

# Red Soil Stabilization Using Silica Fumes and Alccofine

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**Abstract**—The main objective of this research work was to study the engineering characteristics of red soil. The engineering behavior of residual soils in the area, derived from the in-situ weathering and decomposition of parent rock, is determined by certain physical characteristics designated as engineering properties. For this work both Primary and secondary data from organizations were in use. Red soils occur mostly in tropical and sub-tropical regions with hot, humid climatic conditions. It has been suggested that a mean annual temperature of around 25°C is required for their formation, and in seasonal situations there should be a coincidence of the warm and wet periods. The red soil also called as red earth contains kaolinite type clay along with silt & fine sand. It has got its red color due to the presence of considerable quantities of iron oxide. It is less clayey and siltier in nature, and has low humus content. This soil is acidic in nature and is not able to retain moisture. The content of nutrients like nitrogen, phosphorous and lime is very small. Stabilization of soil using cement or lime is well established. Our aim here is to study the effect on engineering properties of soil and its stabilization by using Silica Fume (an industrial waste) with Alccofine. Alccofine is the other revolutionary product developed by Ambuja Cement for the stabilization purposes and to increase the strength of soil. In this study, experimental investigations are done to know the effect of different quantity silica fumes with 5 Alccofine. The results will be then compared with the standard ratio of soil without any stabilizing agent. The simulation will be conducted to verify the various mechanical & physical parameters.

**Index Terms**— Red Soil, Silica Fume and Alccofine.

## 1 INTRODUCTION

Stabilization of soil in a broader sense is the modification of the properties of a soil is improving its engineering performance. Soil stabilization is broadly used in connection with road, pavement and foundation construction. It improves the engineering properties of the soil in terms of volume stability, strength, and durability. Soil stabilization occurs over a longer time period of curing. The effects of blast furnace slag stabilization are usually measured after 0days, 3days, 7days, 15days, and 28days or longer. A soil that is treated with blast furnace slag is modified and its properties are changed which may lead to stabilization. When sufficient amount of blast furnace slag is added to the soil, stabilization occurs. Stabilization is different than modification as strength increases. Over a long time period, the strength increases up to the addition of 10% of blast furnace slag. Red soil is generally, is derived from weathering of ancient metamorphic rocks of the ancient Deccan plateau. It is red colour due to the abundance of iron in it. When iron content is suitably lower, the colour will be yellow or brown colour.

Red soil is usually that group of soil that develops in warm temperature and is generally abundant in moist climate where deciduous or mixed forests are present. They generally have a thin organic and inorganic mineral layer overlaying a yellowish brown layer resting on the alluvial deposits. Red soil is available in many states of India. Red soil is generally found in Odisha, Tamil Nadu, Karnataka, Maharashtra, Chhattisgarh, Birnbaum (West Bengal), Mirzapur, Jhansi, Haripur (Uttar Pradesh), Udaipur, Durgapur, Batswana and Bhilwara districts (Rajasthan), Chotanagpur plateau of Jharkhand, Andhra Pradesh.

## 2 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.



**Figure 1:** Red Soil.

The image processing technique using in many application in the medical image like Magnetic Resonance Imaging (MRI), Computerized Topography (CT), ultrasound imaging and X-ray images ect., this applications is very cost to the patient when it don't clear the re-imaging is more cost for that, then the image operation is one of image processing techniques to solve this problem by less cost and fast. Figure 1 show the modalities of different medical images.

## 3 SOIL STABILIZATION METHODS

The methods of soil stabilization which are in common use are:

- 1) Chemical Stabilization
- 2) Mechanical stabilization

### 3.1 EFFECTS OF STABILIZATION

Soil stabilization may result in any one or more of the following changes:

- 1) Increase in stability, change in properties like density or swelling, change in physical characteristics.
- 2) Change in chemical properties.
- 3) Retaining and desired strength by water proofing.

### 3.2 TECHNIQUES OF SOIL STABILIZATION

Based on the above principles, the various technique of soil stabilization may be grouped Proportioning technique:

- 1) Cementing agents
- 2) Modifying agents
- 3) Water proofing agents
- 4) Water repelling agents
- 5) Water retaining agents
- 6) Heat treatment
- 7) Chemical stabilization

In all the above methods, adequate compaction of the stabilized layers is the most essential requirement.

