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Studies on Properties of Sisal Fiber Reinforced Self Compacting Concrete

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Abstract: To evaluate the mechanical properties of self compacting concrete (M30) with sisal fibers.Self-compacting concrete (SCC) mixes are produced by replacing the cement with Fly ash and with addition of sisal fiber of 0, 0.5%, 1%, 1% and1.5% and length of fibers considered are 5mm, 10mm, and 20mm to the SCC concrete. Sulphonated naphthalene Formaldehyde condensates based SP is used as water reducing agent. Compressive strength and Flexural strength of SCC mix has to be determined at 14 and 28 days. Impact strength of SCC mix has to be determined at 28 days.

I. REVIEW OF EARLIER STUDIES

Ahmed (2013), investigated Properties And Mesostructural Charecteristics Of Linen Fiber Reinforced Self Compacting Concrete In Slender Column. In this study the linen fibers used to reinforced SCC with 2kg/m3 and 4kg/m3 contents. Lime stone powder is used as a mineral admixture to increase the paste volume. High range water reducing admixture RHEOBUILD 1100 was used to obtain the required workability without increasing w/c ratio.

Mansur and Aziz(1982) investigated A study of jute fibre reinforced cement composites: This study was centred at determining the tensile, flexural, compressive and impact strengths of the matrices and composites. Three different matrices corresponding to cement sand ratios of 1:0, 1:1 and 1:2 were employed. The major variables were the length and volume fraction of the fibres. Badrinath and Senthilvelan (2014), investigated Comparative Investigation on mechanical properties of banana and sisal reinforced polymer based composites In this study sisal fiber and banana fibers have been used as the main reinforcing materials with epoxy resin as the matrix in order to increase the effectiveness of natural fibers.

Jayaram et al (2014), investigated Experimental Investigation Of Hybrid Fiber Reinforced Concrete In this study addition of two fibers (Sisal & glass)of different properties can improve the properties of fresh concrete. *Nan su (2001),*investigated A Simple Mix Design Method For Self Compacting Concrete In this study a new mix design method for self-compacting concrete (SCC).

The amount of aggregates, binders and mixing water, as well as type and dosage of superplasticizer (SP) to be used are the major factors influencing the properties of SCC. Slump flow, V-funnel, L-flow, U-box and compressive strength tests were carried out to examine the performance of SCC. The result indicate that the compressive strength of SCC decreased with increasing Packing Factor value. In this design method, the volume of sand to mortar is in the range of 54–60%. The water content of SCC prepared by the proposed method is about 170–176 kg/m3 for the medium compressive strength. PF=1.12–1.16 Muthupriya et al (2014), investigated Strength Study On Fiber Reinforced Self Compacting Concrete With Fly ash and GGBS In this Investigation the strength studies of fiber reinforced self-compacting concrete was studied. Self-compacting concrete (SCC) mixes are produced by replacing the cement with 30%, 40% and 50% of ground granulated blast furnace slag, fly ash and with addition of polypropylene synthetic fiber of 0.05% and 0.10% to the SCC concrete.

Elinwa, Ejeh and Mamuda (2007), investigated Assessing of the fresh concrete properties of self-compacting concrete containing sawdust ash:**.**The aim of this study is to determine the self-compacting characteristics for concrete containing sawdust ash. Burcu Akcay, Mehmet Ali Tasdemir(2011*),* investigated Mechanical behaviour and fibre dispersion of hybrid steel fibre reinforced self-compacting concrete.In this study five different concrete mixes were prepared keeping the cement, silica fume, aggregate and water content the same and varying the amount of steel fibre.

