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Strength Characteristics of Expansive Soils Using Epoxy resin and Silty Soil

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Abstract: ***Improving the properties of soil by stabilization is considered as a means of fulfilling design criteria. Stabilization is usually performed to improve material properties of soil such as strength and stiffness. The use of new materials for soil strengthening is crucial for geotechnical engineering, especially in foundation construction. Experiments were conducted using resins with different epoxy resin polymer-to-water (ER/W) ratios. The results show that by increasing the Epoxy resin polymer in the black cotton soil is increasing its shear strength. The Epoxy resin and hardener in 1:0.1 ratio was used .In this study deal with the obtaining the unconfined compressive strength values and Tri axial test values by fixing 5% Epoxy resin polymer and % varying of Silt Content(10%, 20%, 30%, 40% and 50%). The results indicate that the epoxy resins improve the mechanical properties of soil significantly, and the Silt Content is increasing the shear strength and angle of internal friction, cohesion changes significantly, if successfully grouted into a formation, the resins could provide a suitable solution for the stabilization of foundation material.***

Keywords: Soil, Epoxy Resin Polymer, Silty Soil, Shear Strength

1. Introduction

Increase in population over the last decades has increased the demand for housing and infrastructure facilities this in turn increased the need for habitable land. large areas of kerala are covered with weak soils having poor shear strength and high compressibility. The construction of civil engineering structures on such weak soils is dangerous as they are highly succeptible to differential settlements .A number of failures of engineering structures have been reported in areas covered with weak soil and therefore prior to construction improvement of the soil properties by adopting suitable ground improvement techniques impervative in such areas.
Soil stabilisation refers to the process of changing the soil properties so as to improve its engineering properties thus making it more stable .soils are generally stabilized to increase their strength and durability or to prevent erosion and dust formation in soils..Under this method of soil stabilisation of different manufactured materials are added into the soil which in proper quantities enhances the quality of soil. Under chemical reactions are induced by adding stabilizers.

Improving the properties of soil by stabilization is considered as a means of fulfilling design criteria. Stabilization is usually per-formed to improve material properties of soil such as strength, stiffness, and permeability. There are two major forms of stabilization: chemical and mechanical stabilization. There are also some instances where a combination of mechanical reinforcement of a chemically stabilized soil is used to improve properties such as strength and stiffness or to accelerate the treatment of the soil.

Chemical stabilizers are divided into two groups: traditional stabilizers such as lime, cement, and fly ash, andnon traditional stabilizers such as resin and enzymes. The stabilization or improvement is usually affected by controlling the void ratio of the soil by introducing a cementing additive or waterproofing agent, or by injecting a substance to fill the pore volume. There are several techniques for stabilization, and the selection of an appropriate technique depends on the nature of soil and environmental sensitivity.

Adding resin may enhance the soil-cement mechanical properties. In particular, epoxy resins are one of the principal resins used for grouting. They generally consist of two components. The epoxy component (a-component) is mixed with an amine component (b-component) to obtain the epoxy resin. The final product is strong bond, high durability, high resistance to acids, alkalies, and organic chemicals, and low shrinkage when cured. In addition, some epoxies may be diluted with water up to twice their volume to provide a low-cost product, but their strength consequently de-creases. This reduction of strength is proportional to the amount of water added to the epoxy. Although, numerous studies have been conducted concerning the application of epoxy compounds for structural repair or in fractured concrete.

2. Literature Review

Gopal (1983) studied on use of a few natural resins as dune sand stabilizer. Guar-gum - a product of Rajasthan desert, Terminalia alatatannins and rosin have proved promising for short-term and emergency use in field. Effect of compaction on strength has also been studied in order to optimize the thickness of stabilized surfaces required for construction of roads arid helipads in sandy areas. Effect of temperature and bacteria on stabilized specimens has also been discussed.

Levacic, (2006) determined the properties of a soil sample which mixed with urea formaldehyde resin. Several samples of soil and resin mixed in different ratios were prepared. Investigations of different parameters showed the resin significantly improves geomechanical soil properties. As a result the urea formaldehyde resin applied in the tests can be

used for stabilization.

Seyedaboolhasan (2010) studied the stabilization of silts sand soil with epoxy resin and the effect of wet and dry conditions on strength of stabilised silty sands. specimens were prepared by adding different amount of epoxy resin polymer to silty sand with 0,10,20,30,35,40,45,60% silt content at dry density of 17 kn/m^3.The resuts of study indicated the addition of epoxy resin improves significantly the compressive strength and modulus of elasticity of samples under dry condition. This improvement depends on the content of polymer and silt.

Anagnostopoulos (2012) studied experiments were conducted using resins with different epoxy resin-to-water (ER/W) ratios. The results indicate that the epoxy resins improve the physical and mechanical properties of sand significantly, and if successfully grouted into a formation, the resins could provide a suitable solution for the stabilization of foundation material. Based on the experimental results, a nonlinear regression analysis was performed to correlate the mechanical properties and permeability with curing time and ER/W ratio. The unconfined compressive strength, tensile strength, point load strength, and elastic modulus development of the fine sand/resin mix depend directly on the water content of the epoxy resin solution. Mixes with an ER/W ratio of 2.0 and 1.5 results in high strength and low permeability.

