Experimental Investigation on Metakaolin Modified Fiber Reinforced Concrete

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Abstract - *Crimped steel fiber of aspect ratio 85 & Metakaolin were used with concrete to improve properties of structural concrete of M 60 grade. The effect of Metakaolin & steel fiber on dry density, wet density, Workability & various strength factors are studied. Fiber content varies from 1% to 9% at an interval of 2% & Metakaolin varies from 5% to 25% at an interval of 5% by weight of cement. Cubes of 150 X 150 X150 mm for compressive strength, Cylinders of 150 mm dia. X 300 mm length for split tensile strength, Beam of 150 X 150 X 700 mm for flexure strength& push-off specimen of 150 X 150 X 450 mm for shear strength were cast. Specimen were cured for 28 days & then tested. Ductility of MMFRC (Metakaolin Modified Fiber Reinforce Concrete) is found to be increases as observed from load deflection curve. Workability is found to be decreases with increase of fiber content & Metakaolin. Various strength parameters were improved due to addition of steel fiber & Metakaolin such as compressive strength, flexure strength, split tensile strength & shear strength.*

***Key Words*: Metakaolin, M 60 grade of concrete, crimped steel fiber, etc**

1. INTRODUCTION

Metakaolin is a dehydroxylated form of the clay mineral kaolinite. Rocks that are rich in kaolinite are known as china clay or kaolin, traditionally used in the manufacture of porcelain. The particle size of metakaolin is smaller than cement particles, but not as fine as silica fume .The quality and reactivity of metakaolin is strongly dependent of the characteristics of the raw material used. Cement concrete is the most widely used material for various constructions. Properly designed & prepared concrete result in good strength & durable properties. Even such well designed & prepared cement concrete mix under controlled conditions also have certain limitations because of which above properties of concrete are found to be inadequate for special situations & certain special structures .The main ingredient in the convential concrete is the Portland cement .The amount of cement production emits approximately equal amount f carbon dioxide into the atmosphere. Cement production is consuming a significant amount of natural resources .To overcome above ill effects , the advent of newer materials & construction techniques in this drive , admixture has taken newer things with various administers has became a necessity . Availability of mineral admixtures marked opening of new era for designing concrete mix of higher strength. As a result, the use of new mineral admixtures has considerably increased within the concrete industry. For attaining a high strength & durable concrete for major applications in the constructions such as high rise buildings, tall structures, nuclear power points etc. , the essential need for additives both chemical & mineral are must to improve the performance of concrete. Changes on some mechanical properties of concrete specimens produced by metakaolin, fly ash and steel fibers with the objective to obtain more ductile high strength concrete were observed. Three types of steel fibers were used in the experiments and volume fractions of steel fiber were 0.5% to 4.0%. The mechanical strength as well as ductility was increased due to partial replacement of Metakaolin and steel fibers'. The use of metakaolin increased mechanical strength of concrete. On the other hand, the addition of steel fiber into concrete improves ductility of high strength concrete significantly.

1.1 IDENTIFY, RESEARCH & COLLECTED DATA

1) The crimped steel fibers of aspect ratio 86 were used. Coarse & fine aggregate confirming to IS 383, ordinary Portland cement of 53 grade were used. The fineness modules of coarse & fine aggregate(Artificial sand of zone II) were 7.69 & 2.71 respectively. The physical & chemical properties of ordinary Portland cement, crimped steel fiber, Coarse & fine aggregate & Metakaolin as shown in table 1, 2, 3 & 4.

Table -1: Physical properties of cement (IS 12269-2013)

SR NO	PROPERTIES	VALUE OBSERVED	STANDARD VALUES
1.	Fineness (%)	5.5	Not exceed 10
2.	Specific gravity	3.15	3.15
3.	Standard consistency of cement (%)	27.5	30
4.	Initial setting time (min)	105	>30
5.	Final setting time (min)	215	<600
6.	Compressive Strength N/mm^2 (7 days)	48.96	>37
7.	Compressive Strength N/mm^2 (28 days)	61.80	>53

Table 2 Physical properties of crimped steel Fiber

SR NO.	PROPERTY	VALUES
1	Diameter (d_f)	0.7 mm
2	Length of fiber (l_f)	60 mm
3	Aspect ratio of fiber (d_f / l_f)	86
4	Appearance & Form	Clear, Bright & undulated along length.
5	Modulus of Elasticity	200 GPa
6	Tensile Strength	1000 MPa

Table 3: Test results for coarse Aggregate (20 mm)

SR NO.	PROPERTY	RESULT
1	Fineness Modulus	7.78
2	Specific Gravity	2.93
3	Water Absorption	0.4 %

Table 4: Test results for coarse Aggregate (12.5 mm)

SR NO.	PROPERTY	RESULT
1	Fineness Modulus	6.54
2	Specific Gravity	2.93
3	Water Absorption	0.6 %

The concrete mix design carried out according to IS 456: 2000 .The concrete (M 60) grade having mix proportions **1:0.8518: 1.1481** (**Cement**: Fine aggregate: Coarse aggregate). Stipulation of proportioning as shown in table 5.

