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Experimental Study of Cement Mortar Incorporating Pond Ash with Elevated Temperature Exposure

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Abstract— *Pond ash is to be investigated for its use as a partial replacement for sand in cement mortar (1:4). The effort is to be made for the utilization of Pond Ash as sand replacement material in mortar which may introduces many benefits from economical, technical and environmental points of view. The project will present the results of the cement mortar of mix proportion 1:4 in which sand will partially replace with Pond Ash as 0%, 10%, 30%, 40% and 50% by weight of sand. It is proposed to prepare two set of mixture proportions. First will be a control mix (without Pond Ash with regional fine aggregate (sand) and the other mixing will contain Pond Ash obtained from Thermal Power plant industry. The compressive strength test is to be conducted with partial replacement of Pond Ash with sand. The strength property of mortar with Pond Ash for strength at 28 days as partial replacement with the cement in the cement mortar 1:4 is to be determined. Similarly the other set of cement mortar incorporating Pond Ash is to be kept in elevated temperature up to 1100° C and tested for its compressive strength. The results for controlled cement mortar and Pond Ash mortar for compressive strength at normal temperature and elevated temperature is to be compare.*

Keywords— Pond Ash, Cement Mortar, Elevated Temperature, Compressive Strength.

I. INTRODUCTION

In the present study, Pond Ash samples were collected from disposal sites of Bhusawal- Thermal power plant. The effort made was to study the effect of high temperature on mortar in two sets incorporating pond ash. First cement mortar containing Pond Ash replaced with fine aggregate (0-100percentage) at normal temperature and second set containing cement mortar containing Pond ash replaced with fine aggregate (0-100 percentage) at elevated temperature. In recent years, the research and development by domestic and foreign experts have made available high-performance concrete (HPC) with high strength and high workability. The addition of fly ash and Pond Ash in order to improve workability, enhance durability, minimize environmental pollution and CO2 emission, reduce production cost and utilize resources efficiently nonetheless, research on the effect of high temperature on properties of concrete with fly ash added has been scarce but merits further study. A proper amount of fly ash would give a better and stronger concrete mixture under high temperature and pressure. Concrete containing fly ash is of a denser structure and has better fire resistance compared with that without fly ash added. This study examines the impact of pond ash addition on properties of mortar mixed at different replacement percentages and at high temperature. It is hoped tha the high-temperature properties of pond ash mortar can contribute to a better understanding of the resource recovery of pond ash and its degradation under high temperature.

Occasionally, cement concrete structures are subjected to high temperatures (reactor vessels, thermal shock, fire, coal gasification vessels, some industrial applications, etc.). In most cases, such elevated temperatures result in considerable damage to cement concrete structures and masonry walls. Recently, high-strength concrete and high strength mortar are widely used in different parts of civil engineering structures. As they become more commonly used, the risk of being exposed to high temperatures also increases. Thus, better understanding of the behavior of high-strength mortar at high temperatures gains importance for predicting the mortar properties.

As per Ash Report shown below in table 01 for the year 2013-14 for 210 MW Units following statistical data was collected:

Table.1: Amount of Coal Consumption, FA, PA Generated

Total coal consumption (MT)	Ash generated (MT)	Fly Ash generated (MT)	Pond Ash generated (MT)
2058420	867624	694099	173525

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Fig.1: Ash Generation in Thermal Power Plant-Bhusawal

Figure 01 above shows ash produced after combustion of coal in thermal power plant.

II. LITERATURE REVIEW

Several researches have been done by researchers on different material about the effect of high temperature. Some are discussed herein:

According to the study conducted by M. S. Morsy et al. (2010) the influence of elevated temperatures on the mechanical properties, phase composition and microstructure of silica flour concrete. The hardened concrete was thermally treated at 100, 200, 400, 600 and 800º C for 2 hours. The results showed that the addition of silica flour to OPC improves the performance of the produced blended concrete when exposed to elevated temperatures up to 400º C.[1]

Md. Akhtar Hossain at al. presents their research on fire resistance of cement mortar containing high volume fly ash. Terrorist attack, accidental fire breakout and different type of explosions produce a rapid change of temperature for a short period. In such a situation, the material properties play an important role in minimizing the potential damage due to high rise of temperature. The test results indicate that the mortar containing 50% fly ash as a replacement of cement exhibits greater resistance to high temperature. Also, compressive and bond strengths of mortar containing different percentage of fly ash initially increase with the increase of temperature but after 200º C they decrease with the further increase of temperature.[2]

