APPLICATIONS OF AGRICULTURAL AND DOMESTIC WASTES IN GEOTECHNICAL APPLICATIONS: AN OVERVIEW

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Received November 14, 2010          Accepted February 4, 2011

ABSTRACT

The rapid growth in population and industrialization cause generation of large quantities of wastes. The bulk wastes from industrial, commercial, mining, agricultural and domestic activities are discharged either treated or untreated over the soil leading to changes in soil properties causing improvement or degradation of engineering behavior of soil. If there is an improvement in engineering behavior of soil, there is a value addition to the industrial wastes serving the three benefits of safe disposal of effluent, using as a stabilizer and return of income on it. In this paper the beneficial effects of certain agricultural and domestic wastes in geotechnical applications have been discussed.

Key Words: Agricultural wastes, Burnt Olive waste, Domestic wastes, Construction, Demolition wastes.

INTRODUCTION

The rapid growth in population and industrialization cause generation of large quantities of wastes. The bulk wastes from industrial, commercial, mining, agricultural and domestic activities are discharged either treated or untreated over the soil leading to changes in soil properties causing improvement or degradation of engineering behavior of soil. If there is an improvement in engineering behavior of soil, there is a value addition to the industrial wastes serving the three benefits of safe disposal of effluent, using as a stabilizer and return of income on it.

AIMS AND OBJECTIVES

In many situations, soils in natural state do not present adequate geotechnical properties to be used as road service layers, foundation layers and as a construction material. In order to adjust their geotechnical parameters to meet the requirements of technical specifications of construction industry, studying soil stabilization is more emphasized. It is important to mention here that recent trends on soil stabilization have evolved innovative techniques of utilizing local available environmental and industrial waste material for the modification and stabilization of deficient soil. In the process of soil stabilization and modification emphasis is given for maximum utilization of local material so that cost of construction may be minimized to the minimum extent.

At the same time safe disposal of agricultural and domestic wastes become challenging task for engineers. Hence an attempt has been made by researchers to use agricultural and domestic wastes as soil stabilizers. The beneficial effects of certain agricultural and domestic wastes are discussed in this paper.

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A. Agricultural wastes

Rice husk ash
Rice husk ash is a major agricultural product obtained from paddy. For every 40 kN of rice 10kN of husk is produced. The husk is disposed off either by dumping it in an open heap near the mill site or on the road side to be burnt later. Burning the rice husk generated about 15-20% of its weighing as ash. The ash being very light is easily carried by wind and water contributing to air and water pollution. The huge quantity of ash generated requires large areas for disposal. The high percentage of siliceous material present in rice husk ash indicated that it has pozzolanic properties. The normal method of conversion of husk to ash is by incineration.

Musa Alhassan\(^1\) investigated soil-RHA with respect to compaction characteristics, California bearing ratio (CBR) and unconfined compressive strength (UCS) tests. The results obtained, indicates a general decrease in the Maximum Dry Density (MDD) and increase in Optimum Moisture Content (OMC) with increase in RHA content. There was also slight improvement in the CBR and UCS with increase in the RHA content. Hence Rice husk ash can be used as stabilizer to solve many problems associated with its accumulation.

Sugarcane Bagasse Ash
The Bagasse Ash is the fibrous waste produced after the extraction of the sugar juice from cane. This material usually poses a disposal problem in sugar factories particularly in tropical countries. In many tropical countries there are substantial quantities of Bagasse (the fibrous residue from the crushing the sugar cane) and husks from rice both are rich in amorphous silica, which react with lime. Mohammed Abdullahi\(^2\) investigated and reported that The Optimum Moisture Content (OMC) increased while Maximum Dry Density (MDD) decreased with increasing bagasse and cement content when added with lateritic soil. The cohesion decreases while the angle of internal friction increases. This may be due to reduction of clay - size fraction. The liquid limit reduced while the plastic limit increased and consequently the plasticity index reduced with increase in bagasse ash content. The reduction in plasticity was due to a reduction in liquid limit. Hence sugarcane bagasse ash can be effectively used as a soil stabilizer.

Groundnut shell ash
Groundnut shell is an agricultural waste obtained from milling of groundnut. The ash from groundnut shell has been categorized under pozzolana\(^3\), with about 8.66% Calcium Oxide (CaO), 1.93% Iron Oxide (Fe\(_2\)O\(_3\)), 6.12% Magnesium Oxide (MgO), 15.92% Silicon Oxide (SiO\(_2\)), and 6.73% Aluminum Oxide (Al\(_2\)O\(_3\)). The utilization of this pozzolana as a replacement for traditional stabilizers will go a long way in actualizing the dreams of most developing countries of scouting for cheap and readily available construction materials. Groundnut shell ash has been used in concrete as a partial replacement material for cement\(^4\).

Oriola, Folagbade et al\(^5\) conducted a series of laboratory tests such as unconfined compressive Strength and California Bearing Ratio tests on highly expansive soil with ground nut shell ash and observed improvement of UCC and CBR values. Hence ground nut shell ash in soil stabilization gives greater benefits to the environment than simply disposing it in the environment.

