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Performance of Reinforced Gravel Sub Base Laid on Expansive Soil Sub Grade

J.Chandini Devi
PG Student (SMFE),
Dept. of Civil Engineering,
BVC Engineering College,
Odalarevu, E.G.Dt., AP.

Dr.D S V Prasad
Professor & Principal,
Dept. of Civil Engineering
B V C Engineering College,
Odalarevu, E.G.Dt., AP.

Abstract:
The vehicle load transfer mechanism can be efficiently managed by the inter-connecting layers and their characteristics. The top layers should be strong enough to take care of vehicle stresses; one such is Base-course. Usually Base-course materials are natural soils like gravels, sands, stone particles, etc. Gravel soils in large quantity can be popularly used as Sub Base, Base-course materials in the construction of pavements. When the gravel soil possess considerable amount of fines (silt and clay), they take moisture and deform under loading. To reduce the excess deformations of the gravel soils under saturation and to increase the strength and durability, stabilization is one of the techniques to be adopted and waste plastics/coconut coir can be chosen as stabilizer. Different percentages of waste plastics/coconut coir were added to gravel soils and tests were conducted to assess compaction and strength characteristics. By addition of waste plastics/coconut coir, compaction characteristics are improved thereby improving the California Bearing Ratio (CBR) & UCS values Hence by addition of certain percentages of waste plastics/coconut coir to gravel soils makes them suitable to meet the requirements of Ministry of Road Transport and Highways (MORTH) specifications as Sub-Base material.

In the present work, an attempt is made to use waste plastics/coconut coir chips as reinforcing materials in gravel and compare their strength performance. The direct shear, California Bearing Ratio (CBR), Unconfined compressive strength tests were conducted in the laboratory for gravel with and without reinforcement materials. Based on test results, the optimum percentage of waste materials are found out.

Keywords:- ***Gravel, Waste Plastics, Coconut Coir, and Shear, CBR, UCS Tests***

INTRODUCTION

Gravelly soils are frequently used in road construction as Sub-Base layers & Base course layers and as fill material in Embankments and low-lying areas of several projects. By the nature the composition of gravel soil varying their particles in the range from 75 mm to 2µ. Presence of wider ranges of particles makes the Gravel soil Dense/Compacted which achieves higher strength under shearing. Sometimes the presence of plastic fines like silt and clay particles takes excess moisture and makes these gravel soils to shear. To arrest these plastic deformations, stabilization techniques can be proposed. In this an attempt is made to stabilize gravel soils by reducing the plasticity and improving strength characteristics by adding waste plastics/coconut coiras a stabilizer. Various percentages of waste plastics/coconut coir added to Gravel soils of various degree of plasticity characteristics verifies to suit pavement layers.

Some of the researches on utilization of Gravel and morrum in Geotechnical applications were done by Ramana Murthy. V. et.al, (2003, 2004), Haussmann 1990, Prakash et.al, 1993, Gourley C. S et.al, Nunan T.A et.al, 1990, Thom N. H et.al, 1988, Jain P.K et.al, 2010. They studied the stabilization of Gravel and their

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strength characteristics in terms of CBR as a Road Construction material. Henry Vidal (1968), Hausmannn (1990),Rao (1996). The practice of reinforced earth technique became easy and simple with geosynthetics. Inspite of its wide use in various engineering practices; its application in the construction of pavements is very much limited Prasada Raju (2001).Reinforcement of soils with natural and synthetic fibres is potentially an effective technique for increasing soil strength. The growing interest in utilizing waste materials in civil engineering applications has opened the possibility of constructing reinforced soil structure with unconventional backfills, such as waste plastics. The results of direct shear tests performed on sand specimens by Gray and Osashi (1983) indicated increased shear strength and ductility, and reduced post peak strength loss due to the inclusion of discrete fibers.

In the present study the various percentages of waste plastics/coconut coir were added to gravel soils collected from nearby areas of Odalarevu and tested for plasticity, Compaction, CBR tests, Direct Shear & UCS test to suit as Sub-base-course material in accordance with MORTH specifications.

