Reinforced High Strength Self Compacting Concrete, Study on Strength Characteristics of Steel Fiber

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***Abstract*:- In this experimental study the changes on some mechanical properties of self compacting concrete specimen produced by silica fume, metakaolin, fly ash and steel fibers were investigated. The main objective of this is to obtain High Strength Self Compacting Concrete (HSSCC) which flows under its own weight and homogeneity while completely filling any formwork and passing around congested reinforcement. The Self Compacting High Strength Concrete produced by using silica fume, metakaolin, fly ash, steel fibers and Polycarboxylate-ether base super plasticizer. Three types of steel fibers were used in the experiments and volume fractions of steel fiber were 0.5% to 4.0 %. Addition of silica fume, metakaolin and fly ash into the concrete were 2.5 %, 2.5 % and 10 % by weight of cement content respectively. Water/cement ratio was 0.40. Compressive strength, Split tensile and Flexural strength test were made on hardened concrete specimens. In general, significant improvement in strengths is observed with the inclusion of steel fibres in the plain concrete up to certain limit.**

Keywords - Fly Ash, Steel Fiber Reinforced High Strength Self Compacting Concrete (SFRHSSCC), Flexural strength ,Compressive strength, Split Tensile strength of High Strength Self Compacting Concrete (HSSCC), Metakaolin, Silica fume, Steel Fibers.

I. INTRODUCTION:

Durable concrete structures requires skilled labor for placing and compacting concrete. Self Compacting Concrete achieves this by its unique fresh state properties. In the plastic state, it flows under its own weight and homogeneity while completely filling any formwork and passing around congested reinforcement. In the hardened state, it excels standard concrete with respect to strength and durability. The main objective of this study is to optimize the use of Steel Fiber Reinforced High Strength Self Compacting Concrete (SFRHSSCC)

But the literature indicates that some studies are available on plain SCC but sufficient literature is not available on Steel Fiber Reinforced High Strength Self Compacting Concrete (SFRHSSCC) with different mineral admixtures and steel fibers. Hence an attempt is made in this work to study the mechanical properties of both plain Self Compacting High Strength Concrete (SCHSC) and SFRHSSCC.

II. MATERAL USED

2.1 Cement: Ordinary Portland Cement of 53 Grade conforming to IS: 12269-1987 was used in the investigation. The specific gravity of cement was 3.15.

2.2 Coarse Aggregate: Crushed stone metal with a maximum size of 20 mm from a local source having the specific gravity of 2.7 conforming to IS: 383-1970 was used.

2.3 Fine Aggregate: Locally available river sand passing through 4.75 mm IS sieve conforming to grading zone-II of IS: 383-1970 was used. The specific gravity of fine aggregate was 2.65

2.4 Silica fume: Silica fume is also known as micro silica, condensed silica fume, volatized silica or silica dust. The physical properties and chemical composition of Silica fume are shown in table 2.1and table 2.2 respectively.

2.5 Metakaolin: Metakaolin is not a byproduct. It is obtained by the calcinations of pure or refined Kaolinite clay at a temperature between 6500 C and 8500C, followed by grinding to achieve a fineness of 700-900 m2/kg concrete. The physical properties and chemical composition of metakaolin are shown in table 2.1and table 2.2 respectively.

Table 2.1: Physical Properties of Silica Fume & Metakaolin

Property	Specific Gravity	Bulk Density (g/cm3)	Physical Form	colour
Silica fume	2.26	0.13 to 0.44	Powder	White
Metakaolin	2.62	0.3 to 0.5	Powder	Off White

Table 2.2: Chemical Composition of Silica Fume & Metakaolin

Oxide		**SiO2**	**AL2O3**	**Fe2O3**	**CaO**	**MgO**
% by mass	**Silica Fume**	92.2	0.5	1.3	0.4	0.3
	Metakaolin	51.5	40.2	1.2	1.9	0.13

2.6 Fly Ash: Fly ash, a principal by-product of the coal-fired power plants, is well accepted as a pozzolanic material that may be used either as a component of blended Portland cements or as a mineral admixture in concrete. In commercial practice, the dosage of fly ash is limited to 15%-20% by mass of the total cementitious material. Usually, this amount has a beneficial effect on the workability and cost economy of concrete but it may not be enough to sufficiently improve the durability to sulfate attack, alkali-silica expansion, and thermal cracking. Fly

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ash is available in dry powder form and is procured from Dirk India Pvt. Ltd., Nasik. The light grey fly ash under the product name "Pozzocrete 83" is available in 30 kg bags. The fly ash produced by the company satisfies all the requirements of the IS: 3812-1981.

