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Experimental Study on CBR Properties of Soil Added With Perforated Plastic Waste

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Abstract— **The CBR values of the soil which is one of the factors representing the strength characteristics of the soil will be significantly affected by the addition of waste plastic that is obtained by the shredding of waste beverage bottles. The percentage addition of plastic and the aspect ratio of the plastic strips provided with varying number of perforations, influence the results to a considerable extent. The CBR value of the soil increased with the increase in plastic content percentage and also as the aspect ratio and perforation numbers increased the CBR value considerably improved. The improvement in the CBR properties by the addition of plastic waste can be effectively made use of in the construction of landfill sites, making of pavement for light traffic conditions, in reducing the thickness of the pavement layer and for supporting foundation soils which possess low tensile strength etc. with a minimal cost factor and also facilitating effective reusage of plastic waste generated.**

Keywords— ***CBR values, Soil, Plastic waste, Plastic percentage, Aspect ratio. Perforation numbers***

I. INTRODUCTION

The increasing usage of plastic day by day due to rapid growth in population and urbanization has forced to find us the various means and methods due to which the generated waste plastic can be effectively utilized or reused in an effective manner. Stabilization of Soil is one of the best methods to effectively improve the properties of soil. Addition of plastic waste for improving the soil properties can be categorized under the Soil Reinforcement technique, where in foreign materials like fibers, strips and other materials are externally added to improve the behavior of the soils to a great extent. Reinforced Earth structures have provided effective structural solutions at significant cost savings and have been accepted as standard practice by civil engineering authorities worldwide .Today we have wide range of reinforcing materials that are available in market like steel rods, steel plates, steel strips , Steel Panels, Geosynthetics, Geogrids etc.,. However the usage of waste plastic is quite an economical method for soil reinforcement as the waste plastic is quite easily available at a very cheap rate and also the utilization of plastic waste helps in tackling two problems simultaneously, one is with the stabilization of soil and other is the effective utilization of waste plastic.

The potentiality of recycling the waste plastic is quite low as when compared to the rate at which it is being generated due to day to day activities of the increasing population. Plastic products have become an integral part in our daily life as it has a broad range of application in making of carriage bags, garbage bags, fluid containers, films, wrapping materials, household and industrial products, and a considerable types of building materials which have proved more advantageous with their characteristics like less weight, less cost and more load carrying capacity.

The plastic which will be discarded after its utility is over is generally termed as plastic waste. These plastic wastes remain on the landscape for a very long time as it is a very well known fact that plastics and plastic wastes never degrades. It is also to be noted from the environmental point of view that even recycled plastic products are more harmful as they are added with harmful chemical additives and toxin colours. A permanent solution for discarding of the plastic waste is necessary, as any virgin plastic can only be recycled 2-3 times after which the plastic material quality deteriorates as its life span gets reduced due to thermal changes.

In the present work the focus will be made towards the effective utilization of the waste plastic which are produced mainly in the form of bottles. Currently the major contributor for the piling of the waste plastic is the beverage industry with Bottled water is one of the major key players. According to the international bottled water association (IBWA), sales of bottled water have increased by 500 percent over the last decade and 1.5 million tons of plastic are used to bottle water every year. Plastic bottle recycling has not kept pace with the dramatic increase in virgin resin polyethylene terephthalate (PET) sales and the aspect of reduce / reuse / recycle, has emerged as the one that needs to be given prominence. The general survey shows that 1500 bottles are dumped as garbage every second. PET is reported as one of the most abundant plastics in solid urban waste whose effective reuse/recycling is one of the critical issues which need immediate attention.

II. MATERIALS

The materials used for the present study is Soil-Red earth and plastic strips obtained by shredding of waste water bottles.

Red earth

Table 1 presents the properties of the red earth used; The red earth is classified as Silt of Low compressibility/plasticity according to Indian standard classification system (ISCS).

Table 1: Properties of Soil-Red Earth

PROPERTIES	TEST RESULT
specific gravity	2.78
Liquid Limit (%)	45
Plastic Limit (%)	25
Shrinkage Limit (%)	14
Dry unit weight (kN/m3)	18.2
Optimum Moisture Content (%)	18
Silt + Clay (%)	58 + 18 = 76
Soil classification (IS)	ML

Plastic

Used water bottles manufactured by a particular company are collected from restaurants and old scrap dealers. After splitting it open rectangular sheets are obtained. These sheets are cut in to required dimensions manually using small hand instruments like razors and cutters.

To improve the performance of such shredded plastic – a modification is made for the shredded plastic. 5mm diameter holes are punched in each of the shredded plastic strips at prefixed spacing. Providing such perforation in the shredded plastic is expected to provide confinement to the soil particles at the micro level and thereby may contribute to the improvement in the performance of plastic reinforced red earth.