This paper investigates the performance of industrial waste plastics/coconut coir mixed in gravel materials and to find the optimum percentage. It was observed from the laboratory direct shear and CBR test results that, gravel reinforced material with waste plastics showed better performance as compared to coconut coir reinforced with different percentages of reinforcing materials

Materials Used and Properties:-

The following materials are used in this study.

Gravel: Gravel was collected from odalarevu village, near Amalapuram, East Godavari Dt., is used as base material for this investigation. The soil properties are OMC = 15.23%, MDD = 18.2 KN/m3, I.S. Classification = Well Graded Gravel, Liquid Limit = 28 %, Plasticity Index=8, Specific Gravity =2.68, Cohesion = 12.32, Angle of Friction = 35 and Soaked CBR = 3.14%.

Waste Plastic Strips: Waste plastic strips having a size of 12 mm × 6 mm and a thickness of 0.5 mm was used as reinforcement material in this study, as shown in Fig. 1.

Coconut Coir: Coconut coir fibre was collected from locally available coir industry in Amalapuram, East Godavari District. Coir is used as fiber reinforcement material and its aspect ratio size of 25 x 0.2 mm as shown in Fig.2.

Table: 1 Properties of Coir

Chemical Composition of Coir		Physical Properties of Coir	
Lignin	45.84%	Length in inches	6.8
Cellulose	43.44%	Density(g/cc)	1.40
Hemi-cellulose	00.25%	Tenacity (g/Tex)	10.00
Pectin's and related compound	03.00%	Breaking elongation%	30%
Water soluble	05.25%	Diameter in mm	0.1 to 1.5
Ash	02.22%	Rigidity of modulus	1.8924 dyne/cm2
Swelling in water (diameter)		5%	
Moisture at 65%RH		10.50%	

Fig -1: Waste Plastic Strips

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Fig -2: Coconut Coir

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, Plastic Limit of the samples tried in this investigation.

Compaction Properties

Compaction Properties: Optimum moisture content and maximum dry density of gravel 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 Fig.3. Different percentages of reinforcing materials used in gravel materials were presented in table 2. The required percentage of waste Plastics/coconut coir by dry unit weight of gravel was mixed uniformly. The water content corresponding to OMC of untreated gravel was added to the gravel in small increments and mixed by hand until uniform mixing of the reinforcement strips was ensured. The gravel was compacted to maximum dry density (MDD). The specimens were tested in a 6 cm × 6 cm square box at normal stresses of 3, 5, 7, 9 N/mm2 for each percentage of waste plastics/coconut coir with gravel and sheared at a rate of 1.25 mm/min. The graph was plotted between normal stress and shear stress at failure for each percentage of reinforcement materials for obtaining the shear strength parameters.

California Bearing Ratio (CBR) Tests

Different samples were prepared in the similar lines for CBR test using gravel reinforced with waste plastics/coconut coir and the details of which are given in table 2. The CBR tests were conducted in the laboratory for all the samples as per I.S.Code (IS: 2720 (Part- 16)-1979).

Unconfined Compressive Strength Test

The unconfined compression test is a special form of a triaxial test in which the confining pressure is zero.

Prepare the soil specimen at desired water content and density in the large mould. For the desired water content and the dry density, calculate the weight of the dry soil Ws, required for preparing a specimen of 3.8 cm diameter and 7.6 cm long. The unconfined compressive strength testing machine is used to conduct the tests in accordance with IS 2720-part X. The unconfined compressive strength testing apparatus consists of screw jack with proving ring and deformation dial gauge reading to 0.01mm. The proving ring of 1 kN capacity with 100 divisions in each cycle. The initial length and diameter of the sample is measured. The specimen is placed on bottom plate of loading device the bottom plate is adjusted to make contact with the specimen. Proving ring and deformation dial gauge are set to zero division. Force is applied so as to produce an axial strain rate should be constant as per (IS 2720-part X) to the specimen until the shear failure or until a vertical deformation of 20% is reached. Displacement is measured by strain gauge. Finally, compressive strength is calculated based on failure load and corrected area.

