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Effect of Incorporating Metakaolin on the Properties of High Performance Concrete

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***Abstract*: This paper deals with an experimental work on the effect of incorporating metakaolin by weight of cement by various percentages ie.., 15%, 20%, 25% and 30% on properties of high performance concrete. This deals with the study of properties like workability, compressive strength, flexural strength, split tensile strength and durability for M100 grade concrete. It has been observed that the workability and required strengths are achieved at optimum percentage ie.., 25%. It has also been observed that the mix have been indicated better resistance to the chemical attacks like Hydrochloric acid(HCL) and Magnesium Sulphate($MgSO_4$). The cubes of size 150x150x150 mm were casted to find the average compressive strength for 28 days. The beams of size 500x100x100 mm were casted to find the average flexural strength for 28 days. The specimens of size 150x300 mm were casted to find the average split tensile strength for 28 days. The specimens of size 100x100x100mm were casted to find the percentage weight loss, compressive strength and percentage loss of compressive strength were immersed in the solutions for 60days. The various results which indicate the effect of incorporating metakaolin in high performance concrete are presented in this paper with tabular forms and graphs. The results were compared with reference mix.**

Keywords –High performance concrete (HPC), Metakaolin (MK), workability, compressive strength, flexural strength, split tensile strength and durability.

1.INTRODUCTION

High performance concrete is a concrete, which possess high workability, high strength and high durability when compared to conventional concrete. HPC contains one or more of cementitious materials such as fly ash, silica fume, GGBS or metakaolin and usually a super plasticizer. The term HPC is important because the essential features of this concrete is that the materials and mix proportions are specially chosen to have appropriate properties for structure such as high strength and low permeability. HPC is not a special type of concrete. It is same as conventional concrete. The use of some admixtures and super plasticizers improve the strength, durability and workability qualities to a very high extent.

High performance concrete is designed to give optimized performance characteristics for a given set of load, usage and exposure conditions with the requirements of cost and durability. HPC does not require special ingredients or special equipments except careful design and production. High performance concrete has several advantages like improved durability characteristics and much lesser micro cracking than conventional concrete.

American Concrete Institute (ACI) defines High Performance Concrete as " a concrete, which meets special performance and uniformity requirements that cannot always be achieved routinely by using only conventional materials and normal mixing, placing and compaction without segregation, long term mechanical properties, early age strength, volume stability or service life in severe environments".

Metakaolin is a more recently developed supplementary cementitious material. It is a reactive alumino-silicate pozzolana manufactured by calcining purified kaolinite at a specific temperature range. It is not a by-product of an industrial process nor entirely natural. Metakaolin combines with calcium hydroxide to form calcium silicate and calcium aluminate hydrates. Metakaolin is a valuable admixture for concrete applications. It exhibits favourable engineering properties including the filler effect and pozzolanic reaction. The filler effect is immediate, while the effect of pozzolanic reaction occurs between 3 to 14 days.

Metakaolin increases compressive and flexural strengths. Reduces permeability, shrinkage and efflorescence. It increases resistance to chemical attack, durability.

2. EXPERIMENTAL PROGRAMME

2.1 MATERIALS

Cement used in the investigation was 53 Grade Ordinary Portland cement confirming to IS: 12269. The specific gravity of cement was 3.14.The fine aggregate was conforming to Zone-2 according to IS: 383. The fine aggregate used was obtained from a nearby river source. The specific gravity was 2.65, while the bulk density of sand was 1400 kg/m^3. Crushed granite was used as coarse aggregate. The coarse aggregate was obtained from a local crushing unit having 20mm nominal size, well graded aggregate according to IS: 383. The specific gravity was 2.8, while the bulk density was 1600kg/m^3.Potable water was used in the experimental work for both mixing and curing companion specimens.High range water reducing admixture confirming to ASTM C94 [20] commonly called as super plasticizers was used for improving the flow or workability for decreased water-cement ratio without sacrifice in the compressive strength. In the present investigation, water-reducing admixture Glenium B233

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obtained from BASF Chemicalswas used. The chemicals used for durability are Hydrochloric acid (HCL) and Magnesium sulphate ($MgSO_4$).

3.EXPERIMENTAL PROCEDURE

Concrete testing specimens of required number were casted and cured for 28days for w/c of 0.32, which is corresponding to M100 grade concrete with different percentages of addition of metakaolin by weight of cement ie.., 15, 20,25 and 30.

Concrete specimens of size 150 x 150 x 150 mm were casted to find residual compressive strength and size of 100m x 100mm x 100mm were casted to find percentage weight loss after 60 days of hydrochloric acid and magnesium sulphate immersion.

