Journal of Harbin Engineering University
ISSN: 1006-7043

Vol 45 No. 11
November 2024

Experimental Analysis of Strength and Durability Properties of Self Compacting Concrete with Steel Fibre – Comparision

S Anil Kumar[1, *], Konduru Anand[1], Shruthi V. M[1], Angadi Venkata Krishna[1],S Raj Kamal
[1] Department of Civil Engineering, Ashoka Women's Engineering College, Kurnool, AP, India

Abstract:
Self-compacting concrete (SCC) is a flowing concrete that greatly improves flow ease and rate by using super plasticizers and stabilizers. Without separating the coarse aggregate, it compacts into every portion of the mold or formwork with just its own weight.The current study focuses on the durability SCC of two phases. SCC mixes with and without steel fibers for the various grades (M20, M30, M40 and M60) are created in the first phase.Initial Surface Absorption Test (ISAT) and Chemical Resistance were used to assess the Steel Fiber Reinforced Self Compacting Concrete (SFRSCC) blends durability performance in addition to their compressive strength. The mechanical properties like compressive strength of the different grades were studied.It can be seen that the 28 days compressive strength of plain SCC mixes like M20, M30, M40 and M60 are 26.8 MPa, 38.8 MPa, 51.1 MPa and 66.8 MPa. When Steel fibers are added, the strength observed is 29.6 MPa, 42.4 MPa, 53.6 MPa and 68.4 MPa that are, an increase of 10.44%, 9.27%, 4.89% and 2.39%.

Introduction

Self- compacting concrete is a self- consolidating concrete defined as a concrete which is able to flow under it s self-weight and to fill the formwork incomplete, even in the presence of dense reinforcement, without using any vibration actions, whilst maintaining homogeneity. It was originally first developed in Japan, to overcome the problems caused by lack of complete and uniform compaction through vibrators. Self-compacting concrete is not affected by the shape and quantum of reinforcing bars or the enactment of a structure and, due to its high-property of flowing it easily a changeable quality and resistance to segregation it can be long distances (Bartos, 2000). Okamura (1997) was the model of SCC can be proposed in 1986, but the model was developed in 1988 in Japan, by Professor Ozawa (1989) at the University of Tokyo. This concrete was developed at that time to improvement the durability characteristics of concrete structures.

However, the Bureau of Indian Standards (BIS) has not brought out a standard mix procedure although number of agencies and researchers carried out extensive investigations to establish rational mix design procedure sand self-compatibility testing methods. Since then different research works have been carried out and SCC has been used in practical structures in Japan, mainly by large companies. Investigations for establishing a rational-mix design method and self-compatibility testing methods have been carried out from the viewpoint of making a standard concrete.

Concrete is cast, so there is no additional inner or outer vibration is necessary for the compaction. It flows like a "honey" and as a very smooth surface level after placing of the SCC. With this quantify to its mixture, this concrete consists of materials like in conventionally vibrated concrete, which are cement, aggregates and water, with the adding of mineral and chemical admixtures in same as another proportions. Usually, the chemical admixtures such as high-range of water reducers (Super Plasticizer) and viscosity modifying agents, which change the rheological properties of concrete are used. Mineral admixtures are used as an extra fine material besides cement, and some cases, they replace cement. In this study cement content was partially replaced with mineral admixture, i.e., fly ash. Admixtures that are improve the flowing and strength and durability properties of concrete.

Gao Peiwei. et al (2000) The traditional concrete, which is made up of three ingredients cement, aggregates and water are used for a long time. High Performance Concrete (HPC), which is the new generation of concrete, it became a popular in the concrete construction field, using of the mineral admixtures, chemical admixtures and Viscosity Modifying Agents (VMA) are need apart from cement, aggregates and water. The result is compared with the present-day concrete is to reduce the cement in the HPC. Raghu Prasad et al. (2004) According these authors both initial and final setting times are getting delayed because of using of the admixtures. This is due to the slow pozzolanic reaction caused by the addition of some admixtures. They reported that this type of delayed setting sometimes beneficial during the concreting in hot weather. There will be considerable strength development for blended cements and concretes for longer periods beyond 28 days. Lachemi M, Hossain K.M.A (2004) usage of Viscosity Modifying Agents (VMA) has been proved to be very effective in stabilizing rheology of the Self-Compacting Concrete (SCC). The suitability of four types of polysaccharide-based Viscosity Modifying Admixtures in development of Self-Compacting Concrete (SCC) mixes has been examined. The studies on the new types of VMA are encouraging in the development of satisfactory SCC mixes with fresh and hardened properties which are comparable to or even better than those made with commercially available VMA and Welan gum. The suggested new Type of VMA with 0.05% of dosage satisfies the fresh and hardened properties. Kuroiwa (1993) developed a new type of concrete, in these concrete materials commonly used in conventional concrete, that is, cement, aggregates, water and admixtures. The chemical admixtures are used to improve the deformability and viscosity properties of the concrete. The newly elaborate concrete can be known as super-workable concrete. This has shown considerable resistance to segregation and deformability. It also filled heavily reinforced form works completely without the use of any vibrators. The laboratory tests were showed that the super-workable concrete has superior fresh and hardened state properties with improved durability. This concrete was considered to be suitable for structures having heavy reinforcement areas and used in the construction of twenty-storied buildings.

