Durability Properties of Kaolinite Clay - Metakaolin in Concrete

M. Narmatha, S. Muralikrishnan

Abstract: ***Unfortunately the concrete structures are exposed to fire, which may cause reduce in strength of structural components. In this article , the research , the effect of chloride (NaCl) penetration and temperature variations on metakaolin using in concrete. Here M60 grade concrete mix used and the concrete cubes (150 mm × 150 mm × 150 mm) are cast for cement replacement by metakaolin with 0%, 5%, 10%, 15% and 20%. The 0% specimens are considered as 'Controlled Specimen'. Then these specimens are tested after 28 and 90 days for various temperature of 100, 200, 300 and 400°C with 1, 2 and 3 hour duration and same cubes are cast for M60 mix proportion and tested for Rapid Chloride Penetration Test and use 5% Sodium Chloride (NaCl) concentration. The graphical Presentation is clearly shows that variations in compressive strength for cement replacement by metakaolin in concrete for chloride penetration and different temperature. For chloride penetration results shows that up to 10% to 15% replacement of Metakaolin, concrete gives good compressive strength and after it goes on decreasing,. Thus 10% give a desirable percentage of replacement. And also compressive strength drastically increasing with the age of concrete for various temperature exposures.***

Key words: Temperature Exposure, Chloride Attack, Metakaolin, Cement Replacement and Compressive Strength of Concrete.

I. INTRODUCTION

Generally Durability test of concrete carried out for the ability of new materials added in concrete to withstand against chemical attack, weathering condition, abrasion while maintaining its desired engineering properties. Chloride attack is one of the most serious aspects for consideration when deal with the durability of concrete. Chloride attack is significantly important because it primarily influence the corrosion of reinforcement. Nearly 40 per cent of failure of structures is due to corrosion of reinforcement. The protective passivity layer can be lost due to carbonation. This protective layer also can be lost due to the presence of chloride in the presence of water and oxygen. In reality the action of chloride in inducing corrosion of reinforcement is more serious than any other reasons. Usually sulphates attack the concrete whereas the chloride attacks steel reinforcements.

Manuscript received on February 10, 2020.
Revised Manuscript received on February 20, 2020.
Manuscript published on March 30, 2020.
* Correspondence Author
M. Narmatha*, Asst.Prof., Dr.MGR Educational Research Institute University, Chennai, 600095, India.
S. Muralikrishnan' Asts.Prof,. Arignar Anna Instituteof Science and Technology,Chennai,602117, India

B. METAKAOLIN

Some considerable research done on natural pozzolans, like thermally activated ordinary clay and Kaolinite clay. These un-purified materials called Metakaolin as a dehydroxylated form of the clay mineral kaolinite. Metakaolin is a best admixture using in concrete/cement.
Rocks that are rich in kaolinite are known as china clay or kaolin, traditionally used in the manufacture of porcelain. Metakaolin particles are smaller than cement particles but not as fine as silica fume. Metakaolin, is a new material in the concrete industry and effective in increasing strength reducing Chloride penetration and improving air-void network. reactions of Pozzolanic change the microstructure of concrete and bonding of hydration products by consuming the released Calcium Hydroxide (CH) and production of additional Calcium Silicate Hydrate (C-S-H) resulting the strength will be increased and porosity reduced so as to improve the durability.

Table 1. Comparison between the Properties of Cement and Metakaolin

Chemical composition	Cement %	Metakaolin %
-Silica (SiO_2) - Silicon di Oxide	36	54.312
Alumina Al_2O_3	5.510	39.304
Calcium oxide CaO	59	0.387
Ferric oxide (Fe_2O_3)	4.415	4.276
Magnesium oxide (MgO)	1.262	0.076
Potassium oxide (K_2O)	0.491	0.503
Sulphuric anhydride	1.905	0.223
LOI	1.301	0.678
Specific gravity	3.163	2.501
Physical Form	Soft Powder	Powder
Colour	Grey	white

C. OBJECTIVES

The objectives of this research are to study the chloride effect on metakaoline M60 grade concrete with 5% NaCl solution. The percentage of replacement for metakaoline will be carried out for various percentages as 0%, 5%, 10%, 15% and 20%. The concrete specimens are then allowed for 28days normal curing.

