Self Compacting Concrete Reinforced with Sisal Fibres

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***Abstract*:- Concrete has high compressive strength, but is remarkably weak in tension (about one-tenth its compressive strength), and as such, is usually reinforced with materials that are strong in tension. In the presence of reinforcement, the tensile load is transferred to the reinforcing material. An alternative to increasing the load carrying capacity of concrete in tension is the addition of fibres. Well-dispersed fibres in the concrete act to bridge the cracks that develop in concrete. The incorporation of fibres in a cement matrix leads to an increase in the toughness and tensile strength, and an improvement in the cracking and deformation characteristics of the resultant concrete. Sisal fibre is derived from the leaves of the plant. It is usually obtained by machine decortications in which the leaf is crushed between rollers and then mechanically scraped.**

The present study was carried out to check the fresh and hardened properties of sisal fiber reinforced self -compacting concrete with different percentage of fiber addition. Degree of workability of concrete mix with 0.2% super plasticizer and water cement ratio 0.31 had good workability which is effective, was obtained. Materials were hand mixed with 0.5%, 1% ,1.5% and 2% addition of fiber in M40 mix design and casted in cubes and cylinders. The super plasticizers are used in different percentages like 0.15%0.2%,1%&2%. The obtained specimens were subjected to test the compressive and split tensile strength. And the compressive and split tensile strengths of the specimens were analyzed after 7days and 28days of curing.

***Keywords*: Self compacting Concrete, sisal fibres, Superplasticizer, fly Ash, Mix Design**

I. INTRODUCTION

Self- compacting concrete is a type of concrete, which is not a product of mixing substances having different properties but a combination of several mixes having the same flow characteristics. Usage of Self-Compacting Cements has increased tremendously in the past few years. SCC not only ensures a structure with robust characteristics but also helps in timely completion of building structures . Current Indian scenario in construction shows increased construction of large and complex structures, which often leads to difficult concreting conditions. SCC us the only solution for all such problems.

The Materials used in SCC are the same as in conventional concrete except that an excess of fine material and chemical admixtures are used. Also, a viscosity-modifying agent(VMA) will be required because slight variations in the amount of water or in the proportions of aggregate and sand will make the SCC unstable, that is, water or slurry may separate from the remaining material. The powdered materials are fly ash, silica fume, lime stone powder, glass filler and quartzite filler. The use of pozzolanic materials helps the SCC to flow better. The pozzolanic reaction in SCC, as well as in Conventional Slump Concrete (CSC), provides more durable concrete to permeability and chemical attacks. Sisal is used by industry in three grades:

- The lower grade fibre is processed by the paper industry because of its high content of cellulose and hemicelluloses.
- The medium grade fibre is used in the cordage industry for making: ropes, baler and binders twine. Ropes and twines are widely employed for marine, agricultural, and general industrial use.
- The higher-grade fibre after treatment is converted into yarns and used by the carpet industry.

The fibre is also used for non-woven matting, brushing and roving. The fibre is then washed and dried by mechanical or natural means. The dried fibre represents only 4% of the total weight of the leaf. Once it is dried the fibre is mechanically double brushed. The lustrous strands, usually creamy white, average from 80 to 120 cm in length and 0.2 to 0.4 mm in diameter.Sisal fibre is fairly coarse and inflexible. It is valued for cordage use because of its strength, durability, ability to stretch, affinity for certain dyestuffs, and resistance to deterioration in saltwater.

From ancient times sisal has been the leading material for agricultural twine because of its strength, durability, ability to stretch, affinity for certain dyestuffs, and resistance to deterioration in saltwater. Apart from ropes, twines and general cordage sisal is used in low-cost and specialty paper, dartboards, buffing cloth, filters, geotextiles, mattresses, carpets, handicrafts, wire rope cores and Macrame. Sisal fibers are great alternative to plastic. Woven floor covering, floor tiles, rugs, wall coverings, wainscoting and fabric panels, Handbags, shopping bags etc are now made from Sisal fibre.

