

# Experimental Study of Concrete with Metakaolin as Partial Replacement of OPC

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**Abstract**— Metakaolin is a cementitious materials used as an admixture to produce high strength concrete and is used for maintaining the consistency of concrete. In the case where insufficient or poor curing concrete structure like the underground structure which undergo serve loss of compressive strength, use of metakaolin proves to be very useful to modify the properties of concrete. This paper deals with the properties of concrete with partial replacement of cement by metakaolin in M-25 grade of concrete. The concrete mixes were prepared by replacing 0,5,10,15 and 20 percent mass of cement by Metakaolin. The test results indicated that mineral admixture metakaolin when used at optimum quantity tend to increase the strength of the concrete mix when compared with conventional concrete. The test result revealed that at 10% replacement of OPC by metakaolin, the increase in 28 days compressive strength was found to be 21.67%. therefore this material can be effectively high as partial replacement of OPC and enhance concrete compressive strength.

**Keywords**— Metakaolin, Compressive Strength, OPC.

## I. INTRODUCTION

Concrete is the most widely used and versatile building materials which is generally used to resist compressive force. By addition of some pozzolanic materials, the various properties of concrete viz, workability, durability, strength resistance to cracks and permeability can be improved. Many modern concrete mixes are modified with addition of admixture, which improve the microstructure as well as decrease the calcium hydroxide concentration by consuming it through a pozzolanic reaction.

Metakaolin is pozzolanic materials which is manufactured from selected kaolins, after refinement and calcination under specific condition. It is a highly efficient pozzolana and react rapidly with the excess calcium hydroxide resulting from OPC hydration by a pozzolanic reaction, to produce calcium silicate hydrate and calcium aluminosilicate hydrates.

This paper envisages the use of metakaolin as partial replacement of OPC in M-25 grade of concrete. The percentage replacement of OPC by metakaolin was 0%, 5%, 10%,15% and 20%. The test specimens (cubes) casted and tested as per relevant IS code of practice for 28 days compressive strength.

## II. LITERATURE REVIEW

**Murali G. and Sruthee P.(2012)** studied that when metakaolin is used as a partial replacement for Portland cement, tends to improve the compressive strength of concrete.

**Shrivastava Vikas K. and Rakeshkumar(2012)** investigated the effect of silica fume and metakaolin combination on concrete. They reported that the combination of these materials the compressive strength of concrete and the workability both are improved. **Dinakar P. (2013)** reported on the behavior of a metakaolin on properties of high strength concrete. **Baijiping et al.(2009)** investigated the use of metakaolin and fly ash to improve the consistency of concrete.

Several other researches **Sabir et al. (2001)**, **Papayianni et al. (2005)**, **Justice et al. (2007)** also studied the use of metakaolin as pozzolana and mineral admixture and found that the various properties of concrete have been improved.

## III. EXPERIMENTAL INVESTIGATION

**Materials Cement:**-In this experimental investigation ordinary Portland cement of 43 grade (JP cement) was used.

**Fine Aggregates:-** The fine aggregates used in this investigation was Narmada River sand passing through 4.75 mm sieve with specific gravity of 2.64. The percentage of passing is within the limits as Indian Standard Specification. The fine aggregate corresponds to the zone II gradation as per IS 383:1970.

**Coarse Aggregates:-** Machine crushed broken stone angular in shape was used as coarse aggregates. Two fraction of coarse aggregates were used, 20mm size

having specific gravity of 2.84, and 10mm size having specific gravity of 2.80.

**Water:**-Ordinary tape water clean, potable free from suspended particles and chemical substance was used for both mixing and curing of concrete.

**MIX PROPORTIONS**

Table 1 The mix proportion for different mixes M0,M5,M10,M15 and M20 are given below.

