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A STUDY ON PROPERTIES OF HYBRID FIBER REINFORCED SELF COMPACTING CONCRETE

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ABSTRACT: SCC spreads homogenously due to its own weight, without any additional compaction energy and does not entrap air. The main characteristics of SCC in the fresh state are filling ability, passing ability and segregation resistance. Fibers have been produced with a wide range of materials, shapes and characteristics. They improve the performance (strength and toughness) of brittle cement-based materials by bridging cracks; transmitting stress across a crack and counteracting the crack growth. Fibers are added in SCC to get increased performance mainly in flexure, impact and also in compressive strength. Fibers can affect the flow ability and passing ability through congested reinforcement, which are main aspects when SCC is considered.It is proposed to study the flow and strength properties of the Fiber reinforced self compacting concrete and hybrid fiber reinforced self compacting concrete in comparison with control self compacting concrete. The steel fibers used in this study are crimped steel fibers of size 0.45mm diameter x 12.5mm length (aspect ratio 27.7) and carbon fibers of size 0.2mm diameter x 12 mm length (aspect ratio 60)are added to the SCC mix at various percentages by weight of cement i.e 3%,4% and 5%. Mixes are designated as SCC, SCC3S, SCC4S, SCC5S, SCC3S1C, SCC4S1C, SCC5S1C. Results show that the flow properties are adversely affected. Beyond 4% addition of steel fibers FRSCC mix failed to achieve L-box blocking ratio acceptance limits. 1% carbon fibers added in addition to the above mentioned steel fiber percentages. Mixes are designated as SCC3S1C, SCC3S1C, and SCC5S1C.Compressive strength, Split tensile strength, Flexural strength of all the fiber reinforced SCC mixes is increased compared to control mix SCC0.

Keywords: Self compacting concrete (SCC),Crimped steel fibers,Carbon fibers.

I. INTRODUCTION

Self-compacting concrete was originally developed in Japan and Europe. It is a concrete that is able to flow and fill every part of the corner of the formwork, even in the presence of dense reinforcement, purely by means of own weight and without the need of for any vibration or other type of compaction.As compared to conventional concrete the benefits of SCC comprising more strength like non SCC, may be higher due to better compaction, similar tensile strength like non SCC, modulus of elasticity may be slightly lower because of higher paste, slightly higher creep due to paste, shrinkage as normal concrete, better bond strength, fire resistance similar as non SCC, durability better for better surface concrete."Self-compacting concrete (SCC) is an innovative concrete that does not require vibration for placing and compaction. It is able to flow under its own weight,

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completely filling formwork and achieving full compaction, even in the presence of congested reinforcement."

II.OBJECTIVE AND METHODOLOGY

The main objective of this project is to study the properties of hybrid fiber reinforced self compacting concrete .These properties includes flow and strength properties of hybrid fiber reinforced self compacting concrete.

The flow properties includes

- Filling ability.(V-Funnel)
- Passing ability.(L-Box)
- Resistance to segregation.(Flow table)

The strength properties includes

- Compressive strength.
- Split tensile strength.
- Flexural strength.

Methodology

Self compacting concrete mix of M30 grade is adopted from past researchers .The fiber reinforced self compacting concrete and hybrid fiber reinforced self compacting concrete mixes are obtained by adding fibers to SCC mix. Flow properties are studied through

- Flow table test
- V-Funnel test
- L-Box test

Strength properties are studied through

- Compressive strength of cube specimens of size 150mm x 150mm x 150mm.
- Split tensile strength of cylinder specimens of size 150mm dia x 300mm height.

Flexural strength of beam specimens of size 150mm x 150mm x 700mm.

IV.MATERIALS

In this project materials like cement, Fly ash, river sand, Coarse Aggregates (CA), Super plasticizer(SP) and water steel fibers carbon fibers are used in this study.

CEMENT:

The cement used in all mixtures was commercially available Ordinary Portland cement (OPC) of 53 grade manufactured by KCP company confirming to IS: 12269 was used in this study. The specific gravity and normal consistency of the cement was 3.15 and 33%. The initial and final setting times were found as 105 minutes and 360 minutes respectively.

FLY ASH:

Fly ash obtained from Vijayawada thermal power plant (VTPS), Vijayawada, Andhra Pradesh, India was used in this study. Its chemical admixture is given in Table .The fly ash had a relatively low specific gravity and fineness modulus of 1.975 and 1.195 respectively.

