International Journal For Technological Research In Engineering
Volume 5, Issue 8, April-2018 ISSN (Online): 2347 - 4718

STUDY ON WASTE MATERIALS UTILISATION IN THE CONSTRUCTION OF ROADS IN RURAL AREAS

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Abstract: Research into new and innovative uses of waste material is continually advancing. Many highway agencies, private organization and individuals are in the process of a wide variety of studies and research projects concerning the feasibility, environmental suitability and performance of using recycled products in highway construction. 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 very 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. Expansive soils are so widely spread that it becomes impossible to avoid them for highway construction to keep the network structure for mobility and accessibility. However the roads constructed on expansive soils suffer extensive damage and distress resulting large economic loses running to billion of dollars. As thermal power plants are spatially distributed all over the country, utilization of flyash from these plants for the road construction, not only helps to consume bulk quantities of flyash solving its disposal problem to a certain extent but also to satisfy the construction requirements. Reinforcement of soils with synthetic fibers is potentially an effective Technique for increasing soil strength. In recent years, this technique has been suggested for a variety of geotechnical applications ranging from retaining structure and earth embankments to subgrade stabilization beneath footings and pavements. Research of different type of reinforcement and materials has been conducted by several investigators. However, the amount of information available on randomly oriented fiber reinforcement is still limited. Here an attempt is made to the suitability of different types of waste plastics strips and waste tyre rubber chips reinforcing with gravel and flyash in flexible pavement system on expansive soil subgrade. Commonly Gravel is considered to be suitable for road construction (MOST- 1998).

However in the latest MORTH specifications, several types of gravel are found to be unsuitable for road construction in view of higher finer fraction and excessive plasticity properties. As thermal power plants are spatially distributed all over the country, utilization of flyash from these plants for the road construction, not only helps to consume bulk quantities of flyash solving its disposal problems to certain extent but also to satisfy the construction requirements. By using these (i.e poor Gravel and flyash) waste materials effectively with reinforcing another waste material is good idea for better cost effectiveness and proper utilization. In the present work, an attempt is made to use waste tyre rubber chips andwaste plastic strips as reinforcing materials, mixing with gravel/flyash subbases in flexible pavement system and compare their performance with conventional subbase on expansive soil subgrade. The direct shear and California Bearing Ratio (CBR) tests are conducted in the laboratory for gravel/flyash subbase reinforced and unreinforced with waste plastics and waste tyre rubber chips. Based on direct shear and CBR test results, the optimum percentage of waste plastic strips and waste tyre rubber are found out. The investigation is further carried out by constructing laboratory model flexible pavements for gravel/flyash subbase unreinforced and reinforcing with optimum percentage of waste plastics strips and waste tyre rubber chips. Cyclic plate load tests and heave measurements are carried out on the pavement system at unsaturation state to find out load bearing capacity.

Key words: Dry Density, Shear Strength, C.B.R values.

I. INTRODUCTION

The amount of wastes has increased year by year and the disposal becomes a serious problem. The creation of non decaying waste materials, combined with a growing consumer population, has resulted in a waste disposal crisis. One solution to this crisis lies in recycling waste into useful products. Research into new and innovative uses of waste materials is continually advancing. Many highway agencies. Private organizations, and individuals have completed or are in the process of completing a wide variety of studies and research projects concerning the feasibility, environmental suitability and performance of using recycled products in highway construction. Most developed and developing countries all over the world have huge resources of waste materials such as fly ash, stone dust, and waste plastic. The quantities of wastes that are accumulating in developed and developing countries are causing disposal problems that are both financially and environmentally expensive.

One method to reduce some portion of the waste disposal problem is by utilizing these waste materials for engineering purpose. In recent years, researchers from many fields have attempted to solve the problems posed by industrial wastes. Finding a way for the utilization of these wastes would be an advantageous way of getting free of them. Flyash being the most common pozzolanic material encountered in construction is a by-product of coal burning power plants.

The flyash is disposed of either by sluicing to ponds or hauling to solid waste disposal areas. Disposal operations are quite expensive and require the use of land that could be used for other purposes. Recent projects illustrated that successful waste utilization could result in considerable savings in construction costs. This necessitates effective utilization of this accumulated flyash is being felt by the engineers and scientists.

Conventilnally gravel has been used for construction of all categories of roads in out country. In highway engineering field gravel successfully used for subbase and base courses and construction of embankments. Although gravel is a good construction material, due to scarcity of good quality of gravel, they increase the construction cost at some parts of the country. By modifying the physical properties of this poor gravel by reinforcing with other low cost materials like waste type rubber and waste plastic strips necessitates effective utilization of both the material. This present work deals with effective utilization of gravel and flyash materials reinforcing with waste tyre rubber chips and waste plastic strips.

