Ash Concrete - A Step Towards Environment Protection

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***Abstract*- The environmental pollution and its associated ill effects have become cause of serious concern due to advancement in technology, urbanization, population explosion, green and industrial revolution. Owing to successive increase in production and power generation huge amount of waste is generated which adversely affect the environment and living beings. The disposal of huge amount of waste resulting from food grain production and power plant stations is a challenge to the environmentalist. Different types of ashes resulting from industrial and agricultural by-products can be used as substitution for cement in concrete. Owing to pozzolanic properties of ashes its inclusion in concrete as cement replacement results not only in economy but also improvements in properties in concrete viz. workability, compressive, tensile, flexural, bond, and impact strength. In this paper an attempt is made to study the utilization of different ashes in concrete and its effect on properties of concrete.**

Keywords: Ashes, Pozzolanic, Workability, Utilization

I. INTRODUCTION

Nature maintains the ecological balance and environment through various processes. In the natural state, Earth's life forms live in equilibrium with their environment. Human abilities have made it possible to thrive and flourish beyond natural constraints. However, the natural and manufactured waste generated and released into the biosphere by increased number of human activities and growth of population has upset the natural equilibrium. Our natural resources are limited, while the amount of natural and domestic waste is increasing day by day for the worst state. It has appeared recently that the sustaining and assimilative capacity of biosphere, though tremendous, in not after all infinite. This system has operated, since time immemorial, but now it has it has started showing the signs of stress primarily because of impact of human activities upon the environment. Pollution of environment leads to various types of disease and disorders and almost all the industries pose environment problem of one kind and another. Owing to increasing problem, upliftment of living standard of people, growth of industrialization and urbanization, advancement of farming and other small and cottage industries by introduction of machines, the power requirement of country is increasing day by day. In India nearly 75% of the power generation is based on thermal power plants, out of which 90% is coal based. A thermal power plant generates huge quantity of air, water and land pollutants like fly ash and oxides of sulphur resulting from combustion of fossil fuel especially coal.

Fly ash is finely divided residue, resulting from the combustion of pulverized coal and transported by the flue gases and collected by the electrostatic precipitators. As per the estimates in India about 150 million tonne fly ash is produced per year which is increasing day by day [1]. The disposal of utilization of this fly ash is matter of ponder. The World Bank has cautioned India that by 2015; land disposal of coal ash would require about 1000 sq km of land [2]. In India wheat, rice (paddy), maize and sugarcane are the prime crops. It is estimated that the production of wheat, rice (paddy), maize and sugarcane in India are 80680000, 133700000, 16680000 and 285029000 tonne respectively [3].

Different types of ashes produced from thermal power plants, paddy, wheat, corn cob, sugarcane and wood has possessed pozzolanic properties and can be used as supplementary cementitious material (SCM) as partial replacement of cement in concrete. By adding pozzolanic material, various properties of concrete viz. workability, strength, resistance to cracks and permeability, duration and modules of elasticity can be improved.

II. PROPERTIES OF ASHES:

The physical and chemical properties of ashes depend on method of burning, combustion equilibrium, variation in load of boiler and method of collection.

The physical and chemical properties of ashes viz. a viz. Ordinary Portland Cement (OPC) is given in Table 1 [4 - 12].

