Experimental Investigation on Self Compacting Concrete Using Polypropylene Fiber

Maria Thangaraj.J[1]
Civil Department.
PSR Engineering College, Sivakasi
Tamil Nadu, India

John Xavier Denik.A[2]
Civil Department.
PSR Engineering College, Sivakasi
Tamil Nadu, India

P.Kumar[1]
Assistant Professor
Civil Department.
PSR Engineering College, Sivakasi
Tamil Nadu, India

Abstract—*This Self compacting concrete (SCC) is one of the most important developments in the building industry. It provides solution to the problems occurring in normal concrete such as in adequate compaction which affects the strength of structures. This project is taken up with the objective to evaluate the performance of self compacting concrete for M25grade using polypropylene fiber and by adding suitable super plasticizers and viscosity modifying agent (VMA). Polypropylene fiber with added in various percentage (0.1%, 0.2%and 0.3% by weight of the cement). Basic tests for fine aggregate, coarse aggregate, cement, freshly prepared SCC test such as slump flow test, J-ring test, V-funnel test, U-box test were done and checked against the specifications given by EFNARC guidelines. Then Mechanical properties such as compressive strength, tensile strength and flexural strength were studied and the results were compared with normal SCC mix. The SCC mix the addition of 0.3% polypropylene fiber satisfies the workability limits hardly. Hence further addition of fiber may not satisfy the limits recommended by EFNARC guidelines.*

Keywords—polypropylene fiber; self compacting concrete; strength; workability.

I. INTRODUCTION

Self-compacting concrete (SCC) is a recently developed concept in which the ingredients of the concrete mix are proportioned in such a way that the concrete is compacted by its own weight without any vibration effort assuring complete filling of framework even when access is hindered by narrow gaps between reinforcing bars.

SCC requires a high slump that can easily be achieved by super plasticizer addition to a concrete mixture. To avoid segregation on super plasticizer addition, a simple approach consists of increasing the sand content at the cost of the coarse aggregate content by 4% to 5%. But the reduction in aggregate content results in using a high volume of element which, in turn leads to a higher temperature rise and an increased cost. Chemical admixtures are however expensive and their use may increase the material cost saving in labor cost might offset the increased cost but use the mineral admixtures such as fly ash, furnace slag and micro silica could increase the slump of the concrete mixture without increasing cost.

II. PRELIMINARY TEST ON MATERIALS

A. Testing of cement

1. *Fineness Test of Cement*

Correctly 100grms of cement was weighed and taken in a standard IS sieve no.9 (90 microns).The lumps were broken down and the material was sieved continuously for 15 minutes using sieve shaker. The residue left on the sieve was weighed .This weight does not exceed 5% for ordinary cement. Percentage of residue left on sieve = (weight retained/weight taken) x 100

Result: Percentage of residue left on sieve = 3.45

2. *Consistency Test of Cement*

500 grams of cement was taken and a paste was prepared with 24% quantity of water. After completely filling the mould, shake the mould to expel the air. A standard plunger 10mm diameter and 50mm long was attached and brought down to touch the surface of the paste in the test block and quickly released allowed it to sink to the paste by its own weight. The depth of penetration of plunger was

noted down. The second trail was conducted by 25% of water and the depth of penetration was found out. Similarly number of trials was conducted till the plunger penetrates for a depth of 33 to 35mm from top.

Result: Consistence of given sample of cement = 33 %

B. Testing of Fine Aggregate

1. Sieve analysis of fine aggregate

The sample was brought to air – dried condition before weighing and sieving was achieved after drying at room temperature. The air – dry sample was weighed
Fineness modulus =2.72
Zone conformation = Zone-II

2. Specific Gravity Test of Fine Aggregate

The pycnometer was dried thoroughly and weighed as W_1 gram. 200 gram of fine aggregate was taken in the pycnometer and weighed as W_2 gram. The pycnometer was filled with water up to the top. Then it was shacked well and stirred thoroughly with the glass rod to remove the entrapped air. After the air has been removed the pycnometer was completely filled with water up to the mark. The outside of pycnometer was dried with a clean cloth and it was weighed as W_3 grams. The pycnometer was cleaned thoroughly. The pycnometer was completely filled with water up to the top. Then outside of the pycnometer was dried with a clean cloth and it was weighed as W_4 grams.
Result: Specific Gravity of Fine Aggregate (G) = 2.65

C. Testing of Coarse Aggregate

1. Sieve Analysis of Coarse Aggregate

The sample was brought to air – dried condition before weighing and sieving was achieved after drying at room temperature. The air – dry sample was weighed and achieved successively on the appropriate sieves starting with the largest size sieve.
Result: Fineness modulus =6.16

2. *Specific Gravity Test of Coarse Aggregate*

The container was dried thoroughly and weighed as W_1 gram. 800 gram of fine aggregate was taken in the container and weighed as W_2 gram. The container was filled with water up to the top. Then it was shacked well and stirred thoroughly with the glass rod to remove the entrapped air. After the air has been removed the container r was completely filled with water up to the mark. The outside of container r was dried with a clean cloth and it was weighed as W_3 grams. The container was cleaned thoroughly. The container was completely filled with water up to the top. Then outside of the container was dried with a clean cloth and it was weighed as W_4 grams.

