An Experimental Study on Steel Fibres Reinforced Self Compacting Concrete using Metakaolin as Partial Replacement of Cement

Prof. Nadeem Pasha[1] Sohail Ahmed Kharadi[2] Abrar Ali[3] Mohammad Furqan[4] Vijay[5]
[1]Assistant Professor [2,3,4,5]Student
[1,2,3,4,5]Department of Civil Engineering
[1,2,3,4,5]KBN College of Engineering, Gulbarga India

Abstract— A Self Compacting Concrete (SCC) is a concrete that can flow and completely fill the formwork under its own particular weight, simultaneously maintain its homogeneity regardless of the fact that congested reinforcement is available and later accomplishes complete compaction without any need of external vibration (The Concrete Society and BRE, 2005). Due to this reason concrete is replaced by Metakaolin in various percentages of 0%, 2.5%, 5%, 7.5% and 10% with additional percentages of steel fibres as 0%, 1%, 2%, 3% and 4%, respectively. The size of cube specimen is 150×150 which is used for compression test. The size of cylinder specimen is 150mm diameter and 300mm height for tensile test. Standard prisms of size 100mm x 100mm x 500mm are tested under two point loading to study the flexural strength. The compression, tensile and flexure tests are conducted for the specimens.

Key words: Cement, Self-Compacting Concrete, Steel Fibre, Metakaolin

I. INTRODUCTION

Around the world the construction material that is widely used is concrete. Due to technological advancements concrete properties have been undergoing changes. To improve the properties of concrete several types of concrete are developed. Self-compacting concrete (SCC) is one of them. It is not at all a new concrete but it is somewhat complex and developing technology and innovating idea. SCC is a type of concrete which does not need any external vibration for its placing and compaction. It is capable to flow, completely filling the corners of the formwork and archive complete compaction, even in congested reinforcements. Initially developed to counter the increasing shortage of skilful labour.

Self-compacting concrete was initially proposed in 1986 in Japan by Professor Okamura, however Professor Ozawa in Japan in 1988 at college of Tokyo was first to build up the prototype. SCC was produced to develop the strength of the solid structures. From that time a few tests have been done on SCC and has been used as a part of various structures in Japan. Examinations have been done to build up objective strategies for testing self-similarity and blend plan strategy to make it a standard concrete.

II. MATERIALS USED

A. Cement

Cement utilized as a part of this anticipates is Ultra-Tech concrete 53 Grade conventional Portland Cement according to prerequisites of IS12269. The Cement content for getting self-compacting cement is between 380-600 Kg/m^3. Concrete substance under 380 kg/m^3 may diminish the sturdiness prerequisites, though for the Cement content more noteworthy than 600 kg/m^3 may raise shrinkage. Cement content lesser than 380 kg/m3 can likewise be utilized with the expansion of better mineral admixtures, for example, Metakaolin, Steel Fibres.

B. Coarse Aggregates

Coarse aggregates used for getting SCC should be round and very much evaluated. It should be perfect and free from dirt creases. The little size and the total adjusted improve the workability of cement. The total size should be 20mm and under 20mm. In selecting a coarse total degree is a vital component, where little dimensional components are utilized particularly and where the fortifications are exceedingly congested. The total size of the coarse aggregates in ordinary cement depends on the development sort, according to rule the most extreme total size of coarse aggregates used in making SCC ranges between 20 mm and 10 mm.

C. Fine Aggregate

Locally available natural sand can be used for getting SCC. Adjusted and smashed sand both can be utilized. For the rheology of SCC, fine total substance is essential. The total sum fine aggregate is more than the total coarse aggregates substance in SCC. The measure of fines in SCC affects the blend extents, importantly. More measure of water and super plasticizer is required for fine sand and still requires less filler than coarse sand, comparably.

D. Water

Versatile water should be used for actually taking shape of SCC. If an occurrence of SCC should arise, the expression water to cover proportion is used rather than water to bond proportion in light of the expansion of added substances. That insinuates water content in SCC is in extent to aggregate folios (concrete and added substances). In SCC it has serious impact on both the properties. The solid is much inclined to isolation so as to expand the workability property (filling capacity) if just water is included. And due to this, until a few appropriate super plasticizers were made, it was hard to create SCC.

E. Mineral Admixtures

1) Metakaolin

Metakaolin is obtained from natural Kaolin clay, by heating this clay at a temperature of 650-900˚C, Metakaolin is obtained. The specific surface area, silica & alumina content of Metakaolin is higher than O.P.C.During the hydration of Portland cement Ca(OH)2 is produced which has no contribution towards the strength development of concrete but when Metakaolin combines with Ca(OH)2produces additional cementation compounds and makes concrete strengthen.