II. MATERIALS AND THEIR PROPERTIES

FLYASH

Coal based thermal plants produce flyash as waste by product. The flyash is a finely divided residue that resulted from the combustion of ground or powdered coal. The ash from power station consists of both finer and coarser fraction. The fine-ash which flies up to chimney is called flyash (Singh and Murty, 1998; Suryanarayana, 2000) and is removed from flue gases by mechanical or electrostatic precipitators, which is then collected in hoppers. This fine ash accounts for 75-85% of the ash formed from burnt coal. The course fraction of the ash falls to the bottom of the furnace, which is called bottom ash. The fine ash which is also known as dry ash can be sold to users in cement, road and other construction industries (Murty, 1998; Guruvittal and Murty 1998). If it is not possible to dispose off the ash by sale or otherwise, the ash is mixed with a measured amount of water pumped into lagoons from where it can be later reclaimed.

PROPERTIES OF FLYASH

Three major ingredients in flyash are Silicon, Aluminum and Iron. Flyash to be used as a filling material should not have soluble sulphate content exceeding 1.90gm per liter. Otherwise it should not be deposited within 50cm from concrete or metallic surfaces due to its corroding effects. Depending upon type of coal, its degree of pulverization and combustion techniques, their collection and disposal systems, etc., the properties of flyash vary. However, typical properties of flyash are given below.

Table 2.1.Physical and Chemical Properties of Flyash

S.No	Description	Observed Values
1	Specific Gravity	1.90 – 2.50
2	Plasticity	N.P*
3	Maximum dry density	0.95 – 1.60 gm/cm^3
4	Optimum moisture content (OMC)	19% - 38%
5	Permeability	8x10^{-6} to 7x10^{-4} cm/sec
6	Uniformity	3.0 – 10.5
7	Compression index (Cu)	0.05 – 0.40
8	Cohesion (C)	Negligible
9	Angle of shearing resi□ance ( )	30 – 40
10	Coefficient of consolidation	1.75x10^{-5} to 2.00x10^{-3} m^2/sec
11	Silica (SiO_2)	46.50 (%)
12	Alumina (Al_2O_3)	24.20 (%)
13	Iron (Fe_2O_3)	10.00 (%)
14	Calcium (CaO)	13.00 (%)
15	Magnesium (MgO)	4.00 (%)
16	Sulpher Content (SO_3)	Traces
17	Carbon	1.10 (%)

Table: 2.2 Properties of Indian Flyash Compared to Different Types of Soil

PROPERTY	GRAVEL	SAND	SILT	CLAY	FLYASH
Specific Gravity	2.65 – 2.67	2.65 – 2.67	2.67 – 2.70	2.70 – 2.80	1.90 – 2.55
Plasticity Index	NP	NP	1% - 17%	➤ 17%	NP
Maximum Dry Density (gm/cc)	1.76 – 2.27	1.76 – 1.84	1.52 – 2.08	1.44 – 1.84	0.9 – 1.60
Optimum Moisture Content(%)	7 – 18	9 – 15	10 – 20	15 – 30	18 – 38
Cohesion (kN/m^2)	0	0	6	>6	Negligible
Angle of Internal Friction (□) (Degree)	35-50	27.5 – 45	27 – 35	0 – 6	30 – 40
Coefficient of Consolidation Cv (cm^2/sec)	-	-	5 x 10^{-5}	0.001-2x10^{-4}	1.75x10^{-5} – 2.01x10^{-3}
Compression Index (Cc)	-	0.01 – 0.05	0.05 – 0.15	0.21 – 2.6	0.05 – 0.4
Permeability (cm/sec)	1	10-1 – 10^{-3}	10-5 – 10^{-7}	10-7 & less	8x10^{-6} – 7x10^{-4}
Coefficient of Uniformity	>4	>6	-	-	3.1 – 10.7

Table 2.3 Chemical Composition of Various Indian Flyash

S.No		A	B	C	D	E	F	G	H
1	LOI	0.94	0.33	0.63	0.32	0.58	1.31	0.115	-
2	SiO_2	55.50	63.40	60.10	59.97	64.31	63.04	65.20	64.76
3	Fe_2O_3	4.40	4.52	5.80	5.75	4.45	5.12	7.73	4.09
4	Al_2O_3	36.40	29.79	26.50	27.96	25.60	28.40	23.45	25.64
5	CaO	1.20	0.55	4.80	0.85	1.03	0.50	0.47	0.16
6	MgO	0.50	0.50	1.20	1.0	0.97	0.46	0.46	0.60
7	SO_3	-	-	0.35	-	-	-	0.08	0.07
8	Na	0.30	0.38	0.22	0.15	0.60	0.23	-	-
9	K	0.80	0.85	0.75	0.70	0.02	1.13	-	-

A - Singrauli Super Thermal Power Station
B - Kobra Super Thermal Power Station
C - Ramagudam Super Thermal Power Station
D - Forakka Super Thermal Power Station
E – Vindhyachal Super Thermal Power Station
F – Badarpur Super Thermal Power Station
G – Rihand Super Thermal Power Station
H – Balco Captive Power Project

