VFSTR Journal of STEM Vol. 03, No. 01 (2017) 2455-2062

Engineering/Science/Technology Civil/GET/TE

# Studies On Strength Charactristics Of Pond Ash Replaced By Fine Aggregate In Pavement Quality Concrete

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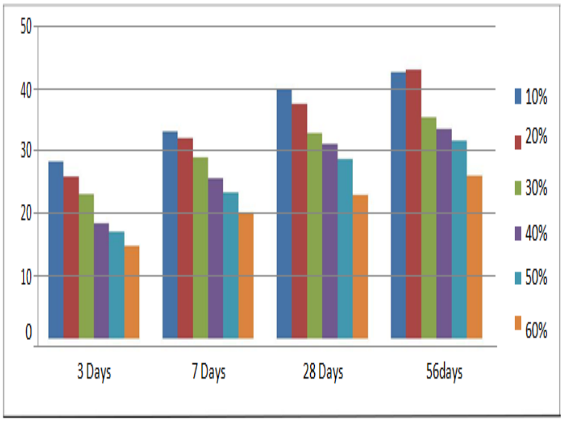
***ARTICLE HISTORY***
*Received: 30 Mar 2017*
*Revised: 15 Apr 2017*
*Accepted: 25 Apr 2017*
*Available online: 10 Jun 2017*

***GRAPHICAL ABSTRACT***




**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. In current scenario using natural sand is costlier due to the increased demand and limited supply. 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. It is also the social responsibility of researchers to encourage the beneficial use of industrial by- products in order to preserve resources, conserve energy and reduce or eliminate the need for disposal of industrial waste in landfills.**

**This study reports the results of experimental studies carried out on the use of Pond ash as Fine Aggregate (FA) in concrete. 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. 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. The test results indicate that the workability of pond ash concrete can be improved and the strength characteristics are comparable to those of conventional concrete.**

***Key words*— Expansive soil; Ground Granulated Blast Furnace Slag; CBR, Standard Proctor; Unconfined compression test.**



2455-2062 | http://dx.doi.org/xx.xxx/xxx.xxx.xxx |

## 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 known as Ash ponds. Most of the Thermal Power plants in Indian adopt wet methods of disposal and storage of the ash in large ponds and dykes. In the wet method, both the Fly ash collected from electrostatic precipitators and the bottom ash are mixed with water and transported to the ponds in a slurry form. Fly ash collected through hoppers has been widely accepted as pozzolonic and is being used by the construction industry. Pond ash being coarser and less pozzolonic is not being used, or more importantly in places where the fine aggregate is contaminated with harmful chemicals such as sulphates and chlorides and pond ash accumulation posing environmental hazards.

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.

## II. LITERATURE REVIEW

In the concrete since the compressive and flexural strength properties of the pond ash replaced concrete are satisfactory. It also solves the problem of disposing of the Thermal Power Plants by-products to a greater extent. It makes up for the shortage of natural sand availability, also reduces the cost of disposing and the environmental hazard due to Ash ponds. The cost of construction can also be reduced considerably. Hence there is a need to conduct experimental investigations to study the applicability of Pond ash in Pavement Quality Concrete.

## III. EXPERIMENTAL STUDIES

*A. Cement:*

Various kinds of cements available in the market are OPC, Rapid hardening cement, Sulphate resisting cement etc. These are used for different conditions. 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 3.1

**Table 3.1.Properties of Soil**

| Test | Results Obtained | Results (IS 12269) |
|---|---|---|
| Normal consistency, % | 31 | 26-33 |
| Setting Time (Initial, Final) | (85, 340) | ( >30, <600) |
| Fineness modulus | 3.4 | (<10 % of weight) |
| Specific gravity | 3.14 | 2.99-3.15 |

*B. Fine aggregate*

Locally available good quality river sand is used in this investigation. The tests conducted on fine aggregates and the results obtained are shown in Table 3.2, Table 3.3 and Fig 3.1

**Table 3.2. 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 |

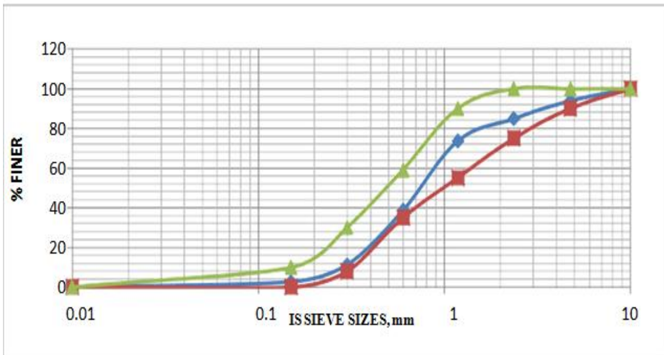



**Fig 3.1 Particle size distribution for natural sand**

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

**Table 3.3 Fine Aggregate Physical Test results**

| Physical Tests | Results Obtained |
|---|---|
| Fineness modulus | 2.95 |
| Specific gravity | 2.63 |
| Bulk density, Loose state, g/cc | 1.377 |
| Dense state, g/cc | 1.480 |

