ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 3, Issue 11 , November 2016

Mechanical Properties of Flyash Concrete Containing Metakaolin

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ABSTRACT:Fly ash is being used in concrete as additive due to superiorpozzolanic action which accounts for the strength gain and reduction in concreting cost.Recently there has been a great demand for high quality concrete structures with highperformance for which additional pozzolanic additives like metakaolin can also be used to improve the quality. The present study aims the influence of metakaolin on the hardenedproperties of concrete. The fly ash is used by replacing cement partially by 20%. The strength property like compressive strength of concrete mixes has been tested at 7 and 28days. The metakaolinis added in varying percentages of cement.

KEYWORDS:Fly ash, metakaolin, compressive, pozzolanic, DOE method.

I. INTRODUCTION

Concrete is a composite material composed of coarse granular material (the aggregate or filler) embedded in a hard matrix of material (the cement or binder) that fills the space between the aggregate particles and glues them together. Now a days concrete is just not only a mixture of cement, sand and aggregate but also it includes admixtures, plasticizers, supplementary cementitious material and many more. These materials are used for improving properties of concrete, performance of concrete and mainly strength of concrete. One of these, Metakaolin is supplementary cementitious material which is used in concrete mix for increasing strength of concrete and performance of concrete.

Metakaolin or calcined kaolin, another type of pozzolan, produced by calcination has the potential to replace silica fume as an alternative material. In India metakaolin can be produced in large quantities, as it is a processed product of kaolin mineral which has widespread proven reserves available in the country (Basu et al., 2000; Tiwari and Bandyopadhyay, 2003). Presently the market price of metakaolin in the country is about 3 to 4 times that of cement. Hence the use of metakaoiln proves economical over that of silica fume.The use of pozzolanas for making concrete is considered efficient, as it allows the reduction of the cement consumption while improving the strength and durability properties of the concrete. Metakaolin when used as a partial replacement substance for cement in concrete, it reacts with $Ca(OH)_2$ one of the by-products of hydration reaction of cement and results in additional C-S-H gel which results in increased strength. Metakaolin is obtained by thermal activation of kaolin clay. This activation will cause a substantial loss of water in its constitution causing a rearrangement of its structure. To obtain an adequate thermal activation, the temperature range should be established between 600 to 750ºC. Metakaolin is used in oil well cementing to improve the compressive and flexural strength of the hardened cement. Metakaolin also reduces the hardened cement permeability to liquids and gases. Hence by partially replacing Portland cement with Metakaolin not only reduces carbon dioxide emissions but also increases the service life of buildings.

The work in this paper is purely experimental, where the effect of Metakaolin on strength of concrete are studied by varying percentage of Metakaolin as7.5%, 12.5%, 17.5%, and 22.5% by weight of cement in concrete.

II. MATERIALS AND METHODOLOGY

A. MATERIALS

Following materials were used in this experimental work.

1. Cement: Ordinary Portland Cement of 43 Grade with 28% of standard consistency was used.
2. Fine aggregate: Crushed sand is used as fine aggregates.
3. Coarse aggregate: 10mm and 20mm size coarse aggregates were used.
4. Water: Portable tap water was used for the preparation of specimens and for the curing of specimens.
5. Additives:
   a) Fly ash: Class C type fly ash is used as main additive by partially replacing 20% of cement by the weight of cement.

ISSN: 2350-0328

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b) Metakaolin: Metakaolin is used as other additive by partially replacing cement by varying percentages by the weight of cement.
c) Superplastisizer: To induce workability PermaPlast PS 34 superplasticizer was used.

Fig.1Metakaolin

Following table shows the Chemical compositions of Metakaolin. The chemical composition of Metakaolin is similar to Portland cement.

Chemicals	Percentage%
SiO2	62.62
Al2O3	28.63
Fe2O3	1.07
MgO	0.15
CaO	0.06
Na2O	1.57
K2O	3.46
TiO2	0.36
LOI	2.00

B. **METHODOLOGY**

Cement, sand and aggregate were taken in a mix proportion 1:1.68:2.52 as per DOE Method which corresponds to M35grade of concrete. 20% of cement by flyash&7.5% to 22.5% of cement by its weight is replaced by Metakaolin in all the mixes. All theingredients were dry mixed homogeneously. To this dry mix, required quantity of water was added (w/c= 0.38) and the entire mix was again homogeneously mixed. Now superplasticizer was added at thedosage of 0.8% (by weight of cement) and again a homogeneous mix was prepared.