F. Chemical Admixtures

In self-compacting solid compound admixtures are utilized as a fixing, which just before blending or at the season of

blending, can be added to the blend with water. The admixture being utilized like water lessening admixtures, high range water reducer's i.e., super plasticizers, retarders and consistency adjusting admixture is essential to enhance the solid properties in crisp and solidified state. In self-compacting concrete, they help in acquiring lower water to cover proportion

III. MIX DESIGN

A. *Mix Design Using M40 Traditional Concrete*

	Cement	Fine Aggregate	Coarse Aggregate	Water
Quantity (kg/m^3)	450	633.91	1161.11	186
Proportions	1	1.43	2.62	0.4

Table 1: Mix design

	Cement	Course Aggregate	Fine Aggregate	S.P	Water
Quantity (kg/m^3)	560	763.4	850.3	8.4	190.9
Proportions	1	1.36	1.52	0.015	0.34

Table 2: Mix Design.

Mix Design of self-compacting concrete using modified Nan Su method

IV. EXPERIMENTAL SETUP

Specimen Name	Specimen Size	Number Of Specimens
Cube	150 mm × 150 mm × 150 mm	36
Cylinders	150 mm diameter and 300 mm height	36
Prisms	100 mm × 100 mm × 500 mm	36

Table 3: Experimental Setup

V. RESULTS

Mix ID	T500	L-Box	V-Funnel Test	T5 Min
CC SCC	4.5	0.9	10.5	13.2
M1	3.6	0.93	9.4	12
M2	3.2	0.95	8.5	10.8
M3	3	0.96	8	10.2
M4	4.5	0.9	10.5	13.2
M5	4.2	0.92	10	12.5

Table 4: Fresh properties of SCC

A. *Cubes*

The specimens of the concrete is tested for 7 days and 28 days in order to determine the initial strength and final strength

B. *Compressive Strength Test Results*

Mix ID	Average Compressive strength in N/mm^2	
	7 days	28 days
CC M40	31.53	43.15
CC SCC	33.14	44.13
M1	30.556	45.271
M2	30.956	46.507
M3	31.392	47.67
M4	32.446	49.29
M5	31.065	47.14

Table 5: Compressive strength Test Results

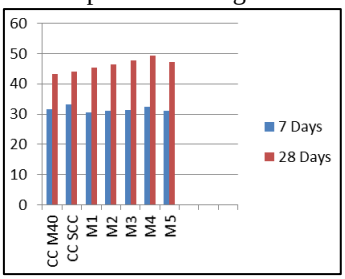

Fig. 1: Compressive Strength Test Results

C. *Cylinder*

The split tensile strength testing was done for 28 days in order to find the strength of cylinder, the results are shown below.

D. *Split Tensile Strength Test Results*

Mix ID	Average split strength in N/mm^2	
	7 days	28 days
CC M40	2.542	4.14
CC SCC	2.616	4.20
M1	2.486	4.070
M2	2.624	4.232
M3	2.671	4.486
M4	3.006	4.729
M5	2.648	4.406

Table 6: Split Tensile Strength Test Results

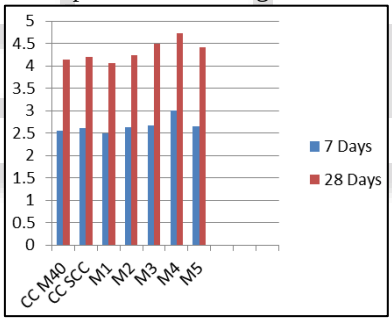

Fig. 2: Split Tensile Strength Test Results

E. *Prisms*

The Flexural strength testing was done for 28 days in order to find the strength of Prisms, the results are shown below

F. *Flexural Strength Test Results*

Mix ID	Average flexural strength in N/mm^2	
	7 days	28 days
CC M40	3.468	4.747
CC SCC	3.645	4.854
M1	3.361	4.980
M2	3.405	5.116
M3	3.453	5.244
M4	3.569	5.422
M5	3.417	5.185

Table 7: Flexural Strength Test Results

VI. CONCLUSIONS

The accompanying conclusions were made in light of trial study on customary cement and SCC of M40 evaluation utilizing mineral admixtures Steel Fibres and Metakaolin are:

1) The maximum compressive strength is achieved at M4 mix containing 3% steel fibre and 7.5% Metakaolin.
2) The maximum split tensile strength is achieved at M4 mix containing 3% steel fibre and 7.5% Metakaolin.
3) The maximum flexure strength is achieved at M4 mix containing 3% steel fibre and 7.5% Metakaolin.
4) The maximum slump is achieved at M4 mix containing 3% steel fibre and 7.5% Metakaolin.
5) The maximum compaction factor is achieved at M4 mix containing 3% steel fibre and 7.5% Metakaolin.
6) After analysing the results of all the mixes, we came to conclusion M4 mix is the best of all mixes containing 3% steel fibre and 7.5% Metakaolin.

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