Table: 2 Different Percentages of Reinforcing Materials

S.No	Material	Reinforcing Material	Different Percentages of Reinforcing Material (% by Dry Unit Weight of Soil)
1	Gravel	Waste Plastic Strips	0.0, 0.1, 0.2, 0.3, 0.4
2	Gravel	Coconut coir	0.0, 0.1, 0.2, 0.3

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Discussion on Test Results

I.S heavy compaction, Direct Shear, CBR, UCS tests were conducted by using different percentages of waste plastics/coconut coir were mixed with gravel for finding the optimum percentages.

Fig.3 Direct Shear Test Apparatus

Fig.4 California Bearing Ratio Test

Fig.5 Unconfined compressive strength test apparatus

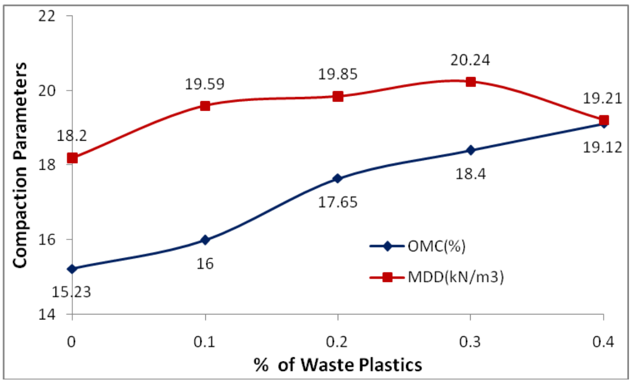

Fig.6 Variation of Compaction Parameters for gravel with Different % of Waste Plastics

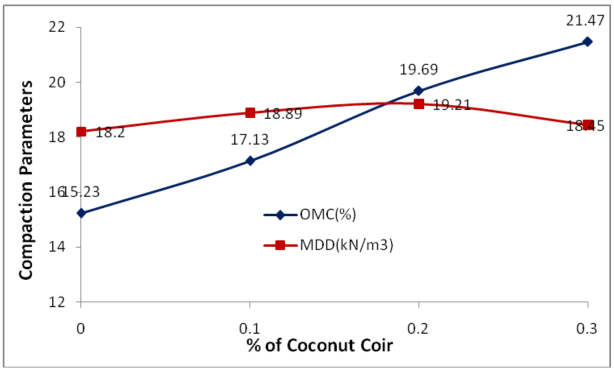

Fig.7 Variation of Compaction Parameters for gravel with Different % of coconut coir fiber

From the compaction test results it is observed that gravel reinforced with waste plastics/coconut coir, the OMC increases continuously where as the MDD for waste plastics increases from 18.2 kN/m3 to 20.24 kN/m3 up to 0.3% and for coconut coir 18.2 kN/m3 to 19.21 kN/m3 up to 0.2% beyond it decreases respectively as shown in figs.5 and 6

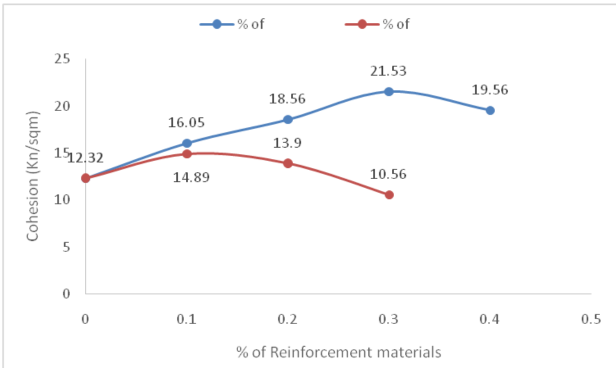

Fig.8 Variation of Cohesion for Gravel Reinforced with Different Percentages of Waste Plastic Strips/Coconut Coir Fiber