Now sisal has been utilized as an environmentally friendly strengthening agent to replace asbestos and fiberglass in composite materials in various uses including the automobile industry. The lower grade fiber is processed by the paper industry because of its high content of cellulose and hemicelluloses. The medium grade fiber is used in the cordage industry for making: ropes, baler and binders twine. Ropes and twines are widely employed for marine, agricultural, and general industrial use. The higher-grade fiber after treatment is converted into yarns and used by the carpet industry.

Other products developed from sisal fiber include spa products, cat scratching posts, lumbar support belts, rugs, slippers, cloths and disc buffers. Sisal wall covering meets the abrasion and tearing resistance standards of the American Society for Testing and Materials and of the National Fire Protection Association. toothed, and gradually lose their teeth with maturity. Each leaf contains a number of long, straight fibers which can be removed in a process known as decortication. During decortication, the leaves are beaten to remove the pulp and plant material, leaving the tough fibers behind.

Fig:1 Sisal plant

II. LITERATURE REVIEW

2.1 Hajime Okamura and Masahiro Ouchi (2003)

The authors report that self-compacting concrete was first developed in 1988 to achieve durable concrete structures and since then, various investigations have been carried out and this type of concrete has been used in practical structures in Japan, in order to shorten the construction period by large-scale constructions, such as, the anchorages of Akashin-Kaikyo (Akashi Straits) Bridge opened in April 1988, and a suspension bridge with the longest span in the world(1,991 meters) is a typical example (Kashima 1999). It is further reported that, SCC was used for the wall of a large LNG tank belonging to the Osaka Gas Company and the adoption of SCC in this project resulted in :

1) Decrease of the construction period of the structure from 22 months to 18 months
2) Reduction of the number of concrete workers from 150 to 50
3) Decrease of the number of lots from 14 to 10 as the height of one lot of concrete was increased.

The authors noted that when self-compacting concrete becomes so widely used that it is seen as the "Standard Concrete" rather than a "Special Concrete", it will have succeeded in creating durable and reliable concrete structures that require very little maintenance work.

2.1.1 R.Sri Ravindrarajah, D.Siladyi and B. Adamopoulos (2003)

This paper reports an investigation into the development of self-compacting concrete with reduced segregation potential. The self-compacting concrete mix having satisfied the criterion recognized by the differential height method is modified in many ways to increase the fine

particle content by replacing partially the fine and coarse aggregates by low-calcium fly ash. It is reported that the systematic experimental approach showed that partial replacement of coarse and fine aggregate could produce self-compacting concrete with low segregation potential as assessed by the V-Funnel test. It further reports the results of bleeding test and strength development with age and concludes that fly ash could be used successfully in producing self-compacting high strength concrete with reduced segregation potential.

2.1.2 Amit Mittal, Kaisare M.B and Shetty R.G (2004)

Self-compacting concrete is suitable for the concreting congested reinforcement structures or where the access is difficult for concreting. The authors in their topic "Use of SCC in a pump house at TAPP 3 & 4 Tarapur", explained in brief the methodology adopted for the design and testing of SCC mixes and the methods adopted for concreting walls and structures housing a condenser cooling water pump at Tarapur Atomic power project 3 & 4 (TAPP).

2.1.3 Frances Yang (2004)

The author in his report describes the self-consolidating concrete as a concrete that exhibits high deformability while maintaining resistance to segregation. This paper investigates the technology behind creating SCC including its components and mix proportioning techniques. It highlights numerous benefits in using SCC and refers to various tools used to parameterize its properties. Further, it reports the precautionary measures that should be taken for developing and working with the mix, and lists some exemplary applications of SCC, such as, Toronto International

Airport, where concrete had to be pumped upwards from the ground to form 101 foot tall columns. In the US, a high strength SCC was imperative for constructing tightly reinforced elements poured in below freezing weather for the 68 Story Trump Tower in New York city.

In conclusion, the author states that self-consolidating concrete is an exciting technology that has found many successful applications. However, he cautioned that educating manufacturers and contractors is the crucial step in expanding the use of SCC's extremely promising technology.

