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Strength Appraisal of High Grade Concrete by using High Reactive Metakaolin

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Abstract: The need of High Grade Concrete is increasing day by day . Also , the availability of natural sand which is a major component of concrete is becoming difficult. With the use of artificial sand instead of natural sand for producing High-grade concrete by using High Reactive Metakaoline may solve the problem. Hence the investigation was carried to study the effect of metakaolin addition on compressive strength and rapid chloride permeability of concrete. The tests were carried out on concrete specimens with 0, 4,6 and 8 % replacement of cement by metakaolin . It was observed that there was a substantial increase in compressive strength and reduction in rapid chloride permeability due to metakaolin addition in concrete. Hence it was concluded that metakaolin clay is the best material for producing high grade concrete with an improved engineering properties.

Keywords: Artificial sand, Core sample, High grade concrete (HGC), High Reactive Metakaoline, Rapid chloride permeability Test.

I. INTRODUCTION

Due to the fast infrastructural development large quantity of concrete is needed to fulfill the requirement. The main constituent of concrete is fine aggregate, coarse aggregate, cement and water. The fine aggregate is a main constituent which is obtained generally from river bed is called as natural sand. Use of a large quantity of natural sand making an adverse effect on the nature .

For a sustainable development , it is necessary to replace a natural sand and cement with artificial sand and high reactive metakaolin respectively. Till the date , the utilization of artificial sand in concrete is 80 % and 60 % in Mumbai and Pune respectively. The utilization rate is still less in Nashik. Hence the study is undertaken to check the effect of partial replacement of cement by metakaolin with an artificial sand on properties of high grade concrete.

II. MATERIALS USED

A.Cement

The Ordinary Portland Cement-53 grade was used . The physical properties of cement were determined in the laboratory and are given in Table 1. The cement satisfies the requirements of IS: 12269-1987 specifications.

TABLE 1: PHYSICAL PROPERTIES OF CEMENT

Sr.No.	Characteristics	Experimental Value	Value as specified by IS : 12269-1987
1.	Standard Consistency	29	--
2.	Fineness of cement as retained on 90 µ. IS sieve	0.40	Max 10.00
3.	Setting time 1. Initial 2. Final	 78 380	 Min 30 mins Max 600 mins
4.	Specific gravity	3.15	3.15

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B.Coarse aggregates

The crushed stone aggregate was collected from the local quarry. The coarse aggregate was used in the experimentation were about 20 mm and 10 mm size aggregate and tested as per IS: 2386-1963 (I, II and III) specifications. Physical properties of coarse aggregates as determined in a laboratory are given in Table 2.

TABLE 2: PHYSICAL PROPERTIES OF COARSE AGGREGATE

Sr.No.	Characteristics	10 mm	20 mm
1.	Specific gravity	2.98	2.98
2.	Fineness modulus	7.55	7.55

C.Fine aggregates

Locally available artificial sand was used as fine aggregate. The physical properties of fine aggregate are determined in the laboratory and given in Table 3. Fine aggregate used is confirmed to grading zone-II as per IS: 383-1970 specification.

TABLE 3: PHYSICAL PROPERTIES OF FINE AGGREGATE

Sr.No.	Characteristics	Value
1.	Specific gravity	2.97
2.	Fineness modulus	3.96

D.Metakaolin

The mineral admixture Metakaolin was obtained from 20 MICRON LIMITED company , Vadodara , Gujarat. The Metakaolin was in conformity with the general requirements of pozzolana. The physical and chemical properties of Metakaolin are given in Table 4. And Table 5. Respectively.

TABLE 4 : PHYSICAL PROPERTIES OF METAKAOLIN (source - www.metakaolin.com)

Property	Value
Specific gravity	2.60
Bulk density (g/cm3)	0.3 to 0.4
Physical form	Powder
Color	Off-white
GE Brightness	79–82
D10	< 2.0 um
D50	< 4.5 um

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TABLE 5: CHEMICAL PROPERTIES OF METAKAOLIN (source-www.metakaolin.com)

Types	% by mass
SiO_2	51.52
Al_2O_3	40.18
Fe_2O_3	1.23
CaO	2.0
MgO	0.12
K_2O	0.53
SO_3	0.0
TiO_2	2.33
Na_2O	0.08
L.O.I	2.01

E.Admixture

Viscocrete 10R (W) from Sika is used for increasing the workability of concrete mix even in case of less water cement ratio. The admixture was used by percentage of mass of cement (1% by mass), The same was adopted for all four mix proportion for maintaining the slump during the fresh concrete condition.

III. EXPERIMENTAL PROGRAMME

The experimental programme consists of casting required numbers of cubes of 150 x150x150 mm and cylinders of size 100 x50 mm.The above specimens were cast , cast using a water binder ratio of 0.29 and cured for 28 days. The specimens were corresponding to M60 grade of concrete with replacement of cement by Metakaolin for various percentages viz. 0, 4, 6, and 8. The cubes were used to find residual compressive strength and the core samples were used to find the rapid chloride permeability. The reference mix of control concrete was shown in Table 6.