T Seshadri Sekhar, P Sravana and P Srinivasa Rao (2005) investigated on SCC mixes of grades M30, M40, M50 and M60 with cast 50 mm dia. cylinders in order to test the permeability characteristics by loading in the cells duly applying constant air pressure of 15 Kg/mm^2 along with water pressure of 2 Kg/mm^2 for a specific period time and obtain co-efficient of permeability to conclude that the higher grade of SCC mixes, more the resistance to the permeability compared to the lower grade of SCC mixes because of the transmission of large pores to fine pores as a consequence of the pozzolanic reaction between cement paste and fly ash to substantially reduce the permeability in the cementitious matrix. M Veera Reddy and M V Seshagiri Rao (2007) presented a mathematical model for complete stress-strain relationship for steel fibre reinforced high-strength concrete and found that the analytical model developed is in close comparison with the experimental test data, and reported that the second degree polynomial form of stress-strain relation suggested by Saenz is one of the better fit which is the same as reported by MLV Prasad, P.Rathish Kumar et al (2009) in the case of GFRSCC. Valeria Corinaldesi and Giacomo Moriconi (2011) investigated the properities of SCC using three types of fibres, steel , poly-Vinyl-Alcohol and Poly Proylene high tough fibres. They have added limestone powder and recycle concrete powder as mineral additions. The fresh and hardened concrete properties like workability, strength and shrinkage were evaluated and they found that SCC with the above fibres and additions behaved well with improved durability. Cunha et al. (2011) carried out to develop numerical model for the tensile behavior of SFRSCC. They have assumed SFRSCC as two-phase material. The nonlinear material behavior of self-compacting concrete is given in 3-D smeared crack model. The numerical model showed good correlation with experimental values. Zhu et al. (2002) carried out a durability tests on Self Compacting Concrete. In this work the various indicators are gas permeability, capillary water absorption and chloride diffusivity for concrete durability performance, of various types of SCC and conventional vibrated reference concrete mixes were assessed and compared. SCC mixes showed significantly lower values of coefficient of permeability and sorptivity of water absorption, compared to the traditional vibrated reference mixes of the same strength grade. SCC mixes also showed similar chloride diffusivity to those of traditional vibrated mixes. However, the chloride diffusivity was found to be very much dependant on the types of powder used in concrete. Both the reference and SCC mixes containing PFA showed much lower values of coefficient of chloride migration than the other mixes. Among the three different SCC mixes, it appeared that the SCC mix containing no additional powder but using the viscosity agent to maintain stability of the fresh mix had the highest permeability, sorptivity and chloride diffusivity, thus less resistant to ingress of aggressive fluids. Venkateswara Rao et al. (2012) observed the durability performance of Self-compacting concrete. They investigated to cast and test the SCC specimens, a total of three grades of concrete were investigated: M20, M30 and M70 grades representing ordinary, standard and high strength concrete respectively. The results observed that the durability aspects of NC and SCC like acid attack, acid durability factors, thermal cycling effect, test for corrosion resistance and tests for sorptivity. The following specific conclusions may be given from this study: With the increase in duration of exposure to the acidic nature, the ASLF was increased for both NC and SCC, With increase in period of immersion of concrete in various solutions (HCL, H_2SO_4), there was a considerable disruption of the concrete near the corners of the standard cube and such disruption in SCC was less than to NC, it indicates the superior durability of SCC, thermal studies indicates that fly ash based SCC mixes of higher grades are performed better compared to NC, the corrosion performance was better in SCC when compared to the NC, SCC mixes are well performance of lower water absorption values in higher grades compared to NC. SCC and NC showed more or less similar percentage loss in strength for the same grade of concrete. The weight loss was greater in NC than in SCC. The average ADLF is greater in NC for all grades than in SCC mixes. Hence, the SCC mixes were better than NC in all grades. Average ADLF may be considered a unified parameter to quantify durability because it considers both strength aspects and performance aspects simultaneously. Thermal studies indicated that the fly ash-based SCC mixes of higher grades performed better than NC of identical grade.