Water cured specimens for 28 days were taken out and allowed to dry under shade and then the same concrete specimens were tested for compressive strength, flexural strength, split tensile strength and durability test.

For durability test the cubes are kept for water curing for 28days were taken out and allowed to dry under shade and the same specimens were kept immersed in 3.5% concentrated HCL and 5% $MgSo_4$ for 60 days for durability observation. Durability test was conducted initially the normal weights of cubes were taken and observed the deteriorating effect after 60 days by taking weights again accurately after washing the specimens in running water. The weight loss due to acid immersion was noted.

4. RESULTS & DISCUSSION

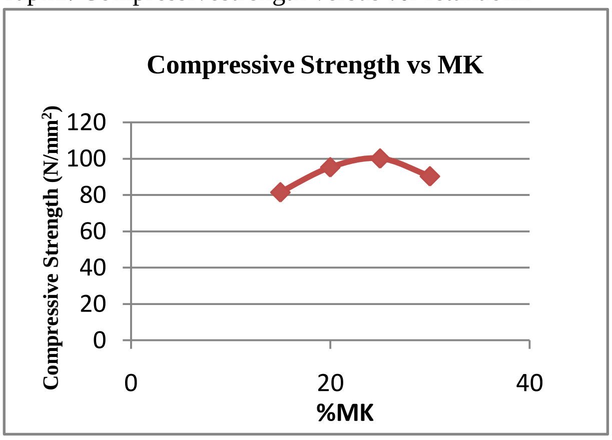
4.1 Compressive Strength test

In this test the optimum content of metakaolin of 25% and super plasticizer dose of 1% gives required strength. The results are tabulated below.

Table: average compressive strength test results

%Metakaolin	28 days (N/mm^2)
0	80
15	81.48
20	95.22
25	100.06
30	90

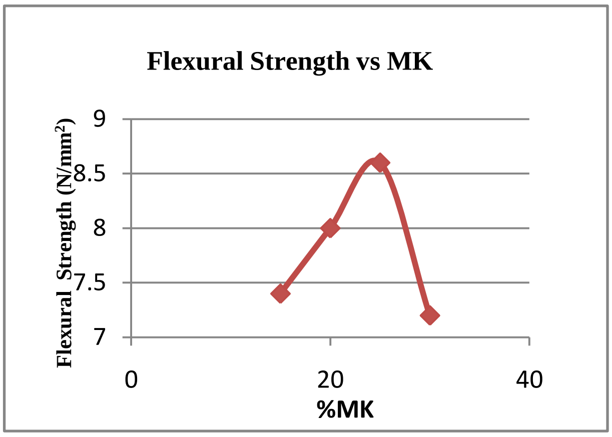
Graph1: Compressivestrength versus %Metakaolin



4.2 Flexural Strength test

Table: average flexural strength test results

%Metakaolin	28 days (N/mm^2)
0	6.1
15	7.4
20	8
25	8.6
30	7.2



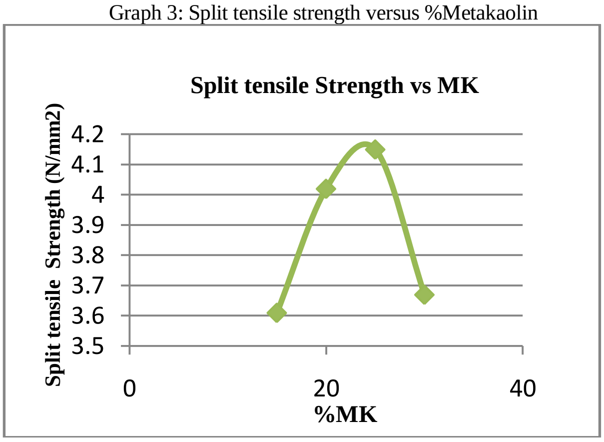
Graph 2: Flexural strength versus %Metakaolin