After that, these cubes are cure in 5% NaCl solution for different periods of time as 28 & 56 days. For temperature parameter, separate concrete cubes are cast and again allowed for 28 days normal curing. Then these cubes are tested after 28 & 90 days, from 100°C to 400°C temperature exposure. These chloride attack and temperature exposure tests give the compressive strength variation. And this variation can be effectively represented by means of the graphs.

II. CONCRETE MIX PROPORTION

A. METHODOLOGY

I. Experimental Investigation

II. Replacement in the Concrete Ingredients Cement with Metakaolin

III. A. Study of Choloride Penetration (RCPT) in concrete mixture using Metakaolin

B. Study of Temperature variatios in concrete mixture using Metakaolin and Analyse the Strength

IV. Comparative study with Conventional Concrete

V. Analysis and Discussionof Test Results

VI. Conclusion

B. MIX DESIGN

For this paper work we have used the M60 grade concrete. We have casted all concrete specimens by using OPC. Also zone-II is selected for the rivers and locality of IS:383(1970). The coarse aggregate is selected which is able to passing through 20mm and retaining on 10 mm IS sieves. As per IS: 10262:2009 we have carried out mix design procedure for M60 grade concrete. After the designing we got the final mix proportion as follows.

III. RESULT AND DISCUSSION

After testing the casted concrete specimens, we have arranged the testing data for getting the defined objectives. The graphical presentation of the same will explain the paper work more effectively. The tests carried out for chloride attacks shows that for the particular percentage replacement, as the age of the concrete go on increasing the corresponding compressive strength of concrete get decreasing. At 5% replacement of cement by MK gives the maximum compressive strength than other percentage replacement by MK. The results also showthatupto15% replacement of cement by MK, we can maintain the strength of concrete greater than control mix. But as we go beyond 15%, the compressive strength decreases below strength that of control mixes. Thus 20% replacement proves unsuitable for achieving compressive strength equal to or greater than control mix. Similarly, test carried out for temperature exposure shows that, the age of concrete go on increasing the corresponding compressive strength of concrete get increases up to the 10% replacement of beyond that the compressive strength of concrete goes on decreasing. It is clearly seen that for 28 & 90 days the compressive strength of concrete goes on decreasing from 15% to 20% replacement of MK. The corresponding strength for that replacement is less as compared to the control mixes. So for temperature exposure, 10% replacement gives the better result for replacement of MK

IV. RAPID CHLORIDE PENETRATION TEST

The chemical resistance tests such as acid, chloride and sulphate resistance were conducted on the developed concrete in this investigation. Test was carried out to evaluate the performance MK0, MK5, MK10, MK15 and MK20 mixes under chemical attack. Results of residual compressive strengths were summarized in Table 3 for different categories of concrete.

Table 2. Tested Results of RCPT

% of MK	Charge passed (Coulombs)		Chloride permeability as per ASTM C 1202	
	28 days	56 days	28 days	56 days
	2566	2048	Moderate	Moderate
5%	1441	1239	Low	Low
10%	1847	1547	Low	Low
15%	1116	885	Low	Very Low
20%	1351	516	Low	Very Low

Table 3. Compressive Strength After RCPT

MK %	CC	Comp. Strength N/mm^2	% of Increasing from control concrete
MK5%	60.59	64.3	6.12%
MK10%	60.59	66.37	9.54%
MK15%	60.59	62.96	3.91%
MK20%	60.59	61.21	1.02%

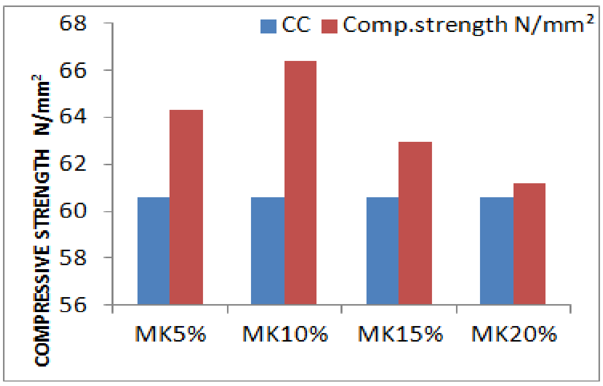

Fig 1 Comparison of Comp. Strength due to RCPT with Metakaolin Concrete

V. INFLUENCE OF ELEVATED TEMPERATURE

The concrete cubes were subjected for various temperature of 100°C, 200°C, 300°C and 400°C for one hour, two hours and three hours duration, respectively.