Burnt olive waste
Olive waste is the by product obtained from extracting the olive oil from olives. The quantity of the by-product olive cake residue generated in most parts of the Mediterranean countries continues to increase and expected to be double in amount within 10–15 years. This increase intensifies the problems associated with the disposal of this by-product. Olive cake residue has a potential for use as a soil stabilizer and large volumes can be beneficially used. This study is directed towards determining if olive cake residue can be utilized to increase the strength and stability of expansive soils which constitute a costly natural hazard to lightweight structures on shallow foundations.

Mousa F. Attom et al\(^6\) proposes a partial solution to the problems associated with the increase of
olive waste in Jordan. Chemical analysis was performed to identify the constituents of the olive waste after burning at 550°C. A laboratory study consists of the following tests on samples treated with burnt olive waste: Atterberg Limits, Unconfined Compressive Strength, Standard Proctor Density, and Swelling Pressure tests. It was found that the addition of 2.5% by weight of the burnt olive waste will increase the unconfined compressive strength and the maximum dry density, while the addition of 7.5% of the olive ash by weight minimizes the swelling pressure of the soil. The test results show promise for this material to be used as stabilizer and to solve many of the problems associated with its accumulation. Zalihe Nalbantoglu et al. conducted a series of laboratory tests on engineering properties of soil, such as Atterberg limits, moisture-density relationship (compaction), swell, unconfined compressive strength were undertaken to evaluate the effectiveness and performance of the olive waste as a soil stabilizer. Test results indicate that an addition of only 3% burned olive waste into the soil causes a reduction in plasticity, volume change and an increase in the unconfined compressive strength. However, it was observed that the presence of burnt olive waste in the soil greater than 3% caused an increase in the compressibility and a decrease in the unconfined compressive strength. Test results indicate that the use of olive waste in soil stabilization gives greater benefits to the environment than simply disposing of the by-product, olive cake residue.

B. Domestic wastes

Domestic waste materials comprise waste generated in the form of post-consumer commercial and household waste. Domestic waste materials include paper waste, plastics, scrap tires, glass/ceramics, and carpet waste.

Waste papers

Waste paper refers to discarded forms of newspaper, magazines, office paper and other paper products of various grades and fibers. According to Tchobanoglous et al. (1993) waste paper constitutes the largest component of municipal solid waste by weight. The types of paper that are recyclable include newspaper, corrugated cardboard, high-grade paper, and mixed paper.

The process of waste paper recycling begins at the community level where it is sorted and left for collection. After collection it is sorted further at the waste collection facility and finally baled or shredded. Although the vast majority of this waste paper is recycled to produce other paper products, its use has been extremely limited in highway applications, mainly in aesthetic applications.

Plastics

Plastics are much more varied in terms of origin and properties. Trash bags, plastic pipes, milk jugs, battery casings, plastic cups/plates, and plastic soda bottles all are potential sources for waste plastic. These sources are composed of various types of polymers among them Poly Ethylene Terephthalate (PETE) in soda bottles, High-Density Polyethylene (HDPE) in milk bottles, Polyvinyl Chloride (PVC) in piping, Low-Density Poly Ethylene (LDPE) in thin film packaging, Polypropylene (PP) in crates, and polystyrene (PS) in cups/plates. The properties of the recycled plastic rest mainly on the type of resin or polymer used in the product, as are recycling options and processing. For example, reclaimed HDPE and PETE bottles are granulated into small flakes and separated by floatation. The flakes are then melted and turned into pellets or formed into plastic lumber.

The plastic wastes exhibit the following engineering properties:

- specific gravity = 1.06
- internal friction angle between 37º and 43º
- tensile strength between 207 and 230 MN/m²
- elastic modulus of 7 GN/m².
- compressive strength = 21000 kPa
- tensile strength = 13000 kPa

Hence plastics can be effectively used in only a few applications – slope stability and soil reinforcement.

Waste glass

The majority of recycled glass is used as feed stock for the production of other glass containers, but it is also used in engineering applications. As a product of super cooling, it is composed primarily of silicon dioxide (sand) and sodium carbonate.
Crushed waste glass typically exhibits angular particles. Further crushing can cause a decrease in the angularity and produce a material similar in properties to natural sand.

The following engineering properties are observed from waste glass\(^\text{14}\):

- unit weight of 11.2 to 19 kN/m\(^3\)
- specific gravity of 1.96 to 2.52
- hardness = 6
- CBR of 42 to 132%
- maximum dry density = 19 kN/m\(^3\)
- optimum water content of 5.7% to 7.5%
- internal friction angle of 51º to 53º
- coefficient of permeability of 0.6 to 2 mm/sec
- abrasion = 36%

Waste glass was investigated for use in asphalt pavement, base, and embankment applications.

**Carpet waste**

Carpet waste, also referred to as carpet fibers, consists of waste from industrial production and discarded consumer carpet. The carpet waste generated each year and accumulated in landfills represents an abundance of useful resources, as it may be converted into various useful products. The rate of carpet disposal is about 2-3 million tons per year in the U.S. and about 4-6 million tons per year worldwide. A carpet typically consists of two layers of backing (usually fabrics from polypropylene tape yarns), joined by CaCO\(_3\) filled styrene-butadiene latex rubber (SBR), and face fibers (majority being nylon 6 and nylon 66 textured yarns) tufted into the primary backing. To use post-consumer carpet as concrete or soil reinforcement, the carpet is shredded to recover fibers. It is generally not necessary to disassemble yarns in the carpet into individual fibers.

