EXPERIMENTAL INVESTIGATION ON STRENGTH OF FIBER REINFORCED CONCRETE CUBES WITH SILICA FUMES AND HIGH REACTIVE METAKAOLIN

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Abstract

*Experimental investigation was carried out to study the cube compressive strength of fibre reinforced concrete cube incorporating Silica Fume and Metakaolin with and without steel fibres of grade M70. Ninety Six cubes of dimension 150*150*150mm with different combinations of materials were casted. The cubes were cured and tested under a Direct Compression Testing machine at time period of 3, 7, 14 and 28 days. The results were tabulated and a relative comparison was made and the conclusions were drawn.*

Keywords: *Cement, Silica Fume, Metakaolin, Super Plasticizer, Steel Fibres, Compressive Strength.*

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1. INTRODUCTION

Concrete is one of the most extensively used construction materials in the world, with two billion tons placed worldwide each year. In reviewing technology advances through the centuries it is evident that material developments place a key role. Considerable efforts are still being made in every part of the world to develop new construction materials. In the construction industry concrete technology is heading towards entirely a new era by the use of supplementary cementitious materials such as Silica Fume, Metakaolin, Rise husk ash and Fly ash in concrete.

While conventional concrete has poor strength, low resistant to tensile cracking, so that its capacity to absorb energy is limited. The weakness in tension is conventionally overcome by strengthening their matrix with steel and more recently by reinforcing with fibrous materials. Concrete when mixed with fibres, give fibrous concrete. The mechanical property of fibrous concrete is superior to that of ordinary concrete. Silica Fume and Metakaolin will be evaluated for use as supplementary cementitious material in cement based system, the performance of Silica Fume and Metakaolin mixtures will be compared to controlled mixtures and mixtures incorporating Metakaolin as partial replacement for cement.

The manifold benefits of usage of Metakaolin, Silica Fume and Steel Fibres in concrete are now well recognised. To improve the usage of Silica Fume and Steel Fibres in structural concrete studies on aspects such as Compressive strength of Metakaolin Silica Fume fiber reinforced concrete are to be undertaken which will spread its usage.

Hence an experimental investigation is carried out to understand the behaviour of conventional concrete and replacement of cement by supplementary cementitious materials such as Metakaolin and Silica Fume in various combinations with and without steel fibres. A comparative study is made on compressive strength.

2. EXPERIMENTAL INVESTIGATION

Recognizing in need for utilization of Silica Fume and Metakaolin in concrete, the present investigation is taken up with an aim to establish or to understand the behaviour of Silica Fume and Metakaolin cement concrete when it is reinforced by steel fibre and subjected to compressive stress which is the most commonly encountered and very important type of loading to which a structural component may be subjected to. The behaviour of reinforced Silica Fume and Metakaolin can be understood better when a relative study is made. To facilitate this comparison of normal concrete or ordinary fibre reinforced concrete cubes tested under the same conditions as fibre reinforced Silica Fume and Metakaolin concrete cubes is considered in the present investigation and the following investigations are carried out

The following different combinations of M_{70} Grade Concrete cubes are casted for conduction of test.

1. Twelve cubes of conventional Concrete. (C.C)
2. The next set of twelve cubes consists of C.C with 2% of Steel fibre concrete. (C.C.Fi)
3. The next twelve cubes continue to be with cement replaced by 10% of Silica Fume. (C.SF)
4. The next twelve cubes continue to be with cement replaced by 10% of Silica Fume and 2% of Steel fibre.(C.SFi)
5. The next twelve cubes continue to be with cement replaced by 10% of Metakaolin.(C.MK)

6. The next twelve cubes continue to be with cement replaced by 10% of Metakaolin and 2% of Steel fibre. (C.MK.Fi)
7. The next twelve cubes continue to be with cement replaced by 10% of Silica Fume and 10% of Metakaolin. (C.S.M)
8. The next twelve cubes continue to be with cement replaced by 10% of Silica Fume, 10% of Metakaolin and 2% Steel fibre.(C.S.M.Fi)

Table 1: Quantity of Cement, Fine Aggregates (FA) and Coarse Aggregates (CA) Used

Mix	Cement in Kg	FA in Kg	CA in Kg
CC	21.25	21.36	33.63
CCFi	21.25	21.36	33.63
CSF	19.12	21.36	33.63
CSFi	19.12	21.36	33.63
CMK	19.12	21.36	33.63
CMFi	19.12	21.36	33.63
CSM	17.00	21.36	33.63
CSMFi	17.00	21.36	33.63

Table 2: Quantity of Metakaolin (MK), Silica Fume (SF) Used

Mix Description	MK in Kg	SF in Kg	Steel fibres at 2% / Kg	Water Liters
CC	--	--	--	5.31
CCFi	--	--	0.425	5.31
CSF	--	2.125	--	5.31
CSFi	--	2.125	0.38	5.31
CMK	2.125	--	--	5.31
CMFi	2.125	--	0.38	5.31
CSM	2.125	2.125	--	5.31
CSMFi	2.125	2.125	0.34	5.31

Fig 1 Cubes Kept for Curing

Poly carboxylate ether based super plasticizer was used at the rate of 2% by weight of cementitious material.

