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Effect of Addition of Polypropylene Fiber on Shear Strength of Fly Ash

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ABSTRACT- Infrastructure projects such as highways, railways, water reservoirs, reclamation etc. requires earth material in very large quantity. In urban areas, borrow earth is not easily available which has to be hauled from a long distance. Quite often, large areas are covered with highly plastic and expansive soil, which is not suitable for such purpose. Extensive laboratory / field trials have been carried out by various researchers and have shown
promising results for application fly ash for this purpose. As fly ash is freely available, for projects in the vicinity of Thermal Power Plants, it can be used as filling material. But it is not suitable as bearing material due to its low shear strength. The present report describes a study carried out to check the improvements in the properties of fly ash with polypropylene fiber in varying percentages. Laboratory trials have been carried out and
results are reported in this report. Shear strength of fly ash reinforced with different percentages of polypropylene fiber is checked. Results show the positive effect of addition of fiber in fly ash.

KEYWORDS- Soil, Expansive Soils, Thermal power plant, Fly ash, Polypropylene Fiber.

I. INTRODUCTION

The combustion of pulverized coal at high temperature and pressure in power stations produces different types of ash. The 'fine’ ash fraction is carried upwards with the flue gases and captured before reaching the atmosphere by highly efficient electro static precipitators. This material is known as Pulverized Fuel Ash (PFA) or 'fly ash’. It is composed mainly of extremely fine, glassy spheres and looks similar to cement. The 'coarse' ash fraction falls into the grates below the boilers, where it is mixed with water and pumped to lagoons. This material is known as Furnace Bottom Ash (FBA) and has gritty, sand-like texture. The use of PFA and FBA in construction has been established for decades. Applications range from providing the cementations material in concrete, to use as a simple fill material or a lightweight aggregate in the manufacture of blocks. Using PFA and FBA makes a positive contribution to the environment. PFA and FBA are used in many applications to replace OPC (Ordinary Portland Cement) & naturally occurring aggregates and minerals respectively, which can reduce significantly the demand for OPC & virgin aggregates. Fly ash has been used in roadways and interstate since the early 1950s. In 1974, the Federal Ad- ministration encouraged the use of fly ash in concrete with Notice N 5080. In addition, in January 1983, the Environmental Protection Agency published federal comprehensive procurement guidelines for cement and concrete containing fly ash to encourage the utilization of fly ash and establish compliance dead- lines [1][3][4].

The quantity of fly ash produced wide-reaching is huge and keeps increasing every day. Four countries, namely, China, India, United State and Poland alone produce more than 270 million tons of fly ash each year. The Indian Environmental Protection Agency supports the beneficial use of coal combustion products as an important priority. The fly ash manufacture in India is around 100 million tons per year and ash ponds presently occupy nearly 64,000 acres of land. Occasional failure of such ash ponds not only affects vast tracts of agricultural land nearby but also pollutes river water even up to 100 kilometers endanger aquatic and human life. A large fraction of the coal ash about 70% of the total production is typically disposed of as a waste in utility disposal sites.

Well-documented, meaningful estimates of current disposal costs are not available. In 1980, however, the estimated disposal costs ranged from $5 to $10 per ton according to ENR (1980.) The current typical costs of borrow materials vary from about $4 to $10 per ton. Thus, considering that disposal costs have certainly climbed in the past 24 years, use of coal ash as a fill material seems to be economically advantageous. According to the American Coal Ash Association (ACAA 2013) both the production and disposal ratios of fly ash and bottom ash are approximately 80:20 by weight. Beneficial use of coal ash in construction projects requiring large material volumes, such as construction, offers an attractive alternative to disposal because substantial economic savings can be attained by the reduction of ash disposal costs and the conservation of natural soils and lands [2][5].

To increase the utilization of fly ash several research works are under process. As the strength of fly ash is less it cannot be used alone in construction industry. So some suitable reinforcement material is to be selected. A fiber named poly-propylene has some properties like construction material and is also cost effective [6]. Polypropylene (PP) fiber is available in the form of fibrillated films and tapes or woven meshes. PP is an unsaturated hydrocarbon, containing only carbon and hydrogen atoms. In 2000, Puppala and Musenda reported that fibers improved unconfined compressive strength and reduction in volumetric shrink- age and swell pressures of expansive clays [7]. This study will include the use of Polypropylene and its effectiveness along with fly ash.