2.1.4 Anne-Mieke Poppe and Geert De Schutter (2005)

In this research, results pertaining to the creep and shrinkage of SCC are reported. Comparison of experimental results were made with some traditional models and it is shown that the ACI model gives accurate prediction. The models suggested by "Delarrard" and "Model Code"

resulted in underestimation of the deformations. The use of SCC requires no extra precautions while considering the shrinkage and creep of the structure.

2.1.5 Cho-Lung Hwang And Chich-Ta-Tsai (2005)

Three different types of aggregate packing and five different paste contents with 1.2,1.4, 1.6, 1.8, and 2.0 % of voids within aggregate were major parameters for the evaluation the properties of SCC. The results indicate that better workability and engineering properties undersufficient paste content were obtained with denser aggregate packing. The Densified Mixture Design Algorithm (DMDA) for designing the SCC for different aggregate packing types can give a high flow ability.

The strength efficiency of self-compacting concrete designed by DMDA method is much higher than the traditional one.

2.1.6 "The European Guidelines for Self–Compacting Concrete" (2005)

These guidelines were prepared by a project group comprising five European Federations which were dedicated to the promotion of advanced materials and systems for the supply and use of concrete. The Self-Compacting Concrete European Project Group was founded in January 2004 with representatives from:

BIBM: The European Precast Concrete Organization

CEMBUREAU: The European Cement Association

ERMCO: The European Ready-Mix Concrete Organization

EFCA: The European Federation of Concrete Admixture

Associations

EFNARC: The European Federation of Specialist Construction Chemicals and Concrete Systems

These guidelines represent a state of the art document addressed to those specifiers, designers, purchasers, producers and users who wish to enhance their expertise and use of SCC. The Guidelines have been prepared using the wide range of experience and knowledge available to the European Project Group. The proposed specifications and related test methods for ready-mixed and site-mixed concrete are presented intending to facilitate standardization at European level. The approach is to encourage increased acceptance and utilization of SCC.

"The European Guidelines for Self-Compacting Concrete" defines SCC and many of the technical terms used to describe its properties and use. They also provide information on standards relating to testing and to associated constituent materials used in the production of SCC.

The guidelines are drafted with an emphasis on ready-mixed and site mixed concrete where there are requirements between supplier and user in relation to the specification of the concrete in both fresh and hardened states. In addition, the guidelines cover specific and important requirements for the user of SCC regarding the site preparation and methods of placing where these are different from traditional vibrated concrete.

III. PRODUCTION OF SCC

Based on the original conception of Okamura and Ozawa, in general three types of SCC can be distinguished:

3.1 Powder type self compacting concrete: This is proportioned to give the required self -compatibility by reducing by reducing the water-powder (material < 0.1mm) ratio and provide adequate segregation resistance. Super plasticizers and air entraining admixtures give the required deformability.

*3.2 Viscosity agent type self- compacting concret*e: This type is proportioned to provide self compaction by the use of a viscosity modifying admixture to provide segregation resistance. Superplasticizers and air entrainment admixtures are used for obtaining the desired deformability.

3.3 combination type self- compacting concrete: This type is proportioned so as to obtain self- compatibility mainly by reducing the water powder ratio, as in the powder type ,and a viscosity modifying admixture is added to reduce the quality of fluctuation of the fresh concrete due to the variation of the surface moisture content of the aggregates and their gradations during the production .This facilitates the production control of the concrete.

IV. APPLICATION OF SISAL FIBER

From ancient times sisal has been the leading material for agricultural twine because of its strength, durability, ability to stretch, affinity for certain dyestuffs, and resistance to deterioration in saltwater.

1. Sisal is used commonly in the shipping industry for mooring small craft, lashing, and handling cargo.
2. It is also surprisingly used as the fibre core of the steel wire cables of elevators, being used for lubrication and flexibility purposes. Traditionally sisal was the leading material for agricultural twine or baler twine. Although this has now been overtaken by polypropylene.

