International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 4, Issue 6, June-2018

TERNARY BLENDING OF FIBRE-REINFORCED SELF COMPACTING CONCRETE (FRSCC) BY ABSOLUTE VOLUME METHOD.

Anilkumar[1], Siddharth B[2] Maneeth P D[3], Brijbhushan S[4], Dr.Shreenivasreddy S[5]

[1]*M.Tech. Student, Department of Construction Technology, Visvesvaraya Technological University, anilkingi1234@gmail.com*
[2]*Assistant Professor, Department of Construction Technology, Visvesvaraya Technological University, siddharthbaeen@gmail.com*
[3]*Assistant Professor, Department of Construction Technology, Visvesvaraya Technological University, maneeth.pd@gmail.com*
[4]*Assistant Professor, Department of Construction Technology, Visvesvaraya Technological University, brijbhushanvtupgct@gmail.com*
[5]*Course co-ordinator, Department of Construction Technology, Visvesvaraya Technological University, Kalaburagi*

Abstract— The current research is carried out to examine the fresh and hardened properties of ternary blended FRSCC with fractional substitution of 10%, 15% and 20% of Metakaolin and a constant 30% of FA by mass of cement, by keeping cement content constant at 600kg/m^3 and water content 180liters, poly-carboxylic based super plasticizer (ROOFPLAST HS 200) was used to enhance workability of the concrete mixes, viscosity enhancing agent (ROOFPLAST VMA2) was used to maintain the homogeneous composition of FRSCC. Workability properties of fresh FRSCC like filling/passing ability and isolation protections of the blends were carried out by adding 0.25% Polypropylene fibers (RECRON 3S) by weight of sum of cement content according to EFNARC guidelines. The fresh properties of FRSCC show better workability as replacement increases. The mix FRSCC -1 (FA 30% and MK 10%) shows better results indicating as the optimal replacement. As the percentage of MK increases beyond 10% the compressive strength decreases, but split tensile & flexural strength increases. Acid attack test was carried out to study the durability characteristics of FRSCC.

Keywords— FRSCC, Fly Ash (FA), Metakaolin (MK), Polypropylene Fibres (PF$_S$), VMA.

I. INTRODUCTION

Coal consuming products comprise of fly ash, pond ash, cenospheres, and molded powder and vent gas de-sulfurisation. Generally ccp's comprise of fly ash and pond ash around 90%(fly powder 75-80% and pond cinder 15-20%) unique things are in follows. Powdered coal when consumed in control stations produces fly ash, when coal is scorched at more noteworthy temperature dirt particles display in coal powder breakers to fine particles containing aluminum silicate and different chemicals. Fly ash is arranged in two classes that is class C and class F fly ash.

Metakaolin (MK) is a dehydroxylated type of the mineral kaolinite which is pozzolanic in nature. It is gotten by calcination of mineral kaolinitic earth at 500°C and 800°C temperature. Clay minerals lose the greater part of absorbed water at temperature of 100°C to 200°C. In the vicinity of 500 °C to 800 °C, the kaolinite moves to calcination by trailing water by dehydroxylization. The crude material contribution to the make of MK ($Al_2Si_2O_7$) is kaolin earth. Kaolin is used in production of porcelain, which is white, fine, earth mineral [2].

In India MK can be delivered in substantial amounts, which have broad established stores available in the country; at present researchers have confirmed a considerable measure of interest for MK as it has both pozzolanic and micro filler attributes. It has additionally been utilized effectively for the improvement of high quality SCC.

Molecule size of MK is littler than cement particles. MK and FA result in synergic activity to enhance the microstructure and performance of concrete. At the point when both Metakaolin and Fly ash are utilized, the resultant upgrade of quality or pozzolanic action was more prominent than super position of commitments of each, for the particular extents. Such synergic impact comes about because of strengthening the transition zone in cement aggregate interface, and in addition hindering of pores.

Fibers are used in concrete to restrain micro crackings and acts as reinforcing bars, workability decreases with increase in fiber content, Recron 3S polypropylene fibers of 12mm length are used to increase the split property and flexural property of concrete.

SELF COMPACTING CONCRETE

SCC is a unique concrete that can flow under its own weight, fundamental qualities of SCC are passing capacity, filling property and protection from isolation [3]. In SCC powder content is high and in all out total volume fine total volume is equal to coarse total volume normally fine total volume to coarse total volume proportion is taken as 50:50 this is on account of as better particles expands flow property of concrete increments coarser particles obstruct the flow of concrete. The idea of SCC was first developed by the Japanese in 1988 to cope with the adversities of site conditions and the scarcity of work that this concrete flows alone in areas of dense reinforcement where the vibration of concrete is not possible.

