International Journal of Future Generation Communication and Networking
Vol. 13, No. 3s, (2020), pp. 429–436

Durability of Concrete by Using Metakaolin as a Partial Replacement of Cement

Mr.Abhishek V Borade[#1], Ms.Rucha V Desai[#2], Mr.Bhushan R Ghodeswar[#3], Mr. Apurva V Gawale[#4]. Mr.Vivek Angulwar[#5]

[#1-4]Deapartment of Civil Engineering, Savitribai Phule Pune University,Pune,
[#5]Asst. Prof., Deapartment of civil engineering, Savitribai Phule Pune University,Pune,

[1]abhiborade71@gmail.com
[2]ruchadesai1798@gmail.com
[3]bhusa39@gmail.com
[4]apurvagavle71@gmail.com
[5]vvk.angulwar@gmail.com

Abstract

Concrete a composite material made from cement, water, fine aggregate and coarse aggregate. But present researchers are in interest of finding new cement materials by waste materials or waste products produced from industries which are harmful to environment. The present research deals with partial replacement of cement with metakaolin which are having silica used as admixture for making concrete. Making partial replacement of cement with metakaolin as constant, 10%,15%,20% metakaolin was made in partial replacement of cement and results were found that and metakaolin usage in partial replacement to cement can be made. It was tested for compressive strength at the age of 7, 28 day and compared with traditional concrete. The overall test results shows that metakaolin could be used in concrete as a partial replacement of cement.

Keywords— Metakaolin, Kaolinite, Mechanical strength

I. INTRODUCTION

Concrete is one of the most widely used manmade construction material in the world. Metakaolin is the cementetious material used as an admixture to produce high strength concrete. Optimum quality of metakaolin for M70 grade of concrete has been worked out, which can replace the cement in order to get better strength and durability. Also identification of the drying shrinkage and permeability characteristics of blended cement has been done.

A versatile material, high strength concrete (HSC) possesses desirable properties other than high strength. The most dramatic and memorable applications stem from this aspect, however as high- rise building like 311 south wackier Drive create striking visual impressions. This structure, at 969ft (295), was the world's tallest concrete building when completed in 1989, utilizing concrete with compressive strengths of up to 12000 psi (83 MPA). Metakaolin is the white powder of 2sio2 by hydrating kaolin at an appropriate temperature (700-900). kaolin is in a layered silicate structure, with the layers binding with each other via the van der weal's bond, among which o is bound firmly metakaolin can be used to manufacture cementetious materials and mix high strength high performance concrete. Metakaolin is a pozzolanic additive product which can provide many specific features. Metakaolin is available in many different varieties and qualities. It is valuable admixture in concrete.

Metakaolin is the white powder of A .2Siby dehydrating kaolin ($Al_2O_3.2SiO_3.2H_2O$) at an appropriate temperature (700-900oC). Kaolin is in a layered silicate structure, with the layers binding with each other. Kaolin, when being heated in air, may experience several structural changes, and when being

ISSN: 2233-7857 IJFGCN

heated to around 600oC, the layered structure of kaolin is damaged due to dehydration to form a transient phase with a poor crystallinity, i.e., metakaolin. As the molecular arrangement of metakaolin is irregular in a thermodynamic met stable condition, it is cementetious under an adequate excitation.With a high activity, metakaolin can be used to manufacture cementetious materials and mixhigh-strength high-performance concrete.

KAOLINITE SOURCES:-

The quality and reactivity of metakaolin is strongly dependent of the characteristics of the raw material used. Metakaolin can be produced from a variety of primary and secondary sources containing kaolinite:

1. High purity kaolin deposits
2. Kaolinite deposits or tropical soils of lower purity
3. Paper sludge waste (if containing kaolinite)
4. Oil sand tailings (if containing kaolinite**)**

USES:-

1. High performance, high strength, and lightweight concrete
2. Precast and poured-mold concrete
3. Fiber cement and ferrocement products
4. Glass fiber reinforced concrete
5. Countertops, art sculptures
6. Mortar and stucco

