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A Review on the Soil Stabilization Using Low-Cost Methods

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ABSTRACT

The soil often is weak and has no enough stability in heavy loading. The aim of the study was to review on stabilization of soil using low-cost methods. Several reinforcement methods are available for stabilizing expansive soils. These methods include stabilization with chemical additives, rewetting, soil replacement, compaction control, moisture control, surcharge loading, and thermal methods. All these methods may have the disadvantages of being ineffective and expensive. Based on literature, Portland cement, lime, fly ash and scrap tire are low-cost and effective to soil stabilization.

Key words: Lime, Fly ash, Scarp Tire, Soil Stabilization.

Introduction

Soil bed should bear all generated stresses transmitted by shallows or piles. The soil often is weak and has no enough stability in heavy loading. In this regard, it is necessary to reinforce and or stabilize the soil. To design of reinforcement, analysis of the generated deformation, stress and strain as well as stability of soil structures is the main objective of many geotechnical analyses at long term service condition. In building systems, every displacement can be led to generate internal stresses which have not been predicted in analysis and design of structures which should be anticipated.

Billions of dollars in damages are attributed to expansive soils in many countries each year. Geotechnical design and analyses in/on/with expansive soils may involve additional complications that otherwise would not have to be dealt with if expansive soils were not present. Traditional methods for chemical stabilization of expansive soils include the addition of lime, class-C or class-F fly ash, Portland cement, or other industrial byproducts such as cement kiln dust, steel or copper slag. Physical stabilization techniques aim at reducing the potential swell pressure and swell percent of the expansive soil without altering the soil chemistry (Carraro *et al.*, 2008). Several reinforcement methods are available for stabilizing expansive soils. These methods include stabilization with chemical additives, rewetting, soil replacement, compaction control, moisture control, surcharge loading, and thermal methods. All these methods may have the disadvantages of being ineffective and expensive (Akbulut *et al.*, 2007).

The aim of this study was to review on the stabilization of soil by low-cost methods.

Soil Stabilization:

Pavement design is based on the premise that minimum specified structural quality will be achieved for each layer of material in the pavement system. Each layer must resist shearing, avoid excessive deflections that cause fatigue cracking within the layer or in overlying layers, and prevent excessive permanent deformation through densification. As the quality of a soil layer is increased, the ability of that layer to distribute the load over a greater area is generally increased so that a reduction in the required thickness of the soil and surface layers may be permitted. The most common improvements achieved through stabilization include better soil gradation, reduction of plasticity index or swelling potential, and increases in durability and strength. In wet weather, stabilization may also be used to provide a working platform for construction operations. These types of soil quality improvement are referred to as soil modification (Joint Departments of the Army and Air Force, 1994).

Different procedures of soil reinforcement:

Soil reinforcement is a procedure where natural or synthesized additives are used to improve the properties of soils. Several reinforcement methods are available for stabilizing problematic soils. Therefore, the techniques

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of soil reinforcement can be classified into a number of categories with different points of view. Some of the methods appeared in Fig. 1 may have the disadvantages of being ineffective and/or expensive (Hejazi *et al.*, 2012). A viable and sustainable alternative to the admixing of expansive soils with traditional nonexpansive geomaterials such as clean sands and gravels is evaluated in this study which addresses the beneficial use of scrap tire rubber (STR) to mitigate the swell potential of expansive soils (Carraro *et al.*, 2008).

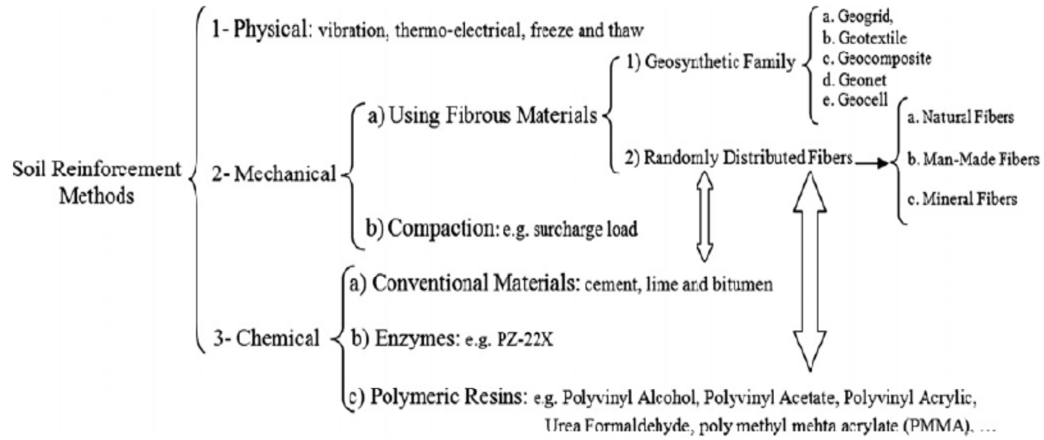

Fig. 1: Different procedures of soil reinforcement (Hejazi *et al.*, 2012).

Stabilization with Portland cement:

Portland cement can be used either to modify and improve the quality of the soil or to transform the soil into a cemented mass with increased strength and durability. The amount of cement used will depend upon whether the soil is to be modified or stabilized (Joint Departments of the Army and Air Force, 1994). Portland cement is hydraulic cement made by heating a limestone and clay mixture in a kiln and pulverizing the resulting material (Kowalski *et al.*, 2007).

