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Studies on Strength Characteristics of Pond Ash Replaced Fibre Reinforced Pavement Quality Concrete

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ABSTRACT
Energy consumption and generation is increasing day by day due to rapid industrialization & urbanization. A major portion of the energy is generated by Thermal Power Plants. Pond ash (PA) and other by-products from these plants are disposed in large quantities. Pond ash utilization helps to reduce the consumption of natural resources. Hence there is scope for using Pond ash as Fine Aggregate (FA). Use of alternative material in concrete such as industrial by-products like Coal Ash (Fly Ash and Pond Ash) is eco-friendly.
This study reports the results of experimental studies carried out on the use of Pond ash as Fine Aggregate (FA) in concrete with and without fibre reinforcement. The properties of Pond Ash were compared to the standard sand. The pond ash added by weight is 10%,20%,30%,40%,50% and 60% respectively as replacement of FA in concrete and 2% low tensile steel fibre was used for reinforcement. Experiments carried out indicate that Pond ash as partial replacement of sand has beneficial effect on the mechanical properties. The strength properties are determined for various percentages (10-60%) of replacement of Fine Aggregate with Pond ash with and without fibre reinforcement. The test results indicate that the optimum PA replacement is 20% for both the cases.

I. INTRODUCTION

Use of industrial by-products in concrete will lead to green environment and such concrete can be called as “Green Concrete”. There are various types of industrial wastes which can be considered for usage in concrete. The most commonly used industrial waste to replace sand and cement in concrete are Fly Ash, Rice Husk Ash, Blast Furnace Slag, Pond ash, Red Mud and Phosphor, Gypsum, Silica Fume, Fumed silica, Crushed glass, Eggshells.

India depends primarily on coal for the requirement of power and its power generation and it is likely to go up with each passing day. The fly ash generation in Indian Thermal Stations is likely to shoot up to several million tonnes. The disposal of fly ash will be a huge problem to environment, especially when the quantity increases from the present level.

Ash is the residue generated after combustion of coal in Thermal Power Plants. Size of the particles of ash varies from 1 micron to 600 microns. The very fine particles (Fly ash) collected from this ash collected by electrostatic precipitators are being used in the manufacture of blended cements. Unused Fly ash and Bottom ash (residue collected at the bottom of furnace) are mixed in slurry form and deposited in ponds which are called as Ash ponds.

Hence worldwide research work is focused to find alternative use of this waste material and its use in concrete industry is one of the effective methods of utilization. Increase in demand and decrease in natural resource of fine aggregate for the production of concrete has resulted in the need of identifying a new source of fine aggregate. The possibility of utilization of Thermal Power Plant by-product Pond ash, as replacement to fine aggregate in concrete is taken into consideration.

1.1 Pond Ash Applications

Pond ash has potential uses in the following areas. (Source: Raichur Thermal Power Plant, Karnataka, India).

- Pond ash is suitable as Fine aggregate in the manufacture of concrete masonry units (CMU) and similar products.
- It is suitable for back filling of low lying areas (abandoned mines).
- Suitable for saline soil/waste land reclamation.
- Appropriate quantity of Pond ash can increase production of agriculture, horticulture and forestry.
- It is suitable for stabilization of soil with appropriate amount of cement/lime & decrease the cost of foundation & pavement.
- Suitable for filing of Reinforced Earth (RE), wall pavements and flyover approaches.

1.2 Fibre Reinforced Concrete (Frc)

Fibre reinforced concrete (FRC) is defined as a composite material made with Portland cement, aggregate and incorporating discrete discontinuous fibres. Plain unreinforced concrete is brittle material, with a low tensile strength and low strain capacity.

The role of randomly distributed discontinuous fibres is forming bridge across the cracks that develop and provides post-cracking (ductility). If the fibres are sufficiently strong, sufficiently bonded to material and permit the FRC to carry significant stresses over a relatively large strain capacity in the post-cracking stage. The real contribution of the fibres is to increase the toughness of the concrete under any type of loading. That is, the fibres tend to increase the strain at peak load and provide a great deal of energy absorption of post-peak portion of the load Vs deflection curve.

1.3 Objectives Of The Study

The objectives of the present study are

- To determine the physical properties of ingredients of pond ash replaced concrete.
- To arrive at mix design and calculate the quantity of constituents of concrete.
- To determine the strength properties of pond ash replaced concrete for reinforcement and unreinforced conditions.
- To arrive at the percentage of pond ash showing maximum strength properties for both the conditions.
- Comparison of the results of reinforced and unreinforced pond ash replaced concrete.

