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A Study on Strength of Reinforced Flyash with Randomly Distributed Fibers

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Abstract:- Flyash is a waste produced from thermal power stations, which contributes to environmental pollution. It is a waste material that can be utilized in construction of roads and embankments. Randomly distributed fiber reinforced soils have recently attracted increasing attention in geotechnical engineering. One of the most promising approaches in this area is use of flyash as a replacement to the conventional weak earth material and fiber/coir as reinforcement will solve two problems with one effort i.e. elimination of solid waste problem on one hand and provision of a needed construction material on other. Disposal of a variety of wastes in an eco friendly way is the thrust area of today's research. This paper investigates to determine the optimum percentage of waste plastics/coconut coir with flyash material by conducting direct shear and CBR tests. It was observed that from the laboratory test results, the optimum percentage of waste plastics and coconut coir with flyash material are 0.3% and 0.2% respectively and also flyash with waste plastics shows better performance as compared to flyash with coconut coir.

Keywords: - Flyash, Waste Plastics, Coconut Coir, and Shear and CBR 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. Making of waste construction materials is increasing in many countries around the world. One of solution for omitting these materials is to use them in pavement layers. The pavement subbase layer has many significant in reduction of road construction project cost, because they use a large quantity of materials. Waste materials can be used in subbase layer and then stabilized to increase the strength of layer. One of important tasks of subbase layer is to decrease the compressive strains. The performance of paved and unpaved roads is often poor after every monsoon and, in most cases; these pavements show cracking, potholes, wheel path rutting and serious differential settlement at various locations. Therefore, it is of utmost importance considering the design and construction methodology to maintain and improve the performance of such pavements. Many highway agencies, private organizations and researchers are doing extensive studies on waste materials and research projects concerning the feasibility, environmental suitability and performance of using recycled products in highway construction are in progress. The amount of wastes as increased year by year and disposal becomes a serious problem. It is necessary to utilize the waste affectively with technical development in each field.

Commonly gravel has been used for construction of all categories of roads in our country. Although gravel is a good construction material, due to scarcity they increase the construction cost at some parts of the country. However, in the latest MORTH specifications, several types of gravel soils are found to be unsuitable for road construction in view of higher finer fraction and excessive plasticity properties.

Flyash is a waste by- product from thermal power plants which use coal as fuel. It is estimated that about 120 million tons of flyash is being produced from different thermal power plants in India consuming several thousand hectares of valuable land for its disposal causing severe health and environmental hazards[1] ,[2]. In order to utilize flyash in bulk quantities, ways and means are being explored all over the world to use it for construction of embankments and roads [3] – [5].

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 [6] indicated increased shear strength and ductility, and reduced post peak strength loss due to the inclusion of discrete fibers. The study also indicated that shear strength is directly proportional to fiber area ratio and length of fiber up to certain limit. These results were supported by number of researchers using consolidated drained triaxial tests like [7]-[14]. The results of compaction tests for a silty, clay soil specimen reinforced with fibers indicate that increasing the volume of fibers in the soil generally causes a modest increase in the maximum dry unit weight, and a slight decrease in the optimum moisture content by[15],[16].

The coir is a naturally occurring fiber derived from the husk of coconut fruit. It is abundantly available at very low cost in India. A large number of coir products are manufactured by coir board in Kerala for various geotechnical applications in the form of grids, textiles and mats. These applications include filtration and drainage applications, reinforcement, erosion control, etc. These products were found to last for as long as four to six years within the soil environment depending on the physical and chemical properties of the soil. Fibers are of two types, natural fibers and artificial fibers. Both the types are used for civil engineering purposes. Natural fibers will not cause environmental problems. The natural fibers are cheap compared to artificial fibers, for long run these natural fibers will undergo biodegradation, exception is for coir fibers. Coir, which is reputed to be the strongest and most durable natural material [17],[18], which is cheaply and abundantly available in India and in a few other Asian countries where coconuts are grown and subsequently processed. Unlike synthetic reinforcing materials, coir is biodegradable; however, due to its high lignin content (about 46%), degradation of coir takes place much more slowly than that in the case of other natural materials. Increasing awareness and demand for environment friendly engineering solutions give coir an edge over synthetic reinforcing materials. Coir fiber made of natural fibers is increasingly finding a place as erosion control, but not for soil reinforcement. This is in spite of the fact that strong fibers like coir which have a very high lignin content can be effectively made use of as a reinforcing material, provided they are given suitable treatment [19]. In recent days it has been investigated that addition of fibers will improve the ductility behaviour of the soil there by reducing the development of crack during shrinkage. Water absorption test conducted [20] up to 180 days and reported that kerosene and bitumen coated coir fibers are better substitute for reducing water absorption of coir fibers. Unconfined compressive strength of black cotton soil reinforced with 1 % (0.5 centimeters) length of bitumen coated coir fiber and compared with uncoated coir fiber, they concluded bitumen coating causes marginal variation of strength [21]. From the literature review it is observed that coir fiber is a strong fiber among all natural fibers, however to increase the life of its utility as reinforcing material to soil, it needs further treatment. 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 subbases reinforced with coir/plastics for its application to flexible pavements on expansive soil subgrades. This paper investigates the performance of waste plastics /coconut coir by mixing with different percentages in flyash materials to find the optimum percentage by conducting direct shear and CBR tests in the laboratory.

