

An Efficient Soil Stabilization of an erodible soil using Hydraulic Shear Stress from Friction Factor Method

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ABSTRACT: In recent years on elucidating the chemical reactions that bring about soil stabilization and modification during soil chemical stabilization without which there won't be the achievement of an anticipated improved soil for most engineering works. In this paper presents highlights the potential of lignosulfonate in stabilizing the erodible soil, which is commonly found in NSW, Australia. It was found that the chemical stabilizers reduced the coefficient of soil erosion and significantly increased the critical shear stress. It was also observed that significantly less amount of lignosulfonate than cement was sufficient to achieve a given increase in the erosion resistance. Meanwhile, proposed system presents a novel Process Simulation Apparatus for Internal Crack Erosion, designed and built at University of Wollongong. Laboratory tests were carried out on typical erodible soils stabilized using chemical admixtures such as lignosulfonate and cement.

KEYWORDS: Soil; Erosion; internal crack; chemical stabilisers

I. INTRODUCTION

Data relating to soil properties are collected during the course of soil surveys. Soil properties are determined by field examination of the soils and by laboratory index testing of some bench mark soils. Established standard procedures are followed. During the survey, many borings are made and examined to identify and classify soils resulting from the soils' chemical and physical properties and to delineate them on the soil maps. Samples are taken from some typical profiles and tested in the laboratory to determine grain size distribution, plasticity, and compaction characteristics.

Highly erodible soils are common in many parts of the world. In recent years, chemical admixtures such as cement, lime, fly ash shows promising aspects in stabilising erodible soil. These chemical stabilisers generally alter the mineralogy of soil resulting in highly stable soil substances having improved inherent properties such as strength and stiffness. Numerous studies were conducted so far to investigate the applicability of traditional stabilisers on problematic soils such as soft clay and erodible soils [1]-[3].

Peat and organic soil represent the extreme form of soft soil. They are subject to instability such as localized sinking and slope failure and massive primary and long-term settlement when subjected to even moderate load increase [4]. Buildings on peat are usually suspended on piles, but the ground around it may still settle, creating a scenario. In addition, there is discomfort and difficulty of access to the sites, a tremendous variability in material properties and difficulty in sampling. These materials may also change chemically and biologically with time. For example further humification of the organic constituents would alter the soil mechanical properties such as compressibility, shear strength and hydraulic conductivity. Lowering of ground water may cause shrinking and oxidation of peat leading to humification with consequent increase in permeability and compressibility.

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Peat actually represents an accumulation of the disintegrated plant remains, which have been preserved under condition of incomplete aeration and high water content. It accumulates wherever the conditions are suitable, that is, in areas with excess rainfall and the ground is poorly drained, irrespective of latitude or altitude. Nonetheless, peat deposits tend to be more common in those regions with comparatively cool wet climate. Physico-chemical and biochemical processes cause this organic material to remain in a state of preservation over a long period of time. In other words, waterlogged poorly drained conditions, not only favor the growth of a particular type of vegetation but also help preserve the plant remains.

The rest of the paper is organized as follows: Related is detailed in Sect. 2. In Sect. 3, Proposed Methodology and the conclusion are in Sect. 5.