The addition of super plasticizer is necessary for SCC to increase the flow property of concrete in some cases; the VMA can also be used to maintain the homogeneity of the concrete. SCC also acts as an environmentally friendly concrete by reducing noise pollution and the safety of work on and around the site is maintained.

II.OBJECTIVE OF THE PROJECT

Because of focused efforts on use of FA has expanded the utilization of FA in development industries, agribusiness, development of street dikes, dumping, asphalts and so forth. As the asset is getting exhausted it is our obligation to locate another option to cement for utilizing as a part of constructional practice, such as FA, MK, silica fume and so on to cement. Indeed, even cement requires extensive measure of energy for generation. So by utilizing of fly ash and metakaolin as pozzolonic materials in concrete generation decreases the interest for cement as well as tackles the issue of its transfer and spares expansive measure of energy and secures condition.

A. SCOPE OF WORK

Scope of the present experimental work is,

1. Collection of sample of materials used for the experimental work on SCC.
2. Characterization of fly ash, metakaolin and other materials according to code of practice.
3. Mix designing SCC by absolute volume method according to EFNARC guidelines. Total cementatious content is fixed as 600 kg/m^3 and 30% of total cementatious content is replaced by FA.
4. Three design mixes are prepared by replacing cement by MK in increasing order up to 20% i.e., (10%, 15% and 20%).
5. Fresh properties of SCC mixes are checked.
6. Results are recorded and compared with standard requirements to be fulfilled according to EFNARC specifications.
7. Based on comparison of results, conclusions are drawn

B. CONSTANT PARAMETERS

TABLE I - CONSTANT PARAMETERS

Total cementatious content	600 kg/m^3
Fly ash	30% of total cementatious content
Water to powder ratio	0.3
Water content	180 liters/m^3
Ratio of fine aggregates to coarse aggregates	50:50
Size of coarse aggregates	20mm downsize (40%).
	12.5mm downsize (60%).
Recron 3S polypropylene fibers	0.25% of cementatious content
Viscosity enhancing admixture	0.2% of cementatious content
Dosage of super plasticizer	8ml/kg of cementatious material

C. VARIABLE PARAMETERS

Metakaolin (MK) content is increased in every trial starting from 10%, 15% up to 20%.

III.MATERIALS USED AND MIX DESIGN

Materials used for the present investigation on fiber-reinforced self compacting concrete (FRSCC) are.

1. Cement (OPC 53 grade).
2. Fly ash (Class F).
3. Metakaolin.
4. Natural river sand.
5. Coarse aggregates.
6. Super plasticizer (ROOFPLAST HS200).
7. Viscosity Enhancing Agent (VEA)
8. Recron 3S polypropylene fibers.
9. Water.

A. CEMENT: MAHA cement of Ordinary Portland cement (OPC) 53 grade confirming to IS 12269:1987 was taken from CASHUTEC RAICHUR, properties of which were tested in the CASHUTEC laboratory, Raichur are given in Table II.

TABLE II

PHYSICAL PROPERTIES OF CEMENT.

PROPERTIES	**VALUES**
Brand	MAHA cement
Grade	OPC 53
Sp.gr	3.13
Early setting time	40 min.
Final setting time	400 min.
Normal consistency	34%
Fineness	9%

B. FLY ASH (CLASS F): The FA was obtained from RTPS confirming to specification IS 3812 Part 1 and 2-2003. The various tests are done confirming to IS 1727-1967 and are used as fines which contribute to powder content in SCC.

TABLE III

PHYSICAL PROPERTIES OF FLY ASH.

Colour	Whitish grey
Form	Powder
Specific gravity	2.02
Residue on 45 micron sieve	15.7%
Fineness	350 m^2 /kg

TABLE VI

CHEMICAL PROPERTIES OF FLY ASH AND METAKAOLIN.

OXIDES	**FLYASH (FA)**	**METAKAOLIN (MK)**
	CONTENT (%)	**CONTENT (%)**
SiO_2	52.62	66.21
Al_2O_3	27.14	19.35
Fe_2O_3	3.56	0.84
CaO	9.43	5.92
MgO	2.29	0.89
SO_3	0.27	0.23
$Na_2O + K_2O$	1.18	0.18
LOI	0.93	3.45

C. METAKAOLIN: Metakaolin (MK) is a dehydroxylated type of the mineral kaolinite which is pozzolanic in nature. The crude material contribution to the make of MK ($Al_2Si_2O_7$) is kaolin earth. Kaolin is used in production of porcelain, which is white, fine, earth mineral [5]. The molecule size of metakaolin is littler than cement particles. The various tests are done to use as fines which contribute to powder content in SCC, properties of which were tested in the CASHUTEC laboratory are given in below Table.

