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PARTIAL REPLACEMENT OF CEMENT WITH METAKAOLIN IN CONCRETE

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Abstract: Cement concrete is the most widely used material for various constructions. Properly designed and prepared concrete results in good strength and durability properties. Even such well-designed and prepared cement concrete mixes under controlled conditions also have certain limitations because of which the above properties of concrete are found to be inadequate for special situations and for certain special structures. Hence variety of admixtures such as fly ash, Silica fume, rise husk ash and stone dust etc., are used along with cement in certain percentages to enhance the properties of the regular cement concrete. Hence an attempt has been made in the present investigation on replacement of cement with recent new pozzolanic material of Metakaolin up to certain percentages. To attain the setout objectives of the present investigations, the grade of concrete M30 mix case have been taken as reference concrete. Hardened concrete is tested for strength properties such as Cube Compressive strength and Split Tensile Strength. The variations of above strengths with variation in different % of Metakaolin have been studied.

Index Terms **– Metakaolin, Compressive strength, Split Tensile Strength**

I. INTRODUCTION

Cement concrete has been used in various structures all over the world since last two decades. In India concrete is about a decade old with major applications in the construction at nuclear power Plants. Recently a few infrastructure projects have also been specific application of cement concrete. The development of cement concrete has brought about the essential need for additives, both chemical and mineral to improve the performance of concrete. Most of the developments across world have been supported by continuous improvement of these admixtures.

A. Role of SCM's in Cement Concrete

Supplementary cementitious materials (SCM's) are a must to produce cement concrete along with a cost-efficient chemical admixture. Metakaolin one of the SCM's which can significantly improve the performance as well as strength of Portland cement based. Metakaolin, also known as high reactive Metakaolin (HRM) is more often used in industrial floorings than structural concrete. There are a few applications of metakaolin concrete for structural application. IS 456-2000 has recommended for use in improving the concrete properties. Metakaolin is obtained by calcinations of pure or refined kaolinite clay at a temperature between 650^0c and 850^0c, followed by grinding to achieve a fineness of 700 to 900m^2/kg. The average particle size of metakaolin is 1.5µm. Metakaolin, available in our country indigenously, is used for paint industries, but scarcely for concrete applications. If this resource can be tapped for concrete application, the cost of cement concrete can be brought down significantly.

B. Properties of Metakaolin concrete

A number of laboratory studies have been conducted to study the behaviour of concrete with replacement and addition of Metakaolin to cement in concrete.

Average Particle Size	1.4 µm
Residue 325 mesh	0.6 (% max)
B.E.T surface area	18 m^2/gm
Pozzolan reactivity MgCa (OH)2	1020 gm
Specific gravity	2.5
Bulk density	300 +or- 30 g/lit
Brightness	80 +or- 2
Physical form	White powder
Chemical composition(wt) $SiO_2+Al_2O_3+Fe_2O_3$ CaO	 96.88% 0.39%

MgO	0.08%
TiO_2	1.35%
Na_2O	0.56%
K_2O	0.06%
L.I.O	0.68%

C. Pozzolanic reactivity

Metakaolin is a lime – hungry Pozzolan that reacts with free calcium hydroxide to form stable, insoluble, strength – adding, cementitious compounds.

When metakaolin – HRM (AS_2) reacts with calcium hydroxide (CaOH), a cement hydration by products, a pozzolanic reaction takes place where by new cementitious compounds, (C_2ASH_8) and (CSH), are formed. These newly formed compounds will contribute cementitious strength and enhanced durability properties to them system in place of the otherwise weak and soluble calcium hydroxide.

II. MATERIALS USED

A. Cement

Ordinary Portland cement of 43-grade cement of Rajasree conforming to IS: 8112 – 1970 was throughout the work. The specific gravity is 3 and fineness modulus is 4.52.

B. Fine Aggregate

Locally Available natural river sand confirming to grading zone – II of table of IS: 383 – 1970 has been used as fine aggregate. The specific gravity is 2.7, and fineness modulus is 3.77.

