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Shear Strength Behavior of the Flyash Treated Lime Columns on Expansive Soils

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Abstract. Expansive soils are the most problematic soils for civil engineering constructions. In recent years, rapid growth in population results in construction of multi storied buildings in even problematic soils to meet their needs. Hence the stabilization of expansive soils is necessary to improve expansive soil mechanical properties. As a civil engineer one should deal with such problematic soils in a proper way because any mistakes in the soil study leads to hazards.
The objective of this work was to investigate the mechanical properties of fly ash treated lime column stabilized expansive soil which is the best solution for civil engineering works which are undertaken in the expansive soil stratum. Remolded compacted clay soils were prepared in tanks with lime columns and fly ash treated lime columns installed in them. The soil samples are extracted after curing and properties of the samples were investigated as a function of fly ash content added and curing periods. It was observed there are significant changes in the shear strength of treated soil due to the reactions between soil and fly ash-lime.

Keywords: *Expansive soils, fly ash treated lime columns, lime columns, Stabilization.*

1 Introduction

Due to rapid increase in population and pollution, it is becoming very difficult to find soils whose strength is sufficient to bear a structure. Developing countries like India, second highest populated country over the world facing number of problems related to soils. Expansive soil is one of the problematic soils that changes in volume with relation to changes in water content. Expansive soils are a worldwide problem, posing challenges for civil engineers. They are considered a potential natural hazard which can cause extensive damage to civil engineering structures. In India 2% of total area is covered with expansive soils. In those areas civil engineers have to face many problems due to the behavior of soil. Bell F.G. [5], [6], Broms BB. [7], Rajasekaran G. [8], and etc., are done extensive research on lime treated and lime column treated soils. Reddy P. P. [4], Basumajumdar A. [2], and many other researchers worked on lime-flyash columns.

2 Materials Used

The following materials are used to study shear strength parameters of the fly ash treated lime columns:

1. Expansive soil.
2. Quick lime.
3. Flyash.
4. Steel containers.

2.1 Expansive Soil:

Expansive soils are found in various parts of our country. It occupies about 40% of land in our country. In this experiment we had used black cotton soil which is collected from Chandragiri locality. The soil sample collected is 1.5m below the ground level. The physical and index properties of the natural clay sample collected are given in table 2.1.

Table 2.1: Physical and Index properties of soil

S.No.	Property	Value
1	Insitu water content	28 %
2	Insitu bulk density	1.7 g/cc
3	Fine fraction	65 %
4	Coarse fraction	35 %
5	Specific gravity	2.5
6	Liquid limit	63 %
7	Plastic limit	20.75 %
8	Shrinkage limit	18 %
9	Plasticity Index	42.25 %
10	Indian standard soil classification system	CH
11	Free Swell Index	61 %
12	Maximum dry density	1.486 g/cc
13	Optimum moisture content	21 %

2.2 Quick lime:

Hydrated lime is dry form of lime. The lime shown in the figure 2.1 is used for our work and the lime collected from a shop in Tirupati. The chemical and physical properties of quick lime used in this study is given in table 2.2.

Fig 2.1: Quick Lime used for the study

Table 2.2: Physical and chemical properties of Quick lime

Property	Value
CaO	82.2 %
MgO	3.1 %
Other compounds	12.5 %
Loss on ignition	1.25
Particle size	<90 µm
Particle density	1.15 g/cc

2.3: Flyash

Flyash is a byproduct obtained from chemical industries. It is collected from brick manufacturing industry in Tirupati. The following figure shows the flyash used for study. The flyash used in the study is classified as class F based on the manufacturer input.

Fig 2.2: Flyash used for the Study

2.4: Test Tanks

Iron cylindrical containers of diameter 40 cm and depth 40 cm are used for filling the soil and determining the shear strength of the soil after installing the lime columns and flyash-lime columns.

3 Experimental Setup

The natural clay was oven dried and the mechanically ground to avoid the lumps. The soil was then mixed with water to have the in-situ moisture content. The desired amount of soil to be filled in test tanks is determined and compacted to have the in-situ bulk density to simulate the natural field conditions.
The soil was compacted in a circular tank of 40 cm in both diameter and height. Soil was filled in four equal layers of 9 cm each and compaction is done manually with tampers.

3.1 Installation of lime piles:
In field applications, a hollow tube was forced into the ground to desired depth and binding agent is applied with pressure. The same technique is used in this study, the installation of five columns in compacted soil block with equal distance from center pile. Columns are made by hollow PVC pipe of 3 cm diameter and 30 cm height, open at both ends. PVC pipe is driven by manually into the soil block.
Then each column was filled with powdered quick lime of uniform mass in one test tank-1 and in test tank-2 powdered lime and fly ash is mixed with equal proportion of weights, was filled in the holes made. This application was in three successive uniform layers with lightly compaction on each layer. In the test tanks, 4 cm in height was left above the soil block. The following figures 3.1, 3.2 and 3.3 shows the procedure we followed during the study.

Fig 3.1: Making piles in soil block.