TABLE V

PROPERTIES OF METAKAOLIN

Colour	White
Form	Powder
Specific gravity	2.5

D. NATURAL RIVER SAND: Natural River sand satisfying to specifications of IS: 383-1970 (zone II) with Sp.gr of 2.65 is used. Natural river sand was taken from Krishna river bed near Kadlur Raichur. Tests on natural river sand were conducted in CASHUTEC laboratory.

TABLE VI

SIEVE ANALYSIS OF SAND.

SIEVE SIZE	**PERCENTAGE PASSING**
4.75mm	97.99
2.36mm	95.4775
1.18mm	44.2225
600 micron	24.125
300 micron	24.125
150 micron	2.0375
Pan	0

TABLE VII

CHARACTERISTICS OF SAND.

PROPERTIES	**VALUES**
Sp.gr	2.65
FM	3.36

E. COARSE AGGREGATES: size of coarse aggregates greatly influences the flow characteristics of SCC. As the maximum size of aggregates increases obstruction to the flow increases, segregation increases so to get good flow ability and passing ability maximum size of coarse aggregates was taken as 20mm (40%) and 12.5mm (60%) down. Coarse aggregates were taken from Guddeballur quarry. The tests were conducted in CASHUTEC laboratory.

TABLE VIII

SIEVE ANALYSIS OF COARSE AGGREGATES

SIEVE SIZES	**PERCENTAGE PASSING**
40mm	100
20mm	61.378
12.5mm	12.433
10mm	4.6
4.75mm	0.99
Pan	0

.

TABLE IX

CHARACTERISTICS OF CA

PROPERTIES	VALUES
Specific gravity (Sp.gr)	2.67
Fineness modulus (FM)	4.12

F. SUPER PLASTICIZER (SP): super plasticizers increase the workability of the concrete and reduce the water to cement ratio. Polycarboxylic based super plasticizer Roofplast HS 200 of Armstrong chemicals is used for the study of SCC [12] . Dosage of admixture was fixed by various trails i.e., 8ml/kg of cementations material.

G. VISCOSITY ENHANCING AGENT (VEA): VEA used to prevent the segregation and bleeding in concrete, VEA by virtue of their capacity to minimize the movement of water and fines away from the bulk concrete and maintain a homogeneous composition. A ROOFPLAST VMA 2 of ARMSTRONG chemical is used for the study of SCC [12].

H. RECRON 3S POLYPROPYLENE FIBERS: they are used in concrete to restrain microcrackings and acts as a reinforcing bars, workability decreases with increase in fiber content, Recron 3S polypropylene fibers of 12mm length, 0.25% of the weight of cementations material is used for the present work.

I. Water: Portable and clean water satisfying to IS 456:2000 is used for preparing concrete.

TABLE X

DETAILS OF THE MIXTURE PROPORTIONS.

MIX DESIGNATION	CONTROL MIX	FRSCC-1	FRSCC-2	FRSCC-3
Cement (kg)	600	360	330	300
FA (kg)	-	180	180	180
MK (kg)	-	60	90	120
SAND (kg)	806	757.74	754.53	751.33
CA (kg)	812.09	763.46	760	757
SP (lit)	4.8	4.8	4.8	4.8
VMA (lit)	-	1.2	1.2	1.2
Fibre (kg)	-	1.5	1.5	1.5
Water (lit)	180	180	180	180

TABLE XI

DETAILS OF THE MIX DESIGNATION.

MIX DESIGNATION	DETAILS
SCC	Controlled self compacting concrete (FA 0% + MK 0%).
FRSCC-1	Fiber reinforced SCC by partial substituting of cement with FA (30%) + MK (10%).
FRSCC-2	Fiber reinforced SCC by partial substituting of cement with FA (30%) + MK (15%).
FRSCC-3	Fiber reinforced SCC by partial substituting of cement with FA (30%) + MK (20%).

IV.RESULTS AND DISCUSSION

This chapter includes the values of the fresh state (FP) and harden state properties (HP) of SCC and comparison of FP results with the standards of EFNARC specifications.