3. It is used in automobile industry with fiberglass in composite materials.
4. Other products developed from sisal fiber include spa products, cat scratching posts, lumbar support belts, rugs, slippers, cloths and disc buffers.
5. Sisal is used by itself in carpets or in blends with wool and acrylic for a softer hand.

V. COMPONENTS OF SCC

5.1. Cement:- Generally Portland cement is used for SCC.

Table(1): Properties of Cement

Grade	**OPC 53 Grade**
Manufacturer	Ramco cement
Specific gravity	3.14
Fineness	5%
Standard consistency	26.75%
Initial setting time	115
Final setting time	295

5.2 Aggregates:-The maximum size of aggregate is generally of size 10 limited to 20mm . Well graded cubical or rounded aggregate are desirable. Aggregates should be of uniform quality with respect to shape and grading.

Fine aggregate can be natural or manufactured. The grading must be uniform throughout the work. The moisture content or absorption characteristics must be closely monitored as quality of SCC will be sensitive to such changes. Particles smaller than 0.125mm i.e. 125 micron size are considered as FINES which contribute to the powder content.

5.3 Mixing water:-Ordinary potable water of normally pH 7 is used for mixing and curing the concrete specimen.

5.4 Admixtures for SCC:-An admixture is a material other than water, aggregates and cement and is added to the batch immediately before or during its mixing. Admixtures are used to improve or give special properties to concrete. The use of admixture should offer an improvement not economically attainable by adjusting the proportions of cement and aggregates and should not adversely affect any properties of the concrete.

5.5 Chemical Admixtures:-Superplasticizer:

Glenium B233 is used because it is essential component of SCC to provide necessary workability.

Table(2):Properties of Glenium B233

Aspect	Light brown
Relative density	1.09 ± 0.01 at 25°C
pH	>6

Fig:2 Glenium B233

5.7 Mineral Admixtures:

Fly Ash: - Fly ash in appropriate quantity may be added to improve the quality and durability of SCC.

5.8 Sisal Fibre:

To enhance the SCC ductility, some mixes were produced with micro-fibres of sisal fibre 12 mm in length and 0.2 mm in diameter.

Fig:3 sisal fibre

Name of fiber	Fiber type	Flame reaction	Color	After Burn order
Sisal	Cellulose fiber	May flair when lit, burn	Soft gray ash	Burning paper or grass

Table 3: Identification of sisal fibres

VI. FRESH PROPERTIES OF SCC

The Fresh properties of SCC in are

1. Filling ability (excellent deformability)
2. Passing ability (ability to pass reinforcement without blocking)
3. High resistance to segregation.

6.1.1. Filling ability

It is the ability of SCC to flow into all spaces within the formwork under its own weight. Tests, such as slump flow, V-funnel etc, are used to determine the filling ability of fresh concrete.

6.1.2. Passing ability

.It is the ability of SCC to flow through tight openings, such as spaces between steel reinforcing bars, under its own weight. Passing ability can be determined by using U-box, L-box, Fill-box, and J-ring test methods.

The mechanisms that govern this property are the viscosity and cohesion of the mixture.

6.1.3 High resistance to segregation

The SCC must meet the filling ability and passing ability with uniform composition throughout the process of transport and placing.

Table 4:Chemical Composition of sisal fibres

Cellulose	65%
Hemicelluloses	12%
Lignin	9.9%
Waxes	2%
Total	100%

VII. TEST METHODS

7.1 Slump Flow Test.

The slump flow is used to assess the horizontal free flow of SCC in the absence of obstructions. It was first developed in Japan for use in assessment of underwater concrete. The test method is based on the test method for determining the slump. The diameter of the concrete circle is a measure for the filling ability of the concrete

7.2 L box test method

The test assesses the flow of the concrete, and also the extent to which it is subjected to blocking by reinforcement