Table 5: Stipulation of proportioning

A) Grade designation	M 60
B)Type of cement	OPC 53 grade
C) Maximum nominal size of aggregate	20 mm
D)Minimum cement content	320 kg/m^3

E)Maximum W/C ratio	0.3
F) Workability	22 mm
G)Maximum cement content	450 kg/m^3

2. PHYSICAL PROPERTIES OF CONCRETE COMPOSITE

2.1 Tests conducted on fresh concrete
Slump cone test-

The apparatus consists of a mold in the shape of a frustum of a cone with a base diameter of 8 inches, a top diameter of a 4inches, and a height of 12 inches. The mold is filled with concrete in three layers of equal volume. Each layer is compacted with 25 strokes of a tamping rod. The slump cone mold is lifted vertically upward and the change in height of the concrete is measured.

2.2 Test Conducted on Hardened Concrete

A) Compressive Strength Test on Cube –

The cube specimen is of size 15 x 15 x 15 cm. Compression testing machine (CTM) of capacity 2000KN used to determine the compressive strength of plain and steel fiber reinforced concrete.

B) Flexure test on plain concrete and FRMC-

Standard beam of size 150 x 150 x 700 mm is supported symmetrically over a span of 400mm and subjected to two points loading till failure of the specimen. The deflection at the center of the beam is measured with the sensitive dial gauge on UTM.

C) Spilt tensile strength on cylinder -

The test is carried out on cylinder by splitting along its middle plane parallel to the edges by applying the compressive load to opposite edges.

D) shear strength test on push-off specimen-

Study of shear transfer strength has carried out using push – off specimen with dimensions of (450 x 150 x 150 mm), with shear plane length of (150mm). The nominal steel reinforcement of 6mm diameter bar was provided away from shear plane to prevent failure other than shear mode. All the specimens are air dried prior to testing machine of 60 tones capacity.

3. DISCUSSION OF RESULT

3.1 Workability- Result of slump cone test of normal concrete (NC) & Metkaolin modified fiber reinforced concrete (MMFRC) Are as shown in Table.

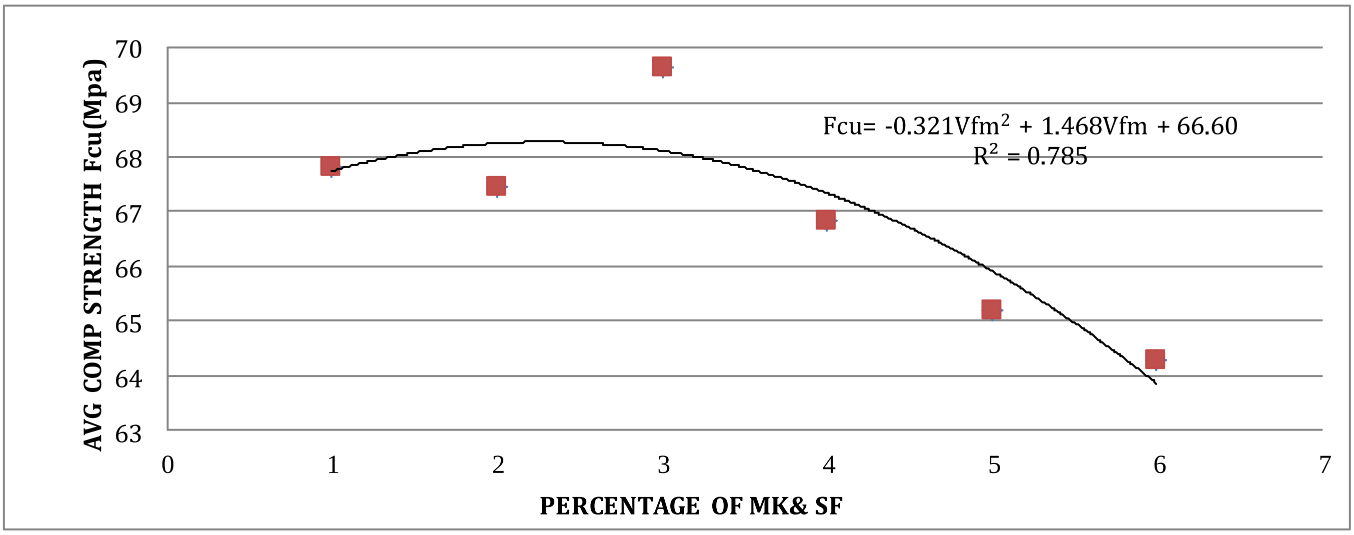
SR NO.	MIX DESIGNATION	SLUMP IN mm
1	NC	22
2	NC+1%SF+5%MK	14
3	NC+3%SF+10%MK	0
4	NC+5%SF+15%MK	0
5	NC+7%SF+20%MK	0
6	NC+9%SF+25%MK	0