### 4 SILICA FUME

Definition: The American Concrete Institute (ACI) defines silica fume as "very fine non-Crystalline silica produced in electric arc furnaces as a by-product of the production of elemental silicon or alloys containing silicon" (ACI 116R). It is usually a gray colored powder, somewhat similar to Portland cement or some fly ashes.

#### 4.1 POZZOLANIC

It will not gain strength when mixed with water. Examples include silica fume meeting the requirements of ASTM C 1240, Standard Specification for Silica Fume Used in Cementitious Mixtures, and low-calcium fly ash meeting the requirements of ASTM C 618, Standard Specification for Coal Ash and Raw or Calcined Natural Pozzolanic for Use in Concrete, Class F.

#### 4.2 CEMENTITIOUS

It will gain strength when mixed with water. Examples include ground granulated blast-furnace slag meeting the requirements of ASTM C 989, Standard Specification for Ground Granulated Blast-Furnace Slag for use Concrete and Mortars, or high-calcium fly ash meeting the requirements of ASTM C 618, Class C.

#### 4.3 PRODUCTION

Silica fume is a by-product of producing silicon metal or ferro-silicon alloys in smelters using electric arc furnaces. These metals are used in many industrial applications to include aluminium and steel production, computer chip fabrication, and production of silicones, which are widely used in lubricants and sealants. While these are very valuable materials, the by-product silica fume is of more importance to the concrete industry.



Figure 2: Production of Silica.



Figure 3: Emission of Silica Fume.

Figure 3 shows a smelter in the days before silica fume was being captured for use in concrete and other applications. The "smoke" leaving the plant is actually silica fume. Today in the United States, no silica fume is allowed to escape to the atmosphere. The silica fume is collected in very large filters in the bag house and then made available for use in concrete.

### 5 ALCCOFINE

ALCCOFINE is a new generation, micro fine material of particle size much finer than other hydraulic materials like cement, fly ash etc. manufactured in India.



Figure 4: Alccofine.

It has unique characteristics to enhance 'performance of concrete' in fresh and hardened stages. It can be used as practical substitute for Silica Fume. Alccofine is manufactured in the controlled conditions with special equipment to produce optimized particle size distribution which is its unique property. Alccofine 1203 and Alccofine 1101 are two types with low calcium silicate and high calcium silicate respectively. The computed blain value based on PSD is approximately 12000cm<sup>2</sup>/gm and is truly ultra-fine. Due to its

ultra-fineness of Alccofine 1203, it provides reduced water demand for a given workability, even up to 70% replacement level as per requirement [8].

## 6 RELATED WORK

In terms of methods of stabilization of soils, there are physical, chemical and biochemical stabilization methods. Various efforts have been made to stabilize expansive soil and dispersive soil for engineering use. Variety of stabilizers may be divided into three groups (a) conventional stabilizers (lime, cement etc.), (b) by-products stabilizers (fly ash, quarry dust, phosphor-gypsum, slag etc.) and (c) non-traditional stabilizers (sulfonated oils, potassium compounds, polymer, enzymes, ammonium chlorides etc.). Disposal of large quantities of industrial by-products as fills on disposal sites adjacent to industries not only requires large space but also create a lot of geo-environment problems. Attempts are being made by various organizations and researchers to use them in bulk at suitable places. Stabilization of expansive soil and dispersive soil is one way of utilization of these by-products. Some of the research work conducted by earlier researchers on the above has been described

### 6.1 STABILIZATION USING SILICA FUME

Silica fume, a co-product from the production of silicon or ferrosilicon metal, is an amorphous silicon dioxide -  $\text{SiO}_2$  which is generated as a gas in submerged electrical arc furnaces during the reduction of very pure quartz. This gas vapour is condensed in bag house collectors as very fine powder of spherical particles, i.e., in average 0.1 to 0.3 microns in diameter with a surface area of 17 - 30  $\text{m}^2/\text{g}$ . The raw materials for the production of silica fume are by-products from the production of silicon metal, and these by-products are further processed to produce cementitious materials for use in concrete.

