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PERFORMANCE OF WASTE TYRE RUBBER ON MODEL FLEXIBLE PAVEMENT

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ABSTRACT

This paper investigates the performance of flexible pavement on expansive soil subgrade using gravel/flyash as subbase course with waste tyre rubber as a reinforcing material. It was observed that from the laboratory test results of direct shear and CBR, the gravel subbase shows better performance as compared to flyash subbase with different percentages of waste tyre rubber as reinforcing material. Cyclic load tests are also carried out in the laboratory by placing a circular metal plate on the model flexible pavements. It was observed that the maximum load carrying capacity associated with less value of rebound deflection is obtained for gravel reinforced subbase compared to flyash reinforced subbase.

Keywords: waste tyre rubber, flyash, expansive soil, gravel, cyclic tests.

1. INTRODUCTION

Reinforced earth technique has been gaining popularity in the field of civil engineering due to its highly versatile and flexible nature. In the recent years, this technique has been suggested for a variety of geotechnical applications ranging from retaining structures and earth embankments, foundation beds for heavy structures on soft grounds, viaduct bridges and other applications (Henry Vidal, 1968; Hausmannn, 1990; Rao, 1996). Reinforcement of soil with synthetic fibers is potentially an effective technique for increasing soil strength. Scrap tyres are a high-profile waste material for which several beneficial uses have been proposed and put into practice (Ahmed, 1993). The use of tyre shreds or mixer of tyre shreds and sand (i.e. rubber-sand) as light weight fills (Bernal *et al*; 1997) could significantly minimize the waste tyre disposal problem that currently exists. Shredded waste tyres have many beneficial engineering properties as a light weight fill material and when it is used in road base or subbase, shredded tyre will improve drainage below the pavement and therefore should extend the life of the road way (Dresher et al; 1991). Shredded tyres also posses vibration and damping properties, a benefit in situations where vibratory compaction is hazardous to the surroundings and it is easily compacted and consolidated (Geisler *et al.*; 1991). The use of waste tyre shreds as back fill material to increase the permeability which resists under compaction and high gravity loads in a soil mass that could result in a decrease of directional strength (Heimdahl,1999). In the present work an attempt is made to use reinforcement material like waste tyre rubber in gravel and flyash subbases in model flexible pavement system laid on expansive soil subgrade and study the relative performance between the reinforced and unreinforced subbase of flexible pavement system. Direct shear and CBR tests are conducted in the laboratory for both gravel and flyash materials with different percentages of waste tyre rubber strips to obtain optimum percentage of reinforcement material. The investigation is further extended by constructing model flexible pavements in laboratory with different subbases reinforced with optimum percentage of waste tyre rubber and cyclic plate load tests are conducted on the pavement system at saturated state.

2. MATERIALS AND METHODS

2.1 Materials used

The following materials were used in this study:

Soil

Expansive soil collected from Godilanka near Amalapuram is used for this investigation as a subgrade material. The soil properties are W_L = 66%, W_P = 32%, W_S =12%, I.S. Classification = CH (Clay of high compressibility), OMC=23%, MDD = 15.69 kN/m^3, Differential Free Swell = 150 %, Soaked CBR = 2 %.

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 %.

Gravel

This soil collected from Dwarapudi, near Rajahmundry is used as subbase course. The soil properties are W_L = 38%, W_p = 19%, OMC = 12%, MDD = 18.5kN/m^3, Soaked CBR = 8.

Road metal

Road metal, which satisfies MOST specifications, is used for the base course. The size of aggregate 20 mm.

Waste tyre rubber

Waste tyre rubber chips passing through 4.75 mm sieve were used in this study, as an alternative reinforcement material (Figure-1).

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Figure-1. Waste tyre rubber chips.

2.2 Laboratory experimentation

Direct shear tests

The direct shear tests were conducted in the laboratory as per IS Code (IS: 2720 (Part-13)-1986). The required percentage of waste tyre rubber by dry unit weight of soil was mixed uniformly with the soil. 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 and flyash materials reinforced with waste tyre rubber strips. The CBR tests were conducted in the laboratory for all the samples as per I.S.Code (IS: 2720 (Part-16)-1979).

