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Strength Properties of Concrete Using Metakaolin

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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 pozzolonic material of Metakaolin up to certain percentages. To attain the setout objectives of the present investigations, the grade of concrete M_{20} mix case have been taken as reference concrete. Hardened concrete is tested for strength properties such as Cube Compressive strength, Split Tensile Strength, Modulus of Rupture and Young's Modulus of Elasticity. The variations of above strengths with variation in different % of Metakaolin have been studied.

Keywords*— Pozzolonic Material, Metakaolin, Compressive strength, Split Tensile Strength, Modulus of Rupture, Young's Modulus of Elasticity.

I. INTRODUCTION

High performance concrete has been used in various structures all over the world since last two decades. In India high performance 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 high performance concrete. The development of high performance concrete (HPC) 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 High Performance Concrete

Supplementary cementitious materials (SCM's) are a must to produce high performance 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 colour 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 kaolintic 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 high-performance concrete the cost of high-performance concrete can be brought down significantly.

B. Properties of Metakaolin concrete

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

Average Particle Size	1.5 µm
Residue 325 mesh	0.5 (% max)
B.E.T surface area	15 m2/gm
Pozzolan reactivity MgCa $(OH)_2$	1050 gm
Specific gravity	2.5
Bulk density	300 +or- 30 g/lit
Brightness	80 +or- 2
Physical form	White powder
Chemical composition(wt)	
$SiO_2+Al_2O_3+Fe_2O_3$	96.88%
CaO	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 pozzolonic 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.

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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 pozzolona.

E. Super Plasticizer

Conplast p211 is a chloride free – water reducing admixture based on selected sugar reduced lignbosulphonates. It is supplied as a brown solution which instantly disperses in water. This produces higher levels of workability for the same water content. Allowing benefit such as water reduction and increased strengths to be taken. The specific gravity is 1.18 to 1.19 at 2500C; fluoride content is less than 0.05% by weight.

F. Water

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

III. METHODOLOGY

In the present investigation M_{20} grade concrete has been used. The mix of concrete is designed as per the guidelines of IS 10262[8], subsequently mixes were prepared with a partial replacement of cement by Metakaolin at percentages of 7.5, 10, 12.5,15 and 17.5 for cubes and cylinders and 0,5,10,15,20,25 for beams, by weight of cement water ratio of 0.5 and constant dosage of 200 ml suerplasticizer for 1 bag of cement is used.

Manual mixing is adopted throughout the experimental work. First the materials cement, Metakaolin, fine aggregate and coarse aggregate are weighed exactly, cement and Metakaolin are mixed first. Then to C.A. & F.A., cement Metakaolin mixture is added and thoroughly mixed.

A solution is prepared by adding the required dosage of suerplasticizer to about 10%of water required for the concrete mix to be used at the added and mixed well. The balance of water is then added to the concrete in small quantities and uniformly mixed. At this stage, the solution containing suerplasticizer is added to the concrete and is again thoroughly mixed until there is uniform color.

The beams are cast in the steel molds of size 150 x150x600 mm (internal). First the moulds are oiled. Later the mixed concrete is poured into the moulds and compaction is done by using table vibrator. Similarly cubes (150x150x150mm) and cylinders (150mmdia and 300 long) are also cast. The specimens are demoulded after curing which is done for a period of 28 days. The cube specimens are tested for compressive strength, the cylinder specimens are tested for Young's Modulus and split tensile strength and the beam specimens are tested for flexural strength.

IV. RESULTS AND DISCUSSION

A. Influence of Metakaolin percentages on Compressive strength of concrete

Referring to table I and fig I the compressive strength of the mix M20 i.e. without mixing of Metakaolin is 23.407N/mm^2 for 28 days respectively. In the present investigation the Metakaolin has been used as replacement to cement up to a maximum of 17.5%. When Metakaolin is used as admixture in different percentages the strength is increased .For e.g., with 7.5% replacement of cement by Metakaolin the compressive strength at 28 days is 47.11 N/mm^2 and there is an increase of compression strength by 8.53 %.Considering 10% replacement, the compressive strength is 51.259 N/mm^2 there is an increase in compressive strength by 15.3%. With 17.5% replacement, the compressive strength is 42.222 N/mm^2, and the decrease in compressive strength by 2.8%. From this strength it is clear that there is no advantage in using Metakaolin beyond 10%. Hence, 10% Metakaolin can be taken as 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 2.971N/mm^2. When 7.5% replacement is used the split tensile strength is 3.16 N/mm^2. There is increase in strength by 6.3%. The split tensile strength at 28 days with 10% replacement is 3.1124 N/mm^2 showing an increase of strength by 27%. With 17.5% replacement the strength for 28 days is 3.1124 N/mm^2. There is increase in strength by about 4.8% only. Hence, it is advisable to use 10% as replacement. Hence the optimum percentage of Metakaolin is again 10% only even in the case of split tensile strength.