WASTE PLASTIC STRIPS

Plastic products have become an integral part in our daily life as a basis need. It produced on a massive scale worldwide and its production crosses the 150 million tonnes per year globally. In India approximately 8 million tonnes plastic products are consumed every year which is expected to rise 16 million tonnes by 2014. Its broad range of application is in packaging films wrapping materials, shopping and garbage bags, fluid containers, clothing toys, household and industrial products, and building materials. It is a fact that plastics will never degrade and remains on landscape for several years. Further, the recycling of a virgin plastic material can be done 2-3 times only, because, after every recycling, the strength material is reduced due to thermal degradation. It is to mention that no authentic estimation is available on total generation of plastic waste in the country however, considering 70% of total plastic consumption is discarded as waste, thus approximately 5.6 million tonnes per annum of plastic waste is generated in country which is about 15342 tonnes per day. With the few reasons cited above, it is very important that we find ways to re-utilize these plastic wastes. Therefore, the investigation and attempt has been made to demonstrate the potential of reclaimed plastic wastes as soil reinforcement for improving the subbase soils. Plastic waste when mixed with soil behaves like a fiber reinforced soil. Plastic waste are distributed throughout a soil mass; they impart strength isotropy and reduce the chance of developing potential planes of weakness. Hence uses of plastic waste for improving the engineering properties of soil are taken up in the present study. Mixing of plastic waste with soil can be carried out in a concrete mixing plant of the drum mixer type(Lindh 1990) or with a self propelled rotary mixer (Santoni and Webster 2001). Plastic waste could be introduced either in specific layers or mixed randomly throughout the soil. An earth mass stabilized with discrete, randomly distributed plastic waste/fibers resembles earth reinforced with chemical compounds such as lime, cement etc. in its engineering properties.

WASTE TYRE RUBBER CHIPS

The growing interest in utilizing waste materials in civil engineering applications has opened the possibility of constructing reinforced soil structures with unconventional backfills, such as tyre shreds. Scrap tyres are a high-profile waste material for which several beneficial uses have been proposed and put into practice (Ahmed, 1993). One approach consists of shredding the tyres into small pieces that are often referred to as tyre shreds or tyre chips, depending on their size. Tyre chips have been used in a variety of application because of their unique engineering properties. The use of tyre shreds or mixtures of tyre shreds and sand (i.e rubber-sand) as lightweight fill (Bernal et al., 1997) could significantly minimize the waste tyre disposal problem that currently exists. Tyre chips will be used as a leachate collection material in municipal solid waste land fills (Ahmet H.Aydilok et al 2006). 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 (Heimdhl, 1999), Shredded tyres were proven to be a viable form of lightweight fill because they are relatively lightweight, inexpensive, and non-biodegradable. The elastic properties of shredded tyres can lead to higher than normal deflections. To begin with, compacted shredded tyre material is more porous than washed gravel. Caltrans, conducted a constant head permeability test on two types of shredded tyres and the permeability coefficients were on the order of 3,000m/day (Dresher et al, 1991). Shredded tyres also posses vibration and damping properties, a benefit in situations where vibratory compaction is hazardous to the surroundings, furthermore, shredded tyres are easily compacted and consolidated. Their angular shape and excellent friction characteristics allow the individual tyre shreds to lock together very well (Geisler et al, 1991) Laboratory testing of soil reinforced by tyre shreds has been considered to be difficult. Lee (1999) also used tyre chips which he defined as shreds that had maximum dimensions of 12mm to 50mm. He was able to obtain consistent results of strength benefits through triaxial testing.

Waste tyre pieces reinforced with soil showed improvement in CBR value with its addition up to 7.5% and there onwards decreased with further increase in tyre content in unsoaked condition. However, waste tyre pieces reinforced with soil does not show any improvement in the CBR value in soaked condition. Its failure in soaked condition may be attributed to the loosening of grip of rubber surface with the soil in submerged condition and due to the properties of the specific soil (CI). But the waste tyre pieces in this particular soil can be effectively used in sub grade to improve its CBR value in areas where the rainfall is less and the ground water table is at a great depth below.

III. TEST RESULTS

Table 3.1 Compaction Parameters for Gravel and Flyash Material Reinforced with Different Percentages of Waste Plastics and Waste Tyre Rubber

% of WP + WTR	Gravel		Flyash	
	OMC %	MDD "kN/m^3"	OMC %	MDD "kN/m^3"
0.0+0.0	14.2	18.2	13.57	13.76
0.1+1.0	15.33	19.4	14.59	14.02
0.2+2.0	16.44	19.52	15.10	14.79
0.3+3.0	16.27	18.8	15.68	15.08
0.4+4.0	-	-	16.71	14.39

Fig 3.1 Variation of optimum moisture contant (OMC) for Gravel Material Reinforced with Different Percentages of Waste Plastics Strips and Waste Tyre Rubber chips

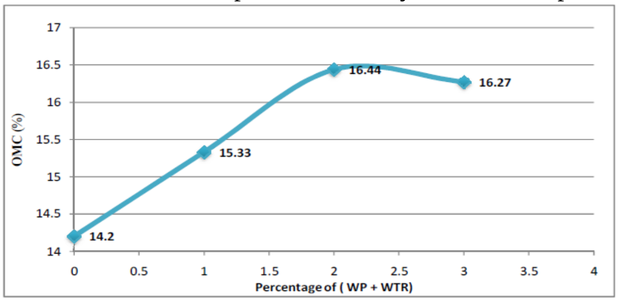


Fig: 3.2 Variation of Maximum Dry Density (MDD) for Gravel Material Reinforced with Different Percentages of Waste Plastics Strips and Waste Tyre Rubber chips.