K. Sobolev at al. conducted their research on the development of high-strength mortars with improved thermal and acid resistance. As granulated blast furnace slag (GBFS) cement, containing up to 60% slag, is sometimes used in repair materials applied at intermediate temperatures of 150–300º C. It was found that the enhancement of GBFS–Portland cement-based materials can be achieved with the help of silica fume (SF) and a super plasticizer (SP). The effect of different SPs on the compressive and flexural strength of SF–blast furnace slag Portland cement mortars was investigated. These mortars, in addition to high strength, demonstrate high thermal and acid resistance.[3]

The effects of high temperature on the mechanical properties of cement based mortars containing pumice and fly ash were investigated by Serdar Aydın et al. Four different mortar mixtures with varying amounts of fly ash were exposed to high temperatures of 300, 600, and 900 °C for 3 h. The residual strength of these specimens was determined after cooling by water soaking or by air cooling. Also, microstructure formations were investigated by X-ray and SEM analyses. Test results showed that the pumice mortar incorporating 60% fly ash revealed the best performance particularly at 900 °C.[4]

Daniel L.Y. Kong et al. studied the effect of elevated temperature on geo polymer paste, mortar and concrete made using fly ash as a precursor. The geo polymer was synthesized with sodium silicate and potassium hydroxide solutions. Various experimental parameters have been examined such as specimen sizing, aggregate sizing, aggregate type and super plasticizer type. The study identifies specimen size and aggregate size as the two main factors that govern geo polymer behavior at elevated temperatures (800 °C). Strength loss in geo polymer concrete at elevated temperatures is attributed to the thermal mismatch between the geo polymer matrix and the aggregates.[5]

A comparative study was conducted by Ahmad A.H. et al. on concrete mixes, reference mix without an additive and that with an admixture. Concrete was exposed to three levels of high temperatures (200,400,600) °C, for a duration of one hour, without any imposed load during the heating. Five types of admixtures were used, super plasticizer, plasticizer, retarder and water reducing admixture, an accelerator and an air entraining admixture. Mechanical properties of concrete were studied at different high temperatures, including: compressive strength, splitting tensile strength, modulus of elasticity and ultimate strain. Test results showed a reduction in the studied properties by different rates for different additives and for each temperature, the decrease was very limited at temperature up to (200°C) but was clear at (400, 600)° C.[6]

III. METHODOLOGY

3.1 Material Used:

Ordinary Portland cement conforming to BIS: 8112 [7] and ASTM C-150 [8] was used throughout the research work. Sand confirms to BIS: 383(1970) [9] and IS:2116-1980 [10]. The sand was properly graded and of medium sized with a fineness modulus of 2.0 to 2.2. Pond ash as per IS:3812:2003 [11], the generic name of the waste product due to burning of coal or lignite in the boiler of a

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thermal power plant is pulverized fuel ash (PFA)11,12. PFA can be fly ash, bottom ash, pond ash or mound ash.

Fly ash is the pulverized fuel ash extracted from the flue gases by any suitable process like cyclone separation or electrostatic precipitation. PFA collected from the bottom of boilers by any suitable process is termed as bottom ash. The terminology pond ash is used when fly ash or bottom ash or both mixed in any proportion is conveyed in the form of water slurry is deposited in pond or lagoon. ASTM C 618-03 categorizes fly ash into two classes; class F and class C, which are equivalent to SFA and CFA, respectively of IS 3812: 2003. Bureau of Indian Standards (BIS) has published the specifications of pulverized fuel ash, IS 3812: 2003 in two parts, Part-I for use as pozzolana in cement, cement mortar and concrete and Part-II for use as admixture in cement mortar and concrete. Both the parts of the code define fly ash as a special class of PFA. This code can be adopted for characterization depending on its use as pozzolana or mineral admixture.

3.2 Test Methods:

All laboratory experiments were conducted in general accordance with the applicable procedures outlined by the IS:4031 (part 1)-1996 ,(part 4)-1988,(part 5)-1988, IS:516-1959.To evaluate the possibility of reducing the cement content of rendering and plastering mortars with pond ash, four tests, compressive strength test, fineness modulus, settling time and consistency were performed. The reference mortar was a cement and sand mortar without addition of pond ash.

