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Experimental Study of Fly Ash Mortar

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Abstract - The use of fly ash as a cement replacement makes the mortar less permeable to harmful ions due to its finer particle size distribution and pozzolanic reactions. This results in an enhanced high performance and more durable mortar. Number of studies of the effects of the fly ashes on the behaviour of cement pastes, mortars, and concretes were also carried out. Paper has examined the effect of fly ash used as replacement addition to the Ordinary Portland cement (OPC) on the compressive strength development of cement mortars of five hopper fly ashes at Khaperkheda Thermal Power Plant. The mix proportion 1:3 of cement mortar in which cement is partially replace with fly ash as 0%, 12.5%, 25% and 37.5% by the weight of cement. Compressive strengths of the mortar specimens were determined at 7, 28, and 90 days. Test results show that strength increases with the increase of fly ash up to an optimum value, beyond which, strength values start decreasing with further addition of fly ash.

Keywords- Fly ash, Mortar & Compressive strength

I. INTRODUCTION

Fly ash is an industrial waste and a material of puzzolanic characteristic occurring due to burning the pulverized coal in the thermal power plants. In India at present produces around 120 Million Ton of Ash per annum. The requirement of power in the country is rapidly increasing with increase in growth of the industrialization. India depends on Thermal power as its main source (around 80% of power produced is thermal power), as a result the Ash quantity produced shall also increase. Indian coal on an average has 35 % Ash and this is one of the prime factors which shall lead to increase in ash production and hence, Ash utilization becomes major problem for the country. Seventy percent of total utilization is covered in the cement industry, in which a large increase in utilization is not expected in the future because of limits to acceptable quantity.

The classification of thermal plant fly ash is considered based on reactive calcium oxide content as class-F (less than 10 %) and class-C (more than 10 %). Indian fly ash belongs to class-F. The burning of harder, older anthracite and bituminous coal typically produces Class F fly ash. This fly ash is pozzolanic in nature, and contains less than 10% lime (CaO). Possessing pozzolanic properties, the glassy silica and alumina of Class F fly ash requires a cementing agent, such as Portland cement, quicklime, or hydrated lime, with the presence of water in order to react and produce cementitious compounds. Alternatively, the addition of a chemical activator such as sodium silicate (water glass) to a Class F ash can lead to the formation of a geopolymer.

The analysis of compressive strength was obtained from the experimental results obtained from the average of 3 samples in each batch. 3 batches of replacement of fly ash for cement mortar specimens and 5 hopper of thermal power plant specimens were used for this analysis. The influence of fly ash and its different specific gravity of five hopper of Khaperkheda power plant on the compressive strength are investigated. Replacing fly ash with cement of an amount of 12.5%, 25% and 37.5% for the age of 7 days, 28 days and 90 days for compressive strength and drying shrinkage measure from 7days to 35 days i.e. 28 days for same percentage of replacement.

II. STUDY OF FLY ASH

Fly ash is a burnt and powdery derivative of inorganic mineral matter that generates during the combustion of pulverized coal in the thermal power plant. The burnt ash of the coal contains mostly silica, alumina, calcium and iron as the major chemical constituents. Depending on the burning temperature of coal, the mineral phases in crystalline to non-crystalline structures such as quartz (SiO_2), mullite ($3Al_2O_3$ 2 H_2O), hematite (Fe_2O_3), magnetite (Fe_3O_4), wustite (FeO), metallic iron, orthoclase (K_2O $Al_2O_3$6 SiO_2) and fused silicates usually occur in the burnt coal ash2. Silica and alumina account for about 75 to 95 % in the ash. The classification of thermal plant fly ash is considered based on reactive calcium oxide content as class-F (less than 10 %) and class-C (more than 10 %). Indian fly ash belongs to class-F. The calcium bearing silica and silicate minerals of ash occur either in crystalline or non-crystalline structures and are hydraulic in nature; they easily reacts with water or hydrated lime and develop pozzolanic property. But the crystalline mineral phases of quartz and mullite present in the ash are stable structures of silica and silicates, and are non-hydraulic in nature. Usually the fly ash contains these two mineral phases as the major constituents. Therefore, the utilisation of fly ash in making building materials like fibre cement sheets largely depends on the mineral structure and pozzolanic property.