II. EXPERIMENTAL STUDIES

2.1 Cement

Ordinary Portland cement of 53 Grade confirming to IS 12269-1987 is used in the study. The physical properties of Cement are shown in the Table 2.1

Table 2.1 Physical Properties of Cement

Sl NO.	Test	Results Obtained	Required results as per IS 12269-1987
1	Normal consistency, %	31	26-33
2	Setting time, Initial setting time, mins Final setting time, mins	 85 340	 > 30 < 600
3	Fineness modulus	3.4	≤10% of wt
4	Specific gravity	3.14	2.99-3.15

2.2 Fine Aggregate

Locally available good quality river sand is used in this investigation. The tests conducted on fine aggregates and the results obtained are presented in Table 2.2, Table 2.3 and Fig 2.1.

Table 2.2 Sieve Analysis of Fine Aggregate

IS sieve No	Percent finer	Percentage Passing			
		Grading Zone-I	Grading Zone-II	Grading Zone-III	Grading Zone-IV
10 mm	100	100	100	100	100
4.75 mm	93.8	90-100	90-100	90-100	95-100
2.36 mm	84.8	60-95	75-100	85-100	95-100
1.18 mm	73.6	30-70	55-90	75-100	90-100
600 µ	38.6	15-34	35-59	60-79	80-100
300 µ	11.2	5-20	8-30	12-40	15-50
150 µ	2.6	0-10	0-10	0-10	0-15

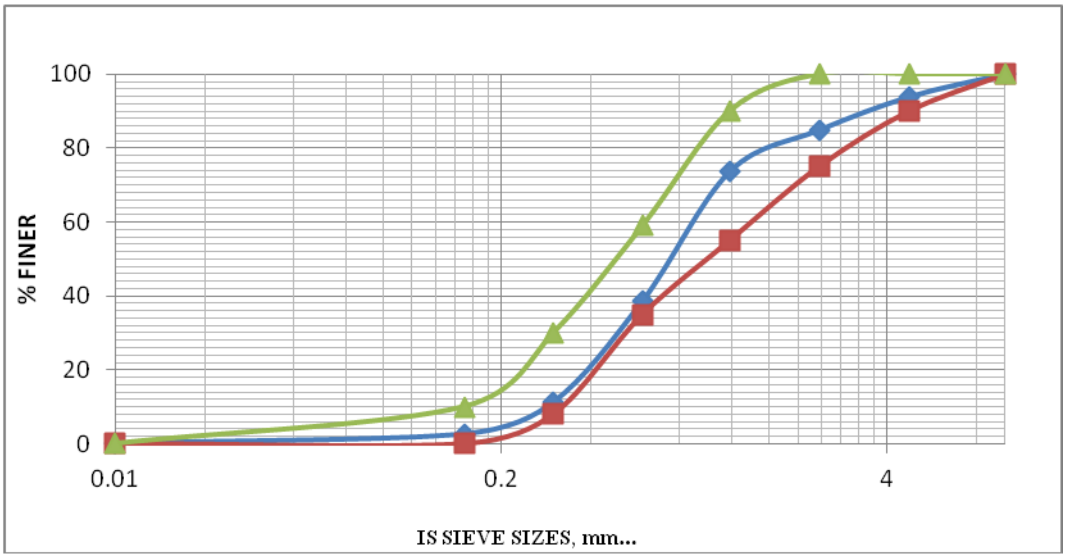

Fig. 2.1 Particle size distribution for natural sand

FM=295.5/100=2.95
Fine aggregate confirming to Zone II as per IS 383-1970.

Table 2.3 Fine Aggregate Physical Test results

Sl No.	Physical Tests	Results Obtained
1	Fineness modulus	2.95
2	Specific gravity	2.63
3	Bulk density, Loose state, g/cc Dense state, g/cc	1.377 1.480

2.3 Pond Ash

The Pond Ash used in this experimental is procured from Raichur Thermal Power Plant Karnataka India. Sieve analysis for the same was done to find the particle size distribution. The tests conducted on Pond ash and the results are presented in the Table 2.4, Table 2.5 and Fig. 2.2

