STUDY ON M60 GRADE STEEL FIBRE REINFORCED SELF COMPACTING CONCRETE

V.JYOSNA DEVI[1], P.J.D.ANJINEYULU[2], U.RANGA RAJU[3], M.K.M.V.RATHNAM[4]

[1]PG Student, DNR college of Engineering & technology, Andhra Pradesh, India
[2]Assistant Professor, DNR college of Engineering & technology, Andhra Pradesh, India
[3]Professor, DNR college of Engineering & technology, Andhra Pradesh, India
[4]Assistant Professor, DNR college of Engineering & technology, Andhra Pradesh, India

---***---

Abstract - *The use of self-compacting concrete is spreading world wide because of its very attractive properties in the fresh state as well as after hardening. SCC improves the quality, durability and reliability of concrete structures and eliminates some of the potential for human error. It will replace manual compaction of fresh concrete with a modern semi automatic placing technology and in that way improve health and safety on and around the construction site. As the main feature of SCC is the behavior in the fresh state, the mix design is especially focused in this point. SCC is designed to be able to flow under its own weight without external vibration and with sufficient viscosity. The flow behavior can be roughly evaluated by the slump flow test. For SCC we will need a high final spread and a maximum limit to the slumping time T 50cm. A concrete mix can only be classified as self compacting concrete if the requirements for all three characteristics i.e. filling ability, passing ability, segregation resistance, are fulfilled.*

Key Words: compression strength, split tensile strength, flexural strengthen of self compacting concrete.

1. INTRODUCTION *11 , cambria font)*

Self Compacting Concrete (SCC) is defined as: "A Category of high-performance concrete that has excellent deformability in the fresh state and high resistance to segregation and can be placed and compacted under its self weight without applying vibration". SCC is also referred as self-leveling concrete, super workable concrete, self-consolidating concrete, highly flowable concrete, non-vibrating concrete etc.

1.1 Advantages of scc

Self-compacting concrete originally developed to offset growing shortage of skilled labour, it has proved beneficial economically because of number of factor including.

- Faster construction
- Reduction in site man power
- Better surface finishes
- Easier placing
- Improved durability and reliability of concrete structures.
- Greater freedom in design
- Thinner concrete sections
- Reduced noise levels, absence of vibration
- Safer working environment
- Improved quality of concrete and reduction of onsite repairs
- Facilitation of introduction of automation into concrete construction.
- Possibilities for utilization of "dusts", which are currently waste products with no practical applications and which are costly to dispose off .
- Improved appearance and consistency in architectural applications
- Excellent bond to steel reinforcing
- Low permeability
- Elimination of micro defects, air bubbles and honey combs.
- With the use of "noise free or silent concrete" construction hours in urban

Areas might be extended to what would otherwise be curfew periods.

1.2 Properties of fresh SCC

SCC differs from conventional concrete in that its fresh properties are vital in determining whether or not it can be placed satisfactory. The various aspects that govern the workability of SCC are: its

- **Filling ability:**

Ability of fresh concrete to flow into and all spaces within the formwork, under its own weight.

- **Passing ability:**

Ability of fresh concrete to flow through tight openings such as spaces between steel reinforcing bars without segregation or blocking.

- **Segregation resistance:**

Ability of concrete to remain homogeneous in its form while in its fresh state. All these need to be carefully controlled to ensure that its ability to be placed remains acceptable.

1.3 Engineering properties of SCC

Compressive strength:

SCC with a similar water cement or cement binder ratio will usually have a slightly higher strength compared with traditional vibrated concrete, due to the lack of vibration giving an improved interface between the aggregate and hardened paste.

Tensile strength:

It may be safely assumed to be the same as the one for a normal concrete,as the volume of paste (cement +fines+water)has no significant effect on tensile strength.

Shrinkage:

Shrinkage is the sum of autogeneous and the drying shrinkage. Autogeneous shrinkage occurs during setting and is caused by the internal consumption of water during hydration .If the volume of the hydration products is less than the original volume of unhydrated cement and water, it results to tensional stresses.

Drying shrinkage is caused by the loss of water from the concrete, to the atmosphere. A decrease in maximum aggregate size, which results in a higher paste volume, increases drying shrinkage. With a low water\cement ratio drying shrinkage reduces and the autogeneous shrinkage can exceed it.