After 28 days of curing the concrete specimens were tested for their respective strengths.For evaluating the compressive strength, specimens of dimensions 150 x 150 x 150 mm werepreprared. They were tested on 2000kN capacity compression testing machine as per IS: 516-1959. Thecompressive strength is calculated by using the equation,

$$F=P/A$$

Where,
F= Compressive strength of the specimen (in MPa).
P= Maximum load applied to the specimen (in N).
A= Cross sectional area of the specimen (in mm2).

For the evaluating the tensile strength, cylindrical specimens of diameter 150mm and length 3000mm were prepared. Split tension test was carried out on 2000 kN capacity compression testing machine as per IS 5816-1999. The tensile strength is calculated using the equation,

$$F= 2P/ (\pi DL)$$

Where,
F = Tensile strength of concrete (in MPa).
P = Load at failure (in N).

ISSN: 2350-0328
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L = Length of the cylindrical specimen (in mm).
D = Diameter of the cylindrical specimen (in mm).

III. EXPERIMENTAL RESULTS

Following table give the results of compressive strength of the Metakaolin concrete for the replacement of 0% cement with flyash and 0% Metakaolin by weight for 7 and 28 days of curing.

% of Metakaolin added	Comp. strength of concrete (MPa)	
	7Days	28 Days
0% FA + 0% MK(reference mix)	29.66	43.62

Following table give the Overall results of compressive strength of the Metakaolin concrete for the replacement of 20% cement with flyash and varying % Metakaolin by weight for 7 and 28 days of curing.

Different % of Metakaolin added	Comp. strength of concrete (MPa)	
	7Days	28 Days
0% MK(reference mix)	29.66	43.62
7.5% MK	22	40
12.5% MK	24	45
17.5% MK	27	51
22.5% MK	20	36

The variation in compressive strength can be represented in the form of a graph as shown in fig 2.

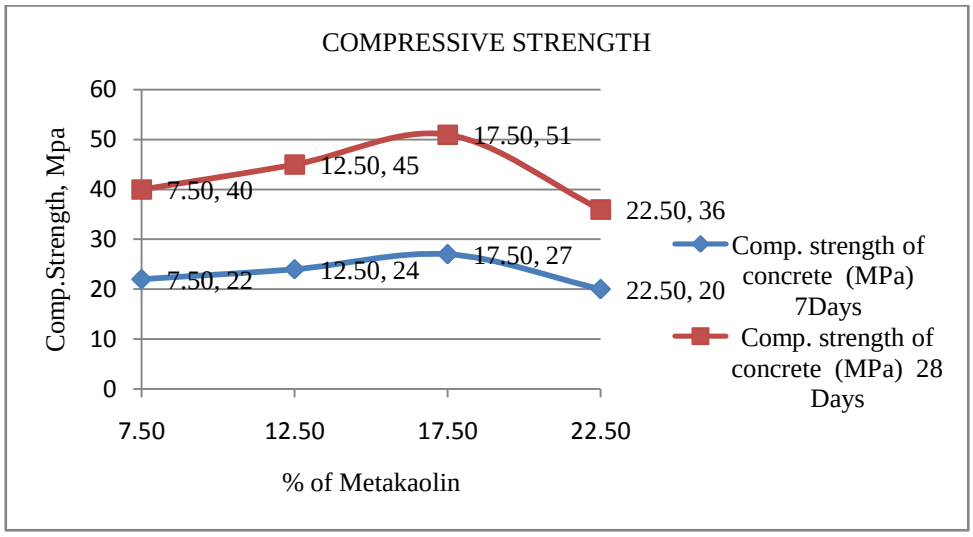

Fig 2. Variation in compressive strength of Metakaolin concrete when cement is replaced with Varying % of Metakaolin.

Following table give the Overall results of compressive strength of the Flyash concrete for the replacement of 20%, 30%, 40% and 50% cement with flyash and 0% Metakaolin by weight for 7 and 28 days of curing.

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Different % of Flyash added	Comp. strength of concrete (MPa)	
	7Days	28 Days
0% FA	29.66	43.62
20% FA	25.8	40.5
30% FA	28.1	48.9
40% FA	22.5	43.4
50% FA	19.1	37.5

The variation in compressive strength can be represented in the form of a graph as shown in fig 3.