Result: Specific Gravity of Coarse Aggregate (G) = 2.7

III. Mix Design

The mix design of self-compacting concrete is a trial and error method. Many references available for mix proportioning of SCC. Here we use mix proportioning based on previous investigation strength data using Japanese method and also based EFNARC guidelines. The Japanese method was suggested by Okamura in 1993, after extensive trials in laboratory and at sites. In the Japanese method coarse and fine aggregate contents are initially fixed so that self-compact ability is achieved by adjusting the water/powder ratio and super plasticizer dosage. Strength requirements are assessed from field trials of SCC at a later stage
In this investigation we incorporate the procedures of EFNARC guidelines. These guidelines gives the range for coarse aggregate and fine aggregate content and based on the limit the approximate mix design for M30 grade of concrete is obtained.

Proportion:

Cement = 1 (506.57/506.57)

F.A = 1.78 (901.5/506.57)

C.A = 1.59 (808.97/506.57)

Therefore ratio =1 : 1.78 : 1.59

W/P = 0.35

As per EFNARC guidelines the w/p ratio should be 0.8 to 1.1.Hence w/p arrived ratio is below than as referred in EFNAC code. So the w/p ratio is 0.8

IV. Properties of Fresh Concrete

A concrete mix can only be classified as self-compaction if it has the following characteristics.

1. Filling Ability
2. Passing ability
3. Segregation resistance

Immediately after the mixing the value of Slump flow J-Ring, V-Funnel and L-box tests were determined for finding out passing ability, filling ability and segregation resistance respectively for SCC by the following methods.

1. Slump Flow Test
2. J ring Test
3. V funnel Test
4. L Box Test

Result of Properties Of Fresh SCC

The results obtained from the above tests for normal SCC,SCC with Polypropylene Fibers (0.1%,0.2%,0.3%) are tabulated below with the allowable limits prescribe by EFNARC, Europe Guidelines for Self-Compacting concrete.

Testing Methods	Units	Workability Values			
		SCC	SCC01	SCC2	SCC02
Slump Flow(Dia)	mm	690	685	670	655
Slump Flow(sec)	sec	2	2.2	2.6	3
V-Funnel	sec	6	7	8	11
L-Box	mm	0.84	0.93	0.90	0.95
J-Ring	mm	6	7	7.2	7.5

V. Mechanical Properties of SCC

A. *Split Tensile Test*

Tensile strength is one of the basic and important properties of the concrete. Tensile strength is define as " The resistance of a material to a force tending to tear it apart, measure as the maximum tension the material can withstand without tearing". However the determination of tensile strength of concrete is necessary to determine the load at which the concrete members may crack. The cracking is a form of tension failure.

This test is conducted on cylinder specimens of 30cm length and 15cm diameter. The split tensile strength is calculated by the following formula.

$F_t = 2P/Pi\ dl\ N/mm^2$ (or) MPa

Where Ft=Split Tensile strength

P=maximum load taken by the specimen

D=Diameter of specimen

L=length of specimen

The split tensile test is conducted on two specimens and the average tensile

Strength was calculated for each mix. The results are tabulated below

S.NO	TYPE	SPLIT TENSILE TEST		REMARKS
		7 DAYS	28 DAYS	
1	SCC-C	1.2	2	Conventional SCC
2	$PFSCC_1$	1.5	2.2	SCC with addition of 0.1% PPF
3	$PFSCC_2$	1.7	2.5	SCC with addition of 0.2% PPF
4	$PFSCC_3$	1.8	2.8	SCC with addition of 0.3% PPF

B. *Flexural Strength Test*

Flexure tests are generally used to determine the flexural modulus or flexural strength of a material. A flexure test is more affordable than a tensile test and test results are slightly different. The material is laid horizontally over two points of contact (lower support span) and then a force is applied to the top of the material through either one or two points of contact (upper loading span) until the sample fails. The maximum recorded force is the flexural strength of that particular sample.

The Flexural Strength or modulus of rupture (f_b) is given by

$f_b = pl/bd^2$ (when a > 20.0cm for 15.0cm specimen or > 13.0cm for 10cm specimen)

or

$f_b = 3pa/bd^2$ (when a < 20.0cm but > 17.0 for 15.0cm specimen or < 13.3 cm but > 11.0cm for 10.0cm specimen.)

Where,

a = the distance between the line of fracture and the nearer support, measured on the center line of the tensile side of the specimen

b = width of specimen (cm)

d = failure point depth (cm)

l = supported length (cm)

p = max. Load (kg)

S.NO	TYPE	FLEXURAL TEST 28 DAYS	REMARKS
1	SCC-C	5.6	Conventional SCC
2	$PFSCC_1$	6.15	SCC with addition of 0.1% PPF
3	$PFSCC_2$	6.5	SCC with addition of 0.2% PPF

4	$PFSCC_3$	6.7	SCC with addition of 0.3% PPF

C. Result and discussion

The basic properties of materials were tested and tabulated the results. In this project used two admixtures are super plasticizers and viscosity modifying agent. The fresh concrete tests like L-box, V-funnel, J-Ring and slump flow tests were conducted to find out the workability.

The casted cylinder and prism were tested and then the mechanical Properties were found out, such as split tensile strength and Flexural strength on various self-compacting concrete mixes with polypropylene fibers (0.1%, 0.2%, 0.3%) at 7 and 28 days.

In this project, the test results show that

1. Split tensile strength shows a gradual increased
2. The flexural strength showed a great increase in 28 days test.

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