Youjiang Wang\(^\text{10}\) studied the use of Recycled carpet waste fibres as reinforcement in concrete and soil to improve their properties. Besides performance enhancement, the use of recycled fibers for concrete and soil reinforcement offers additional benefits such as low cost raw materials, resource utilization and reduced need for land filling.

**Scrap tires**

Scrap tires perhaps rank among the most extensively researched and implemented recycled materials in recent years. Potentially usable forms include whole tires, sliced tires, tire chips, tire herds, and smaller, soil-like particles referred to collectively as crumb rubber. A typical whole scrap automobile tire weighs about 91N, while a typical truck tie weighs about 182N. However, not all of the rubber is recoverable. The size of the tire chips is a function of the shredding machine itself. To produce a smaller sized chip, it is often necessary to employ more than one processing machine. Slit tires are basically whole tires split in half or have the sidewall separated from the tread. Shredded or chipped tires undergo two stages of shredding. Primary shredding produces strips 30 to 45 cm in length. Secondary shredding produces lengths of 10 to 15 cm. Ground rubber is produced as regularly shaped and cubical particles as large as ¾ of an cm. Crumb rubber exhibits fine particles ranging in size from passing No.4 to No.200 sieves. Composed primarily of various types of rubber, recycled tire shreds also contain carbon black, polymers, and fabrics as well as steel wire or belt materials.

Craig H. Benson\(^\text{11}\) after his investigation reported that Shredded tires can be used as lightweight fill, backfill behind the retaining walls, construction of high strength embankments, drainage material, daily cover at a landfill, thermal insulation to protect landfill lining systems from freezing and also used in leachate collecting systems because scrap tires can adsorb toxic organic chemicals normally found in leachate.

**Eggshell powder**

Eggshell Powder (ESP) has not being in use as a stabilizing material and it could be a good replacement for industrial lime, since its chemical composition is similar to that of lime. Chicken eggshell is a waste material from domestic sources such as poultries, hatcheries, homes and fast food centers. This amounts to environmental pollution. Eggshell waste falls within the category of waste food, they are materials from the preparation of foods and drinks, if subjected to adequate scrutiny, and they could be suitable for soil stabilization.
The use of lime for stabilization is becoming expensive requiring an economical replacement. Literature has shown that eggshell primarily contains lime, calcium, and protein. It has being in use as a source of lime in agriculture, which confirms that lime is present in considerable amount in eggshell. Subsequent findings revealed that ESP was used for stabilization of a cohesion less soil in Japan. This study is thus directed towards identifying eggshell powder as an effective stabilizing agent by replacing a certain percentage of lime in the stabilized soil with ESP. Since the quantity of eggshell that may be required for stabilization of a large area may not be met, it is suggested that the ESP be used as a supplement in lime stabilization.

O.O. Amu et al studied the effect of eggshell powder on the Stabilizing Potential of Lime on an Expansive Clay Soil. He conducted series of tests to determine the optimal quantity of lime and the optimal percentage of lime-ESP combination. The optimal quantity of lime was gradually replaced with suitable amount of eggshell powder. Results of the Maximum Dry Density (MDD), California Bearing Ratio (CBR), Unconfined compression test and Undrained triaxial shear strength test all indicated that lime stabilization at 7% is better than the combination of 4% ESP + 3% lime.

RESULTS AND DISCUSSION

Construction and Demolition (C&D) waste is the general term for a host of waste materials generated from the construction industry, consisting of building materials such as concrete, glass, brick, metal, wood, and plaster. C&D waste must be processed, mainly by separation, before it can be incorporated into engineering uses. Because C&D waste is a highly heterogeneous material, a comprehensive characterization is difficult to achieve. The processing of demolition debris involves a series of separations and screenings, starting with the larger materials (lumber, concrete) down to the sand and gravel sized material. Upon arrival to the processing facility the incoming material is separated into concrete and non-concrete materials. The non-concrete material passes through several screens and conveyors in order to remove harmful materials such as asbestos. The concrete material is crushed and a magnet is used to remove any metal and rebar present. C&D wastes are used in asphalt pavement and base/sub base applications.

CONCLUSION

Production of large quantity of agricultural and domestic wastes all over the world faces serious problems of handling and disposal. Safe disposal of agricultural and domestic wastes without adversely affecting the environment and the large storage area required are major concerns. Hence attempts are being made to utilize these agricultural and domestic wastes in geotechnical engineering applications such as construction of embankments, as a backfill material, as a sub-base and foundation material etc. Use of certain agricultural and domestic wastes also improves the engineering behaviour of the soil. Hence there is a value addition to the industrial effluent serving the three benefits of

- Safe disposal of effluent
- Using as a stabilizer and
- Return of income on it.

REFERENCES


