Comparative Study of Properties of Subgrade Soil using Plastic Wastes

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Abstract— Infrastructure is a major sector that propels overall development of Indian economy. The foundation is very important for any structure and it has to be strong enough to support the entire structure. For foundation to be strong the soil around it plays a very important role. Expansive soils like black cotton soil always create problems in foundation. The problems are swelling, shrinkage and unequal settlement. Plastic wastes have become one of the major problems of the world. Use of plastic bags, bottles and other plastic products is exponentially increasing year by year. Due to which we are facing various environmental problems. A review paper is presented here to focus on soil stabilization by using waste plastic products. Tests are liquid limit, plastic limit, standard proctor compaction test, California bearing ratio (CBR) test and unconfined compressive strength (UCS) have been conducted to check the improvement in the properties of black cotton soil.

Key words: CBR, UCS, MSW

I. INTRODUCTION

Industrial development in India has necessitated construction of infrastructure facility such as highways, airports seaports and residential, commercial buildings. There is a need to select a good soil conditions for proper safety consideration of all these projects. Such soils exhibit extreme stages of consistency from very hard to very soft when saturated. Expansive soils contain minerals that are capable of absorbing water. The severe volume changes corresponding to changes in moisture content. They swell or increase in their volume when they imbibe water and shrink or reduce in their volume on evaporation of water (Chen 1998). As we know they have alternate swelling and shrinkage, they result in detrimental cracking of lightly loaded civil engineering structures such as foundations ,retaining walls, pavements, airports, side -walks, canal beds and linings (Chen 1988). Due to these reasons expansive soils are generally poor material for construction. So to improve the engineering properties of soil, stabilization or reinforcement is done. Soil stabilization is the process of blending and mixing materials to improve engineering properties of soil like increasing shear strength, compressibility and permeability, thus improving load bearing capacity of a sub-grade to support pavements and foundations. For many years, engineers have used traditional additives such as lime, cement and cement kiln dust etc. to improve the qualities of readily available local soils. The stabilization of expansive soils can be done by using cement and lime is well documented. Cement stabilization nowadays is less appreciated because of the increasing cost of cement and environmental concerns related to its production. India being the second largest producer of cement has a very heavy impact on CO2 emission. One can imagine from the fact that approximately one tone of CO2 is produced during the production of one tone of cement. On the other hand, lime also contributes CO2 to the world climate during its production. The cost of these additives has also increased in recent years. This has opened the door widely for the development and introduction of other soil types of additives, such as plastic, bamboo, stabilization liquid enzyme soil etc. open. As plastics are inexpensive and even lightweight and durable materials, which can readily be moulded into a variety of products that find use in a wide range of applications. On an average, an Indian uses 1 Kg of plastics per year and the world annual average is an alarming 18 kg. As per data available on Municipal Solid Waste (MSW) 2009, approximately 4000-5000 ton per day plastic wastes are generated. As a consequence, the production of plastics has increased markedly over the last 60 years. Today, every vital sector of the economy has been virtually revolutionized by the application of plastic. According to recent studies, plastic can stay unchanged for as long as 4500 years on earth. Use of this non-biodegradable product is growing rapidly and the problem is what to do the plastic waste. Several million metric tons plastic wastes are produced every year. Natural materials being exhaustible in nature, its quantity is declining gradually. Also, cost of extracting good quality of natural material is increasing. The scientists were looking for alternative materials for soil stabilization, and plastic wastes product is one such category. To deal with the growing disposal problem of these materials is an issue that requires co-ordination and commitment on the part of all parties involved such as government agencies, companies, the public and professionals. One of the method to reduce portion of the plastic waste disposal problem is by recycling and by utilizing these materials in the stabilization of expansive soil. Therefore, for sustainable development use of locally available plastic waste materials should be encouraged. The objective of this study was to make economical and to maintain environmental balance, and avoid problems of waste plastic disposal i.e. the use of plastic waste for stabilization of black cotton soil and its possible combined utilization with various proportions to obtain maximum stability.

A. Data on Generation of Plastic Waste & Plastic Combustion

In 2013 consumption of plastic in India was about 120 lakh tons but it is about to reach 200 lakh tones by the year 2020 due to growing use of different forms of commodity. The consumption of plastic in different forms is increasing by an average of 10% every year. Rate of generation of plastic wastes in Indian cities ranges between 0.20-0.87 kg/day, depending upon the size of the city and living standard. Every year about 8 million tons of plastic waste is dumped in to the world's oceans.

II. LITERATURE REVIEW

S.W. Thakare and S. K. Sonule, (2014) performed laboratory tests to study the effect of reinforcement of sandy soil by

using model plastic water bottle through model plate load tests. The increase in bearing capacity may be due to the additional confinement to the soil in the vicinity of footing similar to that in case of Geocell.