El-Dieb and Reda Taha(2001) investigated Flow characteristics and acceptance criteria of fibre reinforced self-compacting concrete This paper states that the flow characteristics of SCC can be affected by inclusion of fibres, but it is quite possible to achieved self-compacting properties while using fibre reinforcement. In this study different mix compositions were investigated to optimize the mix proportioning of SCC. Three reference mixtures were selected from this study and they were incorporated with five different fibre contents. Several tests such as slump flow, V funnel, J ring, and L box tests were carried out in order to properly evaluate the different flow characteristics of FRSCC. The paper concludes that while the mix composition and fibre type can greatly influence concrete flowability, there exists a maximum fibre content that could be used to produce FRSCC

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Khatib(2007), investigated Performance of self-compacting concrete containing fly ash In this paper the author discussed the need for super plasticizer and role of fly ash in the matrix. In the present work selected properties of SCC containing FA at constant water binder ratio of 0.36 were investigated. The properties comprised workability, density, compressive strength, absorption, ultrasonic pulse velocity and drying shrinkage. According to this paper chemical admixtures are necessary to increase the workability and reduce segregation. The large amounts of powder in SCC such as fly ash, GGBS, are necessary to avoid gravity segregation of larger particles in the fresh mix. High percentages of FA can be used to produce SCC with an adequate strength. Incorporation of increasing amounts of FA in SCC can reduce drying shrinkage.

II. SUMMARY OF LITERATURE

1) From the extensive review of work carried out on SCC and FRC, few works are done in the combination of SCC with steel fibres.
2) In the literature work on natural fibre reinforced conventional concrete was investigated by many authors, in terms of workability and strength. But with respect to the natural fibre reinforced self-compacting concrete, so far no work was carried out, on workability, strength and the durability.
3) With this study it is possible to eliminate the problems of balling effect due to natural fibres in the concrete. As compared to the steel fibres, the natural fibres are lighter to move along with the flow of the matrix and hence the distribution is uniform. Hence in the present study Sisal fibre reinforced self-compacting concrete are studied in terms of workability and strength.

A. *Need For Study*

1) Due to its unique specification, SCC may contribute significantly towards improving the quality of concrete structures.
2) Use of SCC offers several benefits to construction practise such as elimination of compaction, shortening of construction time, noise reduction, improved homogeneity and excellent surface quality.
3) SCC also has improved durability and offers greater freedom in design with a safer working environment.
4) Increase crack resistance, long term ductility, energy absorption capacity and toughness of concrete.

B. *Methodology*

1) Collection of required materials.
2) Investigation of physical properties for Cement, Fly ash, Fine aggregate and Coarse Aggregate, Sisal fiber.
3) Arriving mix proportions by checking the flow properties of SCC.
4) Casting of specimens.
5) Curing of specimens.
6) Testing of specimen at 28 days of age.
7) Correlation of the results.

III. MATERIAL PROPERTIES

A. *Cement*

Grade 43 ordinary Portland cement (OPC) confirming to IS: 12269-1987 has been used. The physical properties of the cement such as consistency, initial and final setting time and specific gravity were tested in accordance with IS: 4031-1968 and given in Table 3.1.

Physical Properties of Cement

Sl.no	Property	Value
1	Standard consistency	31%
2	Initial setting time	140min
3	Final setting time	245min
4	Specific gravity	3.1

B. *Coarse Aggregate*

The coarse aggregate used in the concrete mixtures was crushed stone of size 20mm and 12.5mm.It has a specific gravity of 2.75 and was determined according to IS:2380 (Part- 111) of 1963. The physical properties were also determined and given in Table 3.2.

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Physical Properties of Coarse Aggregates

Sl.No	Property	Value
1	Specific gravity	2.71
2	Fineness modulus	8.07
3	Bulk density	1320kg/m^3
4	Water absorption	1.5%

C. Fine Aggregate

Natural sand was used as fine aggregate with a maximum size of 4.75mm.The specific gravity of the fine aggregate is 2.63 and was determined according to IS:2386(Part-111) of 1963. Sieve analysis was performed on the fine aggregate according to IS: 383-1970. The physical properties are given in Table 3.3.

Physical Properties of Fine Aggregate

Sl.No	Property	Value
1	Specific gravity	2.63
2	Fineness modulus	3.49
3	Bulk density	1430 kg/m^3
4	Water absorption	1%

D. Fly ash

Fly ash of class F type having a specific gravity of 2.01 has been used in the present study. The fly ash is obtained from Ennore, Chennai.

