Strength Characteristics of Gravel-Flyash Reinforced with Waste Fibers

A.Srinivas, Dr. DSV Prasad, Dr. M Anjan Kumar, Dr.GVR Prasada Raju

***Abstract*— Flyash is a waste produced from thermal power stations, which contributes to environmental pollution. It is waste materials that can be utilized in construction of roads and embankments. Disposal of a variety of wastes in an eco friendly way is the thrust area of today's research. Randomly distributed fiber reinforced soils have recently attracted increasing attention in geotechnical engineering. These soils are prevalent as large tracts in many parts of the world. Many highway agencies, private organizations and researchers are doing extensive studies on waste materials and research projects concerning the feasibility and environmental suitability. It is necessary to utilize the waste affectively with technical development in each field. Attempts are made to investigate the stabilization process with laboratory model test tracks over expansive subgrade. Compaction, Shear and CBR tests were carried out in gravel/flyash materials with different reinforcement materials like waste plastics and waste tyre rubber with a view to obtain optimum percentage of reinforcement materials.**

***Index Terms*— Expansive Soil, Flyash, Waste Plastics, Waste Tyre Rubber, CBR, Load Tests.**

I. INTRODUCTION

Civil and environmental engineering includes the analysis, design, construction and maintenance of structures and systems. All are built on, in, or with soil or rock. The properties and behavior of these materials have major influences on the success, economy, and safety of the work. Geoengineers play a vital role in these projects and are also concerned with virtually all aspects of environmental control, including waste disposal. Soils which exhibit a peculiar alternate swell –shrink behavior due to moisture fluctuation are known as expansive soils. These soils are generally found in poorly drained localities where there are marked wet and dry seasons. The clay minerals are formed through extensive physical and chemical weathering of parent material. Indian black cotton soils are formed by weathering of basalt and traps of Deccan plateau and the thickness of the layer is varying from 0.5m to more than 10m.

DTA and X-ray diffraction pattern analysis (Roy and Char, 1969; Lunkad, 1977; Katti, 1979; Panigrahi *et al*., 1994) have shown that montmorillonite is the predominant clay mineral in the black cotton soil. The high percentage of clay content with predominant montmorillonite mineral is responsible for high volumetric changes during wetting and drying. These volumetric changes causes huge damage to all civil engineering structures and pavements resting on them .The amount of wastes has increased year by year and the disposal becomes a serious problem. Particularly, recycling ratio of the plastic wastes in life and industry is low and many of them have been reclaimed for the reason of unsuitable ones for incineration. It is necessary to utilize the wastes effectively with technical development in each field. Reinforced soil construction is an efficient and reliable technique for improving the strength and stability of soils. The technique is used in a variety of applications, ranging from retaining structures and embankments to subgrade stabilization beneath footings and pavements. Venkata Koteswara Rao et al., (2012) made an attempt to compare the quantity of the earth required for the subgrade with and without flyash and polypropylene fibers stabilization and for 1.5% of fiber and 15 % of flyash the thickness of the pavement is decreased by 60% and the 8610 m^3 of soil can be saved for one kilometer length of the road. By addition of the flyash and fiber to the expansive soils the CBR value is increased which can reduce the pavement thickness. Prasad et al.,(2013),has conducted Cyclic plate load tests in the laboratory at OMC to study the relative performance between the reinforced and unreinforced subbases of model pavement system and the results were found that, flexible pavement reinforced with waste plastics and waste tyre rubber has shown better performance as compared to unreinforced subbase, at all deformation levels, flexible pavement system laid on sand subgrade has shown better performance when compared to expansive soil subgrade. Mercy Joseph et al., (2013) conducted CBR and standard proctor tests in the laboratory for finding the optimum percentages of waste plastics, and quarry dust in soil sample. Based on the results as the % of plastic waste increases the maximum dry density decreases, thereby decreasing the CBR value and increase in % of quarry dust increase of maximum dry density and CBR. Sushma et al.,(2014)has conducted shear and CBR tests in the laboratory , observed from the results flyash materials reinforced with different percentages of waste plastics and coconut coir, the optimum percentages were equal to 0.3 % and 0.2 % respectively. The flyash material reinforced with waste plastics has shown better performance when compared to flyash reinforced coconut coir material. Waste plastics and coconut coir reinforced flyash materials has shown maximum improvement compared to unreinforced material. Ghatge Sandeep and Rakaraddi (2014), shredded rubber from waste has been chosen as the reinforcement material and cement as binding agent which was randomly included into the soil at three different percentages of fiber content, i.e. 5% 10% and 15% by weight of soil. California bearing ratio and unconfined compression tests were conducted. The tests have clearly shown a significant improvement in the shear strength and bearing capacity parameters and low strength and high

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compressible soft clay soils were found to improve by addition of shredded rubber and cement. However the results are not conclusive with special reference to coir as a type of the reinforcement material for overcoming the problems of expansive soil. It is evident that not much work has been reported on the gravel/flyash material reinforced with tyre/plastics for its application to flexible pavements on expansive soil subgrades. This paper investigates the performance of waste materials mixed in gravel/flyash materials and to find the optimum percentage. It was observed from the laboratory direct shear and CBR test results that, gravel reinforced material showed better performance as compared to flyash reinforced with different percentages of reinforcing materials.