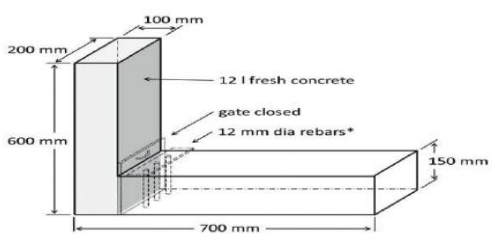

Fig:4 L BOX

7.3 V Funnel Test :

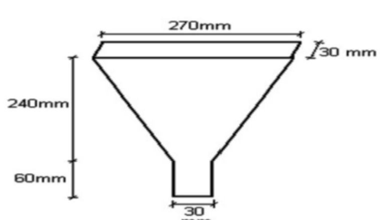

Fig: 5 V FUNNEL

The described V-funnel test is used to determine the filling ability (flow ability) of the concrete with a maximum aggregate size of 20mm. The funnel is filled with about 12 liter of concrete and the time taken for it to flow through the apparatus measured. After this the funnel can be refilled concrete and left for 5 minutes to settle. If the concrete shows segregation then the flow time will increases significantly.

VIII. MIX DESIGN

Step 1.

Maximum size of aggregates = 12mm

Specific gravity of cement = 3.08

Specific gravity of fine aggregate = 2.41

Specific gravity of coarse aggregate = 2.71

Target men strength Fck = Fck + 1.65 s

For M40 grade standard deviation , s = 6.6 (IS-10262)

Fck = 40 + 1.65 * 6.6 = 50.89 N/mm2

Step 2. selection of w/c ratio:

From fig 1 in IS-10262-1982 for 50.89 N/mm2 it is 0.31

For durability aspect maximum w/c ratio for moderate exposure is 0.6 (IS-456-2000)

The lesser value of the above two value has to be adopted.

Hence 0.31 is selected.

From table 5 of IS:10262-1982 the water cement per cubic meter of concrete .

Water content =192 kg/m3

w/c ration = 0.31

workability = 0.8cf

cement = 6.32 kg/m3

As per durability minimum cement content for moderate exposure is 272 kg/m3

As per scc mix specification the cement is limited to 500 kg/m3 for medium grade concrete.

Water	= 196	- 0.39
Cement	= 500	- 1
Fine aggregates	= 425	- 0.85
Coarse aggregates	= 1095	– 2.19

Converting into SCC proportion:

The normal mix proportion are modified as per EFNARC Specifications and different trail mixes were casted .by considering the fresh proportion we finally arrived at following mix proportions.

The w/c ratio limited to = 0.38

Cement taken = 500kg/m3

Water = 190

For 50% of TA as FA

FA =1520*50/100 = 760 Kg/m3

CA =TA – FA

= 1520 – 760

= 760 Kg/m3

The modified SCC proportion

Water = 190 Kg/m3 - 0.38

Cement = 500 Kg/m3 - 1

Fine aggregate = 760 Kg/m3 - 1.52

Coarse aggregate = 760 Kg/m3 - 1.52

IX. TRIAL MIXES

Table:(4) Mix proportion

WATER CONTENT (Kg/m3)	CEMENT (Kg/m3)	FLYASH (Kg/m3)	FINE AGGREGATE (Kg/m3)	COARSE AGGRE-GATES (Kg/m3)	Glenium B23 (Kg/m3)
196	375	125	425	1095	10
190	375	125	500	1020	6
190	375	125	650	870	5
210	375	125	760	760	1.5
225	375	125	760	760	0.75

X. EXPERIMENTAL PROCEDURE

The ingredients of SCC were weighed according to the mix proportion. The water cement ratio taken as 0.31. The required quantity of water was calculated and added thoroughly to get a fine paste. To this various % of superplasticizer was added and mixed thoroughly. The entire mix was thoroughly mixed once again. At this stage, almost the concrete was in a flowable state. Now, the flow characteristic experiments for self compacting concrete like slump flow test, V-funnel test and L-box test were conducted. After conducting the flow characteristic experiments the concrete mix was poured in the moulds required for the strength assessment. After pouring the concrete into the moulds, no compaction was given either through vibrated or through hand compaction.20 cubes were casted for compressive strength and 20 cylinders were casted for split tensile test. Even the concrete did not require any finishing operation. After 24 hours of casting, the specimens were de moulded and were transferred to the curing tank wherein they were allowed to cure for7 & 28 days. For compressive strength assessment, cubes of size 150mmX150mmX150mm were prepared. Indirect tension test (Brazilian test or split tensile test), was carried on these cylindrical specimens. After7day & 28 days of curing the specimens were tested for their respectively strengths