E. Sisal Fibres

The Sisal fibre used in this investigation is locally available in processed form. These fibres are cut into pieces manually to a length of 5mm, 10mm, 20mm respectively. The extent of fibre content that can be used in FRSCC can be fixed either on the basis of volume of concrete or by the weight of the cement. Among these two, most of the investigators have adopted the fibre content based on the volume of the concrete. Hence in this experimental investigation also volume of concrete is considered for determining the fibre content. The fibre content adopted for the study is 0.5%, 1%, 1.5% volume of cement and fibre lengths 5mm, 10mm, 20mm were considered. The properties of sisal fibre are given in

Physical Properties of Sisal Fibre

Sl.no	Property	Results
1	Specific gravity	1.17
2	Water absorption in 24h	180%
3	Diameter	0.15mm
4	Max. tensile strength	62Mpa
5	Length	(30.5-47.5)mm

Various stages in processing of the Sisal Fibres

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F. Water

Ordinary potable water was used for the entire experimental investigation both for making and curing of specimens.

G. Admixtures

Super plasticizer by trade name SUPAFLO M was used. Supaflo M is a non-toxic brown liquid based on sulphonated naphthalene formaldehyde condensates. Supaflo M is a high range water reducing admixture for concrete and grouts confirming to BS: 5075 (Part-3) and ASTM C-494 type F as per manufacturer‘s data. It was used to produce high strength concrete and flowing concrete without addition of water.

IV. PREPARATION AND TESTING OF SPECIMENS

Mix Proportion of SCC

Sl. No	Cement (kg/m^3)	Fly Ash (kg/m^3)	C.A (kg/m^3)	F. A (kg/m^3)	Water (kg/m^3)	SP (kg/m^3)	Slump Flow Value (mm)	V-Funnel Value (sec)	J-Ring Value (mm)
1	385	150	760	885	210	8.5	670	10	6

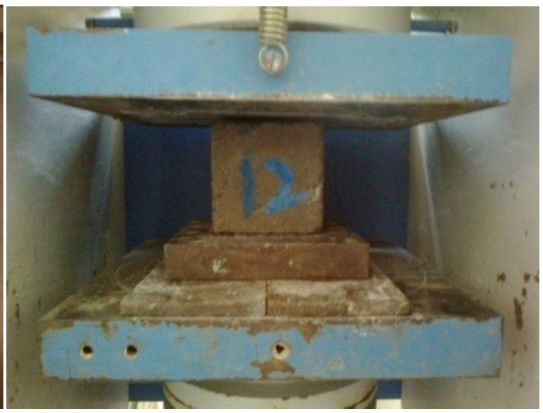
A. Hardened Properties of SFRSCC

Compressive strength was determined using 3000 KN capacity compression testing machine and the Flexural strength is determined by using Wood testing machine provided with Proving ring of 100 N capacity. The above tests are carried out in accordance with IS specifications. (IS: 516-1956 “Method of tests for strength of concrete”). The experimental test setups used for Compressive strength, Flexural strength and Impact strength are shown in Fig 3.5

Slump Flow test Setup

V-Funnel test Setup

Compressive strength test setup



J-Ring test Setup

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Flexural strength test setup

Impact strength test setup

B. Compressive Strength Of SFRSCC

The concrete specimens were tested for compressive strength after 14 and 28 days of water curing. The variation of compressive strength with respect to the fibre content. From the results following are the inferences.

1) The maximum compressive strength is obtained when the fibre content is 0.5%.
2) The percentage increase in compressive strength is 5% with respect to the reference mix.
3) The occurrence of maximum compressive strength (i.e., 0.5%) is same at 14 days and 28days of curing.
4) Across the age of curing i.e., from 7days to 28days, the compressive strength was increased in the range of 2% to 5%, which corresponds to the respective fibre content.
5) The reduction in the compressive strength at 1.5% fibre content is due to the formation of uneven surface/honey combs, while casting the cube elements. This uneven surface/honey combing causes development of micro cracks and ultimately crushes the cube in the early hours of compressive loads.
6) Within the limit, it is found that at the fibre content of 1%, the compressive strength is equal to the reference SCC compressive strength.