II. MATERIALS USED

Details of various materials used during the laboratory experimentation are reported in the following section**.**

Gravel

Gravel satisfying MORTH specification was used as subbase material in this investigation. The properties of gravel used in subbase course are gravel = 60%; sand =30%; fines =10%; liquid limit = 20%; plastic limit = 14%; plasticity index = 6%; maximum dry density = 18.9 kN/m^3 and Optimum Moisture Content = 12%.

Flyash

The flyash collected from Vijayawada thermal power station, Vijayawada is used as a subbase course in this work. The properties of flyash are MDD = 13.24 kN/m^3, OMC = 24%, W_L = 28 %, Soaked CBR = 4 %.

Waste Plastic Strips

Waste plastic strips having a size of 12 mm × 6 mm and a thickness of 0.5 mm was used in this study (Fig. 1).

Waste Tyre Rubber Chips

Waste Tyre Rubber chips passing through 4.75 mm sieve were used in this study (Fig. 2).

Fig.1 Waste Plastics

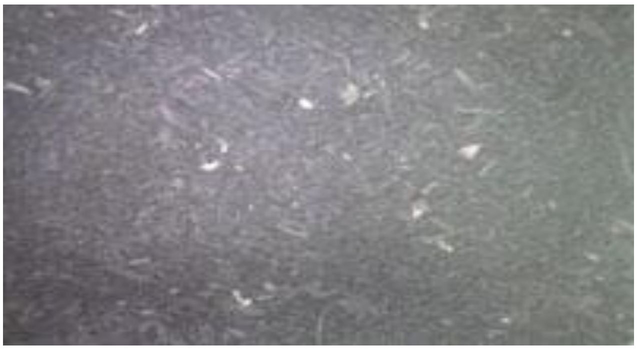

Fig.2 Waste Tyre Rubber

Road Metal

Road metal of size 20 mm conforming to WBM-III, satisfying the MORT Specifications is used as base course material.

III. LABORATORY EXPERIMENTATION

Various tests were carried out in the laboratory for finding the index and other important properties of the material used during the study. Direct shear and CBR tests were conducted by using different percentages of reinforcement materials mixed with gravel/flyash material for finding optimum percentage of waste plastics and waste tyre rubber. The details of these tests are given in the following sections.

Index Properties

Standard procedures recommended in the respective I.S. Codes of practice [IS:2720 (Part-5)-1985; IS:2720 (Part-6)-1972],were followed while finding the Index properties viz. Liquid Limit and Plastic Limit of the samples tried in this investigation.

Compaction Properties

Optimum moisture content and maximum dry density of gravel/flyash were determined according to I.S heavy compaction test (IS: 2720 (Part VIII).

Direct Shear tests

The direct shear tests were conducted in the laboratory as per IS Code (IS: 2720 (Part-13)-1986) as shown in the Fig. 3. The required percentages of waste plastics + waste tyre rubber were mixed in gravel / flyash by dry unit weight uniformly. The water content corresponding to OMC of untreated soil was added to the soil in small increments and mixed by hand until uniform mixing of the strips was ensured. The soil was compacted to maximum dry density (MDD) of untreated soil.

California Bearing Ratio (CBR) tests

Different samples were prepared in the similar lines for CBR test using gravel/flyash materials reinforced with waste plastics + waste tyre rubber. The CBR tests were conducted in the laboratory for all the samples as per I.S.Code (IS: 2720 (Part-16)-1979) as shown in the Fig. 4.

Fig: 3 Direct Shear Test Apparatus

IV. TEST RESULTS

I.S heavy compaction, direct shear and CBR tests were conducted as per (IS: 2720 (Part VIII); IS: 2720 (part XIII, 1986); IS: 2720 (Part-16)-1979) respectively in the laboratory for gravel/flyash materials with and without reinforcement material (waste plastics + waste tyre rubber) with a view to find the optimum percentage and the results are furnished below.