Table:1 Constituents of Fly Ash

S.No	Property	Formula	% content
1.	Silicon Dioxide	SiO_2	59.04
2.	Aluminium Oxide	Al_2O_3	34.08
3.	Iron Oxide	Fe_2O_3	2.0
4.	Lime	CaO	0.22
5.	Sulphur Trioxide	SO_3	0.05
6.	Magnesium Oxide	MgO	0.43
7.	Alakalies	Na_2O	0.5
8.	Alakalies	K_2O	0.76
9.	Loss of ignition	LOI	0.63

SAND:

The sand used in this research for preparation of normal concrete is natural river sand conforming to grading zone-II as per **IS: 383-1970** with specific gravity 2.62 and having fineness modulus as 2.72. The maximum size of FA is taken to be 4.75 mm. The testing of sand is done as per **IS: 2386 – 1963**. The sieve analysis results are shown in below

Table2: Fineness modulus of fine aggregate

I.S. sieve size	Weight of aggregate retained in gms	Cumulative weight retained in gms	Cumulative % of weight retained	% of passing	Remarks
10 mm	0	0	0	100	
4.75 mm	2	2	0.2	99.8	
2.36 mm	5	7	0.7	99.3	Zone-III
1.18 mm	152	159	15.9	84.1	
600 µ	169	328	32.8	67.2	
300 µ	548	876	87.6	12.4	
150 µ	115.0	991	99.1	0.9	
<150 µ	9	1000	100	0	

Weight of aggregate sample taken =1000g
Fineness modulus of fine aggregate=298.75/100 = 2.98

COARSE AGGREGATE (CA)

Locally available 10mm angular crushed stone aggregate is used in this study. Aggregate blocking must be avoided as SCC flows through the reinforcement and the L-box test is indicative of the passing ability of an SCC mix. The maximum aggregate size should generally be limited to 10 – 12 mm, although larger sizes are being used.

STEEL FIBERS

Crimped Steel fibres of 12.5mm length and 0.45mm diameter (Aspect ratio of 27.78) are used in this study. Steel fibers are mainly in 3 shapes flat, undulated & hook, made of cold drawn steel wire, with a min tensile strength of 1100N /mm^2, in size range 0.4 to 1.05mm, in lengths of 5, 12.5, 20, 25, 30, 50,60mm.

CARBON FIBERS

Carbon fibres of 12mm length and 0.2mm diameter (Aspect ratio 60) are used in this study. Carbon fibers are widely used in civil engineering applications and concrete ,it is very attractive due to its thermal conductivity, light weight and modulus of elasticity.

Table3:Properties of steel fibers& carbon fibers

S. No	Property	Steel (crimpled)	Carbon
1	Diameter	0.45 mm	0.2 mm
2	Length	12.5mm	12 mm
3	Aspect ratio L/D	27.7	60
4	Relative density(Specific gravity)	7.80	1.90
5	Tensile strength	500-2600 Mpa	1800-2600 M pa
6	Strain at failure	0.5-3.5%	0.5-1.5%
7	Modulus Of Elasticity	210,000 Mpa	230,000-380,000
8	Appearance	Bright and clean wire	Bright and clean wire

SUPERPLASTICIZER

Poly-carboxylic ether (Master Glenium SKY 8630)type super plasticizer was used in mixes. Superplasticizeris an admixture of a new generation based on modified polycarboxylic ether. The product has been primarily developed for applications in high performance concrete where the highest durability and performance is

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required. This type of superplasticizer is free of chloride & low alkali. It is compatible with all types of cements.

Table4: properties of super plasticizer poly carboxylic ether (Master Glenium SKY 8630)

Colour	Light brown liquid
Relative density	1.08,0.01 at 25°C
Ph	> 6 at 25°C
Chloride ion content	< 0.2%

V. Mix proportion:

Required self compacting concrete Mix proportion was taken from past literature. After casting various trial mixes final mix was arrived as below.Control mix is designated as SCC0 i.e SCC with out any fiber content. The steel fibers were added to control mix in different percentages by weight of cement. Crimped steel fibers content as 3% by weight of cement and size range of 0.45 mm diameter x 12.5 mm length (aspect ratio 27.7)were added. Similarly different percentages of 4%,5% were added in the scc mix. And again with carbon fibers of 0.2 mm diameter x 12 mm length(aspect ratio 60) and steel fibers of 0.45 mm diameter x 12.5 mm length(aspect ratio 27.7) were added in different percentages keeping carbon fiber content as constant at 1% by weight of cement. Mixes were designated as below

CEMENT	FLY ASH	COARSE AGGREGATE	FINE AGGREGATE	WATER	SUPER PLASTCIZER
450	74.955	667.5	988	240.3	4.8
1	0.166	1.48	2.19	0.534	0.0106

SCC0-self compacting concrete without any fibers.

SCC3S-self compacting concrete with 3% steel fibers by weight of cement.

