PRACTICAL EVALUATION ON SHEAR STRENGTH OF SOILS BY USING DIFFERENT MATERIALS

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ABSTRACT

The objective of this paper is to upgrade expansive soil as a construction material using Lime and fly ash, which are waste materials. Remolded expansive clay was blended with Lime and fly ash and strength tests were conducted. The potential of Lime-fly ash blend as a swell reduction layer between the footing of a foundation and sub-grade was studied. In order to examine the importance of the study, a cost comparison was made for the preparation of the sub-base of a highway project with and without the admixture stabilizations.

Stress strain behavior of unconfined compressive strength showed that failure stress and strains increased by 106% and 50% respectively when the fly ash content was increased from 0 to 25%. When the Lime content was increased from 0 to 12%, Unconfined Compressive Stress increased by 97% while CBR improved by 47%.

Therefore, a Lime content of 12% and a fly ash content of 25% are recommended for strengthening the expansive sub grade soil. A fly ash content of 15% is recommended for blending into Lime for forming a swell reduction layer because of its satisfactory performance in the laboratory tests.

Keywords: *Soil, Lime, Fly ash.*

INTRODUCTION

Site feasibility study for geotechnical projects is of far most beneficial before a project can take off. Site survey usually takes place before the design process begins in order to understand the characteristics of subsoil upon which the decision on location of the project can be made. The following geotechnical design criteria have to be considered during site selection.

- Design load and function of the structure.
- Type of foundation to be used.
- Bearing capacity of subsoil.

In the past, the third bullet played a major in decision making on site selection. Once the bearing capacity of the soil was poor, the following were options:

- Change the design to suit site condition.
- Remove and replace the in situ soil.
- Abandon the site.

Abandoned sites due to undesirable soil bearing capacities dramatically increased, and the outcome of this was the scarcity of land and increased demand for natural resources. Affected areas include those which were susceptible to liquefaction and those covered with soft clay and organic soils. Other areas were those in a landslide and contaminated land. However, in most geotechnical projects, it is not possible to obtain a construction site that will meet the design requirements without ground modification. The current practice is to modify the engineering properties of the native problematic soils to meet the design specifications. Nowadays, soils such as, soft clays and organic soils can be improved to the civil engineering requirements. This state of the art review focuses on soil stabilization method which is one of the several methods of soil improvement.

Soil stabilization aims at improving soil strength and increasing resistance to softening by water through bonding the soil particles together, water proofing the particles or combination of the two (Sherwood, 1993). Usually, the technology provides an alternative provision structural solution to a practical problem. The simplest stabilization processes are compaction and drainage (if water drains out of wet soil it becomes stronger). The other process is by improving gradation of particle size and further improvement can be achieved by adding binders to the weak soils (Rogers et al, 1996). Soil stabilization can be accomplished by several methods. All these methods fall into two broad categories (FM 5-410) namely;

- Mechanical stabilization

Under this category, soil stabilization can be achieved through physical process by altering the physical nature of native soil particles by either induced vibration or compaction or by incorporating other physical properties such as barriers and nailing. Mechanical stabilization is not the main subject of this review and will not be further discussed.

- Chemical stabilization

Under this category, soil stabilization depends mainly on chemical reactions between stabilizer (cementations material) and soil minerals (pozzolanic materials) to achieve the desired effect. A chemical stabilization method is the fundamental of this review and, therefore, throughout the rest of this report, the term soil stabilization will mean chemical stabilization.

Through soil stabilization, unbound materials can be stabilized with cementations materials (cement, lime, fly ash, bitumen or combination of these). The stabilized soil materials have a higher strength, lower permeability and lower compressibility than the native soil. The method can be achieved in two ways, namely; (1) In situ stabilization and (2) ex-situ stabilization.

COMPONENTS OF STABILIZATION

Soil stabilization involves the use of stabilizing agents (binder materials) in weak soils to improve its geotechnical properties such as compressibility, strength, permeability and durability. The components of stabilization technology include soils and or soil minerals and stabilizing agent or binders (cementations materials).