Compaction: All the Samples are tested by using for grave/flyash material mixed with varying percentages of reinforcing material .Graphs drawn between water content and dry density for each percentage, from these results Optimum Moisture Content and Maximum Dry Density values are arrived. The MDD increases from 18.12 to 19.52 kN/m^3 for gravel and 13.76 to 15.08 kN/m^3 for flyash material at (0.2% WP+2.0% WTR) and (0.3% WP+3.0% WTR) respectively presented below form the figs 8&9.OMC increases from 13.9% to 16.44 % and 13.57% to 16.87% for gravel and flyash material respectively at (0.2% WP+2.0% WTR) and (0.3% WP+3.0% WTR) shown in the figs. 8&9. Further addition of reinforcing material the maximum dry density decreases.

Direct Shear: The Specimens are tested by using direct shear testing machine for gravel and flyash materials mixed with varying percentages of (waste tyre rubber chips + waste plastics strips). Graphs drawn between normal stress and shear stress for each percentage, from these shear strength parameters such as Angle of internal friction and cohesion values are calculated.Based on the above results, it is observed that, for gravel reinforced with waste plastic strips and waste tyre rubber chips, the angle of internal friction values are decreased from 38^0 to 36^0 and cohesion values are increased from 0.6 to 1.6 kN/m^2 with (0.2% WP + 2.0% WTR). Similarly for flyash materials cohesion values are increased from 1 to 3.2 kN/m^2 and angle of internal friction value increases from 26.33^0 to 29.3^0 with (0.3% WP + 3.0% WTR) respectively and further addition of waste plastics strips and waste tyre rubber does not effect the angle of internal friction and cohesion, as shown in figs. 10 and 11.

California Bearing Ratio (CBR): It is observed from the results, that for gravel reinforced with (waste plastics strips + waste tyre rubber chips), soaked CBR values are increased from 6.13 to 8.25 with (0.2% of WP + 2.0% of WTR).For flyash material soaked CBR values are increased from 4.13 to 7.82 for (0.3% of WP + 3.0% of WTR) and further addition of (WP+WTR) does not affect the CBR value. From the laboratory test results of compaction, direct shear and California Bearing Ratio tests, the optimum percentage for gravel material is (0.2% of WP + 2.0% of WTR), for flyash is (0.3% of WP + 3.0% of WTR) respectively as shown in the fig. 12.

Fig: 4 California Bearing Ratio Test Apparatus

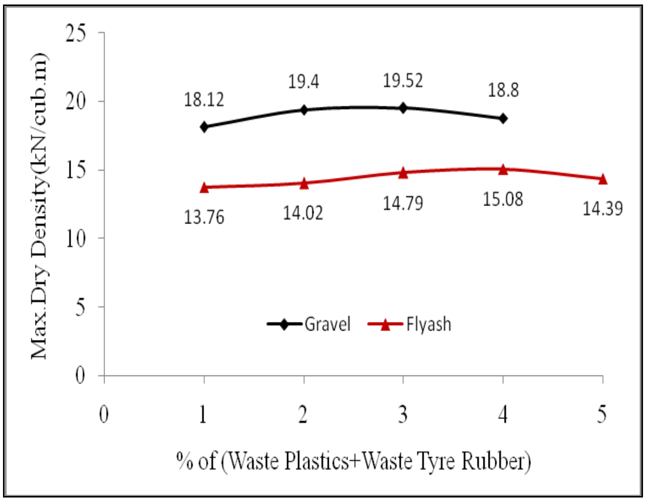

Fig: 8 Variation of Maximum Dry Density (MDD) for Gravel /Flyash Reinforced with Different Percentages of (WP+WTR)

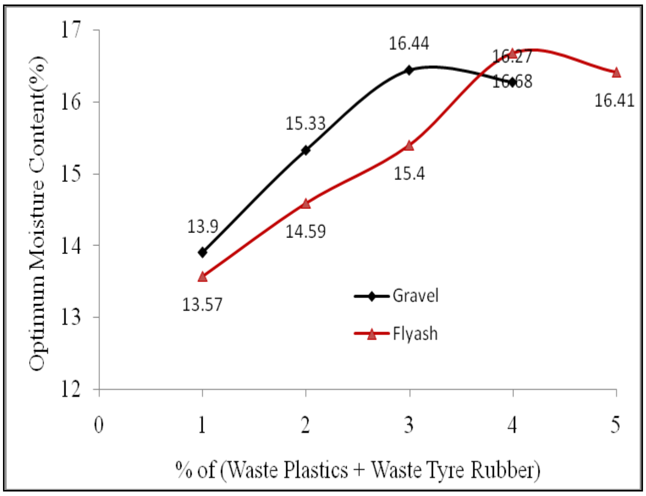

Fig: 9 Variation of Optimum Moisture Content (OMC) for Gravel/Flyash Reinforced with Different Percentages of (WP+WTR)

