An Investigation Of The Cement And Fly-Ash Impacts On Flexible Pavement In Expansive Soils

B. Ravali, Vijay Kumar, M. Madhusudhan Reddy, Suseela Alla, SS.Asadi

Abstract: Out of the many types of soils that prevail on the Earth's crust, expansive soils are observed to be highly problematic by nature. Particularly under conditions of loading, these soils are highly prone to fail due to shear, crushing or excessive settlement. These factors end up expansive soils as unsuitable soils for any construction. If the strength of the soil is poor, then soil stabilization is duly needed. Stabilization is a technique used for improving characteristics of native and weak soils. It can also help in modifying the properties to improve its engineering performance both in terms of strength and durability. Ultimately, this operation helps the weak soils suitable for the purpose of construction and makes it resistant against shear failure. There are numerous stabilizers used for soil stabilization. In the present case study, we are using the materials stabilizing materials to stabilize the expansive soils and observe what is the optimum percentage that these materials should be used to provide maximum stabilization to these soils.

Keywords: California bearing ratio, stabilizing materials, maximum dry density, shear failure, soil stabilization, stability of soil, unconfined compressive strength,

1 INTRODUCTION

Because of fast development in expressway development, there is a need of good Earth. Soil can't be supplanted with great soil wherever as it is expensive and increment the venture cost. This issue can be overwhelmed with progress in properties of soil which is to be utilized for foundation venture. Numerous examinations had been completed to utilize squander materials to improve the dirt properties and to use the waste materials in perspective on better condition. Soil stabilization can be clarified as the modification of the soil properties by physical, chemical or mechanical methods so as to improve the designing nature of the soil. The principle target of the soil stabilization is essentially to build the bearing limit of the soil. It likewise intends to give protection from enduring procedure and soil porousness. The long haul execution of any development venture relies upon the quality, sufficiency, waste and toughness of the hidden soils. Uncertain soils can create substantial complications for pavements and the constructions, and can lead the structure towards failure. Accordingly, stabilization of soil techniques is necessary to eliminate the pessimistic properties of soil and properly sustain the load of the superstructure. This study deals with the complete analysis of the stabilizing materials.

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At various percentages, these materials are added to the collected soil sample as stabilizers and various tests are carried out on these samples to analyze optimum percentage of these materials to attain higher scale strengths and stabilization and get a proper sub-grade for a pavement on an expansive soil, and minimizing the cost of construction and structural maintenance.

Materials Adopted

For this project, we have basically adopted the basic materials as the expansive soil, upon which the primary tests are been carried out. Because this soil doesn't possess sound strength for strengthening the expansive soil, we have adopted stabilizing materials. The description about these materials is as follows.

Expansive Soil

The expansive soils are highly problematic in nature and do not permit smooth construction. The major components of the expansive soils are detrital material and clay material. In case of clay material, the major ingredients are mica, feldspar, quartz, etc. For our project, we selected black cotton soil as an expansive because it is the leading type of expansive soils spread across the globe. The sample for our project is collected from Basuregadi village in Northern Telangana. The sample is collected starting from a depth 0.5 m from GL. A sample of 200 kg is collected and is properly sealed and smoothly transported to our laboratory and further experimentations are carried out on it.

Cement

Cement is the leading material in current construction industry. Today, this material is used in almost all the constructions and possesses supremely higher strength and durability when acted with water. Cement is primarily made with the blend of clay and limestone, and is been used since the 19th century. For our project, we have bought 50 kg bag of UltraTech cement of ordinary Portland cement type for stabilizing the expansive soils.

Fly-Ash

Fly-ash is also known as pulverized ash. It is primarily obtained by combustion of coal in thermal energy plants and other places, in the form of ash been produced by burning the coal and this ash is being carried away by air. Hence, it is called as fly-ash. Fly-ash consists of considerable amounts of SiO_2, Al_2O_3 and calcium oxide CaO. The fly-ash used for our project is collected from fly-ash bricks manufacturing plant in Bharath Nagar, Hyderabad, to carry out the operation of soil stabilization for expansive soils. The stabilizing materials are used as a stabilizing material in expansive soils for the pavement design.

