solidifying the soil particles together.

#### V. METHODOLOGY

The common tests that are performed to check whether soil is expansive soil or not includes following laboratory tests.

- Grain size distribution
- Specific gravity
- Liquid Limit
- Plastic limit
- Hydrometer
- Swell index

The common tests that are performed by various researcher on use of Terrasil and Micro silica fume to improve soil by adding in different ratio includes following laboratory tests.

- Grain size distribution
- Specific gravity
- Liquid Limit
- Plastic limit
- Differential Free Swell test
- Proctor test
- California Bearing Ratio test
- Unconfined Compressive Strength test
- Permeability test

#### VI. CONCLUSION

Various type of possible and cost effective stabilization technique of the soil properties enhancement were presented in this literature review. It is clear that by use of terrasil and micro silica fume almost all the engineering properties of weak soil get modified.

- 1) The liquid limit and plastic limit of the soil decrease with the addition of terrasil and micro silica fume to the soil in a proper proportion.
- 2) Permeability is found to be decreasing in the case of soil treated with terrasil and micro silica fume.
- 3) All the studies conclude that the CBR value of soil get increased with addition of terrasil and micro silica fume.
- 4) Combining two locally available materials (terrasil and micro silica fume) can effectively improve the properties of expansive soil.

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