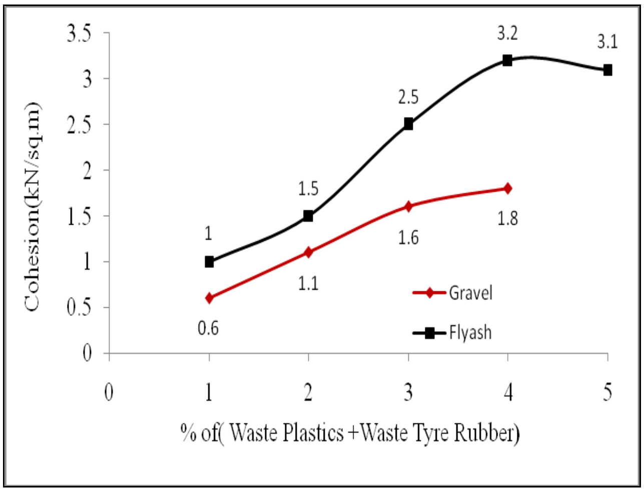

Fig: 10 Variation of Cohesion values for Gravel/Flyash Material Reinforced with Different Percentages of (WP+WTR)

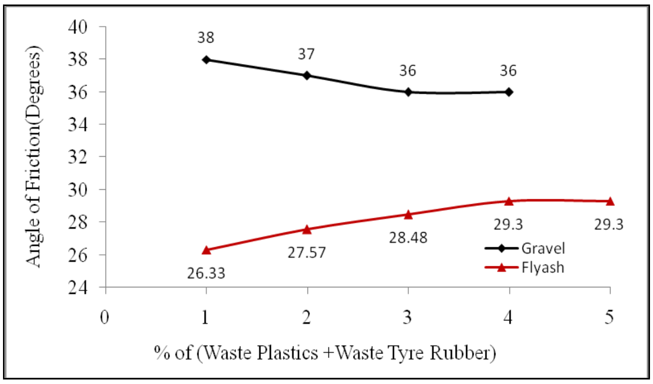

Fig: 11 Variation of Angle of Internal Friction values for Gravel/Flyash Reinforced with Different Percentages of (WP+WTR)

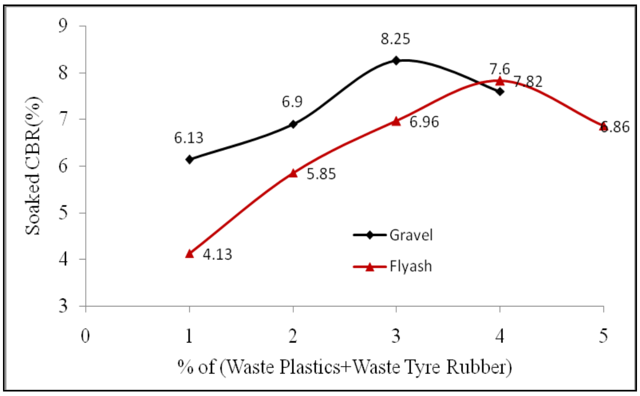

Fig: 12 Variation of Soaked CBR values for Gravel/Flyash Reinforced with Different Percentages of (WP+WTR)

V. CONCLUSION

CBR and direct shear tests were carried out for finding the optimum percentages of waste plastics and waste tyre rubber in gravel subbase material. Based on these results, laboratory model pavement studies were conducted with optimum percentage of waste plastics and waste tyre rubber in gravel subbase, laid on expansive soil subgrade in the flexible pavement system. Based on the laboratory studies carried out in this work, the conclusions that can be drawn here.

1. Addition of (waste plastics + waste tyre rubber) inclusions in gravel and flyash results in an appreciable increase in the shear characteristics and CBR value.

2. From the result of direct shear and CBR tests, gravel and flyash reinforced with different percentage of (waste plastics + waste tyre rubber), for gravel the optimum percentage of waste plastic strips and waste tyre rubber is equal to (0.2+2.0) % of dry unit weight of soil, Similarly for flyash it is equal to (0.3+3.0) % of dry unit weight of soil. The addition of (waste plastics + waste tyre rubber), beyond (0.2+2.0) % does not improve the strength characteristic values for gravel and similarly for flyash beyond (0.3+3.0) % does not improve the strength characteristic values appreciably.

3. The gravel material reinforced with (waste plastics + waste tyre rubber) has shown better performance when compared to flyash reinforced material.

4. The optimum percentage for gravel is (0.2% WP + 2.0% WTR), for flyash is (0.3% WP + 3.0% WTR).

Based on the findings, waste plastic and waste tyre rubber to be used as alternative reinforcement materials in place of conventionally used reinforcing materials. Further research is recommended to extend the study to field and the cost economics of the use of waste materials in rural roads.

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