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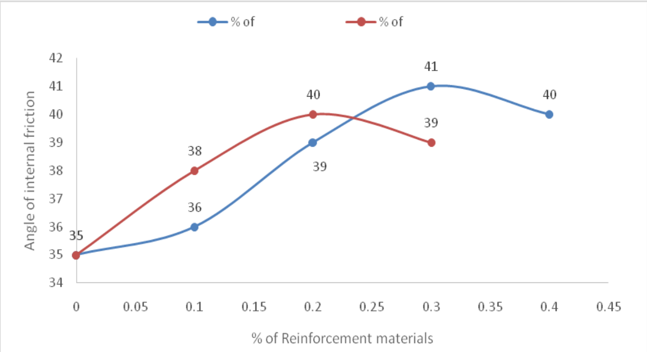

Fig.9 Variation of Angle of Internal Friction for Gravel Reinforced with Different Percentages of Waste Plastic Strips/Coconut Coir Fiber

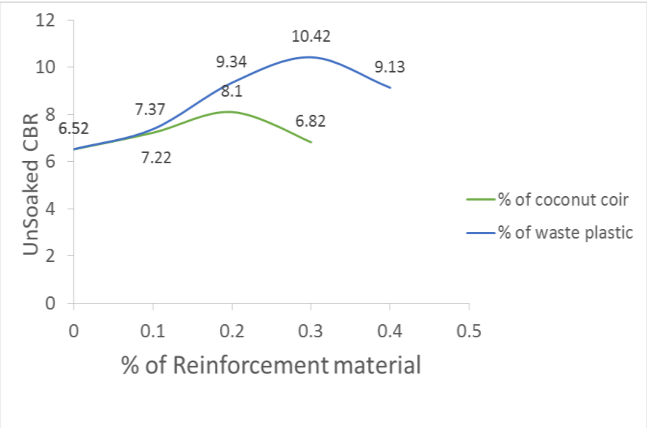

Fig.10 Variation of UnSoaked CBR for Gravel Reinforced with Different Percentages of Waste Plastic Strips/Coconut Coir Fiber

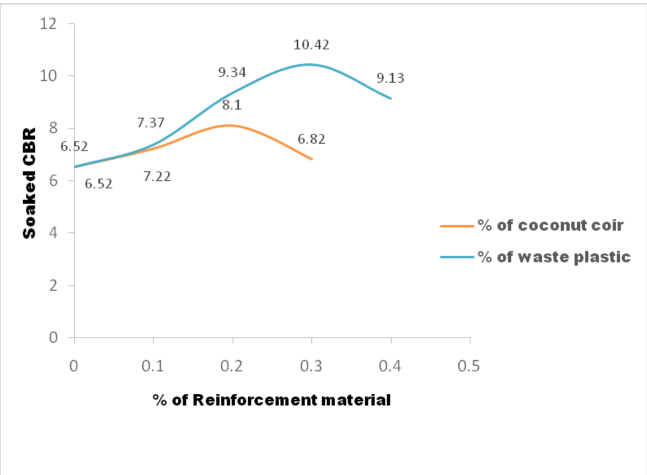

Fig.11 Variation of Soaked CBR for Gravel Reinforced with Different Percentages of Waste Plastic Strips/Coconut Coir Fiber

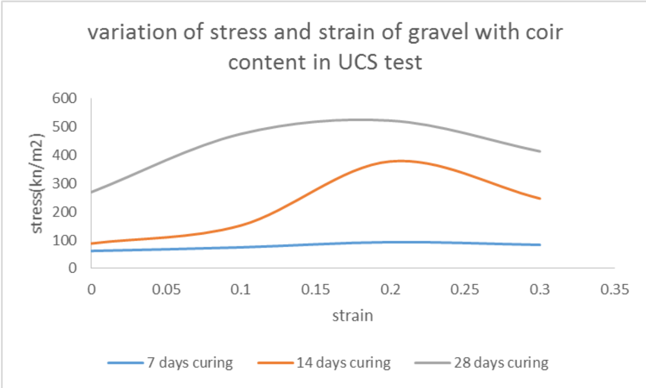

Fig.12 Variation of UCS for Gravel With Different % of Coconut Coir Fiber for 7,14,28 days curing