Nishant Singh et al. (2016) were discussed about the Strength and Durability properties of Eco-SCC Using Recycled Aggregate from Building Demolished Waste (BDM). This paper consists of developing recycled and natural aggregates SCC mix proportions mix-A and mix-B based on Nan Su specifications. In this study, In Self Compacting Concrete, with 100% replacement for natural aggregates, Recycled-SCC achieved sufficient fresh properties with slight change in water reducing admixture. The compressive strengths are slightly less in RSCC specimens than NSCC specimens. For A-mix, the increase in compressive strength is 26.96% for NSCC compared to RSCC, whereas, in mix B, the increase in strength is 46.99% for NSCC compared to RSCC. The durability factors are high for RSCC specimens than NSCC specimens and low grade concretes it is quite higher than high grades. Overall it can be stated that Recycled coarse and fine aggregates obtained from construction demolished waste can be an effective alternative for natural aggregates. Recycled aggregates are well suited for Eco-SCC. Srihari and Seshgiri Rao (2016) developed a strength and durability properties of SCC with GBFS and Meta Kaolin. In this development, test results of compressive strength of cubes and cylinders are lower values with the using of 100% river sand and Strength increased in 40% of GBFS with 10% of Meta Kaolin were replaced with the river sand.In this literature, the physical and chemical properties of GBFS are suitable for the production of concrete mix. The rapid chloride permeability test and water absorption was conducted, with the using of Meta Kaolin and increasing % of fly ash with GBFS an improvement in the impermeability of concrete and also the compressive strength and split tensile strength are lower for 0% replacement. Percentage of water absorption gradually decreases with the use of GBFS with Meta Kaolin. Results proved that combination of MK with GBFS gradually decrease in Coulomb charge.

Previous literatures on SCC extend the possibility of use of different mineral byproducts in its manufacturing and with the densification of the matrix, mechanical behavior as measured by compressive, tensile and shear strengths are increased. Alternatively, the use of Super Plasticizers or high range of reducers improves the stiffening, unwanted air entrainment and flowing ability of the concrete. The use of SCC not only shortens the construction period but also ensures the quality and durability of concrete. This non vibrated concrete allows faster placement and less finishing time leading to improved productivity. Hence, the summary of the above articles found in the literature review can be divided into three phases. In present work, the specimens are developed with self compacting concrete (SCC), steel fiber reinforced self-compacting concrete (SFRSCC) are fabricated. The specimens of SCC and SFRSCC are prepared and tested for fresh, hardened and durability Studies.

Materials used in Preparation of Concrete

SCC

In this investigations, low strength standard grade and high-grade concrete i.e. M20, M30, M40 and M60 of SCC mixes are developed using mineral and chemical admixtures to study its fresh and hardened properties. For developing SCC of different grades, the mix proportions were designed based on Nan-Su et al (2001) and SV Rao et al (2010) using fly ash as mineral admixture and chemical admixtures like Super Plasticizer (SP), Viscosity Modifying Agents (VMA). Finally, SCC mixes which have given required compressive strengths with satisfactory fresh properties were taken for the next investigations.

Figure 1: OPC53 Gradecement

Figure 2: Fine Aggregate

Figure 3: Coarse aggregates

Figure 4: Fly ash

Figure 5: ComplastSP430

Figure 6: RoofplastVMA2

An SCC mixes of M20, M30, M40 and M60 were aimed and the initial mix proportions were obtained using the mix design methods as mentioned above. The mix proportions thus obtained were fine-tuned by incorporating different guidelines available and making various trail mixes to obtain the mix which satisfies fresh and hardened properties.

Table 1: Mass of ingredients used for cubic meter concrete

Grade	Cement (kg)	Fine Aggregate (kg)	Coarse Aggregate (kg)	Fly ash (kg)	Water (Lit.)	Super plasticizer		VMA (%)
						Lit.	%	
20	258	900	685	309	186	5.67	1	0.06
30	388	885	700	318	210	10.8	1.5	0.06
40	468	884	700	350	240	12.27	1.5	0.06
60	660	850	730	310	260	9.7	1	-

SFRSCC

Steel fibers were added in different quantities are selected for SCC mixes of investigation and Steel Fiber Reinforced Self Compacting Concrete (SFRSCC) was developed. After adding the Steel fibers to SCC mixes, to ensure its influence of the fresh and hardened properties of the SFRSCC. The tests on fresh and hardened SFRSCC were conducted in the same way as per conducted in SCC. Addition of Steel fibres to

SCC Mixes Steel fibres were added in different dosages to selected the SCC mixes in the first batch of investigation and Steel Fibre Reinforced Self Compacting Concrete (SFRSCC) was developed. After adding the Steel fibres to SCC mixes, to ensure its influence of the fresh and hardened properties of the SFRSCC. The tests on fresh and hardened SFRSCC were conducted in the same way as per conducted in SCC.