TABLE 6: REFERENCE MIX OF CONTROL CONCRETE FOR (M^3)

Types	Cement content in Kg	Artificial Sand in Kg	20 mm Aggregate in Kg	10mm Aggregate in Kg	Water in Litrs.	Admixture 1% of Cement
Quantity	500	907	614	409	145	5

The experimental set up and sample preparation for RCPT Test are shown in fig.1 and fig.2 respectively.

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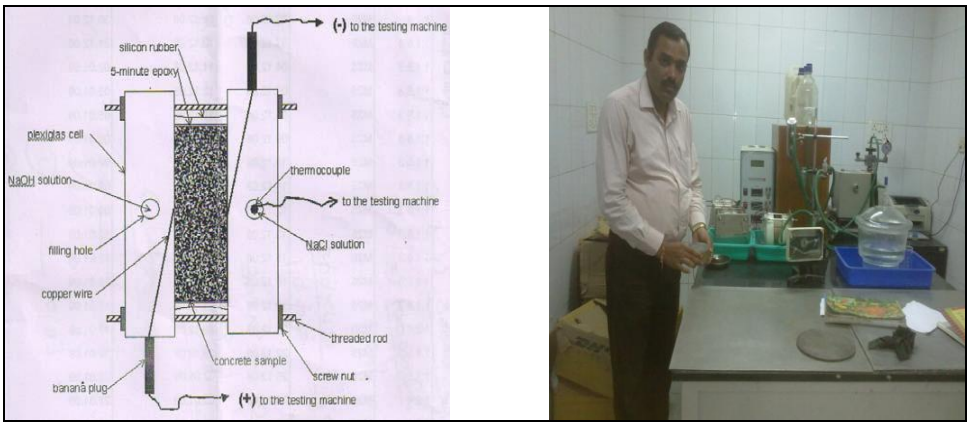

Fig. 1:ASTM C1202 test setup.

Fig. 2:Sample preparations for RCPT Test Specimens

IV. EXPERIMENTAL RESULTS

A. Compressive Strength Test

In Table 7 and Table 8 shows the results of compressive strength of control concrete specimens and metakaolin blended concrete are shown respectively.

TABLE 7: COMPRESSIVE STRENGTH FOR CONTROL CONCRETE SPECIMEN

Sr. No	Cube ID	Cube Wt. (Kg)	Load (kN)	Strength (MPa)	Avg. Strength (MPa)
1	CC1	9.10	2070.0	92.00	
2	CC2	9.13	2061.0	91.60	92.00
3	CC3	9.13	2079.0	92.40	

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TABLE 8: COMPRESSIVE STRENGTH METAKAOLIN BLENDED CONCRETE

Sr. No	Metakaolin (%)	Cube ID	Cube Wt.(Kg)	Load (kN)	Strength (MPa)	Avg. Strength(MPa)
1	4%	A54	9.13	2272.50	101.00	100.36
2		A55	9.12	2198.95	97.73	
3		A56	9.10	2302.98	102.35	
1	6%	A39	8.96	2343.37	104.15	104.15
2		A40	9.08	2358.60	104.82	
3		A41	9.00	2328.44	103.48	
1	8 %	A18	9.05	2452.40	109.20	112.00
2		A19	9.04	2601.40	115.00	
3		A20	9.00	2521.10	112.04	

B. Rapid chloride permeability test

In Table 9 and Table 10 shows the results of the rapid chloride permeability test in coulombs of control concrete specimens and metakaolin blended concrete are shown respectively.

TABLE 9: RAPID CHLORIDE PERMEABILITY TEST FOR CONTROL CONCRETE CORE

Sr. No	Core ID	Charge Passed in Coulombs	Avg. Charge Passed in Coulombs
1	RC1	2985	2985
2	RC2	2990	
3	RC3	2980	

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TABLE 10: RAPID CHLORIDE PERMEABILITY TEST METAKAOLINE BLEND CONCRETE CORE

Sr. No	Metakaolin (%)	Core ID	Charge Passed in Coulombs	Avg. Charge Passed in Coulombs
1	4%	RC10	1540	1535.00
2		RC10	1520	
3		RC10	1545	
1	6%	RC11	1433	1436.33
2		RC11	1447	
3		RC11	1429	
1	8 %	RC12	1303	1300.30
2		RC12	1298	
3		RC12	1300	

V. OBSERVATIONS AND DISCUSSIONS

It has been observed that the compressive strength of Metakaolin based HGC increases with the increase in percentage of Metakaoline. Fig. 3 shows the variation of compressive strength of HGC with different Metakaoline content of 4 %, 6 % and 8 %. As the Metakaoline increases from 4% to 8% the compressive strength increases about 9.23 MPa for 4 % Metakaoline , 12.98 MPa for 6 % Metakaoline and 20.87 MPa for 8 % Metakaoline . The increase in compressive strength due to the addition of Metakaoline is due to pozzolonic activity. The compressive strength of HGC increases by 10.13 %, 14.24 % and 22.90% due to addition of Metakaoline content of 4 %, 6 % and 8 % respectively in comparison with control concrete specimens of HGC.

