IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 21, Issue 3 Ser. 2 (May. – June. 2024), PP 57-60
www.iosrjournals.org

Review On Use Of Pond Ash As Partial Replacement Of Cement In Concrete

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Abstract:
The majority of the power production in India comes from the thermal power plants, using pulverized coal as fuel. The non-combustible constituents of pulverized coal form combustion residue or ash. The finer fraction of ash, entrained in the flue gas, which gets collected in the electrostatic precipitators, is referred as fly ash (FA). The part of ash that falls at the bottom of the boiler in the form of hot clinker is known as bottom ash. It is crushed before disposal. As a general practice in India, FA and bottom ash are mixed with water and transported to ash ponds/ lagoons. The ash thus deposited in lagoons is called lagoon ash (LA) or pond ash(PA). The thermal power plants in India use low quality mineral coal with average ash content of about 40%. This paper presents Review on Use of Pond Ash as Partial Replacement of Cement in Concrete.

Key Word: *Pond Ash, Bottom ash, Cement, Coal, Thermal power plant*

Date of Submission: 24-05-2024 Date of Acceptance: 04-06-2024

I. Introduction

Concrete is one of the most important construction material all over the world. The studies predicts that the need of concrete will increases further to almost 7.5 billion m^3 (about 18 billion tons) a year by 2050. To cater to the need, alternative to concrete must be developed which can reduce the harmful effect on environment. At least three-quarters of the total volume of concrete consists of coarse and fine aggregates. Natural resources such as river sand are depleting due to human irresponsible activities. At the same time the power required for the country and the society as a whole is rapidly increasing. In India, coal-fired thermal power plants fulfill about 65% of the country's electricity requirements. The coal-fired thermal power plants burn about 407 million tons of coal and produce about 131 million tons of coal ash annually from which 15–20% ash is bottom ash and the balance is fly ash. The research shows, that, it is possible to partially replace cement by PA in concrete without compromising on strength and durability.

To fulfill the demand of concrete, the demand for Portland cement also increases. On the other hand, the climate change due to global warming has become a major concern. The global warming is caused by the emission of greenhouse gases, such as carbon dioxide (CO_2), to the atmosphere by human activities. As far as the cement industry is concerned, the production of one ton of Portland cement emits approximately one ton of CO_2 into the atmosphere. Several efforts are in progress to reduce the use of Portland cement in concrete in order to address the global warming issues. These include the utilization of supplementary cementing materials such as fly ash, silica fume etc. and the development of alternative binders to Portland cement. In most of the thermal power plants, the coal ash is dumped in the nearby low lying areas which results into the formation of ash pond. Pond Ash is usually dumped into the environment as it does not find similar utilization as fly ash due to a lack of pozzolanic properties. However, smaller quantities of pond ash are utilized for land filling, manufacturing bricks, etc. The pond ash is a mixture of fly ash and bottom ash. The main difference between pond ash and fly ash is in their particle size. The pond ash being coarser and less pozzolanic and hence is not being accepted as pozzolana. Pond ash contributes to two major environmental problems, generation of respirable particulate matter (a major air pollutant) and pollution of soil and water due to leaching of heavy metals. As the accumulation in the pond ash (PA) around the thermal power plant is posing threat to environment, its proper management is becoming essential.

Pond Ash

As per IS 3812 (Part-1):2003, Pond ash is defined as Fly ash or bottom ash or both mixed in any proportion and conveyed in the form of water slurry and deposited in pond or lagoon. 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.