Table 2.4 Sieve Analysis of Pond Ash

IS sieve No	Percent finer	Percentage Passing			
		Grading Zone-I	Grading Zone-II	Grading Zone-III	Grading Zone-IV
10 mm	100	100	100	100	100
4.75 mm	100	90-100	90-100	90-100	95-100
2.36 mm	99.5	60-95	75-100	85-100	95-100
1.18 mm	92.1	30-70	55-90	75-100	90-100
600 µ	74.54	15-34	35-59	60-79	80-100
300 µ	28.62	5-20	8-30	12-40	15-50
150 µ	6.54	0-10	0-10	0-10	0-15

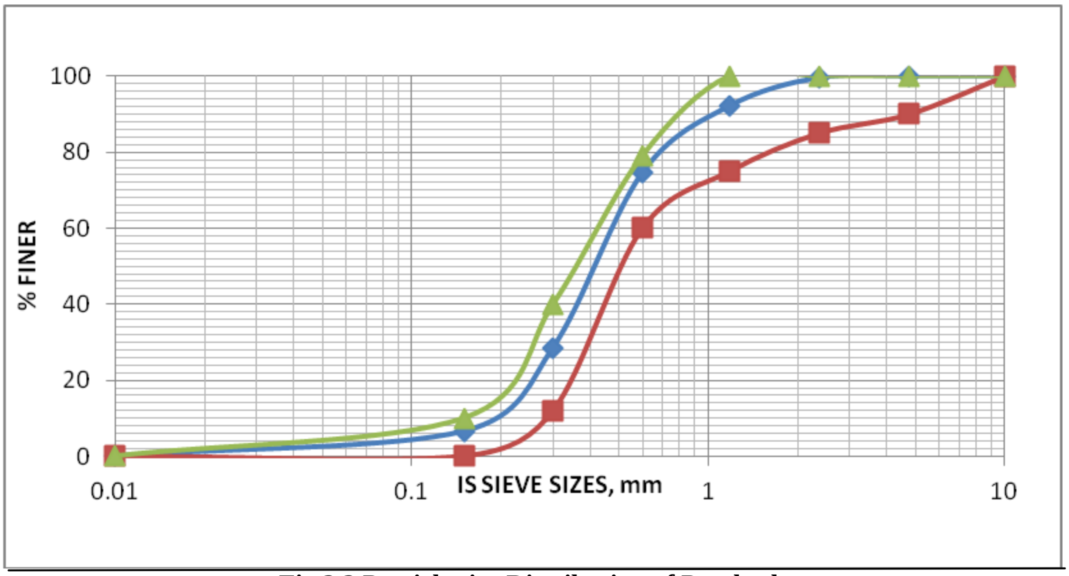

Fig.2.2 Particle size Distribution of Pond ash

FM= 301/100=3.01
The pond ash is confirming to Grade III as per IS 383-1970

Table 2.5 Pond Ash Test Results

Tests	Results obtained
Fineness modulus	3.01
Specific gravity	1.69
Water absorption,%	0.4

2.4 Pond Ash Mixed With Natural Sand

Sieve analysis tests were conducted for pond ash dry mixed with the fine aggregate. The particle size distribution of Pond ash replacement (PA-10, PA-20, PA-30, PA-40, PA-50, PA-60) was determined as per IS 383-1970.

Table 2.6 Sieve Analysis of Pond Ash mixed with Sand

S.NO	Sieve size	Percent Passing					
		PA-10	PA-20	PA-30	PA-40	PA-50	PA-60
1	4.75 mm	94.60	95.90	97.86	99.60	100	100
2	2.36 mm	98.63	98.92	97.38	98.12	99.80	99.80
3	1.18 mm	75.32	77.45	80.65	90.12	90.52	93.56
4	600µ	50.04	58.25	56.86	75.86	73.02	79.90
5	300µ	22.94	24.68	30.10	40.56	44.18	55.72
6	150µ	7.62	8.93	10.3	15.20	20.44	28.94
Grading Zone		**II**	**II**	**II**	**III**	**IV**	**IV**