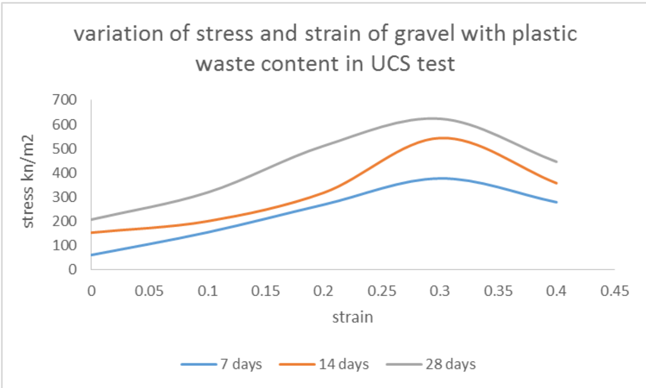

Fig.13 Variation of UCS for Gravel With Different % of Waste Plastics for 7,14,28 days curing

From the test results it is observed that gravel reinforced with waste plastics has better performance as comparative to coconut coir reinforced gravel. From the direct shear test results , it is observed that for gravel reinforced with waste plastics, the cohesion and angle of internal friction values are increased from 12.32 to 21.53 kN/m2 and 35^0 to 41^0 respectively with 0.3 % of waste plastics and there after decreased.

It is also observed that gravel reinforced with coconut coir cohesion and angle of internal friction values are increased from 12.32 to 13.9 kN/m2 and 35^0 to 40^0respectively with 0.2 % of coir and there after decreased. Soaked CBR values are increased from 3.14 to 4.95 for 0.30 % of waste plastics and 3.14 to 3.87 for coconut coir at 0.2 % as shown in Figs.7 to9. From the results of Direct Shear, California Bearing Ratio,

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Unconfined compressive strength tests, the optimum percentage of waste plastics and coconut coir are 0.3% and 0.2 % respectively

DESIGN FOR PAVEMENT THICKNESS

After doing testing on various samples,with the help of CBR design chart recommended by Indian road congress IRC :SP:20-2002 the total thickness is found out to cover the subgrade for all samples.

It is assumed that there are 400 no.of commercial vehicles per day.so, curve D is used for obtaining thickness over subgrade.CBR curves for Flexible pavements design (IRC:SP:20-2002).

Table:3 Thickness of pavement above subgrade from IRC:SP:20-2002

S.NO	% OF COIR	SOAKED CBR VALUE	THICKNESS OF FLEXIBLE PAVEMENT (mm)
1	0	3.14	390
2	0.1	3.42	380
3	0.2	3.87	360

S.NO	% of waste plastics	SOAKED CBR VALUE	THICKNESS OF FLEXIBLE PAVEMENT (mm)
1	0	3.14	390
2	0.1	3.67	370
3	0.2	4.52	320
4	0.3	4.95	300

From the above table it shows that thickness of flexible pavements of different percentages of CBR values of coconut coir and waste plastic fibers. The gravel added with 0.3% of plastic waste fibre gives the best results of CBR as compared to coconut coir of 0.2%, so the thickness of flexible pavement of this result is 300mm.It is the minimum thickness as compare to other samples. The cost of pavement is reducing to add this waste material.

CONCLUSION

The optimum percentages of waste plastics from the IS heavy compaction, Direct Shear, California bearing ratio and UCS tests for gravel materials are 0.3% and the optimum percentages of coconut coir mixed in gravel materials are 0.2 % respectively. From the result of compaction, direct shear, CBR and UCS tests, gravel reinforced with waste plastics has shown better performance as compared to coir reinforced gravel.

According to Design flexible pavement, the thickness of pavement recommended is 300mm

Table : 4 Optimum Percentage of Reinforcing Material

S.NO	Subbase Material	Reinforcing Material	Optimum Percentage of Reinforcing Material	
1.	Gravel	Waste Plastics Chips	0.3	0.3
2.		Coconut Coir fiber	0.2	0.2

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