Fire resistance

The fire resistance of SCC is similar to normal concrete. In general a low permeability concrete may be more prone to spalling but the severity depends upon aggregate type, concrete quality and moisture content. The use of polypropylene fibres in concrete has been shown to be effective improving resistance to spalling. The mechanism is believed to be due to fibres melting and being absorbed in the concrete mix. The fibre voids then provide expansion chambers for steam, thus reducing the risk of spalling.

Durability:

The durability of a concrete is closely associated to the permeability of the surface layer. The durability will depend upon the selection of materials and the effective water cement ratio\water binder ratio, concrete composition, as well as on degree of supervision during placing, impaction, finishing and curing.

SCC with right properties will be free from lack of compaction of the surface layer, due to vibration difficulties in narrow space between the form work and the re-bars or other inserts (e.g. post-tensioning ducts) has been recognized as a key factor of poor durability .It offers less weak points for deleterious actions of the environment and, hence better durability.

Bond strength:

Reinforced concrete is based on an effective bond between concrete and the reinforcing bars. Poor bond often results from a failure of the concrete to fully encapsulate the bar during placing or bleed and segregation of the concrete before hardening which reduce the quality of contact on the bottom surface. SCC fluidity and cohesion minimize these negative effects.

Coefficient of thermal expansion:

The coefficient of thermal expansion of concrete is the strain produced in concrete after a unit change in temperature, where the concrete is not restrained either internally (by reinforcing bars) or externally.

Static modulus of elasticity

The modulus of elasticity (E-value, the ratio between stress and strain), is used in the elastic calculation of deflection, other the controlling parameter in slab design, and of pre or post tensioned elements.

Creep

Creep is defined as the gradual increase in deformation (strain) with time for a constant applied stress, also taking into account other time dependent deformations not associated with applied stress, i.e. shrinkage, swelling and thermal deformation.

FIBRE REINFORCED SCC

Fibre reinforced Self Compacting Concrete is considered as new technology for the construction industry. However this technology has found wide acceptance amongst the construction industry. The use of concrete as a structural material is limited to certain extent due to the deficiencies like brittleness, poor resistance to impact, fatigue and low durability. Its use is also very much limited when it is subjected to dynamic or fatigue loading. Commonly used types of fibres are steel or polymer in SCC. Fibres may be used to enhance the properties of SCC in the same way as for normal concrete. Steel fibres are used normally to enhance the mechanical characteristics of the concrete such as flexural strength and toughness. Polymer fibres may be used to reduce segregation and plastic shrinkage, or to increases the fire resistance.

1.4 Requirements for constituent materials

Cement

All typical of cements conforming to IS 12269 are suitable, Selection of the type of cement will depend on the overall requirements for the concrete, such as strength, durability etc.,

Aggregates

Sand

All normal concreting sands are suitable for SCC. Both crushed or rounded sands can be used. Siliceous or calcareous sands can be used.

Coarse Aggregates

All types of aggregates are suitable. The normal maximum size is generally 16-20 mm; however particle sizes up to 40mm or more have been used in SCC. Consistency of grading is of vital importance.

Admixtures

The most important admixtures are the superplasticizers (high range water reducers), used with a water reduction greater than 20%.

Additions

Additions are commonly used in SCC due to the need for substantial contents of fine particles. All additions conforming to the EN standards are suitable.

Fibers

Very fine synthetic fibers may prevent flow and generally the content should not exceed 1kg/m³.