Afterwards they were tested under Compression Testing Machine to determine their residual strength at 28 days and 90 days. The residual compressive strength after the test is shown for M60 concrete in below Table 4.

Table 4. Variations of Compressive Strength with Different Temperatures

Replacement Level	Temperature in ° C	Compressive strength in N/mm²					
		1 hour		2 hours		3 hours	
		28 Days	90 Days	28 Days	90 Days	28 Days	90 Days
MK 5 %	100	68.2	73	67	72.25	65	71
	200	67.5	72.5	66	71	63	69.5
	300	66.7	71.7	65	70	60.8	67
	400	65	70	63.8	69	58	65
MK 10 %	100	69.8	75	68	74	66.2	72.5
	200	69	74	67	73	65	71
	300	68	72.7	65.2	72	63	69
	400	67	71	63	70	61.2	67
MK 15 %	100	67.5	72	66	71	64.2	69
	200	67	71	66	69.5	64.2	68
	300	65.5	69.5	64	68	62	66.2
	400	64	68	63	67	61	65
MK 20 %	100	65.5	71	64	70	62	68
	200	65	70	64	69	61.8	67
	300	64	69	62	67.5	60	65
	400	63	67.8	60	65	58	63
CC	100	67	73.5	66	72	64	70
	200	65	72	65	70	62.8	67.5

	300	63.5	71	63	69	60	65
	400	61	69.8	61	67	57	62

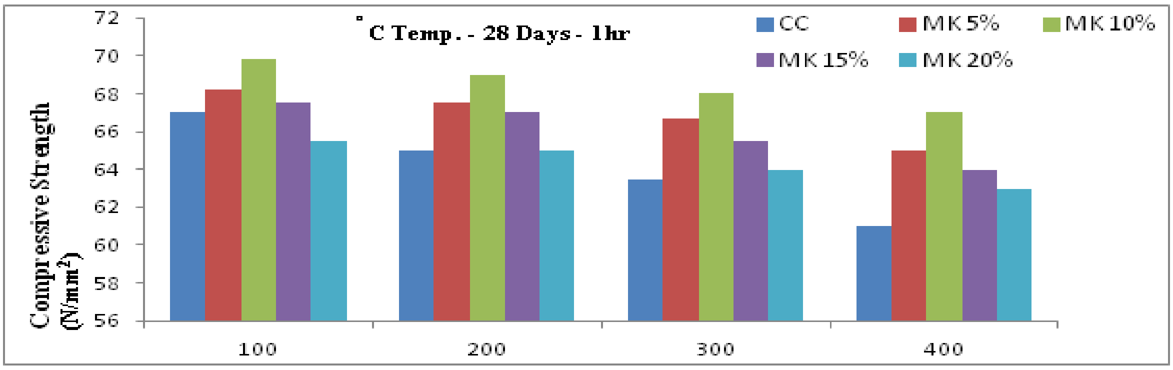

Fig 2. Variation of compressive strength after exposing to elevated temperature for 1 hour at 28 days

