

Stabilisation of Clayey Soil by Using Lime

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ABSTRACT: This paper presents the laboratory investigation of an Expansive soil treated with lime. The soil mixes were tested for Proctor Compaction Test and Compaction Curve (O.M.C. and M.D.D.) was plotted. The lime was added in gradually increasing percentage to the soil and proctor test was performed. Results indicate the variation of optimum moisture content and maximum dry density with different percentage of lime. The dry density of the lime-soil mixture increases significantly, while the water requirement reduces due to the addition of lime. The increase of dry density compromises higher strength. Lime is used to improve the strength and reduce swell shrink of an expansive soil.

KEYWORDS: Expansive soil, Maximum dry density, Optimum moisture content, Proctor compaction test.

I. INTRODUCTION

Soils can be stabilized generally by the addition of cement, lime or fly ash. Such stabilization processes improve the various engineering properties of the soil. Increase in soil strength, durability stiffness, and reduction swelling/shrinkage potential are the benefit of soil stabilization. The concept of stabilization is 5000 years old. When expansive soils containing sulfates was treated with calcium-based stabilizers, the calcium from the stabilizer reacts with soil sulfates and alumina to form the expansive mineral ettringite. The first soil stabilization tests were performed in the United States in 1904. Cement was introduced as a stabilizer to construct a street in Sarasota, FL, in 1915 (ACI 1997), and lime was first involved in short stretches of highway with the expansion of roads to cater for the growth of vehicle traffic in 1924.

II. SOIL STABILIZATION

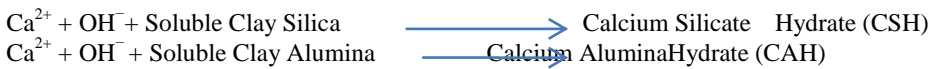
Generally, soil stabilization is a method of improving soil properties by blending and mixing other materials. Improvements include increasing the dry unit weight, bearing capabilities, volume changes, the performance of in situ subsoil's, sands, and other waste materials in order to strengthen road surfaces and other geotechnical applications.

III. STABILIZATION USING LIME

Limestone is broken down at elevated temperatures to form lime. As a result, three forms of lime are produced: quicklime (calcium oxide—CaO), hydrated lime (calcium hydroxide—Ca [OH]₂), and hydrated lime slurry; all of which can be used to treat soils. Quicklime is manufactured by chemically transforming calcium carbonate (limestone—CaCO₃) into calcium oxide. Furthermore, hydrated lime is created when quicklime chemically reacts with water. When hydrated lime is mixed with clay particles, it permanently forms strong cementitious bonds. Lime has been known to reduce the swelling potential, liquid limit, plasticity index and maximum dry density of the soil, and increases its optimum water content, shrinkage limit and strength. It improves the workability and compact ability of subgrade soils. If quicklime is used, it immediately hydrates (i.e., chemically combines with water) and releases heat. Soils are dried, because water present in the soil participates in this reaction, and because the heat generated can evaporate additional moisture. The hydrated lime produced by these initial reactions will subsequently react with clay particles. These subsequent reactions will slowly produce additional drying because they reduce the soil's moisture holding capacity. If hydrated lime or hydrated lime slurry is used instead of quicklime, drying occurs only through the chemical changes in the soil that reduce its capacity to hold water and increase its stability. After initial mixing, the calcium ions (Ca²⁺) from hydrated lime migrate to the surface of the clay particles and displace water and other ions. The soil becomes friable and granular, making it easier to work and compact. At this stage the Plasticity Index of the soil decreases dramatically, as does its tendency to swell and shrink. The process, which is called "flocculation and agglomeration," generally occurs in a matter of hours.



When adequate quantities of lime and water are added, the pH of the soil quickly increases to above 10.5, which enables the clay particles to break down. Silica and alumina are released and react with calcium from the lime to form calcium-silicate-hydrates (CSH) and calcium-aluminate-hydrates (CAH). CSA and CAH are cementitious products similar to those formed in Portland cement. They form the matrix that contributes to the strength of lime-stabilized soil layers. As this matrix forms, the soil is transformed from a sandy, granular material to a hard, relatively impermeable layer with significant load bearing capacity. The matrix formed is permanent, durable, and significantly impermeable, producing a structural layer that is both strong and flexible. These reactions may be summarized as:



Lime stabilization enhances engineering properties of soils, such as improved strength, higher resistance to fracture, fatigue, and permanent deformation, enhanced resilient properties, reduction in swelling; and resistance to the harmful effects of moisture. The most considerable improvements in these properties are observed in moderately to highly plastic clays.