TABLE XII

TYPICAL RANGE OF VALUES FOR SELF COMPACTING CONCRETE ACCORDING TO EFNARC SPECIFICATIONS [13].

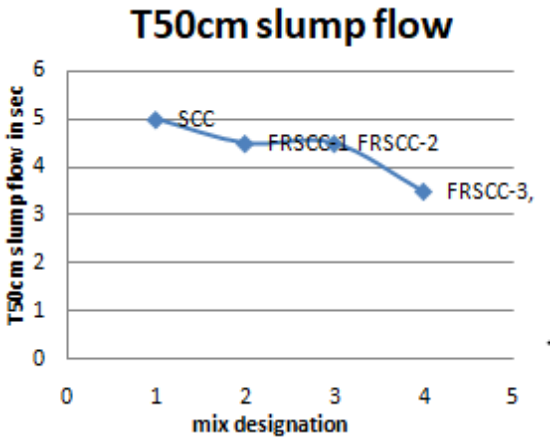
METHOD	TYPICAL RANGE OF VALUES		UNIT
	MINIMUM	MAXIMUM	
SLUMP FLOW	650	800	Mm
T_{50CM} SLUMP FLOW	2	5	Second
V-FUNNEL	6	12	Second
V-FUNNEL AT T_{5MIN}	0	+3	Second
L-BOX	0.8	1.0	H_2/H_1
U-BOX	0	30	Mm

A. FRESH STATE TEST OUTCOME OF THE EXPERIMENTAL WORK

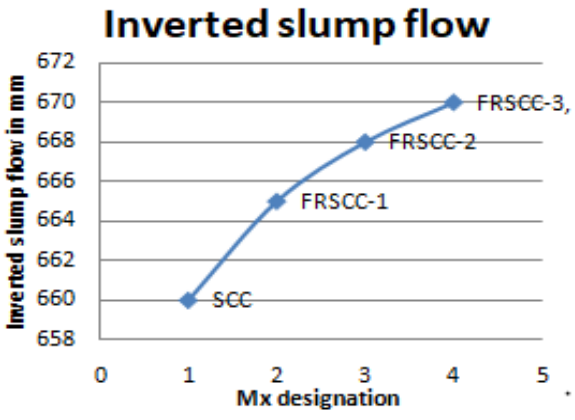
TABLE XIII

FRESH PROPERTIES OF SCC

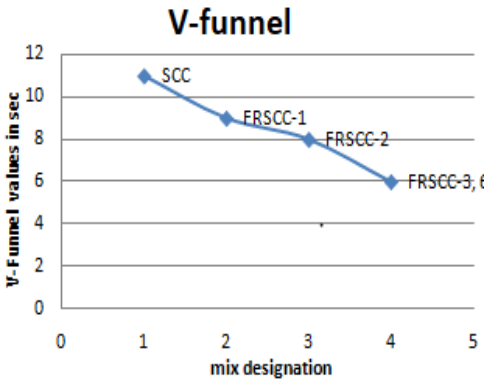
TEST METHOD	SCC	FRSCC-1	FRSCC-2	FRSCC-3
INVERTED SLUMP FLOW (MM)	660	665	668	670
T_{50CM} SLUMP FLOW (SEC)	5	4.5	4.5	3.5
V-FUNNEL (SEC)	11	9	8	6
V-FUNNEL AT T_{5MIN} (SEC)	14	12	11	9
L-BOX	0.875	0.89	0.92	0.95
U-BOX (MM)	29	28	25	20