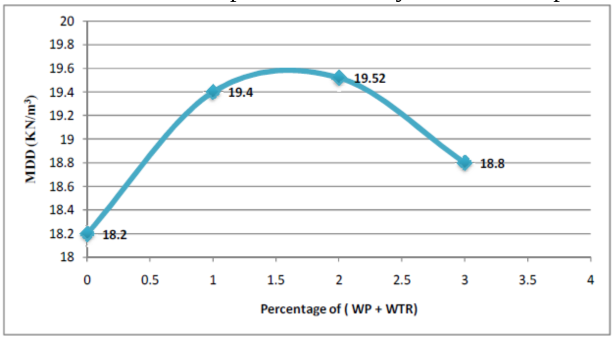


Fig 3.3 Variation of optimum moisture contant (OMC) for Flyash Material Reinforced with Different Percentages of Waste Plastics Strips and Waste Tyre Rubber chips.

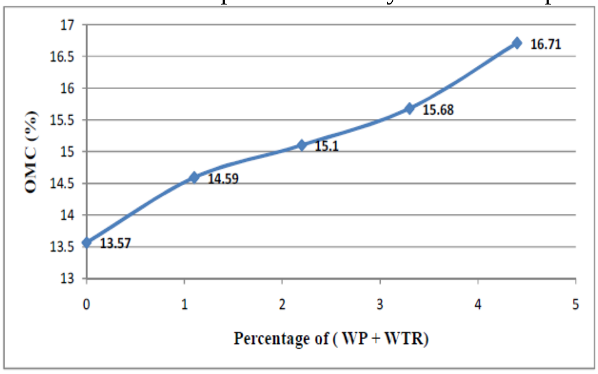
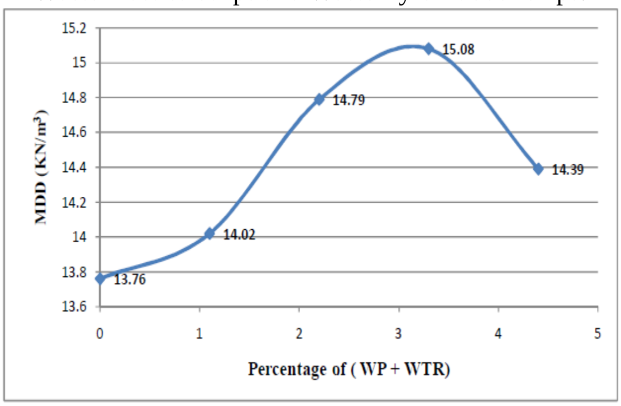


Fig: 3.4 Variation of Maximum Dry Density (MDD) for Flyash Material Reinforced with Different Percentages of Waste Plastics Strips and Waste Tyre Rubber chips.



Direct Shear Test Results :

Table 3.2 Shear Strength Parameters for Gravel and Flyash Material Reinforced with Different Percentages of Waste Plastics and Waste Tyre Rubber

% of WP+WTR	Gravel		Flyash	
	Cohesion (kN/m²)	Angle of Internal Friction (Ø⁰)	Cohesion (kN/m²)	Angle of Internal Friction (Ø⁰)
0.0+0.0	0.6	38	1	26.33
0.1+1.0	1.1	37	1.5	27.57
0.2+2.0	1.6	36	2.5	28.48
0.3+3.0	1.8	36	3.2	29.3
0.4+4.0	-	-	3.1	29.3

Fig: 3.5 Variation of Cohesion Values for Gravel Material Reinforced with Different Percentages of Waste Plastics Strips and Waste Tyre Rubber chips.

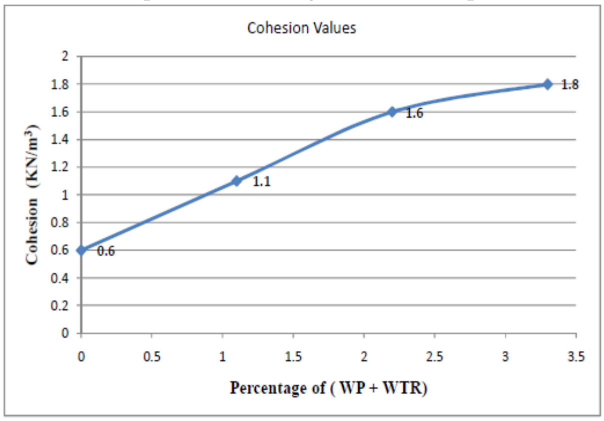


Fig: 3.6 Variation of Cohesion Values for flyash Material Reinforced with Different Percentages of Waste Plastics Strips and Waste Tyre Rubber chips.