C. Coarse Aggregate

Machine crushed granite confirming to IS: 383 – 1970 (23)consisting 20mm maximum size of aggregate have been obtained from the local quarry. It has been tested for specific gravity i.e., 2.73.

D. Metakaolin

The Metakaolin is obtained from the 20 MICRONS LIMITED COMPANY at Vadodara in Gujarat. The specific gravity of Metakaolin is 2.54. The Metakaolin is conformity with the general requirements of pozzolana.

E. Water

Potable water has been used in this experimental study for mixing and curing.

III. METHODOLOGY

In concrete, we are partially replaced cement with metakaolin. In the range of 5%,10%,15% respectively. For M30 grade of concrete the ratio is 1:1.36:1.94, which means 1 part cement, 1.36 parts sand and1.94 parts aggregates for making 1 cubic meter concrete. We check the workability with the tests of compaction test and slump cone test. At first casting of 3 cubes and 3 cylinders without any replacement. Then we keep the cubes and cylinders in curing pond and we check compressive strength and split tensile strength at an age of 7,14,28 days Again we cast the cubes and cylinders with partial replacement of cement with metakaolin in concrete. Then we kept it in curing pond Finally we check cubes for compressive strength and for cylinders we check split tensile strength at an age.

IV. RESULTS AND DISCUSSION

A. Influence of Metakaolin percentages on Compressivestrength of concrete

Referring to table I and fig I the compressive strengthof the mix M30 i.e. without mixing of Metakaolin is 31.917N/mm^2 for 28 days respectively. In the present investigation the Metakaolin has been used as replacement to cement up to a maximum of 20%. When Metakaolin is used as admixture in different percentages the strength is increased.

For e.g., with 5% replacement of cement by Metakaolin the compressive strength at 28 days is 32.77 N/mm^2 and there isan increase of compression strength by 3 %. Considering 10% replacement, the compressive strength is 33.33 N/mm^2 there is an increase in compressive strength by 5%. With 15% replacement, the compressive strength is 34.61N/mm^2, and the increase in compressive strength by 9%. With 20% replacement, the compressive strength is 32.71N/mm^2, and the decrease in compressive strength by 3% From this strength it is clear that there is no advantage in usingMetakaolin beyond 15%. Hence, 15% Metakaolin can be takenas the optimum dosage, which can be mixed as a partial replacement to cement for giving maximum possible compressive strength at any stage

B. Influence of Metakaolin percentages on Split Tensile strength of concrete

In the case of split tensile strength (table no 2 and fig 2) the 28 days value without Metakaolin is 3.82N/mm^2. When 5% replacement is used the split tensile strength is 4.07 N/mm^2. There is increase in strength by 7%. The split tensile strength at 28 days with 10% replacement is 4.23 N/mm^2 showing an increase of strength by 11%. With 15% replacement the strength for 28 days is 4.36 N/mm^2. With 20% replacement the strength for 28 days is 4.17 N/mm^2. There is increase in strength by about 14% only. Hence, it is advisable to use 15% as replacement. Hence the optimumpercentage of Metakaolin is again 15% only even in the caseof split tensile strength.

C. Figures and Tables

TABLE 1. CUBE COMPRESSIVE STRENGTH OF CONCRETE WITH % OF METAKAOLIN

S.No	%of Metakaolin	@7days (N/mm^2)	@14 days (N/mm^2)	@28days (N/mm^2)
1	0	19.68	26.06	31.91
2	5	20.42	26.76	32.77
3	10	21.42	27.33	33.33
4	15	21.68	28.26	34.61
5	20	20.05	26.70	32.71

TABLE 2. SPLIT TENSILE STRENGTH OF CONCRETE WITH % OF METAKAOLIN

S.No	%of Metakaolin	@7days (N/mm^2)	@14 days (N/mm^2	@28 days (N/mm^2)
1	0	2.37	3.29	3.82
2	5	2.48	3.54	4.07
3	10	2.69	3.65	4.23
4	15	2.77	3.85	4.36
5	20	2.51	3.61	4.17

