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Swell-Shrink Cycles of Lime Stabilized Expansive Subgrade

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Abstract

Subgrades of expansive nature are one of the main causes of damage to road network in Australia. Consequently, lime stabilization has been widely used to reduce the swell- shrink potential of these types of soils and thus reduce the associated damage. After stabilization and compaction, the subgrade will naturally be exposed to cycles of full swell and or partial shrinkage due to climatic cycles. This paper investigates this behaviour for lime stabilized compacted expansive soil from weathered Quaternary Volcanic geological deposits located in Western Victoria; Australia. These soils were stabilized with varying percentages of hydrated lime (2, 3, 4, 6 and 8 percent) and the swell-shrink paths of both untreated and treated soils were studied. Test specimens were compacted at optimum moisture content and maximum dry density. The samples were subjected to full swell-shrink cycles under a surcharge of 25 kPa to reach structural stabilization and to simulate the impact of climatic wetting and drying cycles. Vertical deformation and swell-shrink cycle relationships for untreated and treated samples were obtained and analyzed. The results of lime stabilization indicate that equilibrium is reached after three cycles for both untreated and treated samples. In addition, results suggest that maximum deformation occurs in the second swelling cycle. Vertical deformation of untreated sample was reduced to a third after adding 2 percent lime and reduced to a sixth after adding 3 percent lime. The gradient of swelling and shrinkage path reduced to about a sixth and third when it is treated with 2 and 3 percent, respectively. The treated samples reached maximum swelling at a higher degree of saturation than the untreated sample.

Keywords: Expansive clay, Lime stabilization, swell-shrink cycles;

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1 Introduction

Expansive soils are considered a problematic soil in many countries, especially where the climate is arid to semi-arid. Australia is one country where the swell-shrink potential of an expansive soil can damage a road network significantly and prematurely. Many studies have been performed to assess the swell-shrink potential or volume change characteristic of undisturbed expansive clays as a function of moisture content (Marinho & Stuermer 2000). In the majority of these studies, clay specimens were dried under no external pressure for one cycle to evaluate shrinkage potential. However, Haines (1923) identified different deformation stages that occur as a result of continuous drying. These stages are now known as structural shrinkage, normal shrinkage, and residual shrinkage. Further, Laboratory cyclic swell- shrink tests on reactive clays have shown that swelling deformation may decrease or increase by a factor of two when compared to the initial cycle (Tripathy, Subba Rao & Fredlund 2002). Therefore, estimating the behavior of expansive clay without considering cyclic fluctuation may underestimate the soil swelling potential. These studies suggest that equilibrium is reached after four or five cycles, indicating that the vertical displacement during swelling and shrinkage are the same after a certain number of cycles (Al-Homoud, Khedaywi & Al-Ajlouni 1995). Tripathy, Subba Rao and Fredlund (2002) studied the effect of initial condition (dry density and water content) on swell- shrink path at different surcharge pressures suggesting that the effect of initial condition on equilibrium swell-shrink path can be neglected. Gould et al. (2011) created a mathematical model to define the shrinkage curve at equilibrium cycle. This paper studies the behavior of lime stabilized compacted expansive soil under swell-shrink cycles. The optimum lime content was selected based on one dimensional swell test results. To measure these untreated and treated samples at various percentages of added lime were exposed to induced cyclic swell- shrink under a nominal pressure of 25 kPa.

2 Methodology

A series of laboratory tests were performed to identify the behavior of lime stabilized and compacted expansive soils under cycles of swell- shrink. The first series of tests were conducted to classify the expansive clay characteristics before stabilization and included specific gravity, organic content, Atterberg limit and linear shrinkage. The second series were conducted to find the optimum lime content based on swelling potential that included pH concentration, standard proctor compaction and one-dimensional swell. The third series was performed to investigate the effect of lime stabilization on the swell-shrink path under cyclic conditions.

3 Test Results

3.1 Classification

The classification of the untreated expansive soil is presented in Table 1. The selected expansive soil is classified as Clay of High plasticity (CH) with low organic content (due to the presence of remaining vegetation at shallow depth). The samples were selected from Western Victoria. The surface geology of Western Victoria is derived from weathered Quaternary age basaltic rocks (McAndrew J & Marsden M.A 1973). These soils were classified as highly to extremely expansive (Peck et al. 1992).