PHYSICAL PROPERTIES:-

1. Physical form-powder
2. fitness of metakaolin-white/grey
3. specific gravity-2.50

Table I

CHEMICAL COMPOSITION

Chemical components	**Percentage (%)**
Silica	54.3
Alumina	38.3
Ferric oxide	4.28
Calcium oxide	0.39
Magnesium oxide	0.08
Sodium oxide	0.12
Potassium oxide	0.50

ADVANTAGES:-

1. .Strength and durability of concrete increases.
2. .Accelerates initial setting time of concrete.
3. .Cross section of structure can be reduced safely .i. e amount of concrete used can be reduced.
4. .Reduces shrinking in concrete.
5. .Ecofriendly by reducing amount of co2 emission.
6. .Reduces heat of hydration leading to shrinkage and Crack control.

ISSN: 2233-7857 IJFGCN

II. METHODOLOGY.

This study focuses on the strength performance of concrete with metakaolin. Strength is the most important property of concrete since the first consideration in structural design is that the structural elements must be capable of carrying the imposed loads. Strength characteristic is also important because it is related to several other important properties which are more difficult to measure directly.
With regard to this matter, the development of compression strength of metakaolin concrete is studied. Cement replacements by 10%, 15% and 20% with metakaolin are studied. Concrete tests were conducted on the concrete samples at the specific ages. All the strength tests were limited to the ages of 28 days.
In this research work, **6** Standard cubic specimens of size 150mm of normal concrete based on the design mix were casted for the compressive strength of concrete and were kept under curing for 7 days & 28 days of age. The compressive strength of these control specimen was further used to compare with the concrete with metakaolin.
24 Standard cubic specimens of size 150 mm (six sample for each percentage of Metakaolin and 100% Natural Sand) were casted for the compressive strength.
TABLE II
QUANTITY OF CUBES

Sr. No.	**Specification**	**No. of cubes**	
		7 Days	28 Days
1	Control Specimens	3	3
2	10% MK+ 90% OPC	3	3
3	15% MK+ 85% OPC	3	3
4	20% MK+ 80% OPC	3	3
Total number of cubes casted		24	

III. RESULTS AND DISCUSSIONS.

WORKABILITY OF CONCRETE

As per Indian Standard Code, IS: 6461 (Part VII) -1973,

"Workability can be defined as that property of freshly mixed concrete or mortar which determines the ease and the homogeneity with which it can be properly mixed, placed, compacted and finished."
Table III
Results of Workability

Sr no.	**Specification**	**Avg slump (mm)**
1	Normal M20 grade concrete.	79
2	10%MK+90%OPC	52.33
3	15%MK+85%OPC	37.33
4	20%MK+80%OPC	32.33