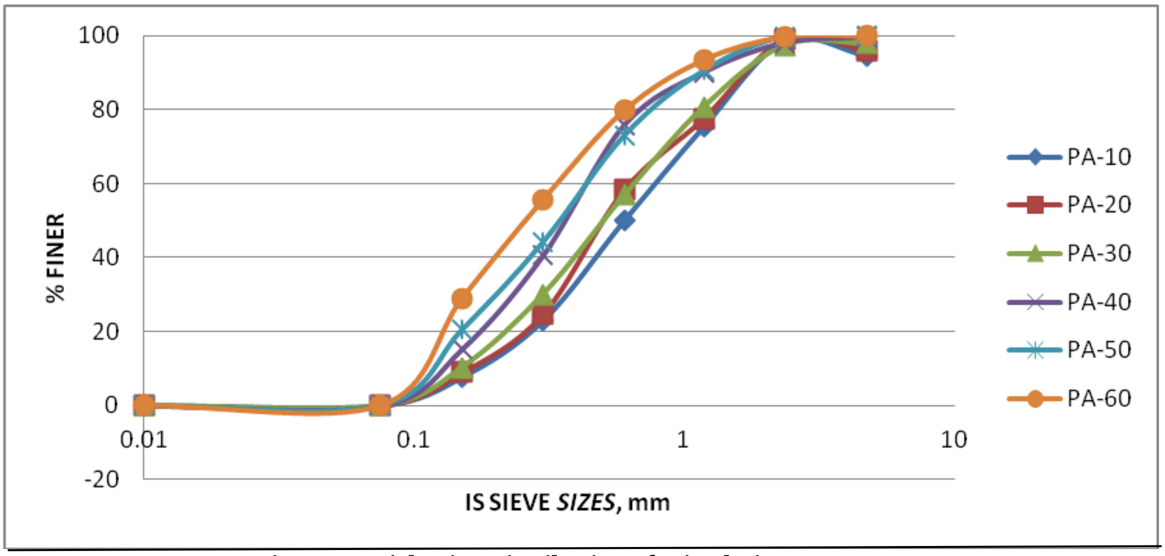

Fig 2.3 Particle Size Distribution of mixed Fine aggregate

The sieve analysis results of the PA-10, PA-20 and PA-30 confirm to Zone II, PA-40 confirms to Zone III, PA-50 and PA-60 confirm to Zone IV as per IS 383-1970.

2.5 Coarse Aggregate

Locally available crushed aggregate passing through 20mm and retained on 10mm IS sieve were used. The tests conducted and the results obtained are presented in the Table 2.7

Table 2.7 Coarse Aggregate Test results

Tests	Results obtained	Required results as per IS 383
Specific gravity	2.64	-
Water Absorption, %	0.3	2 max
Bulk density, Loose state, g/cc Dense state, g/cc	1. 463 1.687	-
Impact value,%	22.63	30 max
Crushing value,%	25.23	30 max
Los Angeles Abrasion value,%	25.38	35 max

2.6 Super-Plasticizer

Pond Ash is a material that requires larger amount of water which affects workability. To get a good workable mix the water content should be increased, which affects the water-cement ratio which in turn affects the strength. The alternative option is to use a water reducer. Super plasticizer is an excellent water reducing agent. Therefore Polycarboxylic ether (PCE) based super-plasticizer (Glenium 3030) is used.

2.7 STEEL FIBER

Low tensile steel fiber cut into small pieces of aspect ratio of 50 and 2% by weight of concrete is used in the concrete.

2.7 Flow Table Test

Flow test is conducted to arrive at optimum dosage of Super-Plasticizer for all the replacements of pond ash using truncated cone. Then for every dosage of admixture the slump value was also tested and the slump values are as in Table 2.8, and Fig 2.4

Table 2.8 Dosage of Super-Plasticizer

Type	PA-10	PA-20	PA-30	PA-40	PA-50	PA-60
Super-plasticizer %	0.40	0.425	0.45	0.5	0.6	0.8
Slump value, mm	20	18	19	23	21	24

