SOIL STABILIZATION USING LIME

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ABSTRACT:
Soil stabilization can be explained as the alteration of the soil properties by chemical or physical means in order to enhance the engineering quality of the soil . The main objectives of the soil stabilization is to increase the bearing capacity of the soil ,its resistance to weathering process and soil permeability. The long-term performance of any construction project depends on the
soundness of the underlying soils. Unstable soils can create significant problems for pavements or structures, Therefore soil stabilization techniques are necessary to ensure the good stability of soil so that it can successfully sustain the load of the superstructure especially in case of soil which are highly active, also it saves a lot of time and millions of money when compared to the method of cutting out and replacing the unstable soil. This paper deals with the complete analysis of the improvement of soil properties and its stabilization using lime.

I. INTRODUCTION

Improving an on site soil's engineering properties is called soil stabilization. Soils containing significant levels of silt or clay, have changing geotechnical characteristics: they swell and become plastic in the presence of water, shrink when dry, and expand when exposed to frost. Site traffic is always a delicate and difficult issue when projects are carried out on such soils. In
other words, the re-use of these materials is often difficult, if not impossible. Once they have been treated with lime, such soil can be used to create embankments or subgrade of structures, thus avoiding expensive excavation works and transport. Use of lime significantly changes the characteristics of a soil to produce long-term permanent strength and stability, particularly with
respect to the action of water and frost. The mineralogical properties of the soils will determine their degree of reactivity with lime and the ultimate strength that the stabilized layers will develop. In general, fine-grained clay soils (with a minimum of 25 percent passing the #200 sieve (74mm) and a Plasticity Index greater than 10) are considered to be good candidates for
stabilization. Soils containing significant amounts of organic material (greater than about 1 percent) or sulfates (greater than 0.3 percent) may require additional lime or special construction procedures.

II. CHEMISTRY OF LIME TREATMENT

1) Drying: 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 (discussed below). 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. In fig.1 water content Wn is reduced to W'n after treatment with lime.

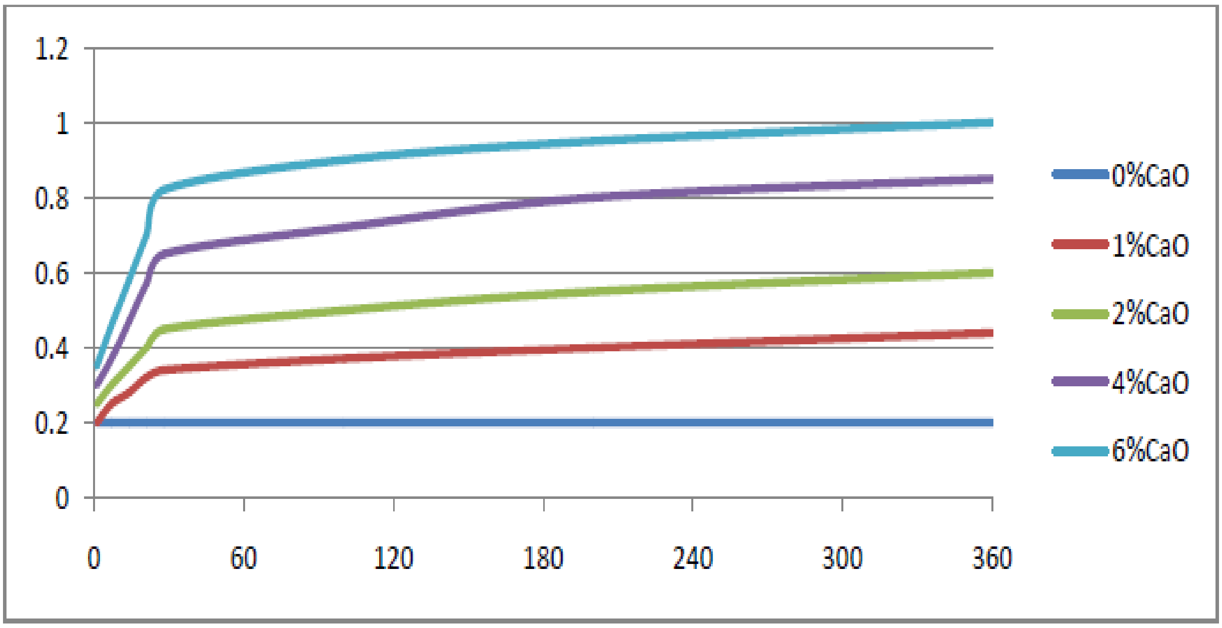
2) Modification: After initial mixing, the calcium ions (Ca++) from hydrated lime migrate to the surface of the clay particles and displace water and other ions. The soil becomes friable and granular, making it easier to work and compact. At this stage the Plasticity Index of the soil as shown in fig. 1 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.

