Performance of Fine Aggregate Replaced Pond Ash on strength of Concrete

A Srikanth¹, K Adithya Nandini², Y Anand Babu³.
¹ Assistant Professor, Department of civil engineering, VVIT.
² Assistant Professor, Department of civil engineering, VVIT.
³ Lecturer, School of Civil and Environmental Engineering, Jimma University, JIMMA, Ethiopia

Abstract: There is a great demand for the concrete, the second largest consumed material and concrete making materials, for constructions due to stimulated growth of infrastructure worldwide. This lead to the scarcity of natural resources, resulting in creating vast interest in the research area to look for alternative materials which could satisfy both strength and performance criteria of concrete constructions. Pond ash, a waste product of thermal power plants, is one such material, that can be adopted as a suitable material as a fine aggregate in concrete, replacing natural sand partially or fully. Encouraging the usage of such a waste material as constituent in concrete so as to address the issues related to its disposal, environmental and ecological problems, is a social responsibility of researchers, thus contributing to 3Rs-Reduce Reuse and Recycle, thereby promoting sustainable construction. It is commonly thought that as inert filter, fine aggregate has a very little effect on the finished concrete properties. However fine aggregate (natural sand or alternative material) and its characteristics play a substantial role in controlling the workability, strength, and durability of concrete constructions. Thus its detailed characterization is essential to boost the confidence of user. So in this report behavior of pond ash is studied. Change in compressive strength and slump values are studied.

1. Thirty six concrete matrices were designed with 0, 10, 20, 30, 40 and 100 percent pond ash by replacing fine aggregate.
2. The concretes of M20 with 0 percent pond ash and 100 percent fine aggregate shows compressive strength at 28 days curing 89.51 percent higher than conventional comparison mixes respectively.
3. The slump values got on decreasing from 50mm for 0 percent pond ash to 0mm for 100 percent pond ash.

1. INTRODUCTION

POND ASH
The idea of using by-products to replace natural aggregates is another alternative solution to achieve environmental conservation as well as to obtain a reasonable concrete cost. After burning the coal, 70% extracted as fly ash and remaining 30% precipitated as bottom ash. The obtained bottom ash is usually combined with fly ash. This blended fly ash and bottom ash together is referred to as Pond ash. Approximately 30 percent of the coal ash is handled wet and disposed as Pond ash. With a growing content of pond ash, there has been are relatively greater increase of compressive strength, compared to normal concrete, and such a trend might be a consequence of decreased water/cement ratio induced by the absorption of mixing water.

NECCESITY OF CHARACTERIZATION
Pond ash is potentially useable as fine aggregate, but the properties of pond ash depend on various factors such as source of coal, and its type, design of coal fired boilers, power plant operating parameters, point of
disposal of wet coal ash, the efficiency and type of coal grinding processes adapted at the power plant. More over because of differences in the unit weight of fly ash and bottom ash, the coarser bottom ash particle settle first and the finer fly ash remains in suspension longer. The ash deposited in about 100m of ash slurry discharge point in the pond is coarser as compared to the ash deposited away from 100m, in between these two areas is of medium particle size. Hence it is the necessary for the researchers to know the variation in properties of pond ash for a given plant by collecting pond ash at different locations around the discharge outlet, studying its properties as fine aggregate and comparing it with the properties of natural sand. Characterization of pond ash thus plays a very important role in assessing its sustainability as a material in the field of concrete construction.

LIMITATIONS OF STUDY

As all of us knew, every coin has two sides. Until this moment we tend to saw solely the straightforward approach of use of pond ash as replacement of natural sand however from another facet there are some limitations on such replacement. This study is work on the concept of partial and full replacement of sand (one of the important ingredient of concrete) by pond ash (waste byproduct of thermal power plant), with different proportions. The investigation of previous papers show that, if the replacement of sand exceeds some limit that affects the properties of concrete on large scale in practically.

• Skilled supervision will require while replacing the pond ash with fine aggregate in concrete.
• This replacement is suitable only for mass concreting projects as like construction of dam structures. This replacement is not economical if the concreting is on small scale.
• Also pond ash might not out there simply, availability of pond ash depends upon the construction site distance and ash ponds.
• The CaO content is a smaller amount within the pond ash so plasticizer property of pond ash is small. Hence, we will observe the decrement in compressive strength.

2. MATERIALS AND METHODS

Samples of pond ash were collected as per IS 6491-1972 at 4 different pits (P1-P4) from Ash pond at Dr. Narlatatarao thermal power station, Ibrahimpatnam, selecting 2 pits around 200m away from each other and 2 pits 75 m from discharge outlet of Ash pond. These samples were oven dried at 100°C and detailed characterization was carried out as fine aggregate in concrete as per IS codes of practice. 53 grade OPC (Ordinary Portland Cement) and coarse aggregate with particle size 20mm was used for the preparation of concrete mix. Table 1 shows the physical characteristics of each material.

| Material     | Specific gravity |
|--------------|------------------|
| Cement       | 3.16             |
| Fine aggregate | 2.69            |
| Coarse aggregate | 2.98        |
| Pond ash     | 2.22             |
MIX DESIGN FOR M20 GRADE OF CONCRETE

HOW MY PROJECT DIFFERS FROM OTHERS

From the all the journals and literature review I have observed one common point i.e., replacement of fine aggregate by pond ash is done in weight replacement method. Let us consider an example of 10 kg of fine aggregate in which 25% replacement of fine aggregate has to be done with pond ash. Weight of pond ash quantity replaced is equal to 2.5 kgs in weight replacement method.