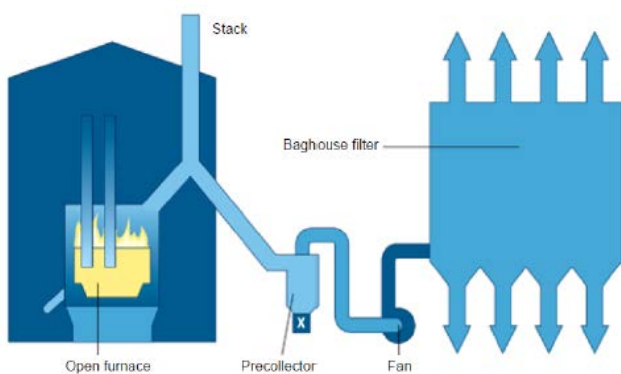


Figure 5: Production of Silica Fume.

Silica fume is a by-product of the manufacture of silicon metal and ferro-silicon alloys. The process involves the reduction of high purity quartz ( $\text{SiO}_2$ ) in electric arc furnaces at temperatures in excess of  $2,000^\circ\text{C}$ . Silica fume is a very fine powder consisting mainly of spherical particles or microspheres of mean diameter about 0.15 microns, with a very high specific surface area (15,000–25,000  $\text{m}^2/\text{kg}$ ). Each microsphere is on

average 100 times smaller than an average cement grain. At a typical dosage of 10% by mass of cement, there will be 50,000–100,000 silica fume particles per cement grain. Above Figure 1.2 shows the production of silica fumes as a by product of ferrosilicon manufacture. Most of the smoke or 'fume' from the furnace condenses into spherical particles of silica fumes. These are drawn through cooling pipes into a pre collector to remove coarse particles, filtered, batched and packaged.

### 6.2 STABILIZATION OF SOIL USING ALCCOFINE

P J Patel et al studied the effect Alccofine and fly ash on compressive and flexural strength of high performance concrete. The study concluded that:

- 1) The strength increase up to 7 days was excellent, between 7 to 28 days, strength increase was comparatively less, but between 28 to 56 days, strength rise was high due to of presence of fly ash. The 28 days compressive strength was 1 to 10% less than accepted compressive strength.
- 2) More than 150 mm slump was determined for all mixes.
- 3) 90 days compressive strength achieved was better than the strength achieved in 28 days. Maximum compressive strength achieved was 78.58 MPa for M2 mix, which was more than target strength.
- 4) The acceptable flexural strength was obtained for all mixes. The maximum flexural strength of 7.05 MPa in M4mix was achieved during the study.
- 5) From the studies of the available literature, it was observed that various efforts have been made to study the possible utilisation of different industrial wastes for stabilization of expansive soil.

Sunil Suthar et al examined the effects of alccofine & fly ash on the strength properties of HPC (high performance concrete). A combination of cementitious materials such as Portland cement, fly ash, and alccofine presents the significant advantages over binary blends and even more improvements in strength properties over Portland cement. The alccofine used in the concrete mix as mineral admixture with fly ash is found to improve the early age strength of hardened concrete. Concerning the durability aspects of concrete, combination of alccofine and fly ash proved to be superior to Portland cement.

The compressive strength of concrete mix prepared with 8% alccofine and different fly ash mixes was found to have higher than 10% silica fumes. A combination of cementitious materials such as Portland cement, fly ash, and Alccofine had achieved high compressive strength than all other silica-fume mixes. The high strength concrete can be achieved with the combination of 8% alccofine and 20% fly ash.

- 1) Fly ash improves the long-term strength development of the concrete mix.
- 2) Use of super plasticizer reduces the water demand with increased workability of concrete.
- 3) The blend of alccofine and fly ash possesses very high resistance to chloride ion permeability.
- 4) Alccofine helps in increasing the packing of the concrete particles and which in turn increases the strength of concrete.
- 5) If Fly ash was not used in the mix prepared with silica

fume, it increases the water demand.