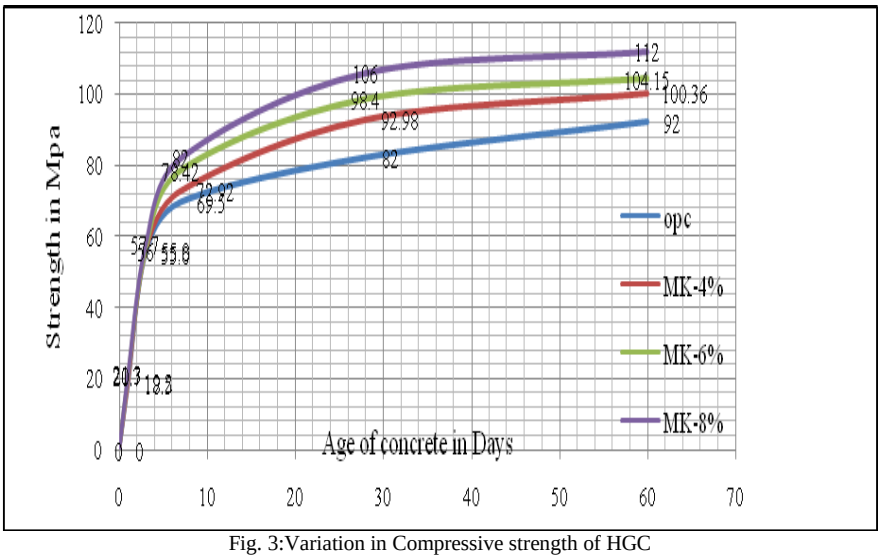

Fig. 3:Variation in Compressive strength of HGC

fig. 4 shows the variation of RCPT values in HGC for different proportions of Metakaoline blended concrete. It has been observed that as the percentage of Metakaoline increase , the permeability of concrete decreases. Also, it was observed that values of rapid chloride permeability of HGC decrease up to 1450 coulombs, 1548.67 coulombs and 1684.70 coulombs for 4% , 6% and 8% of metakaolin respectively in comparison to control

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concrete specimens. The percentage reduction in permeability values in coulombs was 48.57 %, 51.88 % and 56.43% for Metakaoline content of 4%,6% and 8% respectively.

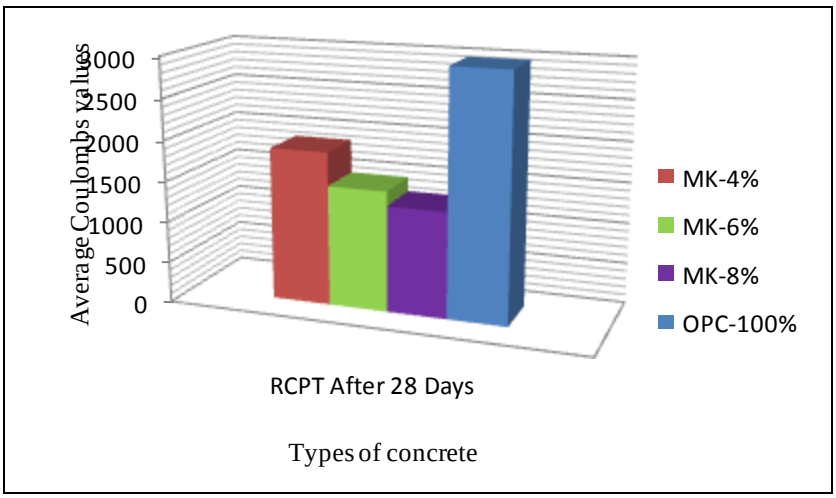

Fig. 4: Rapid chloride permeability of HGC with variation of percentage in Metakaolin

VI. CONCLUSIONS

It can be concluded that the compressive strengths of HGC mixes increases with increasing in percentage of Metakaolin.

Rapid Chloride permeability of HGC decreases with increasing in percentage of Metakaolin. From the above observations and discussions, it can be concluded that metakaoline clay is the best material for producing high grade concrete for any structural engineering works. Also it can be concluded that the impermeable concrete may be produced by using metakaoline clay.

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BIOGRAPHY

Mr. Ajay P. Shelorkar was born in 1973 in Bhopal City. He received his Bachelor of Engineering degree in Civil Engineering from the Sant Gadge Baba Amravati University, Amravati in 1996. In 2012 he received his Master's Degree in Civil (structures) from University of Pune , Pune. He joined Nashik District Maratha vidya prasarak samaja's karmaveer Advocate Baburao Ganpatrao Thakare College of Engineering as a faculty in 2008 where he is now Assistant Professor in Civil Engineering Department with a total experience of 15 years in the field of Research and education. He has published papers in International Journals.

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