II. RELATED WORK

Various studies had already been carried out on fly ash and polypropylene fiber materials differently. Fly ash is used with various geo grids in major projects in India also. Use of polypropylene is not so common but proves economical in various projects in US. Numerous studies have been completed in which the engineering properties and the physical and chemical characteristics of fly ash and bottom ash were determined in the laboratory.

N Bhanumathidas& N Kalidas presented their study, “Fly ash: The resource for construction Industry” in Indian concrete journal, 2003. In this paper it has been established that fly ash proves to be the best soil substitute with superior shear strength and engineering properties [8]. Fly ash has high internal friction angle, low unit mass, low compressibility, ease of compaction and also self-hardening properties. Gray (1983), Shewbridge (1989), and Bauer (1991) carried out laboratory test on certain fiber-reinforced sands and silty sands. Siva kumar Babu (2008), Salah Sadek(2010), Consoli(2011), Mohanty of unreinforced fly-ash-soil specimen and cement-stabilized specimen both [9].

A Pilot study on the mechanical behavior of soil with inclusion of polypropylene fiber and lime in IAEG2006 Paper number 637 was published by Yi Cai (2011), Chacko (2013) and Trivedi (2013)] carried out tri axial compression tests on arbitrarily distributed fiber-reinforced soils. Chemical stabilization using lime or cement is an established technique of improving the overall performance of soils. Lima (1996) reported a large increase in compressive strength with the addition of cement and lime to fiber-reinforced soils [10]. Fly ash is a Pozzolanic material and therefore its engineering performance can be improved by addition of cement or lime. However, information about the effect of fiber inclusions on the geotechnical characteristic of fly ashes is inadequate. An experimental investigation was conducted to study (i) cement stabilization on the geotechnical properties of fly ash-soil mixtures and (ii) the individual and mutual influence of arbitrarily distributed fiber reinforcement with cement stabilized fly ash soil blends. Correlations for unconfined compressive strength and secant modulus as functions of curing time, amount of fly ash, and amount of cement have been established. Correlations for water content as functions of curing time and amount of cement have also been established. In order to study the behavior of cement stabilized fiber-reinforced fly ash soil mixtures, Suratgarh and Kota fly ashes were blended with silt and sand in different ratios. The geotechnical properties of fly ash specimens containing 1.5% arbitrarily distributed polyester fiber reinforcements were studied. Unconfined compression tests (UCS) were conducted on fly ash-soil specimens prepared with 4% and 8% cement c cement and 1.5% fiber contents, after different periods of curing. The investigation shows that cement stabilization increases the strength of the unreinforced fly ash-soil specimens. The fiber reinforcement significantly changes the behavior of mix in terms of strength and ductility. There is noticeable improvement in the strength,

Bin Shi, Chaosheng Tang & Baojun Wang from Nanjing University. This paper is about the behavior of soft soil when polypropylene fiber is included in it along with lime was carried out. 6 samples were tested with different fiber ratios. It was found that this fiber increases the compressive strength & shear strength of soil because of the increase in friction between fiber and soil particles. Action between soil particles and fiber is mechanical and not chemical. Inclusion of fiber in soil also improves its plasticity and hence results the variation of failure mode from brittle to ductile failure. Maximum value of internal friction angle (37.7) and cohesion (198.6kPa) was found at 0.1% fiber in soil treated with 8% lime. Effect of polypropylene fiber and lime admixture on engineering properties of expansive soils was also studied by S. Twinkle, M.K.Sayida, Senior Lecturer, College of Engineering Trivandrum, and presented in Proceedings of Indian Geotechnical Conference, December 15-17, 2011, Kochi (Paper No.H-085). In this study black cotton soil was stabilized using lime. Optimum value of lime finds out to be 6%. Then further addition of fiber in different percentages was used to prepare a number of samples with this %age of lime in black cotton soil. It was found that inclusion of fiber increases optimum moisture content and decreases dry density. Unconfined compressive strength for lime stabilized black cotton soil has maximum value at fined compressive strength for lime (i.e., 260.16 kN/m2 which is 3 times as compared to untreated soil). CBR value also increases with the inclusion of fiber in soil. It has also maximum value at 0.75% fiber (i.e., 30.1% which is 3.19 times as compared to untreated soil). Thus, it can be concluded that polypropylene fiber enhances the shear strength properties of soil up to an optimum dosage which can be found out for specific soil by testing a number of samples [3][5][8].