The bearing capacity increases with the increase in width of reinforcement and number of layers. Thus, the use of plastic bottles as reinforcement was recommended to reduce the quantity of plastic waste which creates the disposal problems.

Harish and Ashwini, H.M. (2016) studied the effect of plastic bottles strips as a stabilizer for two soil samples, red soil and black cotton soil. Red soil consists of 4 % gravel, 88S.W. Thakare and S. K. Sonule, (2013) carried out various laboratory tests to investigate the effect of reinforcement of sandy soil with model plastic water bottle through model plate load tests. The increase in bearing capacity may be due to the additional confinement to the soil in the vicinity of footing similar to that in case of Geocell.

The bearing capacity increases with the increase in width of reinforcement and number of layers.

Harish and Ashwini, H.M. (2016) studied % sand and 8% silt and clay and black cotton soil 2.6% gravel, 15.1 %sand and 82.3 % silt and 0.18 % of clay. They used plastic stripes in making the pavement and it was found that there was an increase in the strength of the soil. Authors conducted a CBR ratio test to find out MDD and OMC. They observed an increase in the strength of soil and bearing ratio of 2.9 for red soil and 3.3 for the black cotton soil by mixing 0.7 % of waste plastic strips to red soil and 0.5 % for the black cotton soil.

Jasmin Varghese Kalliyath (2016) studied the effect of plastic fibers. Various tests such as Standard Proctor, UCC were carried out with different samples of silty clay. The test results also showed that with 1% replacement, MDD and UCC were less than the 0.5 % replacement but greater than the untreated soil. Further increase in the plastic replacement showed decrease in the MDD and the UCS. MDD of the soil with 2% replacement is due to the decrease in the number of voids with the addition of plastic which leads to effective compaction and also increase in the cohesion. Thus authors concluded that optimum percentage of plastic was 0.5 % for optimum results.

Mercy Joseph Poweth (2014) investigated the effect of plastic granules on weak soil sample with plastic and without plastic granules in varying percentage. Even the CBR value also decreases 0.25 % plastic is added but it was found to be increased for 0.75 % of plastic. Authors also observed that for the same percentage of plastic, shear stress was maximum.

Satyam Tiwari (2016) investigated the effect of waste polypropylene fiber on shear strength of unsaturated soil samples. Here, the percentage of specific gravity of the soil increases 0.3% by using 0.5% of fiber.

Chebet (2014) conducted experiments to determine the increase in shear strength and bearing capacity of two samples of locally available soil due to random mixing of strips of high density polythene material from plastic shopping bags. These results indicate that the increased strength of soil was due to tensile stresses mobilized in the reinforcements.

Achmad Fauzi (2016) used two soil samples R2 and R24 collected from various sites of KUANTAN. Waste cutting HDPE and crushed waste glass were used as additives. The variations of additive contents were 4%, 8 %, 12 % by dry total weight of soil sample respectively. Sieve analysis, Atterberg limit, Specific gravity, Standard Compaction, soaked California bearing ratio and tri-axial test of the soil sample before stabilization and after stabilization. The result showed that on addition of waste HDPE and glass there was an increase in PI, about 10% for R24 and 2% for R2 samples respectively. The value of optimum water content decreases and MDD increases when content of waste HDPE and glass were increased but there was an increase in CBR value. Authors also observed that there was a decrease in the value of cohesion and increase in friction angle of R2 and R24 samples with additives.

A.I.Dhatrak (2015) calculated the engineering properties by mixing waste plastic. In ratio of 0.5%, 1%, 1.5%, 2%, and 2.5% of the weight of dry soil, plastic waste was used to calculate CBR value. They concluded that by using plastic waste strips will improve the soil strength and can be used as sub grade. It is economical and eco-friendly method to dispose waste plastic.

Anas Ashraf (2011) studied on the possible use of plastic bottles for soil stabilization. The bottles cut to halves placed at middle and one third position of tank. The test results showed that cut bottles placed at middle position were the most efficient in increasing strength of soil.

Rajkumar Nagle (2014) conducted various experiments to compare CBR of soil reinforced with natural waste plastic. They mixed polyethylene plastic bottles food packaging and shopping bags etc. as reinforced with three soil samples of expansive soil (black cotton soil), silty-clay and sandy soil.

III. METHODOLOGY

Black cotton soil was used for the determining the basic properties of the soil such as wet and dry sieve analysis, Atterberg Limits, Standard Proctor Test, Differential Free Swell Test, Swelling Pressure Test and California Bearing Ratio Test. The tests were performed on samples with lime content varying from 2.5% to 7.5% and then compared to the results obtained from soil without lime.

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