ISSN: 2233-7857 IJFGCN

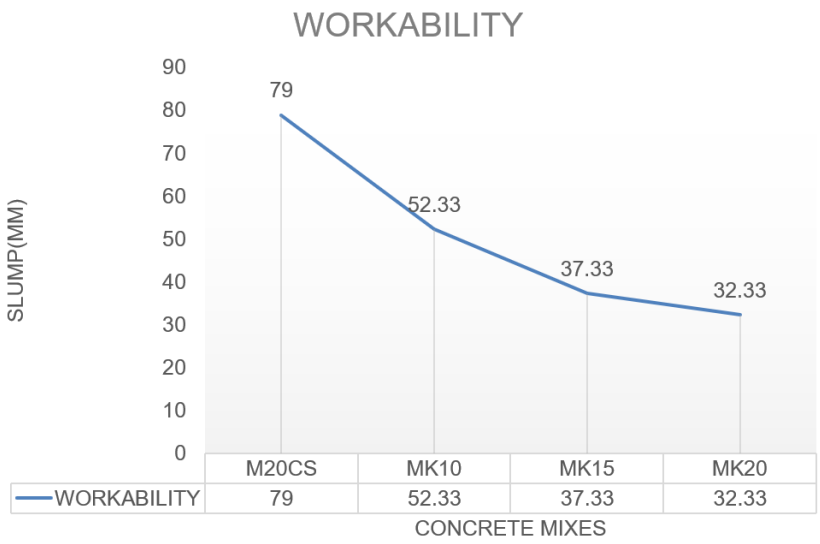

Fig. 1. Worakbility of concrete for various grades

The graph depicts the change of slump with respect to percentage of Metakaolin. Tests have shown that the workability decreases with an increase the percentage of Metakaolin. It was observed that higher dosage of addition or replacement makes the mortar and concrete stickier which reduces the flowability of concrete. Therefore, 10% Metakaolin was found to be optimum.

COMPRESSIVE STRENGTH RESULTS OF SPECIMENS AFTER 7 DAYS CURING

Table IV

M20 GRADE CONTROL SPECIMENS

Date of casting.	**Date of testing.**	**Max load at failure (N).**	**Compressive strength (N/mm2)**	**Avg. compressive strength (N/mm2)**
13/02/2020	20/02/2020	368064	16.3584	16.21
		364140	16.184	
		362178	16.0968	

Table V

10% METAKAOLIN + 90% OPC

Date of casting.	**Date of testing.**	**Max load at failure (N).**	**Compressive strength (N/mm2)**	**Avg. compressive strength (N/mm2)**
		411228	18.2768	

ISSN: 2233-7857 IJFGCN

13/02/2020	20/02/2020	379710	16.876	17.73
		406262	18.056	

Table VI

15% METAKAOLIN + 80% OPC

Date of casting.	**Date of testing.**	**Max load at failure (N).**	**Compressive strength (N/mm2)**	**Avg. compressive strength (N/mm2)**
13/02/2020	20/02/2020	409142	18.184	18.70
		436608	19.4048	
		416988	18.5328	

TABLDE VII

20% METAKAOLIN + 80% OPC

Date of casting.	**Date of testing.**	**Max load at failure (N).**	**Compressive strength (N/mm2)**	**Avg. compressive strength (N/mm2)**
13/02/2020	20/02/2020	**400248**	**17.88**	16.97
		392400	17.44	
		353160	15.696	