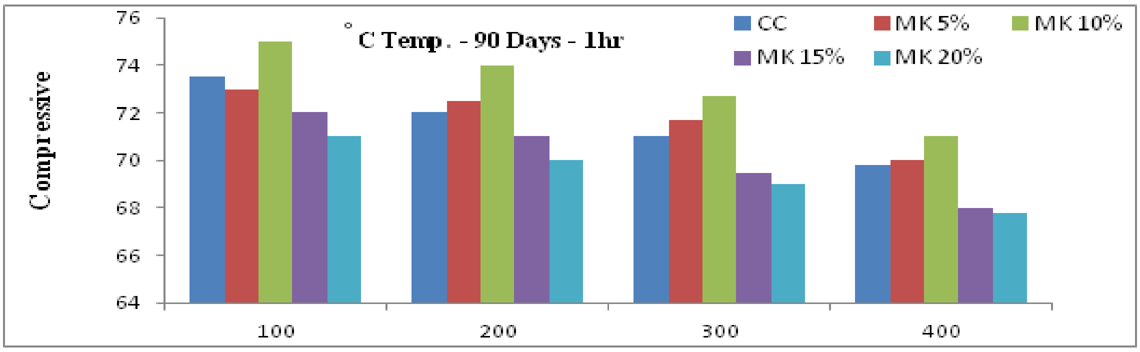

Fig 3. Variation of compressive strength after exposing to elevated temperature for 1 hour at 90 days

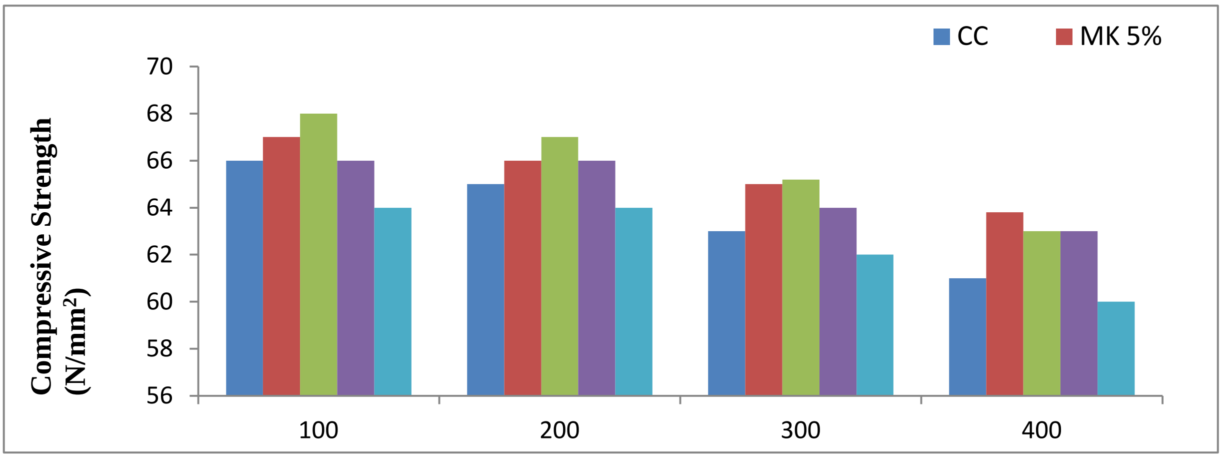

Fig 4. Variation of compressive strength after exposing to elevated temperature for 2 hours at 28 days

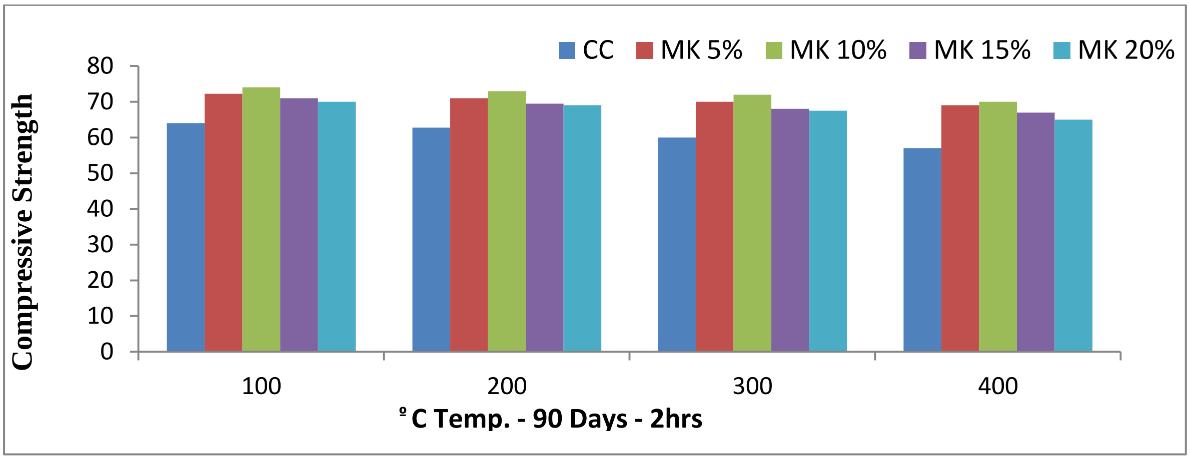

Fig 5. Variation of compressive strength after exposing to elevated temperature for 2 hours at 90 days