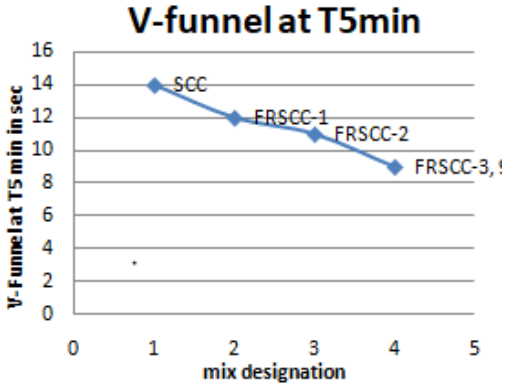
GRAPH 1: T_{50CM} SLUMP FLOW



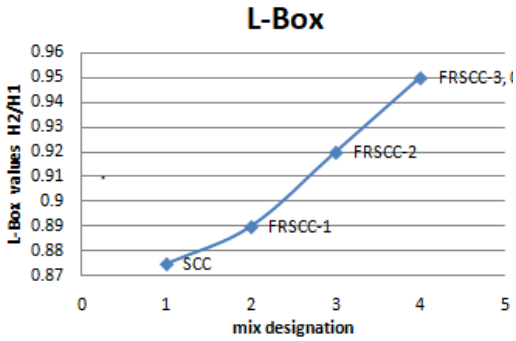
GRAPH 2: INVERTED SLUMP FLOW



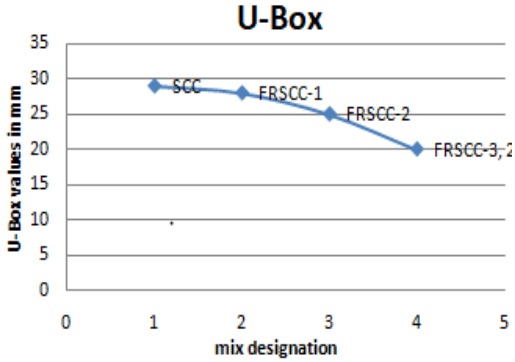
GRAPH 3: V-FUNNEL



GRAPH 4: V-FUNNEL AT T_{5MIN}



GRAPH 5: L-BOX



GRAPH 6: U-BOX

B. HARDEN STATE TEST RESULTS OF THE EXPERIMENTAL WORK

TABLE XVI

COMPRESSIVE STRENGTH OF SCC MIX IN N/MM^2

CURING	SCC	FRSCC-1	FRSCC-2	FRSCC-3
3 DAYS	22.96	24.34	20.88	20
7 DAYS	36.19	32.07	20.12	24.74
28 DAYS	50.46	52	49.80	46.74