Two classes of fly ash are defined by ASTM C618: Class F fly ash and Class C fly ash. The chief difference between these classes is the amount of calcium, silica, alumina, and iron content in the ash. The chemical properties of the fly ash are largely influenced by the chemical content of the coal burned (i.e., anthracite, bituminous, and lignite).

A) Class F Fly Ash:

The burning of harder, older anthracite and bituminous coal typically produces Class F fly ash. This fly ash is pozzolanic in nature, and contains less than 10% lime (CaO). Possessing pozzolanic properties, the glassy silica and alumina of Class F fly ash requires a cementing agent, such as Portland cement, quicklime, or hydrated lime, with the presence of water in order to react and produce cementitious compounds. Alternatively, the addition of a chemical activator such as sodium silicate (water glass) to a Class F ash can lead to the formation of a geopolymer.

B) Class C Fly Ash:

Fly ash produced from the burning of younger lignite or sub bituminous coal, in addition to having pozzolanic properties, also has some self-cementing properties. In the presence of water, Class C fly ash will harden and gain strength over time. Class C fly ash generally contains more than 20% lime (CaO). Unlike Class F, self-cementing Class C fly ash does not require an activator. Alkali and sulfate (SO_4) contents are generally higher in Class C fly ashes.

III. STUDY OF MATERIALS

A) Ordinary Portland Cement

43 Grade Ordinary Portland Cement (as per IS: 8112 1989 - Reaffirmed 2005) are manufactured by intimately mixing together calcareous and argillaceous and /or other silica, alumina or iron oxide bearing materials, burning them at clinkering temperature and grinding the resulting cement clinker with natural or chemical gypsum so as to produce cement capable of complying the IS specifications. Fly ash up to 5% conforming to IS: 3812 part 1 can be used as a performance improver in the manufacturing of these cements. The grades of this Ordinary Portland Cement are designated based on its 28-days average compressive strength requirement.

B) Sand:

As hydraulic cement is commonly mixed with certain proportions of sand, when used in construction, the nature and quality of sand used, and the method of manipulating the materials in forming the mortar have quite as important, an effect upon the final strength of the work as the quality of the cement itself.

C) Fly Ash

Class F type Fly ash with various Specific gravity obtained from Khaparkheda thermal power plant, conforming to IS 3812-Part 1-2003

Table 1 specific gravity of all hopper fly ashes

Physical test	specific gravity(gm/cc)
Hopper 1	2.13
Hopper 2	2.13
Hopper 3	2.07
Hopper 4	2.133
Hopper 5	2.2

D) Water

Water used for mixing and curing is clean and free form injurious amounts of oils, acids , alkalis, salts, sugar , organic material or other substances that may be deleterious to concrete or steel. Water is one of the important materials for the mortar. The quality of the water must best on the BS3148. The criterion of portability of water is not absolute. Water with Ph 6 to 8 which not tested saline or brackish is suitable for use.

IV. EXPERIMENTAL PROGRAMS

The evaluation of fly ash for the use of supplementary cementitious material i.e. as a pozzolona, begins with the mortar testing. Mortar is similar to concrete in that it contains cement, water and aggregate, except that in fine aggregate is the only aggregate present. With the control mortar i.e. without fly ash, 12.5%, 25% and 37.5% of the ordinary Portland cement (OPC) conforming IS 296 is placed with the fly ash. The quantities of mixing of material are given in table which contains 1:3 proportion of cement to sand for all five hopper fly ash.