SCC4S-self compacting concrete with 4% steel fibers by weight of cement.

SCC5S-self compacting concrete with 5% steel fibers by weight of cement.

SCC3S1C-self compacting concrete with 3% steel fibers by weight of cement& 1% carbon fibers by weight of cement.SCC4S1C-self compacting concrete with 4% steel fibers by weight of cement&1% carbon fibers by weight of cement.SCC5S1C-self compacting concrete with 5% steel fibers by weight of cement&1% carbon fibers by weight of cement.After preparing every SCC mix, following flow tests were conducted to study the flow properties.

1. Slump flow test
2. V-funnel test
3. L-box test

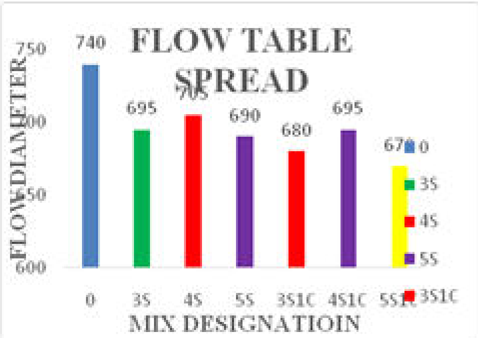
VI.RESULTS

1 FLOW PROPERTIES

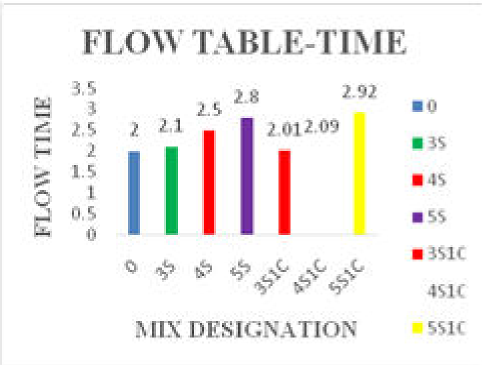
PERCENTAGE	**NAME OF THE EXPERIMENT**				
	FLOW TABLE		**V-FUNNEL**	**L-BOX**	
	TIME(t500 sec)	**D avg**	**TIME(t sec)**	**TIME(t sec)**	**H2/H1**

SCC0	**2**	**740**	**7**	**5.5**	**0.87**
SCC3S	**2.1**	**695**	**8.5**	**5.70**	**0.82**
SCC3S1C	**2.01**	**680**	**9**	**6.02**	**0.80**
SCC4S	**2.50**	**705**	**8.6**	**5.5**	**0.787**
SCC4S1C	**2.09**	**695**	**9.1**	**6.1**	**0.787**
SCC5S	**2.8**	**690**	**8.79**	**5.55**	**0.769**
SCC5S1C	**2.92**	**670**	**9.10**	**5.59**	**0.769**

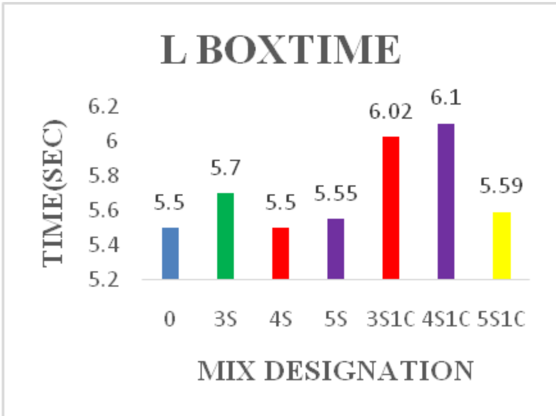
Shows variation of flow diameter at different percentages of fibres in SCC mix



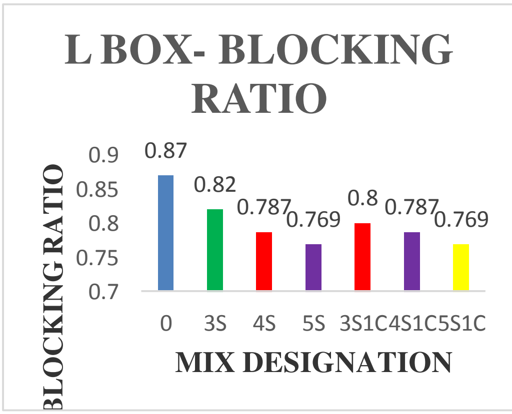
Shows variation of flow time at different %ges of fibres in SCC mix



