"METAKAOLIN AS A PARTIAL REPLACEMENT OF CEMENT IN CONCRETE STRUCTURES."

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I. INTRODUCTION

Abstract: The main principle of this work is to calculate the compressive strength of conventional concrete with the concrete cubes partially replaced by the supplementary materials known as metakaolin in various percentage of its replacement for cement in concrete. Various tests performed on cement, sand, aggregate is carried out as per Indian standard code. Also the testing for metakaolin has been passed out for its usage as a partial replacement for cement and found its cementitious property comparable. The concrete cubes are casted by performing a mix design as per IS 10262-2009.

The concrete cubes with conventional concrete and with partial replacement with metakaolin were prepared for various percentage of replacement and the analysis was carried out on Compressive Strength machine and the result for compressive strength were evaluated. These results are then analyzed and are compared in graphical as well as in tabular form.

Concrete is universally used material for construction. The worldwide production and usage of cement has greatly increased since 1991. Manufacture of cement results in an allocation of environmental pollution as it involves the making of CO_2 gas. High quantity of cement used in concrete means high heat of hydration which cause cracks in concrete. Supplementary cementitious materials are thinly ground solid materials that are used to replace a part of cement in concrete mixture. These additional materials may be naturally taking place, industrial or artificial waste. Numerous types of pozzolanic materials that develop cement properties in cement industry for long time.

The demand for cement is rising enormously in developing countries. Ordinary Portland cement creation is one of the most important reasons for CO_2 emissions into atmosphere. It is due to the use of fossil fuels, counting the fuels necessary to produce electricity during cement industrialized process. The use of pozzolana for manufacture concrete is measured effective, as it allows the reduction of the cement utilization while improving the strength and durability of the concrete.

1.1 INTRODUCTION TO METAKOLIN

Metakaolin is a pozzolanic additive/product which can provide numerous specific features. Metakaolin is available in countless dissimilar varieties and qualities. The clarity will define the free lime. Some of them also give different reactivity. Metakaolin is a treasured admixture for concrete and or cement applications. The pozzolanic reaction starts at the time of mixing, continues between 7 to 28 days.

Metakaolin is a dehydroxylated aluminium silicate. It is an unstructured non glassy material, constituted of lamellar particles. From the current investigate works using Metakaolin, it is apparent that it is a very energetic pozzolanic material and it successfully improves the strength parameters of concrete. Cement partialiy replace by metakaolin. It reacts with Calcium hydroxide is another the by-products of hydration reaction of cement and results in extra Calcium-Silicate-Hydrate gel gel. The Calcium-Silicate-Hydrate gel improved the strength. Metakaolin is achieved by thermal stimulation of kaolin clay. This activation of extra c-s-h gel will origin an extensive loss of water in its composition causing a reorganization of its structure. To obtain an enough thermal activation, the temperature range should be recognized between 600º to 750ºC. Partial replacement of cement by Metakaolin reduces carbon dioxide emissions, also increases the life of buildings. The cautious program was intended to investigate metakaolin as a partial replacement with cement was done at 5%, 10%, 15%. The sample was casted with M20 grade of concrete with different replacement quantity of metakaolin.

II. MATERIALS USED

2.1 Materials used

Cement: Ordinary Portland Cement (OPC) of 53 Grade was used all over the experimental investigation. The brand of cement used was Ambuja OPC with grade 53. The cement is well powdered and color was grey and free from lumps. The specific gravity of cement obtained is 3.15.

Table 1 Properties of 53-Grade ofcement

Sr No.	Name of test	Result	Reference IS code and permissible limit
1	Consistency	31 %	IS:12269: 1987
2	Time initial setting time	30.2 minute	IS:12269: 1987
3	Final setting time	600 minute	IS:12269: 1987
4	Specific gravity	3.15	IS 269 & (3.15)
5	Fineness of cement	2.6 %	IS 4031: 1996 (Part1)
6	Soundness of cement	2mm	Is 4031: 1996 (part3) & IS 5514: 1996

Fine aggregate: In this examine work fine aggregates used was river sand zone II. These materials were simply available from local market. The specific gravity of fine aggregate (sand) is 2.38 and fineness modulus is 2.75.