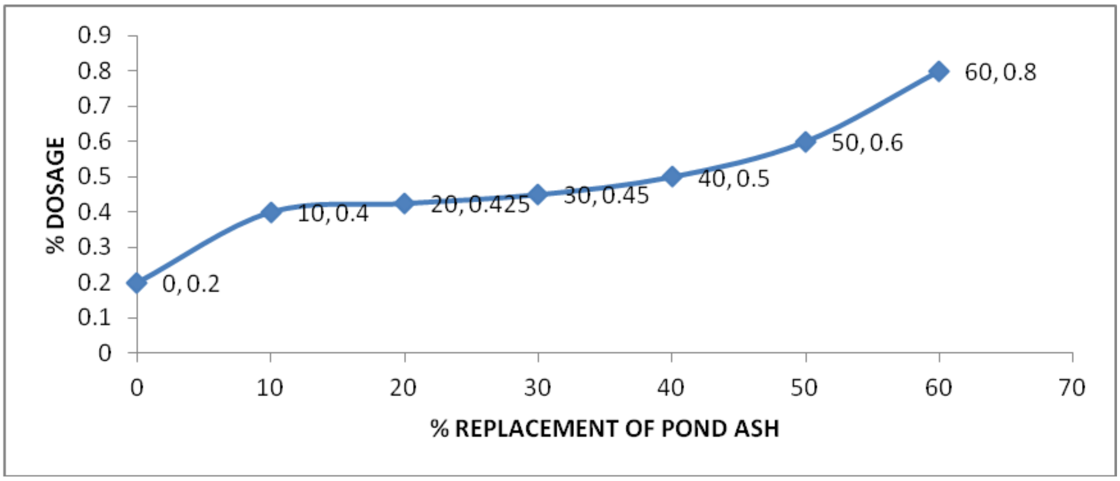

Fig 2.4 S-P Dosage Vs. percentage replacement of Pond ash

2.8 Mix Proportions

To arrive at the mix proportion of Pond Ash replaced concrete, IRC:44-2009 method was adopted. The mix proportions arrived at, are shown in Table 2.9.

Table 2.9 Mix Proportions (Weight, Kg per m^3 of Concrete)

Type	Cement	Fine Aggregate	Pond Ash	Coarse Aggregate	Water	Super-plasticizer Dosage %
PA-0	416	673.00	---	1200.77	158.1	0.200
PA-10	416	605.59	43.10	1200.77	158.1	0.400
PA-20	416	538.40	86.14	1200.77	158.1	0.425
PA-30	416	471.10	129.22	1200.77	158.1	0.450
PA-40	416	403.80	172.30	1200.77	158.1	0.500
PA-50	416	336.40	197.70	1200.77	158.1	0.600
PA-60	416	269.20	237.20	1200.77	158.1	0.800

III. ANALYSES OF DATA

3.1 Compressive Strength

Compressive strength of concrete is defined as the load which causes the failure of specimen, per unit area of c/s in uniaxial compression under given rate of loading. The compressive strength tests are conducted for the cubes after 3, 7, 28 and 56 days of curing and the results obtained are in the Table 3.1 and Fig 3.1

Table 3.1 Compressive Strength of PA replaced concrete at various curing days

Days of curing	Compressive Strength, N/mm^2					
	PA-10	PA-20	PA-30	PA-40	PA-50	PA-60
3	28.29	25.93	23.11	18.37	17.03	14.75
7	33.13	32.02	29.31	25.60	23.33	20.15
28	39.01	37.63	32.89	31.12	28.81	22.96
56	42.66	43.07	35.46	33.56	31.67	26.04

Table 3.2 Compressive Strength of PA replaced FRC concrete at various curing days

Days of curing	Compressive Strength, N/mm^2					
	PA-10	PA-20	PA-30	PA-40	PA-50	PA-60
3	30.16	27.52	24.41	19.12	17.72	15.02
7	35.64	34.42	30.94	26.64	24.47	21.18
28	45.26	41.52	35.05	33.02	30.27	23.96
56	47.93	48.36	39.01	36.82	34.42	27.66

3.1.1 ***Discussion***

It is observed that the compressive strength of the concrete with 10% Pond ash replacement as Fine aggregate has higher strength for 3,7 and 28 days of curing but the strength is higher for 20% replacement for 56 days of curing. The same trend is observed for FRC as well. The percentage increase in compressive strength of FRC over the unreinforced pond ash replaced concrete is marginal.

3.2 Flexural Strength

Flexural strength is the measure of the tensile strength of concrete. It is the measure of the resistance of the beam for failure in bending. Flexural strength can be determined by Dynamic & Static Flexural strength tests. Static flexural strength is adopted for the testing of the beam specimens. The Flexural strength tests are conducted for the beams after 28 days of curing and the results obtained are in the Table 3.2 and Fig 3.2

Table 3.2 Flexural Strength of PA replaced concrete at 28 days curing

Specimen	Flexural Strength, N/mm^2					
	PA-10	**PA-20**	**PA-30**	**PA-40**	**PA-50**	**PA-60**
PA replaced Concrete	4.23	4.57	3.89	3.85	3.68	3.30
PA replaced FRC Concrete	6.44	6.60	4.91	4.88	4.32	3.73

3.2.1 ***Discussion***

The Flexural strength of the Pond ash replaced concrete decreases with increase in the percentage of replacement but PA-20 shows maximum flexural strength. The same trend is observed for FRC as well. The percentage increase in flexural strength of FRC over the unreinforced pond ash replaced concrete is substantial, since the steel fiber improves the tensile strength of the concrete.