TABLE XV

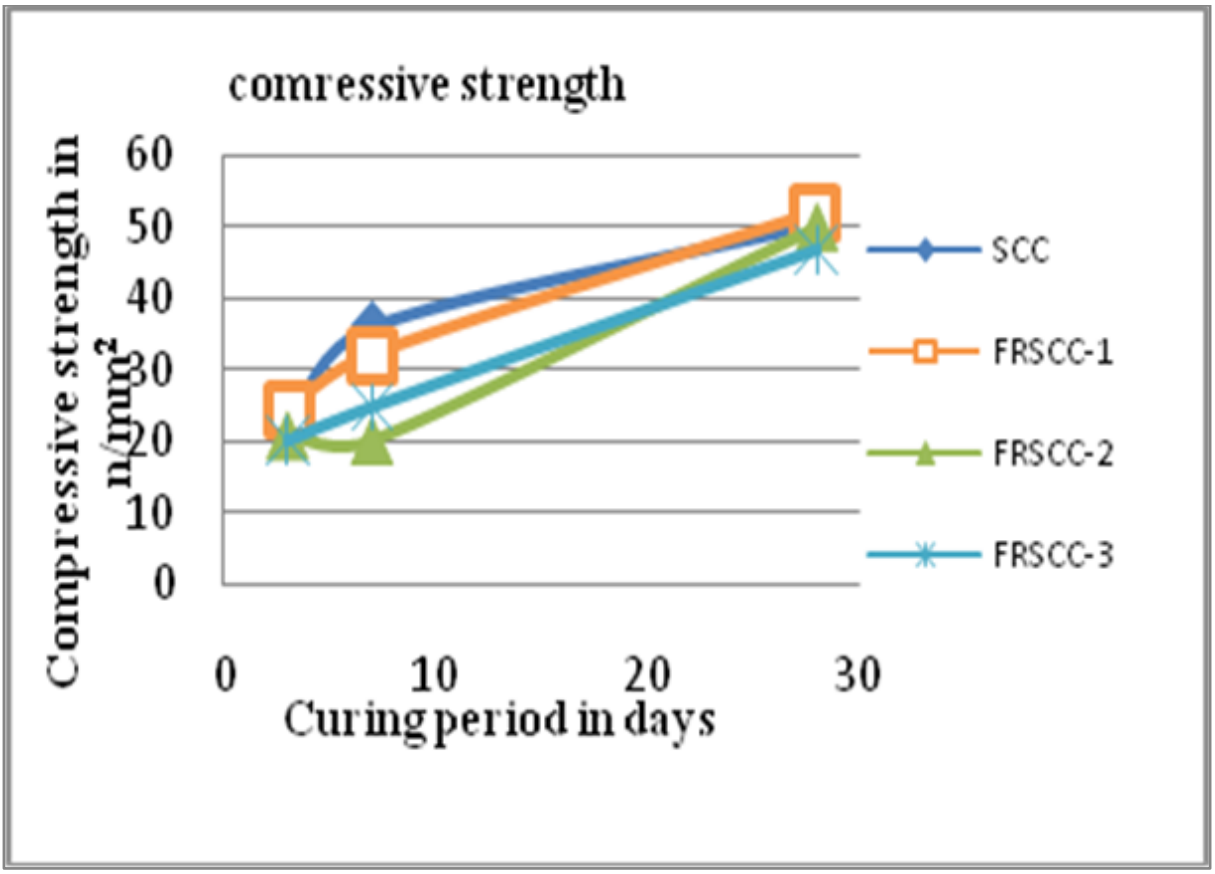
FLEXURAL STRENGTH OF SCC MIX IN N/MM^2

CURING	SCC	FRSCC-1	FRSCC-2	FRSCC-3
3 DAYS	2.55	2.70	2.32	2.22
7 DAYS	4.01	3.56	2.74	2.74
28 DAYS	5.6	5.18	5.52	5.77

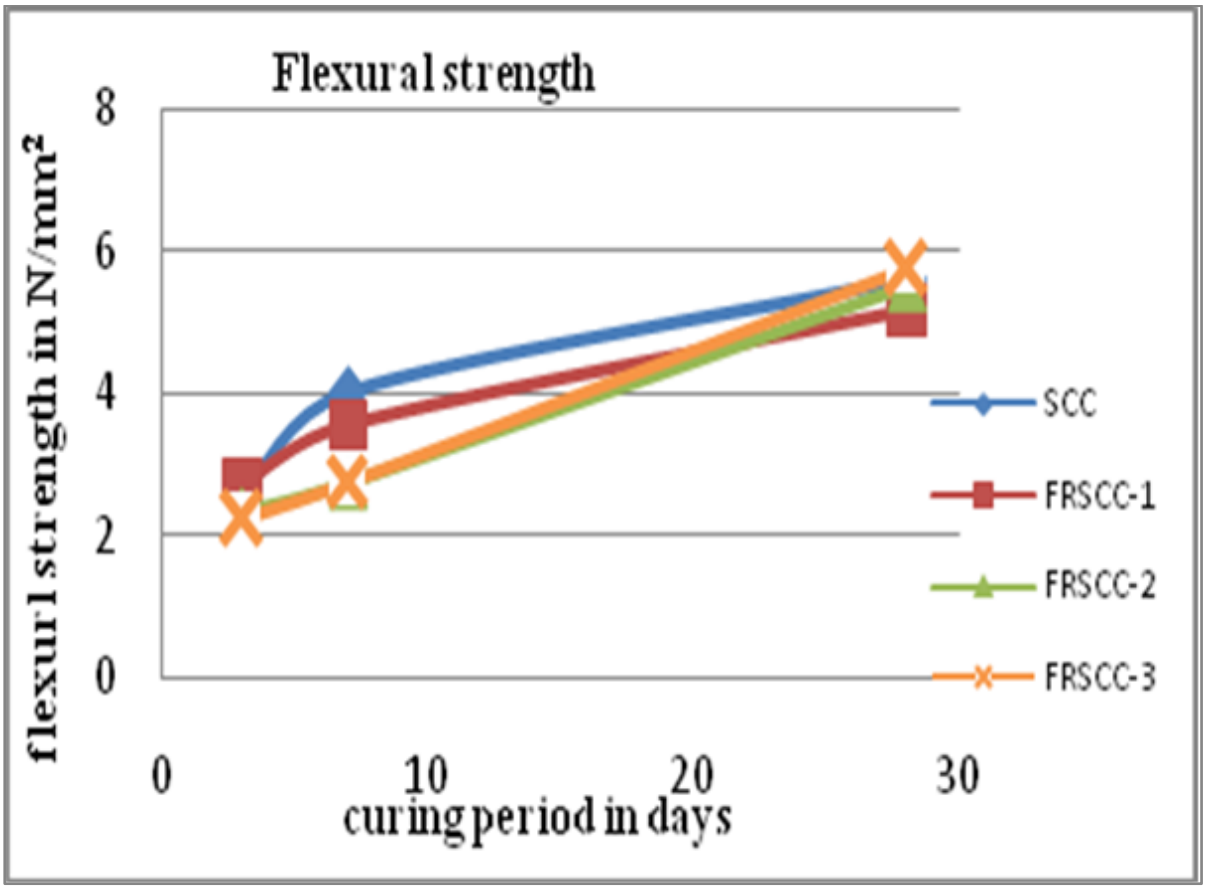
TABLE XVI

SPLIT TENSILE STRENGTH OF SCC MIX IN N/MM^2

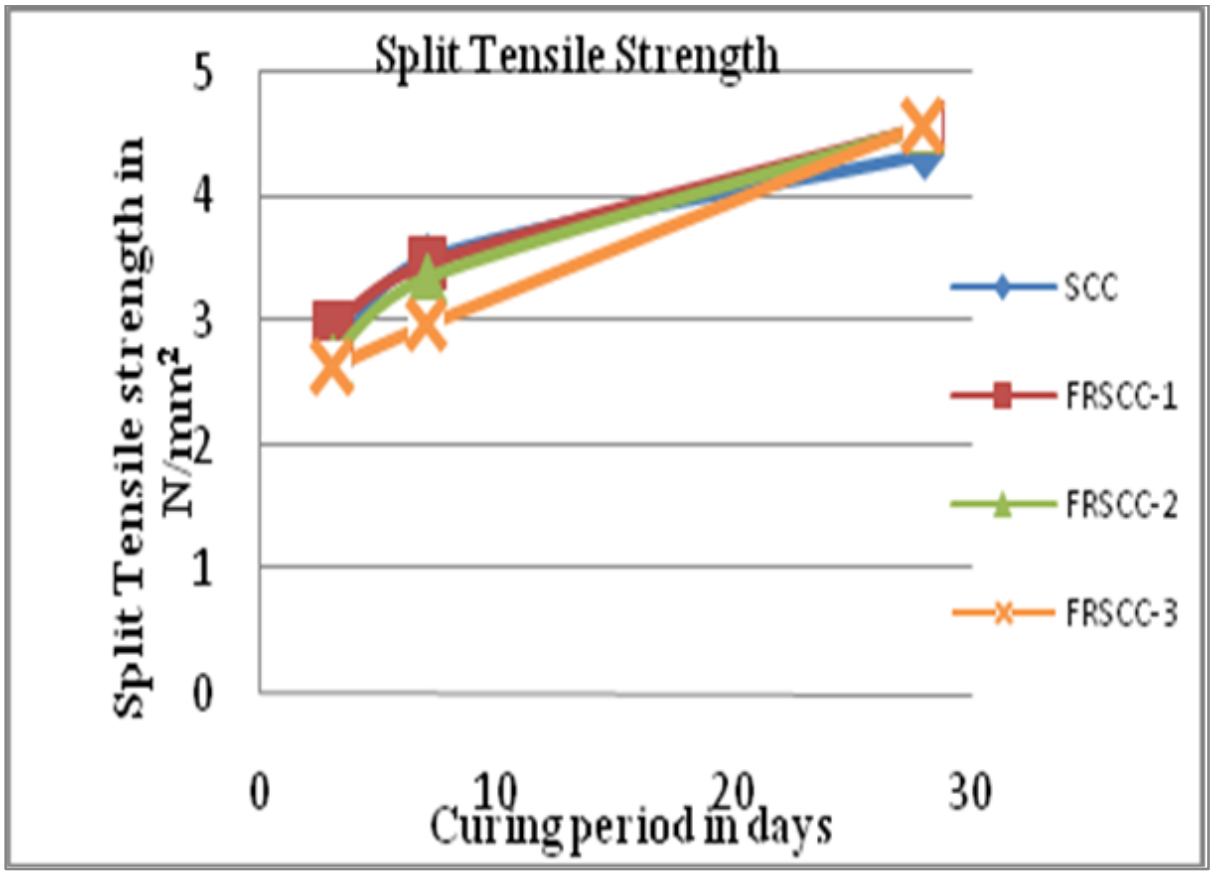
CURING	SCC	FRSCC-1	FRSCC-2	FRSCC-3
3 DAYS	2.65	2.95	2.69	2.63
7 DAYS	3.5	3.46	3.34	2.97
28 DAYS	4.34	4.55	4.56	4.57



GRAPH 7: COMPRESSIVE STRENGTH OF CUBES



GRAPH 8: FLEXURAL STRENGTH ON BEAMS.



GRAPH 9: SPLIT TENSILE STRENGTH OF CYLINDERS.

V. CONCLUSIONS

From the results and discussions of the previous chapter it can be concluded that FA and MK can be replaced to cement in SCC up to 50% i.e., (FA 30% and MK 20%) as the fresh concrete properties are satisfied according to EFNARC specification.