3. Objectives

The main objective of this study is to improve the engineering properties of soil by adding resins .

- To investigate the effects of resin on optimum content of clay
- To predict the engineering behavior of soil with varying percentage of resins (1%,2%,3%,4%,5% and 6%).
- Finding the Maximum Shear Strength of the soil by adding epoxy resin.
- Evaluate the Shear strength of the soil by using Silty Soil with 5% Epoxy resin polymer.

4. Materials and Methodology

Following are the materials which are used in the present study:

1. Expansive Soil

The soil sample was locally collected from near Vinayaka nagar at Aalam Khan Palli, kadapa district. The sample was extracted by 100 cm deep. The soil lumps were broken into small pieces and screened through 4.75 mm size sieve to make it free from roots, pebbles, gravel etc. The following table shows the various soil properties obtained:

2. Epoxy Resin

A commercial product of Epoxy Resin (bisphenol A) and a polyamide hardener was used in this research. A multi component resin grout that usually provides very high, tensile, compression and bond strengths. The additive mixture was composed of a 1:0.10 of epoxy resin to polyamide hardener

3. Silt Soil

Silt is granular material of a size between sand and clay, whose mineral origin is quartz and feldspar. Silt may occur as a soil (often mixed with sand or clay) or as sediment mixed in suspension with water (also known as a suspended load) and soil in a body of water such as a river. Silt is easily transported in water or other liquid and is fine enough to be carried long distances by air in the form of dust. Thick deposits of silty material resulting from deposition by aeolian processes are often called loess. Silt and clay contribute to turbidity in water.

Table 1: Properties of Expansive Soil

S. No	Properties	Expansive soil
1	Specific Gravity	2.42
2	Free Swell Index	76
3	Liquid Limit	65
4	Plastic Limit	30
5	Plasticity Index	35
6	Standard Proctor Compaction	OMC-28.69%
		MDD- 1.38g/cc
7	Unconfined Compressive Strength	0.5595kg/cm^2

5. Experimental Work

In the present study optimum moisture content and maximum dry density of soil mixed with epoxy resin of varying percentages such as 1%,2%,3%,4%,5% and 6% was determined by conducting Indian standard light compaction test as per IS 2720 part 7 (1980). The optimum dosage was determined by conducting unconfined compressive strength test as per IS 2720 PART 1 (1991).

The optimum dosage was 5% Epoxy resin fixing to determine the Shear strength and angle of internal friction, Cohesion of soil by adding of Silty Soil With percentage of 10%, 20%, 30%, 40% and 50%.

6. Results & Discussion

Results of experimental tests show that the strength values of the Epoxy resin polymer treated soils mainly depend on Three factors: (1) type of soil, (2) Moisture content)(3) Epoxy resin polymer content.

- Standard compaction test for the Black cotton soil was conducted, it was observed that optimum moisture content was 28.69% and maximum dry density was found to be 1.38gm/cc.
- It is observed that the Optimum moisture content decrease with increasing Epoxy resin polymer content in the soil-Epoxy resin mixture. Then Maximum Dry Density (MDD) increase with increasing Epoxy resin polymer content in the soil-Epoxy resin polymer mixture. Maximum Dry Density (MDD) was found to change with varying content of Epoxy resin polymer, then highest value observed being at Epoxy resin polymer content of 5% by weight.
- The Unconfined Compressive Strength (UCS) of the soil with variation of Epoxy resin polymer content showed. the

fact that the peak value was observed for a Epoxy resin polymer content of 5% by weight

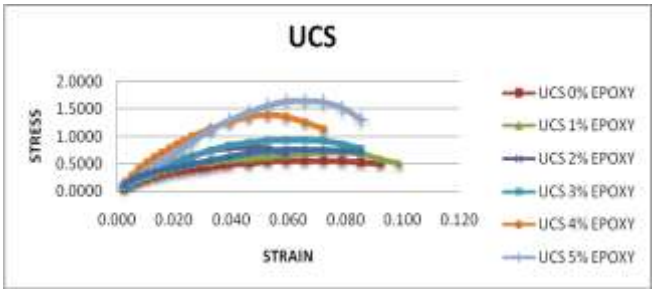

Figure 1: Unconfined Compressive Strength for Expansive Soil & ER

Table 2: SP for ER & Different % Of Silty Soil 1day Curing

Shear parameters	5% epoxy +10% Silt Content	5% epoxy +20% Silt Content	5% epoxy +30% Silt Content	5% epoxy +40% Silt Content	5% epoxy +50% Silt Content
Cohesion kg/cm²	0.02	0.12	0.36	0.42	0.34
Angle of internal friction	13º	9º	6º	4º	6º
Shear Strength kg/cm²	0.323	0.382	0.468	0.506	0.445

