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Enhancing the CBR Strength and Freeze–Thaw Performance of Silty Subgrade Using Three Reinforcement Categories

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Abstract

Silty subgrade soil cannot satisfy the requirements of highway construction because of its low strength and durability problems. A wide range of reinforcements have been used to improve soil performance. Improving the soil properties has caused more interest in identifying new accessible resources for reinforcement. This paper investigates the effect of including different reinforcement types on reducing the rapid accumulation of pavement damage caused by freeze–thaw cycles or low strength of a silty pavement foundation. The improvement of CBR strength and freeze-thaw behavior was tested with the inclusion of three reinforcement categories: i) randomly distributed fibers (natural palm fibers and chemical polypropylene fibers), ii) chemical additives (lime and cement), and iii) waste or by-product materials (fly ash and silica fume). To represent unsaturated and saturated soil conditions for various field applications, both unsubmerged and submerged samples were investigated. Mass losses were also calculated after freezing–thawing cycles as criteria for durability behavior. The test results for the reinforced specimens were compared with unreinforced samples to clarify the effectiveness of each reinforcement type and content. Unsubmerged samples especially that reinforced with waste materials provided a significant improvement in CBR strength. For submerged conditions, the best performance was observed from the specimens treated with chemical additives. 10% of cement reinforcement and 20% of waste materials provide the highest resistance against the freeze–thaw cycles.

Key words: CBR Strength; Freeze-Thaw Behavior; Silty Subgrade; Reinforcement.

1. Introduction

The rapid and extensive development has recently led to the construction of industrial cities and the associated network of roads. This resulted in the utilization of virgin lands and large-scale urbanization programs. One of the typical problems in the construction of roads is the presence of weak fine-grained soils. Weak soft soils are associated with many geotechnical problems. Because of that, some of the pavements located on weak soil have exhibited various types of deterioration in recently built highways and expressways [1]. The usual approach to soft subgrade reinforcement is to remove the soft soil and replace it with a stronger material of crushed rock. The high cost of replacement has caused highway agencies to evaluate alternative methods of highway construction and one approach is to use stabilized soil for soft subgrade [2]. The natural durability and strength of the soil can be improved through the process of 'soil reinforcement' using different types of stabilizers. The aim of soil reinforcement materials is to increase the resistance against destructive forces of the weather by increasing strength and cohesion, reducing moisture movement in the soil and imparting water proofing characteristics. Reinforcement of soils with low-bearing capacity is an economical way to strengthen the earth for building purposes and to diminish the amount of soil exchanges [3]. In spite of the quantity of research conducted on the resultant characteristics of using different

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