III. SCOPE OF WORK

The list of topics given below could be studied further as an extension to the study. These topics are related to current developments in the field of fly ash utilization and need to be studied technically and commercially.

- Fly ash for construction of roads and embankments.
- Feasibility study of the large-scale Fly ash brick manufacturing units.
- Fly ash utilization for manufacturing of pre-Fabricated products.
- Fly ash in Aerated Autoclave Concrete.
- Considering the fly ash - lime - gypsum- sand combination idea-can be extended to manufacture cement from it.

The report is to carry out a detailed techno market evaluation of various high value-added products and applications of fly ash with a view to identify the viable technologies available in India and determine the market potential of these technologies within existing constraints. The report is to address whether fly as apart from its high-volume low technology uses could also become a resource material for various low volume but high value products and specialized applications, provided the mechanism of its formation is adequately and scientifically understood, users and manufacturers are sufficiently informed and educated and an infrastructure could be evolved for its proper characterization and grading

IV. MATERIALS USED

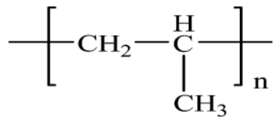
Fly ash: Is also known as flue-ash, is one of the residues generated in combustion, and comprises the fine particles that rise with the flue gases. Ash which does not rise is termed bottom ash. In an industrial context, fly ash usually refers to ash produced during combustion of coal. Fly ash is generally captured by electrostatic precipitators or other particle filtration equipment before the flue gases reach the chimneys of coal-fired power plants and together with bottom ash removed from the bottom of the furnace is in this case jointly known as coal ash. Depending upon the source and makeup of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide (Si02) (both amorphous and crystalline) and calcium oxide (CaO), both being endemic ingredients in many coal-bearing rock strata. In the past, fly ash was generally released into the atmosphere, but pollution control equipment mandated in-recent decades now requires that it be captured prior to release. In India, fly ash is generally stored at coal power plants or placed in landfills. About 43% is recycled, often used to supplement Portland cement in concrete production. Fly ash particles are generally spherical in shape and range in size from 0.5 um to 300pm. For proper operation of fly ash, physical, chemical and engineering categorization of fly ash is essential. Variability of material properties arising from different plants, same plant over period of time due to different coal supply and methods of operation of plant and variation in power generation further necessitate the need for classification of fly ash from different sources [3][5][8].

CLASS F FLY ASH: The burning of harder, older anthracite and bituminous coal typically produces Class F fly ash. This fly ash is Pozzolanic in nature, and contains less than 20% lime (CaO). Possessing Pozzolanic properties, the glassy silica and alumina of Class F fly ash requires a cementing agent, such as Portland cement, quicklime, or hydrated lime, with the presence of water in order to react and produce cementitious compounds. Alternatively, the addition of a chemical activator such as sodium silicate (water glass) to a Class F ash can leads to the formation of a geo polymer [4][6].

CLASS C FLY ASH: Fly ash produced from the burning of younger lignite or sub-bituminous coal, in addition to having Pozzolanic properties, also has some self-cementing properties. In the presence of water, Class C fly ash will harden and gain strength over time. Class C fly ash generally contains more than 20% lime (CaO). Unlike Class F, self-cementing Class C fly ash does not require an activator. Alkali and sulphate (SO4) contents are generally higher in Class C fly ashes. At least one US manufacturer has announced a fly ash brick containing up to 50% Class C fly ash [1

Polypropylene: It is a thermoplastic polymer used in a wide variety of applications including packaging, labeling, textiles (e.g., ropes, thermal underwear and carpets), stationery, plastic parts and reusable containers of various types, laboratory equipment, loudspeakers, automotive components, and polymer banknotes. It is a linear structure based on the monomer CnH2n. It is manufactured from propylene gas in presence of a catalyst such as titanium

chloride. Beside PP is a by-product of oil refining processes [5][8].
Polypropylene monomer
Most polypropylene used is highly crystalline and geometrically regular (i.e. isotactic) opposite to amorphous thermoplastics, such as polystyrene, PVC, polyamide, etc., which radicals are placed randomly (i.e. atactic).
It is said that PP has an intermediate level of crystalline



between low density polyethylene (LDPE) and high-density polyethylene (HDPE); On the other hand PP has higher working temperatures and tensile strength than polyethylene. Al- so polypropylene is resistant to fatigue, most plastic living hinges, such as those on flip-top bottles, are made from this material. However, it is important to en- sure that chain molecules are oriented across the hinge to maximize strength [7][8].