Table 3: SP for ER & Different % Of Silty Soil 3day Curing

Shear parameters	5% epoxy +10% Silt Content	5% epoxy +20% Silt Content	5% epoxy +30% Silt Content	5% epoxy +40% Silt Content	5% epoxy +50% Silt Content
Cohesion kg/cm²	0.04	0.24	0.5	0.64	0.48
Angle of internal friction	11º	7º	3º	0º	3º
Shear Strength kg/cm²	0.356	0.428	0.560	0.640	0.540

Table 4: SP For 5%Of ER & Different % Of Silty Soil 7day Curing

Shear parameter	5% epoxy +10% Silt Content	5% epoxy +20% Silt Content	5% epoxy +30% Silt Content	5% epoxy +40% Silt Content	5% epoxy +50% Silt Content
Cohesion kg/cm²	0.08	0.28	0.46	0.76	0.44
Angle of internal friction	10º	8º	5º	3º	3º
Shear Strength kg/cm²	0.3962	0.5620	0.6921	0.8470	0.5069

The above Tables are shows days of curing and variation in shear parameters like shear strength, angle of internal friction and cohesion of the soil with adding of constant epoxy resin and various percentages of silt soil. The below fig. shows that days of curing and variation in shear parameters like shear strength, angle of internal friction and cohesion of the soil with adding of constant epoxy resin and various percentages of silt soil.

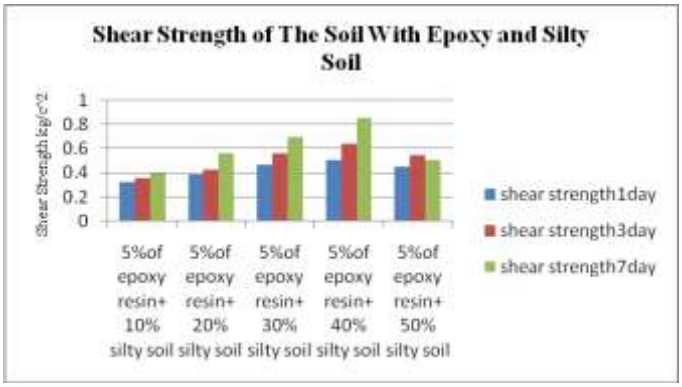

Figure 2: Shear strength of soil with Epoxy resin and Silty soil

The above fig. shows that 5%of Epoxy resin and 40%of Silty Soil gives a maximum Shear Strength in 7th day curing

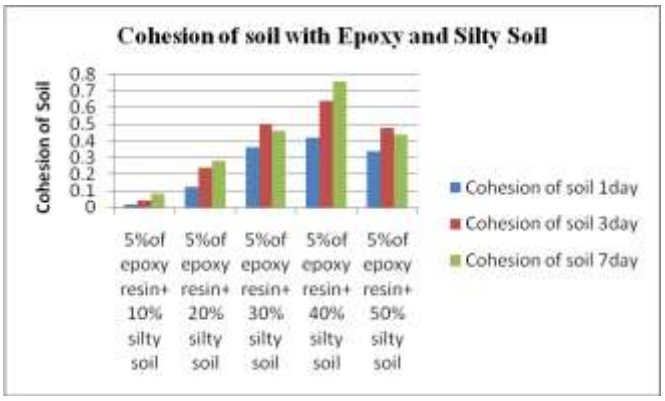

Figure 3: Cohesion of soil with Epoxy and Silty Soil

The above Fig. shows that the maximum Cohesion value obtained at 5%epoxy resin and 40% Silty Soil.

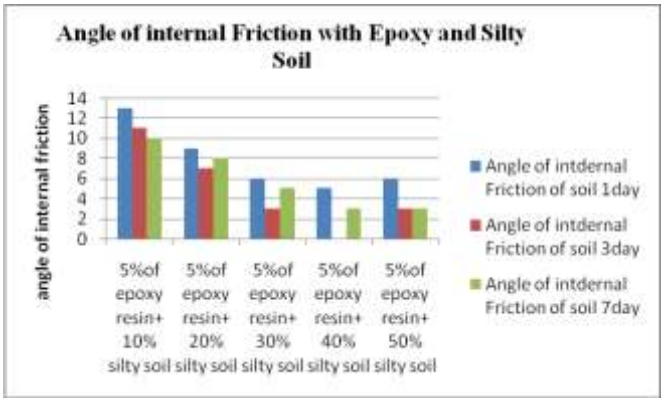

Figure 4: Angle of internal Friction with Epoxy and Silty Soil

The above Fig. shows that the angle of internal friction is decreasing with increasing of Silty Soil this research recommended 5% of Epoxy and 40% of Silty Soil

7. Conclusions

The addition of varying percentages of resins to Expansive Soil caused The UCS value increases when compared to the original soil after adding different percentage of resin.

The Epoxy Resin polymer is taking as 5% and adding different percentage of Silty Soil 10%,20%,30%,40% and 50% .

The Research recommended that 5% of Epoxy resin is suitable for improving Shear Strength.

The Research recommended that 5% of Epoxy resin and 40% of Silty Soil is improving the Cohesion of soil and Shear Strength of soil, and decreasing the Angle of internal Friction.

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