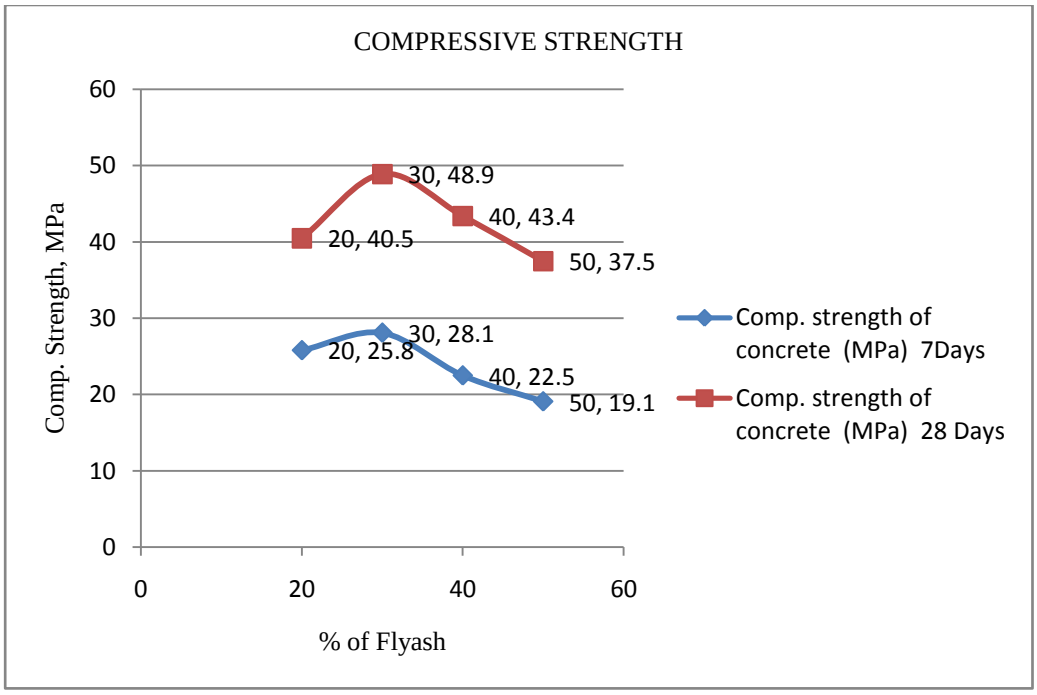

Fig 3. Variation in compressive strength of Metakaolin concrete when cement is replaced with Varying % of Metakaolin.

Following table give the Overall results of compressive strength of the Flyash concrete for the replacement of 20%, 30%, 40% and 50% cement with flyash and varying % Metakaolin by weight for 7 and 28 days of curing.

Different % of Flyash&Metakaolin added	Comp. strength of concrete (MPa)	
	7Days	28 Days
30+7.5	22	40
30+12.5	24	45
30+17.5	27	51
30+22.5	20	36

The variation in compressive strength can be represented in the form of a graph as shown in fig 4.

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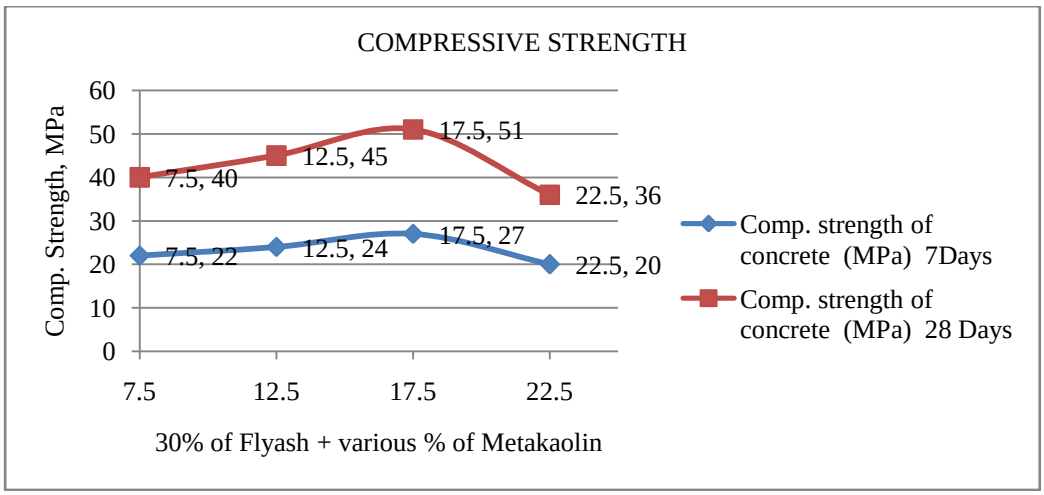

Fig 4. Variation in compressive strength of Metakaolin concrete when cement is replaced with 30% of Flyash and various % of Metakaolin.

IV. CONCLUSION

From this study, it is observed that the compressive of strength concrete increases for addition of 12.5% to 17.5%of metakaolin and further increase in metakaolin beyond 17.5% reduces the strengths rapidly.The concrete mix with 30% partial replacement of fly ash shows maximum compressive strength at 7 and 28 days. Similarly, the concrete mix with fly ash 30% and metakolin 17.5% shows maximum compressive strength at 7 and 28 days.

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