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Comparative Study on Soil Stabilization with Polyethylene Waste Materials and Binders

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Abstract

In some cases, the production of solid waste is experiencing an uncontrolled and continuous increase, especially wastes from plastic products. Given that the process of transforming plastic waste into raw material involves high energy consumption, plastic can be used in geotechnical engineering works. This paper is based on comparing two solutions to improve the soil parameters. The first solution is to improve the soil with plastic waste material and the second solution is to improve the soil with cement. Ongoing tests, performed as a part of the research program have shown the effect of the polyethylene waste material and cement on soil mechanical parameters, cohesion and internal friction angle.

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Keywords: waste material; soil stabilization; direct shear test; cement; polyethylene.

1. Introduction

Soil-cement is a mixture of soil, cement and water, which is well compacted. It is used on a large scale to improve the foundation soil for roads, parking areas, dykes and dams. This mixture was firstly used for slope protection for the first time in 1951, at Bonny Dam by the United States Bureau of Reclamation (USBR), where they conducted an experimental section. This section has been observed for 10 years and have found good results behaviour over time [1]. Section test from Bonny Reservoir located in eastern Colorado has endured cycles of freeze-thaw and countless cycles of wetting and drying for 33 years. The performances were rather remarkable given that methods of mixing in

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situ were used. Erosion cavities appeared at the bottom of the layer, caused by the lower content of cement and less compaction in these areas [4]. At Optima Dam from Oklahoma, the Corps of Engineers took samples from the slope protected soil-cement layer after 1 year and reported a good connection between layers, as they were executed through brushing, for improving ties. Brown and Root reported good links between the layers at cooling pond essential for South Texas Nuclear Plant, where it was used the bonding technique of the dry cement [1]. Cheney Dam performance is described by Holtz and Hansen's and Gray Davis and Jones's article [1], [2], [3]. In Romania soil-cement mixture was used to create an embankment against flood. A defence system against flooding is located on the river Vedea in Icoana village from Olt County. It is for the first time in Romania when this technology is used to build a levee and the main reason that led to this solution was the reluctance of landowners to allow occupation of land surfaces. Through this technology, the area of land occupied by construction of levee halved since the slope embankment dams has increased significantly, thereby reducing footprint levee.

The usage of plastic waste for soil stabilization was also studied in research programs from around the world. A study conducted by W.R Azzram [5] illustrates the application of using polymer stabilization in creating a new nanocomposite material with clay soil. Various tests with different polymer contents were performed to study the effect of using polypropylene as a stabilizing agent on both microstructure and geotechnical clay properties. The experiments showed that the resulting nanocomposites acted as nanofiller materials which decreased the plasticity and compressibility parameters of the treated clay. The constructed inclusions filled the inter-assembling pores thus notably producing a higher vertical effective yield stress which again reduced the volumetric shrinkage and created isotropic and compressible materials with a lesser extent of desiccation cracks. It also increased the tensile and the shear strength of the stabilized clay with an increase in the nanocomposites size. Botero et al [6] study proposes an alternative reuse method for certain types of plastic waste (bottles and containers used for liquid storage that are processed using discrete fibers) in geotechnical construction projects. The principal objective of their research was to study the mechanical behavior of a silty soil that was reinforced with aleatorily distributed PET fibers. To meet this objective, UU triaxial laboratory tests were performed on soil specimens with fiber contents of 0.0 - 1.0% of the soil dry weight. The test results indicated that the reinforced specimens presented an increment of shear strength that was associated with the increasing quantities of the PET fiber. Furthermore, the laboratory tests indicated that the reinforced soil had a greater deformation capacity, which can be a positive characteristic in some cases because the deformation capacity can reduce the risk of crack formation in certain soil layers for specific geotechnical problems. Finally, this reinforced soil presents interesting mechanical properties and could be used in structures that require a high deformation capacity, such as landfills, sewage treatment deposits and dams (among other uses), to prevent failures due to cracking and to prevent the possible leakage of contaminants or water.

Other studies combined the cement stabilization with plastic materials. Correia et al. [7] studied the effect of binder and fibre quantity on the mechanical behaviour of a soft soil, chemically stabilised with binders and reinforced or not with short polypropylene fibres. The results indicated that increases in binder content cause an increment in the stiffness, the compressive and tensile strength, but have a lower impact on the specimens reinforced with fibres. In general, the addition of a low quantity of fibres to the stabilised soft soil originates a decrease in the stiffness, compressive and direct tensile strength, a reduction of the loss of strength after peak and a change in behaviour, from brittle to more ductile. Chen et al. [8] paper presented a laboratory evaluation on the strength behavior of cement-clay admixture improved by polypropylene fiber. The recycled waste polimer textile bags was applied in soft soil improvement works, such as compacted-pavement base/subbases. In order to verify the effectiveness of fiber bundles used in soil mixing, a series of laboratory investigation were conducted on fiber-reinforced cement-improved soft Shanghai clay. In the tests, two types of polymer fibers were employed; the first one was monofilament polypropylene fiber and the other was fiber bundles split from polymer textile bags. The tests were conducted using unconfined compressive strength (UCS) test after the specimen of fiberesoilecement admixture were cured for some period. The results showed that fiber additive can significantly improve the strength and ductility of the cement treated Shanghai clay. The UCS of fiberesoilecement admixture is related to both content and length of fiber. Both two kinds of fiber-reinforced cement clay reached their peak strength at fiber content of 0.5%. UCS will slowly reverse if the fiber content continues to increase. Even though the polypropylene fiber worked better than the fiber bundles, the difference was less than 5%. These results indicated that the fiber bundles