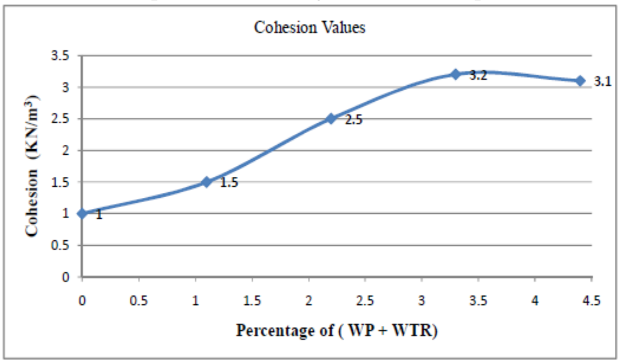


Fig: 3.7 Variation of Angle of Internal friction Values for Gravel Material Reinforced with Different Percentages of Waste Plastics Strips and Waste Tyre Rubber chips.

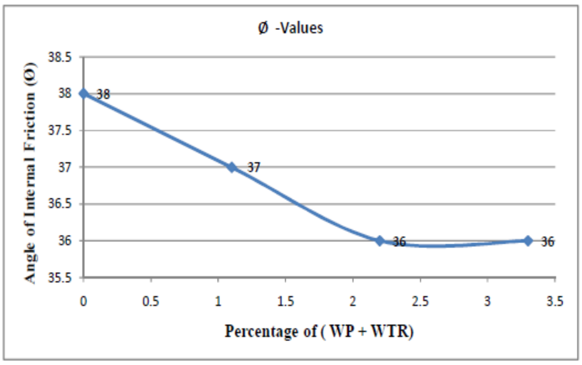
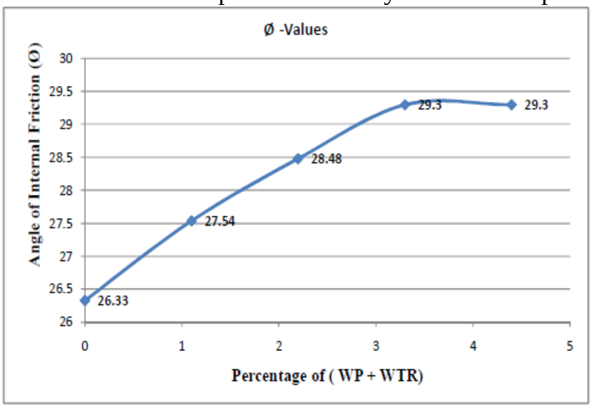


Fig: 3.8 Variation of Angle of Internal friction Values for Flyash Material Reinforced with Different Percentages of Waste Plastics Strips and Waste Tyre Rubber chips.



C.B.R Test Results :

Table 3.3 Variation of Soaked CBR values for Gravel and Flyash Materials Reinforced with Different Percentages of Waste Plastics and Waste Tyre Rubber

% of WP + WTR	Gravel	Flyash
	Soaked CBR (%)	Soaked CBR (%)
0.0+0.0	6.13	4.13
0.1+1.0	6.9	5.85
0.2+2.0	8.25	6.96
0.3+3.0	7.6	7.82
0.4+4.0	-	6.86

Fig: 3.9 Variation of Soaked CBR values for Gravel Material Reinforced with Different Percentages of waste Plastics strips and waste Tyre Rubber chips

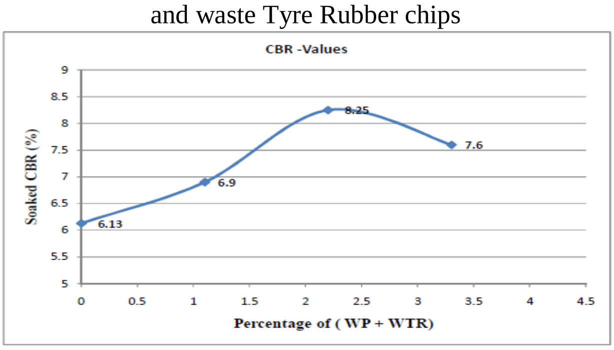


Fig: 3.10 Variation of Soaked CBR values for Flyash Material Reinforced with Different Percentages of waste Plastics strips and waste Tyre Rubber chips

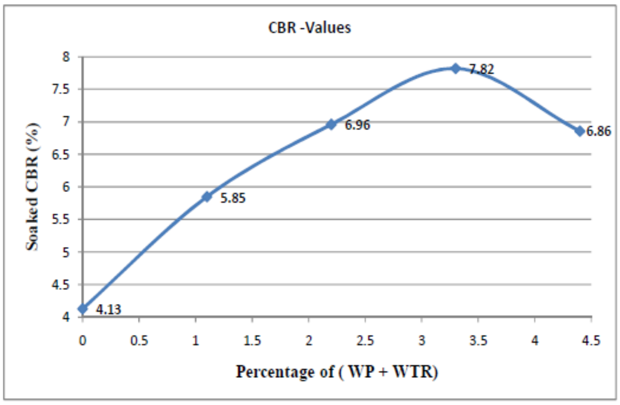


Table 3.4 Heave – Time Plot for Different Model Flexible Pavements Laid on Expansive Soil Subgrade with Gravel Subbase