V. METHOLODGY

To determine the properties of fly ash & polypropylene, a number of tests were performed in laboratory several times, so as to have an exact value of different parameters influencing the behavior and characteristics of fly ash under different situations as well as subjected to different conditions. The major tests performed were:

- Specific Gravity Test
- Liquid Limit Test
- Standard Proctor Test
- Relative Density Test
- Direct Shear Test

VI. EXPERINMENTS & RESULTS

A. Specific Gravity Analysis for Fly Ash

Specific Gravity analysis:
G = (Wps - Wp)/{(Wps – Wp) – (Wb Wa)}
Where Wp = weight of empty pycnometer
Wps = weight of pycnometer with dry soil
Wb = weight pycnometer and soil and water
Wa = weight of pycnometer filled with water only
G = specific gravity ofsoil
Weight of empty pycnometer, (Wps) = 622.5 gm.
Weight of pycnometer and fly ash, (Wp) = 759.0 gm.
Weight of fly ash alone, (W0) = Wp - Wps = (759-622.5) = 136.gm.
Weight of pycnometer + fly ash + water, (Wa) = 1447.5 gm.
Weight of pycnometer and water, (Wb) = 1379.0 Therefore, Specific Gravity, Gs = Wo/{Wo + (Wa – Wb)}
=136.5/{136.5-(1447.5-1397)} =136.5/86 Gs = 1.58

B. Liquid Limit Test: shown in below Table 1

Table 1: Results of Liquid Limit Test

S.No.	Determination No.	1	2	3
01	No. of blows	36	20	13
02	Container no.	1	2	4
03	Mass of container + wet fly ash (gm)	28	27	45
04	Mass of container + dry fly ash (gm)	26	24.5	37
05	Mass of water (03-04) (gm)	2	2.5	8
06	Mass of container (gm)	19	18	20.5
07	Mass of dry fly ash (04-06) (gm)	7	6.5	16.5
08	Moisture content (05/07 x 100%)	28.57	38.46	48.48

Liquid limit for fly ash (34.5%) lies in the range of silt and clay of medium compressibility.
Plot a flow curve with the points obtained from each determination on a semi-logarithmic graph representing water content on the arithmetical scale and the no. of drops on the logarithmic scale.
The flow curve is a straight line drawn as nearly as possible through the four or more plotted points.
The moisture content corresponding to 25 drops as read from the curve shall be rounded off to the nearest second decimal and is reported as liquid limit of the fly ash.

C. Relative Density Test

1) Calculations

Calculate the minimum index density (Yd(min)) as follows:
Yd(min) = Ws/Vc where,
Ws = Weight of tested-dry fly ash
= weight of mold with fly ash placed loose — weight of mold
Vc = Calibrated volume of the mold
Calculate the maximum index density (Yd(max)) as follows:
Yd(max) = Ws/V
were
V = Volume of tested-dry fly ash = Vc — (Ac*H)
Ac = the calibrated cross-sectional area of the mold
H = height of sample reduced in the mould due to vibrations
Then relative density can be calculated using formula:
But in this project, we are concerned with the properties of fly ash at different relative densities. So, we will use RD — 50, 60 & 70 % to calculate the respective dry densities which will be used in other experiments.

2) Observations

Diameter of mould =15cm
Height of mould, H =17cm
Weight of mould: W1 = 10990gm
Weight of mould + fly ash: W2 = 13300gm
Initial volume of fly ash in mould, Vc= πr2h =3.14 x (15/2)2 x 17 = 3000cm3
Minimum dry density, Yd(min) = (13300-10990) / 3000 = 0.77gm/cc
Height of fly ash in mould after vibrations =13cm
Final volume of fly ash in mould Vt = Vc -Ach
Vt= 3000- {π x (15/2)2 x (17-13)}
Vt= 2297.28 cm3
Maximum dry density Yd(max) = (13300-10990) / 2297.28 = 1.005gm/cc
Now for calculating dry density of fly ash at Different relative densities (RD) sown in Table 2
Using this equation, we will calculate dry density at RD = 50%, 60% & 70%