Preparation of model flexible pavement

The model flexible pavements are prepared in a circular steel tank of 60 cm diameter with a depth of 30 cm (Figure-2). Out of which 20 cm depth is for lying subgrade, 5 cm is for subbase and 5 cm for base course. In the circular tank the pulverized expansive soil mixed with water at OMC is laid in 10 layers such that each layer of 2 cm compacted thickness amount to a total thickness of 20 cm subgrade. On the prepared subgrade gravel / flyash subbase, mixed with optimum percentage of waste tyre rubber, of compacted thickness 5 cm is laid in 2 layers by compact to OMC and MDD. On the prepared subbase 2 layers of WBM - III each of 2.5 cm compacted thickness is laid to a total thickness of 5 cm. A sand bed of 2cm thick is placed before placement of subgrade soil in the tank and sand drains were provided by means of 3 vertical sand columns of 4 cm diameter from bottom to top of the subgrade soil for saturation.

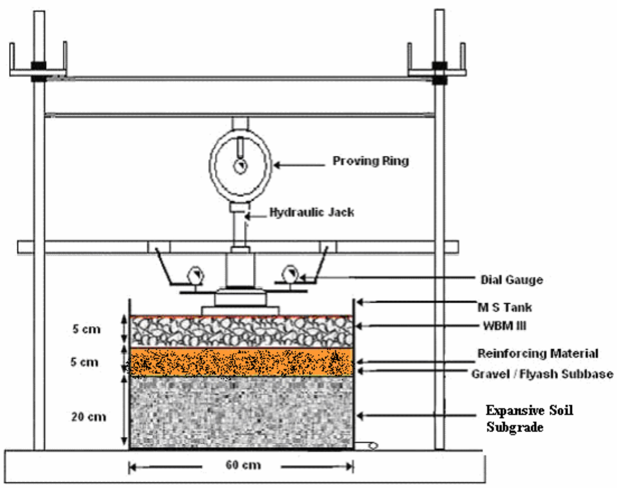

Figure-2.

Details of model flexible pavements

In this investigation four model flexible pavements were prepared in laboratory with different alternatives as given in Table-1. Expansive soil is used as a subgrade soil for all the tests. For all the four alternative stretches, WBM-III is used as base course was laid uniformly.

Table-1. Details of model flexible pavements.

S. No.	Subgrade	Subbase	Base course
1.	Expansive soil	Gravel	WBM III
2.	Expansive soil	Gravel + Waste tyre rubber strips	WBM III
3.	Expansive soil	Flyash	WBM III
4	Expansive soil	Flyash + Waste tyre rubber strips	WBM III

Cyclic load testing

Cyclic Plate load tests were carried out at complete saturated condition on the model flexible pavement system in a circular steel tank of diameter 60 cm as shown in Figure-2. The soil was allowed to absorb water by providing a thin sand layer (10 mm thick) at the bottom and also through vertical sand drains. Two inlet valves are welded on opposite sides of the tank through which water was supplied. The loading was done through a circular metal plate of 10 cm diameter laid on flexible pavement system. The steel tank was placed on the pedestal of the compression testing machine. A five ton capacity proving ring was connected to the loading frame and the extension rod welded to the circular plate was brought in contact with proving ring. Two dial gauges of least count 0.01 mm were placed on the metal flats welded to the vertical rod to measure the vertical displacements of the loading plate. The load is applied in increments corresponding to tyre pressures of 500, 560, 630, 700 and 1000 kPa and each pressure increment was applied cyclically until there was insignificant increase in the settlement of the plate between successive cycles. The testing was further continued till the occurrences of failure to record the ultimate loads.

Heave measurements

The model flexible pavement system was saturated completely by pouring water above the base course. Heave readings were taken with the help of dial gauges at regular intervals for the expansive soil subgrade pavements. These readings were measured until there was no significant change between consecutive readings observed.

3. TEST RESULTS

3.1 Laboratory test results

Direct shear tests and CBR tests are conducted by using different percentages of waste tyre rubber mixed with gravel and flyash materials for finding the optimum percentage of waste tyre rubber. Cyclic load tests are conducted for gravel and flyash subbases, reinforced with optimum percentage of waste tyre rubber.

