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Utilization of Fly ash in Improving Concrete Properties

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Abstract

The following paper is related with finding out the utilization of fly ash in improving concrete properties and its several environmental benefits. Fly ash is pozzolonic material & it improves the properties of concrete like compressive strength & Durability. Here the method used for determining this is experimental. Here cubes casted with different amounts of fly ash proportions ranging from 10%-30% are used and their 7 and 28 days strength are found out. The strength of cubes was found out by the use of compressive testing machine. Their degree of economy has also been found out. In the present study the results obtained are discussed and compared with the available literature.

Keywords: Fly ash

Introduction

The concrete construction industry is not sustainable due to one or other reason. First, it consumes huge quantities of virgin materials. Second, the principal binder in concrete is Portland cement, the production of which is a major contributor to greenhouse gas emissions that are implicated in global warming and climate change. Third, many concrete structures suffer from lack of durability which has an adverse effect on the resource productivity of the industry. Use of industry waste like fly ash, silica fume, grounded furnace slag to partly replace cementing material concrete system addresses all three sustainability issues, its adoption will enable the concrete construction industry to become more sustainable. Looking to the production of the Fly ash, worldwide in general and India in particular the utilization of Fly ash is almost negligible. The developing nation like India, having the vision and mission to be developed country by 2020, a dream of honorable president the scarcity and long term planning of the natural material in form of minerals, raw material for different industries and the natural resources like water and oil are of prime consideration. The people and society connected with nation building should look into the matter for innovation, promotion for the alternate source of energy and substituting material to be utilized in the different sectors. Fly ash, an industrial waste arising from coal fired Thermal Power Stations currently poses a serious operational constraint and environmental hazard. A 100 MV thermal power plant generates about 0.15 million tones of fly ash per annum when using coals with an ash content of 40%. Fly ash, on the other hand, possesses both ceramic as well as pozzolana properties and therefore it can be utilized in a unique way for manufacturing pozzolana cement, Activated Fly ash Blended Cement, light weight cindered aggregates,
High Volume Fly Ash Concrete, Cellular Light Weight Concrete, Fly ash based polymer composites as wood substitute, ready mixed fly ash concrete and fly ash bricks etc.

Literature review

Effects of water to cementations ratio on compressive strength of cement mortar containing Fly Ash in these paper Minnick et al. indicated that inclusion of fly ash can increase or decrease the water requirement of mortar or concrete mixes depending upon the carbon content (LOI), and the amount of material retained by the 45 μm sieves. The increase in water demand results due to water absorption by carbon particles and other porous materials, and coarse particles cause increased frictional resistance of the mix systems, especially between the paste and coarse aggregate particles. Therefore, mixes containing large and/or coarse fly ash particles, higher amounts of water will be required relative to the control mix in order to produce mortars/concrete at a fixed workability level. In general, mixes containing fly ash with finer particles show decrease in water demand with increasing amount of fly ash in the mixture.

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Helmuth reviewed critically the water-reducing properties of fly ash in cement pastes, mortars, and concretes. Based on his critical analysis of test data derived from several studies, he concluded that the reduction in water requirement in these mixes may not be because of ball bearing effects of spherical fly ash particles, as generally described in the literature, but it may be primarily due to absorption of very fine fly ash particles on cement particles surfaces which in turn causes dispersion of the cement particles similar to that obtained through addition of organic water-reducing admixtures.

Durability of Concrete Incorporating High-Volume of Low-Calcium (ASTM Class F) Fly Ash by V.M.Malhotra This Research on structural concrete incorporating high volumes of low-calcium (ASTM Class F) fly ash has been in progress at CANMET since 1985. In this type of concrete, the cement content is kept at about 150 kg/m^3. The water-to-cementitious materials ratio is of the order of 0.30, and fly ash varies from 54 to 58% of the total cementitious material. A large dosage of a super plasticizer is used to achieve high workability.

This paper presents data on the durability of this new type of concrete. The durability aspects considered are: freezing and thawing cycling; resistance to chloride ion permeability; and the expansion of concrete specimens when highly reactive aggregates are used in the concrete. The investigations performed at CANMET indicate that concrete incorporating high volumes of low-calcium fly ash has excellent durability with regard to frost action, has very low permeability to chloride ions and shows no adverse expansion when highly reactive aggregates are incorporated into the concrete.

