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Effect of Steel Fibres as Reinforcement in Self Compacting Concrete

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***Abstract* -Self compacting concrete is a type of concrete which flows under the influence of gravity without segregation is used in heavily reinforced structural members. It avoids the need of vibration equipment. Steel fibres can improve crack resistance, impact and fatigue resistance, shrinkage reduction and toughness. This project explores the strength studies of self-compacting concrete using steel fibres as reinforcement to enhance the mechanical properties. Various tests are to be carried out to determine the properties of fresh and hardened concrete such as workability test, compressive test, flexure and tensile test. The mix design for SCC was arrived as per the guidelines of EFNARC**

Keywords—Self compacting concrete; gravity; segregation; vibration equipment; EFNARC – The European Federation of National Associations for Representing Concrete

I. Introduction

Self compacting concrete (SCC) represents one of the most significant advances in concrete technology for decades. Inadequate homogeneity of the cast concrete due to poor compaction or segregation may drastically lower the performance of mature concrete in-situ. SCC has been developed to ensure adequate compaction and facilitate placement of concrete in structures with congested reinforcement and in restricted areas. SCC was developed first in Japan in the late 1980s to be mainly used for highly congested reinforced structures in seismic regions. As the durability of concrete structures became an important issue in Japan, an adequate compaction by skilled labours was required to obtain durable concrete structures. This requirement led to the development of SCC and its development was first reported in 1989. SCC can be described as a high performance material which flows under its own weight without requiring vibrators to achieve consolidation by complete filling of formworks even when access is hindered by narrow gaps between reinforcement bars. SCC can also be used in situations where it is difficult or impossible to use mechanical compaction for fresh concrete, such as underwater concreting, cast in-situ pile foundations, machine bases and columns or walls with congested reinforcement. The high flow ability of SCC makes it possible to fill the framework without vibration. Since its inception, it has been widely used in large construction in Japan. Recently, this concrete has gained wide use in many countries for different applications and structural configurations. Fibres are usually used in concrete to control cracking due to plastic shrinkage and drying shrinkage. They also reduce the permeability of concrete and thus reduce bleeding of water. Some types of fibres produce greater impact, abrasion, and shatter resistance in concrete. Steel fibres in Concrete can improve crack, impact and fatigue resistance, shrinkage reduction and toughness by preventing or delaying crack propagation from micro-cracks to macro-cracks.

II. OBJECTIVE OF THE WORK

- To determine the properties and strength of conventional self-compacting concrete without fibres.
- To determine the properties and strength of steel fibre reinforced self-compacting concrete.
- To compare the normal self-compacting concrete with steel fibre reinforced self-compacting concrete. Maintaining the Integrity of the Specifications

III. Materials

A. Cement

Cement is a binder, a substance used in construction that sets and hardens and can bind other materials together. Ordinary Portland cement of 53 grade conforming to Indian Standard IS 12269-1987 was used in the experiment. The typical fineness of cement ranges from 350 to 500 m2/kg respectively. More than 500 kg/m3 cement can be dangerous and increase the shrinkage. Less than 350 kg/m3 may only be suitable with the inclusion of other fine filler, such as fly ash, pozzolana.

TABLE I. Composition of Portland Cement

Ingredients	Percentage Content
CaO (Lime)	60-70
SiO2 (Silica)	17-25
Al2O3 (Alumina)	3-8
Fe2O3 (Iron Oxide)	0.5-6
MgO (Magnesia)	0.1-4
Alkalies	0.4-1.3
Sulphur	1-3

B. Fine Aggregate

Sand is a naturally occurring granular material composed of finely divided rock and mineral particles. It is defined by size being finer than gravel and coarser than silt. Fine aggregate (sand) used for this investigation is river sand conforming to zone-II of IS 383- 1970 and it was well graded, passing through 4.75mm sieve. The sand was air dried and sieved to remove any foreign material, prior to mixing.

C. Coarse Aggregates

The coarse aggregate chosen for SCC is typically round in shape, is well graded, and smaller in maximum size than that used for conventional concrete. As with conventional concrete construction, the maximum size of the coarse aggregate for SCC depends upon the type of construction. Typically, the maximum size of coarse aggregate used in SCC ranges from approximately 10 mm to 20 mm. The coarse aggregate should have a maximum of 12mm. It is to be confirmed as per the BIS specifications. Using lesser size aggregates improves the flow ability of concrete.