Fig 3.2: Soil block ready for lime treatment.

Fig 3.3: Surface of soil block after lime piles installation.

3.3 Curing:

After installation of lime piles, setup was covered with a thin cloth and it is covered with a layer of sandy soil of particle size 2 mm up to 2 cm thick as shown in fig. 3.4. then supplied water to maintain the natural water content of soil block. The soil blocks were left to react chemically with piles for a curing period of 28 days. The following figure 5 shows the test tanks covering with polythene covers and kept for curing.

Fig 3.4 a: Cloth covering soil block.

Fig 3.4 b: Sand layer on the cloth.

Fig 3.5: Soil with lime columns in Tank1 and soil with flyash-lime columns in Tank 2 are placed for Curing

4 Experimental Results and Discussions

4.1 : Unconfined Compression Strength Test:

Unconfined compression tests are conducted on the natural soil samples, soils samples extracted between the lime columns from Tank 1 and Tank 2 according to the Indian Standards code IS 2720 (Part 10): 1991 [9].
Unconfined compressive strength tests are done on three samples collected from the testing tanks. The samplers were pushed slowly into the treated soil block with aid of hydraulic jack for collecting less/undisturbed soils. The soil samples are collected in between the lime and flyash-lime columns and tested for UCS. The results showed that there is tremendous improvement in the UCS of soil samples treated with lime and flyash-lime columns compared with natural soil samples. The comparison of UCS of soil samples are given in the table 4.1.

Table: 4.1 Comparison of UCS of soil samples

S.No	Description	UCS* (kg/cm^2)	% Increase w.r.t. NSS**
1.	Natural Soil Samples	0.51	-
2.	Soil samples extracted from lime columns Tank	0.85	66%
3.	Soil samples extracted from flyash-lime columns Tank	0.81	58.82%

*Unconfined Compressive Strength
**NSS: Natural Soil Sample

The Figure 4.1 showing the variations of unconfined compressive strengths of the natural soil samples and soil samples extracted from lime columns Tank and flyash-lime columns Tank. The increase in the UCS of soil samples extracted from the natural ground and Tank 1 are due to pozzolanic reactions occurred between the lime and soil [3]. The strength of the UCS soil sample extracted from Tank 1 is less than soil samples extracted from Tank 2 and it is attributed to the flyash mixed is not having sufficient pozzolanic material as like lime. But the combination is economical as flyash is available for very lesser cost when compared with lime. The curing period is taken as 28 days, because it can give reliable results than 7 days curing period [1].

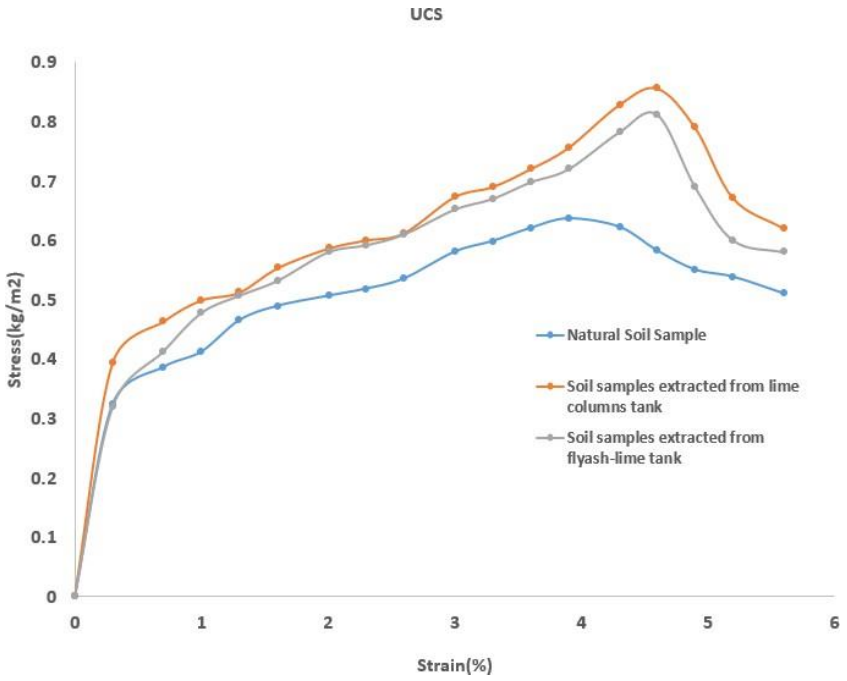

Fig 4.1: Variations of unconfined compressive strengths of the soil samples

5 Conclusions

The following conclusions are drawn from the experiments conducted and results obtained from the experiments.

1. The unconfined compressive strength of the soil specimens obtained from lime columns and lime-flyash columns treated soil tanks are appreciably greater than the natural soil samples.
2. The soil samples extracted from the flyash replaced lime columns tank has the unconfined compressive strength lesser than the soil samples extracted from lime columns treated soil tank and the percentage decrease of strength is very less.
3. The lime-flyash columns treated soils are the better and sustainable solution for stabilizing the expansive soils.

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