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A Comparative Study on Hardened Properties of Concrete by Partial Replacement of Cement with Metakaolin by Experimental and ANSYS Approach

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Abstract: ***The literature study shows that some industrial waste material such as fly ash, GGBS, silica fume, metakaoline, etc. are good way to exchange cement in concrete and make it durable, strong, economic and environment friendly and also gives strength as per conventional concrete. These materials are often used as supplementary cementitious material because the replacement of cement in various percentages and make it high performance concrete which may be utilized in high rise building, flyovers, bridges, etc In this literature review study metakaoline looks to be promising supplementary cementitious material for high performance concrete. The substitution proportion of metakaoline is to be used was 0%, 10%, 20%, 30%, 40% by the weight of the cement. The cubes were made to check the compressive strength at 7, 28 and 56 days of curing. The results shows the many difference between the replacing mix upto last percent has effect on strength as compared with mix without metakaolin.***

Keywords: Metakaoline, concrete mix, compressive strength, ANSYS

I. INTRODUCTION

Development and growth of construction industry is addicted to concrete and main ingredient of concrete is cement in which during production of cement it emits large amount of CO2 gas which causes increase in pollution. There is a necessity to make a bright and sustainable future so as to stipulate the sustainability**.** Among many admixtures metakaolin shows high pozzolanic reactivity due to their amorphous structure and high surface area. Metakaolin has smaller particle size (-1-2µm) composed with portland cement. Metakaolin is supplementary cementitious material used as an admixture or substitution to cement to produce high strength concrete. Optimal quantity of metakaolin for M50 grade of concrete has been worked out which can replace the cement in order to get better strength.

II. MATERIAL USED

A. Metakaolin

It is the dehydroxylated form of clay mineral kaolinite (china clay), is heated to between 600°C to 800°C. it is commonly used in production of ceramics but can be used as cement replacement in concrete. Replacing portland cement with metakaolin produces a concrete mix that exhibits favourable engineering properties including the filler effect, the acceleration of OPC hydration and therefore the pozzolanic reaction. The filler effect is immediate while the pozzolanic reaction occurs between 3 and 14 days.

B. Advantages

1) Increased compressive and flexural strengths
2) Increased resistance to chemical attack.
3) Increased durability
4) Enhanced workability and finishing of concrete.
5) Improves water tightness and impermeability of concrete hence is safe for using in water retaining structure, off shore structure, etc
6) Reduced permeability (including chloride permeability) Reduced effect of alkali silica reactivity (ASR)
7) Reduced shrinkage due to ‘particle packing’ making concrete dense
8) Reduced potential for efflorescence which occurs when calcium is transported by water to the surface where it combines with CO2 from the atmosphere to make calcium carbonate which precipitates on the surface as a white residue.

C. Typical Analysis

Particle size *< 10 micron* *< 2 microns*	 95 ± 2 80 ± 1
Specific gravity	*2 ± 0.1*
Bulk density(gms/lt)	*320 ± 20*

D. Chemical Composition

SiO2	52.8
Al2O3	36.3
Fe2O3	4.21
MgO	0.81
CaO	<0.10
K2O	1.41
LOI	3053

E. ANSYS

ANSYS is Analytical System Software based on Finite Element Method (FEM). The concrete model is made and simulated in ANSYS. FEM analysis is a way to simulate loading condition on a design and determine design's response to those conditions. ANSYS is the most advanced comprehensive and reputable finite element analysis and design software package available for heavy structural engineering projects. ANSYS software version 15 will be used to do the analytical work through many runs to get the compression stresses in concrete and displacement in z-direction (the direction of applying the load).

III. LITERATURE REVIEW

1) Pendyala Chanakya and Diptikar Behra(2016) investigates the effects of metakaoline & super plasticizer on strength properties of M-35 grade concrete. The experimental program is meant to seek out the compressive strength of concrete by partially replacing the cement in concrete production. The replacement levels of cement by metakaoline are selected as 4%, 8%, 12%, 16% and 20% for constant water-cementitious material ratio of 0.43. For all mixes compressive strength is decided at 3, 7, 28 days for 150 X 150 X 150 mm size cubes. Current experimental study shows that 12% replacement of cement by metakaoline gives higher strength. From 16% there is decrease in compressive strength for 3, 7 and 28 days of solidifying amount. The use of supplementary cementitious material in production of concrete may result in major saving of energy and cost. It also helps to enhance strength, durability, impermeability and chemical resistance of concrete.