A) Study of Compressive Strength of Mortar

The standard (IS 4031: 1988-Part 7) covers the procedure for determining the strength of masonry cement as represented by compressive strength tests on 50 mm mortar cubes. For the quantity of mixing of material are given in table which contains 1:3 proportion of cement to sand. The amount of water used for gauging shall be such as to produce a flow of 110±5 percent with 25 drops in 15 second. Immediately following completion of the flow test, return the mortar from the flow mould to the mixing bowl. Fill the mould and tamp the mortar in each cube compartment 32 times in about 10 second in four rounds, each round to be at right angles to the other and consisting of eight adjoining 1 strokes over the surface of the specimen. All test specimens, immediately after moulding and compaction, shall be kept in the moulds on plane plates in a moist cabinet, maintained at a temperature of 27±2°C and a relative humidity of 90 percent or more and then place in water for curing process.

Storage And Curing of Specimens

All test specimens, immediately after moulding and compaction, shall be kept in the moulds on plane plates in a moist cabinet, maintained at a temperature of 27±2°C and a relative humidity of 90 percent or more, from 48 to 52 hr. in such a manner that the upper surfaces shall be exposed to the moist air. The cubes shall then be removed from the moulds and placed in the moist cabinet for five days in such a manner as to allow free circulation of an around at least five faces of the specimens. After five days curing in moist cabinet, the cubes for 7 day compressive strength shall be removed for testing whereas the cubes for 28-day compressive strength test shall be immersed in clean water for another twenty-one days in storage tanks of non-corrosive materials.