Table 2 Properties of Fine aggregate (sand)

Sr No.	Name Of Test	Result	Reference Is Code
1	Specific gravity	2.38	IS 383:1970
2	Water absorption	2.27 %	IS 383:1970
3	Moisture content	3.2 %	IS 383:1970
4	Fineness modulus	2.75	-

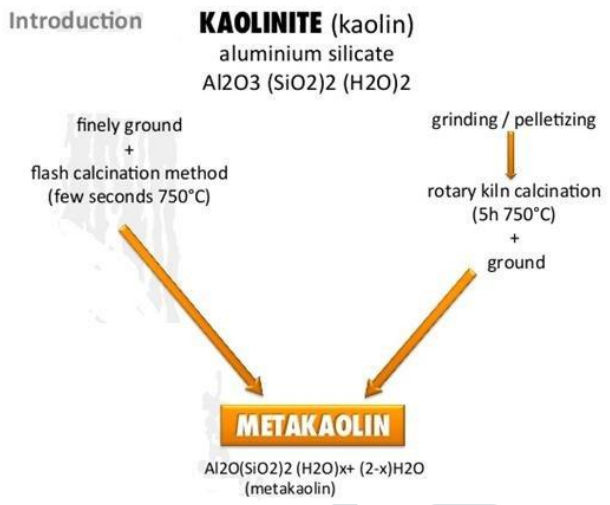
Coarse aggregate: To prepare a mix of a concrete the coarse aggregate was available at local crushing unit. The size of aggregate used in this study is 20mm. The specific gravity of coarse aggregate is 2.630 and fineness modulus is 7.25.

Table 3 Properties of Coarse aggregate

Sr No.	Name of Properties	Result	Reference IS Codes
1	Specific gravity	2.630	IS 383: 1970
2	Water absorption	1.6 %	IS 383: 1970
3	Moisture content	1.0 %	IS 383: 1970
4	Crushing value	22%	IS 383: 1970
5	Impact value	9.09 %	IS 383: 1970
6	Abrasion value	7.33 %	IS 383: 1970
7	Fineness modulus	7.25	-

Water: Portable water was used for washing aggregates, mixing and curing of concretes. The water available in the Anjuman College of Engineering & Technology has been used for this investigational work.

Metakaolin: Metakaolin used in this investigational work was obtained from the supplier Gautam Dyes & Chemicals, Banglore. The specific gravity is 2.44.



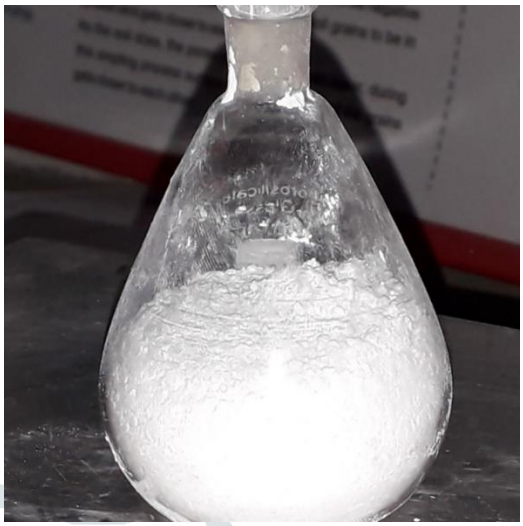


Fig 1. Formation of Metakaolin

Fig 2. Appearance of Metakaolin

Table 4 Properties of cement and metakaolin

Chemicals	**Cement (%)**	**Metakaolin (%)**
SiO_2	19.41	62.61
Al_2O_3	4.82	28.62
Fe_2O_3	3.41	1.06
MgO	2.81	0.16
CaO	65.42	0.07
Na_2O	0.22	1.58
K_2O	-	3.47
TiO_2	-	0.37
LOI	1	2
SO_2	3	-

III. METHODOLOGY

3.1 Method Adopted

1. Various Properties of concrete ingredient i.e., cement, fine aggregates (sand), coarse aggregates and Metakaolin were determined by carrying out various tests.
2. As per IS: 10262- 2009 concrete mix of M20 Grade, which was used as reference mix.
3. Partially replacement of cement by Metakaolin at 5%, 10% and 15%.
4. Six sample cubes casted for each changeable percentage of Metakaolin at 7, 14 and 28 days was tested.
5. Total 24 cube was casted and curing was done.
6. Compressive strength test was done at 7, 14 and 28 days.

3.2 Specimen Details

Cube specimen of size 0.15m x 0.15m x 0.15m were casted to study the hardened properties of concrete such as compressive strength. Mix notations

3.3 Mix Proportions

The prepare mix of M20 grade of concrete is cast. The design is based on IS 10262-2009. The quantities obtained for per cubic meter from this design. The quantities were tabulated in table 1.
C- Conventional mix, M1- 5% metakaolin , M2- 10% metakaolin , M3- 15% metakaolin.