Durability Properties of SCC and SFRSCC

According to IS 456-2000 (BIS 2000) standards, a total of 40 cubes of SCC and 40 cubes of SFRSCC for testing of durability properties like acid attack and sulphate attack. The properties of the constituent acids and sulphate used in the present investigation are LR (laboratory grade) hydrochloric acid 35–38% with specific gravity 1.18 kg/l, LR sulfuric acid 98%, 98.07 g/mol with specific gravity 1.835 kg/l and sodium sulphate with specific gravity of1.464, molecular weight 142.036 g/mol were used in this study at concentrations of both acids and sulphate is 5%.A eight specimens each for SCC and SFRSCC of size 100mm×100mm were casted for testing of water absorption using sorptivity test. The experimental setup consisted of casting and testing SCC specimens. Nan Su method and S V Rao et al method of mix designs (Su et al., 2001) was adopted to prepare specimens as per EFNARC specifications (EFNARC, 2005) and several trials were done in producing SCC. A total of four grades of concrete (M20, M30, M40 and M60 grades respectively) were investigated.

Results and Discussions:

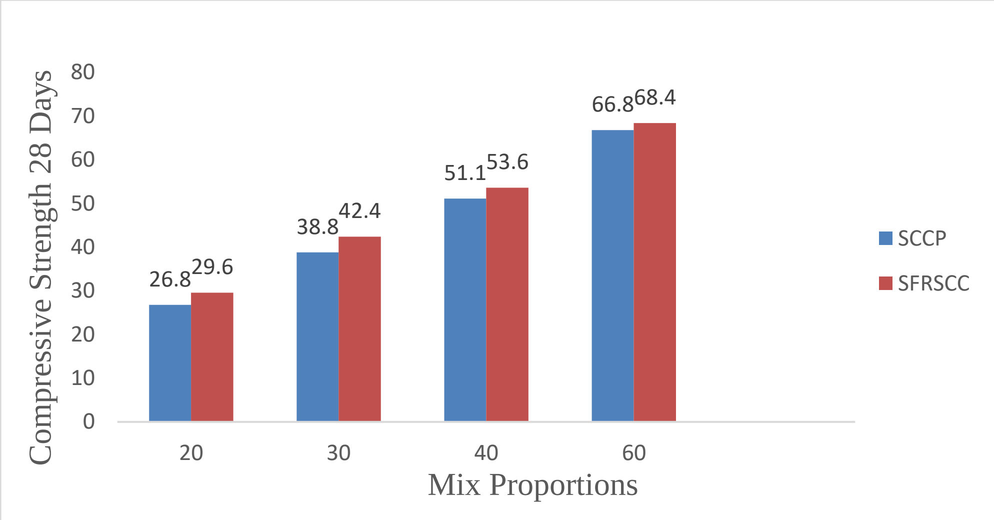
Table 2: Fresh Properties of SCC and SFRSCC

Grade	Fresh Properties			Designation
	lump flow test Sec	V-Funnel test Sec	-Box test H2/H1	
20	3.89	7.02	0.983	SCC
	4.07	7.05	0.90	SFRSCC
30	2.70	6.76	0.94	SCC
	3.20	7.58	0.915	SFRSCC
40	3.59	7.53	0.956	SCC
	3.98	7.98	0.88	SFRSCC
60	3.03	8.01	1	SCC
	3.42	8.64	0.954	SFRSCC

Table 3: Hardened Properties of SCC and SFRSCC at 7 and 28days

S.No.	Grade	Designation	Cube Compressive Strength, Mpa	
			7 Days	28 Days
1	20	SCC	17.85	26.8
2		SFRSCC	19.16	29.6
3	30	SCC	24.7	38.8
4		SFRSCC	27.4	42.4
5	40	SCC	33.5	51.1
6		SFRSCC	35.2	53.6
7	60	SCC	41.9	66.8
8		SFRSCC	45.03	68.4