D. Water

Generally, water that is suitable for drinking is satisfactory for use in concrete. The water used in concrete plays an important part in the mixing, laying, compaction, setting and hardening of concrete. The strength of concrete directly depends on the quantity and quality of water used in the mix. Ordinary potable water of pH 7 is normally used for mixing and curing the concrete specimen.

E. Steel Fibres

Steel fibres are made of cold-drawn steel wire with low content of carbon or stainless steel wire. Steel fibres in concrete can improve crack, impact and fatigue resistance, shrinkage reduction and toughness by preventing or delaying crack propagation from micro-cracks to macro-cracks.

Fig. 1 *Steel fibres*

F. Viscocrete 20 HE

Viscocrete-20 HE is a third generation superplasticizer for concrete and mortar. The product is suitable for tropical and hot climatic conditions. It is a light brownish colour liquid. Viscocrete-20 HE is especially suitable for the production of concrete mixes which require high early strength development, powerful water reduction and excellent flow ability.

Fig. 2 *Viscocrete 20 HE*

IV. PROPERTIES OF MATERIALS USED

A. Properties of cement

TABLE II. PROPERTIES OF CEMENT

S.No	PROPERTIES	VALUES
1.	Specific Gravity	3.15
2.	Bulk Density	1440 kg/m3
3.	Surface area	225 m2/kg
4.	Initial setting time	30 min
5.	Final setting time	600 min

B. Properties of fine aggregate

TABLE III. PROPERTIES OF FINE AGGREGATE

S.No	PROPERTIES	VALUES
1.	Specific Gravity	2.63
2.	Bulk Density	1318.18 kg/m3

C. Properties of coarse aggregate

TABLE IV. PROPERTIES OF COARSE AGGREGATE

S.No	PROPERTIES	VALUES
1.	Specific Gravity	2.7
2.	Bulk Density	1404.2 kg/m3
3.	Size	10 mm

V. RESULTS AND DISCUSSION

A. Fresh properties

Workability of self-compacting concrete can be characterized by three parameters- filling ability, passing ability and resistance to segregation. The fresh properties of concrete are assessed by doing the following experiments such as slump flow test, L-box test, U-box test and V-funnel test.

The results for various additions of steel fibres are tabulated below.

TABLE V. FRESH CONCRETE TEST RESULTS

ADDITION OF STEEL FIBRES IN %	T50cm SLUMP FLOW (sec)	SLUMP FLOW (mm)	L-BOX (H2/H1)	V-FUNNEL (sec)	U-BOX (mm)
0	2	750	0.95	6	28
0.5	2	740	0.95	6	26
1	3	720	0.9	8	25
1.5	3	700	0.85	9	22
2	4	690	0.8	11	20
2.5	5	680	0.8	12	17
3	6	660	0.75	14	16

As per guidelines of EFNARC, for slump flow, the typical range of value is 650-800 mm, for T50cm, range is 2 to 5 sec and for V-funnel, range is 6-12 sec, for L-box, the range is 0.82 to 1, for U-box, the range is 0 to 30 mm. The addition of steel fibres reduces the workability of fresh concrete. But the mix almost satisfies the range specified by EFNARC guidelines.

B. *Hardened Properties*

1) Compressive strength test: Compressive strength tests are carried out on cubes of size 150 mm x 150 mm x150 mm. The specimens are tested after keeping it for curing at the age of 7 and 28 days. The results obtained are compared with the results of a control mix specimens. The results are tabulated below.

TABLE VI. COMPRESSIVE STRENGTH TEST RESULTS

ADDITION OF STEEL FIBRES IN %	7 DAYS RESULTS		28 DAYS RESULTS	
	Load (KN)	Compressive strength (N/mm2)	Load (KN)	Compressive strength (N/mm2)
0	520	23	810	36
0.5	670	29.77	930	41.33
1	830	36.88	1150	51.11
1.5	970	43.11	1340	59.55
2	1000	44.44	1380	61.33
2.5	730	32.44	1010	44.88
3	720	32	1000	44.44