Lime stabilization has been the most common stabilization methods adopted for soil treatment. Lime stabilization is the most preferred method for plastic clays; however, it proves to be ineffective in sulphate rich clays and performs poorly under extreme conditions. With such drawbacks, lots of researches have been undertaken to address the issues faced with each stabilization method, in particular, the use of solid wastes for soil stabilization.

IV. MATERIALS AND METHODS

Required amount of clayey soil was taken from a potter (Badshahi Bagh, Saharanpur, U.P.) and dried in air for about 7 days. The sample was sieved through the 19mm IS Sieve. Lime was taken from the market in the powdered form and added with the increasing percentage (1%, 2%, 3%, 4% and 5%) in the clayey soil. The lime was mixed uniformly in the soil and Standard Proctor compaction tests were carried out to determine the optimum moisture content and maximum dry density of all lime-soil mixtures. The mould, of 1000 cm³ capacity with baseplate attached, was weighed to the nearest 1 g. The mould was placed on a concrete floor and the moist soil was compacted into the mould, with the extension attached, in five layers of approximately equal mass, each layer was given 25 blows from the 4.9-kg rammer dropped from a height of 450 mm above the soil. The blows were distributed uniformly over the surface of each layer by the free fall of rammer. The extension was removed and the compacted soil was leveled off carefully to the top of the mould by means of the straightedge. The mould and soil shall then be weighed nearest to 1 g.

The compacted soil specimen shall be removed from the mould and placed on the mixing tray. The water content of a representative sample of the specimen was determined by the oven drying method.

V. RESULTS AND DISCUSSION

The addition of lime has the tremendous effect on the stabilization of clayey soil. With the increasing percentage of lime the value of the Maximum Dry Density (MDD) increases and the value of Optimum Moisture Content (OMC) decrease.