II. Literature Review

V. Vidyadhara *et al.*(2020) has collected Pond ash(PA) of different storage durations, i.e. freshly ponded, two year ponded and Six-year ponded ash from Bellary Thermal Plant (BTP). All three kinds of PA were mechanically activated by grinding in Industrial Hammer Mill. Mineralogical and Morphological characteristics were analyzed through X-ray Diffraction and Electron Microscopic studies. Unprocessed Pond Ash (UPA) and Ground Pond Ash (GPA) were characterized for Particle Size Distribution (PSD) by Laser-diffraction analyser. Chemical composition of PA was analyzed. The pozzolanicity of PA and other Supplementary Cementitious Materials (SCM) was determined and compared by conducting Lime reactivity test. XRD patterns and Chemical analysis clearly indicate the presence of relatively more amorphous phases in a fresh batch of PA compared to the one which is ponded for a longer duration. Lime reactivity strength (LRS) of UPA was far behind the LRS of commonly used SCM's. Mechanical activation of PA improved the LRS from 0.57 MPa to 2.41 MPa. The results suggest the possibility of enhancing the reactivity of PA with early use and more efficient grinding process, thus add value to PA for its use in concrete.

K. M. Bagwan *et al.*(2015) has investigated the use of pond ash in concrete. The concrete was prepared with different percentage of pond ash (15, 25, 35, 45 and 55 %) and it was tested at different ages (3,7,28,56,90, and 180 days). The results of pond ash concrete were compared with control concrete. A property of pond ash concrete in fresh state and hardened state was tested. It was found that rate of increase of compressive strength at early ages mainly 3,7 and 28 days was low and during later age this rate was faster. This shows that later age strength of pond ash concrete is very good and has a scope to use in concrete which are of great importance in the context of sustainability in the construction field.

Badrinarayan Rath *et al*.(2021) has done detail study on workability, durability, and strength of concrete by replacing cement with fly ash by weight up to 40% and sand with pond ash by volume up to 20% with a constant dose of glass fiber of 0.1% of the volume of the concrete. Various tests like rheology, shrinkage, electrical resistivity, ultrasonic pulse velocity, heat conductivity, leaching, compressive strength and flexural strength were conducted on various mixes of new coal ash fiber reinforced concrete. From these results, a mixed design process was proposed for the preparation of sustainable concrete from locally available industrial by-products.

Jayeshkumar R. Pitroda *et al.* (2013) has studied replacement of cement by pond ash in the range of 0%, 10%, 20%, 30% and 40% by volume for M-25 and M-40 mix. Concrete mixtures were produced, tested and compared in terms of modulus of elasticity with the conventional concrete. The test was carried out to evaluate the modulus of elasticity after 56 days. The modulus of elasticity of concrete is a very important mechanical parameter reflecting the ability of the concrete to deform elasticity.

J. D. Bapat *et al.* (2006) has investigated the effect of Pond ash replacement of cement (55–65%) in concrete. The test specimens were prepared with and without superplasticizer. No air-entraining agent was used. The slump retention property of the concrete with superplasticizer and lagoon ash was studied. A substantial increase in the setting time (initial and final) was observed. The development of early strength (1,3) days was low. The 28-day strength for concrete with lagoon ash, without the addition of superlasticizer, was in the range of 16.4–24.3 MPa for 65 and 55% cement replacement, respectively. The change in strength of concrete was observed over a period of 365 days in the present study. The investigation shows a scope to utilize lagoon ash in concrete.

Milind P. Bhamare *et al.* (2012) has replaced cement by pond ash with different percentages like 0,2.5,5,7.5,10,12.5,15,17.5,20,22.5% by mass of cement. Materials used in this research work were an OPC cement, pond ash and fine aggregate. Materials are tested as per Indian standard. From the examination on pond ash used for cement replacement it can be inferred that the normal consistency of cement defer according to the percentage of pond ash. Also, it can be inferred that the pond ash acts as retarder & increases the initial setting time of the cement paste. It was observed from the analysis of the compressive strength results that as the pond ash percentage increases in the cement paste the compressive strength decreases due to low pozzolanic property of the pond ash.

