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Interpretation of Shear Strength of Fiber Reinforced Pond Ash

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Abstract- The constant increase in thermal power generation in India has the cascading effect of increased production of coal ash which if not utilized is an environmentally hazardous material. The unutilized fly ash and bottom ash is deposited in the pond in slurry form.Huge amounts is spent on operation and maintenance of ash ponds. Moreover, the ash ponds are occupying more than 50,000 hectares of cultivable land. Hence, it is necessary to increase the utilization levels of pond ash. However, it possible only when the engineering behaviour of pond ash is well understood. Many times, the pond ash in applications of pavement, retaining walls, bridge abutments etc. Needs to be reinforced.The reinforcement can be fabric or in fiber form. Investigations are carried out on pond ash reinforced with fabric. However, there is scope for understanding the behaviour of fiber reinforced pond ash.In view of the above, in the present study, efforts are made to reinforce the pond ash with staple fiber derived from a polymeric woven geotextile in various substitution percentage of 0.5, 1, 3 and 5%. At each substitution percentage, the aspect ratio is varied at 5, 10, 20 and 50. The strength behaviour is studied by conducting the direct shear tests on composite sample dry density of 70%, 80%, and 90% of MDD.The results indicated effect of the density of composite, effect of fiber percentage and the aspect ratio on shear parameters.

Keywords: Pond ash, Cohesion, Aspect ratio,% fiber,MDD

1. INTRODUCTION

In India, the electricity sector has an installed capacity of 186 GigaWatt (5'h largest in the world) and thermal plants constitute 659 of the in alled capacity. About 80% of these Thermal Power plants use coal for power generation and this leads to immense coal ash production. Indian coal is of low caloric value and this leads to more percent of coal ash generation, thus, about 130 million tons of coal ash is produced per year in India. Pond ash is waste material; it is produced from thermal power plants.

Pond Ash disposal involves consumption of huge quantities of land and water, loss of agriculture-based employment, and environmental pollution. In India,pond ash utilization is just at about 32% and this is small when compared to potential pond ash utilization at Hence, there is an immediate need to increase pond ash utilization. India is also witnessing huge roads / highway construction and real estate boom that are consuming the limited supplies of natural soil. To meet these needs, Pond Ash is utilized in a limited manner in agriculture, embankments and landfills. However, the research on pond ash utilization is limited and the current project aims to provide the research that helps in building strong civil engineering constructions, using Pond Ash while saving costs andprotecting environment.

The inherent strength of the compacted pond ash and its mass reduces considerably due to the saturation. Pond Ash particles cannot withstand tensile stress much and this is specifically explicit in case of cohesion less soils. Such soils cannot be stable on steep slopes when external loads are imposed on them. To retain the strength of compactedpond ash cementing agents are required.

The stress-strain behavior of compacted pond ash mass can also improve by inclusion of the fiber reinforcements. It has become popular lately due to the availability of variety of synthetic materials at affordable prices. When earthly materials are combined with fiber reinforcements, frictional forces or interlock forces are developed between the soil and reinforcement, this increases the shear strength and cohesion of the compositestructure. The failure load also increases. With fiber reinforcements, pond ash's improved strength can also sustain wetting. In a way, these fiber reinforcements are and extension of the reinforcements like steel rods, grids, sheet materials, rope orwood usedin construction. The major requirements of the reinforcing materials are strength, durability, case of handling, high adhesion or friction with soil and availability at low-cost. The reinforcement materials, particularly fibers, should also be highly restraint tobacteria, alkalis and acid.

The advantages of fiber reinforced soil are increased shear strength, increased ductility, increased seismic performance, more erosion control lower shrinkage and swell pressure of expansion soil, no appreciable change in permeability and immunity to weather conditions.

II. METHODOLOGY

2.1 Experimental work:

Specimens were tested in a 60 mm square box at normal stresses of 50,100,150,200 kPa and sheared at rate of 1.25 mm per min according to IS 2720 (1986).