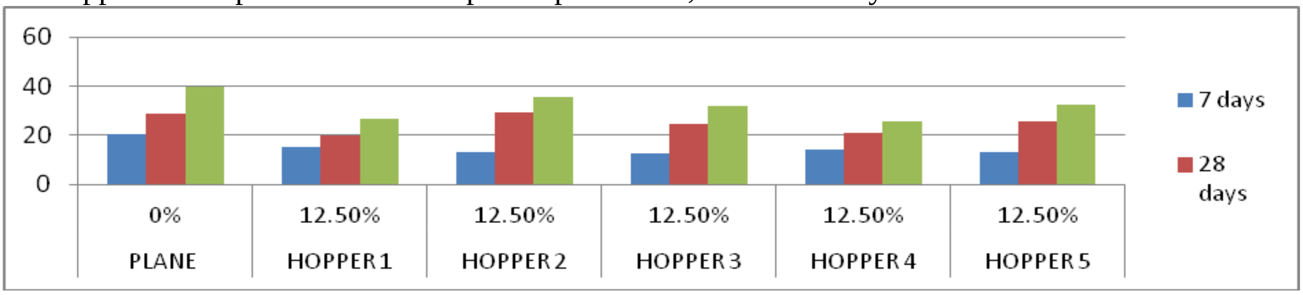
V. TESTING RESULTS AND DISCUSSION

Table 2: Results of Compressive Strength And Drying Shrinkage

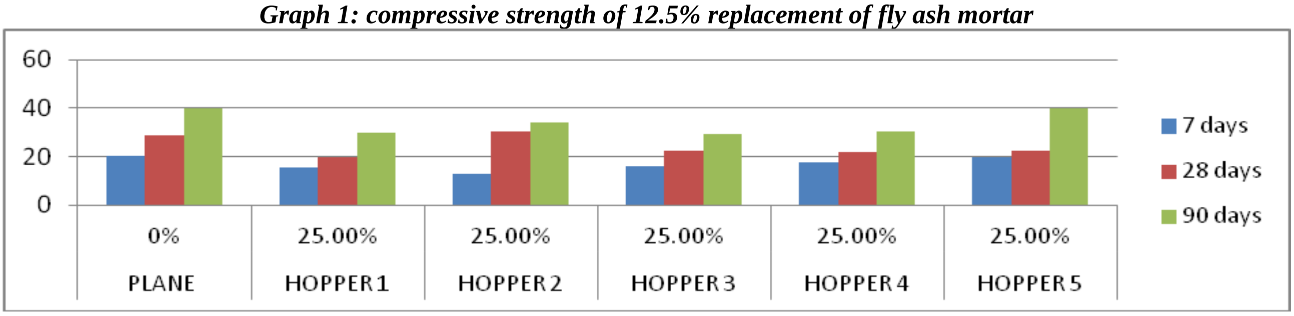
		Compressive Strength, N/mm2		
		7 Days	28 Days	90 Days
Plane	0%	20.18	28.72	39.87
hopper 1	12.50%	15.41	19.87	26.5
	25%	15.42	20.03	30.1
	37.50%	12.45	16.76	24.18
hopper 2	12.50%	13.23	33.01	35.55
	25%	13.04	33.52	31.95
	37.50%	15.57	21.36	24.43
hopper 3	12.50%	12.31	24.38	23.08
	25%	15.95	16.41	19.41
	37.50%	17.53	19.89	22.16
hopper 4	12.50%	14.27	21.06	25.44
	25%	17.84	21.75	30.64
	37.50%	17.43	19.89	24.27
hopper 5	12.50%	13.04	29.55	32.32
	25%	19.61	22.69	39.89
	37.50%	15.04	21.89	41.71

The specimen for each cast with different percentage of FA with gradual increase of fine fly ash 12.5%, 25% and 37.5%, of hopper 1 to 5 replacing with cement by weight. . Three specimens, preferably from different batches, are made for testing at each selected age. The testing for compressive strength carried out for 7, 28, and 90 days of age. The result of compressive strength for each batch and different age shown above table

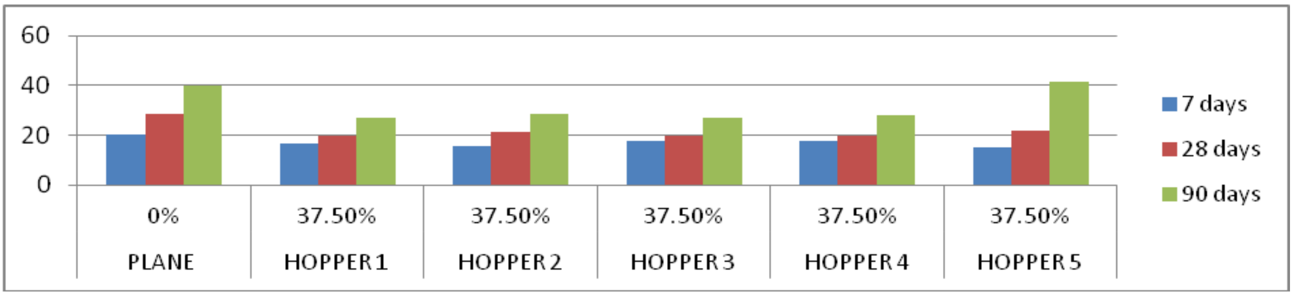
Below graph shows compressive strength of 12.5%, 25%, and 37.5% replacement of fly ash for five hopper of Khaparkheda thermal power plant for 7, 28 and 90 days.



Graph 1: compressive strength of 12.5% replacement of fly ash mortar



Graph 2: compressive strength of 25% replacement of fly ash mortar



Graph 3: compressive strength of 37.5% replacement of fly ash mortar

The compressive strength of prepared cement mortars was examined after 7, 28, and 90, of hydration. The results show that the developed compressive strengths increase with time for all the samples. From the above graph it shows that as percentage of fly ash increases then strength is goes on decreases except for the hopper 5 fly ash and in 25% and 37.5% hopper 5 fly ashes gives more strength than plane (0% replacement) sample.

VI. CONCLUSION

The following are the conclusion made in this paper:

- The results show that the developed compressive strengths increase with time for all the samples and also replacement of percentage up to 37.5%.
- Hopper 5 fly ash having specific gravity 2.2 greater than other hopper gives better result.

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