2) Mahindra, T. Abhiram Reddy, P. Rajkumar and T.Harish (2018) studied the high performance concrete (HPC) due to heavy development in infrastructure. Different type of pozzolonic materials like metakaolin ,silica fume, and fly ash etc, the material having same properties of cement were studied . The cement is replaced with metakaoline by 0%, 5%,10% and 20%. The experimental results shows that the usage of 15% of partial replacement of metakaolin with cement gives the maximum compressive strength. Usage of less than 10% of metakaolin doesn't give desirable benefits whereas increase in proportion of metakoalin in concrete mix makes to use more amount of super plasticizer to acquire desirable workability.

3) M. Narmatha and Dr. T. Felixkala(2016) investigates the HPC (high performance concrete) which is used in many projects such as nuclear power projects, flyovers, multi- storeyed buildings. The replacement of cement is to be used was 5%, 10%, 15%, 20% by weight of the cement. From this study they concluded that the strength of metakaoline concrete mixes increase the strength of OPC and 15% cement replacement is superior to all other mixes.

4) Prasad studied the M-35 grade of concrete. Mechanical properties like compressive strength, split tensile strength and flexural strength are compared with modified concrete. Apart from that, the modified concrete has been evaluated using non destructive tests like rebound hammer and ultrasonic pulse velocity. Also a relationship developed between the compressive strength and non destructive test. The conclusion made that the maximum 10% can be replaced cement with metakaoline. Fresh properties like workability is increases as the percentage of metakaoline increases.

5) D Viswanadha Varma , G V Rama Rao, P Markandeya Raju , M Pavan Kumar studied the optimal quality of metakaoline which will partially replace the cement for M20, M30, M40,M50,M60, M70, M80 grades of concrete to urge the higher strength and durability. The mix proportions of OPC concrete are obtained for M20, M30, M40, M50, M60, M70, M80 as per IS 10262- 2009(1). Mix proportions with partial replacements of cement by 0%, 10%, 15%, 20%, 25%, 30% of Metakaolin with concrete were determined. From this study it concluded that Maximum compressive strength of 11.68% and 10.00% is obtained for M80 grade concrete with replacement of cement by 15% Metakaolin for 28 days curing and 90 days curing to regulate specimen (0% Metakaolin at 27 occuring).

6) Mayuri A. Chandak and P. Y. Pawade investigates that use of 25% MK in replacement of cement increases the strength of all basics properties viz. compressive strength, flexure strength , split tensile strength, etc. and durability improvement.

7) M. Sivaraj, Dr. R. Sundararajan, K. Vivek And Dr. T. Senthil Vadivel studied the partial replacement of cement with metakaoline with varying percentages such as 0%, 2.5%, 5%, 7.5% and 10% by weight of cement. Shredded plastic waste of 0.5% by weight was added to concrete by replacing coarse aggregate in concrete. M20 grade concrete is used for beams. Optimum replacement percentage of metakaolin was decided from the tests. Ultimate load carrying capacity of beams produced with the optimum replacement percentage was compared with the numerical investigation done by finite element modelling package ANSYS 12.0.

8) Dr. B. Krishna Rao and M. Anil Kumar (2016) studied the partial replacement of cement with metakaoline and fine aggregate with waste foundry sand and M 25 grade of concrete were prepared and evaluated the properties at fresh and in hardened state like compressive strength test, split tensile strength test, flexural strength test and modulus of elasticity. The OPC is replaced with 10% constant, while the fine aggregate is replaced with waste foundry sand at 0,10,20,30 and 40% by weight. The results shows that the utilization of metakaoline and waste foundry sand improves the mechanical properties of concrete. The rise in compressive strength at 28 and 56 days was found to be 29% and 28.9%, which is 40.1 MPa and 41 MPa in comparison to nominal mix wich is 31 MPa and 31.8 Mpa respectively.

IV. CONCLUSION

From the literature survey, following are the conclusions

1) The use of supplementary cementitious material in production of concrete may result in major saving of energy and cost.

2) It also helps to enhance strength, durability, impermeability and chemical resistance of concrete.

3) Use of MK in preparing acid resistant concrete like as chloride permeability and sulfate resistance shows good result.