- **Soils**

Most of stabilization has to be undertaken in soft soils (silty, clayey peat or organic soils) in order to achieve desirable engineering properties. According to Sherwood (1993) fine-grained granular materials are the easiest to stabilize due to their large surface area in relation to their particle diameter. A clay soil compared to others has a large surface area due to flat and elongated particle shapes. On the other hand, silty materials can be sensitive to small change in moisture and, therefore, may prove difficult during stabilization. Peat soils and organic soils are rich in water content of up to about 2000%, high porosity and high organic content. The consistency of peat soil can vary from muddy to fibrous, and in most cases, the deposit is shallow, but in worst cases, it can extend to several meters below the surface. Organic soils have high exchange capacity; it can hinder the hydration process by retaining the calcium ions liberated during the hydration of calcium silicate and calcium aluminates in the cement to satisfy the exchange capacity. In such soils, successful stabilization has to depend on the proper selection of binder and amount of binder added.

2.2 Stabilizing Agents

These are hydraulic (primary binders) or non-hydraulic (secondary binders) materials that when in contact with water or in the presence of pozzolanic minerals reacts with water to form cementations composite materials. The commonly used binders are:

2.2.1 Cement

Cement is the oldest binding agent since the

invention of soil stabilization technology in 1960's. It may be considered as primary stabilizing agent or hydraulic binder because it can be used alone to bring about the stabilizing action required. Cement reaction is not dependent
on soil minerals, and the key role is its reaction with water that may be available in any soil. This can be the reason why cement is used to stabilize a wide range of soils. Numerous types of cement are available in the market; these are ordinary Portland cement, blast furnace cement, sulfate resistant cement and high alumina cement. Usually the choice of cement depends on type of soil to be treated and desired final strength.

Hydration process is a process under which cement reaction takes place. The process starts when cement is mixed with water and other components for a desired application resulting into hardening phenomena. The hardening (setting) of cement will enclose soil as glue, but it will not change the structure of soil. The hydration reaction is slow proceeding from the surface of the cement grains and the centre of the grains may remain unhydrated. Cement hydration is a complex process with a complex series of unknown chemical reactions. However, this process can be affected by

- presence of foreign matters or impurities
- water-cement ratio
- curing temperature
- presence of additives
- Specific surface of the mixture.

Depending on factor(s) involved, the ultimate effect on setting and gain in strength of cement stabilized soil may vary. Therefore, this should be taken into account during mix design in order to achieve the desired strength. Calcium silicates, *C3S* and *C2S* are the two main cementations properties of ordinary Portland cement responsible for strength development. Calcium hydroxide is another hydration product of Portland cement that further reacts with pozzolanic materials available in stabilized soil to produce further cementations material. Normally the amount of cement used is small but sufficient to improve the engineering properties of the soil and further improved cation exchange of clay. Cement stabilized soils have the following improved properties:

- decreased cohesiveness (Plasticity)
- decreased volume expansion or compressibility
- Increased strength.

MATERIALS AND METHODS

As discussed in the preceding chapters about the materials used in the analysis of the fiber reinforced soil, in this chapter the basic characteristics of the materials from various classification and other tests is discussed. In the present study materials used for the experimental studies and the methods followed to study the behavior of fiber reinforced soil is detailed. In the present study the materials used are sand, Raichur fly ash, red soil, plastic waste (from water bottles), geogrid waste.