II. MATERIALS AND THEIR PROPERTIES

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

A. Flyash*:* Flyash was collected from Vijayawada thermal power station, Vijayawada. The properties of flyash are furnished in Tables 1&2.

B. 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.

C. Coconut Coir*:* *The coir is used as an alternative reinforcing material and having the aspect ratio of 25mm × 0.2 mm shown in the Fig. 2.*

Fig -1: Waste Plastic Strips

Fig -2: Coconut Coir

1) Table -1: Properties of Flyash

Property	Value
Specific Gravity	1.95
Grain Size Distribution	
Sand (%)	25
Silt (%)	70
Clay (%)	5
Compaction Properties	
Maximum Dry Density (kN/m^3)	14.11
O.M.C. (%)	19.7
Liquid Limit. (%)	28
IS Classification	ML
Soaked CBR. (Compacted to MDD at OMC) (%)	4
Permeability (cm/sec)	0.5×10^{-6}

Table -2: Chemical Composition of Flyash (Courtesy: VTPS, Vijayawada)

Name of the Chemical	Symbol	Range by % of weight
Silica	SiO_2	61 to 64.29
Alumina	Al_2O_4	21.60 to 27.04
Ferric Oxide	Fe_2O_3	3.09 to 3.86
Titanium dioxide	TiO_2	1.25 to 1.69
Manganese Oxide	MnO	Up to 0.05
Calcium Oxide	CaO	1.02 to 3.39
Magnesium Oxide	MgO	0.5 to 1.58
Phosphorous	P	0.02 to 0.14
Sulphur Trioxide	SO_3	Up to 0.07
Potassium Oxide	K_2O	0.08 to 1.83
Sodium Oxide	Na_2O	0.26 to 0.48
Loss on ignition		0.20 to 0.85

III. LABORATORY TESTS

Various tests were carried out in the laboratory for finding the index and other important properties of the soils used during the study. Direct shear and CBR tests were conducted by using different percentages of waste plastics and coconut coir mixed with flyash material for finding optimum percentage of waste plastics and coconut coir. 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, Plastic Limit and Shrinkage Limit of the samples tried in this investigation.

Compaction Properties: Optimum moisture content and maximum dry density of 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 Fig. 3. Different percentages of reinforcing materials used in flyash materials were presented in table 3.The required percentage of waste Plastics/coconut coir by dry unit weight of soil was mixed uniformly with the soil. The water content corresponding to OMC of 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).The specimens were tested in a 6 cm × 6 cm square box at normal stresses of 3, 5, 7, 9 N/mm^2 for each percentage of waste plastics / coconut coir with flyash 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 waste plastics / coconut coir for obtaining the shear strength parameters.

California Bearing Ratio (CBR) Tests: Different samples were prepared in the similar lines for CBR test using flyash materials reinforced with waste plastics and coconut coir and the details of which are given in table 3. 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

Fig -4: California Bearing Ratio Test Apparatus

Table -3: Different Percentages of Reinforcing Materials

Subbase Material	Reinforcing Material	Different Percentages of Reinforcing Material (% by Dry Unit Weight of Soil)
Flyash	Waste Plastic Strips	**0.0, 0.1, 0.2, 0.3, 0.4, 0.5**
	Coconut Coir	**0.0, 0.1, 0.2, 0.3**

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 flyash materials with and without reinforcement material (waste plastics/coconut coir) with a view to find the optimum percentage and the results are furnished below.