Yatin Patel et al discussed the durability characteristics of HPC (high performance concrete) with alccofine and fly ash. In the study, the effect of alccofine on the strength and durability properties of concrete was discussed. The study concluded that:

- 1) The compressive strength of concrete at 28 and 56 days achieved with the combination of 8 % alccofine and 20% fly ash was 54.89Mpa and 72.97 MPa respectively.
- 2) The minimum loss of weight and compressive strength of concrete was achieved in the chloride resistance test and sea water test in fly ash and alccofine mix concrete. Reason for less permeability of concrete was more compactness with high packing effect. This converts leachable  $\text{Ca}(\text{OH})_2$  into insoluble, non- leachable cementitious product. The pozzolanic action of alccofine and fly ash is responsible for the higher impermeability of concrete. Also the removal of  $\text{Ca}(\text{OH})_2$  helps in reducing the effect of chloride attack on concrete.
- 3) Due to the pore filling and pore refining ability of alccofine, the loss of weight of steel in the alccofine mix concrete was comparable in accelerated electrolytic corrosion test and normal cover was proved to be sufficient to prevent steel reinforcement from corrosion.

Deval Soni et al carried out an investigation on HPC (High-Performance Concrete), developed by combination of alccofine and fly ash in an optimum proportion. The study concluded that:

- 1) The combination of 8% Alccofine and 16% of fly ash was found an optimum proportion of HPC
- 2) Alccofine was found to have better performance as well as work ability when compared to other supplementary cementitious materials such as micro silica, GGBFS etc.

Praeen Nayak S. et al compared the hardened properties of concretes prepared with silica fume and alccofine and performance optimization technique was used for the comparative study. The study concluded that:

- 1) Compressive strengths and flexural strength of alccofine mix concrete was superior to micro silica mix. Optimum proportion of silica fume and alccofine was found to be 13.36% addition or replacement level.
- 2) Splitting tensile strengths of concrete with micro silica was found to be better than concrete with alccofine at the same addition or replacement level.
- 3) Impact Strength of micro silica mix was found to be slightly superior to alccofine.

## 7 PROPOSED METHOD

The proposed simulation selected the stabilizer as silica fume and alccofine which even in a small percentage increase the strength of red soil many folds. The proposed steps:

- 1) To study and analyze different properties of silica fume and alccofine
- 2) Adding alccofine with different quantity of silica fume
- 3) Different samples of blend will be analyzed w.r.t strength gain
- 4) Quantify other physical parameter along with comparison.

## 8 SIMULATED RESULTS

In this section, the proposed algorithm is evaluated via computer simulation using MATLAB simulator. All simulation results are obtained on the basis of proposed method are picked and concentrated on. Figure 6 show the front end window.

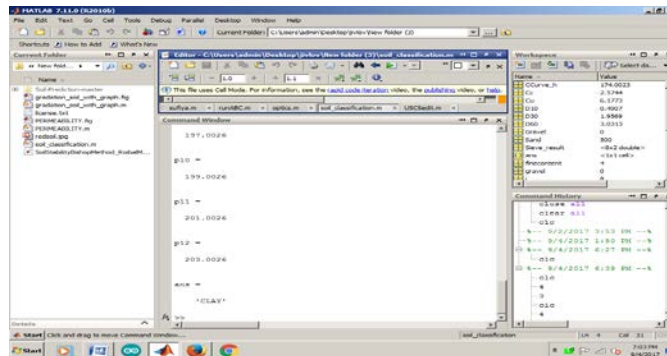


Figure 6: Front End Window.

As demonstrated in Figure 7, provides the user with the ability to analyze a sieve analysis lab data. It can calculate Sand and Gravel content, draw a sieve analysis curve, estimate D10, D30, D60 values by using linear interpolation, and it can classify the soil according to USCS (Unified Soil Classification System).

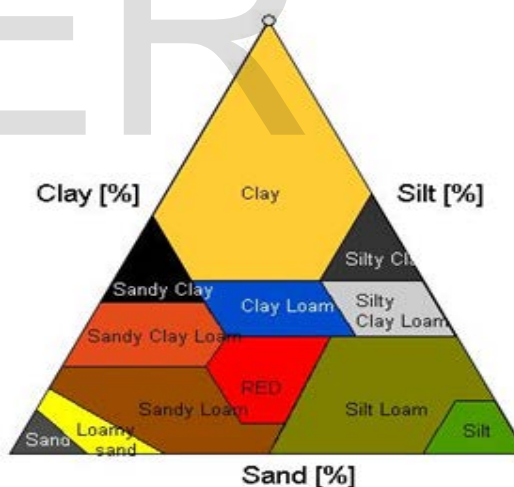


Figure 7: Unified Soil Classification System.