From the compressive cube strength results shown in it can be seen that the 28days compressive strength of plain SCC mixes like M20, M30, M40 andM60 are 26.8 MPa, 38.8 MPa, 51.1 MPa and 66.8 MPa. When Steel fibers are added, the strength observed is 29.6 MPa, 42.4 MPa, 53.6 MPa and 68.4 MPa that are, an increase of 10.44%, 9.27%, 4.89% and 2.39%. The above results clearly show that the addition of fibres has enhanced the compressive strength which is due to the holding of the concrete, which is, confining the concrete. However, the effect is different in different grades concrete, and enhanced the confining effect partly due to the presence of hooked end steel fibers holding the concrete at micro-crack level.



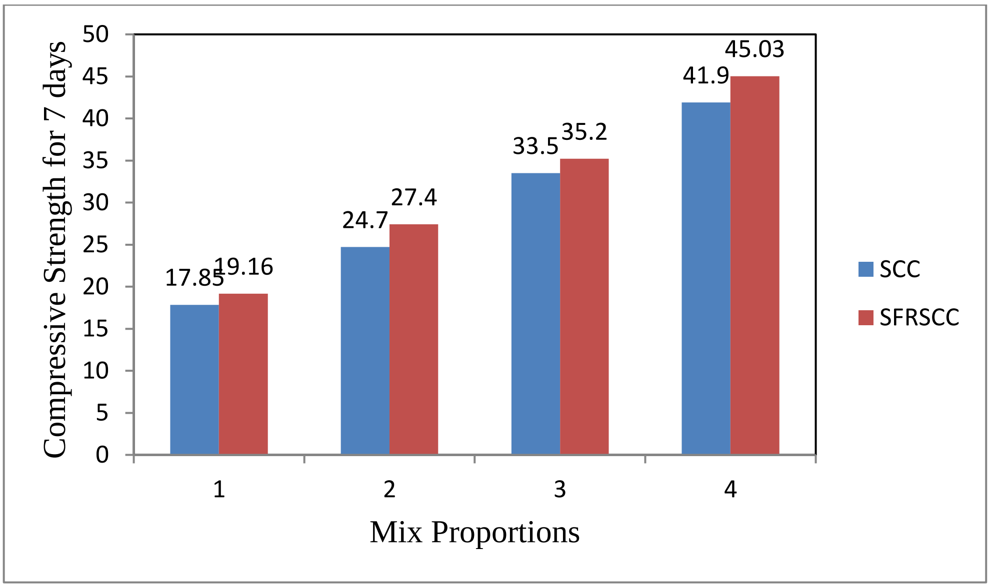


Figure 7: Variation of Cube Compressive Strengths for SCC and SFRSCC for 7 & 28 days

Acid Strength Loss Factor for SCC and SFRSCC

From the results obtained based on acid effect on SCC and SFRSCC specimens, it was noted that most of the SFRSCC specimens performed well compared with SCC specimens. To estimate the effects of acid on SCC and SFRSCC are determined.

Table 4: Acid and Sulpahte Strength Loss

Type of Concrete	Grade of Concrete	Acid Strength Loss (%)					
		Na_2SO_4		HCL		H_2SO_4	
		28 Days	56 Days	28 Days	56 Days	28 Days	56 Days
SCC	20	4.10	8.2	7.83	15.67	34.01	68.02
	30	3.47	6.95	9.92	19.84	37.24	74.48
	40	2.83	5.67	9.09	18.19	36.49	72.99
	60	1.94	3.89	9.35	18.71	33.48	66.97
SFRSCC	20	3.41	6.82	7.09	14.18	32.06	64.12

	30	2.94	5.89	8.84	17.68	30.30	60.61
	40	1.97	3.95	8.75	17.51	28.63	57.27
	60	1.52	3.04	8.41	16.82	29.31	58.62