2.2 Test Material:

2.2.1 Pond Ash from Raichur thermal power station

Materials from thermal plants, produced when fly ash and bottom ash is mixed with water as slurry

Figure 2.1: Pond ash obtained from Raichur thermal power plant

2.2.2Synthetic Fiber (Polypropylene)

The aspect ratio of synthetic fiber is about 5,10,20 and 50.

Figure 2.2: Sample of Synthetic Fiber

2.3 Specimen Preparation:

The project is obtained shear strength of fiber reinforced pond ash at 70 % of MDD.It is to utilize fiber contents of (0.5, 1.3, 5%) and aspect ratio of fiber of (5,10,20,50) the corresponding dry density is to taken as 0.861 g/cc, weight of pond ash is 108 48g, when 0.5% fiber is taken, weight of ash is 107.98 g. Weight of fiber is 0.54g. aspect ratio is (5,10, 20. 50) and weight of water is 21.15 cc then for each corresponding shear strength parameters will be evaluated to get C and Φ.

Therefore we will get 16 (C, Φ) values and their graphs (with shear stress vs. Normal stress graphs). The normal load of shear test is of (50,100,150,200 kPa) such as totally 64 tests are conducted and by changing each 4 loads and noting PRR and with time we will get one (C, Φ) value.Direct shear is used to determine shear strength parameters of soil.

2.4 Characterization of Pond Ash :

A variety of experiments were conducted to evaluate characteristics of pond ash. The strength of pond ash is improved using fiber reinforcement and measured.

Table 2.1 Properties of Pond Ash

PROPERTY	VALUES
Specific Gravity	2.04
Wet Sieve Analysis	Finely graded soil
Coefficient of uniformity (Cu)	8.125
Coefficient of curvature (Cc)	0.658
Differential free swell teat	Nil
Plastic limit; Liquid limit; Shrinkage limit	NP ; 9.3%; NP
Compaction test	Engineering Properties
OMC(%); MDD (gm/cc)	28% ,1.23gm/cc
Angle of unreinforced soil at 70% MDD	40.64^0
Cohesion	0.04 (kg/cm^2)

III. EXPERIMENTAL RESULTS

3.1 Shear Stress Calculations:

The pond ash composite of is calculated from the MDD calculated earlier (1.23 g/cc) and%

of MDD.

Weight of Dry Pond Ash = MDD * % of MDD * Volume of DST snmple

Weight of water = (% of MDD * Weight of dry pond ash * Water content, w) / 100

The following table illustrates the pond ash, water composition calculations.

Table 3.1: Calculation of Pond ash, water composition

No (% of MDD)	Sample		Volume of DST sample (cc)	Weight of Dry pond Ash (gm)	Weight of water (gm)
	Density (g/cc)	Water Content W (%)			
50%	0.615	12	126	77.49	4.65
70%	0.861	18	126	108.49	13.67
89%	1.0947	22	126	122.75	24.02
100%	1.23	28	126	154.98	43.39

At MDD=70%,the shearing stress values are as below.The pond ash mixture used includes 108.49 g of pond ash and 13.67 cc of water,as calculated earlier.

Table 3.2: Shearing stress calculations-70 % MDD-108.49 g Pond ash & 13.67 cc water

Sr. No.	Normal Stress (kpa)	PRR	Time (min)	Shear Load (kg)	Corrected area (cm^2)	Shear stress (kpa)
1	0					4
2	50	14	2.03	14.14	32.95	43
3	100	27	2.367	27.27	32.45	87
4	150	41	3.383	41.41	30.92	134
5	200	53	5.267	53.53	28.095	186

The shearing stress is plotted against normal stress.This graph represents Column's equation.The graphical representation of Column's equation is a straight line as observed.