*C. Pond ash*

The Pond Ash used in this experimental is procured from Raichur Thermal Power Plant. Sieve analysis for this pond ash was done to find the particle size distribution. The tests conducted on Pond ash and the results are in the Table 3.4, Table 3.5 and Fig. 3.2

**Table 3.4 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 |

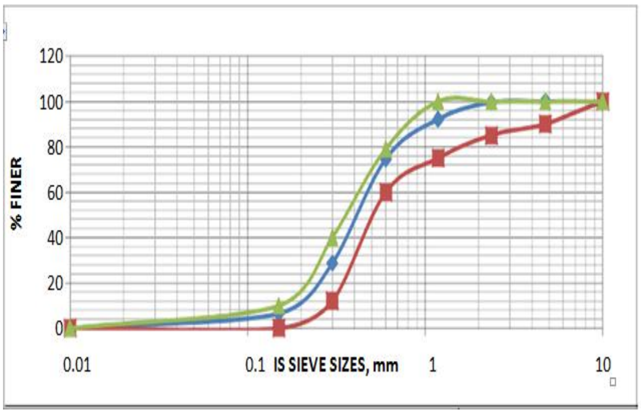



**Fig 3.2 Particle size Distribution of Pond ash**

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

**Table 3.5 Pond Ash Test Results**

| Tests | Results obtained |
|---|---|
| Fineness modulus | 3.37 |
| Specific gravity | 1.69 |
| Water absorption,% | 0.4 |

*D. 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 3.6 Sieve Analysis of Pond Ash mixed with Sand**

| S. NO | Sieve size | 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 |

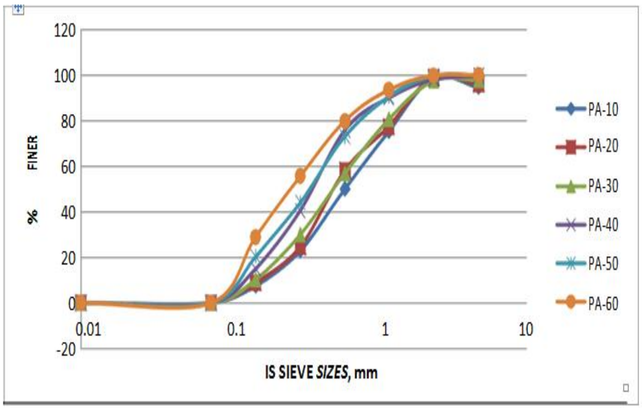



**Fig 3.3 Particle Size Distribution of mixed Fine aggregate**

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.

*E. Coarse aggregate*

Locally available crushed aggregate passing through 20 mm and retained on 10 mm IS sieve were used. The tests conducted and the results obtained are in the Table 3.7

**Table 3.7 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<br>Dense state, g/cc | 1. 463<br>1.687 | - |
| Impact value,% | 22.63 | 30 max |
| Crushing value,% | 25.23 | 30 max |
| Los Angeles Abrasion value,% | 25.38 | 35 max |

*F. 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.

*G. 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 3.8, and Fig 3.4

**Table 3.8 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 |

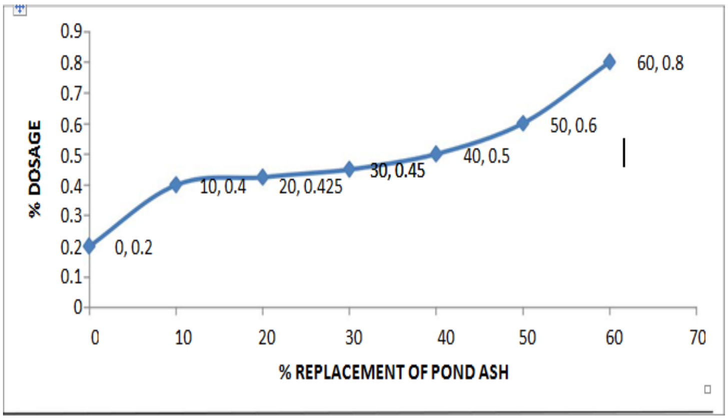



**Fig 3.4 S-P Dosage for percent replacement of Pond ash**

*H. 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 3.9.