Performance Characteristics of Class F Fly Ash Concrete Rafat Siddique In these paper more than 88 million tones of fly ash is generated in India each year. Most of the fly ash is of Class F type. The percentage utilization is around 10 to 15%. To increase its percentage utilization, an extensive investigation was carried out to use it in concrete. This article presents the results of an experimental investigation dealing with concrete incorporating high volumes of Class F fly ash. Portland cement was replaced with three percentages (40%, 45%, and 50%) of Class F fly ash. Tests were performed for fresh concrete properties: slump, air content, unit weight, and temperature. Compressive, splitting tensile and flexural strengths, modulus of elasticity, and abrasion resistance were determined up to 365 days of testing. Test results indicated that the use of high volumes of Class F fly ash as a partial replacement of cement in concrete decreased its 28-day compressive, splitting tensile and flexural strengths, modulus of elasticity, and abrasion resistance of the concrete. However, all these strength properties and abrasion resistance showed continuous and significant improvement at the ages of 91 and 365 days, which was most probably due to the pozzolanic reaction of fly ash. Based on the test results, it was concluded that Class F fly ash can be suitably used up to 50% level of cement replacement in concrete for use in precast elements and reinforced cement concrete construction.

Abrasion Resistance of High-Strength Concrete made with Class C Fly Ash by Tarun R. Naik. In this paper Synopsis This work was undertaken to evaluate the abrasion resistance of concrete proportioned to have five levels of cement replacements (15, 30, 40, 50, and 70%) with one source of Class C fly ash. A reference concrete without fly ash was proportioned to have the 28-day compressive strength of 41 MPa. Concrete specimens were subjected to abrasion according to the ASTM C- 944 test method. In this work, all the concretes made with and without fly ash passed the abrasion resistance requirements per ASTM C-779, Procedure C. Depth of wear values produced by the ASTM C-944 test, were quite low (less than 1 mm) for the strength levels tested in this work.

An accelerated test method was developed and used to evaluate abrasion resistance of high strength concrete. This method used the grinding wheels with smaller size washers, and standard Ottawa sand was applied to the surface being abraded at an interval of one minute. The accelerated test results showed that abrasion resistance of concrete having cement replacement up to 30% was comparable to the reference concrete without fly ash. Beyond 30% cement replacement, the fly ash concrete exhibited slightly lower resistance to abrasion relative to the no fly ash concrete.

Langan et al**.** studied compressive strength and durability of concrete containing substitute materials at 35% replacement level by weight of Portland cement used. Seven fly ashes, together with a limestone as an inert filler material (silica flour), were used as replacement materials. The results revealed that the presence of fly ash at high levels of cement replacement increased the weight loss due to

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abrasion at all ages relative to the concrete without fly ash.

Materials and methods

Mix design of concrete

It includes test of ingredients and then fly ash concrete mix design. Fly ash concrete mix was prepared as per the guidelines and norms in book M.S SHETTY and www.engineeringcivil.com for M 20 grade of concrete the replacement of cement with class C fly ash was ranging from 20% to 30% by weight of cement for M 20 grade of concrete. As the primary objective of improving the Workability and compressive strength properties of concrete

Tests on ingredients

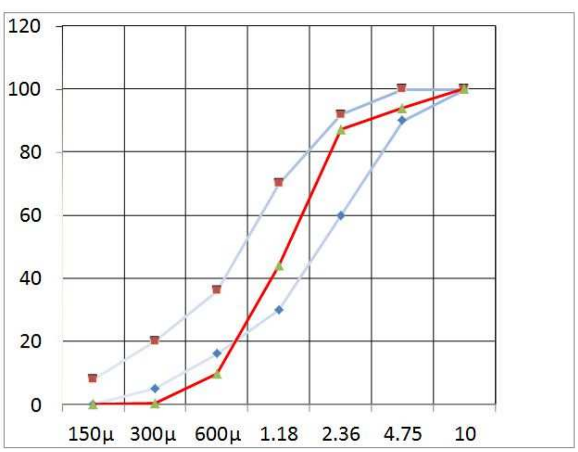
Fine Aggregates

- Dry rodded density =1472 kg /m^3
- Loose bulk density = 1280 kg /m^3
- Specific gravity=2.6043
- Fineness modulus =2.65
- Zone : 1
- Water content =2%

Figures

TABLE 1: Physical Properties of Sand

Properties	Fine Aggregate
Specific Gravity	2.60
Fineness Modulus	2.65



"FIG 1: Particle Size Distribution

*Table 2: **Coarse aggregate***

Properties	Coarse Aggregate
Size of Aggregate	20 mm
Specific Gravity	2.60
Fineness Modulus	2.65
Density(kg/m^3)	1483
Water Absorption	1.6%

Table 3: Physical Properties of Cementitious Materials

Materials	Sp. Gravity	Blaine's Air Permeability Fineness (cm^2/gm)	Initial Setting time (Min. 60 mm)	Final Setting time (Max. 600 mm)
OPC	3.15	2250	90	310
FA	2.20	3890	105	320