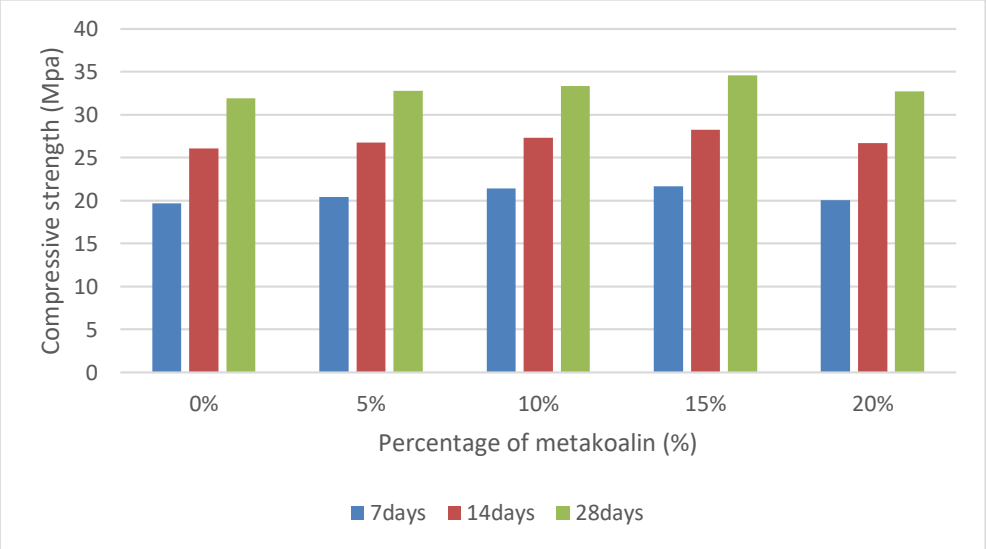

Fig. 1 Cube Compressive Strength of Concrete With % Of Metakaolin

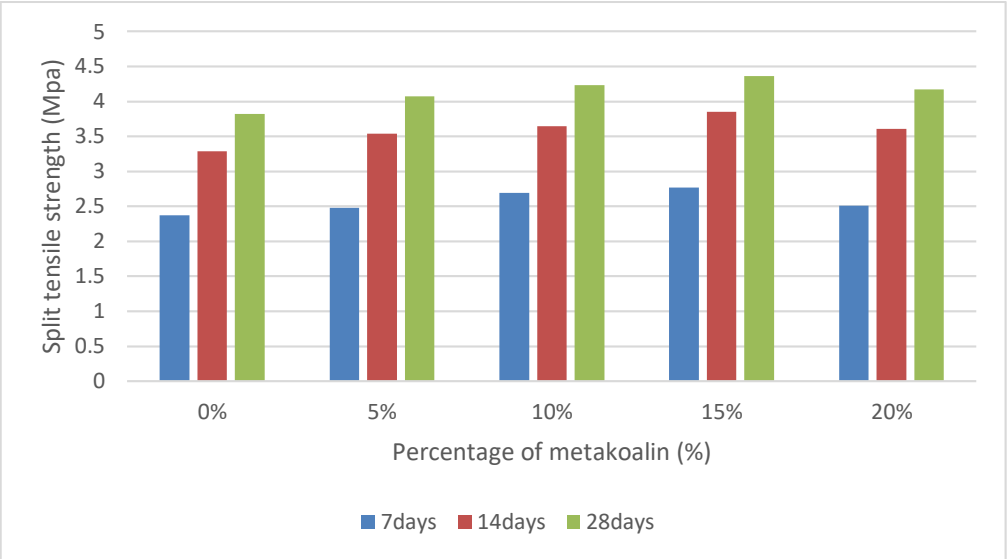

Fig 2. SPLIT TENSILE Strength of concrete with % of metakaolin

V. CONCLUSIONS

Based on the present experimental investigation, thefollowing conclusions are drawn:

1. 15% Metakaolin can be taken as the optimum dosage. Mixed as apartial replacement to cement for giving maximum possible compressive strength at any stage.
2. The optimum percentage of Metakaolin is gain at 15% in the case of Split Tensile Strength.
3. Metakaolin addition to concrete leads to decrease in workability.

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