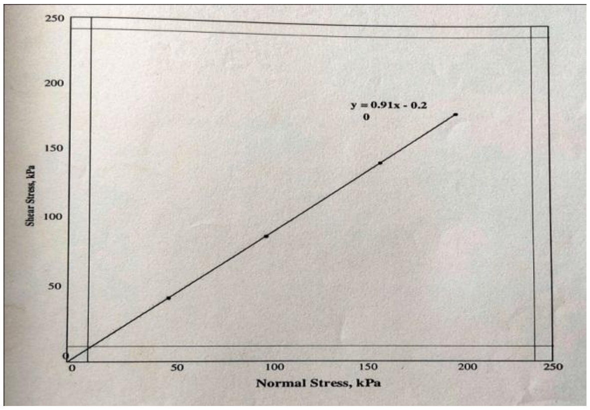

Fig 3.1: Shear stress vs Normal stress plot (MDD 70%)

The angle of internal friction and shearing strength of the soil is determined from the graph. The intercept made by the straight line on the Y-axis represents cohesion C and the slope of the plot gives friction angle or angle of shearing resistance. From the chart , C= 4 kpa& Φ =40.64

3.2 Shear Stress variation with fiber addition:

The shear strength has been calculated for Aspect ratios 5,10,15,20 for fiber 0.5%,1%,3% and 5% for target molding density 70%.

The table below summarizes the variation in strength with change in fiber characteristics:

Table 3.3:Variation of pond ash characteristics (C, Φ) with % fiber

Variation of pond ash strength with fiber								
Target moulding density	Corresponding dry density (g/cc)	Weight of solids (g)	% of fiber	Aspect ratio	Weight of ash (g)	Weight of fiber(g)	Cohesion (C)	Angle of internal friction
70%	0.861	108.48	0.50	5	107.9	0.542	0.13	39.00
				10			0.15	38.50
				20			0.20	36.50
				50			0.40	36.00
			1.00	5	107.4	1.085	0.20	38.00
				10			0.25	37.00
				20			0.30	35.50
				50			0.50	35.00
			3.00	5	105.2	3.254	0.23	38.50
				10			0.30	38.00
				20			0.38	36.00
				50			0.53	35.00
			5.00	5	103.1	5.424	0.25	38.00
				10			0.35	36.00
				20			0.45	35.50
				50			0.61	34.00

IV. ANALYSIS OF RESULTS AND OBSERVATION

4.1 Variation of Cohesion with fiber content:

Cohesion of pond ash sample increases with an increase in % fiber. The cohesion varies from 0.12 to 0.61.At constant aspect ratio, increasing the % fiber increases the pond strength.

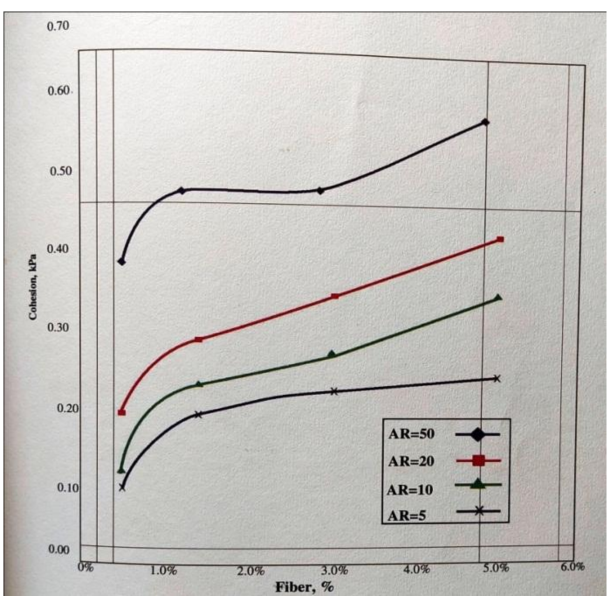

Fig 4.1 Variation of Cohesion with fiber content

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4.2 Variation of Cohesion with aspect ratio :

Cohesion of pond ash sample increases with an increase in aspect ratio. The cohesion varies from 0.12 to 0.61kg/cm^2.At constant % fiber, increasing the aspect ratio increases the pond strength.