Table 1: Physical Properties and Chemical Composition of Ashes

Properties	OPC	Fly Ash (FA)	Rice Husk Ash (RHA)	Wheat Straw Ash (WSA)	Bagasse Ash (BA)	Corn Cob Ash (CCA)	Saw Dust Ash (SDA)	Ground Nut shell Ash (GNA)	Cattle Manure Ash (CMA)
Physical Properties									
Specific gravity	3.1	2.12 - 2.57	2.06	2.31	2.22	2.97	2.29	--	--
Fineness passing 45 µ sieve (%)	85	57 - 85.48	99	94.5*	--	--	--	--	--
Mean grain size (µm)	22.5	--	3.80	--	--	--	--	--	--
Bulk density (g/cm^3)	--	--	--	--	--	--	0.83	--	--
Dense	1.56	--	0.49	--	--	--	--	--	--
Loose	1.16	--	0.40	--	--	--	--	--	--
Specific area (cm^2/gm)	3250	3296 - 6091	--	4850	--	--	--	--	--
Colour	Grey	Grey to black	Grey to black	Grey to black	Grey to black	Grey to black	Grey to black	Grey to black	Grey to black
Chemical Composition (%)									
Silicon dioxide (SiO_2)	20.25	46.9 – 57.14	87.32	73.06	62.44	67.33	67.20	33.36	41.75
Aluminium oxide (Al_2O_3)	5.04	19.65 – 27.7	0.22	3.9	6.74	7.34	4.09	1.75	6.23
Iron oxide (Fe_2O_3)	3.16	4.32 – 19.60	0.28	1.75	5.77	3.74	2.26	2.16	4.33
Calcium oxide (CaO)	63.61	0.62 – 3.19	0.48	8.12	6.16	10.29	9.98	10.91	18.2
Magnesium oxide(MgO)	4.56	0.62 – 3.19	0.28	2.8	2.97	1.82	5.80	4.72	7.33
Loss on ignition	3.12	1.26 – 15.81	2.10	8.79	2.58	--	4.67	--	2.30
Sodium oxide (Na_2O)	0.08	--	1.02	1.83 #1	3.15	0.39	0.08	9.3	2.58
Potassium oxide (K_2O)	0.51	--	3.14	5.85 #2	6.87	4.30	0.11	16.18	8.62

Δ IS: Sieve No. 325, * Fineness passing 90 µ sieve (%), #1 Na, #2 K

III. PROPERTIES OF ASH CONCRETE (AC)

The important properties of concrete containing different ashes in green as well as in hardened state are presented below:

Workability – It is that property of freshly mixed concrete or mortar which determines the ease and homogeneity with which it can be mixed, placed, consolidated and finished. It is reported that at a given water-binder ratio , the spherical shape of most fly ash particles offers greater workability than the convectional concrete (CC) [13]. The increased ratio of solid volume to water volume produces a paste with improved plasticity and cohesiveness. The adding of fly ash in concrete upto 50% results significant improvement in workability and require shorter vibration time [14]. It is reported that in general addition of fly ash in concrete improves the workability [15].

In concrete containing ground Rice Hush Ash (RHA) the slump loss was faster (30-60 min) than that of CC (105 min) [16]. It is reported that water-binder ratio of Rice Hush Ash Concrete (RHAC) was higher than that of OPC concrete and tended to increase with higher replacement rates [17]. The partial replacement of OPC leads to an increased water demand which can be compensated by use of super plasticizers [18]. It is reported that incorporation of RHA resulted marked increase due to high surface area of RHA [19].

It is reported that incorporation of wood ash as in concrete as cement replacement reduces the workability, mixes with greater water content to achieve a reasonable workability. The increased water demand may be due to the high carbon content in wood ash [20].

Compressive Strength – The strength of ash concrete is affected by several factors viz. type of cement, quality of ash, replacement level and curing temperature. Concrete containing Class F fly ash may develop lower early strength; however it gives high ultimate strength if properly cured. Slow gain of strength is due to relatively slow pozzolanic action of fly ash. It is reported that strength of fly ash concrete increasing with amount of fly ash upto an optimum value (about 40% of cement) [21]. Compressive strength of fly ash concrete at 40% cement replacement was found to be 5% more than that of concrete without fly ash [22].