Compaction: I.S.Heavy compaction tests are conducted as per IS: 2720 (Part VIII). All the Samples are tested by using for flyash material mixed with varying percentages of reinforcing material ie waste plastics and coconut coir fiber. 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 results and graphs from these tests are presented below form charts. 1 & 2.

Direct Shear: Based on the results, shown in the charts. 3 & 4, it is observed that, for flyash reinforced with waste plastics , the angle of internal friction values are increased from 30^0 to 38^0 with 0.3 % of waste plastics chips and thereafter decreased with further additions. The cohesion values are increased from 6.85 to 15.7 kN/m^2 with 0.3 % of waste plastics chips and thereafter decreased. It is also observed that, for flyash reinforced with coconut coir chips, the cohesion and angle of internal friction values are increased from 6.85 to 7.9 kN/m^2 and 30^0 to 34^0 respectively with 0.2 % of coconut coir chips and there after decreased.

California Bearing Ratio (CBR): CBR tests were conducted for flyash materials reinforced with different percentages of waste plastic chips and the results were presented in the charts 5&6. It is observed from that for flyash reinforced with waste plastic chips, the soaked CBR values are increased from 4.0 to 7.91 and 4.0 to 6.65 for 0.3 % and 0.2 % of waste plastic chips and coconut coir respectively.

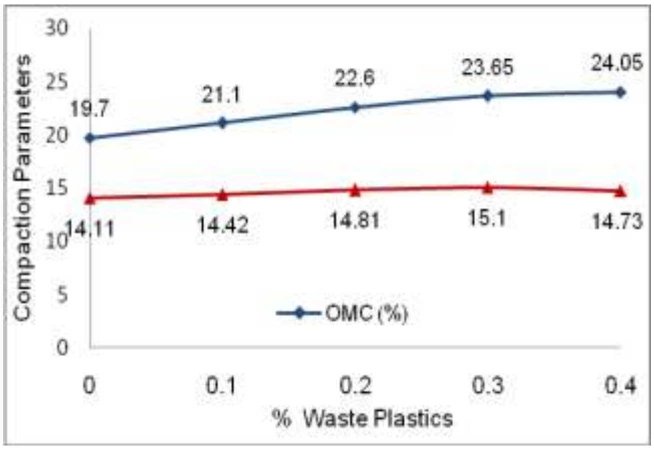

Fig -5 Variation of Compaction Parameters for Flyash with Different % of Waste Plastics

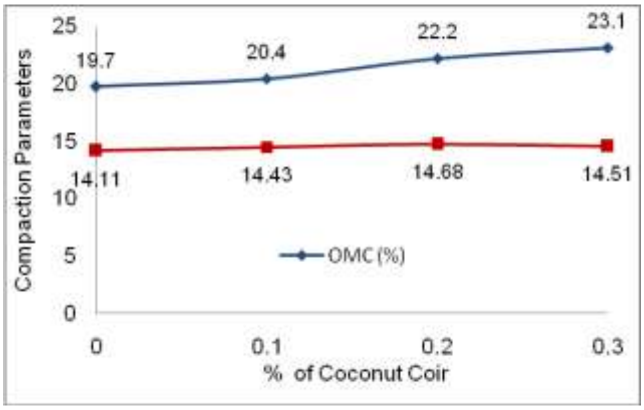

Fig -6 Variation of Compaction Parameters for Flyash with Different % of Coconut Coir Fiber

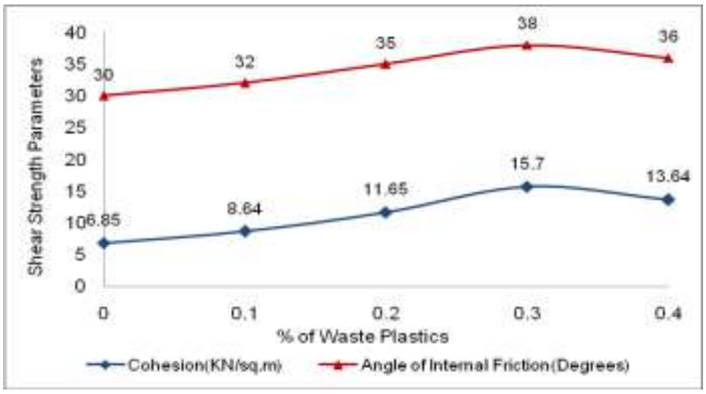

Fig -7 Variation of Shear Strength Parameters for Flyash Reinforced with Different % of Waste Plastic Strips