C. Influence of Metakaolin percentages on Modulus of Rupture of concrete

In the case of rupture (table no 3 and fig no 3) the 28 days value without Metakaolin is 3.84 N/mm^2. When 5% replacement is used the flexural strength is 4N/mm^2. There is increase in strength by 4.17%.

The flexural strength 28 days with 10%replacement is 4.216 N/mm^2 showing an increase of strength by 37.6%. With 15% replacement the strength for 28 days is 3.9N/mm^2. There is increase in strength by about 1.56%. Hence it is advisable to use 10% Metakaolin as replacement. For other percentage there is decrease in strength with respective to 0% of Metakaolin. Hence the optimum percentage of Metakaolin is again 10%only even in the case of flexural strength. At optimum percentage the beam shows the higher stiffness.

D. Influence of Metakaolin percentages on Modulus of Elasticity of concrete

In the case of Modulus of elasticity (table 4) the 28 days value without Metakaolin is 28651N/mm^2. When 7.5% replacement is used the Modulus of Elasticity is 30884 N/mm^2. There is increase in strength by 7.79%. The Modulus of Elasticity at 28 days with 10% replacement is 39140N/mm^2 showing an increase of strength by 36.6%. With 17.5% replacement the strength for 28 days is 26992 N/mm^2. There is decrease in strength by about 5.79%. Hence it is advisable to use 10% as replacement. Hence the optimum % allowed Metakaolin is again 10% only even in the case of Modulus of Elasticity.

E. Figures and Tables

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

S.No	%of Metakaolin	@7days (N/mm^2)	@28days (N/mm^2)
1	0	19.407	23.407
2	7.5	39.407	47.111
3	10	41.185	51.259
4	12.5	39.111	45.63
5	15	38.667	44.148
6	17.5	38.111	42.222

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

S.No	%of Metakaolin	@7days (N/mm^2)	@28 days (N/mm^2)
1	0	2.871	2.971
2	7.5	3.065	3.160
3	10	3.208	3.773
4	12.5	3.208	3.348
5	15	2.971	3.490
6	17.5	2.971	3.112

TABLE 3. MODULUS OF RUPTURE OF CONCRETE WITH % OF METAKAOLIN

S.No	%of Metakaolin	Flexural strength (N/mm^2)
1	0	3.84
2	5	4.0
3	10	4.216
4	15	3.9
5	20	3.75
6	25	3.086

TABLE 4. MODULUS OF ELASTICITY OF CONCRETE WITH % OF METAKAOLIN

S.No	%of Metakaolin	Modulus of Elasticity (N/mm^2)
1	0	28651
2	7.5	30884
3	10	39140
4	12.5	31660
5	15	29425
6	17.5	26992