2. RESULTS AND DISCUSSIONS

Workability Parameters

Sl. No:	Test method	property	unit	EFNARC Values		% of Fibres by volume of concrete (aspect ratio =50)						
				Min.	Max.	0	0.25	0.50	0.75	1.00	1.25	1.50
1.	Slump flow	filling	mm	650	800	780	720	715	700	690	680	650
2.	V – Funnel	filling	sec	6	12	6.00	7.00	8.00	9.20	9.60	10.00	11.20
3.	V – Funnel 5 min.	segregation	sec	11	15	11.00	12.10	12.90	13.10	13.90	14.30	15.00
4.	L – Box	passing	%	0.80	1.00	1.00	0.94	0.90	0.88	0.84	0.82	0.81
5.	T – 20 sec		sec	1.00	2.00	1.00	1.20	1.30	1.50	1.60	1.65	2.00

Compression strength

S.NO	DESCRIPTION	CROSS SECTIONAL AREA(sq.mm)	LOAD IN COMPRESSIVE STRENGTH MACHINE(KN)		COMPRESSIVE STRENGTH IN 3 DAYS(N/sq.mm)		AVERAGE COMPRESSIVE STRENGTH(N/sq.mm)
			CUBE1	CUBE2	CUBE1	CUBE2	
1	plain concrete cubes	22500	693	679.5	30.80	30.20	30.50
2	0.25% of steel fibre concrete cubes	22500	742.5	657	33.00	29.20	31.10
3	0.50% of steel fibre concrete cubes	22500	798.8	657	35.50	29.20	32.35
4	0.75% of steel fibre concrete cubes	22500	785.3	681.8	34.90	30.30	32.60
5	1.0% of steel fibre concrete cubes	22500	776.3	717.8	34.50	31.90	33.20
6	1.25% of steel fibre concrete cubes	22500	816.8	713.3	36.30	31.70	34.00
7	1.50% of steel fibre concrete cubes	22500	515.3	726.8	22.90	32.30	27.60

S.NO	DESCRIPTION	CROSS SECTIONAL AREA(sq.mm)	LOAD IN COMPRESSIVE STRENGTH MACHINE(KN)		COMPRESSIVE STRENGTH IN 7DAYS(N/sq.mm)		AVERAGE COMPRESSIVE STRENGTH(N/sq.mm)
			CUBE1	CUBE2	CUBE1	CUBE2	
1	plain concrete cubes	22500	980.5	997.6	43.58	44.34	43.96
2	0.25% of steel fibre concrete cubes	22500	1039.7	1024.2	46.21	45.52	45.86
3	0.50% of steel fibre concrete cubes	22500	1187.5	1184.8	52.78	52.66	52.72
4	0.75% of steel fibre concrete cubes	22500	1213.7	1211.8	53.94	53.86	53.90
5	1.0% of steel fibre concrete cubes	22500	1218.6	1221.4	54.16	54.28	54.22
6	1.25% of steel fibre concrete cubes	22500	1111.9	1107.7	49.42	49.23	49.32
7	1.50% of steel fibre concrete cubes	22500	1029.2	1031.5	45.74	45.84	45.79

S.NO	DESCRIPTION	CROSS SECTIONAL AREA(sq.mm)	LOAD IN COMPRESSIVE STRENGTH MACHINE(KN)		COMPRESSIVE STRENGTH IN 14DAYS(N/sq.mm)		AVERAGE COMPRESSIVE STRENGTH(N/sq.mm)
			CUBE1	CUBE2	CUBE1	CUBE2	
1	plain concrete cubes	22500	1234.7	1240.5	54.88	55.13	55.00
2	0.25% of steel fibre concrete cubes	22500	1329.5	1331.9	59.09	59.20	59.14
3	0.50% of steel fibre concrete cubes	22500	1415.6	1420.7	62.92	63.14	63.03
4	0.75% of steel fibre concrete cubes	22500	1463.9	1461.4	65.06	64.95	65.01
5	1.0% of steel fibre concrete cubes	22500	1507.1	1505.3	66.98	66.90	66.94
6	1.25% of steel fibre concrete cubes	22500	1393.7	1396.8	61.94	62.08	62.01
7	1.50% of steel fibre concrete cubes	22500	1303.2	1306.2	57.92	58.05	57.99