II. RELATED WORK

In [1] authors described the short-term development (typically, over the first 3 to 7 days) of electrical conductivity and penetration resistance of LKD-modified soils. The normalized net change of electrical conductivity is solely related to the LKD dosage. The decrease of electrical conductivity with time coincides with the increase of penetration resistance with time. The correlations of electrical conductivity with strength gain in LKD and lime-modified soils suggest that electrical conductivity measurements can potentially be useful for quality control in field applications. In [2] introduced an analytical model to model the erosion of a soil capturing its tensile behavior based on the law of energy conservation. The erosion rate can be determined using the proposed model if the tensile force – deformation characteristics, dry density, mean particle diameter, and mean flow velocity are known. In [3] authors discussed the applications in precision farming where EC maps are proving useful in improving economic returns to precision farming. The usefulness of soil conductivity stems from the fact that sands have a low conductivity, silts have a medium conductivity and clays have a high conductivity. Consequently, conductivity (measured at low frequencies) correlates strongly to soil grain size and texture. One of the applications of an EC map, which will be covered in this paper, is to view it in conjunction with other information layers. In [5] authors studied the experimental results on the use of Portland cement in the modification and stabilization of soils in the state of Washington, USA. Cement was added in percentages of 2.5, 5, 7.5, and 10%, by dry weight of the soils. Laboratory tests to determine the drying rate of the soil, Atterberg limits, compaction characteristics, unconfined compressive strength, and consolidated-undrained triaxial behavior were performed. Results of the investigation showed significant improvement in drying rate, workability, unconfined compressive strength, and shear strength. The improvement is dependent on the type of soil. In [6] authors analyzed the test data consisted of determining the average strength, in terms of unconfined compressive strength, of three replicate specimens of each mixture. The average strength of the three replicates of each additive was compared with the average strength results of the remaining nontraditional additives, the traditional stabilization results, and a series of control specimens that were not stabilized. The experiment results indicate an increased strength of some nontraditionally stabilized specimens when compared with that of both the control series and the traditional stabilization alternatives. In [7] authors investigated its advantages over traditional admixtures (cement) have been presented. Lignosulfonate is a non-toxic admixture that can stabilize certain erodible and dispersive soils effectively, without causing any adverse environmental impact on the ground unlike some traditional stabilizers. Test results show that the erosional parameters such as critical shear stress and coefficient of soil erosion are improved with the increase in the amount of lignosulfonate. Knowledge about the clay particles and lignosulfonate interaction mechanisms is pertinent for long-term environmental sustainability of treated soils, a factor which is poorly understood at microscopic level.

III. PROPOSED METHOD

The proposed system accepts the reactions between soil and cement, bitumen, and the chloride compounds. It has been established that the chemical compounds found in soil; quartz, feldspar, dolomite, calcite, montmorillonite, kaolinite etc. react with the chemical constituents found in different identified chemical stabilizers.

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A. SOIL REACTION

The long-term performance of any construction project depends on the soundness of the underlying soils. Unstable soils can create significant problems for pavements. Indeed the structural strength of limestabilized soils can be factored into pavement designs. Lime can be used to treat soils to varying degrees depending upon the objective. The least amount of treatment is used to dry and temporarily modify soils. Such treatment produces a working platform for construction or temporary roads, (NLA, 2004). Lime in the form of quick lime (calcium oxide-CaO), hydrated lime (Calcium hydroxide-Ca (OH) 2), or lime slurry (a suspension of hydrated lime in water) can be used to treat soils. Quicklime is manufactured by chemically transforming calcium carbonate (limestone-CaCO₃) into calcium oxide. And hydrated lime is created when quick lime chemically reacts with water. It is hydrated lime that reacts with clay particles and permanently transforms them into a strong cementitious matrix. Most lime used for soil treatment is “high calcium” lime, which contains no more than 5% magnesium oxide or hydroxide. On some occasions, however, “dolomitic” lime is used. Dolomitic lime contains 35 to 46% magnesium oxide or hydroxide. Dolomitic lime can perform well in soil stabilization, although the magnesium fraction reacts more slowly than the calcium fraction. Soil stabilization 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,

B. INTERNAL CRACK EROSION TEST

Internal crack erosion studies were conducted using the Process Simulation Apparatus for Internal Crack Erosion (PSAICE) shown in Figure 1. Detailed explanation of testing equations and testing procedure can be found elsewhere. The erosion behaviour of treated and untreated soils have been examined in terms of erosion rate and hydraulic shear stress to calculate the erosion parameters, namely, the critical shear stress and the coefficient of soil erosion. The critical shear stress, τ_c is defined as the minimum hydraulic shear stress required to initiate erosion. Figure 2 shows the variation of the erosion rate with the hydraulic shear stress. The critical shear stress was calculated by extrapolating the straight line to the X-axis, and the slope of the linear line represents the coefficient of soil erosion. The typical plot of effluent turbidity and flow rate with time. It was observed that the turbidity increased initially, and then decreased as erosion occurred.