IV. CONCLUSIONS

Based on the investigations carried out the following conclusions were drawn.

- The physical properties of the constituents of the Pond ash replaced concrete satisfy the requirements as per respective codes.
- Workability of concrete decreases with the increase in Pond ash and introduction of fibre, hence the super-plasticizer Glenium-3030 is used in increasing dosage as the Pond ash percentage replacement increases.
- Strength gain in Pond ash replaced concrete and Pond ash replaced FRC decreases with the increase in Pond ash replacement for 28 days of curing but the strength is higher for 20% replacement for 56 days of curing.
- The compressive strength and flexural strength of 10% Pond ash replaced concrete is found to be highest after 3, 7 and 28 days of curing but the compressive strength for 56 days is found to be slightly higher for 20% pond ash replacement than 10% replacement.
- There is a marginal increase in the compressive strength and substantial increase in flexural strength of FRC when compared to Pond ash replaced concrete.

REFERENCES

[1] **Arumugam K Ilangovan, James Manohar**, *"A Study on Characterization and use of Pond Ash as Fine aggregate in Concrete"* International Journal of Civil and Structural Engineering Volume 2, No 2, 2011

[2] **Bhangale. P .P, Nemade. P. M**, *" Study of Pond ash (BTPS) use as Fine Aggregate In Cement Concrete - Case Study"* International Journal of Latest Trends in Engineering and Technology (IJLTET) ISSN: 2278-621X Vol. 2 Issue 2 March 2013.

[3] **Bharathi Ganesh, Sharada Bai .H, Nagendra. R and Narendra. B. K** *"Characterization of Pond Ash as Fine Aggregate in Concrete"* proceedings of International Conference on Advances in Architecture and Civil Engineering (AARCV 2012), 21st – 23rd June 2012, Paper ID SAM189, Vol. 1

[4] **Jay Patel, Kunal Patel, Gaurav Patel**, Department of Structural Engineering, B.V.M, Gujarat, India *"Utilization of Pond Fly Ash as a partial replacement in Fine Aggregate with using Fine Fly Ash and Alccofine in HSC"* International Journal of Research in Engineering and Technology (IJRET) Volume: 02 Issue: 12, Dec-2013.

[5] **Gaurav Kantilal Patel, Jayeshkumar Pitroda**, B.V.M. Engineering College, Vallabh Vidhyanagar, Gujarat India *"Assessment of Natural Sand and Pond Ash in Indian Context"* International Journal of Engineering Trends and Technology (IJETT) – Volume 4 Issue 10 - Oct 2013

[6] **Patil Shweta, Rupali Kavilkar**, *Gogte Institute of Technology, Belgaum,*

Karnataka, "Study of Flexural Strength in Steel Fibre Reinforced Concrete" IJRDET **(ISSN 2347 - 6435 (Online) Volume 2, Issue 5, May 2014.**

[7] **Bang. R. S, Ghugal. Y. M, Pateriya. I .K,** Civil Engineering Dept., Government Polytechnic, Jalna, India ,APMD, Government College of Engineering, Aurangabad, 431005, India *"Strength Performance of Pond Ash Concrete"* International Journal of Earth Sciences and Engineering ISSN 0974-5904, Volume 05,No.01February 2012.

[8] **Waysal. S. M, Dhake1. P. D and Kadam. M .P** research paper on *"Effect on Concrete properties by replacement of Sand as Thermal Power Plant Pond Ash"* International Journal of Structural and Civil Engineering Research (IJSCER**),** Vol. 3, No. 2, May 2014**.**

[9] **Amit Rana** Adhoc Lecturer, Sarvajanik College of Engineering & Technology, Surat "Some Studies on Steel Fiber Reinforced Concrete" *IJETAE* Volume 3, Issue 1, January 2013.

[10] **Milind P. Bhamare, Yogesh N. Bafna and Arun K. Dwivedi** *"Engineering Properties of Cement containing Pond ash"* IOSR Journal of Engineering (IOSRJEN)" Volume 2, Issue 10 October 2012.