MECHANICALLY ACTIVATED POND ASH BASED GEO-POLYMER CONCRETE

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Keywords:

Pond Ash, Mechanical Activation, Geo polymer concrete, Wet grinding and Dry grinding.

Introduction:

1. Fly ash from electrostatic precipitator which will be unused and bottom ash from boiler after milling is conveyed to ponds in the form of water mixed slurry. This stored slurry in ponds results in the generation of Pond ash. It consists of both highly reactive fine particles and non-reactive coarser particles and they are porous in nature and consist of greater voids.
2. Geopolymer concrete is basically concrete without cement as the basic binding component. The concrete is hardened by the polymerization reactions between pozzolanic material (in present study pond ash), rich in silica and alumina, and the alkaline solution which acts as an activator.
3. R.V. Ranganath, B. Bhattacharjee, and S. Krishnamoorthy "Influence of size fraction of ponded ash on its pozzolanic activity" *Cement and Concrete Research, Vol. 28, No. 5, pp. 749–761, 1998*, The paper indicates that Pond ash contains both reactive and non-reactive particles. Further the study categorized pond ash particles in three fractions:

Fine Fraction	<20 micron	- Highly Reactive
Medium Fraction	20 micron to 75 micron	- Moderately Reactive
Coarse Fraction	> 75 micron	- Less Reactive

4. V Vidyadhara, T Shamanth Gowda and R V Ranganath **"An Investigation on Pozzolanicity of Mechanically Activated Pond Ash"** *IOP Conference Series: Materials Science and Engineering 936 (2020) 012004*, Study indicated that Lime reactivity of ground pond ash (2.41 Mpa) is higher when compared to unground pond ash (0.60 Mpa.) Higher reactivity is because of reduction in particle size and elimination of pores in unground pond ash

Objectives:

a. Optimization of mechanical activation parameters such as dry grinding, wet grinding and (Pond Ash)/water ratio.
b. Characterization of physical, morphological, mineralogical and chemical properties of mechanically activated pond ash.
c. To study the mechanical and micro-structural parameters of mechanically activated pond ash-based Geo polymers concrete.
d. To compare economical aspects of mechanically activated pond ash-based Geo polymer concrete with other available alternatives.

Methodology:

a. Stage 1: Procurement

The pond ash used for experimentation is procured from Bellary thermal power station located in Kudathini, Bellary district, Karnataka.

b. Stage 2: Mechanical Activation

The pond ash obtained shall be mechanically activated by dry and wet grinding method using suitable technique (Activation is achieved by Industrial Hammer mill and Planetary Ball Mill) with (Pond Ash)/Water content, Speed of Rotation and duration of milling as variables. The ratio of weight of charges and pond ash in ball mill is maintained at 1:1(180grams of charges are introduced for 180 grams of Pond ash grinding in jar).

c. Stage 3: Characterization of mechanically activated pond ash

Physical Properties: Specific gravity, Water absorption, Lime reactivity & surface area.
Morphological Studies: Scanning Electron Microscopy analysis
Mineralogical studies: XRD analysis
Chemical Composition: Chemical analysis and EDAX analysis.

d. Stage 4: Evaluation of fresh, hardened and micro structural properties of Geo-polymer concrete with unground pond ash as fine aggregate and optimized activated pond ash as binder.

Fresh and Hardened Properties

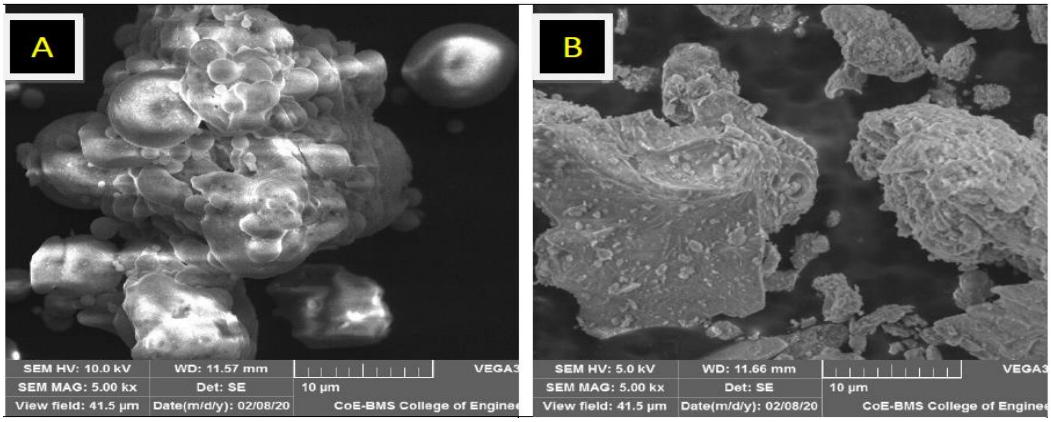
- Slump and flow analysis
- Compression test
- Split tensile test
- Flexural test
- Ultra-Sonic Pulse Velocity test
- Water permeability test
- Sorptivity Test
- Micro structural studies of geo-polymer concrete

Results & Discussion:

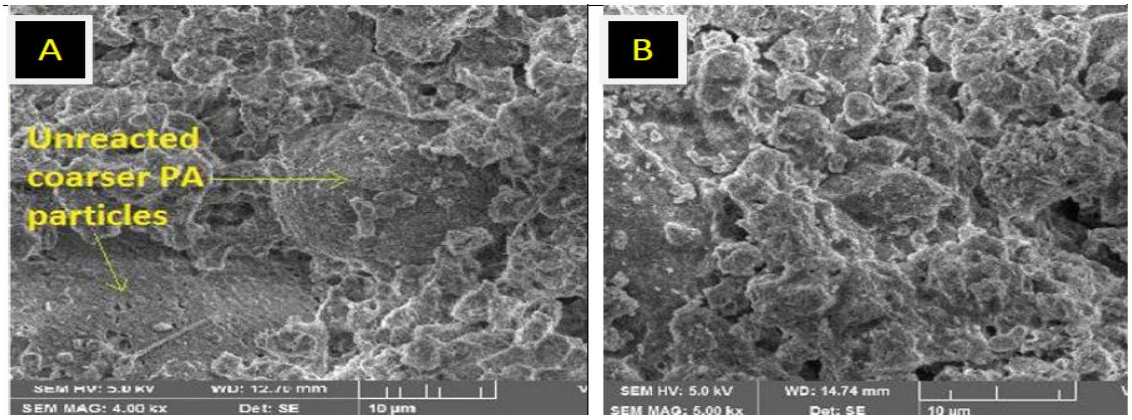
Milling Type	Particulars	Sp. Gravity	Flow (mm)	Lime Reactivity Strength (MPa)
No milling	Unprocessed Pond Ash (UPA)	2.01	170	1.183
Hammer Mill	Dry Milled	2.24	170	1.825
	Wet Milled - PA/W = 10	2.31	168	2.97
	Wet Milled - PA/W = 7.5	2.32	170	3.01
	Wet Milled - PA/W = 5.0	2.37	170	3.1
Planetary Ball Mill	**Wet Milled - PA/W = 5.0, Speed =250rpm**			
	Duration = 1Hr	2.48	170	4.15
	Duration = 2Hr	2.49	170	5.15
	Duration = 3Hr	2.55	172	6.86
	Wet Milled - PA/W = 5.0, Duration = 1 Hr			
	Speed = 200 rpm	2.28	165	3.09
	Speed = 150 rpm	2.11	165	3

The above table indicated the various activation methods undertaken along with parameters considered for optimization. It also indicated corresponding lime reactivity results performed for assessing the reactivity of Pond Ash. It is evident that Milling process significantly increases the reactive nature of Pond Ash. From table, it is seen that the lime reactivity strength of Unprocessed Pond ash from 1.183 Mpa increases to 1.825 Mpa (for Dry milling using hammer mill) and 3.1 Mpa (for wet milling using hammer mill) this indicated that wet milling is a better activation method compared to dry milling and with the increase in PA/Water content the reactivity increases. Later using these results, the further activation method was attempted using Planetary Ball mill with (PA)/water kept constant at 5.0 and it is observed that the reactivity is improved when compared to that of Hammer mill. This is because milling in ball mill is achieved with multiple forces (Impact, friction and centrifugal forces) while that in hammer mill is only due to Impact forces. Further it is observed that the reactivity increases with increase in duration of milling (evident from above table) and speed of milling.

On consideration of the reactivity results the optimum is taken at PA/Water content of 5.0, speed of rotation of 250 rpm and duration of 1hr for further study.



SEM studies were conducted on pond ash before and after grinding to determine its morphology. SEM images of unground pond ash shows spherical and agglomerated particles whereas ground pond ash shows angular and dispersed particles.



SEM of Lime reactivity (LR) tested samples was done to verify the changes between unground LR tested sample and ground LR tested sample. It can be seen that the unground LR sample has coarser unreacted particles whereas ground LR sample has uniformly dispersed particles.

Geo polymer mixes were casted with for the finial mix with 30% of GGBS as replacement to Ground Pond Ash (Binder) with Water/Binder at 0.485.

The designation of mixes are as follows

MX-1 – Dry Ground Pond Ash as binder using Hammer mill

MX-2 – Wet Ground Pond Ash as binder using Hammer mill

MX-3 – Dry Ground Pond Ash as binder using Planetary Ball mill

MX-4 – Wet Ground Pond Ash as binder using Planetary Ball mill

Mix Designation	**MX-1**
Compressive Strength	
1 day Strength (MPa)	3.78
3-day Strength (MPa)	18.54
7-day Strength (MPa)	28.63
28-day Strength (MPa)	40.84
56-day Strength (MPa)	44.30

Compressive strength is done to find out the resistance offered by concrete under uniaxial load. The testing procedure is done as per mentioned in IS516 specification. Minimum of three cubes of dimension 100mm are tested and average of three values are reported as compressive strength of cube. The CS of cubes is found out for 1, 3, 7 and 28 days.

Mix Designation	**MX-1**
Flexural Strength	
28-day Strength (MPa)	3.70

Mix Designation	**MX-1**
UPV Test	
Velocity (Km/s)	3.51

Flexural strength is done to find out the resistance offered by concrete under two-point flexural load. The testing procedure is done as per mentioned in IS516 specification. Minimum of three Beams of dimension 100mm x 100mm x 500mm are tested and average of three values are reported as flexural strength of beam. The beams are tested at 28 days of curing.
UPV test is conducted to access the quality of concrete by passing Ultra-sonic pulse waves from a transmitter from one end and received at the other end by a receiver. The velocity measure of the wave passed indicated the presence of voids and faults in the concrete. The result indicated in the table above shows that the quality of concrete is Good since the Velocity is 3.51 Km/s.

Works in progress

The casting of other mixes has been completed and are now in the curing period. The results are anticipated by next month.

Future scope

a. The activation technique using ball mill can be taken for higher Speed of rotation so that there could be a potential decrease in milling duration.
b. The durability studies on mechanically activated pond ash based Geo-Polymer concrete needs to be explored.