3.2 Compressive strength test- Compressive strength for 3% SF & 10% MK is more suitable for improving compressive strength for structural concrete, as shown in table.

SR NO	PERCENTAGE OF FIBER CONTENT	PERCENTAGE OF METAKAOLIN	AVG COMPRESSIVE LOAD IN KN (28 DAYS)	AVG COMPRESSIVE STRENGTH Fcu(Mpa)
1	0	0	1526.26	67.83
2	1	5	1517.40	67.44
3	3	10	1566.90	69.64

4	5	15	1504.33	66.85
5	7	20	1466.46	65.18
6	21	9	25	1446.00

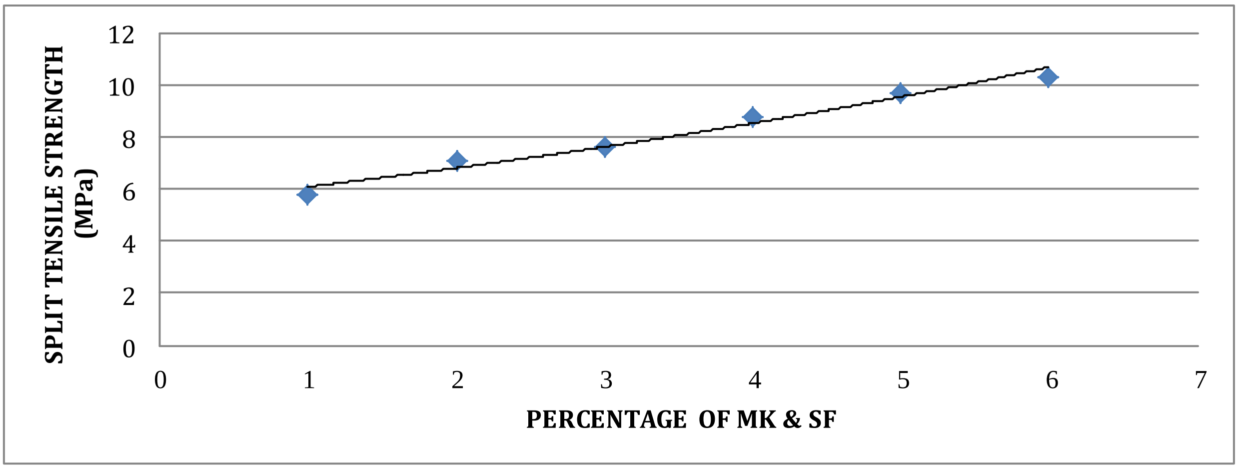
Graphical presentation of avg. compressive strength vs percentage of MK & SF.



3.3 Split tensile strength test- As increase of percentage of MK & SF split tensile strength of cylinders increases, as shown in Table.

SR NO	DESIGNATION	PERCENTAGE FIBER CONTENT	PERCENTAGE OF METAKAOLIN	SPLIT LOAD	SPLIT TESNSILE STRENGTH (M Pa)
1	3	0	0	410	5.81
2	7	1	5	490	7.13
3	11	3	10	560	7.64
4	15	5	15	640	8.82
5	19	7	20	680	9.68
6	23	9	25	730	10.32

