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AN EXPERIMENTAL STUDY ON OPTIMUM USAGE OF METAKAOLIN & FLY ASH FOR MAKING OF HIGH-STRENGTH CONCRETE (HSC)

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Abstract *— The word high strength concrete is defined as concrete that meets special combinations of strength and uniformity requirements that cannot always be achieved routinely using conventional constituents and normal mixing, placing, and curing practices. The concrete is widely used in large scale in the construction industry, not only for its strength and also with the demands of high strength, high performance and high durability at desirable cost and also at the same time the demand for reducing the usage of cement quantity with partial replacement of other pozzalanic materials to save the environment without any deviations in the concrete strength blended cement is introduced into the construction industry to partial replacement of cement with any other pozzalonic materials to reduce the quantity of ordinary Portland cement, and also to reduce the cost of concrete. The blended cements are also used to increase the compressive strength of concrete and sometimes to prepare high performance concrete. In this research work Metakaolin and Fly ash materials are used for partial replacement of cement. To achieve required strength, the water cement ratio within the specified range have been selected water cement ratio has 0.45 for and M30 grade of concrete respectively. The optimum dosage of percentage of replacement of cement with metakaolin was found 30%, 20% and 20% for the constant of cement replacement with fly ash is 10%, 20% and 30% respectively.*

Keywords*-metakaolin ; fly ash ; cement; compressive strength;optimum*

I. INTRODUCTION

The Quality of concrete can be achieved by the selection of suitable materials, cementitious materials, admixtures, the choice of mix proportion, water cement ratio and use of proper methods of mixing, placing and curing. All these aspects depend upon the selection of materials and admixtures. Usually the materials used in concrete are cement, aggregates, water and admixtures. And in this present work we are using Ordinary Portland cement (OPC) of Ultra Tech Company and the cementitioius materials Metakaolin from ACC Company and also fly ash (FA) carried from thermal power station, Vijayawada. And locally available fine and coarse aggregates confirming to IS 383-1970 is used.

II. NEED FOR HIGH-STRENGTH CONCRETE (HSC)

To build high-rise buildings by reducing column sizes and increasing available space.
to get the concrete structure in to service at much earlier age, for example opening the pavement at 3 days. To build the superstructures of long span bridges and to enhance the durability of bridge decks. To satisfy the specific needs of special applications such as durability, modulus of elasticity and flexural strength. Some of these applications include dams, grandstand roofs, marine foundations, parking garages, and heavy duty industrial floors.The primary difference between high-strength concrete and normal-strength concrete relates to the compressive strength that refers to the maximum resistance of a concrete sample to applied pressure.

III. EXPERIMENTAL SETUP

In this stage collection of materials required and the data required for mix design are obtained by sieve analysis and specific gravity test. Sieve analysis is carried out from various fine aggregates (FA) and coarse aggregates (CA) samples and the sample which suits the requirement is selected. Specific gravity tests are carried out for fine and coarse aggregate. The various materials used

IV MATERIALS

Raw materials required for the concreting operations of the present work are cement, fine aggregate, coarse aggregate (CS a SS) and water. Cement ordinary Portland cement (OPC) of 53 grade is used.

4.1 PROPERTIES OF PORTLAND CEMENT

Table 1

Fineness	340 m^2/kg

Specific gravity	3.10
Initial setting time (min)	65
Final setting time (min)	190

4.2 AGGREGATES:

(1) FINE AGGREGATE :

PROPERTIES OF FINE AGGREGATE:

Table 2

Properties	**Results Obtained**
Specific gravity	2.94
Water absorption	0.8%
Fineness Modulus	2.73

(2) COURSE AGGREGATE:

PROPERTIES OF COARSE AGGREGATE:

Table 3

Specific gravity	2.94
Water absorption	0.4%
Fineness Modulus	3.61

4.3 ADMIXTURES:

1. **Mineral admixtures**
   - Metakaolin
   - Fly ash

Only mineral admixtures are used in this work. The mineral admixtures are fly ash (FA) (procured from thermal power station, Vijayawada.) and Metakaolin (Chennai).

V. EXPERIMENTAL PROGRAMME

The experimental program was designed for the mechanical properties i.e. compressive strength, and flexural strength of concrete with M30 grade of normal concrete. As per IS code (456). In the design mix the Portland cement was replaced by fly ash by 0%, 10%, 20% and 30% and metakaolin of 10% to 50% and the specimens are casted.

5.1 COMPRESSIVE STRENGTH OF CONCRETE

The compressive strength test was carried out conforming to IS 516-1959 to obtain compressive strength for M40 and M30 grade of concretes. The compressive strength of concrete with ordinary Portland cement at age of 7 days, 28 days, 56 days and 90 days are conducted. There is significant improvement in the strength of concrete because of the high pozzolanic nature of the fly ash and metakaolin and its void filling ability.