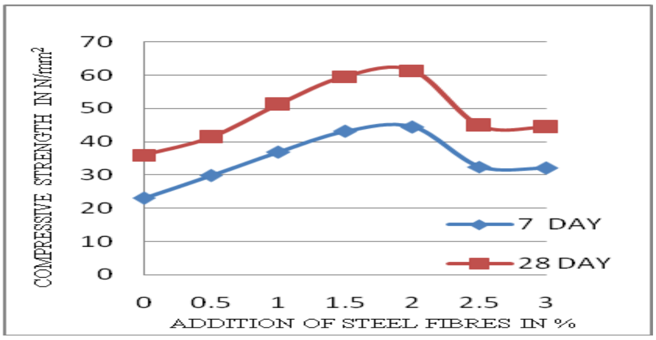

Fig. 3 *Graphical compressive strength results*

2) Split tensile strength test: For the determination of split tensile strength of concrete, cylinder specimens of diameter 150 mm and height 300 mm were casted. The cylinders were casted for different addition of steel fibres. The tests were conducted on cylinders at an age of 7 and 28 days. The results are tabulated below.

TABLE VII. SPLIT TENSILE STRENGTH TEST RESULTS

ADDITION OF STEEL FIBRES IN %	SPLIT TENSILE STRENGTH (N/mm2)	
	7 DAY RESULTS	28 DAY RESULTS
0	3.36	4.2
0.5	3.82	4.5
1	4.25	5.0
1.5	4.6	5.4
2	4.67	5.48
2.5	3.99	4.67
3	3.96	4.66

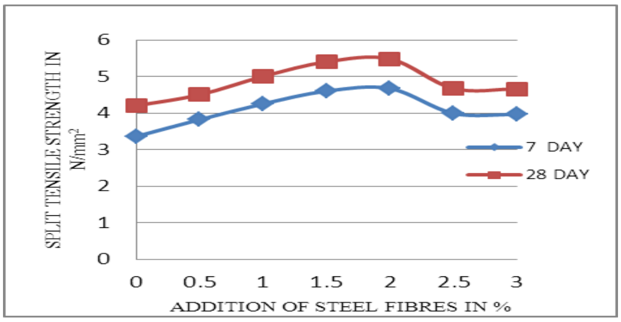

Fig. 4 *Graphical split tensile strength results*

3) Flexural strength test: Flexural strength test is carried out on prism specimens of dimensions 100 mm x 100 mm x 500 mm. The test is carried out by applying two point loading on the prism at the age of 7 and 28 days. The tests are carried out at various percentages of steel fibres. The results are tabulated below.

TABLE VIII. FLEXURAL STRENGTH TEST RESULTS

ADDITION OF STEEL FIBRES IN %	FLEXURAL STRENGTH (N/mm2)	
	7 DAY RESULTS	28 DAY RESULTS
0	16.1	25.2
0.5	20.84	28.93
1	25.82	35.78
1.5	30.18	41.68
2	31.12	42.93
2.5	22.71	31.42
3	22.4	31.12

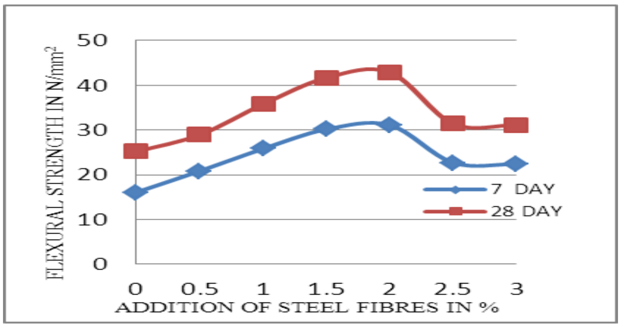

Fig. 5 *Graphical flexural strength results*

VI. CONCLUSION

The following conclusions are arrived from the project:

- The even dispersion of steel fibres has proven that it is possible to develop steel fibre reinforced self-compacting concrete without any effects to its workability.
- The steel fibre reinforced self-compacting concrete has exhibited a maximum compressive strength of 61.33 MPa at 28 days, with a fiber content of 2%.
- The steel fibre reinforced self-compacting concrete has exhibited a maximum compressive strength of 61.33 MPa at 28 days, with a fiber content of 2%.
- In general, significant improvements in various strengths are observed with the addition of end hooked steel fibres. However it appears that maximum gain in strength of concrete is found to depend on the optimum dosage of fibre content.
- The compressive strength, the split tensile strength and the flexural strength increase with increase in the percentage of fibre content upto 2% only.
- The optimum fibre content for maximum increase in strength is 2% and percentage increase in compressive strength is 70.36% over normal SCC.
- Satisfactory workability was maintained with increasing volume fraction of fibers by using super plasticizer.
- With increasing fiber content, mode of failure was changed from brittle to ductile failure when subjected to compression and bending.

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