Specimens were casted with at most care and moulds were removed after 24 hours and cured in clean and potable water for various curing periods of 3, 7,14 and 21 days.

Compression test: At each desired curing periods specimens were taken out of water and kept for surface drying. The cubes were tested in 200T capacity compressive testing machine to get the compressive strength of concrete.

Constant Parameters:

1. Size of specimen 150mmX150mmX150 mm.
2. Grade of concrete M70.
3. Replacement of mineral admixture and steel fibres.

Fig 2 Testing of Cubes in Direct Compression Testing Machine

3. RESULTS OBTAINED BY THE INVESTIGATION

The strength of concrete plays a very vital role in its structural behavior and design of cement concrete structural members. The strength of concrete is commonly considered as most valuable property of concrete. It usually gives the overall picture of quality of concrete, as the strength is directly related to structure of hardened cement paste. The strength so obtained is helpful for selecting the particular mix to the practical applications.

The results are tabulated in the Table 3, the graphical comparison is made in the figure 3, 4, 5, 6.

Table 3: Test Results of Mix M_{70} for Different Combination at Differrent Period of 3, 7, 14 and 28 Days.

Sl. No	Mix	Compressive Strength of Cube in N/mm2			
		3 Days	7 days	14 days	28 Days
1	CC	40.56	42.46	44.48	55.40
2	CCFi	49.73	52.90	57.20	61.32
3	CSF	50.07	53.80	59.25	69.99
4	CSFi	55.92	60.04	63.00	75.82
5	CMK	65.78	73.71	79.30	85.65
6	CMFi	69.21	75.65	80.41	88.98
7	CSM	54.12	59.36	61.50	73.56
8	CSMFi	70.29	77.31	83.91	89.32

