



Experimental Investigation on Metakaolin as Partial Replacement of Cement

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Abstract—

To reduce the amount of cement in concrete supplementary material are used. For this purpose metakaolin is replaced by 0%, 5%, 10%, 15% & 20% by the weight of cement. Water binder ratio is taken 0.45 for M-20 & M-25 grade of concrete. Various tests were conducted in the research which showed the results of the same percentage at the different of 0%, 5%, 10%, 15% & 20% for the time period of 28 days curing as a substitution of cement by metakaolin on compressive strength, and workability.

Keywords: Metakaolin, water cement ratio, Workability, compressive strength

1. INTRODUCTION

Metakaolin (MK) is a de-hydroxylated aluminium silicate. It is non-crystallized-amorphous material, consisting of lamellar particles. MK is natural pozzolanic material present in the form of kaolin clay. This Kaolin after refinement and thermal activation at specified temperature range (generally 650 to 800°C), can be used as SCM. This thermal activation leads to subtraction of moisture and reorganization of particles. Production every ton of metakaolin leads to 175 kg of CO₂ emission, which is very less in comparison to Portland clinkers. While using metakaolin as partial substitution of the cement, it reacts with Calcium hydroxide (CH) a waste product of hydration reaction of cement. Due to this very reason MK helps to generate additional Calcium-Silicate-Hydrate gel, a sole cause of straight gain in concrete. MK helps to enhancement of early age strength due its filler effect and speedy cement hydration. Metakaolin makes the concrete more resistive to diffusion of harmful ions by modifying the pore structure of cement paste and makes concrete more impermeable which may prevents the degradation of matrix. All these advantages increase the serviceability life of the construction

2. MATERIAL USED

2.1 Cement:

Portland Pozzolana cement (PPC) is used in this research work.

2.2 Sand:

Sand is available near Narmada River. This sand is used for the above research work.

2.3 Natural aggregate:

20 mm natural coarse aggregate is used having a specific gravity of 2.72.

2.4 Metakaolin:

In this experiments metakaolin having particle size less than 90 micron was Used. Chemical composition of glass powder is as follows

Table 2.1: Physical composition of Metakaolin

Physical	Properties
Bulk Density (g/cc)	0.5461 (When packed)
Color	White

Specific Gravity	2.30
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Table 2.2: Chemical composition of Metakaolin

Chemical	Composition
SiO	50% - 55%
Al ₂ O ₃	38% - 42%
CaO	1%-3%
TiO ₂	0.8-1.2
Na ₂ O	<1%
Fe ₂ O ₃	0.2-0.5
K ₂ O	<1%
MnO	<0.5%
MgO	<0.1%
Loss on Ignition	Max 1.5%

3. EXPERIMENTAL WORK AND TEST

3.1 Workability Test:

This test is conducted to determine workability of fresh concrete. Slump test gives an idea about consistency of concrete mix and indirectly measures the workability of the concrete mix taken. This test is conducted only when nominal size of aggregate does not exceed 20mm as per IS 456:2000.

3.2 Compressive Strength Test:

The mould is prepared for cubes used in the compression test having a size of 0.15mX0.15mX0.15m. After preparing cubes rest on the compression testing machine and load is applied. After applying load the value noted from the dial gauge. Compressive strength determine at 28 days.

4. TEST RESULTS

4.1 Workability Results:

The below table shows the slump cone test results for different percentage of MK which is vary from 0%-20% for M-20 & M-25 grade of concrete.

Table 4.1: Result of Workability for different % of MK for M-20 & M-25 Concrete

S. NO.	MK (%)	SLUMP (mm) (M-20)	SLUMP (mm) (M-25)
1	0	85	100
2	5	73	90
3	10	65	85
4	15	55	75
5	20	50	65

4.2 Compressive Strength;

The below table shows the compressive strength for different percentage of MK which is vary from 0%-20% for M-20 & M-25 Concrete.