XI.TEST RESULTS

11.1 Fresh Properties of Concrete: Fresh properties of SCC are carried out to check the the optimum percentage of superplasticizer and percentage addition of fibres. The following tests are conducted for fresh concrete

1. T500&Slump Flow Test
2. V funnel Test
3. L Box Test

Table:5. slump flow test

Trial no.	% of SP	T 500mm	Slump flow
		(2-5 sec)	(600-800 mm)
1	0.15	5.7	630
2	0.2	8	580
3	1	15	560
4	2	24	510

Table:6. V funnel TEST :

Trial mix	%of Superplasticizer	V-Funnel (6 -12)sec
1	0.15	9
2	0.2	14
3	1	28
4	2	31

Table: 7.L BOX TEST :

Trial mix	% of Superplasticizer	L Box(0.8-1)
1	0.15	0.812
2	0.2	0.75
3	1	0.72
4	2	Blockage

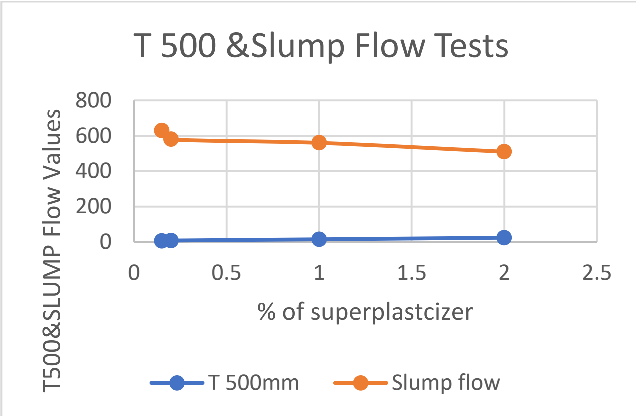

Fig:6 slump flow result

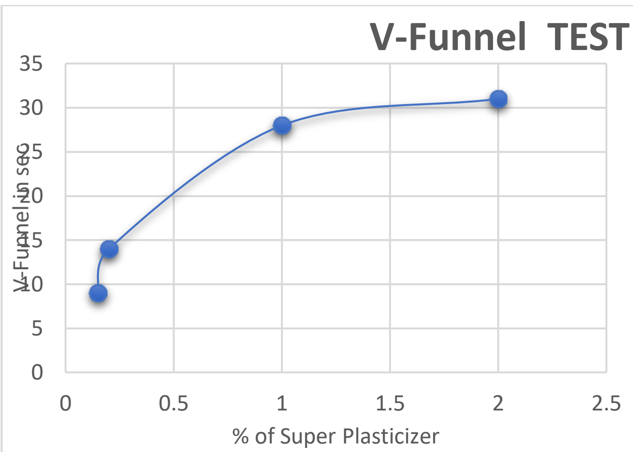

Fig:7.V funnel Test Results

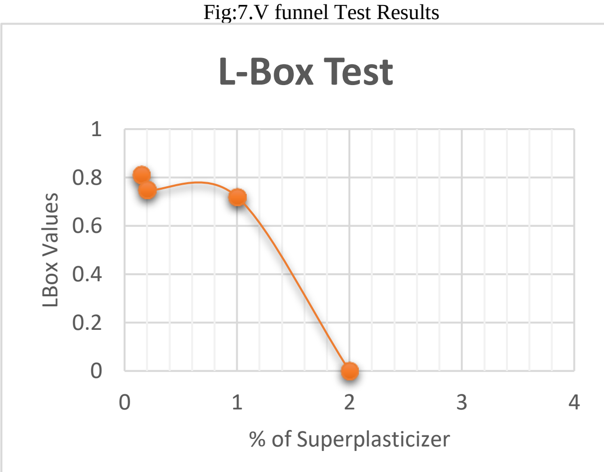

Fig:8 L-Box Test Result

11.2 Hardened Properties of Concrete:

The hardened properties of concrete such as compressive strength &split Tensile Strength of SCC were checked.