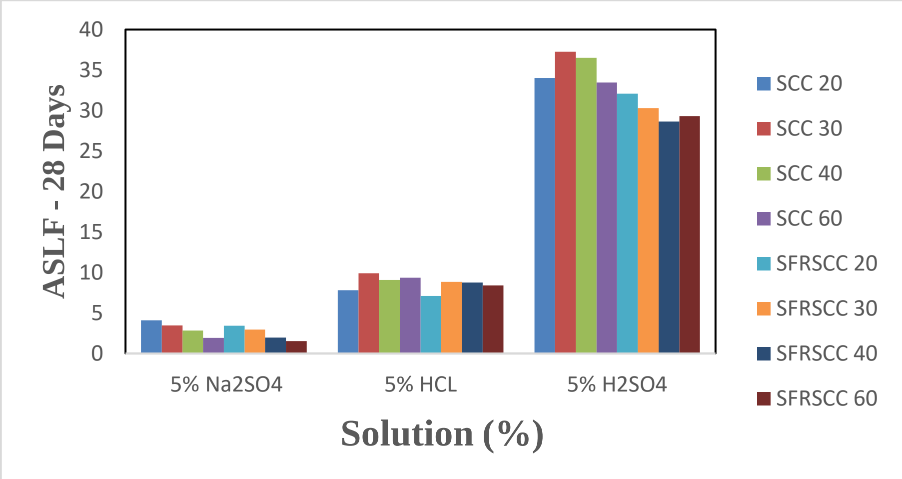


Figure 8: Acid Strength Loss Factors (ASLF) for SCCP and SFRSCC at 28 Days

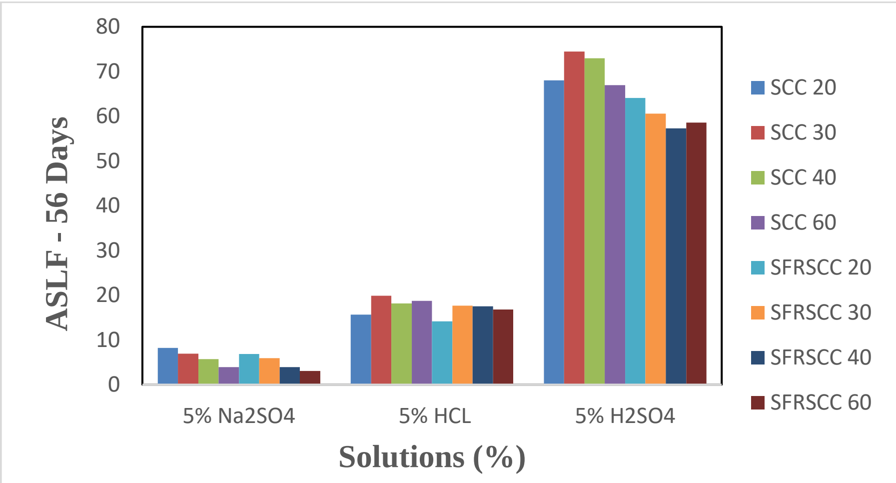


Figure 9: Acid Strength Loss Factors (ASLF) for SCCP and SFRSCC at 56 Days

Acid Attack Factor (AAF) for SCC and SFRSCC

The variation of AAF in SCC and SFRSCC for 28 days and 56 days of immersion in acids. This indicates that there is less loss of diagonal (i.e. greater dimensional stability) in SFRSCC mixes than in SCC mixes.This can be found when specimens were subjected to H_2SO_4, HCl and Na_2SO_4. However, there was a greater loss of dimensional stability with H_2SO_4 at 28 days than with HCl than Na_2SO_4 and further 56 days of immersion; the dimensional stability is more when compared to 28 days of immersion.

Table 5: Acid attack factor

Type of Concrete	Grade of Concrete	Acid Attack Factors					
		Na_2SO_4		HCL		H_2SO_4	
		28 Days	56 Days	28 Days	56 Days	28 Days	56 Days
SCC	20	0.85	1.78	3.51	7.87	10.39	18.56
	30	0.71	1.30	2.72	4.73	11.62	19.09
	40	0.85	1.77	5.06	7.69	11.76	18.03

	60	0.784	1.21	3.98	7.19	13.14	15.78
SFRSCC	20	0.64	1.08	3.14	6.72	9.98	18.40
	30	0.49	0.99	1.85	3.70	10.92	14.70
	40	0.78	1.28	2.47	4.18	10.69	12.61
	60	0.284	0.854	2.35	4.63	11.40	13.89