III. METHODOLOGY

Plastic waste strips are mixed at different percentages i.e., 0.5%, 1.0%,1.5%, 2.0% and 2.5% to the dry weight of soil. Series of California Bearing Ratio tests were conducted to determine the strength and CBR values of soils. Mixing of plastic strips in soil have be done carefully such that these strips are distributed uniformly in the soil. The mixing is done manually and proper care is taken to prepare a homogeneous mixture.

California Bearing Ratio test

The California Bearing Ratio test is conducted for evaluating the suitability of the subgrade and materials used in sub-base and base course of a flexible pavement. CBR is defined as the ratio of force per unit area required to penetrate a soil mass with a circular plunger of 50mm diameter at the rate of 1.25mm/min to that required for corresponding penetration of a standard material. The specimens are prepared in a cylindrical mould of 150 mm-diameter and 175-mm height and compacted in three layers at its MDD and OMC based on the standard Proctor compaction. The tests were conducted in accordance with ASTM D1883-07 (ASTM 2007). The mould is kept under CBR testing machine and the load corresponding to the 2.5mm and 5.0mm are taken from load penetration curve to determine the CBR Values.

CBR Value = (Test load/Standard load) × 100

Soaked CBR tests were conducted for examining the performance of plastic waste mixed soil when it is in its worst condition. After compacting the plastic waste mixed soil in CBR mould, the set up is kept submerged in water for about 4 days. The specimen is covered with surcharge mass to simulate the effect of overlying material. After 96 hours of submergence, it is taken out and tested to determine the soaked CBR Value.

IV. RESULTS AND DISCUSSION

Soaked CBR Test

In soaked CBR test, after preparing the specimens, the specimens are immersed in water and soaked for 4 days to simulate the worst condition of soil. After soaking period is completed, the specimens are tested using CBR testing machine. The soaked CBR condition was selected as it reflected the worst condition to which a pavement soil can be subjected to, as when compared to the unsoaked CBR test conditions. The load (kN) against penetration (mm) for various percentages of plastic with varying aspect ratio and also with varying number of perforations are as presented below.

The graphs pertaining to comparison between the varying percentages of plastic addition along with varying Aspect ratio and number of perforations are as given in the Fig.3, Fig.4 and Fig.5.

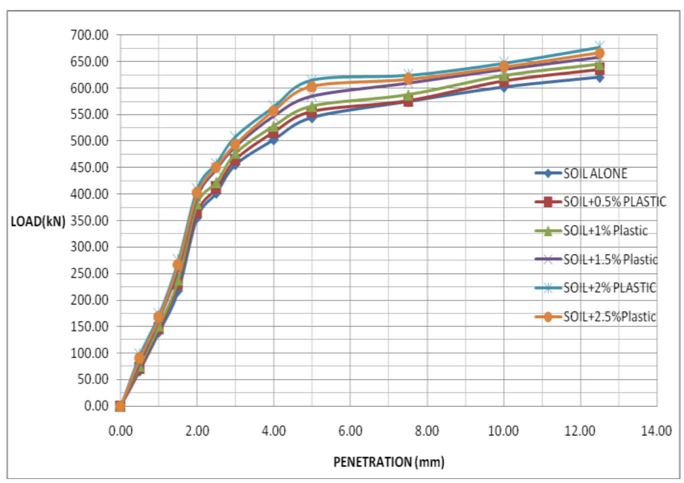

Fig 3: Comparison of CBR Graphs for varying plastic percentages (A/R=1 and No of perforations=1)

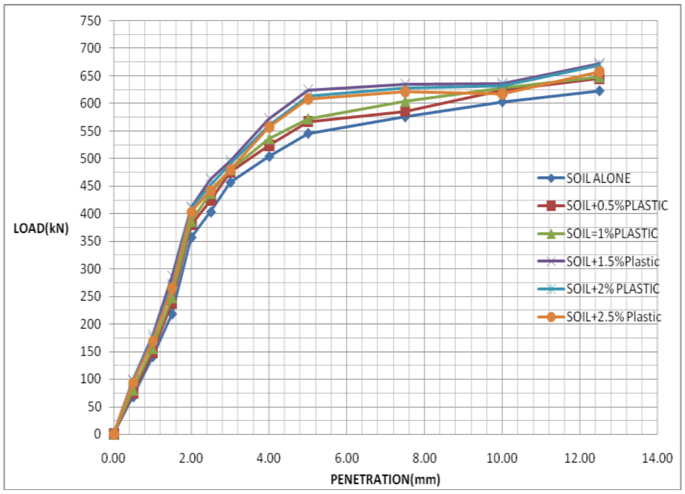

Fig 4: Comparison of CBR Graphs for varying plastic percentages (A/R=2 and No of perforations=2)