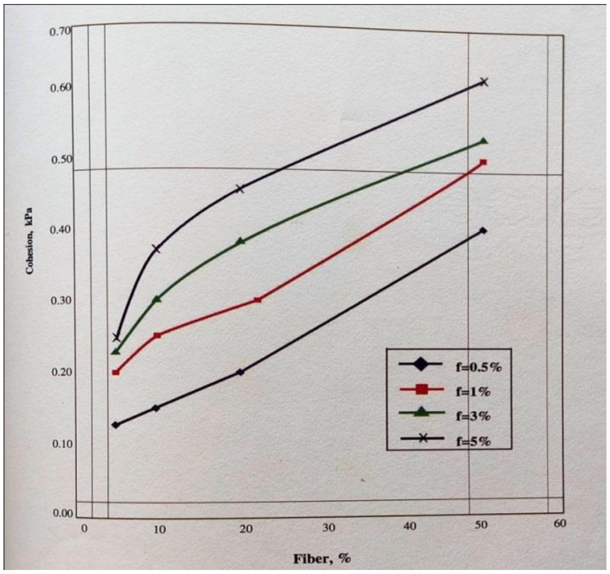

Fig 4.2 Variation of Cohesion with aspect ratio i.e fiber length

4.3 Variation of Angle of internal friction with % fiber:

The angle of internal friction ranges from 34 degrees to 39 degrees.The angle of internal friction decreases with an increase in % fiber.

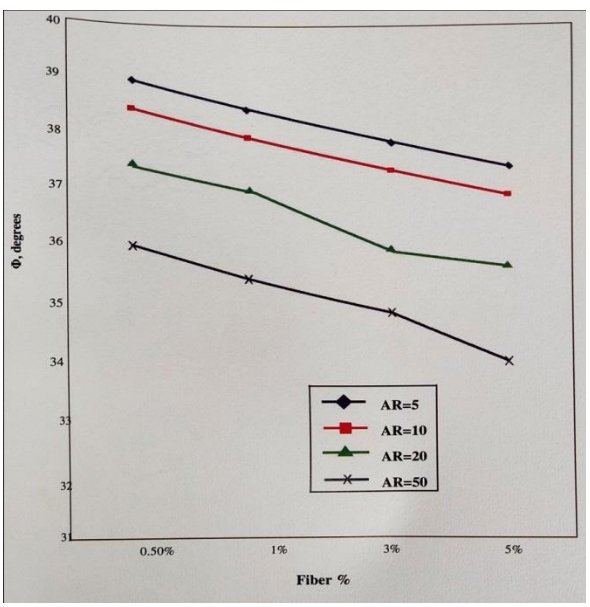

Fig 4.3Variation of Angle of internal friction with % fiber

4.4 Variation of Angle of internal friction with aspect ratio :

The angle of internal friction ranges from 34 degrees to 39 degrees. The angle of internal friction decreases with an increase in aspect ratio.

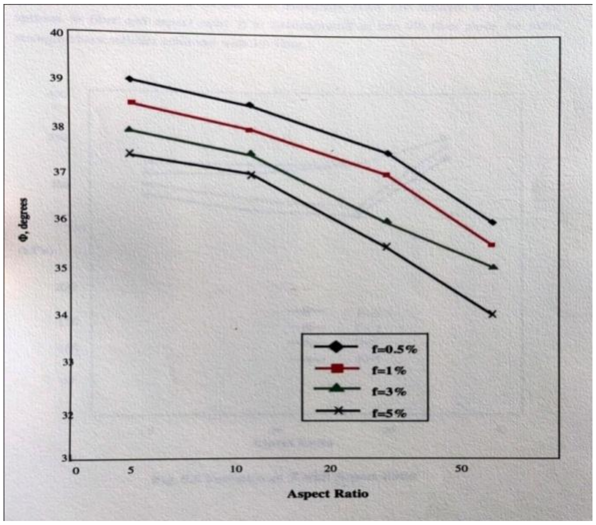

Fig 4.4 Variation of Angle of internal friction with aspect ratio

4.5 Variation of τ with aspect ratio :

The maximum pond ash strength is reached for optimal % fiber and aspect ratio. It is uneconomical to use 5 % fiber since the same strength characteristics achieved with 3% fiber.