Compressive Strength Values of SFRSCC

Sl.No	Fibre content		Compressive Strength @ 14 days (N/mm^2)	Compressive Strength @ 28 days (N/mm^2)
	%	Aspect ratio		
1.	0	0	30.2	40.1
2.	0.5	33	31.2	42.3
		66	32.2	41.5
		133	29.1	32
3.	1	33	30.4	43.6
		66	33.6	43
		133	22	22
4.	1.5	33	25	35
		66	27	30
		133	20	26

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C. Flexural Strength of SFRSCC

The concrete specimens were tested for Flexure strength after 28 days of water curing. The test results are given in the Table 4.4.The variation of flexural strength with respect to the fibre content From the results, following inferences were drawn.

1) The maximum flexural strength is obtained when the fibre content is 0.5%.
2) The percentage increase in the flexural strength is 8.5% with respect to the reference mix and the aspect ratio increased the flexural strength is decreased.
3) At the maximum fibre content of 1%, the increase in flexural strength is 2% with respect to the reference SCC.
4) At the aspect ratio of 33 the strength is 8.5% increased than reference SCC and above 33 aspect ratio the strength is 2% is increased than the reference SCC.
5) The observation in the using of sisal fibre in SCC at three different fiber volume and three different aspect ratios minor fractures only occur after loading compare to reference SCC.

Flexural Strength Values of SFRSCC

Sl. No	Fibre content		Flexural Strength @ 28 days (N/mm^2)
	%	Aspect ratio	
1.	0	0	5.86
2.	0.5	33	6.36
		66	6.24
		133	6.19
3.	1	33	5.92
		66	4.35
		133	3.88
4.	1.5	33	3.82
		66	3.06
		133	2.91

D. Impact Strength of SFRSCC

The impact strength was conducted and the results are shown in Different type of failure pattern was observed for different fibre content of concrete. The type of failure pattern is visible from the following figures.

1) The maximum impact strength is obtained when the fibre content is 1.5%.
2) The percentage increase in impact strength is 93.5% with respect to the reference mix.
3) The reduction in the impact strength at increasing the aspect ratio of fibres is due to the formation of uneven surface/honey combs, while casting the cube elements. This uneven surface/honey combing causes development of micro cracks and ultimately crushes the cube in the early hours of impact loads.

The fractured specimen of SFRSCC

Impact Strength Values of SFRSCC

Sl.No	Fibre content		No.of blows		Impact Strength @ 28days (Joules)	
	%	Aspect ratio	Initial crack	Final crack	Initial crack	Final crack
1.	0	0	10	15	401	601
2.	0.5	33	23	25	922	1003
		66	19	23	762	922
		133	4	7	660	720
3.	1	33	24	28	962	1123
		66	10	13	762	944
		133	9	12	546	780
4.	1.5	33	27	29	1083	1163
		66	20	24	802	962
		133	5	9	512	795

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V. CONCLUSIONS

A. In the present investigation the maximum sisal fibre content can be used in SCC is 1%, where the slump flow is 17.24% less than the reference slump flow value.

B. At the sisal fibre content of 1.5%, the mix proportion of SCC for M30 grade of concrete has to be revised especially with respect to the finer portions of the mix, so that the mix will be consistent, without separation of sisal fibres from the cement matrix.

C. The maximum compressive strength of SFRSCC is at 0.5% fibre content and it is 10% higher than that of the compressive strength of reference mix of SCC.

D. Across the age of curing from 14 days to 28 days of the SFRSCC, there is no loss of strength. Instead the compressive strength improved in the range of 4% to 10%. Hence the sisal fibre are durable in alkaline environment.

E. The maximum impact strength of SFRSCC is at the aspect ratio of 33 and at 0.5%, 1%, 1.5% fibre content and it is 93.5% higher than that of the impact strength of reference mix of SCC.

F. The maximum flexural strength of SFRSCC is at 0.5% fibre content and it is 8.53% higher than that of the flexural strength of reference mix of SCC.