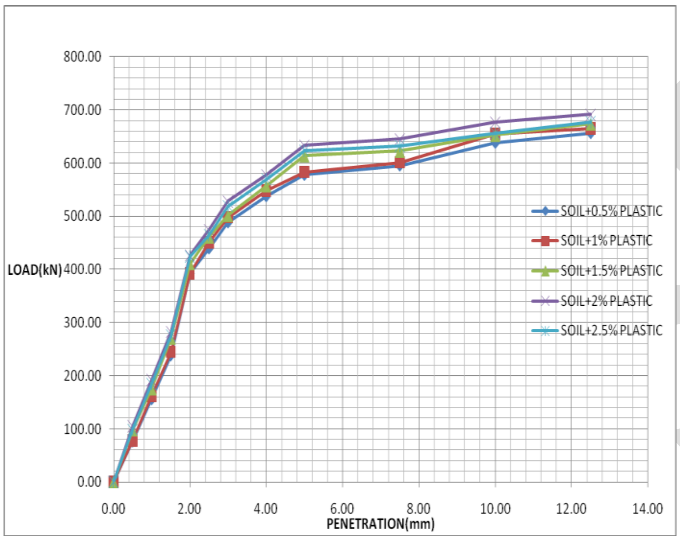

Fig 5: Comparison of CBR Graphs for varying plastic percentages (A/R=3 and No of perforations=3)

The CBR values of the Soil-Red earth shows a significant improvement with the increasing percentage of Plastic. However it can also be noticed that the CBR values are further more on the improving side with the increase in the Aspect ratio (A/R), which is varied from 1to 3, and also Number of perforations that were made in the waste plastic strips plays a vital role in influencing the CBR values, as the perforations tend to provide interlocking spaces between the soil particles and the plastic strips, and this interlock between the soil particles and plastic strips prevents the slippage of the strips, which inturn increases the tensile strength of the soil, ultimately resulting in higher CBR values.

CBR value comparison for 0%, 0.5%, 1%, 1.5%, 2%, 2.5% plastic waste addition. With varying aspect ratio (A/R) of A/R=1, 2, 3 and Number of perforations=1, 2, 3

	A/R=1 **No of Perforations** **=1**	**A/R=2** **No of Perforations** **=2**	**A/R=3** **No of Perforations** **=3**
SOIL ALONE	2.70	2.70	2.70
SOIL+0.5% PLASTIC	2.76	2.81	2.87
SOIL+1% PLASTIC	2.81	2.84	2.90
SOIL+1.5%PLASTIC	2.90	3.10	3.04
SOIL+2%PLASTIC	3.05	3.04	3.14
SOIL+2.5%PLASTIC	2.99	3.02	3.09
Percentage increase in CBR (with reference to CBR value of Soil Alone)	13%	15%	16.29%

The details pertaining to the comparison of varying percentages of Plastic along with varying Aspect ratio and number of penetrations are tabulated for comparison , and it can be observed that with 2% Plastic addition along with an A/R of 3 and Perforations=3, the maximum percentage increase of 16.29% in the CBR value can be obtained and it can also be observed that 2% of plastic addition turns out to be the optimum plastic percentage in all the three cases of varying A/R and Varying number of perforations.

IV. CONCLUSIONS

All the experiments conducted with varying percentages of plastic along with different number of perforations indicated that the CBR value for the soils mixed with plastic waste though considerably increased, but a very clear cut indication about the optimum percentage of plastic content to be added was not accurately found. The increasing percentages of plastic and increasing number of perforations, though increased the CBR value, it was quite uncertain whether the same increasing trend would be observed, if the plastic percentage is continuously increased, but however there was a limitation on the percentage addition of plastic as well as the dimensions of the plastic strips that were to be added, considering the size of the mould that was used for the preparation of sample and conduction of the CBR test.

Plastic strips with longer dimensions (after A/R=3) were not used for the testing procedure as, the longer size of the strips, would induce the boundary effect conditions on the soil sample, which would have resulted in inconsistent results. However, the, on a general observation, it can be concluded that the addition of waste plastic in the form of strips with perforations incorporated in it, will certainly enhance the CBR value to a certain extent and thereby improving the tensile strength of the soil. Thus waste plastic which is also forms a major part of the solid waste generated , can be utilized to some extent in a fruitful manner, for small works like, village road construction, construction of lightly loaded structures etc.

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