Table 5 Mix Proportion of Concrete

Sr no.	Material	Units	Material quantities			
			C	M1	M2	M3
1	Cement	Kg	394	411.73	411.73	411.73
2	Metakaolin	Kg	0	21.67	43.34	65
3	Fine aggregate	Kg	645.46	631.18	629.75	627.40
4	Coarse aggregate	Kg	1069.89	1046.21	1043.85	1040.50
5	Water	Lit.	197	197	197	197

IV. RESULTS AND DISCUSSION

4.1 Compressive Strength: The Compressive Strength related to manage specimen with numerous percentages of Metakaolin. Compressive Strength results of specimens presented in Table. The 7 day Compressive Strength varied between 17 and 22 MPa. The 14 day Compressive Strength varied between 23 and 29 MPa. The 28 day strength varied between 27 and 34 MPa. After 28 days the compressive strength for MK 5% increases in 13% when compared to control specimen. The compressive strength for 10% and 15% increases in approximately 13% and 22% respectively. MK 15% increases in higher strength, when related to all other mixes.

Age of test	C (0%)		M1 (5%)		M2 (10%)		M3 (15%)	
	Specimen 1	Specimen 2	Specimen 1	Specimen 2	Specimen 1	Specimen 2	Specimen 1	Specimen 2
7 days cube strength (N/mm^2)	17.33	17.56	19.56	20	20.67	21.11	21.14	21.42
	17.45 (AVG)		19.78 (AVG)		20.89 (AVG)		21.28 (AVG)	
14 days cube strength (N/mm^2)	23.78	23.33	26.44	26.67	28.44	27.78	29.01	28.46
	23.56 (AVG)		26.54 (AVG)		27.86 (AVG)		28.74 (AVG)	
28 days cube strength (N/mm^2)	26.89	27.11	30.38	30.63	31.99	32.26	32.80	33.07
	27.08 (AVG)		30.50 (AVG)		32.22 (AVG)		32.93 (AVG)	
% of increasing from MK (Approx.)	-		**13 %**		**19%**		**22%**	