It is observed that form the compressive strength of M30 at 28 days age, with replacement of cement by fly ash and metakaolin was increased normally up to an optimum replacement level of 40%, 40% and 50%, for different trials and the compressive strength are highly increased at 90 days and . After 50% of replacement the strengths are decreased gradually. And after 60% and 70% replacement of cement the strength are decreased gradually. These comparisons are presented in the form of tables, graphs and bar charts.

Fig. 1 FLY ASH

Fig. 2 METAKAOLIN

Fig. 3 Cubes Of Concrete With Replaced Cement By Fly Ash & Metakaolin

TABLE-4 SHOWING VARIATIONS IN STRENGTH

MIX ID	7 days Mpa	14 days Mpa	28days Mpa	56 days Mpa	90 days Mpa
F0-M0-C100	18.18	25.49	37.12	47.44	51.49
F10-M10-C80	17.96	24.12	41.89	47.71	52.47
F10-M20-C70	19.24	26.49	37.41	48.19	54.18
F10-M30-C60	**18.19**	**25.89**	**38.56**	**55.62**	**55.62**

Compressive strength for different percentages of Metakaolin and constant 10% of Fly ash for M30

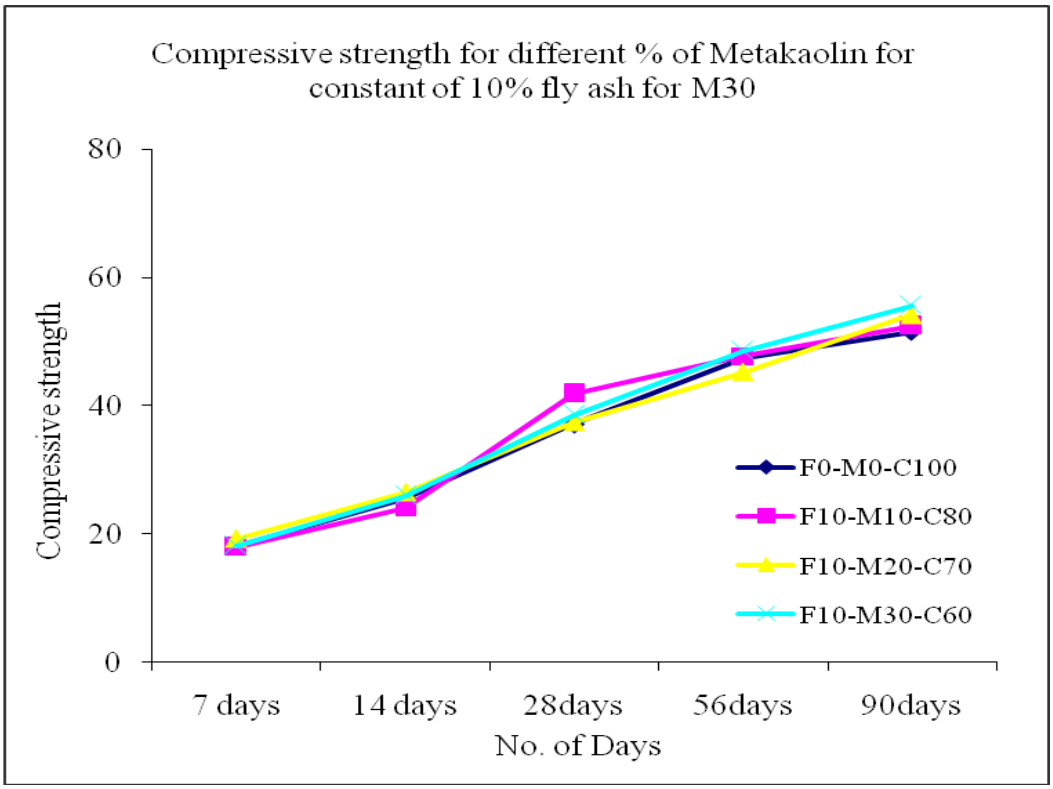

Fig. 4 Compressive strength for different percentages of METAKAOLIN and constant 10% of Fly ash for M30

TABLE-5 SHOWING VARIATIONS IN STRENGTH

MIX ID	7 days Mpa	14 days Mpa	28days Mpa	56 days Mpa	90 days Mpa
F0-M0-C100	18.18	25.49	37.12	47.44	51.54
F20-M10-C70	17.96	24.12	41.89	48.25	53.42
F20-M20-C60	**19.24**	**30.52**	**44.25**	**50.16**	**56.48**
F20-M30-C50	18.19	27.59	39.48	49.58	54.12