Objectives

- To analyse and evaluate the collected expansive soil properties and is to determine the optimum content by the addition of stabilizing materials.
- To increase durability, erosion resistance, weathering and traffic loading and try to be control the swelling and shrinkage characteristics of soil caused by humidity changes.
- To increase the strength and bearing capacity, to reduce the thickness of pavement, and minimize the cost of construction.

2 METHODOLOGY

After collection of the sample, few important tests mentioned below are carried out on it. Then various percentages of 2.5%, 5%, 7.5% and 10% of stabilizing materials are added to the soil sample. Then again the same tests are carried out on those samples and the results are analysed. As stated in Figure 1, we have carried out all the experiments in the chronological order.

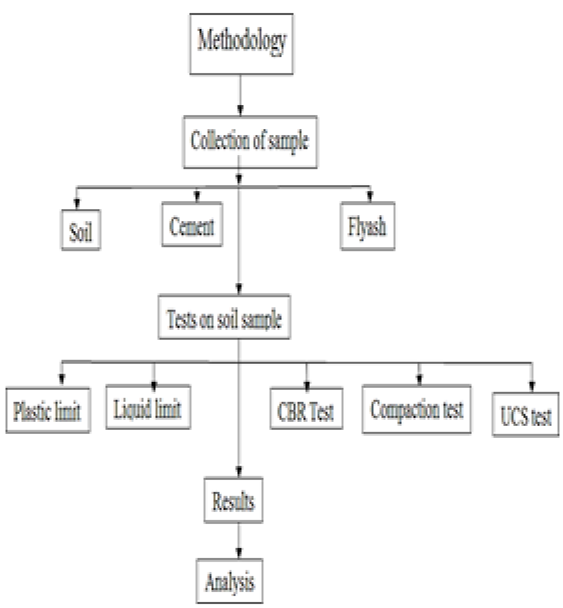


Fig. 1: *Methodology chart*

3 RESULTS AND DISCUSSIONS

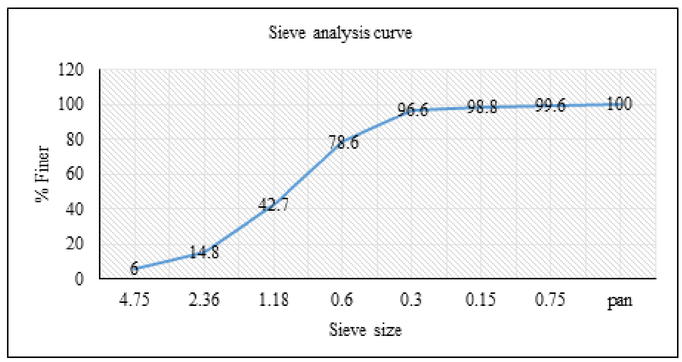
After the soil sample has reached the laboratory, it is kept in an oven for about 24–48 hours, to remove all the moisture contents from it. Later few tests including sieve analysis test, Atterberg's limits including liquid limit and plastic limit, compaction factor and, finally, CBR test are done on the soil. Later all the same tests, except sieve analysis, are repeated on soil samples with varying percentages of 2.5%, 5%, 7.5% and 10% of stabilizing materials. The results of these tests are stated as follows.

Sieve Analysis Test

Initially, sieve analysis experiment is carried out on the sample after drying the sample in the oven for 48 hours. This test is done over the sieves of sizes 4.75 2.36, 1.18 mm, 600 , 300, 150, 75 µ, and pan on a sieve-shaking apparatus. Let us have a look over the results of that test shown in Table 1 and Graph 1.