Table 1: General weight replacement of Pond ash

| Sl. no | Fine aggregate(kg) | % of replacement | Fine aggregate(kg) | Pond ash(kg) |
|--------|-------------------|------------------|-------------------|-------------|
| 1      | 10                | 25               | 7.5               | 2.5         |

From the Table1, we clearly observed that specific gravity of pond ash is 2.22 which is less than specific gravity of fine aggregate i.e., 2.69. As specific gravity is inversely proportional to volume, less the specific gravity more the volume occupied. Doing replacement in such type increase the volume of mix which is limited to kg/m³.

In order to maintain the volume of mix to kg/m³ I have done replacement in absolute weight method. If I consider 10 kg of fine aggregate with same 25% replacement pond ash my quantity of pond ash will be 2.1675 kg in absolute weight replacement method and fine aggregate is equal to 7.8325 kg.

Table 2: Absolute weight replacement of Pond ash

| Sl. no | Fine aggregate(kg) | % of replacement | Fine aggregate(kg) | Pond ash(kg) |
|--------|-------------------|------------------|-------------------|-------------|
| 2      | 10                | 25               | 7.9368            | 2.063       |

Replacement of Pond Ash = FA*(SG of PA/SF of FA)*(%PA/100)

In all the journals the ratio of specific gravity of pond ash to specific gravity of fine aggregate is taken as 1, that is the reason why volume is exceeding kg/m³. But the ratio is less than 1 it is equal to 0.8252.

MIX PROPORTIONS

- Cement = 339.28 kg
- Coarse aggregate = 1272.998 kg
- Fine aggregate = 740.877 kg
- Water = 190 lit

VOLUMES OF MATERIALS AND SPECIMEN

- Vol. of cubes = \(0.15 \times 0.15 \times 0.15 \times 6 = 0.02\) m³
- Vol. of cylinders = \((3.14 \times 0.15 \times 0.15 \times 0.3)/4\) \(\times 3 = 0.02\) m³
- Total vol. = \(1.2 \times (0.02 + 0.02) = 0.04\) m³
- FA = \((\text{Total volume} \times \text{FA})/(100-\%\text{FA})/100\)
- %PA = \(\text{FA} \times (\text{SG of PA}/\text{SG of FA})\times(%\text{PA}/100)\)
Table 3: Mix proportions for each mix

| Mix       | Cement (kg) | CA (kg) | Water | FA (kg) | Pond Ash (kg) |
|-----------|-------------|---------|-------|---------|---------------|
| M20 0 PA  | 14.72       | 55.23   | 8.24  | 32.14   | 0.00          |
| M20 10 PA | 14.72       | 55.23   | 8.24  | 28.93   | 2.65          |
| M20 20 PA | 14.72       | 55.23   | 8.24  | 25.71   | 4.77          |
| M20 30 PA | 14.72       | 55.23   | 8.24  | 22.50   | 6.36          |
| M20 40 PA | 14.72       | 55.23   | 8.24  | 19.29   | 7.43          |
| M20 100 PA| 14.72       | 55.23   | 8.24  | 0.00    | 15.91         |

3. RESULTS AND DISCUSSIONS

COMPRESSIVE STRENGTH

- The compressive strength of hardened concrete is that the most vital of all properties of concrete.
- Strength tests don't seem to be created on neat cement paste due to difficulties of excessive shrinkage and succeeding cracking of neat cement.
- Casted cubes are kept in curing for 7 & 28 days.
- After removal of cubes they are allowed to lose moisture by exposing to sun.
- Place the required specimen in Compressive Testing machine and apply the load at 35 N/sq.mm/minute.

Compressive strength is the ratio of maximum load applied just before breakage to area of cube.

Table 4: Compressive strength of M20 concrete

| Mix        | Compressive strength (7 days) N/sq.mm | Compressive strength (28 days) N/sq.mm |
|------------|--------------------------------------|----------------------------------------|
| M20 0 PA   | 27.843                               | 31.846                                 |
| M20 10 PA  | 29.624                               | 32.549                                 |
| M20 20 PA  | 31.105                               | 34.364                                 |
| M20 30 PA  | 33.475                               | 39.376                                 |
| M20 40 PA  | 31.846                               | 38.363                                 |
| M20 100 PA | 31.105                               | 34.364                                 |

SLUMP VALUES

- Vertical settlement of concrete is defined as slump.
- Slump is done to find the workability of concrete. This test measures the consistency of concrete in specific batches.
- The length of cone is 30 cm with top diameter 10 cm and bottom diameter 20 cm.
- Slump is of three types
  - Collapse slump
  - Shear slump
  - True slump
Table 5: Slump values of Different Mixes

| Mix         | Slump (mm) |
|-------------|------------|
| M20 0 PA    | 50         |
| M20 10 PA   | 45         |
| M20 20 PA   | 40         |
| M20 30 PA   | 30         |
| M20 40 PA   | 10         |
| M20 100 PA  | 0          |

**PA=Pond Ash

Graph 1: Comparative Compressive strength of M20 Grade concrete

**DISCUSSION ON TEST RESULTS:**

- With the addition of pond ash there is reduction in slump value of fresh concrete. It is clearly observed from the table 5; slump is reduced from 50 mm to 0 mm.
- The 7days, 28days strength shows that the strength increases from standard Concrete up to the addition of 30% replacement of fine aggregate with pond ash. Initially strength of concrete at 0 % PA for 7 days curing is 27.843 N/mm² and it has increased to 33.475 N/mm² for 30 % PA for 7 days curing.
- The 7days and 28days strength get reduced on further additions of pond ash as sand replacement 30%. At 30 % PA for 7 days curing strength is 33.475N/mm² and it got reduced to 31.846 N/mm² for 40 % PA and 31.105 N/mm² for 100 % PA for 7 days of curing.
- For 7 days of curing strength for 0 % PA is 27.843 N/mm² and for 28 days of curing strength is 31.846 N/mm². It is clear that strength of concrete increases with increase in age of concrete.
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