Fig.1. Effect of liming on the consistency of soil

3) Stabilization: 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 process begins within hours and can continue for years in a properly designed system. The matrix formed is permanent, durable, and significantly impermeable, producing a structural layer that is both strong and flexible.

III. IMMEDIATE EFFECT: SOIL IMPROVEMENT

1. A reduction in the plasticity index: The soil suddenly switches from being plastic (yielding and sticky) to being crumbly (stiff and grainy). In the latter condition it is easier to excavate, load, discharge, compact and level.
2. An improvement in the compaction properties of the soil: The maximum dry density drops, while the optimal water content rises, so that the soil moves into a humidity range that can be easily compacted. This effect is clearly advantageous when used on soils with a high water content, A treatment with quicklime therefore makes it possible to transform a sticky plastic soil, which is difficult to compact, into a stiff, easily handled material. After compacting, the soil has excellent load-bearing properties.
3. Improvement of bearing capacity: In most cases, two hours after treatment, the CBR (California Bearing Ratio) of a treated soil is between 4 and 10 times higher than that of an untreated soil. This reaction greatly relieves on-site transportation difficulties.



Graph 1

IV. MEDIUM TERM EFFECT : SOIL STABILIZATION

When lime comes into contact with a substance containing soluble silicates and aluminates (such as clay and silt), it forms hydrated calcium aluminates and calcium silicates. As with cement, this gives rise to a true bond upon crystallization. Called a pozzolanic reaction, this bonding process brings about improved resistance to frost and a distinct increase in the soil's compressive strength and CBR. In general, in non-winter conditions, the soil develops sufficient strength after three to six months. A slow curing process during road construction is a marked advantage, as it allows greater flexibility when working with the treated soil. The long-term hardening facilitates the design of foundations for industrial platforms. The stabilizing effect gives load-bearing qualities to the treated soil.

V. METHODOLOGY

A. **Scarification and Initial Pulverization**: After the soil has been brought to line and grade, the subgrade can be scarified to the specified depth and width and then partially pulverized. It is desirable to remove non-soil materials larger than 3 inches, such as stumps, roots, turf, and aggregates. Scarification is done because a scarified or pulverized subgrade offers more soil surface contact area for the lime at the time of lime application

Fig. 2 Scarification before lime application

B. **Lime Spreading**: the soil is generally scarified and the slurry is applied by distributor truck. Because lime in slurry form is much less concentrated than dry lime, often two or more passes are required to provide the specified amount of lime solids. To prevent runoff and consequent non-uniform lime distribution, the slurry is mixed into the soil immediately after each spreading pass.