Direct shear test results

It is observed from the Figures 3 and 4 that cohesion and angle of internal friction values for gravel materials are increased from 11.77 to 26.48 kN/m^2 and 36^0 to 43^0, respectively with 5.0 % of waste tyre rubber chips and thereafter decreased. For flyash the cohesion and angle of internal friction values are increased from 7.85 to 18.64 kN/m^2 and 33^0 to 39^0, respectively with 6.0% of waste tyre rubber chips and thereafter decreases. From the test results, the optimum percentage of waste tyre rubber for gravel and flyash are equal to 5 % and 6%, respectively. Test results showed that gravel material reinforced with waste tyre rubber has shown better performance when compared to flyash reinforced material.

California bearing ratio (CBR) test results

From the Figure-4, the soaked CBR values are increased from 8.0 to 13.32 and 4.0 to 8.73 for 5.0 % and 6.0 % of waste tyre rubber, respectively for gravel and flyash subbase materials and hence the optimum percentage of waste tyre rubber for gravel and flyash are equal to 5% and 6%, respectively.

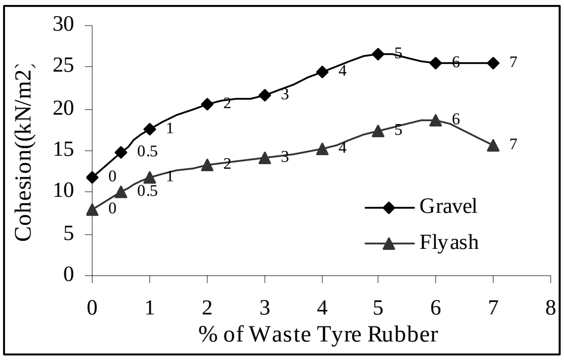

Figure-3. Variation of cohesion values for gravel and flyash materials reinforced with different percentages of waste tyre rubber chips.

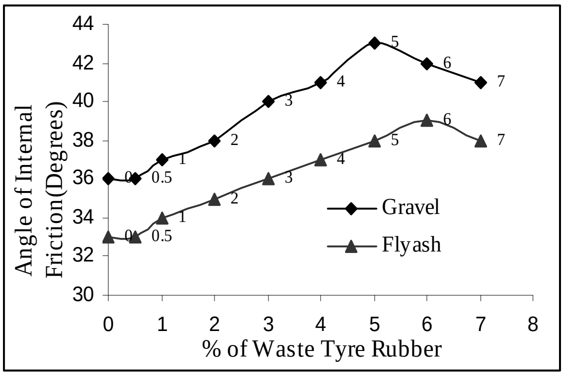

Figure-4. Variation of angle of internal friction values for gravel and flyash materials reinforced with different percentages of waste tyre rubber chips.

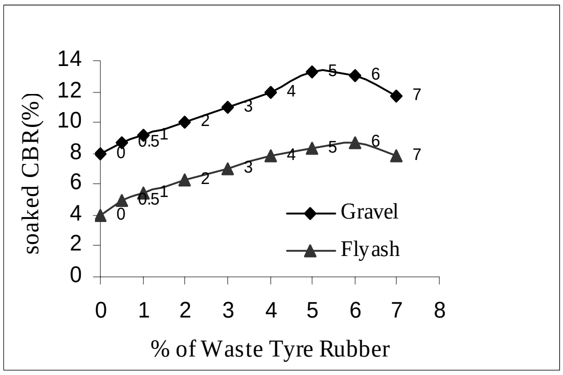

Figure-5. Variation of soaked CBR values for gravel and flyash materials reinforced with different percentages of waste tyre rubber chips.

Cyclic load test results

Pressure-deformation behaviour on gravel/flyash subbases reinforced with waste tyre rubber

From the test results as shown in Figures 6 and 7 it is observed that load carrying capacity has substantially increased for waste tyre rubber reinforced model flexible pavement. At all the deformation levels gravel reinforced subbase shows better performance as compared to flyash reinforced subbase.