Stabilization with lime:

In general, all lime treated fine-grained soils exhibit decreased plasticity, improved workability and reduced volume change characteristics. However, not all soils exhibit improved strength characteristics. It should be emphasized that the properties of soil lime mixtures are dependent on many variables. Soil type, lime type, lime percentage and curing conditions (time, temperature, and moisture) are the most important (Joint Departments of the Army and Air Force, 1994). Lime is a white or grayish-white, odorless, lumpy, very slightly water-soluble solid, CaO, that when combined with water forms calcium hydroxide (slaked lime). Calcium hydroxide is used chiefly in mortars, plasters, and cements (Kowalski *et al*., 2007).

Stabilization with fly ash:

Fly ash is fine particulate ash created by the combustion of a solid fuel, such as coal, and discharged as an air born emission, or recovered as a byproduct for various commercial uses. Fly ash is used chiefly as a reinforcing agent in the manufacture of bricks, concrete, et cetera. There are two major classes of fly ash, C and F. Class F is produced from burning anthracite or bituminous coal; it usually has cementitious properties in addition to pozzolanic properties. Class C is produced by burning sub-bituminous coal and lignite, and is rarely cemetitious when mixed with water alone.
White (2005) reported:

✓ Iowa self-cementing fly ashes are effective at stabilizing fine-grained Iowa soils for earthwork and paving operations.
✓ Fly ash increases compacted dry density and reduces the optimum moisture content.
✓ Strength gain in soil-fly ash mixtures depends on cure time and temperature, compaction energy, and compaction delay.
✓ Rapid strength gain of soil-fly ash mixtures occurs during the first 7 to 28 days of curing, and a less pronounced increase continues with time due to long-term pozzolanic reactions.
✓ Fly ash effectively dries wet soils and provides an initial rapid strength gain, which is useful during construction in wet, unstable ground conditions. Fly ash also decreases swell potential of expansive soils by

replacing some of the volume previously held by expansive clay minerals and by cementing the soil particles together.

- ✓ Soil-fly ash mixtures cured below freezing temperatures and then soaked in water are highly susceptible to slaking and strength loss. Compressive strength increases as fly ash content and curing temperature increase.
- ✓ Soil stabilized with fly ash exhibits increased freeze-thaw durability.
- ✓ Soil strength can be increased with the addition of hydrated fly ash and conditioned fly ash, but at higher rates and not as effective as self-cementing fly ash.
- ✓ CaO, Al_2O_3, SO_3, and Na_2O influence set time characteristics of self-cementing fly ash.

Scrap Tire:

Tire wastes can be used as lightweight material either in the form of whole tires, shredded or chips, or in mix with soil. Many studies regarding the use of scrap tires in geotechnical applications have been done especially as embankment materials (Ghani *et al.*, 2002).

Tires have been reused in many different applications mainly related to production of new rubber based materials. Another major form of tire recycling is burning tires for fuel at tire derived fuel (TDF) facilities. There have also been reports that describe construction related applications for waste tires such as crumb rubber modifiers for highway pavement and shredded tires as fill material. The reuse application for tires is dependent on how the tires are processed. Processing basically includes shredding, removing of metal reinforcing, and further shredding until the desired material is achieved (Carreon, 2006).

Fig. 2: Scrap tire rubber.

Literature review:

White (2005) reported; Soil compaction characteristics, compressive strength, wet/dry durability, freeze/thaw durability, hydration characteristics, rate of strength gain, and plasticity characteristics are all affected by the addition of fly ash

Bernal *et al.* (1996) reported; It has been found that the use of tire shreds and rubber-sand (with a tire shred to mix ratio of about 40%) in highway construction offers technical, economic, and environmental benefits. The salient benefits of using tire shreds and rubber -sand include reduced weight of fill, adequate stability, low settlements, good drainage (avoiding the development of pore water pressure dunng loading), separation of underlying weak or problem soils from subbase or base materials, conservation of energy and natural resources, and usage of large quantities of local waste tires, which would have a positive impact on the environment.

Akbulut *et al.* (2007) investigated modification of clayey soils using scrap tire rubber and synthetic fibers. This result showed that the unreinforced and reinforced samples were subjected to unconfined compression, shear box, and resonant frequency tests to determine their strength and dynamic properties. These waste fibers improve the strength properties and dynamic behavior of clayey soils. The scrap tire rubber, polyethylene, and polypropylene fibers can be successfully used as reinforcement materials for the modification of clayey soils.

Brooks (2009) investigated the soil stabilization with flayash and rice husk ash. This study reports; stress strain behavior of unconfined compressive strength showed that failure stress and strains increased by 106% and 50% respectively when the flyash content was increased from 0 to 25%. When the rice husk ash (RHA) content was increased from 0 to 12%, Unconfined Compressive Stress increased by 97% while California Bearing Ratio (CBR) improved by 47%. Therefore, an RHA content of 12% and a flyash content of 25% are recommended for strengthening the expansive subgrade soil. A flyash content of 15% is recommended for blending into RHA for forming a swell reduction layer because of its satisfactory performance in the laboratory tests.

Conclusion:

Annually, a lot of waste rubber are generated and occupied a great space. It is necessary to find a solution to solve this problem. Based on literature, one of the solutions is use of different size waste rubber in soil reinforcement. Based on literature, Portland cement, lime, fly ash and scrap tire are low-cost and effective to soil stabilization.

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