Time (Hours)	Heave (mm)	
	Gravel	WTR+WP
0.000	0	0
0.017	0.04	0.03
0.050	0.05	0.04
0.084	0.0	0.055
0.117	0.06	0.0625
0.150	0.07	0.0725
0.200	0.085	0.0825
0.267	0.1	0.1025
0.400	0.24	0.16
0.467	0.255	0.1775
0.583	0.31	0.195
0.600	0.36	0.225
0.750	0. 38	02725
1.000	0.48	0.3
1.500	0.54	0.3725
2.000	0.75	0.4325
3.000	0.85	0.6
22.000	3.01	2.21
23.000	3.17	2.34
24.000	3.25	2.44
25.000	3.42	2.58
32.700	4.84	3.94
36.500	4.91	4.2
41.900	5.14	4.7
51.000	7.05	6.015
70.000	7.35	6.72
72.000	7.5	6.92
75.000	7.6	60935
94.000	7.8	6.7375
96.000	7.85	6.79
105.000	7.92	7.14
110.000	8.02	7.235
120.000	8.1	7.375

Table 3.5 Heave-Time Plot for Different Model Flexible Pavements laid on Expansive Soil Subgrade with Flyash Subbase.

Time (Hours)	Heave (mm)	
	Gravel	WTR+WP
0.000	0	0
0.017	0.05	0.1775
0.050	0.08	0.065
0.084	0.1	0.0865
0.117	0.12	0.137
0.150	0.15	0.1725
0.200	0.31	0.325
0.267	0.43	0.36
0.400	0.65	0.495
0.467	0.78	0.675
0.583	0.83	0.795
0.600	1.03	0.855
0.750	1.05	0.9
1.000	1.29	1.196
1.500	1.58	1.32
2.000	1.28	1.59
3.000	2.06	1.66
22.000	2.48	1.75
23.000	2.88	2.09
24.000	3.38	2.555
25.000	4.04	3.225
32.700	4.87	4.775
36.500	5.27	5.52
41.900	6.2	5.95
51.000	6.49	6.68
70.000	7.93	6.885
72.000	8.15	7.055
75.000	8.4	8.135
94.000	8.63	8.7
96.000	8.71	8.9
105.000	8.92	9.195
110.000	9.03	9.28
120.000	9.13	9.535

Fig: 3.11 Laboratory Heave – Time Plot for Waste Tyre Rubber Chips Reinforced Model Flexible Pavements laid on Expansive Soil Subgrade with Gravel Subbase.

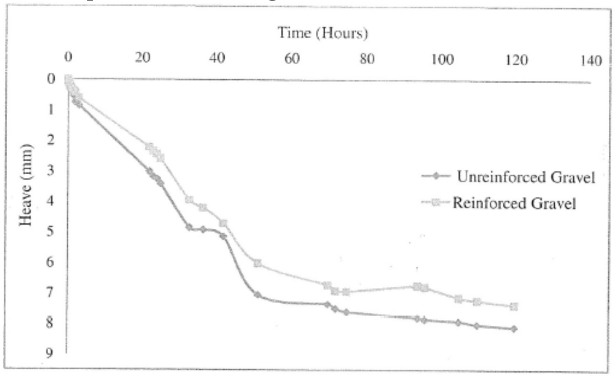


Fig: 3.12 Laboratory Heave- Time Plot for Waste Tyre Rubber Chips Reinforced Model Flexible pavements laid on expansive Soil Subgrade with Flyash Subbase.

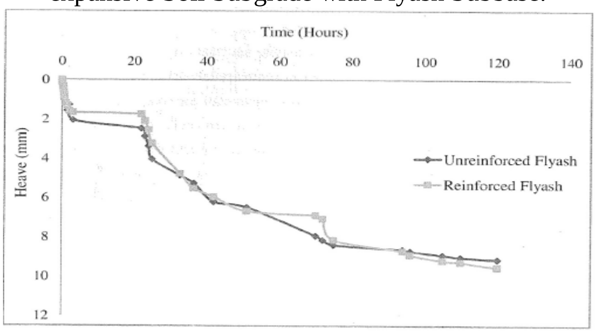


Fig: 3.13 Cyclic Curve Values for Gravel with Waste Plastics and Waste Tyre Rubber Subbase on model Flexible Pavement System Laid on Expansive Soil Subgrade at OMC.