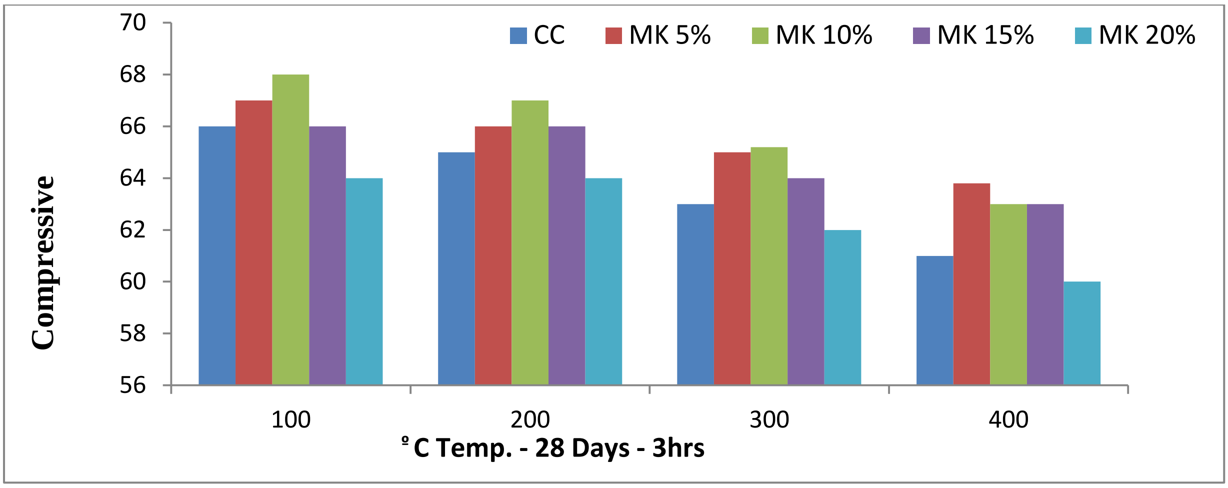

Fig 6. Variation of compressive strength after exposing to elevated temperature for 3 hours at 28 days

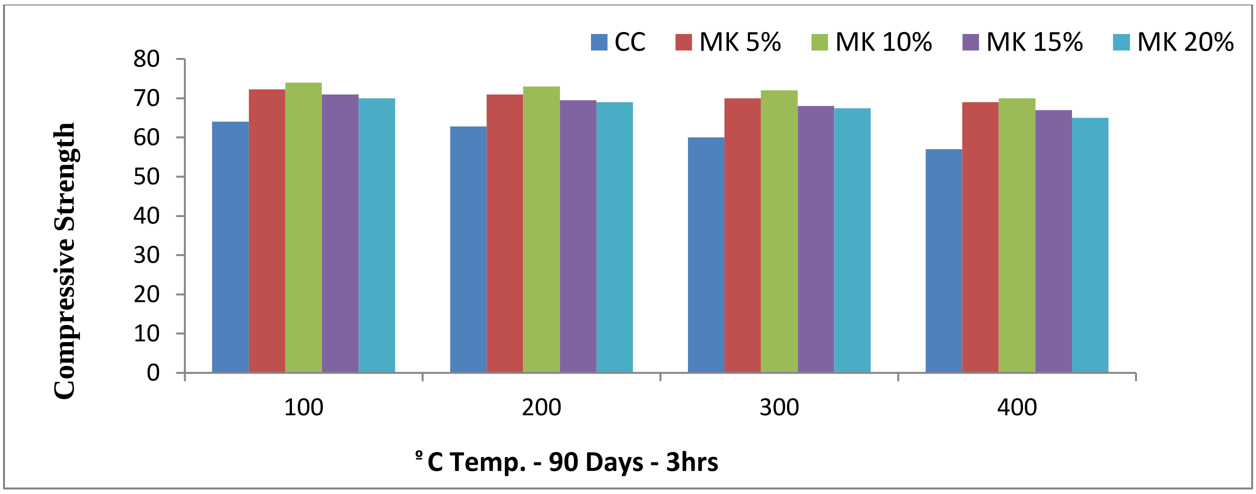

Fig 7. Variation of compressive strength after exposing to elevated temperature for 3 hours at 90 days

