EFFECT OF WASTE PLASTIC FIBRE ON THE STRENGTH CHARACTERICTICS OF THE HIGHWAY SUBGRAD

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***Abstract*: The biggest challenge for developing countries like India is to build a complete network of road systems and provide a limited source of funding. The use of local materials can greatly reduce construction costs. If the stability of the local soil is insufficient to support the wheel load, the performance is improved by soil stabilization techniques; for example, the use of geogrids to use randomly distributed fibers or waste plastics in the subgrade soil, which helps to increase the strength of the roadbed. Research has been carried out in this field to improve the engineering properties of subgrade soils by adding different types of waste plastics. In this study, different types of waste plastics were randomly mixed with soil and then subjected to a series of California Bearing Ratio (CBR) tests to assess the strength of the subgrade soil. Various percentages of high density polyethylene (HDPE), low density polyethylene (LDPE) and polypropylene (PP) are used to improve soil strength. The results of the CBR test indicate that the addition of these materials to the subgrade soil provides effective strength for the subgrade soil. It was observed that the CBR value increased to a certain percentage as the fiber content increased, but decreased as the waste plastic content was further added. The pavement section adopts modified subgrade design, using HDPE, LDPE and PP, and analyzes the critical strain value of the top of the subgrade and the bottom of the asphalt layer, and compares it with the allowable value of IRC: 37-2012 The traffic load of the four-lane regional road project is 150 MSA. The reduction in crustal thickness and project cost savings were compared by different waste plastics and different plastic content.**

***Index Terms*: Highway, Waste Plastic, High density polyethylene (HDPE), Low density polyethylene (LDPE), Polypropylene, CBR**

I. INTRODUCTION

In developing countries like India, the biggest handicap to provide a complete network of road system is the limited finances available to build roads. Use of local materials, including local soils, can considerably lower down the construction cost. If the stability of local soil is not adequate for supporting wheel loads, the properties are improved by soil stabilization techniques. The stabilization of soil for use in subgrade for pavement is an economic substitute of costly paving materials. There are many techniques for soil stabilization either mechanical or chemical, but all of them require skilled manpower and equipment to ensure adequate performance.

Randomly distributed at different percentages by volume of fibre, when used an insertion in highway subgrade, can produce a high performance in the stabilization of weak roads. Many investigators have used various types of fibres under different test conditions. The most important findings of the previous research work is that the use of certain fibre, such as synthetic and natural, in road construction can significantly increase pavement resistant to rutting as compared to the resistance of non-stabilized pavement over a weak subgrade. Permanent deformation in each layer is the indicator of rut formation at the road surface. Consequently this is used as a criterion of pavement performance. However, it is difficult to comprehensively include permanent deformation. There are problems in assessing the contribution made by each individual layer to the total rut depth visible at the pavement surface.

Hence, the deformation that appears at the surface of a pavement is the sum of deformation of each of the pavement layers, together with that in the subgrade. The standard fiber-reinforced soil is defined as a soil mass that contains randomly distributed, discrete elements, i.e. fibers, which provide an improvement in the mechanical behavior of the soil composite. Fiber reinforced soil behaves as a composite material in which fibers of relatively high tensile strength are embedded in a matrix of soil. Shear stresses soil mobilizes tensile resistance in the fibers, which in turn imparts greater strength to the soil.

II. LITERATURE REVIEW

Ghavami et al. (1999) [1] found that inclusion of 4% sisal, or coconut fiber, imparted considerable ductility and slightly increased the compressive strength. It was also found that introduction of bitumen emulsion did not improve the bonding between the soil and fibers; but did significantly improve soil durability.

Puppala and Musenda (2000) [2] indicated that PP fibre reinforcement enhanced the unconfined compressive strength (UCS) of the soil and reduced both volumetric shrinkage strains and swell pressures of the expansive clays.

Gosavi et al. (2000) [3] reported that by mixing nylon fibers and jute fibres, the CBR value of soil is enhanced by about 50% of that of unreinforced soil, whereas coconut fiber increases the value by as high as 96%. The optimum quantity of fiber to be mixed with soil is found to be 0.75% and any addition of fiber beyond this quantity does not have any significant increase in the CBR value.

Prabakar and Siridihar (2002) [4] used 0.25%, 0.5%, 0.75% and 1% of sisal fibers by weight of raw soil with four different lengths of 10, 15, 20 and 25 mm to reinforce a local problematic soil. They concluded that sisal fibers reduce the dry density of the soil. The increase in the fiber length and fiber content also reduces the dry density of the soil. As well it was found that the shear stress is increased non-linearly with increase in length of fiber up to 20 mm and beyond, where an increase in length reduces the shear stress. The percentage of fiber content also improves the shear strength. But beyond 0.75% fiber content, the shear stress reduces with increase in fiber content.

Consoli et al. (2003) [5] investigated the load–settlement response carried out on a thick homogeneous stratum of compacted sandy soil reinforced with PP fibres. The PP-reinforced specimens showed a marked hardening behavior up to the end of the tests, at axial strains larger than 20%, whereas the non-reinforced specimens demonstrated an almost perfectly plastic behavior at large strain. This improvement suggests the potential application of fiber reinforcement in shallow foundations, embankments over soft soils, and other earthworks that may suffer excessive deformation.

III. METHODOLOGY

The methodology involved for the study is as follows.