The main objective of this study is to evaluate the feasibility of using Silica fume as soil stabilization material. In this paper the effect of Silica fume on engineering characteristics of expansive RED like RED Soil has been presented. A series of experiment has been conducted on RED soil blended with Silica fume content from 0% to 10% by weight of dry soil. The experimental results showed a significant increase in California bearing ratio and unconfined compressive strength. The Differential free swell of the soil is reduced from 7% to 2% with increase in Silica fume content 20% and Alccofine content from 0 to 10 % respectively.

**Table1:** Characteristics of Mixture (Alcofine and Silica Fume).

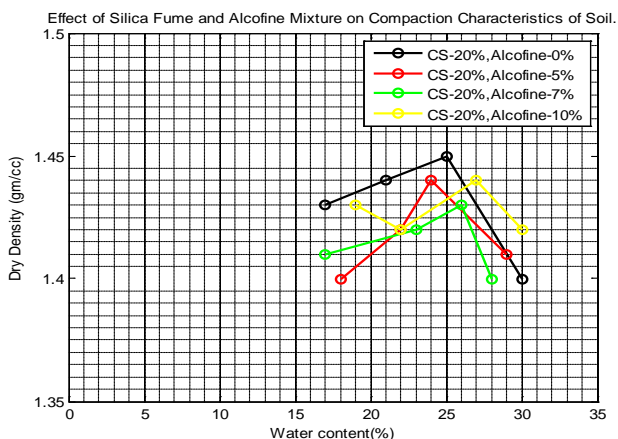
Chemical Analysis	Mass %	Physical Analysis	Range
CaO	30-34	Bulk Density	600-700Kg/m <sup>3</sup>
Al <sub>2</sub> O <sub>3</sub>	18-25	Surface Area	12000cm <sup>2</sup> /gm
Fe <sub>2</sub> O <sub>3</sub>	.8-3.0	Particle shape	Irregular
SO <sub>3</sub>	.1-4	Particle Size, d <sub>10</sub>	< 2μm
MgO	6-10	d <sub>50</sub>	< 5μm
SiO <sub>2</sub>	30-36	d <sub>90</sub>	< 9μm

The Proctor compaction results showed a small decrease in Maximum dry density and increase in Optimum moisture content. From this investigation it can be concluded that the Silica fume and Alcofine mixture as a potential to improve the characteristics of RED soil and Alcofine mixture as a potential to improve the characteristics of RED soil.

In soil, Silica fume and Alcofine are mixed on percentage basis i.e. 20-0%, 20-5%, 20-7% and 20-10% by weight of dry soil. The following Tests were conducted on RED soil and mixture (Silica Fume and Alcofine); as per relevant IS Code.

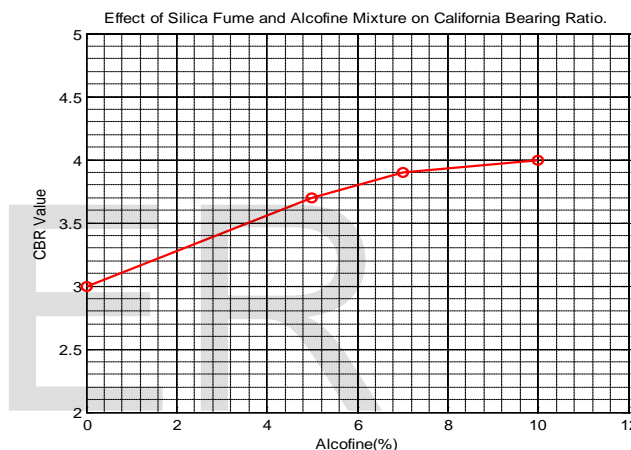
- 1) Compaction Test
- 2) California Bearing Ratio
- 3) Unconfined Compressive Strength
- 4) Differential Free Swell

As demonstrated in Figure 8, provides the effect of silica fume and Alcofine Mixture on compaction characteristics of soil.