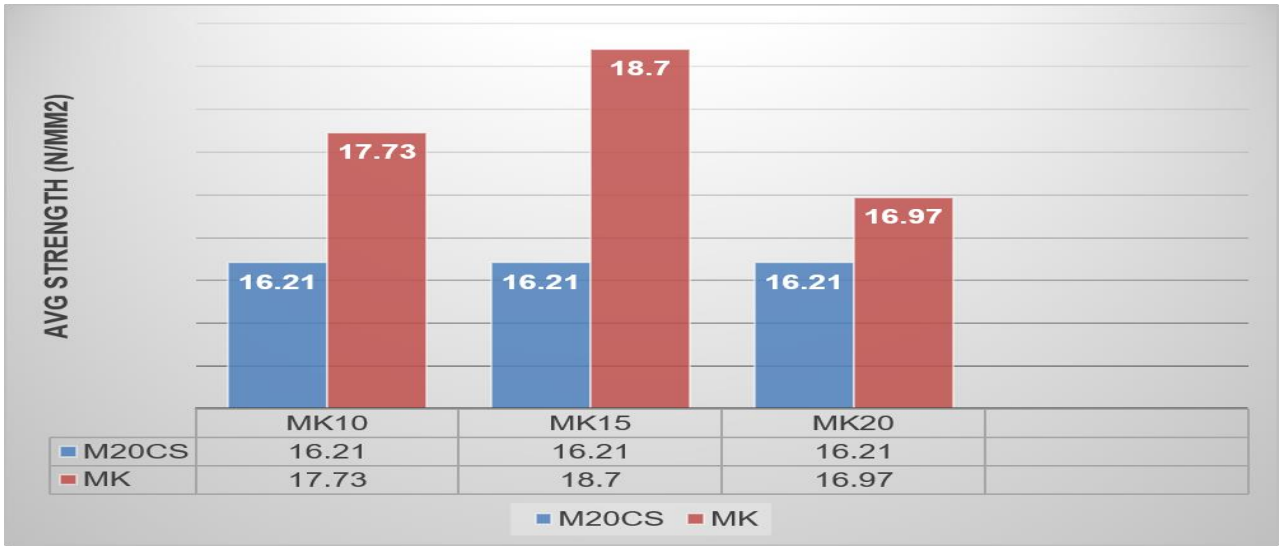

Fig. 2 Compressive strength of concrete for various grades at the end of 7 days

ISSN: 2233-7857 IJFGCN

On comparing the test samples with M20 Grade Control Specimens, the 7 days strength of concrete with metakaolin was found to be more than that of M20 grade control specimens for 10% and 15% MK.On the other hand, it was found to be decreased for 20% MK as compared to 10% and 15% grade control specimens.

COMPRESSIVE STRENGTH RESULTS OF SPECIMENS AFTER 28 DAYS CURING

Table VIII

M20 grade control specimens.

Date of casting.	**Date of testing.**	**Max load at failure(N).**	**Compressive strength (N/mm2)**	**Avg. compressive strength (N/mm2)**
13/02/2020	12/03/2020	634644	28.206	28.06
		608220	27.032	
		651258	28.944	

TABLE IX

10% METAKAOLIN + 90% OPC.

Date of casting.	**Date of testing.**	**Max load at failure(N).**	**Compressive strength (N/mm2)**	**Avg.compressive strength(N/mm2)**
13/02/2020	12/03/2020	775908	34.4848	35.4734
		829822	36.8810	
		788724	35.0544	

TABLE X

15% METAKAOLIN + 85% OPC.

Date of casting.	**Date of testing.**	**Max load at failure (N)**	**Compressive strength (N/mm2)**	**Avg. compressive strength (N/mm2)**
13/02/2020	12/03/2020	723060	32.136	31.64
		709202	31.5201	
		703440	31.2640	

TABLE X

20% METAKAOLIN + 80% OPC.

Date of casting.	**Date of testing.**	**Max load at failure(N).**	**Compressive strength (N/mm2)**	**Avg. compressive strength (N/mm2)**
13/02/2020	12/03/2020	687744	30.5664	30.07
		638694	28.3864	
		703440	31.2640	