Table-2: Dry Density of fly ash at different Relative densities

Relative density (%)	Yd (gm/cc)
50	0.8721
60	0.896
70	.921

D. Standard proctor Test:

1) Calculations

Determine weight of the mold, W1
Determine weight of the mold + compacted moist fly ash, W2 Determine weight of the compacted moist fly ash: w2-w1
Moist unit weight, Y = weight of the compacted moist fly ash / volume of mold = (W2 – W1) /1000
Determine mass of moisture can, W3
Determine mass of moisture can + moist fly ash, W4
Determine mass of moisture can + dry fly ash, W5
Compaction moisture content, Ww (%) = {(W4 – W5) x 100}/ (W5 – W3).
Dry unit weight, Yd = Y / (1 + w/100).

2) Result

Results of Standard Proctor Test of Sample 1: - 28% shown in Table 3 below:

Table 3: Standard proctor test data at 28% water content

S.No.	Determination	Units	Observe values			
01	Mass of mould	gm	4303.5			
02	Mass of mould+ Compacted fly ash	gm	5669			
03	Mass of compacted fly ash Wt =02 –01	gm	1365.5			
04	Wet densitygt=Wt/V	gm/cc	1.365			
	Crucible Number		**1**	**2**	**3**	
05	Mass of crucible + wet fly ash	gm	37	35.5	46	
06	Mass of crucible+ Dry fly ash	gm	33	3	39.5	
07	Mass of water = 05 – 06	gm	4	4.5	6.5	
08	Mass of crucible	gm	20.5	16.5	18	
09	Mass of dry fly ash = 06 - 08	gm	13.5	14.5	21.5	
10	Water content W = (07/09)*100	%	29.629	31.03	30.23	30.23
11	Dry density gd = gt/(1+W)	gm/cc	1.053	1.04	1.048	1.047

Results of Standard Proctor Test of Sample 2: - 32% shown in Table 4 below:

Table 4: Standard proctor test data at 32% water content

S. No.	Determination	Units	Observed values			
01	Mass of mould	gm	4303.5			
02	Mass of mould+ Compacted fly ash	gm	5746.5			
03	Mass of compacted fly ash Wt = 02 –01	gm	1443			
04	Wet density gt =Wt/V	gm/cc	1.443			
	Crucible Number		**1**	**2**	**3**	
05	Mass of crucible + wet fly ash	gm	32	32	9.5	
06	Mass of crucible + Dry fly ash	gm	29	29	42.5	
07	Mass of water = 05 – 06	gm	3	3	7	
08	Mass of crucible	gm	0	19	20.5	
09	Mass of dry fly ash = 06 - 08	gm	9	10	22	
10	Water content W = (07/09)*100	%	3	\\0	31.82	31.716
11	Dry density gd = gt/(1+W)	gm/cc	1.08	1.11	1.095	1.095

The Moisture content of fly ash at start of test is taken equal to 28%
and then with an increment of 4% every time.
Total mass of fly ash taken for sieve analysis = 20 kg= 20,000gm. Fly
ash retained on 20mm sieve = 100 x 107/20,000 =0.53%
Fly ash retained on 4.75mm sieve = 100 x 2127/20,000 = 10.67%
Fly ash passing from 4.75mm sieve = 100 x 17766/20,000 =88.83%

E. Direct Shear Test

1) Calculations

Shear stress is calculated from applied load S and
area under this load = t = S/ area of specimen.
Report: Graph is plotted between direct stress and
shear stress.
Angle of friction for fly ash alone and reinforce with different amount of fiber is reported at the end which is calculated using formula:

Table 5: Shear strength of Fly ash at maximum 38% dry density (Yd(max))

σ (kg/cm2)	**Initial reading (kg)**	**Highest reading (kg)**	**Load (kg) = High-est - Initial**	**T (kg/cm2) = load/area**
0.25	8.6	18.7	18.7–18.6= 10.1	10.1/36 = 0.28
0.50	9.0	20.0	20.0 -9.0 = 11.0	11.8/36= 0.32
1.00	12.1	28.1	28.1–12.1= 16.0	16.0/36 = 0.444

(1) Dry density (at RD = 50%) = 0.8721 gm/cc, (2)Weight of sample = 90 x 0.8721 = 78.49 = 79 gm