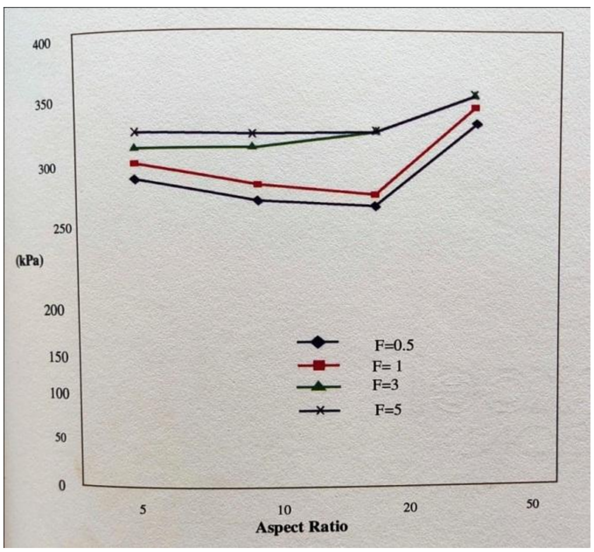

Fig 4.5 Variation of τ with aspect ratio

4.6 Variation of BCR with % fiber:

The bearing capacity ratio varies from 1.12 to 1.44.

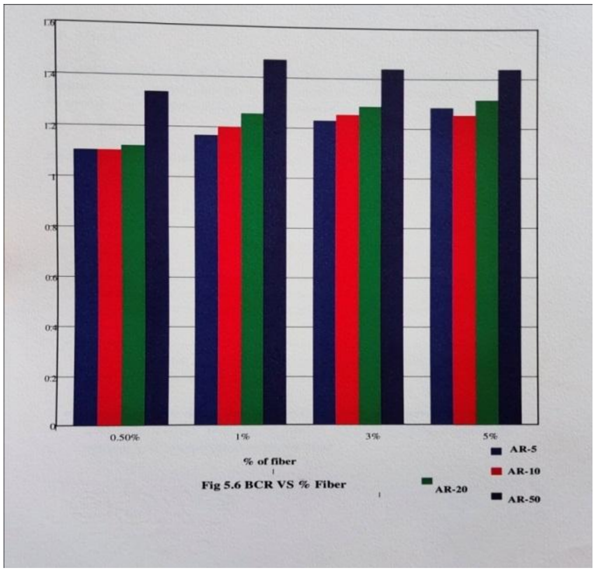

Fig 4.6 BCR vs % Fiber

V. CONCLUSION

Based on the experimental investigations carried out in the study,the following conclusions were made:

1. The strength of pond ash, in general increased when it is reinforced with randomly distributed fiber indicating its potential for improvement and thereby enhances its scope for bulk utilization in geotechnical engineering applications.

2. For a given pond ash reinforced with a given fiber, the level of improvement of shear strength of the randomly distributed fiber reinforced pond ash is dependent on the fiber characteristics namely, percentage fiber and aspect ratio.

3. For the materials used in this study, the maximum Pond Ash strength is reached for optimal% fiber and aspect ratio. It is uneconomical to use 5% fiber since the same strength characteristics achieved with 3% fiber.

4. At constant Aspect Ratio, increasing the % Fiber increasing the Pond Ash strength up-to optimal value. Similarly, at constant % fiber, increasing Aspect Ratio increasing pond ash strength up to optimal value.

5. The Bearing Capacity Ratio varies from 1.12 to 1.44.

6. Cohesion of Pond Ash sample increases with an increase in % fiber and aspect ratio. The Cohesion varies from 0.12 to 0.61.

7. The Angle of Internal Friction ranges from34 degrees to 39 degrees.

8. The relationship between Shear Stress and Normal stress is linear for a specific Aspect Ratio, fiber content, and MDD.

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