2.7 Super plasticizer: Polycarboxylatether base Muraplast FK 30 super plasticizer obtained from MC-Bauchemie (India) Pvt. Ltd. was used. It conforms to IS: 9103-1999.

2.8 Steel Fibres: The main variables used in the study are three different types of steel fibres, i.e. Waved Steel Fibres (WSF), Hook Ended Steel Fibres (HESF) and Flat Steel Fibres (FSF) with different dosages of fibres are used by weight of cementations material.

Table 2.3: Properties of Steel Fibres used

Type	Length L (mm)	Diameter d (mm)	Aspect Ratio (L/d)
WSF	25	0.55	45
FSF	30	2 mm thick	15
HESF	25	0.55	45

2.9 Water: Fresh portable water which is free from concentration of acid and organic substances is used for mixing the concrete and curing.

III.MIXTURE PROPORTION AND SPECIMEN PREPARATION

The experimental investigation was carried out to study the properties of high strength concrete of M40 grade which was design by modified Nansu method. Silica fume was added as 2.5 % weight of cementitious material and fly is by 10 % weight of cementitious material. There are three types of steel fibress are used in this investigation, i.e. Waved Steel Fibres (WSF), Hook Ended Steel Fibres (HESF) and Flat Steel Fibres (FSF) with different dosages of fibres are used by 0.5%,1%, 1.5%,2 %,2.5%,3%,3.5% and 4% weight of cementations material.

Table 3.1 shows the mixtures used and their compositional contents.

Table 3.1: Mix Proportion

Sl. No	Material	Mass
1.	Cementitious Material	560 Kg/m3
2.	Ordinary Portland Cement (85% of CM)	476 Kg/m3
3.	Silica fume (2.5% of CM)	14 Kg/m3
4.	Met kaolin (2.5 %)	14 Kg/m3
5.	Fly Ash (10 % of CM)	56 Kg/m3
6.	Fine Aggregate	763 Kg/m3
7.	Coarse Aggregate	850 Kg/m3
8..	Water	191 Kg/m3
9	Super plasticizer	18 ml per kg of water
10.	Water Binder Ratio	0.34

IV.METHODOLOGY AND RESULTS

2.10 Compressive Strength:

For Compressive strength test,cubes of dimension (150x150x150mm) were cast.The specimen were demoulded after 24 hours of casting and were transferred to curing tank for 28 days.The compressive strength of concrete was determined in accordance with Indian Standards IS: 516 – 1959.The results obtained are shown in Table 4.1

Table: 4.1: Compressive Strength at 28 Days

Sl.No	Fibres Volume Fraction Vf (%)	Compressive Strength At 28 Days (MPa)		
		WSF	FSF	HESF
1.	0	46.25	46.00	45.75
2.	0.5	48.00	47.50	47.00
3.	1.0	49.50	49.25	48.75
4.	1.5	50.25	50.00	49.75
5.	2.0	51.00	50.75	50.25
6.	2.5	51.25	51.00	50.75
7.	3.0	51.75	51.50	51.00
8.	3.5	52.00	51.75	51.25
9.	4.0	51.25	50.50	50.00

2.11 Split Tensile Strength:

For Split Tensile strength test,cylinders of dimension (150x300mm) were cast.The specimen were demoulded after 24 hours of casting and were transferred to curing tank for 28 days.The compressive strength of concrete was determined in accordance with Indian Standards IS: 5816 – 1970.The results obtained are shown in Table 4.2

Table: 4.2: Split Tensile Strength at 28 Days

Sl.No	Fibres Volume Fraction Vf (%)	Split tensile strength at 28 days(MPa)		
		WSF	FSF	HESF
1.	0	4.62	4.6	4.59
2.	0.5	4.82	4.75	4.71
3.	1.0	4.92	4.91	4.81
4.	1.5	5.02	5.0	4.97
5.	2.0	5.10	5.07	5.02
6.	2.5	5.12	5.10	5.07
7.	3.0	5.17	5.15	5.10
8.	3.5	5.20	5.17	5.12
9.	4.0	5.12	5.05	5.00

2.12 Flexural Strength

For Flexural strength test,prisms of dimension (100x100x500mm) were cast.The specimen were demoulded after 24 hours of casting and were transferred to curing tank for 28 days.The flexural strength of concrete was determined in accordance with Indian Standards IS: : 516-1959.The results obtained are shown in Table 4.3