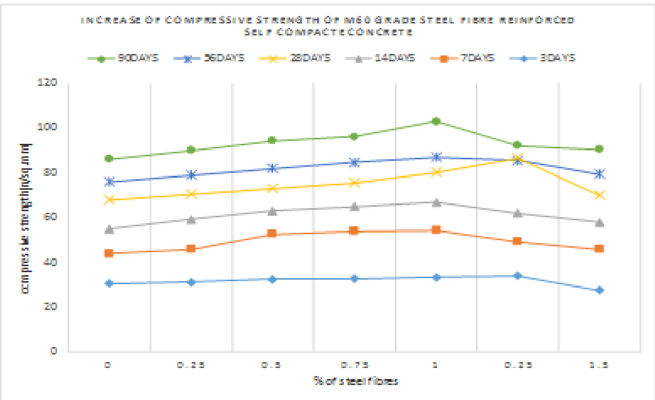
S.NO	DESCRIPTION	CROSS SECTIONAL AREA(sq.mm)	LOAD IN COMPRESSIVE STRENGTH MACHINE(KN)		COMPRESSIVE STRENGTH IN 28 DAYS(N/sq.mm)		AVERAGE COMPRESSIVE STRENGTH(N/sq.mm)
			CUBE1	CUBE2	CUBE1	CUBE2	
1	plain concrete cubes	22500	1487.1	1573.3	66.09	69.92	68.01
2	0.25% of steel fibre concrete cubes	22500	1364.5	1809.2	60.64	80.41	70.53
3	0.50% of steel fibre concrete cubes	22500	1638.4	1649.1	72.82	73.29	73.06
4	0.75% of steel fibre concrete cubes	22500	1752.2	1649	77.88	73.29	75.58
5	1.0% of steel fibre concrete cubes	22500	1872.1	1737.9	83.20	77.24	80.22
6	1.25% of steel fibre concrete cubes	22500	1987.3	1908.7	88.32	84.83	86.58
7	1.50% of steel fibre concrete cubes	22500	1589	1559.1	70.62	69.29	69.96

S.NO	DESCRIPTION	CROSS SECTIONAL AREA(sq.mm)	LOAD IN COMPRESSIVE STRENGTH MACHINE(KN)		COMPRESSIVE STRENGTH IN 56 DAYS(N/sq.mm)		AVERAGE COMPRESSIVE STRENGTH(N/sq.mm)
			CUBE1	CUBE2	CUBE1	CUBE2	
1	plain concrete cubes	22500	1711.3	1709.2	76.06	75.96	76.01
2	0.25% of steel fibre concrete cubes	22500	1775.9	1776.8	78.93	78.97	78.95
3	0.50% of steel fibre concrete cubes	22500	1848.7	1843.2	82.16	81.92	82.04
4	0.75% of steel fibre concrete cubes	22500	1910.8	1903.9	84.92	84.62	84.77
5	1.0% of steel fibre concrete cubes	22500	1955.2	1960.1	86.90	87.12	87.01
6	1.25% of steel fibre concrete cubes	22500	1933.2	1918.2	85.92	85.25	85.59
7	1.50% of steel fibre concrete cubes	22500	1796.4	1779.4	79.84	79.08	79.46

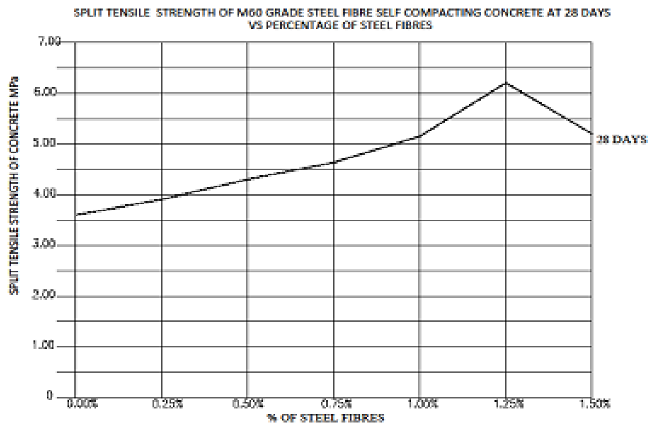
S.NO	DESCRIPTION	CROSS SECTIONAL AREA(sq.mm)	LOAD IN COMPRESSIVE STRENGTH MACHINE(KN)		COMPRESSIVE STRENGTH IN 90DAYS(N/sq.mm)		AVERAGE COMPRESSIVE STRENGTH(N/sq.mm)
			CUBE1	CUBE2	CUBE1	CUBE2	
1	plain concrete cubes	22500	1926.8	1948.3	85.64	86.59	86.115
2	0.25% of steel fibre concrete cubes	22500	2002.5	2047.5	89.00	91.00	90
3	0.50% of steel fibre concrete cubes	22500	2152.5	2092.5	95.67	93.00	94.335
4	0.75% of steel fibre concrete cubes	22500	2148.7	2182.9	95.50	97.02	96.26
5	1.0% of steel fibre concrete cubes	22500	2340	2295.4	104.00	102.02	103.01
6	1.25% of steel fibre concrete cubes	22500	2056.1	2088.7	91.38	92.83	92.105
7	1.50% of steel fibre concrete cubes	22500	1989.2	2076.7	88.41	92.30	90.355