Arunkumar Dwivedi *et al*.(2013) have presented an experimental investigation on the effect of addition of pond ash partially replaced with cement and sand in the mortar. Effect of pond ash on compressive strength, flexural strength and bulk density were observed under standard curing conditions. Pond ash of 0% to 40% (with increase of 5%) by weight to cement and sand replacement respectively were used. The specimens were casted and cured under standard curing conditions for 3, 7, 28 and 90 days. At the end of each curing period, compressive strength and flexural strength values were determined. Dry bulk densities for each replacement were recorded after 28 days curing period. The result shows that in case of cement replacement in compression as well as flexure strength gives higher values for 15% to 20% replacement of pond ash. The result

of dry bulk density test also indicates that the values of density for cement replacement as well as sand replacement decreases with increase in percentage of pond ash.

Jung, Sang Hwa *et al.* (2013) For this work, two types of pond ash (anthracite and bituminous coal) were selected from two reclamation sites. Cement mortar specimens considering two w/c (0.385 and 0.485) ratios and three replacement ratio of sand (0%, 30%, and 60%) are prepared and their workability, mechanical, and durability performance were evaluated. Anthracite pond ash has high absorption and smooth surface so that it shows reasonable workability, strength development, and durability performance since it has dense pore structure due to smooth surface and sufficient mixing water inside. Reuse of PA is expected to be feasible since PA cement mortar has reasonable engineering performance compared with normal cement mortar.

Aditya Verma *et al*. (2016) have presented a review on utilization of pond ash as partial replacement of cement concrete mix. This study combines the work done in this area by various researchers and shows the effect of addition of pond ash on different properties of concrete.

Fang-Chen Lo *et al*.(2021) has investigated an effective way to reuse coal fly ash (CFA), coal bottom ash (CBA), and rice husk ash (RHA) as partial replacements of ordinary Portland cement in pervious concrete. In experiments, single and binary replacement by these ash materials was conducted via cement material substitution in pervious concrete. The pervious concrete specimens contained 30% ash by volume and had a water-to-cement ratio of 0.21. The ash materials and pervious concrete specimens were characterized by field emission-scanning electron microscopy, X-ray fluorescence spectroscopy, X-ray powder diffraction, and Fourier transform infrared spectroscopy. The compressive strength, water permeability, and toxicity characteristic leaching procedure (TCLP)-released metals were investigated to evaluate the pervious concrete quality. The compressive strength of pervious concrete with single-ash partial replacement by CFA and CBA was higher than that of the control group. The result of the carbon footprint showed that the replacement of ash materials reduced the total carbon footprint by 9.9%–20.6% per m^3 of pervious concrete compared to the control group. The results indicated that CFA, CBA, and RHA replacement in cement materials yielded an acceptable compressive strength and water permeability

Harshkumar Patel *et al*.(2019) the study has been carried out on concrete produced using fly ash, pond ash and OPC 53 grade. An attempt will be made to investigate characteristics of OPC concrete with combined fly ash and pond ash mixed concrete for Compressive Strength test, Split Tensile Strength test, Flexural Strength test and Durability tests.

J Venkateswara Rao *et al.* (2020) have discussed the relative results of flexural and compressive strength of conventional uni-paver concrete blocks of M-40 grade with the paver blocks produced by the combined partial replacement of the cement and fine aggregate with fly ash and pond ash respectively. Initially, fine aggregate and cement were replaced in percentages of 5, 10, 15 and 20 separately with pond ash and fly ash respectively. Later on, both fine aggregate and cement were replaced and the performance of paver block is evaluated in terms of its mechanical properties.

III. Result & Discussion

From the literature review following results can be drawn

1) Later age strength of pond ash concrete is very good as compared to early age.
2) Mineralogical and Morphological characteristics of pond ash may vary depending on the location and storage duration.
3) Normal consistency of cement defer according to the percentage of pond ash.
4) The pond ash acts as retarder & increases the initial setting time of the cement paste.

IV. Conclusion

From the study, it has been concluded that the pond ash with good mineralogical and morphological characteristics can replace cement in concrete upto certain percentage and can be used as replacement material without compromising on strength and durability.

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