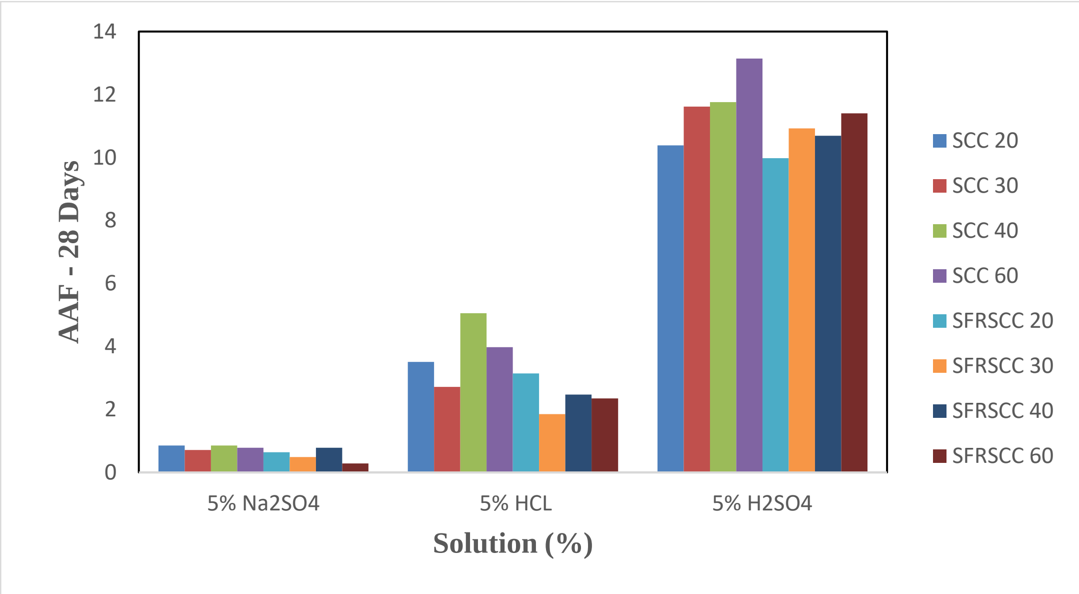


Figure 10: Acid Attack factors (AAF) for SCC and SFRSCC at 28 days of immersion

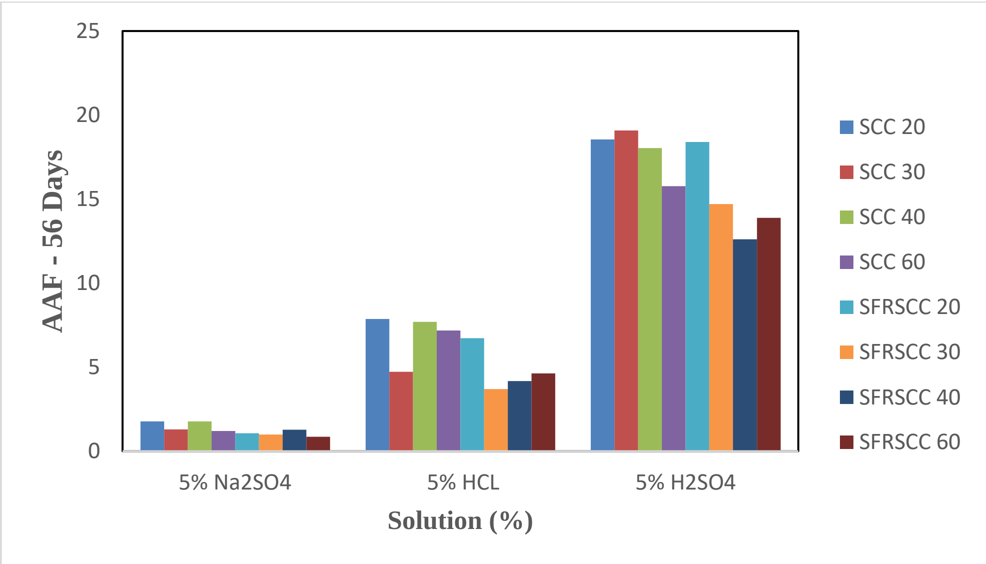


Figure 11: Acid Attack Factors (AAF) for SCC and SFRSCC at 56 days of immersion

Acid Weight Loss Factor (AWLF) for SCC and SFRSCC

The AWLF in SCCP and SFRSCC for 28 days and 56 days of immersion in acid. This indicates that there isa less loss weight inSFRSCC mixes than inSCCP mixes. This can be found specimens were subjected to Na_2SO_4, HCL and H_2SO_4. From the figure 12 and 13, the greater AWLF in SCCP grades of concrete M40 and M60 in H_2SO_4 for 28 days and also AWLF in SCCP of grade M30 in H_2SO_4 for 56 days more effective. It indicates the more loss of weights in H_2SO_4.