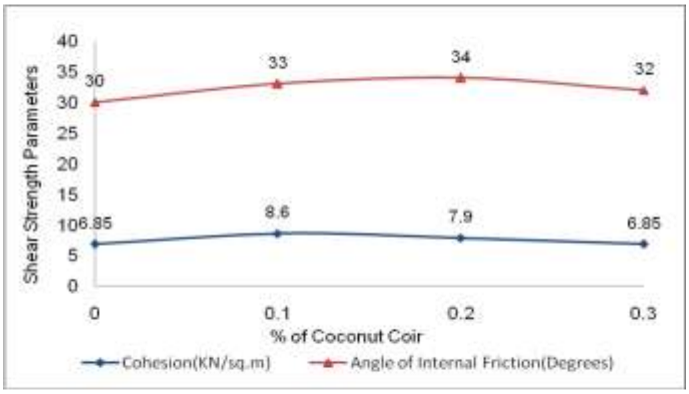

Fig -8 Variation of Shear Strength Parameters for Flyash Reinforced with Different % of Coconut Coir Fiber

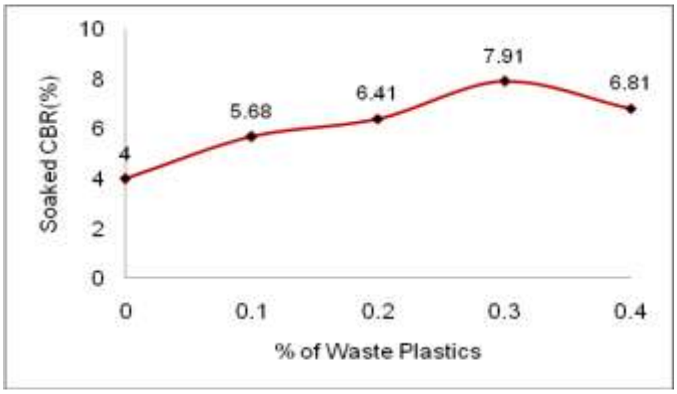

Fig -9 Variation of Soaked CBR values for Flyash Reinforced with Different % of Waste Plastics

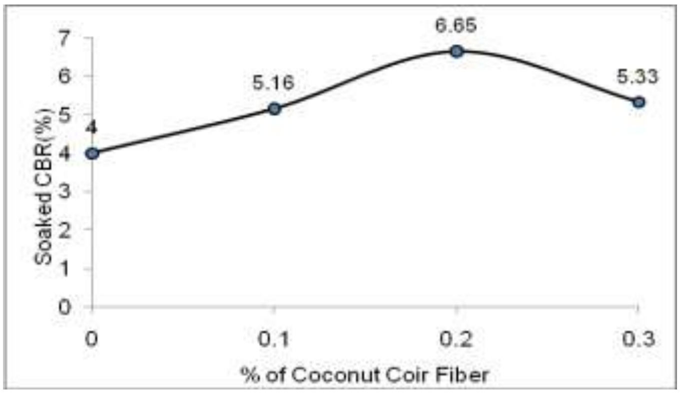

Fig -10 Variation of Soaked CBR values for Flyash Reinforced with Different % of Coconut Coir Fiber

Table -4: Optimum Percentages of Waste Plastics Chips and Coconut Coir Fiber

Base Material	Reinforcing Material	Optimum % of Reinforcing Material	
		Direct Shear Test	CBR Test
Flyash	Waste Plastics Chips	0.3	**0.3**
	Coconut Coir fiber	**0.2**	**0.2**

It is observed from the test results that the flyash reinforced with waste plastic chips has shown better performance when compared to flyash reinforced with coconut coir material. It is also observed that direct shear and CBR values of waste plastic chips /coconut coir reinforced flyash materials has shown maximum improvement compared to unreinforced flyash material. From the results of compaction, direct shear and California Bearing Ratio Tests, the optimum percentages of waste plastic chips and coconut coir for flyash materials are presented in table 4.

V. CONCLUSIONS

It is observed from the results of direct shear and CBR tests that for 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.

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