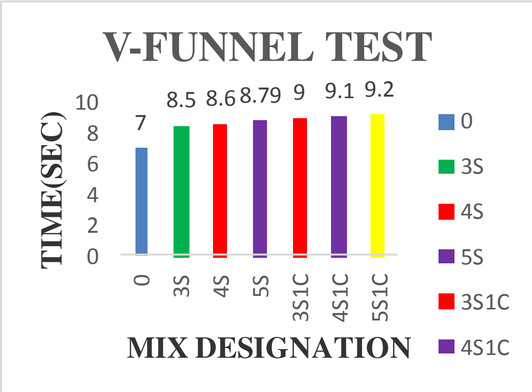
Shows variation of passing time at different %ges of fibres in SCC mix



Shows variation of blocking ratio at different %ges of fibres in SCC mix



Shows variation of filling time at different %ges of fibres in SCC mix



STRENGTH PROPERTIES

TABLE 6.2 STRENGTH PROPERTIES

MIX Designation	STRENGTH(N/mm^2)			
	7 DAYS COMPRESSIVE STRENGTH	28 DAYS COMPRESSIVE STRENGTH	28 DAYS SPLIT TENSILE STRENTH	28 DAYS FLEXURAL STRENGTH
SCC0	22.12	26.66	2.122	3.5
SCC3S	19.55	26.66	2.122	3.75
SCC3S1C	21.33	33.77	2.546	3.33
SCC4S	23.06	27.55	2.546	3.74
SCC4S1C	28.44	36.88	2.824	3.511
SCC5S	22.22	31.55	2.824	3.955
SCC5S1C	25.77	36.44	3.112	3.733

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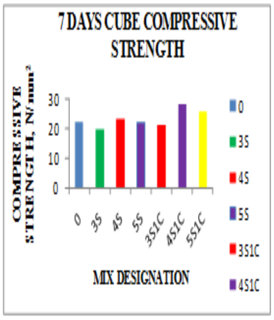
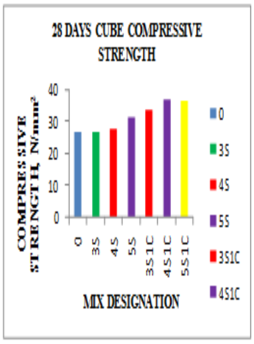
Shows variation of compressive strength(7 days) at different %ges of fibres



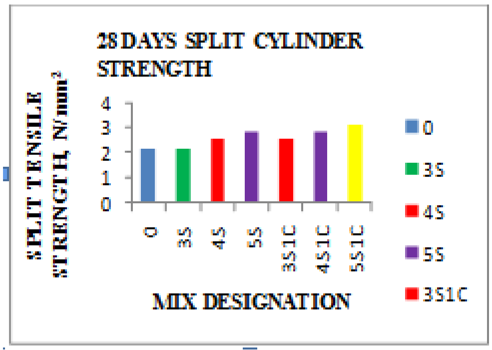
in SCC

Shows variation of compressive strength(28days) at different %ges of



fibres in SCC

Shows variation of flexural strength(28days) at different %ges of fibres in SCC



VII.CONCLUSIONS

Following are the conclusions from the study:

1. As there is increase in fiber content in the SCC mix the flow properties are adversely affected. Beyond and at 4% addition of steel fibers SCC4S mix is failed to achieve L-box blocking ratio accepetance limits.(table 1)
2. Addition of hybrid fibers at 4%(3%steel +1%carbon) in the mix SCC3S1C shows that all flow properties are achieved including blocking ratio which was failed in SCC4S mix. It shows that by use of hybrid fibres in SCC the flow properties can be improved rather than using single type fibres in the SCC mix.
3. At higher dosages than 4% (3S+1C),blocking ratio values are not within the acceptance limit but all other flow property results are within the acceptance limits upto 6% (5S+1C) fibres content.(Fig:27)
4. Compressive strengths of all the fibre reinforced SCC mixes are increased compared to control mix SCC0. (Fig:29)
5. The Compressive strength is increased with the increase in percentage of hybrid fibres added. At the same percentage of total fibers added, the Compressive strength of HFRSCC is more than that of SFRSCC type of fibres.(Fig:30)
6. Splint tensile strengths of all the fiber reinforced mixes are increased compared to control mix SCC0. (Fig:31)
7. The splint tensile strength is increased with the increase in percentage of hybrid fibres added. At the same percentage of total fibers added, the Split tensile strength of HFRSCC is similar to the split tensile strength of SFRSCC type of fibres.(Fig:31)
8. Flexural strengths of all the fibre reinforced SCC mixes are increased compared to control mix SCC0.(Fig:32)
9. **The** flexural strength is increased with the increase in percentage of fibres added. At the same percentage of total fibers added, the Flexural strength of

HFRSCC is less than that of SFRSCC type of fibres.(Fig:32)

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