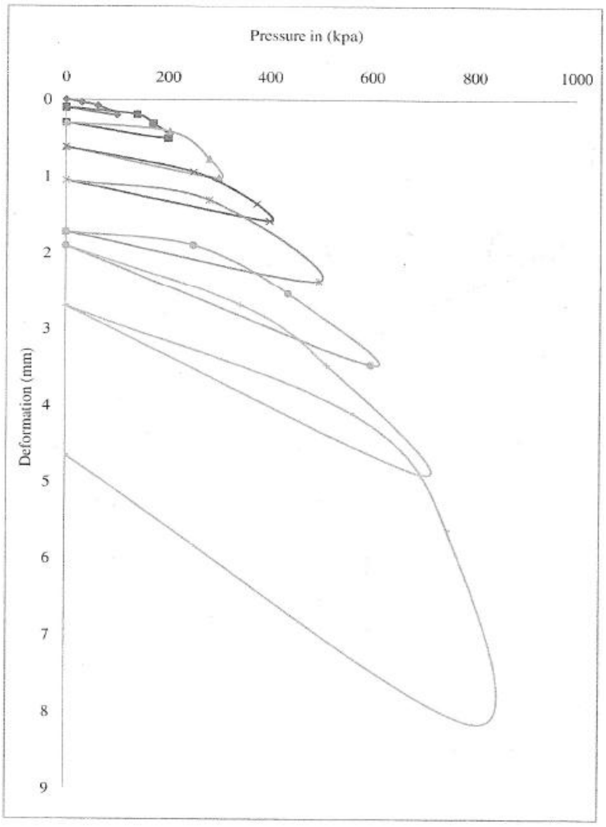


Fig: 3.14 Cyclic Curve Values for Flyash with Waste Plastics and Waste Tyre Rubber Subbase on Modal Flexible Pavement System Laid on Expansive Soil Subgrade at OMC.

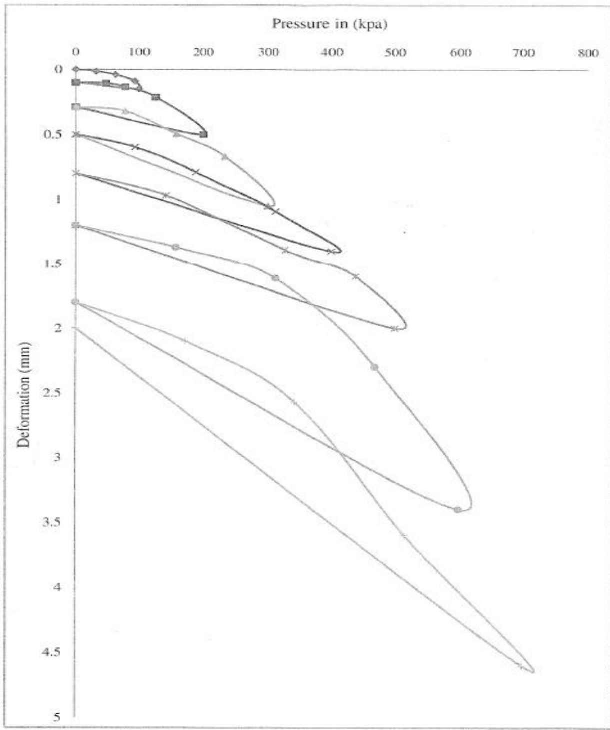


Table: 3.6 Pressure-Deformation Values for Different Reinforcement Materials in Gravel Subbase of Flexible Pavement System laid on Expansive Soil Subgrade (Tested at Unsaturated State)

Pressure (kPa)	Gravel Reinforced with WP+ WTR		Unreinforced Gravel	
	Total Deformation (mm)	Elastic Deformation (mm)	Total Deformation (mm)	Elastic Deformation (mm)
0	0	0	0	0
100	0.2	0.1	0.35	0.31
200	0.5	0.2	1	0.56
300	1.02	0.405	1.52	0.85
400	1.58	0.524	2.275	1.06
500	2.365	0.645	2.85	1.275
600	3.47	1.57	4.15	2.975
700	4.9	2.2	-	-
800	8.15	3.5	-	-

Table: 3.7 Pressure-Deformation Values for Different Reinforcement Materials in Flyash Subbase of Flexible Pavement System Laid on Expansive Soil Subgrade (Tested at Unsaturated State)

Pressure (kPa)	Gravel Reinforced with WP+ WTR		Unreinforced Gravel	
	Total Deformation (mm)	Elastic Deformation (mm)	Total Deformation (mm)	Elastic Deformation (mm)
0	0	0	0	0
100	0.515	0.34	0.87	0.65
200	1.12	0.67	1.71	0.91
300	1.64	0.91	1.98	1.28
400	2.58	1.18	3.2	1.54
500	3.01	1.34	3.7	2
600	4.8	3.57	-	-
700	6.4	4.36	-	-

Fig: 3.15 pressure – Total Deformation Curves For Waste Plastic Strips and Waste Tyre Rubber Chips Reinforced Material in Gravel Subbase of Flexible Pavement Laid on Expansive Soil Subgrade at Unsaturation.