It is further reported that the incorporation of RHA in concrete increased the compressive strength particularly for the lower water-binder ratio concretes [23]. It is also reported that at 20% replacement level of OPC by RHA gave higher compressive strength (upto 5%) [17]. The use of RHA to replace OPC at 20% and 35% by weight of binder by recycled aggregate concrete gave higher compressive strength (4%-8%) as compared to referral concrete [16]. It is concluded that an increased compressive strength (about 6%) at 28 day and onwards can be obtained by replacing OPC with RHA [19]. Partial replacement of OPC upto 20% by weight of RHA yielded increased compressive strength (6%-21% at 7 days and 15%-22% at 28 days) [18]. In inclusion of 5%-30% RHA in concrete increases the compressive strength in the range of 0.1%-8.5% at 28 days the respective change is about 12%-23% [24]. It is observed that at 10% and 15% replacement of OPC by Wheat Straw Ash (WSA) increase the compressive strength by 6.15% and 11.92% respectively at 28 days; however this effect is more prominent after 18 months and increase in strength is found 36.64% and 46.02% respectively as compared to referral concrete [25]. It is reported that on inclusion of 5% to 20% bagasse ash as SCM in general not shows any substantial change compressive strength at 28 days for different doses (2%-4%) of super plasticizer as compared to referral CC [8].

It is reported that the compressive strength of CCA blended cement concrete is lower than that of plain cement concrete (PCC) at early curing stages but improves significantly at later stages and in fact has higher percentage gain in strength the later. The optimum level of CCA replacement from structural load view point is 8%. To enjoy the maximum benefit of strength gain, the concrete needs to be cured for a minimum of 120 days [9]. At 8% replacement level of OPC by CCA compressive strength of 1:2:4 is found to be 29.82 MPa at 28 days [26].

It is observed that at 5%, 10% and 15% replacement of OPC by saw dust ash strength are reported as about 93%, 78% and 68% respectively [10].

It is concluded that partial replacement of OPC with about 10% of Bambara groundnut shell ash in concrete is acceptable as per strength criteria [11].

It is reported that 56th day compressive strength of samples 5%, 10% and 15% Cattle Manure Ash (CMA) provided the best results which were determined as 96 %, 95% and 94% of the controls value respectively.

Tensile Strength – It is reported that the tensile strength of fly ash concrete at 40% replacement level is slightly more than that of CC at 180 days; however it was slightly lower at 28 days [27]. It is also observed that addition of fly ash as fine aggregate replacement increases the tensile strength upto 50% replacement level. The rate of increase in strength is more prominent after 25 days. Tensile Strength of concrete is found to be increased by 16.7% and 30% at 28 and 91 days respectively [28].

It is reported that the use of RHA did not change much the tensile strength of recycled aggregate concrete. The average value of tensile strength was 8.15% of its compressive strength which was well within the range [16]. Splitting Tensile Strength of RHA blended concrete increased by 18% with RHA content upto 20% and then at 30% RHA Splitting Tensile Strength was equivalent to that of CC.

Durability – It is reported that the RHA mortar is of low pH and less susceptible to sulphate attacks [16]. RHA reduces the chloride permeability of concrete from a moderate to low or very low ASTM clarification depending on the adding rate. Further, the RHAC is slightly more efficient in resisting surface scaling due to tensing shots [29]. In corporation of RHA in concrete enhances its durability property by referring the pore structure [30].

It is reported that resistance to the chloride ion penetration was significantly higher for the concrete incorporating fly ash than for the CC [31].

Concretes where corn cob ash used as a fine aggregate showed highest abrasion resistance compared to the other specimens. The greater abrasion resistance of concretes to added fine wheat straw ash and corn cob ash is believed to result from denser pore structure of a mortar binder. Furthermore this might be explained by the fact that ash allows as a good interference [25].

Negative effects of surface exposure on WSA Concrete and CCA Concrete were less than the CC. The decrease in compressive strength due to sulphate effect in WSA and CCA are 23% and 21% respectively; however it was 29% in case CC.

IV. CONCLUSION:

Following conclusions are drawn

- Ash concrete is suitable alternative of conventional concrete.
- Concrete with FA and RHA showed substantial improvement in compressive strength. However, CCA, GNA, BA and CMA show at par or slightly lower compressive strength as compared to CC.
- Tensile strength of ash concrete is almost similar to CC.
- Durability of ash concrete is better than that in CC.

V. REFERENCES

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