Sand is a naturally occurring granular material made up of fine rock particles. It comprises of particles, or granules, ranging in size from 75µm to 4.75 mm. The most common constituent of sand is silica (silicon dioxide, or SiO2), usually in the form of quartz. Sand collected from the local area is used in this study. The basic properties of sand obtained are tabulated below:

Load-Displacement Curves

The CBR tests were performed sequentially for various percentages of plastic waste under both un soaked and soaked conditions. The load-displacement response for both the conditions is summarized in the plots shown below

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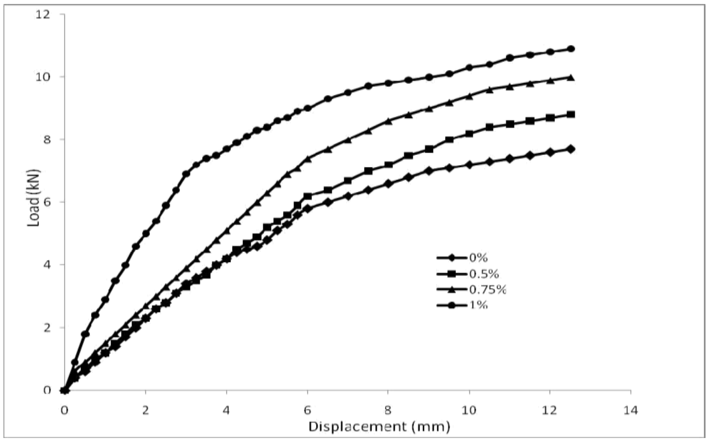

Fig 4.19 Load-Displacement Curves for un soaked conditions (Sand)

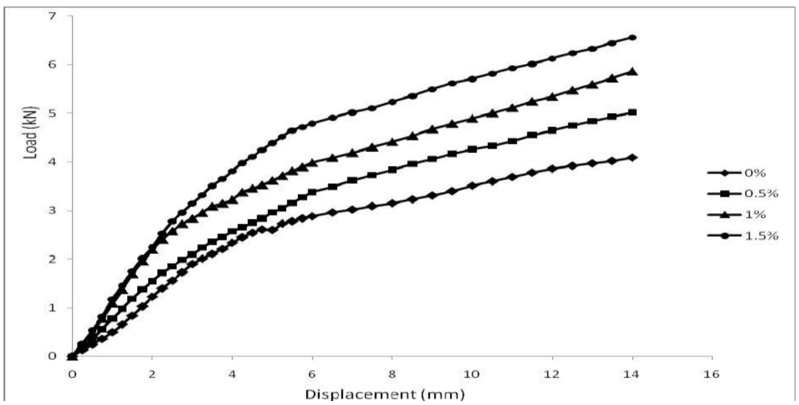

Fig 4.20 Load-Displacement Curves for soaked conditions (Sand)

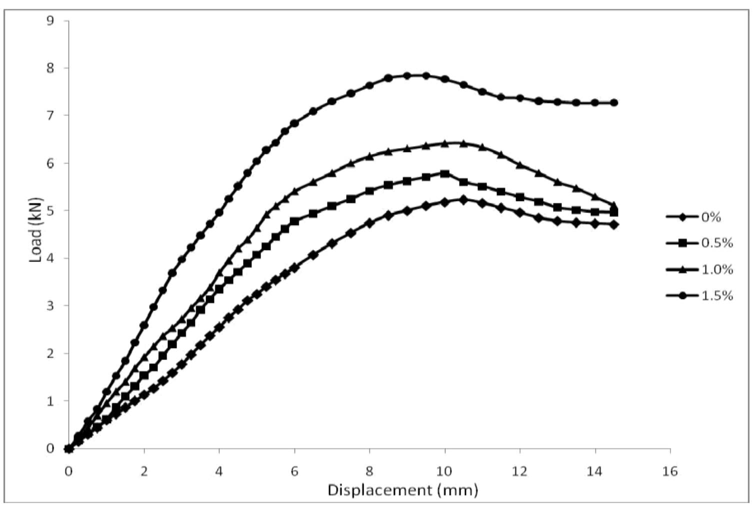

Fig 4.21 Load-Displacement Curves for un soaked conditions (Fly Ash)