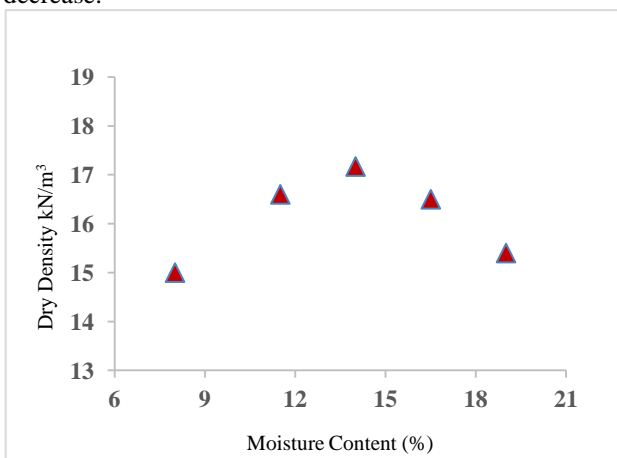


Fig. 1 Moisture Content v/s Dry Density Curve With 1% lime

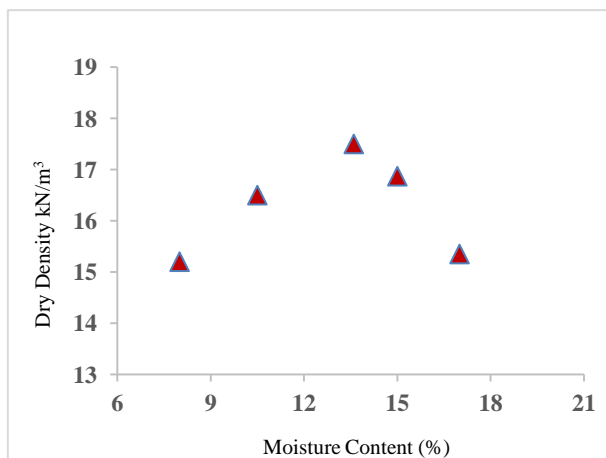


Fig. 2 Moisture Content v/s Dry Density Curve With 2% lime

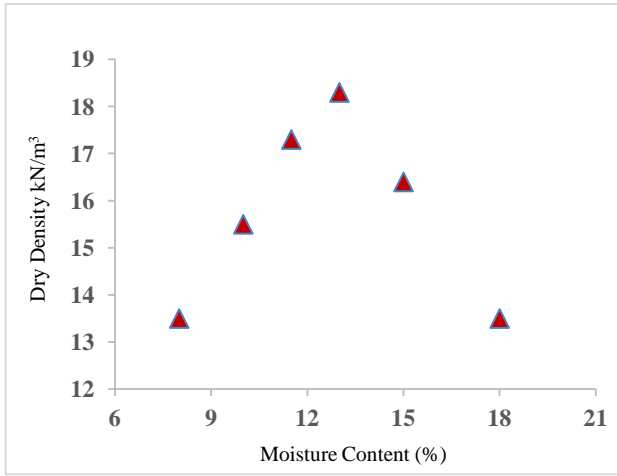


Fig. 3 Moisture Content v/s Dry Density Curve With 3% lime

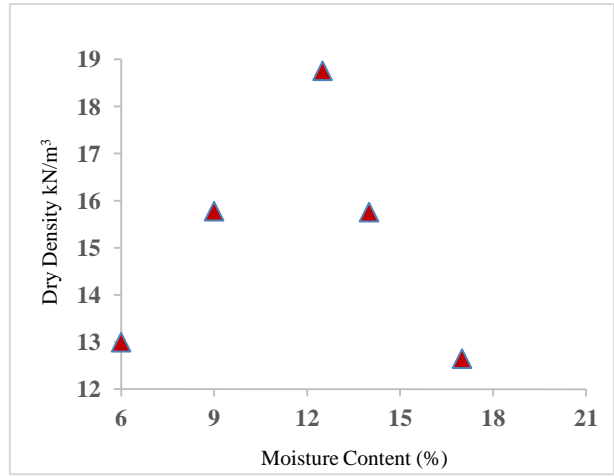


Fig. 4 Moisture Content v/s Dry Density Curve With 4% lime

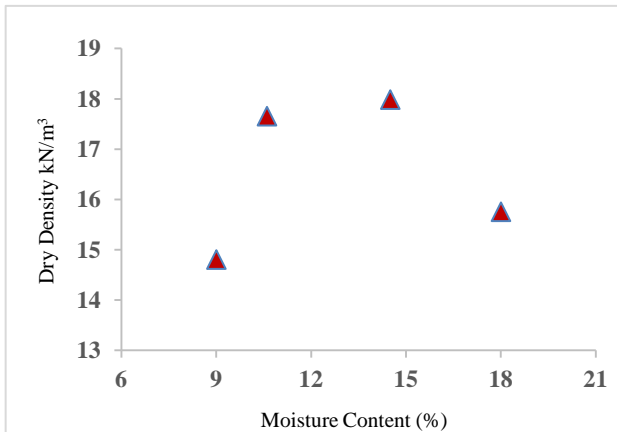


Fig. 5 Moisture Content v/s Dry Density Curve With 5% lime

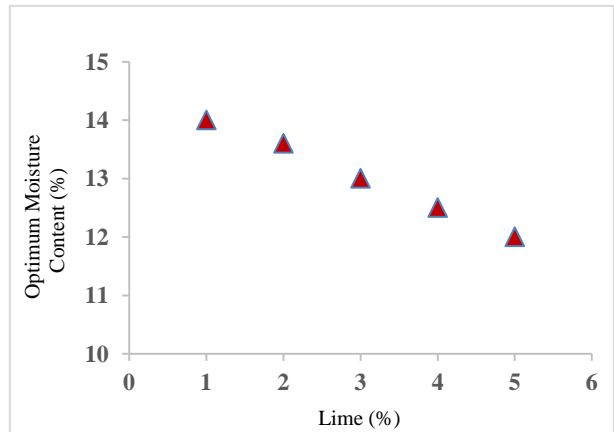


Fig. 6 Variation of Moisture Content with lime

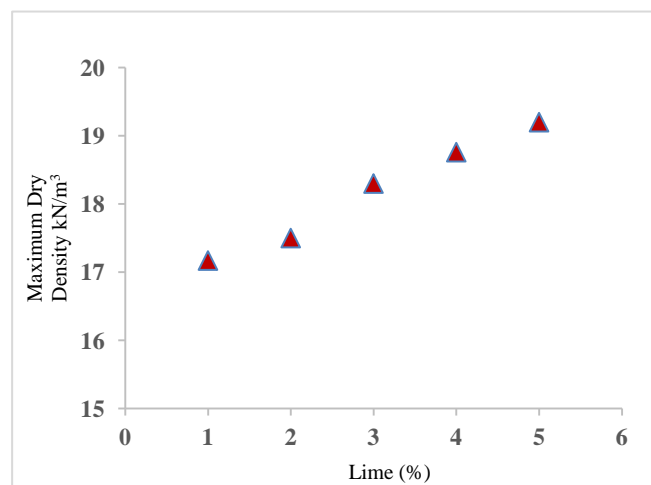


Fig. 7 Variation of Maximum Dry Density with Lime

VI. CONCLUSION

Based on the work done following conclusions can be drawn:

1. The dry density of the lime-soil mixture increases significantly, while the water requirement reduces due to the addition of lime.
2. The increase of dry density compromises higher strength.
3. Lime is used to improve the strength and reduce swell shrink of an expansive soil.

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