Table 4: Concrete Mix Design

Type of concrete	OPC	OPC + FLY ASH	OPC + FLY ASH	OPC + FLY ASH
Material	Kg /m^3	Kg /m^3	Kg/m^3	Kg/m^3
Replacement (%)	0	20	25	30
Cement	320	256	240	224
Fly ash	0	64	80	96
Coarse aggregate	1135	1135	1135	1135
Fine aggregate	650	650	650	650
Water	163 (lit)	163(lit)	163(lit)	163(Lit)

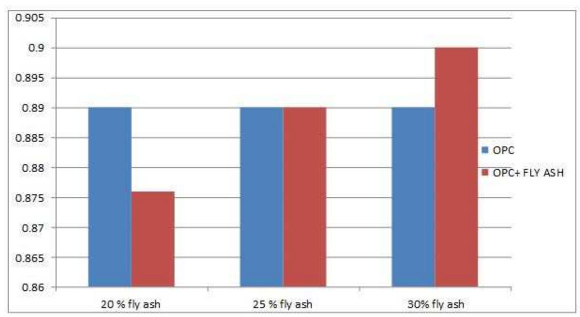


Fig.2

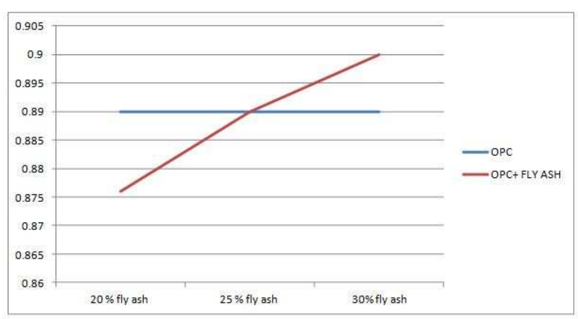


Fig. 3.Compaction factor test for workability measurement

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Compressive Strength of Hardned Concrete

Out of many test applied to the concrete, this is the utmost important which gives an idea about all the characteristics of concrete. By this single test one judge that whether Concreting has been done properly or not. For cube test two types of specimens either cubes of 15 cm X 15 cm X 15 cm or 10cm X 10 cm x 10 cm depending upon the size of aggregate are used. For most of the works cubical moulds of size 15 cm x 15cm x 15 cm are commonly used.

Concrete is poured in the mould and compacted in vibration machine so as not to have any voids. After 24 hours these moulds are removed and test specimens are put in water for curing. The top surface of these specimens should be made even and smooth. This is done by putting cement paste and spreading smoothly on whole area of specimen. These specimens are tested by compression testing machine after 7 days curing and 28 days curing. Load should be applied gradually at the rate of 140 kg/cm^2 per minute till the Specimens fails. Load at the failure divided by area of specimen gives the compressive strength of concrete.

Compressive strength of concrete after 7 days of curing

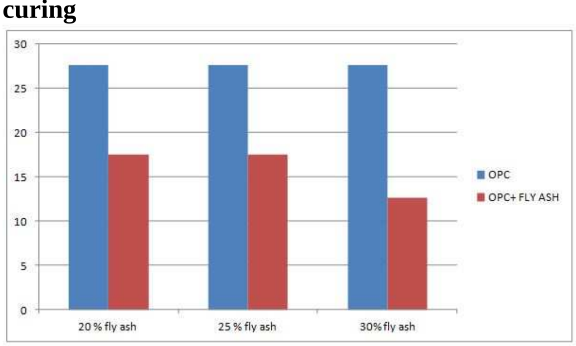
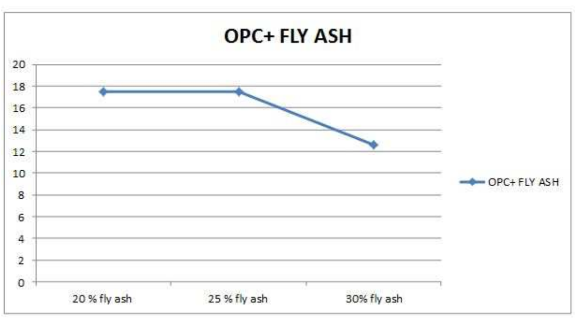


Fig.4



"FIG 5: COMPRESSIVE STRENGTH → (%) REPLACEMENT"