Table 6 Compressive strength in MPa

4.2 Graphical Comparision

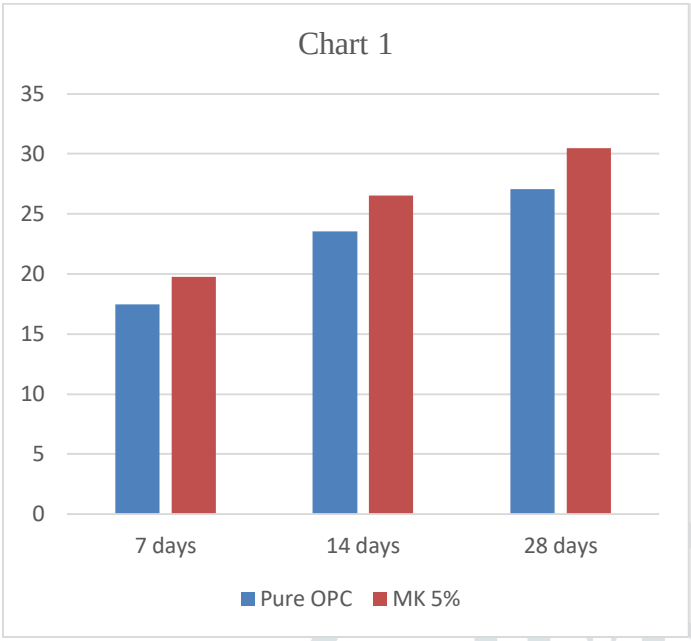


Fig 3.1 Variation of Compressive strength between Pure OPC and 5% Metakaolin

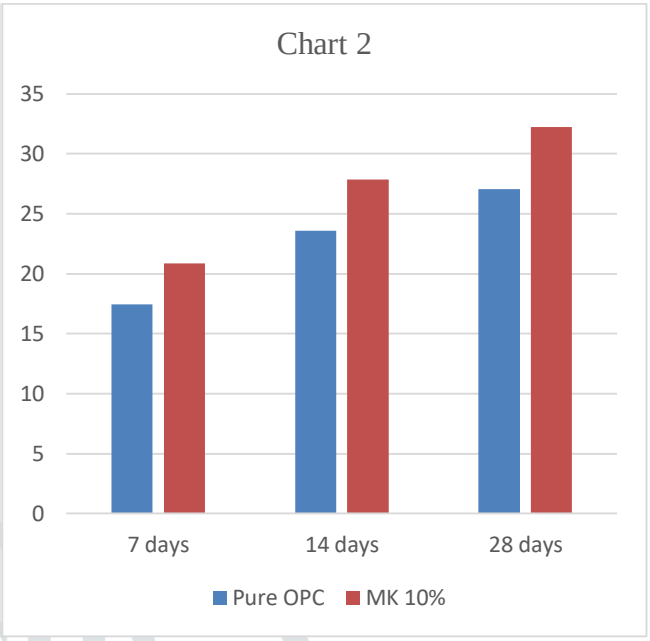


Fig 3.2 Variation of Compressive strength between Pure OPC and 10% Metakaolin

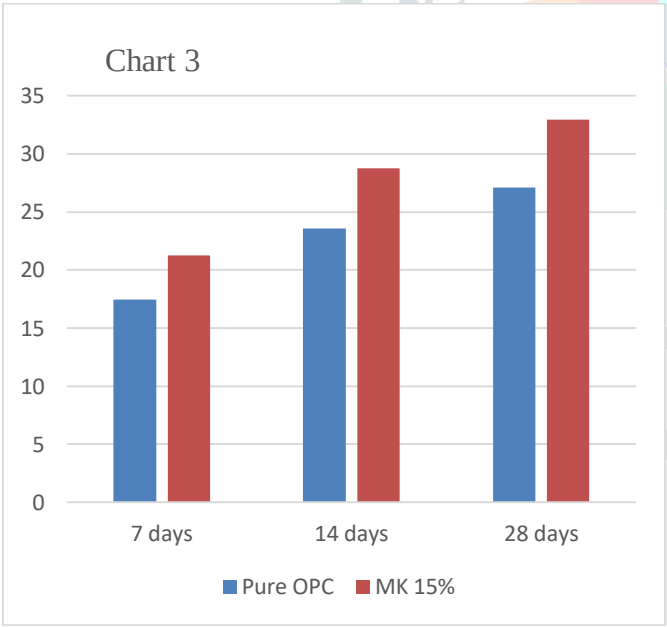


Fig 3.3 Variation of Compressive strength between Pure OPC and 15% Metakaolin

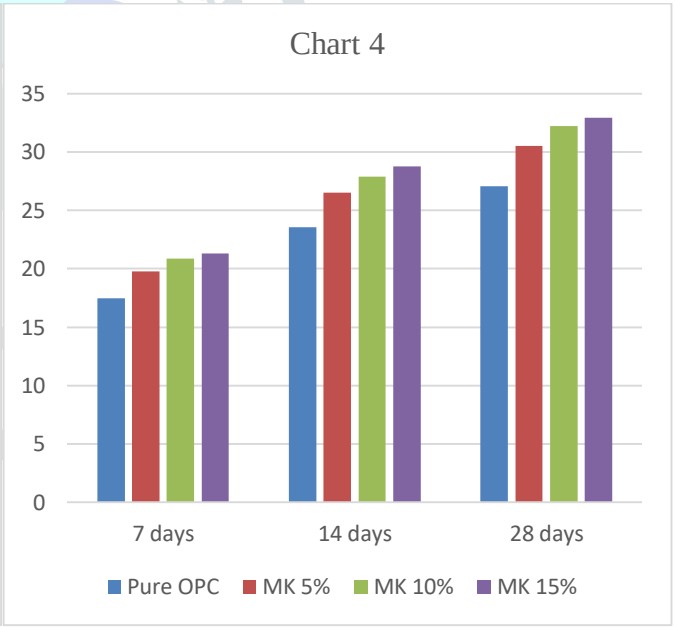


Fig 3.4 Overall Comparison of Compressive strength with various percentage of Metakaolin

V. CONCLUSION

From then present investigation of partial replacement of cement with Metakaolin in concrete is as follows;

1. The strength of every single one Metakaolin mixe is more as compared to strength of Pure OPC.
2. 15% replacement of cement by Metakaolin is higher to all other mixes.
3. The increase in Metakaolin quantity increases the Compressive strength up-to 15% replacement.
4. It can be done that the addition of Metakaolin increases the resistance to acid attack of HPC. Most advantageous results obtained were at 15% replacement of cement by Metakaolin.
5. By varying the percentage replacement of cement by Metakaolin 13%, 19% and 22% of increment in strength as compared to Pure OPC is achieved at 7, 14, and 28 days respectively.

VI. REFRENCES

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