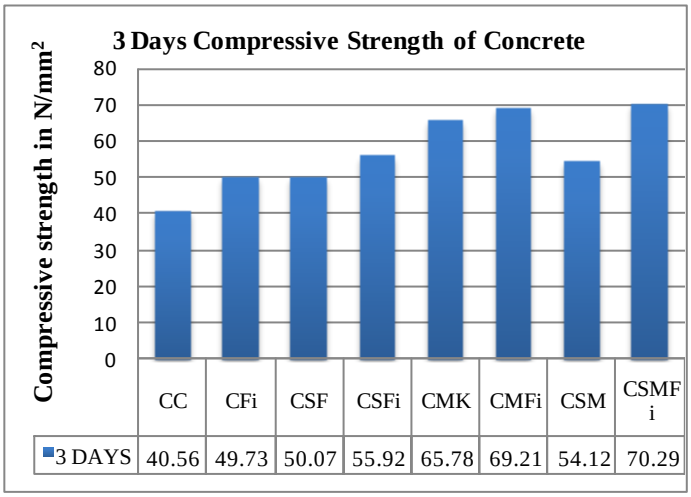

Fig 3. Graph of 3 Days Compressive Strength of Concrete

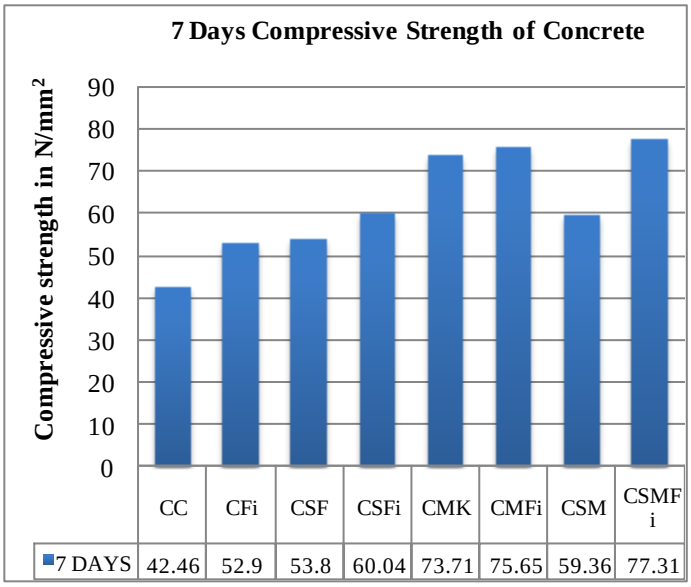

Fig 4. Graph of 7 Days Compressive Strength of Concrete

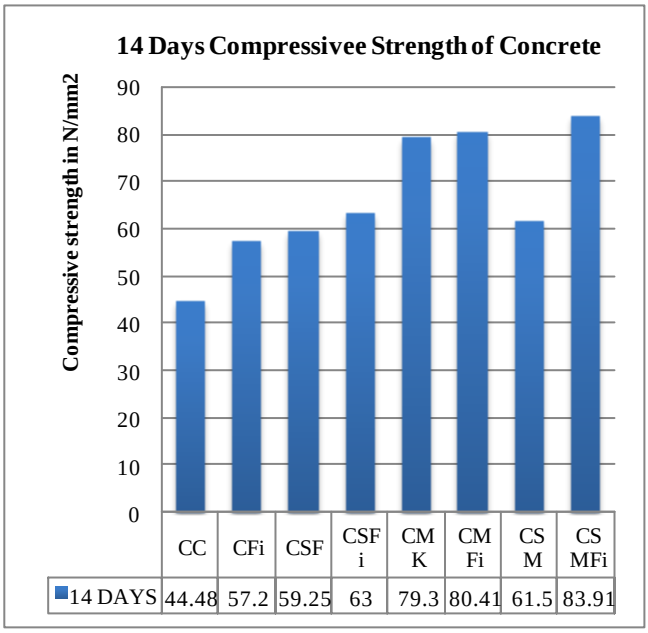

Fig 5. Graph of 14 Days Compressive Strength of Concrete

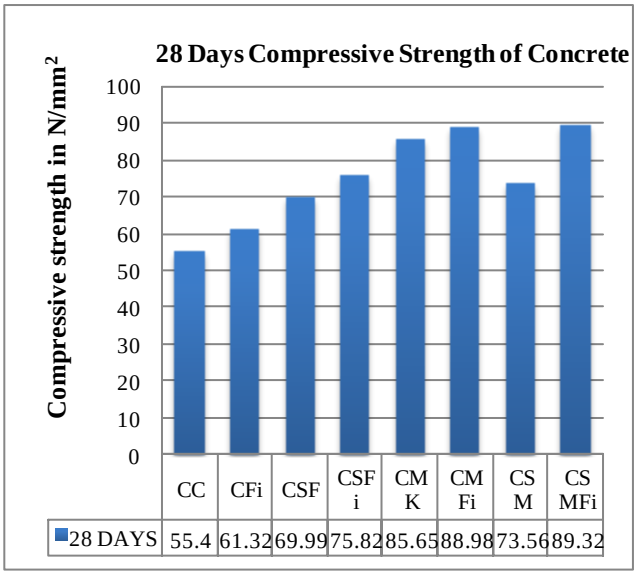

Fig 6. Graph of 28 Days Compressive Strength of Concrete

4. DISCUSSION AND CONCLUSION

A concrete mix of grade M_{70} was designed. A total of 96 cubes were casted under various mix namely CC, CCFi, CSF, CSFi, CMK, CMKFi, CSM, CSMFi and are tested under direct compression. Based on the results so obtained the following conclusions are made.

1. Silica Fume and Metakaolin generally requires addition of super plasticizer so that concrete could attain its desired workability. Since Silica Fume is found to consume water either by absorption or reaction.
2. Concrete keeps gaining strength over a period of time compressive strength of metakaolin and silica fume concrete is higher than that of normal concrete, Silica fume concrete and concrete containing metakaolin for curing up to 28 days.

3. Due to the above vision as stated silica fume and metakaolin concrete can be advantageously utilized for preparing concrete mixes which are stronger and more durable compared to normal concrete .Thus addition of Silica fume and Metakaolin significantly improves the performance of concrete matrix, hence Silica fume and metakaolin concrete can be used for specialized applications.
4. It is been observed that the strength of concrete is been increased by the use of steel fibres.
5. The strength of Metakaolin concrete is been increased by 54.6% as compared with Conventional concrete. Addition of steel fibres has increased by 45.10% as compared with Conventional concrete containing fibres.
6. The strength of Silica fume concrete is increased by 26.3% compared with normal concrete. Also addition of steel fibres has increased 23.6% in strength as compared with Conventional concrete containing steel fiber
7. At an age of 3, 7, 14 and 28 days CSMFi is found to gain more strength than any other.

SCOPE FOR FUTURE WORK

1. Strength of concrete incorporating different replacement ratio of Metakaolin and silica fume can be determined.
2. Strength of concrete with different percentage of crimped end steel fibres can be determined.
3. Comparison of cube strength of concrete for higher grades such as M_{80}, etc can be determined.
4. Flexure and shear behavior of M_{70} and higher grades can determine by casting of beams.

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