Density of concrete after 7 days of curing

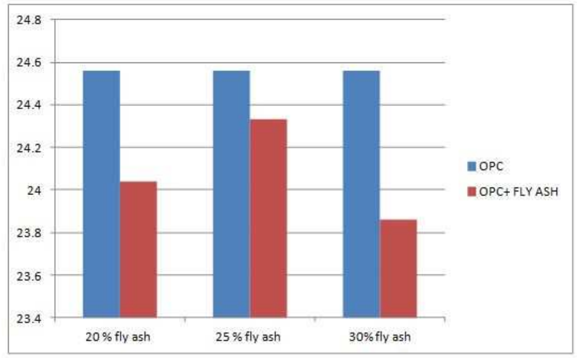
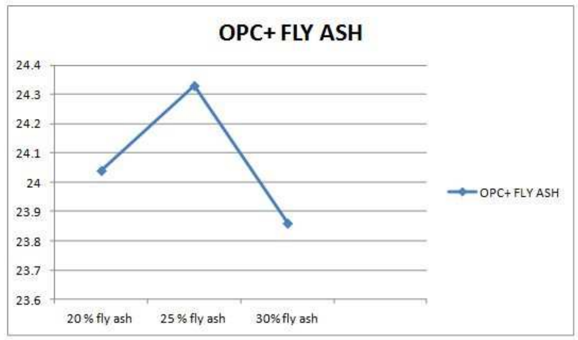


Fig.6



"FIG 7: DENSITY OF CONCRETE (KN/M^3) → (%) REPLACEMENT"

Compressive strength of concrete after 28 days of curing

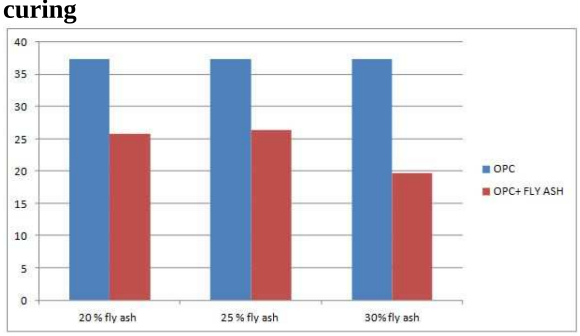
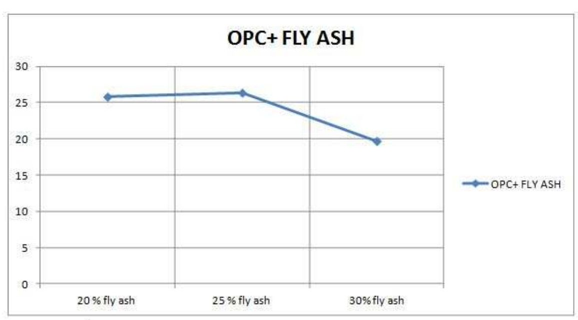


Fig 8



"FIG 9: COMPRESSIVE STRENGTH → (%) REPLACEMENT

Density concrete blocks after 28 days of curing

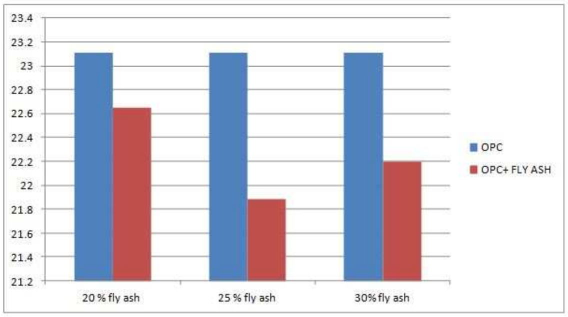
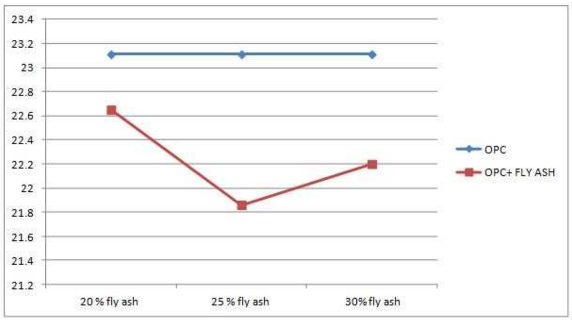


Figure 10.



"FIG 11: DENSITY OF CONCRETE (KN/M³) → (%) REPLACEMENT"

Conclusion

- The Mix for 0%, 20% 25% and 30% replacement of cement for seems to be Cohesive, Workable, with no sign of any segregation and bleeding.
- It has been found that addition of fly ash to OPC in concrete improves the properties of fresh concrete i.e. workability.
- As compared to normal concrete fly ash concrete strength was less after 7 days but it was increased after 28 to about 10% to 15%.
- For M 20 grade of concrete 25 % replacement of fly ash by mass of cement gives best compressive strength results for hardened concrete .
- For water cement ratio of 0.6 , 25% replacement of cement by mass gives best results for workability .
- For M20 grade of concrete cost saving per cubic meter of concrete is shown on table

Table 5: *Rate of cement considered in above calculation is 300 Rs/bag.

% replacement of cement	Cement content replaced by fly ash in (Kg)	Cost *of OPC 53 grade cement	Saving(Rs) per m^3 of concrete
0	0	6.4	0
20	64	6.4	410
25	80	6.4	512
30	96	6.4	615

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