3.3 Mix Proportions:

In the present study, total of 2 mixes in 1:4 fractions were prepared. In the first series of mixes one part of cement and 4 parts of sand & pond ash is taken with pond ash replacement in sand varying from 0 to 100%. In the second series of mixes one part of cement & pond ash (PA) and 4 parts of sand is taken with pond ash replacement in cement varying from 0 to 100%. All mixes are prepared at room temperature and elevated temperature.

IV. RESULT AND DISCUSSION

The Experimental work consists of conduction of compressive strength test for all proportions of cement mortar cubes of 7.07 mm x 7.07 mm size shown in figure 01 below. There were two sets of sample series tested (Series-I-Pond Ash Replaced with Sand & Series –II-Pond Ash Replaced with Cement). The result showed considerable gain in the strength when pond ash is replaced with sand up to 40-50 %. Further with increase in percentage the strength goes down. It is observed in Series –II that the gain in strength is limited only up to 10-20 % replacement.

Fig.1: Mortar cubes prepared during experimental work for curing and compressive testing in the

Table.2: Compressive Strength at Normal Temperature

Sr No	% Replacement Proportion	Compressive Strength (MPa) Sand Replacement	Compressive Strength (MPa) Cement Replacement
1	0%	13.4	13.4
2	10%	10.8	14.13
3	20%	6.7	10.67
4	30%	6.5	5.63
5	40%	5.95	3.56
6	50%	4.68	1.97
7	60%	2.53	0.8
8	70%	1.15	0
9	80%	1.36	0
10	90%	1.16	0
11	100 %	1	0

Table 03: Compressive Strength at Elevated Temperature

Sr No	% Replacement Proportion	Compressive Strength (MPa) Sand Replacement	Compressive Strength (MPa) Cement Replacement
1	0%	2.97	2.97
2	10%	2.43	2.467
3	20%	2.27	2.99
4	30%	2.73	1.46
5	40%		1
6	50%	3.06	0.33
7	60%	2.53	---
8	70%	2.06	---
9	80%	1.48	---
10	90%	0.87	---
11	100 %	1.42	--

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It is observed from table 02 and 03 that the values of compressive strength taken after burning that the cement replacement mortar sustained to elevated temperature as compared to sand replacement mortar. The graph below in figure 02 and 03 shows considerable drop in the compressive strength when exposed to elevated temperature.

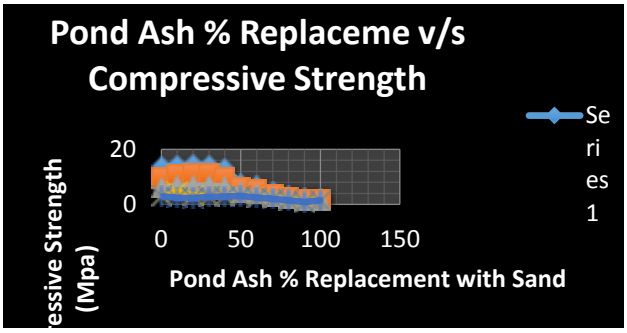

Fig.2: Drop in the strength of cement mortar incorporating pond ash with sand

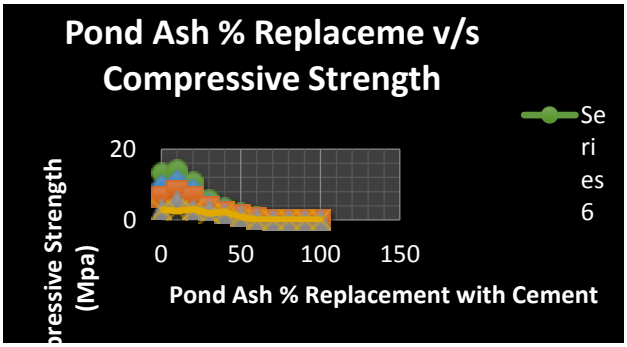

Fig.3: Drop in the strength of cement mortar incorporating pond ash with cement

V. CONCLUSION

The compressive strength test was done in two sets – sand replacement with pond ash and cement replacement with pond ash (0%-100%). Four cubes of each percent were made, two for atmospheric temperature and two for elevated temperature and observing the difference between them. For sand replacement, compressive strength of 0%-40% at normal temperature was about 13-14 MPa and after 50% strength was decreasing. At 200oc-400oc strength was optimum but after 400oc cubes give negative results i.e. they melt. But the compressive strength of cement replacement was optimum up to 20% replacement only. Above 20%, it gives very low strength values.

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