4.3 Split tensile Strength test

Table: average split tensile strength test results

%Metakaolin	28 days (N/mm^2)
0	3
15	3.61
20	4.025
25	4.15
30	3.67

Graph 3: Split tensile strength versus %Metakaolin



4.3 Durability Test

4.31 Durability test immersed in HCL

Table: average % weight loss

%Metakaolin	60 days
0	6.20
15	5.69
20	5.30
25	5.03
30	5.17

Graph 4: avg % weight loss versus %MK

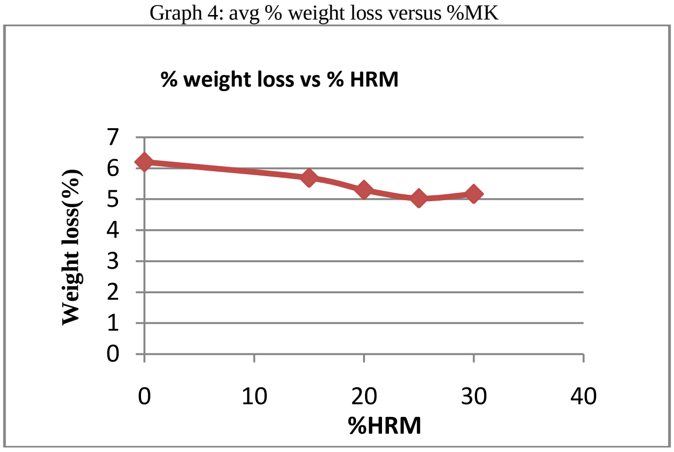
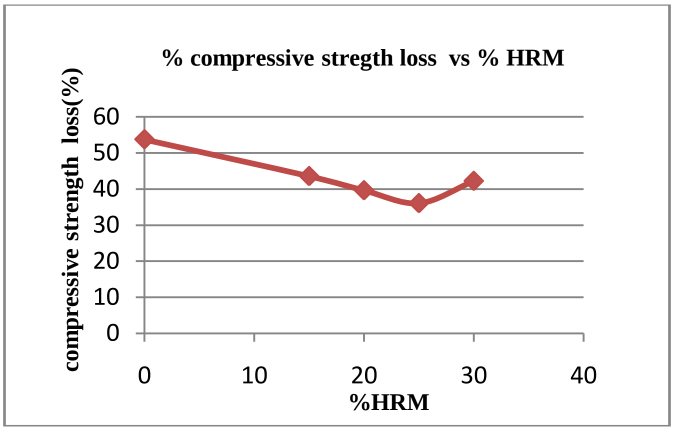


Table: average % compressive strength loss

%Metakaolin	Compressive strength avg loss(%) 60 days
0	53.75
15	43.54
20	39.60
25	36.03
30	42.20

Graph 5: % compressive strength loss versus % MK



4.32 Durability test immersed in $MgSO_4$

Table: average % weight loss

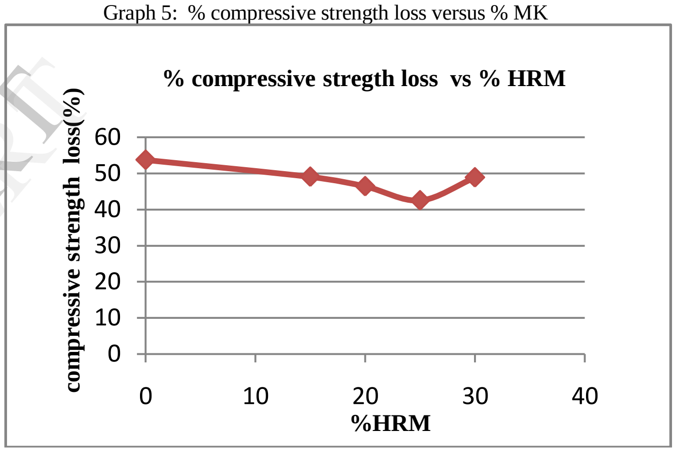
%Metakaolin	60 days
0	5.10
15	5.05
20	4.98
25	4.59
30	4.89

Graph 5: avg % weight loss versus %MK

Table: average % compressive strength loss

%Metakaolin	Compressive strength avg loss(%) 60 days
0	53.75
15	49.06
20	46.43
25	42.53
30	48.88

Graph 5: % compressive strength loss versus % MK



CONCLUSIONS:

1. The compressive strength of concrete increases at optimum dosage of 25% metakaolin with 1% super plasticizer.
2. For compressive strength test the average value for 28 days was found to be 100.06N/mm^2. For flexural strength test the average value for 28 days was found to be 8.6N/mm^2. For split tensile strength the average value for 28 days was found to be 4.15N/mm^2.
3. The % loss of compressive strength of concrete with 25% Metakaolin (by weight of cement) is reduced only 36.03% when compared to control mix is by 53.75% when immersed in HCL solution for 60 days.
4. The % loss of compressive strength of concrete with 25% Metakaolin (by weight of cement) is reduced only 42.53% when compared to control mix is by 53.75% when immersed in $MgSo_4$ solution for 60 days.
5. It can be concluded that the percentage weight loss due to HCL and $MgSo_4$ solutions for 25% metakaolin is minimum.

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