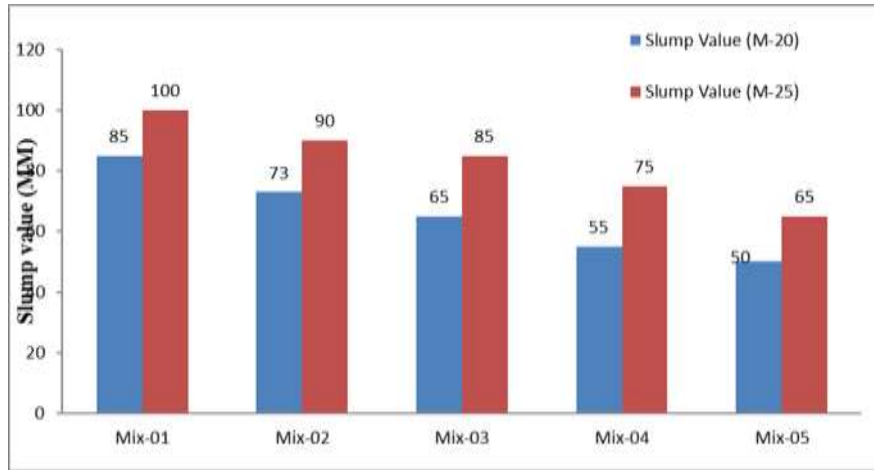
Table 4.2 : Compressive Strength Result

Mix Design	% MK	28 days Compressive Strength (M-20) (N/mm ²)	28 days Compressive Strength (M-25) (N/mm ²)
Mix-01	0	25.59	30.20
Mix-02	5	29.96	34.46
Mix-03	10	28.67	33.56
Mix-04	15	28.17	32.28
Mix-05	20	27.36	31.90

5. DISCUSSION ON TEST RESULTS

5.1 Workability Results:

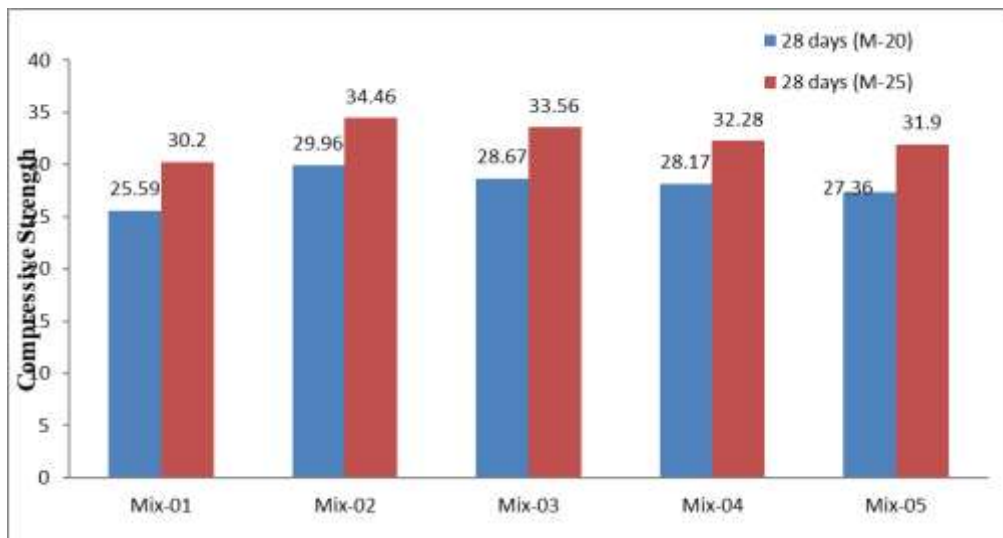
From the graph 1 it is conclude that value of slump decreases when percentage of metakaolin increases for M-20 & M-25 concrete.



Graph: 1. Slump Value in mm

5.2 Compressive Strength Test:

From the graph 2 it is conclude that 28 days compressive strength 17.07% increases for M-20 concrete when percentage upto 5%. After that strength decreases when percentage of MK increases. From the graph 2 it is conclude that 28 days compressive strength 14.10% increases for M-25 concrete when percentage upto 5%. After that strength decreases when percentage of MK increases.



Graph: 2. Compressive Strength in N/mm²

6. CONCLUSIONS:

Based on the various tests conducted on concrete with varying proportion of MK the results were obtained and discussed in previous chapter from which the following conclusions are drawn.

1. It is conclude that value of slump decreases when percentage of metakaolin increases for M-20 & M-25 concrete.
2. It is conclude that 28 days compressive strength 17.07% increases for M-20 concrete when percentage upto 5%. After that strength decreases when percentage of MK increases.

3. It is conclude that 28 days compressive strength 14.10% increases for M-25 concrete when percentage upto 5%. After that strength decreases when percentage of MK increases.

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