Table 6: Shear strength of Fly ash at RD = 50%

σ (kg/cm^2)	**Initial reading (kg)**	**Highest read-ing (kg)**	**Load(kg) = Highest - Initial**	**τ (kg/cm^2) = Load/Area**
0.25	7.5	11.4	11.4–7.5= 3.9	3.9/36 = 0.11
0.50	7.8	14.0	14.0–7.8= 6.2	6.2/36 = 0.17
1.00	7.9	16.2	16.2–7.9= 8.3	8.3/36 = 0.23

(1) Dry density (at RD = 60%) = 0.896 gm/cc, (2) Weight of sample = 90 x 0.8721 = 80.64 gm

Table 7: Shear strength of Fly ash at RD = 60%

σ (kg/cm^2)	**Initial reading (kg)**	**Highest reading (kg)**	**Load(kg)=Highest - Initial**	**τ (kg/cm^2) = Load/Area**
0.25	7.9	4.0	14.0–7.9= 6.1	6.1/36 = 0.17
0.50	8.2	5.5	15.5–8.2=7.3	7.3/36 = 0.202
1.00	7.4	7.6	17.6–7.4=10.2	10.2/36 =0.283 ..

After that direct shear tests are also performed for Fly ash mixed with polypropylene fiber. Fly ash at different dry densities is mixed with different ratios of along with fiber. Fiber is used as replacement of same %age of fly ash from the sample. Different ratios of PP fiber used with fly ash are given in the table below. As the volume of direct shear box is 90cm3, so the weight of sample is calculated and shown in Table 8 below:

Table 8: Calculation of weight of fly ash for different shear tests RD (%)Total weight of sample (Fly ash)

+PP).ol;(gm)	**PP fiber**	**Weight of fiber (gm)**	**Weight of fly ash(gm)**	
50	79	.5	0.395	78.605
		0.75	0.592	78.407
		1.0	0.790	78.210
60	80.64	5	0.403	80.237
		0.75	0.605	90.035
		1.0	0.806	79.834
70	83	0.5	0.415	82.585
		0.75	0.622	82.377
		1.0	0.830	82.170

Direct shear test is conducted for different densities of fly ash alone and with polypropylene also. First test was conducted for fly ash alone at its MDD found in standard proctor test. Type of tests conducted is Un drained Unconsolidated test (UU TEST). For this test direct shear box, we have:
Area of box = 6 x 6 = 36 cm2
Volume of sample = 36 x 2.5 = 90 cc,Max dry density = 1.097 gm/cc,Weight of sample = 90 x 1.097 = 98.6 gm, Weight of water = 38/100 x 98.6 =38 ml (at OMC=38% of sample weight. Result of Shear strength at 38% Dry density is shown in Table 5 below & Table 6 shows the Shear strength of Fly ash at Dry Density = 50%,Table 7 shows the Shear strength of Fly ash at RD = 60%
Table 9 shows the Shear strength of Fly Ash at Dry Density with various PP Fiber Ratio
Table 10 shows the Shear strength of Fly ash at RD = 60% with varying PP ratio % PP Fiber.

Table 9: Shear strength of Fly ash at RD with varying PP ratio

% PP Fiber	**σ (kg/cm²)**	**Initial reading**		**Highest reading**	**Load(kg) = Highest-Initial**	**τ(kg/cm2)load /Area**
0.5	0.25	12.4		17.3	4.9	0.136
	.50	13.4		20.4	7.0	0.194
	1.00	11.6		19.5	7.9	0.22
0.75	0.25	10.5		17.2	6.7	0.186
	.50	11.3		18.7	7.4	0.205
	1.00	15.8		24.6	8.8	0.244
1.0	0.25	11.8		20.5	8.7	0.241
	0.50	12.1		21.6	9.5	0.265
	1.00	11.7		24.1	12.4	0.344

Table 10: Shear strength of Fly ash at RD = 60% with varying PP ratio % PP Fiber

%PP fiber	**σ(kg/cm²)**	**Initial reading**	**Highest reading**	**Load(kg)=Highest-Initial**	**τ(kg/cm²) = Load/Area**
0.5	0.25	11.2	17.1	5.9	0.164
	0.50	11.8	19.1	7.3	0.202
0.75	0.25	12.3	19.5	7.2	0.202
	0.50	13.1	21.1	7.9	0.221
	1.00	11.2	20.2	9.0	0.251
1.0	0.25	12.1	19.3	9.0	0.251
	0.50	12.4	21.1	10.6	0.294
	1.00	12.9	25.6	12.7	0.352