Fig. 3 Spreading of lime over scarified soil

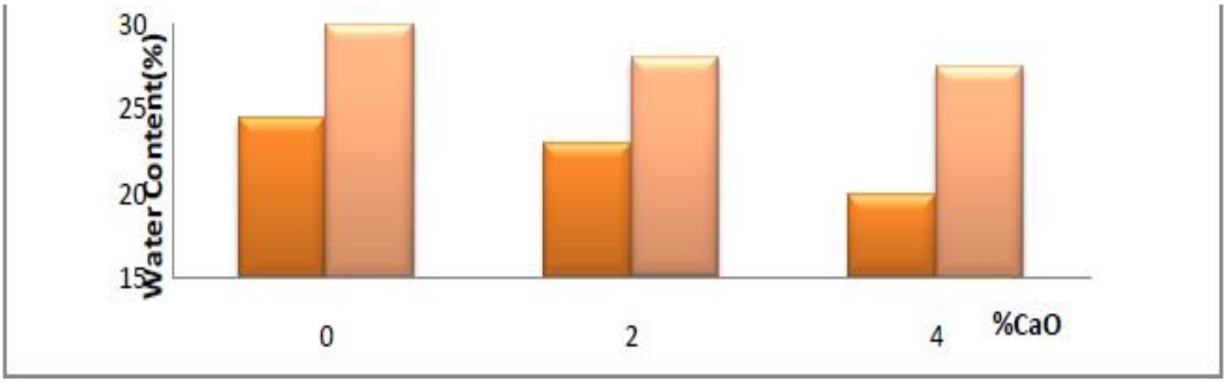
C. **Preliminary Mixing and Watering**: Preliminary mixing is required to distribute the lime throughout the soil and to initially pulverize the soil to prepare for the addition of water to initiate the chemical reaction for stabilization. During this process or immediately after, water should be added to ensure the complete hydration and a quality stabilization project.

Fig.4 Adding water after dry lime application

D. **Final mixing and pulverization**: To accomplish complete stabilization, adequate final pulverization of the clay fraction and thorough distribution of the lime throughout the soil are essential.

Fig. 5 Mixing and pulverization

E. **Compaction**: Initial compaction is usually performed as soon as possible after mixing, using a sheeps foot type roller or a vibratory pad foot roller. After the section is shaped, final compaction can be accomplished using a smooth drum roller. The equipment should be appropriate for the depth of the section being constructed.



Graph 2

Fig.6 Sheepsfoot (above) & padfoot (below) rollers

F. **Final curing**: Before placing the next layer of subbase (or base course), the compacted subgrade (or subbase) should be allowed to harden until loaded dump trucks can operate without rutting the surface. During this time, the surface of the lime treated soil should be kept moist to aid in strength gain. This is called "curing" and can be done in two ways:

1) Moist curing, which consists of maintaining the surface in a moist condition by light sprinkling and rolling when necessary, and

2) Membrane curing, which involves sealing the compacted layer with a bituminous prime coat emulsion, either in one or multiple layer.

Fig. 7 Prime coat emulsion for curing

VI. NUMEROUS ADVANTAGES IN BROAD RANGE OF APPLICATION

 In the time of a few hours, an unconditional soil is transformed by lime into a stabilized soil which can carry the traffic load sufficiently. An added bonus is that the soil becomes less sensitive to moisture. This immediate and spectacular effect makes it possible to build job site roads that can be used regardless of weather condition.

 The technique makes it possible to retain high quality raw materials for quality applications. The building of embankments using moist plastic soils treated with lime can result in considerable savings on materials brought in from elsewhere, often at great cost, and the inevitably high costs of waste soil disposal.

 Lime treatment makes it possible to construct good quality capping layers and beds for roads, railway tracks, and runways. The stiffening/curing of the structure means that the slopes of the structure have greater stability.

 Because it is such a simple process, lime-stabilization of soil is easy to apply to "small" works, such as foundations for car parks, industrial platforms, and agricultural and forestry roads. The greatest benefits of this procedure, namely the savings on aggregate and disposal charges, are indeed the same as for all major earth moving works

. VII. ECONOMIC BENEFITS OF LIME STABILISATION

 Limitation of the need for embankment materials brought in from outside and the elimination of their transporting costs.

 Reduction of transport movements in the immediate vicinity of the construction site.

 Machines can move about with far greater ease. Delays due to weather conditions are reduced, leading to improved productivity. As a result, the overall construction duration and costs can be dramatically reduced.

 Structures have a longer service life (embankments, capping layers) and are cheaper to maintain.

VIII. CONCLUSION

 Lime is used as an excellent soil stabilizing materials for highly active soils which undergo through frequent expansion and shrinkage.
 Lime acts immediately and improves various property of soil such as carrying capacity of soil, resistance to shrinkage during moist conditions, reduction in plasticity index, increase in CBR value and subsequent increase in the compression resistance with the increase in time.
 The reaction is very quick and stabilization of soil starts within few hours.
 The graphs presented above give a clear idea about the improvement in the properties of soil after adding lime.

IX. REFERENCES

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