**Table 3.9 Mix Proportions (Weight, Kg per m3 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 |

*H. Casting and curing of specimens:*

A total of seventy two cube specimens of dimensions 150X150X150 mm are cast to determine compressive strength of concrete, eighteen beams specimens of dimensions 500X100X100 mm are cast to determine flexural strength of concrete. Ingredients were taken as per the mix design mentioned in Table 3.9. The mixing procedure adopted in this study is as follows,

- Sand and Pond ash were dry mixed until it was thoroughly blended.
- Cement was added to F.A and dry mixed till a uniform colour is obtained.
- Coarse aggregate was then added and mixed.
- Calculated amount of plasticizer was added to the water and stirred thoroughly.
- The water-plasticizer mix is then mixed with the other ingredients and mixed properly till a uniformly mixed concrete is attained.
- Then concrete was filled in moulds in 3 layers by tamping with the use of tamping rods.
- After compaction, the top most layer of the concrete was smoothened using the trowel.
- The test specimens were placed in humid environment for 48 hours.
- The specimens were demould and cured for the period of 3, 7, 28 and 56 days.

## IV. ANALYSIS OF DATA

*A. 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 4.1 and Fig 4.1

**Table 4.1 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 |

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| | | | | | | |
|---|---|---|---|---|---|---|
| 56 | 42.66 | 43.07 | 35.46 | 33.56 | 31.67 | 26.04 |

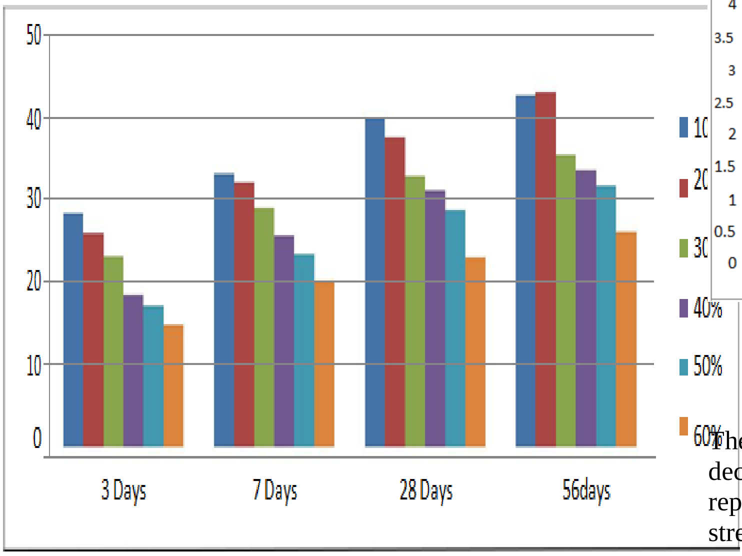


**Fig 4.1 Compressive Strength V/s % Pond ash replacement**

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.

*A. 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 4.2 and Fig 4.2

**Table 4.1 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** |
| 1 | 4.57 | 4.04 | 3.56 | 3.77 | 3.61 | 3.08 |
| 2 | 4.38 | 3.83 | 3.91 | 4.00 | 3.69 | 3.52 |
| 3 | 4.77 | 4.18 | 4.21 | 3.83 | 3.75 | 3.28 |
| **Average** | **4.57** | **4.01** | **3.89** | **3.85** | **3.68** | **3.30** |

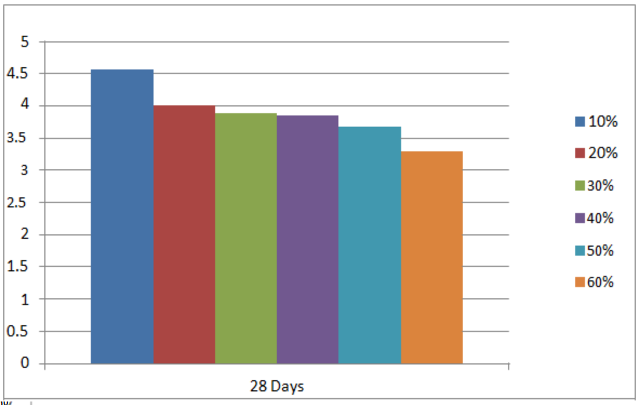


**Fig 4.2 Flexural Strength Vs % Pond ash replacement**

The Flexural strength of the Pond ash replaced concrete decreases with increase in the percentage of replacement. Hence PA-10 has maximum flexural strength.

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 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 decreases with the increase in Pond ash replacement for 28 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.

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