Collection of Material: Soil taken is locally available in the region of Ambala Cantt, Haryana (India). The investigation of Soil is done by Indian Standard code. The index properties of soil such as Liquid limit, Plastic limit, and Plastic index are determined. Three types of waste plastic used are High density Polyethylene (HDPE), Low density Polyethylene (LDPE) and Polypropylene (PP). These waste materials are purchased from waste plastic recycle industries, where rag picker supplies the waste plastic which they collect from waste dump around Ambala Cantt. Different types of waste plastic were crushed into irregular strip which were further converted into granular particles which are used in this study.

Compaction Test: This test is done to determine the maximum dry density and the optimum moisture content of soil using by proctor test as per IS: 2720-Part viii (1995). Compaction is the process of densification of soil mass by reducing air voids. The degree of compaction of a soil is measured in terms of its dry density. For a given compaction energy every soil attains the maximum dry density at a particular water content which is known as optimum moisture content.

***CBR Test*:** It is the ratio of force per unit area required to penetrate a soil mass with standard circular piston at the rate of 1.25 mm/min. to that required for the corresponding penetration of a standard material. IS 2720- Part xvi (2002) is used for this test.
The feasibility of reinforcing soil with different waste plastic content (i.e. HDPE, LDPE, PP) is investigated in this study. Granular size materials are randomly mixed with locally available soil and tested.

IV. COLLECTION OF MATERIALS

A brief description of the materials and methods used in this investigation is given as following.

***Sand*:** Soil taken is locally available in the region of Ambala Cantt, Ambala City, and Yamuna Nagar. The investigation of Soil is done by Indian Standard code. The index properties of soil such as Liquid Limit, Plastic Limit, and Plastic Index are determined.

***Grain size*:** It is done to determine the percentage of various grain sizes. The grain size distribution helps in determining the textural classification of soils whether it is gravel, sand, silt, clay, etc. which is then useful in evaluating the engineering characteristics. IS: 2720- Part iv (2006) is used. The sieves for soil tests used are 4.75 mm to 75 microns and grain size distribution

***Waste Plastic*:** Three types of waste plastic used were High Density Polyethylene (HDPE), Low Density Polyethylene (LDPE) and Polypropylene (PP). These waste materials were purchased from waste plastic recycle industries, where rag picker supplies the waste plastic which they collect from waste dump around Patiala. Different types of waste plastic were crushed into irregular strip which were further converted into granular particles which were used in this study. The cost of different waste plastic varies from INR 40 to INR 65 per kg.

V. SUBGRADE SOIL TESTS

Atterberg Limits Test (IS 2720- Part 5): The Liquid and Plastic Limits (Atterberg Limits) of soil indicate the water contents at which certain changes in the physical behavior of soil can be observed. From Atterberg limits, it is possible to estimate the engineering properties of fine-grained soils. Plasticity is the property that enables a material to undergo deformation without noticeable elastic recovery and without cracking or crumbling.

Plasticity Index (Pl) = LL – PL

Soil sample has been collected from poor surface condition.

Table 1 Summary of Atterberg Limit Test

Liquid Limit	Plastic Limit	Plasticity Index	Coefficient of curvature	Uniformity coefficient
18.58 %	13.33	5.25	0.42	5.3

***Compaction Test*:** The Proctor compaction test is a laboratory method of experimentally determining the optimal moisture content at which a given soil type will become most dense and achieve its maximum dry density

Table 2 Compaction Test on Unreinforced Soil

S. No.	Water Content (%)	Dry Density (kN/m^3)
1	7.5	18.4
2	11	18.6
3	12.5	18.8
4	16.5	17.8

VI. OBJECTIVES

Randomly distributed fibre, when used an insertion in highway subgrade, can produce a high performance in the stabilization of weak roads. In this dissertation, we have used various types of fibres under different test conditions. The most important findings of the current research work is that the use of certain fibres, such as synthetic and natural, in road construction can significantly increase pavement resistant to rutting as compared to the resistance of non-stabilized pavement over a weak subgrade.

VII. CONCLUSION

The feasibility of reinforcing soil with different waste plastic content i.e. (HDPE, LDPE, PP) was investigated in this study. Granular size materials were randomly mixed at different percentages with locally available soil and tested to determine CBR values of subgrade soil. Based on the results, the following conclusions are drawn:

1. Addition of HDPE, LDPE, PP waste plastic, to local soil increases the CBR value.
2. The CBR value of the unreinforced soil was 7.9 % which were increased to 26.9% for 5% HDPE waste plastic content, 20.38 % for 5% LDPE and 23.2% for 5% PP.
3. The maximum improvement in CBR value was obtained when waste plastic content was 5%. Bearing Ratio Index (BRI) value was found approximately 3.40 for HDPE waste plastic whereas for LDPE and PP, BRI was 2.57, and 2.93.
4. It was observed that there is large decrease in pavement crust thickness with the addition of HDPE, LDPE & PP in the subgrade soil. With 5% HDPE waste plastic content, the total crust thickness was reduced from 635mm to 455mm as compared to LDPE and PP where the reduction in crust is 490mm and 470 mm respectively.
5. Pavement construction cost of 20% can be saved by using 5% of HDPE content in the subgrade of the four lane divided carriageway whereas 5% & 15% of pavement cost can be saved with 5% of LDPE & PP content in the similar crust section.

VIII. SCOPE

By using these waste plastics in the subgrade, a trial pavement sections can be constructed and the performance of these pavements can be evaluated under the repetitive loading for the rutting and the fatigue distresses.

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