Table: 9 Compressive Strength Test Result

Table:9 Split Tensile Strength Test Result

% OF SISAL FIBRES	FAILURE LOAD (KN)		COMPRESSIVE STRENGTH (Mpa)	
	7 DAYS	28 DAYS	7 DAYS	28 DAYS
SCC	568.3	877.5	23.4	39
0.5%	537.6	896	23.88	39.8
1%	580.5	967.5	25.8	43
1.5%	602.42	1005.7	26.82	44.7
2%	553.5	922.5	24.6	41

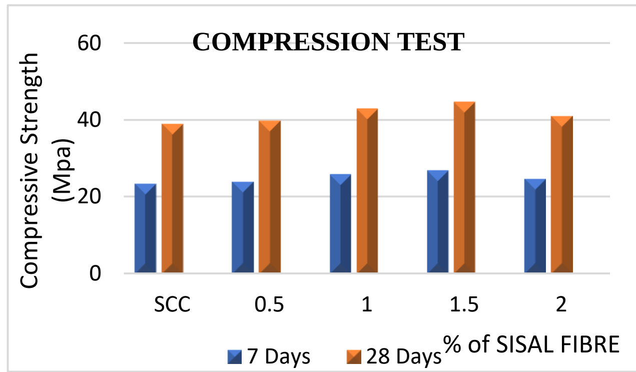

Fig:9 Compression Test Result

% OF SISAL FIBRES	FAILURE LOAD (KN)		SPLIT TENSILE STRENGTH (Mpa)	
	7 DAYS	28 DAYS	7 DAYS	28 DAYS
SCC	327.9	541.45	2.32	3.83
0.5%	339.2	562.6	2.40	3.98
1%	356.2	607.89	2.52	4.3
1.5%	381.7	626.27	2.70	4.43
2%	343.53	565.48	2.43	4.05

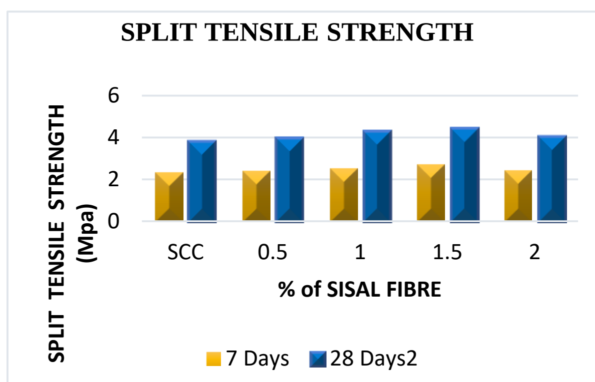

Fig10: Split Tensile Strength test (Mpa)

XII. CONCLUSION

We found out that the compressive as well as split tensile strength of the specimen was maximum at 1.5%..At 28 days was maximum when the percentage of fibre used was 1.5 % after which there was a decrease in the strength with addition of fibres. The superplasticizer percentage increases the fresh properties of SCC started decreasing The optimum percentage of superplasticizer found to be 1%. Compressive strength increased by almost 45% and split tensile strength increased by almost 5% after the addition of 1.5% fiber. Split tensile strength of SCC with sisal fiber in comparison to plain SCC is found 50% more respectively addition of fibers is significantly affecting the splitting tensile strength. Addition of sisal fiber at particular volume fraction is found not to affect the workability of SCC. SCC is easily mixed with sisal fibers, although while casting some of the samples, workability of Reinforced SCC mix can be improved by using lower percentage of fibers. Addition of sisal fibers does not affect the finish ability of SCC outer surface of concrete after casting was as smooth as plain SCC

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