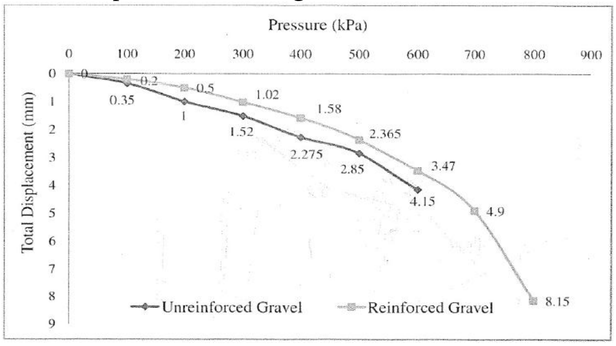


Fig: 3.16 pressure – Elastic Deformation Curves For Waste Plastic Strips and Waste Tyre Rubber Chips Reinforced Material in Gravel Subbase of Flexible Pavement Laid on Expansive Soil Subgrade at Unsaturation.

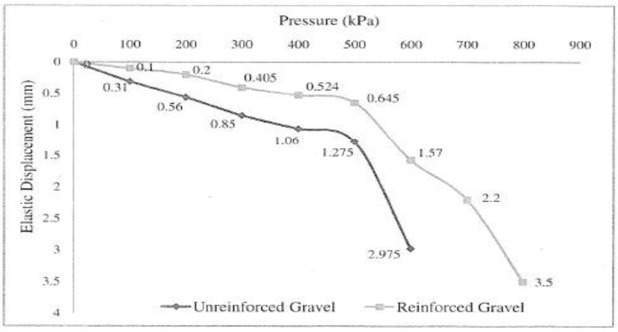


Fig: 3.17 Pressure – Total Deformation Curves for Waste Plastic Strips and Waste Tyre Rubber Chips Reinforced Materials in Flyash Subbase of Flexible Pavement Laid on Expansive Soil Subgrade at Unsaturation

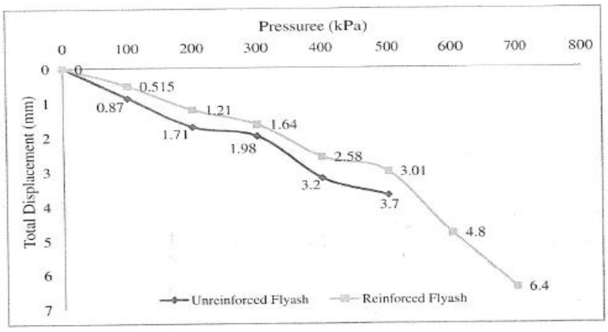
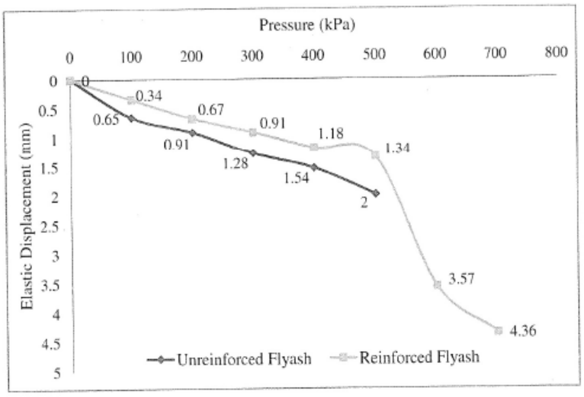


Fig: 3.18 Pressure – Elastic Deformation Curves for Waste Plastic Strips and Waste Tyre Rubber Chips Reinforced Materials in Flyash Subbase of Flexible Pavement Laid on Expansive Soil Subgrade at Unsaturation



IV. CONCLUSION

On the whole, this study has attempted to provide an insight into the compaction, direct shear and CBR behavior of gravel and flyash reinforced with waste plastics and waste tyre rubber. Utilizing some portion of the waste in this way will reduce the quantity of waste requiring disposal. More so the disposal in this way will be in an environmentally friendly manner. The study yielded the following conclusions based on the laboratory experimentation carried out in this investigation.

- Addition of (waste plastics + waste tyre rubber) inclusions in gravel and flyash results in an appreciable increase in the shear characteristics and CBR value.
- 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 (03+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.
- No significant control of heave is observed when reinforcement is placed in flexible pavement subbase laid on expansive soil subgrade.
- The total and elastic deformation values of flyash

the flexible pavement system are increased is when compared to gravel by the provision of the (waste plastics + waster tyre rubber), reinforcement laid on expansive soil subgrade, in comparison with the conventionsl flexible pavement system.

- The total carrying capacity of the laboratory model flexible pavement system is significantly increased by introducing (waste plastics + waster tyre rubber) reinforcement material in gravel and flyash subbase laid on expansive soil subgrade.
- The maximum load carrying capacity followed by less value of rebound deflection is obtained for waste plastic strips and waste tyre rubber reinforced stretch laid on the flexible pavement system.
- Based on the findings, waste plastic and waste tyre fubber 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 economic of the use of waste materials in rural roads.

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