G. Within the limit of study, where in without affecting the slump flow and strength of the composite, it is possible to use a maximum sisal fibre content of 1%.

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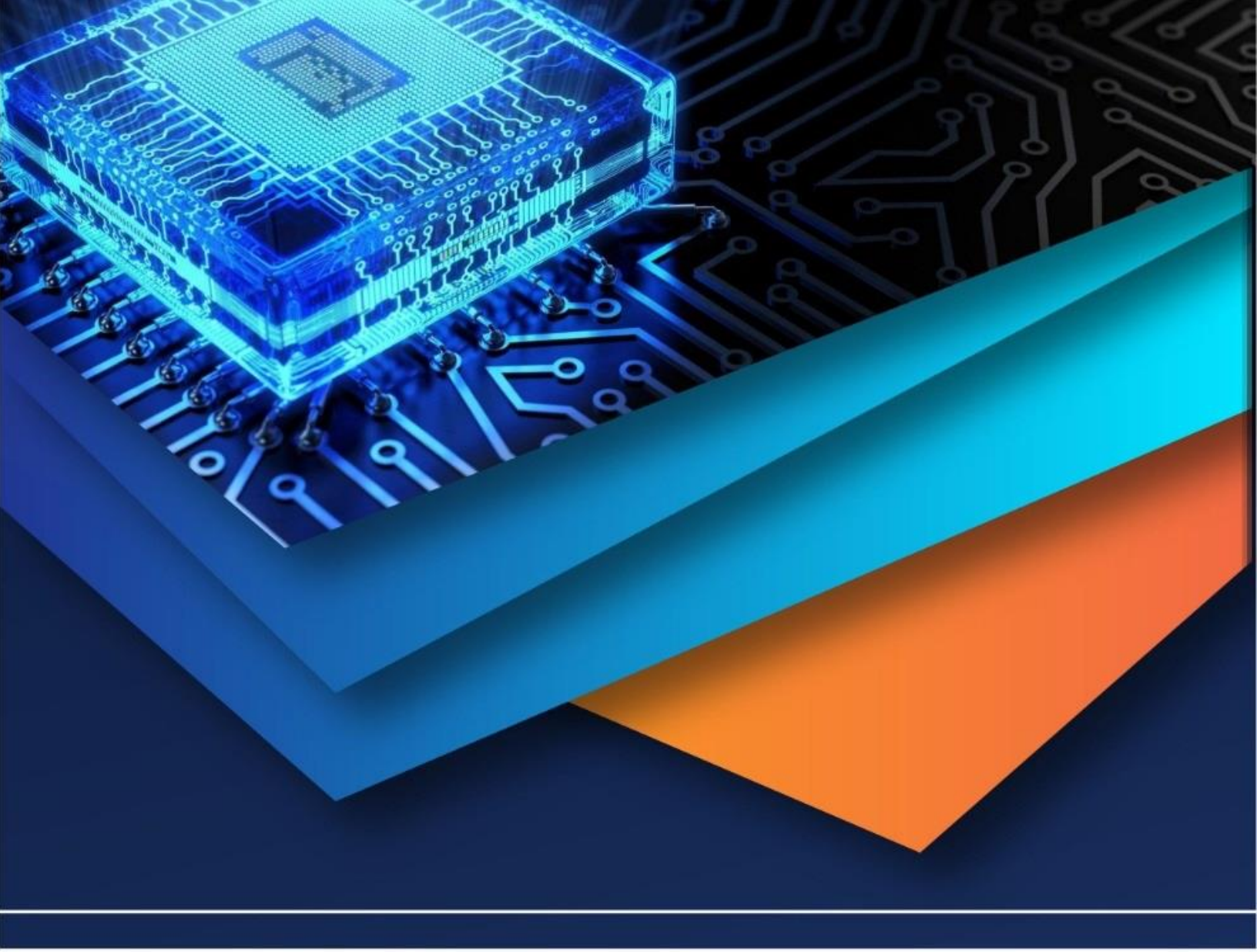

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