VI. CONCLUSIONS

In temperature exposure the compressive strength goes on increasing as age of concrete increases. But for 28& 90 days test result shows that 5% & 10% replacement of MK gives more compressive strength as compare to control mix, 15% & 20% replacement. So 5% to 10% gives good replacement instead of 15% &20% replacement. In chloride attack, it is clearly seen that for the replacement of MK the compressive strength of concrete goes on decreasing. But in that decrement, 5% & 10% gives the more compressive strength as compare to 15% & 20% replacement. For 5% & 10% replacement compressive strength is 50% greater than that of 15% &20% replacement. So 5% to 10% gives beneficial replacement of MK.

REFERENCES

1. Narmatha, M & Felixkala, T 2014, 'High Performance Concrete Using Metakaolin and Flyash with Partial Replacement of Cement', International Journal of Applied Engineering Research, vol. 9, no. 23, pp. 19541 - 19562
2. Narmatha, M & Felixkala, T 2016, 'Metakaolin - The Best Material for Replacement of Cement in concrete', International Journal of Advanced Research, vol. 4, no. 7, pp. 1690 - 1696
3. Narmatha, M & Felixkala, T 2016, 'Metakaolin - The Best Material for Replacement of Cement in concrete', IOSR - Journal of Mechanical and Civil Engineering, vol. 13, no. 4, pp. 66 – 71
4. Narmatha, M & Felixkala, T 2016, 'Metakaolin and Flyash with Partial Replacement of Cement Using in HPC', International Journal of Earth Sciences and Engineering, vol. 9, no. 1, pp. 106 - 109
5. Narmatha, M & Felixkala, T 2017, 'Strength Properties of Metakaolin with Flyash in concrete', International Journal of Engineering Research, vol. 5, no.1, pp. 139 - 142
6. Narmatha, M & Felixkala, T 2017, 'Analyse the Mechanical Properties of Metakaolin Using as a Partial Replacement of Cement in concrete', SSRG International Journal of Civil Engineering , vol. 4, no.1, pp. 25 – 31
7. Narmatha, M & Felixkala, T 2017, 'Metakaolin and Flyash with Partial Replacement of Cement Using in HPC', International Journal of Civil and Structural Engineering Research, vol. 4, no. 2, pp. 101 – 106
8. Narmatha, M & Felixkala, T 2017, 'Analyse the Mechanical Properties of Metakaolin Using as a Partial Replacement of Cement in concrete', International Journal of Advance Research, Ideas and Innovations in Technology, vol. 3, no. 1, pp. 310 - 316
9. Narmatha, M & Felixkala, T 2017, 'Experimental Investigation of Strength Properties of Metakaolin Using in concrete', European Journal of Scientific Research, vol. 144, no. 2, pp. 204 - 212

AUTHORS PROFILE

Dr. Narmatha has done my Ph.D. in the area of Concrete Materials using Metakaolin, from Dr.M.G.R Educational and Research Institute, Deemed to be University, India in 2018. I have significant contribution in carrying out several research projects in the area of concrete members with local available materials. Now a days in our country control the CO_2 emission for Manufacturing cement. So I carried out lot of research work in replacement of cement.

S. Muralkrshnan Is A Research Scholar Doing His Ph.D. In The Area Of Concrete Materials Using M-Sand In St.Peters Deemed University, Chennai. He Has Significant Contribution In Carrying Out Several Research Projects In The Area Of Concrete Members With M-Sand And Its Properties.

Retrieval Number: F7281038620/2020©BEIESP
DOI:10.35940/ijrte.F7281.038620
Journal Website: www.ijrte.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication