Utilization of Natural Fibers and Geosynthetics in Improving the Pavement Subgrade Strength – A Review

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Abstract

The improvement of subgrade strength by reinforcing the soil dates back centuries. The weak subgrade is a common problem that engineers often encounter, and they resort to constructing pavements in areas with problematic soils that are difficult to work with. To overcome such issues, subgrade modification technologies are adopted. Soft soils such as silts and clays are the most problematic soils due to their characteristics of high swelling shrinkage and low bearing capacity. Although the modification of subgrade is traditionally done through the 'excavation and replacement' technique, it is inarguably costly and time-consuming. Therefore, alternatives should be considered in modifying such subgrade. Such alternatives for modifying the subgrade are natural fiber reinforcement, synthetic reinforcement and chemical stabilization of the soil. Geosynthetics that are most commonly used as subgrade reinforcement in increasing strength characteristics are; polypropylene fibers (PP), Polyester fibers (PET), Polyethylene fibers (PE), Glass fibers, Nylon fibers, Steel fibers and Polyvinyl alcohol fibers (PVA). Coir fibers, sisal fibers, palm fibers, jute fibers, flax fibers, bamboo fibers and cane fibers are the most commonly used natural fibers due to their eco-friendliness, renewability and low costs. The durability of natural fibers in subgrade improvement is known to be around 20 to 30 years in time for them to decompose and biodegrade fully, relevant to the soil condition they are mixed with. The use of both natural and synthetic reinforcement is known to increase soil properties. The arrangement and composition of various fibers and geosynthetics will be another key factor as of how well the soil may improve. The objective of this paper is to review the use of different fibers and geosynthetics in improving existing soil and their benefits. A number of studies have been conducted on problematic soils, such as clay or silt being reinforced with fibers. Most literature has adopted different lengths of fibers from 1cm to 5cm (with a variation of 1cm), whereas the composition of 0.2% to 1.5% of the weight of soil (with an increment of 0.1%) that is used was adopted in their studies. In some studies, the arrangement of fiber was also shown to be a variable in improving the soil, so the soil was mixed in layered arrangements at the top and bottom of the soil sample as well as random distribution of fiber in the soil. The soil was initially tested with the aid of several laboratory experiments such as sieve analysis, sedimentation analysis, Atterberg limits, and Standard Penetration Cone (SPC) tests where the soil was classified; this was considered the control sample. The soil that was reinforced with different fibers of varying lengths and compositions was tested against triaxial tests and soaked/unsoaked CBR (California Bearing Ratio) tests. The studies that were conducted on the soil by adopting the mentioned varying length, composition, and arrangement of different fibers showed promising results in the improvement of the soil's strength. According to studies, the soil behaved well and increased shear strength and the axial strain to failure, increased load bearing capacity and increased the CBR strength; and furthermore, the studies present a range of optimum lengths and composition percentages where maximum strength is attained. The studies reviewed in this paper show that the CBR strength of the soil effectively increased by a factor within the range of 2.3 to 4.6. From the review, it is concluded that the expansive problematic soil can be efficiently stabilized for

the placement of road pavements using both natural and synthetic fibers. In this paper, an extensive review of the available studies and their improvements are analyzed and presented.

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