Compressive strength for different percentages of METAKAOLIN and constant 20% of Fly ash for M30

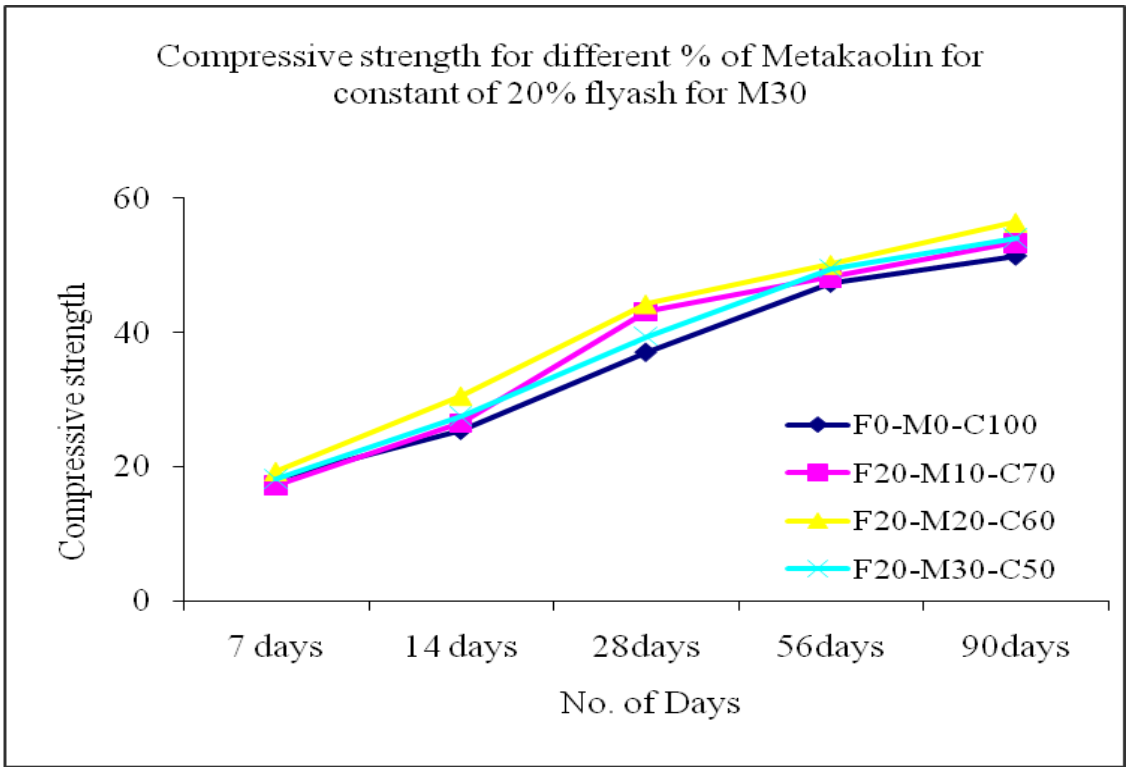

Fig. 5 Compressive strength for different percentages of METAKAOLIN and constant 20% of Fly ash for M30

Table 6: Compressive strength for different percentages of METAKAOLIN and constant 30% of Fly ash for M30

MIX ID	7 days Mpa	14 days Mpa	28days Mpa	56days Mpa	90days Mpa
F0-M0-C100	18.18	23.47	37.12	47.44	51.49
F30-M10-C60	15.26	25.83	41.14	46.25	52.16

F30-M20-C50	**17.89**	**32.79**	**45.26**	**52.18**	**54.77**
F30-M30-C40	14.26	24.16	38.74	48.49	52.14

VII. DISCUSSIONS & CONCLUSIONS

Present Study comprising of comprehensive study intend to decrease the contribution of cement in concrete and M 30 with water cement ratio (W/C) 0.45 and cement replacement levels with fly ash is 10% to 30% and with metakaolin is 10% to 50%. And the total replacement of cement with both in combination of fly ash and metakaolin are from 0% to 80%. The optimum replacement levels once 40%, 40% and 50%, which includes both the combinations fly ash and metakaolin, without any change in compressive strength of concrete, when compared with total cement.

The optimum dosage of percentage of replacement of cement with metakaolin was found 30%, 20% and 20% for the constant of cement replacement with fly ash is 10%, 20% and 30% respectively. Finally the optimum replacement of total cement in combination of metakaolin and fly ash is found 40%, 40% and 50% for different combination of fly ash and metakaolin. with replacement of cement by fly ash and metakaolin was increased normally up to an optimum replacement level of 40%, 40% and 50%, for different trials and the compressive strength are highly increased at 90 days and . After 50% of replacement the strengths are decreased gradually. And after 60% and 70% replacement of cement the strength are decreased gradually.

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