S.No.	Specimen size	% of steel Fibres of aspect ratio 50.	Load in kN		AVG. Load In KN	AVG Split tensile Strength in N/mm² (2P/πld)
I	150x150mm	0.00%	128.2	132.0	130.1	3.68
II	150x150mm	0.25%	139.1	137.4	138.3	3.91
III	150x150mm	0.50%	152.0	153.5	152.8	4.32
IV	150x150mm	0.75%	161.8	163.5	162.7	4.60
V	150x150mm	1.00%	186.1	188.0	187.1	5.29
VI	150x150mm	1.25%	220.1	218.3	219.2	6.20
VII	150x150mm	1.50%	187.2	186.2	186.7	5.28

Graphical representation of results



Compressive strength vs percentage of steel



Split tensile strength vs percentage of steeel

3. CONCLUSIONS

1. Steel Fiber SCC mix requires high powder content, lesser quantity of coarse aggregate, high range super-plasticizer and viscosity modifying agent to give stability and fluidity to the concrete mix.
2. The improvement in Compressive strength of Steel fiber SCC for M_{60} at 28 days in comparison with ordinary SCC was found to be 5.08%, for 0.25% Steel fiber, 18.70% for 0.50% Steel fiber, 19% for 0.75% Steel fiber, 19.70% for 1.00% Steel fiber, 13.21% for 1.25% Steel fiber, 9.56% for 1.50% Steel fiber with aspect ratio of 50.In the same way the remaining compressive strength calculated from the tests which are held on 3days, 14 days, 56 days, and 90 days are also improved.
3. The improvement in Split Tensile strength if Steel fiber SCC for M_{60} @ 28 days in comparison with ordinary SCC was found to be 6.26% for 0.25% Steel fiber , 17.40% for 0.50% Steel fiber, 25% for 0.75% Steel fiber, 43.75% for 1.00% Steel fiber, 68.50% for 1.25% Steel fiber, 43.50% for 1.50% Steel fiber with aspect ratio of 50.
4. The improvement in Flexural strength of Steel fiber SCC for M_{60} @ 28 days in comparison with ordinary SCC was found to be 39.60% for 0.25% Steel fiber, 41% for 0.50% Steel fiber, 42.80% for 0.75% Steel fiber, 57.50% for 1.00% Steel fiber, 71.70% for 1.25% Steel fiber, 40% for 1.50% Steel fiber content with aspect ratio of 50.

REFERENCES

[1] EFNARC specifications and guide lines for self compacting concrete, Feb.2002.
[2] Concrete technology theory and practice by M.S.SHETTY, Reprint 2005.

[3] Concrete technology, M.L.Gambhir, the MC graw-hill companies, civil engineering series, third edition.

[4] SP 23, 1982,Hand book on concrete mixes (Based on Indian standards), Bureau of Indian standards, New Delhi, Reprint in1999.

[5] IS 269-1958; Indian standard specification for ordinary, Rapid Hardening and low heat Portland cement, Revised and reprinted-Aug. 1965.

[6] IS 383-1970,Specifications for coarse and fine aggregate from Natural Resources for concrete (second revision), 9 th Reprint 1993.

[7] IS 4031 (Part1-15), Methods of physical tests for Hydraulic cements.

[8] IS 516-1959,Methods of test for strength of concrete, 16 th reprint, Jan-1976.

[9] IS 2386-1963 (ALL PARTS), Methods of tests for aggregates for concrete.

[10] Is3812-1981,Indian standard specifications for fly ash for use as pozzolana and admixture,june1981.