IS sieve size	*4.75 mm*	*2.36 mm*	*1.18 mm*	*600 µ*	*300 µ*	*150 µ*	*75 µ*	*Pan*
Cumulative weight of soil retained on each sieve (grams)	*60*	*148*	*427*	*786*	*966*	*988*	*996*	*1000*
% Finer with respect to 4.75-mm sieve	*6*	*14.8*	*42.7*	*78.6*	*96.6*	*98.8*	*99.6*	*100*

Table1. *Sieve analysis results*



Graph1. *Sieve analysis graph.*

4 RESULT

Coefficient of curvature, $C_c = 0.863$
Coefficient of Uniformity, $C_u = 2.64$

Atterberg's Limits

Liquid Limit

L.L of the soil is defined as "the state of change of soil from the liquid state to semi-solid state". Following the test procedure stated above, the soil is tested with various percentages of stabilizing materials, and here are the results shown in Table 2 and Graph 2.

Plastic Limit

P.L of the soil is defined as "the percentage of water that the soil stops being in semi-solid state and enters into plastic state". Following the test procedure, the soil is tested with various percentages of stabilizing materials, and the results are shown in Table 3 and Graph 3.

	0% Stabilizing materials	*2.5% Stabilizing materials*	*5% Stabilizing materials*	*7.5% Stabilizing materials*	*10% Stabilizing materials*
Liquid limit (water	*30.4*	*37.04*	*79.5*	*40.05*	*30.4*

content)					

***Table2** Test results for liquid limit test*

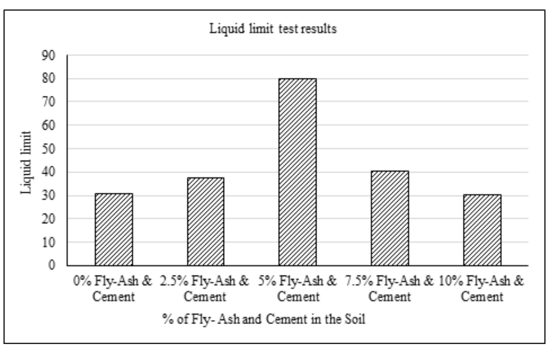
	0% Stabilizing materials	*2.5% Stabilizing materials*	*5% Stabilizing materials*	*7.5% Stabilizing materials*	*10% Stabilizing materials*
Plastic limit (water content)	*25.65*	*14.81*	*21.82*	*18.3*	*25.65*

Compaction Factor Test
Compaction factor test is done to find the optimum moisture content and max.dry density of a given soil sample. This test is also done to soil at various percentages of stabilizing materials. Below table represents the results along with the graph.

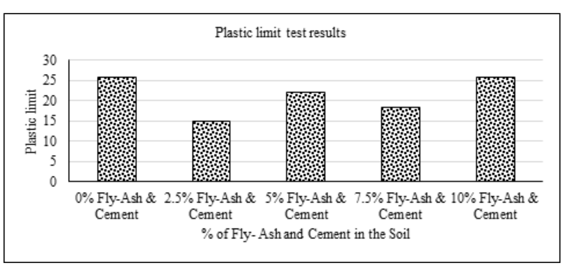
Compaction factor	**0% Stabilizing materials**	**2.5% Stabilizing materials**	**5% Stabilizing materials**	**7.5% Stabilizing materials**	**10% Stabilizing materials**
a) Water content (%)	**20.74**	**9.29**	**10.91**	**9.467**	**10.37**
b) Dry Density (KN/m^3)	**1.721**	**1887.67**	**1849.81**	**1882.47**	**1834.25**

***Table4.**Test results for compaction factor test*

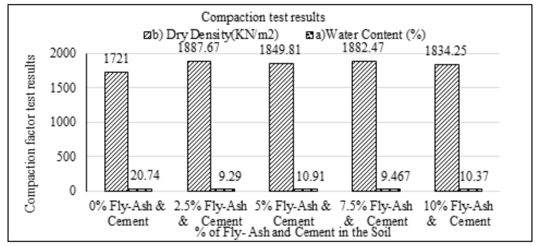
Tabl3. Test results for plastic limit test



***Graph2.** Liquid limit test*



***Graph3.** Plastic limit test*



***Graph4.** Compaction factor test*

California Bearing Ratio Test
This test is done to determine the sub-grade strengths for roads and pavements. This result plays a key role in construction and design of the pavements. Following the test procedure, the results of the soil sample with changing percentages of cement and fly- ash are shown in Table 5 and Graph 5.