Mix	Cement(kg/m <sup>3</sup> )	Metakaolin (kg/m <sup>3</sup> )	FineAggregate (kg/m <sup>3</sup> )	Coarse Aggregate (20mm size 60% & 10mm size40%) (kg/m <sup>3</sup> )	W/C
M0	372	0	698	1238	0.50
M5	352.40	18.6	698	1238	0.50
M10	334.80	37.20	698	1238	0.50
M15	316.20	55.80	698	1238	0.50
M20	297.6	74.4	698	1238	0.50

- M0- concrete mix without any replacement.
- M5- concrete mix with 5% replacement of OPC by metakaolin.
- M10- concrete mix with 10% replacement of OPC by metakaolin.
- M15- concrete mix with 15% replacement of OPC by metakaolin.
- M20- concrete mix with 20% replacement of OPC by metakaolin.

**Grade of Concrete:**-The mix proportion of this investigation was **1:1.87:3.32** and **M25** grade of concrete was adopted.

**IV. PREPARATION OF SPECIMENS**

The strength characteristics of concrete with varying percentage of metakaolin were studied by casting cubes. The constituents of the concrete viz, cement, fine aggregate and coarse aggregate were mixed to appropriate proportion by adding water. Metakaolin is added to the different mix in varying proportion as a partial replacement for cement. Moulds for cube of size 150x150x150mm were prepared and concrete was poured in to the mould layer by layer and vibrate thoroughly. The specimens were removed from the moulds after 24 hours and then the specimens were cured with water for 28 days.

**V. RESULT AND DISCUSSIONS**

It was found from the experimental results that the compressive strength has increased for the specimens with varying percentage of metakaolin as replacement for cement when compared with the conventional concrete. The test result obtained are presented in table 2.

Table 2. 28 days compressive strength of concrete containing various percentage of metakaolin

Mix	% of Metakaolin	Compressive Strength (N/mm <sup>2</sup> )
M0	0	31.90
M5	5	35.84
M10	10	38.81
M15	15	32.58
M20	20	32.00

It is observed that 10% replacement of cement with metakaolin increased the compressive strength of concrete by 21.67%. The compressive strength of various mixes is shown in fig-1.

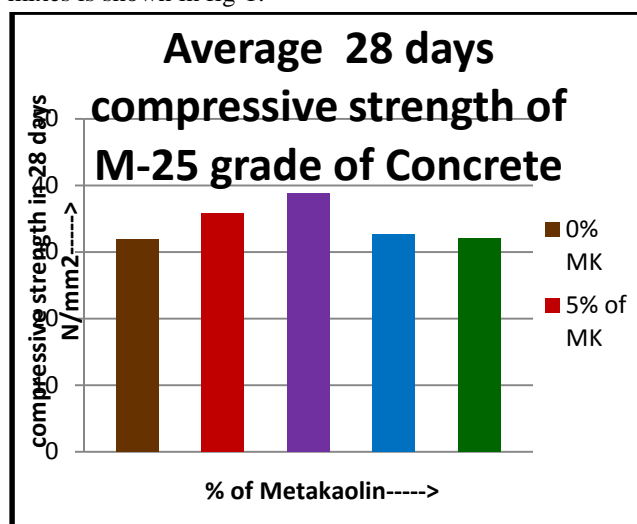


Fig. 1 Average compressive strength of M-25 grade of concrete with different % of Metakaolin



Fig. 2 Compression Testing Machine (2000KN)

## VI. CONCLUSIONS

In this study series of the experiments have been conducted on concrete with the addition of metakaolin as partial replacement of OPC. In the metakaolin was used as partial replacement of OPC in different percentage that is 0%, 5%, 10%, 15% and 20% of the dry weight of the cement. The experiments were conducted on M-25 grade of concrete as per relevant IS code of practice. Based on the test results obtained from this study the following conclusion can be drawn.

1. The addition of metakaolin in the concrete as partial replacement of OPC increases the 28 days compressive strength significantly.
2. The 28 days compressive strength goes on increasing and it was found to be maximum at 10% replacement and after this the strength is decreases.
3. The increase in 28 days compressive strength at 10% replacement was found to be 21.67% .
4. At 20% replacement the strength is approximately same as the strength without any replacement of OPC by metakaolin.

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