

Permeability Studies in Marine Clays Stabilized with Lime Column

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ABSTRACT

Soft marine clays are very sensitive to changes in the stress system, moisture content and system chemistry of the pore fluid. Geotechnical engineers feel a necessity to improve the behavior of these deposits using any one of the available ground improvement techniques. In the present investigation an attempt has been made to improve the permeability of a marine clay using the lime column technique. The experimental program was carried out with model lime columns installed in two test setups. In the first setup, a single lime column was installed in the center of a circular tank. Having established the diffusion of lime from the single lime column setup, tests were carried out in the second stage with a lime column group installed in a rectangular tank to study the interaction of lime columns. A marine clay from the east coast of India was used for all the tests. A number of samples were collected from all the setups at different radial distances from the lime columns and at varying time periods. From the tests carried out using these samples, it has been established that the lime diffused into the surrounding soil for large distances; this is indicated by an improvement in pH values. Reaction products formed as a result of reaction between lime and clay were identified by the X-ray Diffraction (XRD) technique. Permeability (k) values show an enormous improvement and the k values were improved up to 23 times. This shows good promise for improving the soft coastal deposits and the offshore deposits.

INTRODUCTION

Weak marine soil deposits have been found both on the coast and in several offshore areas spread over many parts of the world. When clay particles precipitate in salt water, there is a tendency for the clay particles to flocculate and stick together giving rise to some sort of edge-to-face arrangement. As a result, clay, silt and fine sand particles settle almost at the same rate and the final sediment formed consists of particles with a very loose cardhouse-like structure (Bjerrum, 1973). Hence the marine sediments can be considered loose sediments, usually formed with high void ratios. Problems are associated with these fine-grained soils deposited at a soft consistency. Fine-grained soils are very sensitive to changes in the stress system, moisture content and system chemistry of the pore fluid. In addition to these, the problems arising out of high compressibility and low shear strength of these weak marine deposits expose geotechnical engineers to considerable challenges in the construction of various coastal and offshore structures. The performance of these soft fine-grained deposits under different conditions of environment varies over wide limits.

In order to improve the engineering behavior of soils, several improvement techniques are available in geotechnical engineering practice. The fact that the selection of any one of these methods for any problem can be made only after a comparison with other techniques proves that the method is well suited for a particular system. In fine-grained soils chemical stabilization methods are well suited to improve their engineering behavior and to make them less sensitive to environmental factors. The addition of lime to soft and expansive soils in one form or the other has been

effectively used in improving the soil characteristics. The irreversible changes produced by the chemical reaction between soil and chemical additives have been mainly brought about through lime or admixtures of lime.

The influence of lime on the various soil properties has been reported by many investigators. Some of the earlier investigators (Clare and Cruchley, 1957; Mateous, 1964) suggested that the addition of lime to the soil caused considerable reduction in the plasticity index of high-plasticity soils and improved their workability. The work of Thompson (1964) indicated considerable improvements in the engineering properties of lime-treated soils and these beneficial changes are explained through mechanisms, namely cation exchange, flocculation/aggregation and pozzolanic reactions. Many investigators supported these mechanisms and recommended lime stabilization in improving the soil characteristics, especially for subgrade soils in highway and airfield pavements. Quite a good number of investigators (Glenn, 1967; Willoughby et al., 1968; Kawamura and Diamond, 1975) identified the pozzolanic reaction products. These reaction products are mainly the cementation compounds like calcium silicate hydrate (CSH), calcium aluminate hydrate (CAH) and many other calcium compounds; these are like pozzolanic compounds in Portland cement. The cementation compounds aggregate the particles, as a result of which large floccules are formed, and this almost amounts to effective particle growth. With increase in the particle size, considerable increase in the permeability is expected. Based on the success of lime stabilization in highways, efforts are now being made to extend this as an in-situ ground improvement technique through lime columns and lime injections. Broms and Boman (1975) brought out the concept of lime columns: in this method, preformed bores were made and filled with soil-lime mix. It was believed that this improved soil-lime column could support the superstructure. Okumura and Terashi (1975) reported a method of lime injection for improving the soft submarine soils in Japanese harbors. Based on these early works of lime

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