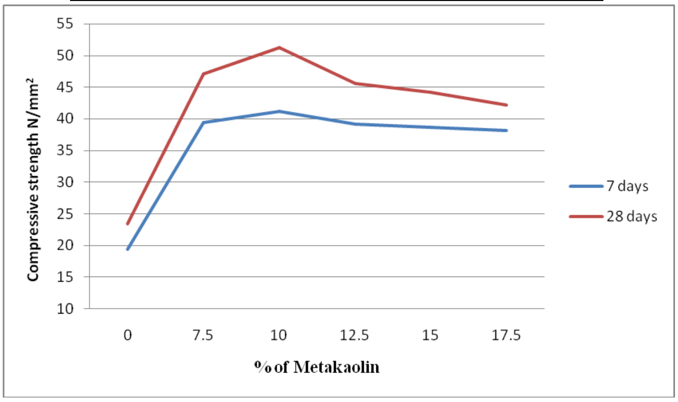

Fig. 1 Cube Compressive Strength Of Concrete With % Of Metakaolin

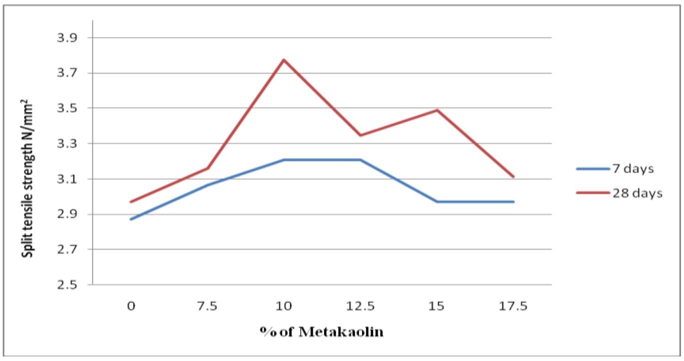

FIG 2. SPLIT TENSILE Strength of concrete with % of metakaolin

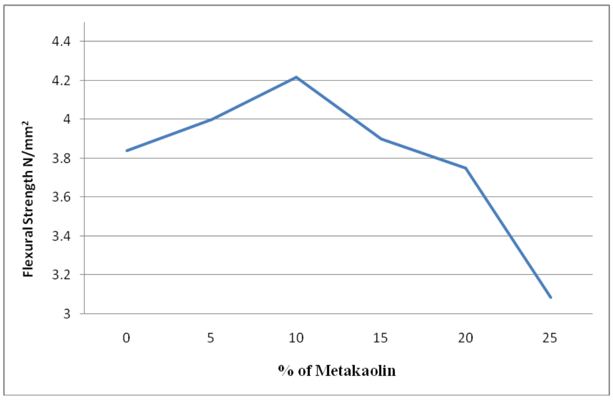

FIG 3. FLEXURAL Strength of concrete with % of metakaolin

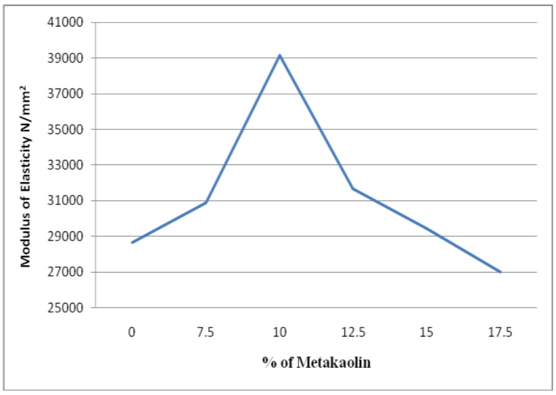

FIG. 4 MODULUS OF ELASTICITY of concrete with % of metakaolin

CONCLUSION

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

1. 10% Metakaolin can be taken as the optimum dosage, which can be utilized by using super plasticizer. Mixed as a partial replacement to cement for giving maximum possible compressive strength at any stage.
2. The optimum percentage of Metakaolin is again 10% in the case of Split Tensile Strength, Flexural Strength and Modulus of Elasticity.
3. Metakaolin addition to concrete leads to decrease in workability which has to be compensated by adding Super plasticizers.

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REFERENCES

[1] E.Moulin, P. Blanc, and D.Sorrentino, "Influence of key cement chemical parameters on the properties of metakaolin blended cements," Cement & concrete composites, Vol. 23, Issue 6, pp. 463-469, December 2001.
[2] Tiwari, A. K., and P. Bandyopadhyay, "Metakaolin for high performance concretes in India." The Indian Concrete Journal 4, 9-11, 2003.
[3] Rafat, Siddique and JuvasKlaus, "Influence of metakaolin on the properties of mortar and concrete: A review," Applied clay science, Vol. 43, Issue 3-4, pp. 392-400, March 2009.
[4] Chi-Sun Poon, Salman Azhar, Mike Anson and Yuk-Lung Wong, "Performance of metakaolin concrete at elevated temperatures," Cement and concrete composites, Vol. 25, Issue 1, pp. 83-89, January 2003.
[5] K.A.Gruber, Terry Ramlochan, Andrea Boddy, R.D.Hooton and M.D.A. Thomas, "Increasing concrete durability with high-reactivity metakaolin," Cement and concrete composites, Vol. 23, Issue 6, pp. 479-484, December 2001.
[6] A.A.Ramezanianpour and H.Bahrami Jovein, "Influence of metakaolin as supplemetary cementing material on strength and durability of concretes," Construction and Building Materials, Vol. 30, pp. 470-479, May 2012.
[7] P.Dinakar, Pradosh K.Sahoo and G.Sriram, "Effect of metakaolin content on the properties of high strength concrete," Concrete structures and Materials, Vol. 7, pp. 215-223, September 2013.