ISSN: 2233-7857 IJFGCN

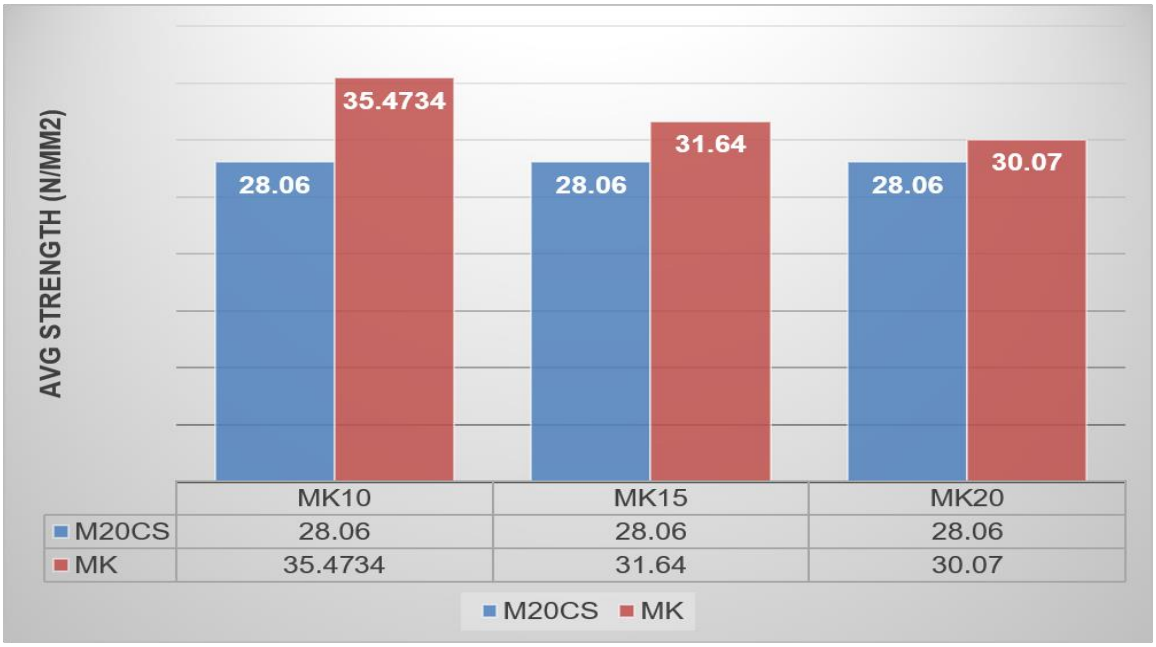

Fig. 3 Compressive strength of concrete for various grades at the end of 28 days

On comparing the test samples with M20 Grade Control Specimens, it was found that for all the percentages of Metakaolin (MK) the average compressive strength was increased.
Therefore, 10% Metakaolin is optimum for the gaining ultimate strength after 28 days.

IV. CONCLUSION.

It was observed that the workability to concrete decreases with an increase in Metakaolin content. Higher dosage of addition or replacement makes the mortar and concrete stickier which reduces the flow-ability of concrete. The concrete with 10%MK was found to be within the workable limits. Metakaolin enhanced and increased the mechanical strength of concrete.
10% partial replacement of cement gives maximum strength 28 days further addition reduces the strength but is higher than the traditional concrete. Use of Metakaolin saves our environment, since during the production of Metakaolin there is no emission of carbon dioxide. By addition of metakaolin powder, the compressive strength of specimen increases at optimum dose of 10%. Therefore we can replace cement upto 10% by metakolin to reduce cost an to increase strength of concrete.

ACKNOWLEDGEMENT

We take this opportunity with great pleasure to express our deep sense of gratitude towards our guide Mr. V. A. Angulwar for his valuable guidance, encouragement and cooperation extended to us during this project work. We are so thankful to Mr. I .M. Jain, Head, Department of Civil Engineering for providing departmental facilities for this work. We would also like to thank Dr. R. S. Prasad, Principal, Sinhgad Institute of Technology and Science for their unflinching help, support and cooperation during this project work.We would also like to thank the Sinhgad Technical Educational Society for providing access to the institutional facilities for our project work.

ISSN: 2233-7857 IJFGCN

REFERENCES

[1] *Sanjay N. Patil et.al (2014)*: Metakaolin- Pozzolanic Material for Cement in High Strength Concrete. (IOSR-JMCE) ISSN: 2278- 1684, PP: 46-4.

[2] Alaa M. Rashad (March 08, 2014) Metakaolin: fresh properties and optimum content for mechanical strength in a comprehensive overview.

[3] J.M. Khatib et.al (2012): High Volume Metakaolin as Cement Replacement in Mortar. World Journal of Chemistry, ISSN 1817- 3128.

[4] Ong Chee Huat, Performance of concrete containing metakaolin as cement replacement material (Master thesis, Faculty of Civil Engineering, University Teknologi Malaysia, 2006).

[5] Tiwari, A. K., & Bandyopadhyay, P. (2003) High performance concrete with Indian metakaolin. In International symposium on innovative world of concrete, 19–21 September. Pune: Indian Concrete Institute.

[6] Murali G, Sruthee P, "Experimental study of concrete with metakaolin as partial replacement of cement" International journal emerging trends in engineering and development, Issue 2 vol 4(May 2012)

[7] Jian-Tong Ding and Zongjin Li "Effects of Metakaolin and Silica Fume on Properties of Concrete" ACI Materials Journal/July-August 2002

1. B. B. Sabir: Metakaolin and calcined clays as pozzolans for concrete: a review.

ISSN: 2233-7857 IJFGCN