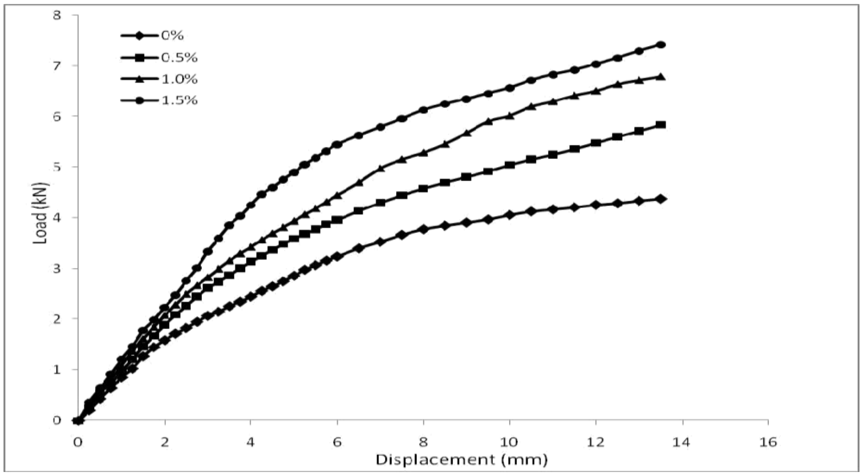

Fig 4.22 Load-Displacement Curves for soaked conditions (Fly Ash)

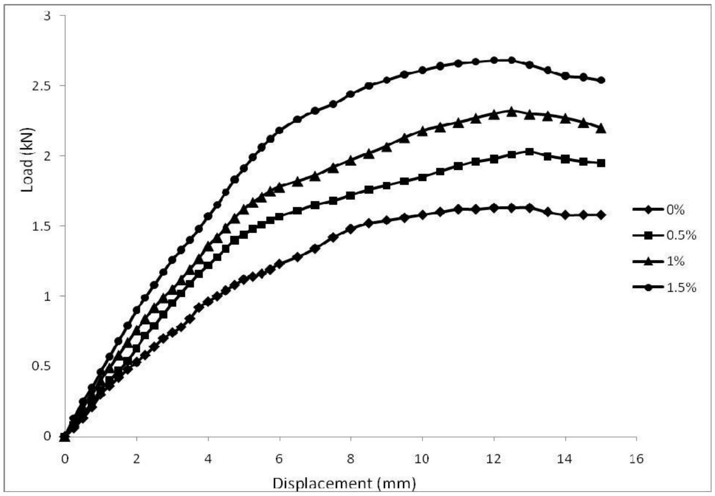

Fig 4.23 Load-Displacement Curves for un soaked conditions (Red Soil)

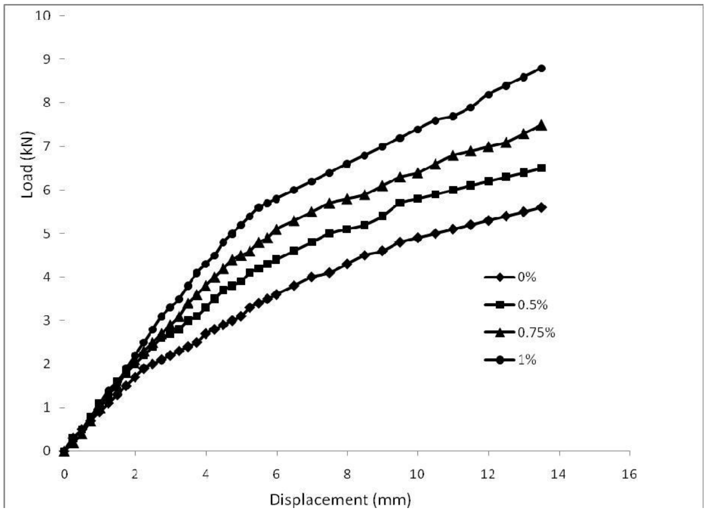

Fig 4.24 Load-Displacement Curves for soaked conditions (Red Soil)

From the load-displacement curves, it is clear that the penetration resistance of soil increases substantially on addition of plastic waste. The increase in resistance was observed to be greater for higher percentages of plastic waste. The difference was more clear-cut for higher strains under soaked conditions. This increase in strength can be more clearly characterized by computing and comparing the CBR values, as mentioned in the following section.

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