Graphical presentation of avg split tensile strength vs percentage of MK & SF



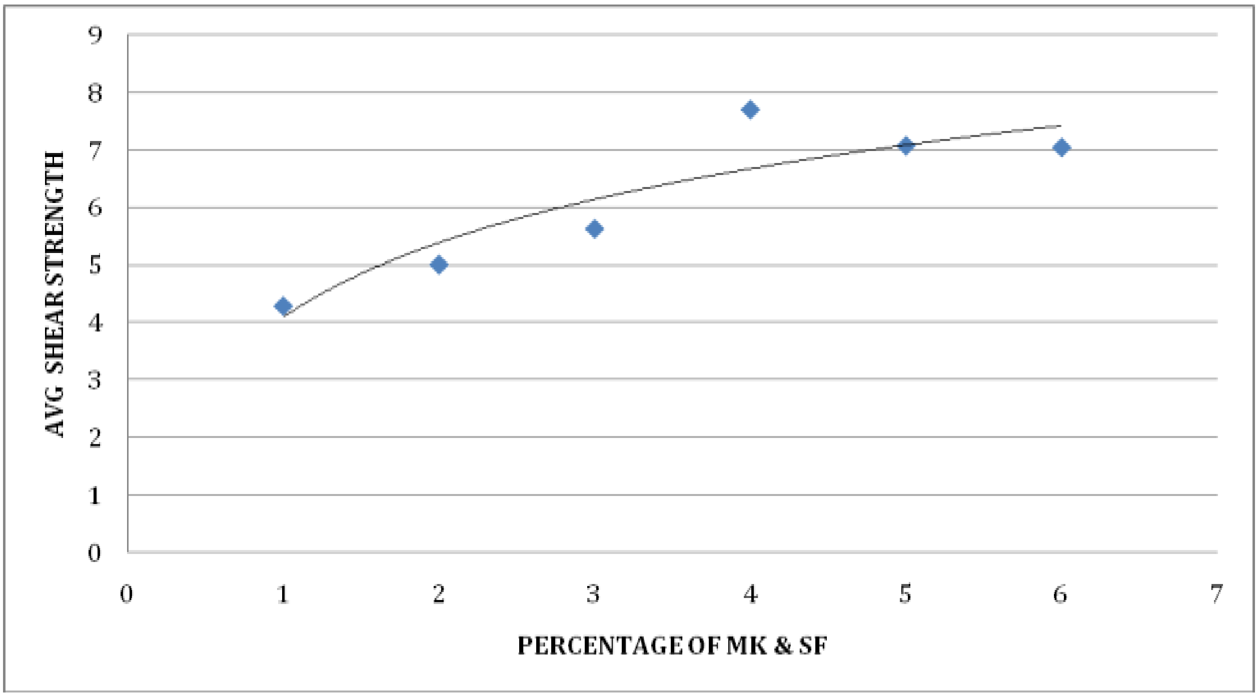
3.4 Flexural strength test- As increase of percentage of MK & flexure strength of beams increases, as shown in Table.

SR NO	DESIGNATION	PERCENTAGE FIBER CONTENT	PERCENTAGE OF METAKAOLIN	AVERAGE FLEXURAL LOAD (KN)
1	2	0	0	17.38
2	6	1	5	18.35
3	10	3	10	23.11
4	14	5	15	28.58
5	18	7	20	34.79
6	22	9	25	37.07

3.5 Shear strength test- As increase of percentage of MK & shear strength of push-off specimen increases, as shown in Table.

SR NO	DESIGNATION	PERCENTAGE FIBER CONTENT	PERCENTAGE OF METAKAOLIN	SHEAR FORCE IN kN
1	4	0	0	96.700
2	8	1	5	112.970
3	12	3	10	127.046
4	16	5	15	173.740
5	20	7	20	159.636

Graphical presentation of avg shear strength vs percentage of MK & SF



4. CONCLUSIONS

The following conclusions are drawn on the use of steel fiber reinforced concrete with metakaolin:

1. Workability decrease with increase in percentage of addition of steel fiber & MK in concrete mix.
2. Dry density increases with increase in steel fiber & MK in concrete mix.

3. Compressive strength increased for 3% fiber & 10 % metakaolin & it is increased by 3.2 % as compared to normal concrete.
4. Flexural strength increases with increase in percentage of steel fiber & MK in concrete mix. Maximum flexural strength was obtained at 9 % fiber content by volume fraction & 25 % MK by weight of cement. Flexural strength becomes twice as compared to normal concrete.
5. Split tensile strength increases with increase in percentage of steel fiber & MK in concrete mix. Maximum Split tensile strength was obtained at 9 % fiber content by volume fraction & 25 % MK by weight of cement. Split tensile strength increased by 56.29 % as compared to normal concrete.
6. Maximum Shear strength was obtained at 9 % fiber content by volume fraction & 20% MK by weight of cement. Shear strength increased by 60.64 % as compared to normal concrete.

5. REFERENCES

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