VII. DISCUSSION OF RESULTS

Specific gravity of fly ash is calculated to be 1.58, which is comparable to fine soils (clay and silt). Liquid limit for fly ash (34.5%) lies in the range of silt and clay of medi- um compressibility. Standard Proctor test shows the MDD for fly ash is 1.097 & OMC is 32.5%. OMC for fly ash is much higher as compared to sand and clay. Normally all kind of soil have OMC less than 20%. Effect of relative density on the shear strength of fly ash is shown in table 10. It is clear that with the increase in RD shear strength increases. Thus, with more compaction more stability can be attained in fly ash. With the addition of polypropylene fiber in fly ash, its strength increases. At a specific RD, with different ratios of fiber and fly ash, change in shear parameters is there, which shows the positive effect of addition of this fiber in fly ash.

VIII. CONCLUSION

The project was that fly ash can be used as a construction material. Our results do support our hypothesis. We think that the tests which we did went smoothly and had no problems except for the fact that the same test was repeated several times by different members of group which might increase the possibility of human error. Therefore, we had to take the measurements quickly. Fly ash utilization in the country has remained less than 10% during the past 5 years and it might take several years to reach the final goal of cent percent utilization. Every year nearly 70 million tons of ash is produced in India, of which NTPC stations alone contribute to the extent of about 22 million tones. To utilize such a huge quantity of ash, we have to take necessary actions from government side and from non-government side for utilization point of view.

In the tests performed, we observed that fly ash properties resemble properties of a good filler material in embankments and similar other applications. It possesses good shear strength when mixed with polypropylene fiber. Also, fly ash possesses maximum angle of shear resistance at RD-70% and PP content of 1%.

Thus, we can conclude that use of fly ash reinforced with PP fiber is possible in several fields of construction industry. As PP fiber enhances the properties of fly ash, it can be used in high value works also, with a specific ratio of fly ash and fiber.

CONFLICTS OF INTREST

The author declares that they have no conflicts of interest.

REFERENCES

[1] Singh, P., Singla, S. and Bansal, A., 2021. Evaluation of Land Use and Land Cover Transformation and Urban Dynamics Using Multi-Temporal Satellite Data. Geodetski list, 75(3), pp.257-279.

[2] Kumar, A., Singla, S., Kumar, A., Bansal, A. and Kaur, A., 2022. Efficient Prediction of Bridge Conditions Using Modified Convolutional Neural Network. Wireless Personal Communications, pp.1-15.

[3] Singh, A., Singla, S. and Garg, R., 2020, November. Performance analysis of Papercrete in presence of Rice husk ash and Fly ash. In IOP Conference Series: Materials Science and Engineering (Vol. 961, No. 1, p. 012010). IOP Publishing.

[4] Ashraf, S., Kaur, S. and Singla, S., 2022. Water Quality Assessment of Anchar Lake, Srinagar, India. Civil and Environmental Engineering Reports, 32(1), pp.88-115.

[5] Ahmad, Uzair. (2018). A Study on Effect of Polymers on the Properties of Vg-10 Grade Bitumen. International Journal for Research in Applied Science and Engineering Technology. 6. 2572-2576. 10.22214/ijraset.2018.4433.

[6] Singh, J., Singh, B. and Singla, S., Enhancement of Expensive Soil by Addition of Stone Dust and LDPE Fibre.

[7] Singh, P. and Singla, S., 2023. Estimation of Land Surface Temperature of Srinagar City, India Using Landsat 8 Data. Sustainability, Agri, Food and Environmental Research, 12(1).

[8] Irshad, U and Singla, S.,2019 "Impact of Road Conditions on Traffic Management-A Case Study of Chenab Valley." International Journal of Scientific & Technology Research 8 1179-1186.

[9] IS Codes: (1987) Compendium of Indian Standards on Soil Engineering. Part-I, Bureau of Indian Standards November, New Delhi, India.

[10] S. Twinkle, M.K. Sayida; Effect of polypropylene fiber and lime admixture on engineering properties of expansive soil; Proceedings of Indian Geotechnical Conference December 15-17- 2011, Kochi (Paper No.H-085)