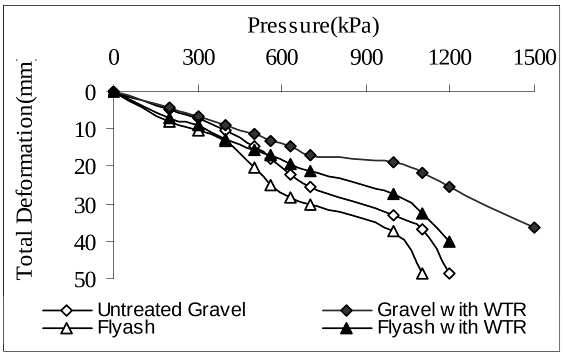

Figure-6. Pressures-total deformation values for gravel /flyash subbase of flexible pavement system laid on expansive soil subgrade.

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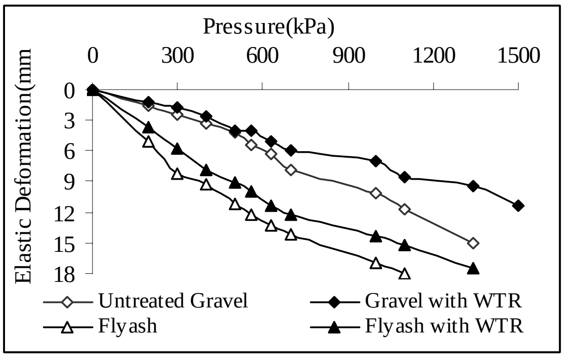

Figure-7. Pressures-elastic deformation values for gravel /flyash subbase of flexible pavement system laid on expansive soil subgrade.

3.2 Heave studies

The in-situ heave-time plots, as shown in fig.8 for model flexible pavements with gravel/flyash subbases mixed with optimum percentage of waste tyre rubber are presented. It is observed from the figure that there is no significant control of heave for gravel/flyash subbases reinforced with waste tyre rubber. This behaviour is evident from the fact that there is no heave control mechanism with the reinforcement in the pavement system. In fact, it is intended to incorporate reinforcement in the flexible pavement system to strengthen it with little emphasis on heave control.

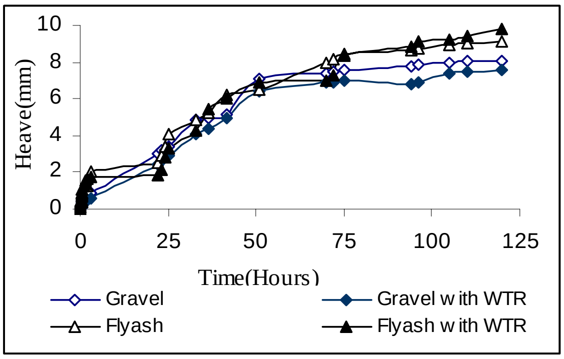

Figure-8. Heave-time plot for model flexible pavements laid on expansive soil subgrade with gravel/flyash subbase.

3.3 Comparison between gravel and flyash subbases reinforced with waste tyre rubber

From the above studies gravel reinforced model pavement has shown better performance compared to the flyash reinforced model pavement. The improvement in the load carrying capacity could be attributed to improved load dispersion through reinforced subbase on to the subgrade. This in-turn, results in lesser intensity of stresses getting transfer to subgrade, this loading to lesser sub grade stress. Further, it is also observed that heave of the expansive soil subgrade considerably decreases the load carrying capacity of the stretch.

4. CONCLUSIONS

From the result of direct shear tests and CBR tests for gravel and flyash materials reinforced with different percentage of waste tyre rubber, the optimum percentages of waste tyre rubber are equal to 5% and 6% of dry unit weight of soil, respectively.

The load carrying capacity of the laboratory model flexible pavement system has significantly increased for both gravel and flyash subbases reinforced with optimum percentage waste tyre rubber laid on expansive soil subgrade.

No significant control of heave is observed for the laboratory model flexible pavements for both the gravel and flyash reinforced with waste tyre rubber tried in this investigation, laid on expansive soil subgrade.

At all the deformation levels, gravel reinforced with waste tyre rubber in model flexible pavement has shown better performance, compared to flyash subbase reinforced with waste tyre rubber.

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