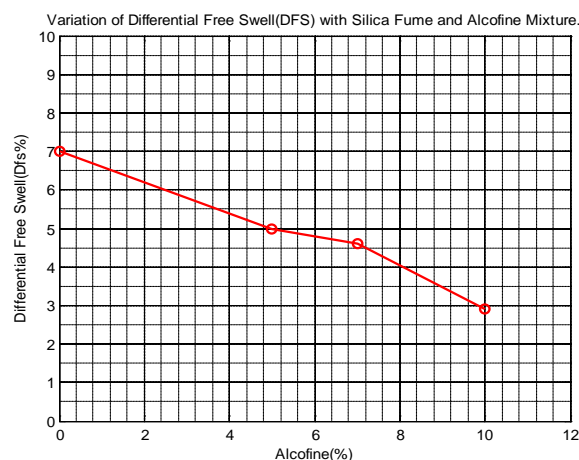
**Figure 8:** Effect of Silica Fume on Compaction Characteristics of Soil.

As demonstrated in Figure 9, provides the effect of silica fume and Alcofine Mixture on California Bearing Ratio.



**Figure 9:** Effect of Silica Fume on California Bearing Ratio.

As demonstrated in Figure 10, provides the variation of Differential Free Swell (DFS) with silica fume content.

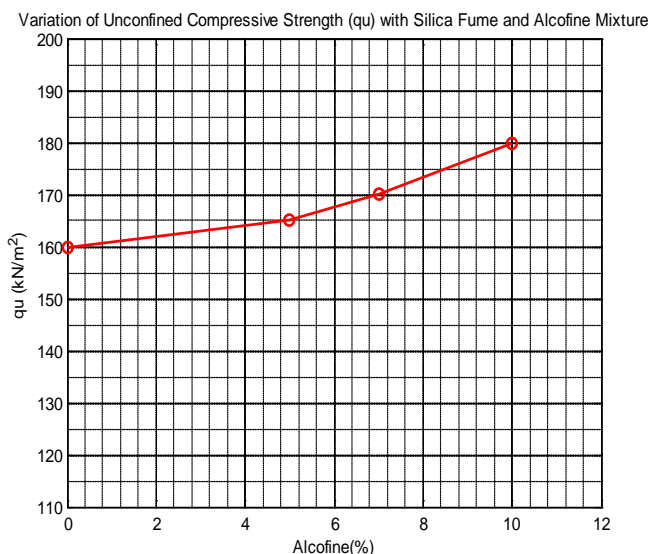


**Figure 10:** Effect of DFS with silica fume content.

**Table 2: Result Observation.**

S/N	Particulars	Observational Results			
		CS-20%, Alccofine-0%	CS-20%, Alccofine-5%	CS-20%, Alccofine-7%	CS-20%, Alccofine-10%
1	Composition characteristics				
	Optimum Moisture Content (%)	17	21	24	30
	Maximum Dry Density	1.43	1.44	1.45	1.41
2	California Bearing Ratio	3	3.7	3.9	4
3	Swelling Characteristics Differential free swell(%)	7	5	4.6	2.9
4	Unconfined compressive strength	160	165	170	180

As demonstrated in Figure 11, provides the variation of Unconfined Compressive Strength ( $q_u$ ) with silica fume content.



**Figure 11:** Effect of UCS with silica fume content.

## 7 CONCLUSION

The present investigation deals with the behavioural aspect of soil. From the experimental results, conclusions have been obtained that Red soil also called as red earth contains kaolin-

ite type clay along with silt & fine sand. It has got its red color due to the presence of considerable quantities of iron oxide. It is less clayey and siltier in nature, and has low humus content. This soil is acidic in nature and is not able to retain moisture. For further here is to study the effect on engineering properties of soil and its stabilization.

From the above laboratory investigations the following conclusions can be drawn Table 2:

- 1) The RED soil changes the proctor compaction parameters. The addition of mixture to the RED soil increases the optimum moisture content and decreases the maximum dry density with the increase in mixture content.
- 2) The addition of mixture to the RED soil improves the soaked CBR considerably. The addition of 20% silica fume and 10 Alccofine to the RED soil increases the CBR strength by 70% approximately.
- 3) There is a significant decrease in the swelling characteristics of the soil. The degree of expansiveness reduces from "High to Low".
- 4) The addition of mixture also increases the unconfined compressive strength. The UCS of stabilized samples significantly increases from 160.0 kN/m<sup>2</sup> to 180 kN/m<sup>2</sup> i.e. approximately 18% increase.
- 5) From the investigation it can be concluded that the industrial wastes like silica fume an Alccofine has the potential to modify the engineering characteristics of expansive RED soil.

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