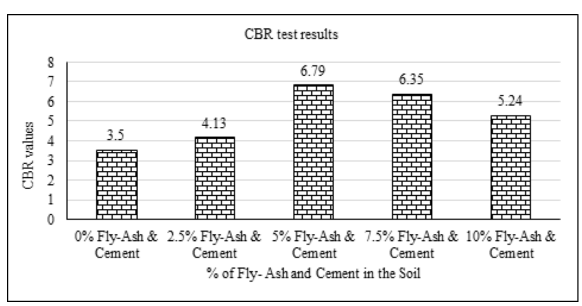
Unconfined Compression Test
This test is generally executed to analyse the mechanical properties of soils and fine soils. This test also helps to find the un-drained strength and stress–strain characteristics of the soil. Following the test procedure, the results for the test for soil at various percentages of stabilizing materials are shown in Table 6 and Graph 6.

	0% Stabilizing materials	*2.5% Stabilizing materials*	*5% Stabilizing materials*	*7.5% Stabilizing materials*	*10% Stabilizing materials*
CBR test results	*3.5*	*4.13*	*6.79*	*6.35*	*5.24*

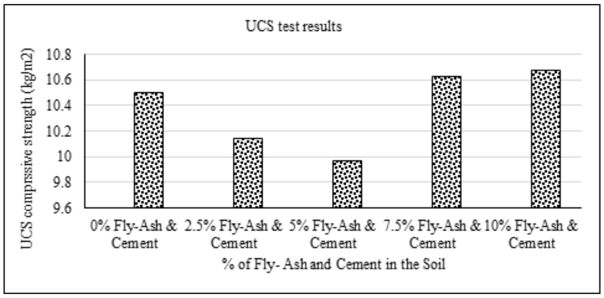
***Table 5**. Test results for compaction factor test*

	0% Stabilizing materials	*2.5% Stabilizing materials*	*5% Stabilizing materials*	*7.5% Stabilizing materials*	*10% Stabilizing materials*
UCS test results (kg/m^2)	*25.65*	*14.81*	*21.82*	*18.3*	*25.65*

***Table6.** Compaction factor test results*



***Graph5.** CBR test graph.*



Graph6. *UCS test*

- Fly-ash mixed with cement stabilizes granular materials with few fines producing a hard cement-like mass. Its roll in stabilization process is to act as pozzolana and to reduce air voids.
- Ordinarily, the measure of concrete utilized is little, however adequate to improve the building properties of soil.
- Concrete can be utilized either to adjust and to improve the nature of the soil or to change the soil into an established mass with expanded quality and strength.
- With addition of stabilizing materials, the L.L. and P.L. of soils gradually decrease with the increase of stabilizing materials contents. The maximum decrease is observed at 7.5% fly-ash or 7.5% cement content.
- Increase in stabilizing materials content in soil increases OMC and MDD at 15% stabilizing materials content.
- By adding 10% of stabilizing materials, the shear strength is more compared to 5% and 15% of stabilizing materials, respectively.
- Sub-base of pavement will be more stabilized by adding 10% stabilizing materials in expansive soils compared with normal soil.
- The pavements designed on the expansive soil by adding 10% stabilizing materials will have large serviceability compared to the normal design.
- Water content of expansive soil is equal for both soils, i.e. 0% stabilizing materials soil compared to 10% stabilizing materials soil.
- The addition of stabilizing materials increases the strength properties of black cotton soil.
- Bulk density and dry density of a expansive soil are higher when the stabilizing materials are added to it as compared to normal soil.

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