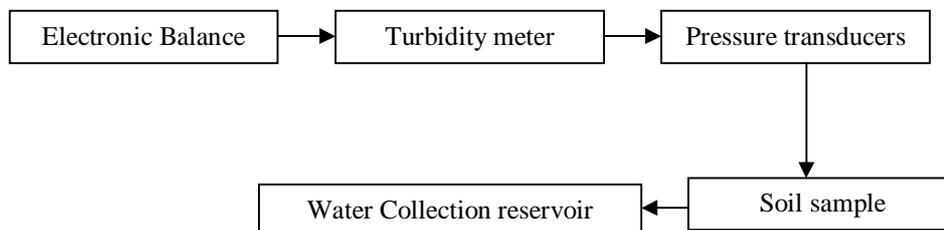


Fig 1: Process Simulation Apparatus

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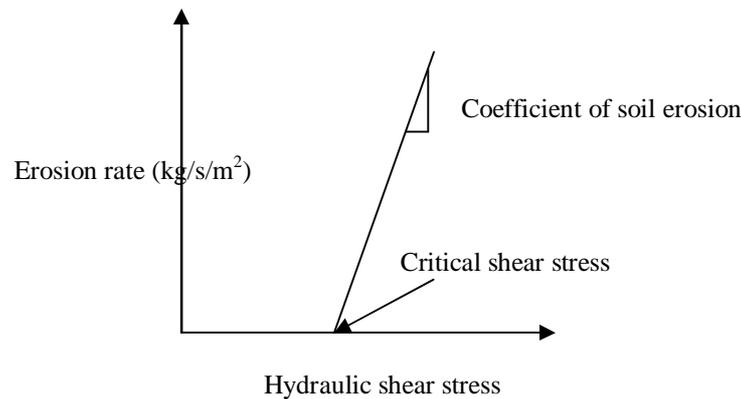


Fig 2: Typical plot of erosion rate versus hydraulic shear stress

C. HYDRAULIC SHEAR STRESS FROM FRICTION FACTOR METHOD

The hydraulic shear stress can be estimated from:

$$\tau_a = \frac{f \rho_w v^2}{8} \quad \text{eqn. (1)}$$

where, f is the friction factor, P_w (kg/m^3) is the density of the eroding fluid; and v (m/s) is the mean velocity of the flow through the crack at time t . The friction factor was calculated from the Moody diagram based on the relative roughness and the Reynolds number. The relative roughness can be calculated by the following equation:

$$\epsilon = \frac{D}{2\phi} \quad \text{eqn. (2)}$$

where, D (m) is the mean particle diameter, ϕ (m) is the diameter of soil pipe at time t .

The Reynolds number can be calculated using Equation (3):

$$R_e = \frac{\rho_w v \phi}{\mu} \quad \text{eqn. (3)}$$

Where, μ ($\text{kgm}^{-1}\text{s}^{-1}$) is the dynamic viscosity of the eroding fluid.

IV. CONCLUSION

In this paper presents highlights the potential of lignosulfonate in stabilizing the erodible soil, which is commonly found in NSW, Australia. It was found that the chemical stabilizers reduced the coefficient of soil erosion and significantly increased the critical shear stress. It was also observed that significantly less amount of lignosulfonate than cement was sufficient to achieve a given increase in the erosion resistance. Meanwhile, proposed system presents a novel Process Simulation Apparatus for Internal Crack Erosion, designed and built at University of Wollongong. Laboratory tests were carried out on typical erodible soils stabilized using chemical admixtures such as lignosulfonate and cement. To apply to the soil erosion we need to refine the adjacency matrix by move with reasonable velocities pursuing as future research.

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