1. Up to 30% fly ash and 10% MK can be replaced to cement in SCC with further replacements the compressive strength of concrete decreases.
2. Super plasticizers greatly improve the workability of concrete but dosage of admixture is to be determined by carrying out various trials.
3. Large scale utilization of FA can be done in concrete production as a replacement to cement which can help in reducing depletion of natural resources and can save large area of land for fly ash disposal.
4. In fly ash based SCC, maximum size of coarse aggregates play important role in determining the passing ability of concrete.
5. If coarse aggregates size increases passing ability of concrete decreases therefore Coarse aggregates of size 12.5mm can be used to get good passing ability.
6. Use of fibers in the SCC slightly reduces fresh state properties, But the harden properties of SCC will shows good strength.
7. Use of VEA (ROOFPAST VMA 2) in SCC gives good results in accordance with bleeding and segregation of concrete.
8. Usages of polycarboxylate based super plasticizer (ROOFPLAST HR 200) in SCC reduce the water demand and improve the FP and HP of SCC.
9. The mix FRSCC-1 (fly ash 30% and MK 10%) shows better results indicating that the optimum replacement of FA is 30% and MK of 10% to the cement.
10. As the percentage of MK substitution increases beyond 10% the compressive strength decreases but split tensile, flexural strength increases.

REFERENCES

1) Jai Prakash Reddy, Maneeth P D, "Assessment of Fresh Properties of Pond Ash SCC," International Journal of Science and Research (IJSR), Volume 5, Issue 7, July 2016, pp. 1870-1875.

2) N. Aruna et.al, Influence of metakaolin and fly as on fresh and hardened properties of self compacting concrete, International Journal of Advanced Research in Engineering and Technology (IJARET), ISSN 0976 – 6480(Print), ISSN 0976 – 6499(Online) Volume 4, Issue 2, March – April (2013).

3) EFNARC, Specification and Guidelines for Self-Compacting Concrete. 2002 edition.

4) Ahmed Razvi et.al, Experimental Study On Properties Of Ternary Blended Self Compacting Concrete By Adding Fiber Reinforcement And Replacing Quarry Dust As Sand, Global Journal Of Engineering Science And Researches, Issn 2348 – 8034, October 2015.

5) V Kannan et.al, Mechanical properties of self-compacting concrete with binary and ternary cementations blends of metakaolin and fly ash, Journal of the South African Institution of Civil Engineering Vol 56 No 2, August 2014, Pages 97–105, Paper 913.

6) Abdullah Mustafa Saba et.al, Influence of fly ash on the properties of self-compacting fiber reinforced concrete, Global Journal of Researches in Engineering: E Civil And Structural Engineering, Online ISSN: 2249-4596 & Print ISSN: 0975-5861 Volume 17 Issue 1 Version 1.0 Year 2017.

7) P.Muthupriya et.al, Strength study on fiber reinforced self-compacting concrete with fly ash and GGBFS, International Journal of Advanced Structures and Geotechnical Engineering ISSN 2319-5347, Vol. 03, No. 02, April 2014.

8) Daniel c et.al, Bulk usage of fly ash in self compacting concrete for m50 grade. International Journal of Engineering Research and General Science Volume 4, Issue 3, ISSN 2091-2730, May-June, 2016.

9) K. S. Johnsirani et al, Experimental study of fiber reinforced self compacting concrete, International journal of science, engineering and technology, ISSN: 2348-4098 volume 02 issues 06 July 2014.

10) Dinesh. A et al, Experimental Study on Self Compacting Concrete, International Journal of Engineering Sciences & Research Technology, ISSN: 2277-9655, March, 2017.

11) Zeeshan Adib Ahmed et.AL, High Strength Self-Compacting Concrete using Fly Ash, International Journal for Research in Applied Science & Engineering Technology (IJRASET) ISSN: 2321-9653, Volume 4 Issue VIII, August 2016.

12) Kishan P Pala et.al, Use of Marble Powder and Fly Ash in Self Compacting Concrete, International Journal for Innovative Research in Science & Technology, Volume 1/ Issue 12 ,ISSN: 2349-6010, May 2015.

13) OKAMURA et.al. "Self-Compacting Concrete", in Structural Concrete: Journal of the fib, vol.1, No. 1, Thomas Telford Ltd, March 2003, p. 3-17.

14) IS: 516-1959, Procedure for Curing of Concrete Cubes.