Table: 4.3 Flexural Strength at 28 Days

Sl.No	Fibres Volume Fraction Vf(%)	Flexural Strength At 28 Days (MPa)		
		WSF	FSF	HESF
1.	0	5.61	5.60	5.59
2.	0.5	5.82	5.74	5.71
3.	1.0	5.92	5.90	5.81
4.	1.5	6.02	6.0	6.97
5.	2.0	6.10	6.05	6.02
6.	2.5	6.11	6.10	6.07
7.	3.0	6.17	6.14	6.10
8.	3.5	6.20	6.17	6.11
9.	4.0	6.11	6.05	6.00

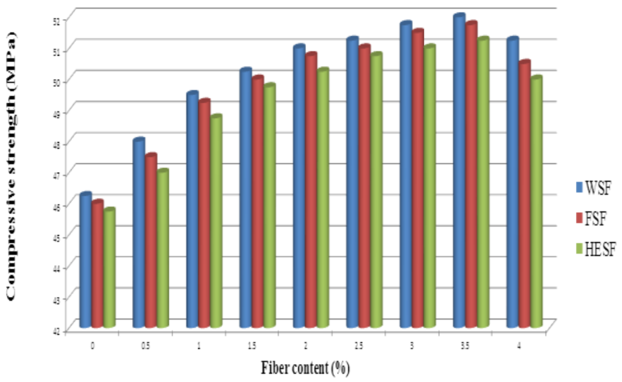

Fig 4.1 Compressive strength of concrete with percentage variation of steel fibers

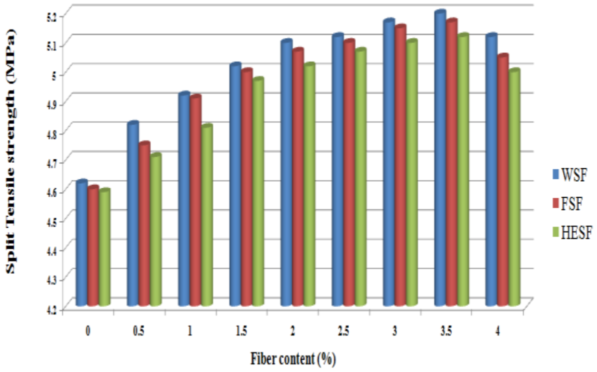

Fig 4.2 Split tensile strength of concrete with percentage variation of steel fibers

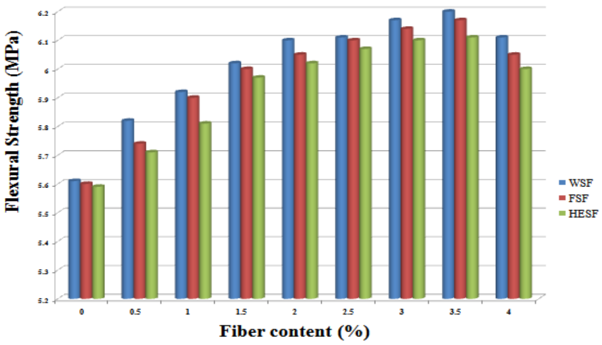

Fig 4.3 Flexural strength of concrete with percentage variation of steel fibers

V. CONCLUSION

Following conclusions are drawn based on the result discussed above:

1. In general, the significant improvement in compression, split tensile and flexural strengths is observed with the inclusion of steel fibers in the plain concrete up to certain limit. The effect of Silica fume, metakaolin, fly ash and steel fibers on compression, split tensile flexural strength of concrete is significant

2. In general, the compression, split tensile flexural strength of the concrete having Waving Steel Fibers (WSF) was higher than that of concrete with Flat Steel Fibers (FSF) and Hook Ended Steel Fibers (HESF) at the same volume fractions of steel up to the 3.5% of fibers.

3.The compressive strength of concrete with steel fibers is increased up to the 3.5 % of fibers volume fraction and then decreases. The maximum values of compressive strength at 3.5 % fibers volume fraction are 52 MPa, 51.75MPa and 51.25 MPa for WSF, FSF and HESF respectively

4.The maximum values of split tensile strength at 3.5 % fibers volume fraction are 5.20MPa, 5.17MPa and 5.12 MPa for WSF, FSF and HESF respectively.

5.The maximum values of flexural strength at 3.5 % fibres volume fraction are 6.20 MPa, 6.17 MPa and 6.11 MPa for WSF, FSF and HESF respectively

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