4) 10% replacement level was the optimum level in terms of compressive strength. Beyond 10%, the strength was decreased but remained higher above the control mixture.

5) Workability of concrete decreases with the rfise in MK replacement level.

6) By using partial replacement for cement decreased the plastic density of the mixture and reduce water permeability, absorption and chloride permeability as the replacement percentage increases.

7) The use of MK are often utilized by adding super plasticizers to compensate the decreased in permeability by addition of MK.

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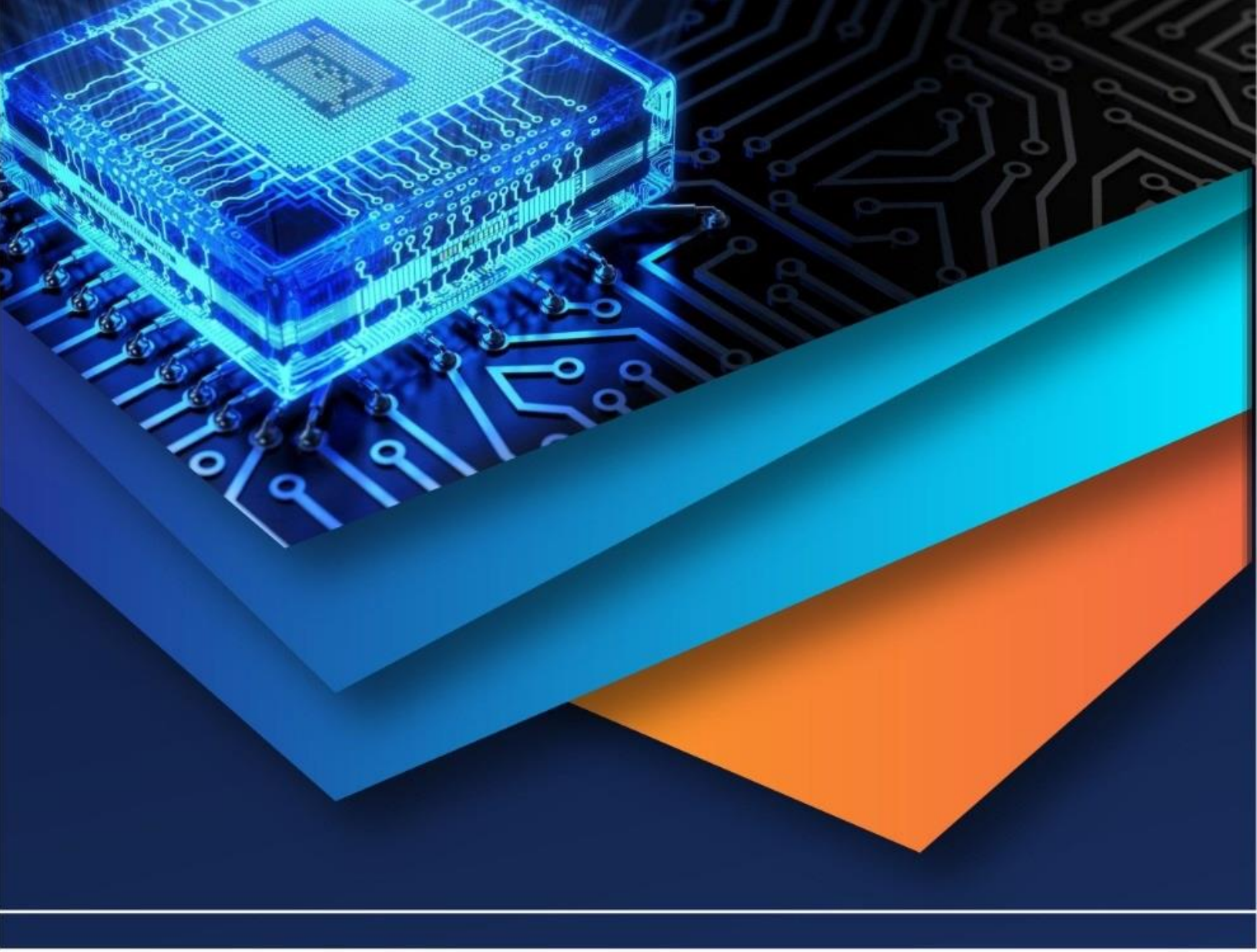

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