Table 6: Acid weight loss factor

Type of Concrete	Grade of Concrete	Acid Weight Loss Factors					
		Na_2SO_4		HCL		H_2SO_4	
		28 Days	56 Days	28 Days	56 Days	28 Days	56 Days
SCC	20	1.69	3.38	4.29	10.72	14.58	22.91
	30	1.28	3.00	6.03	11.20	13.79	32.75
	40	1.69	2.96	5.93	12.71	16.03	23.20
	60	1.28	2.56	5.57	9.87	15.87	23.60
SFRSCC	20	1.35	2.71	3.68	8.71	13.76	20.18
	30	0.86	1.72	3.87	9.05	11.15	29.18
	40	0.89	1.78	3.58	7.17	13.45	20.17
	60	0.87	1.74	3.91	7.39	11.35	20.52

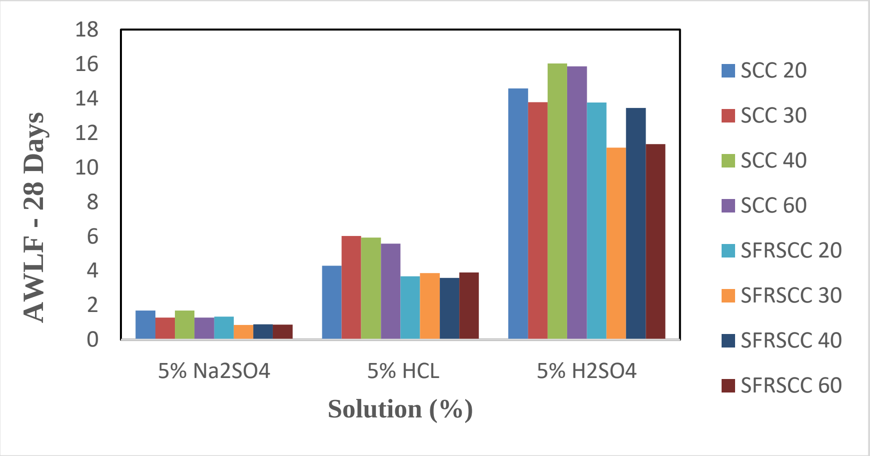


Figure 12: Acid weight loss factors (AWLF) for SCC and SFRSCC at 28 days of immersion

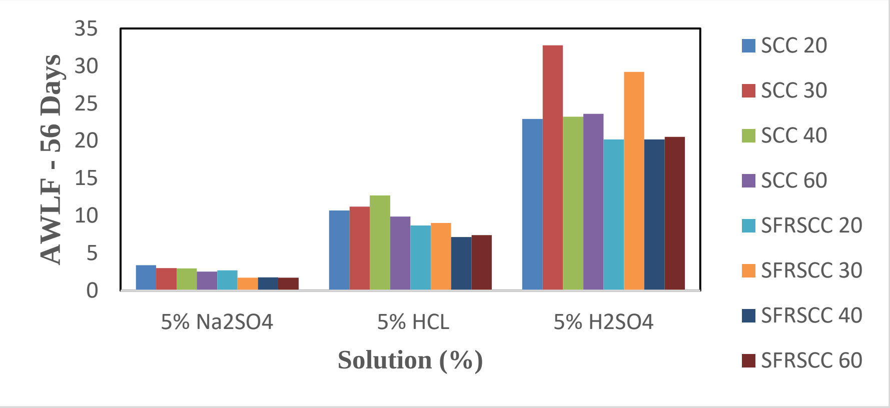


Figure 13: Acid weight loss factors (AWLF) for SCC and SFRSCC at 56 days of immersion

Acid Durability Loss Factor for SCC and SFRSCC

Table 7: Acid durability loss factor

Type of Concrete	Grade of Concrete	Acid Durability Loss Factors					
		Na2SO4		HCL		H2SO4	
		28 Days	56 Days	28 Days	56 Days	28 Days	56 Days
SCC	20	65.93	552.30	634.84	7114.6	2422.26	13598.2

	30	42.27	362.89	657.37	4246.55	2044.65	15955.0
	40	67.74	494.21	1227.23	7996.1	2544.9	11298.1
	60	48.21	297.71	900.93	5768.76	3422.86	12300.6
	Average	56.03	426.77	855.09	6281.5	2608.66	13287.9
SFRSCC	20	40.25	272.71	495.83	5023.14	2463.6	13322.6
	30	19.82	160.25	294.68	2756.48	2397.41	15896.1
	40	33.33	218.84	364.66	2472.27	3071.15	10868.1
	60	11.97	144.07	382.14	2846.06	2577.07	10794.2
	Average	26.34	198.96	384.32	3274.48	2452.3	12220.2

It can be seen that, the Acid Durability loss Factors for the SCCP and SFRSCC at 28 days and 56 days of immersion. From the figure 14 and 15, the acid durability loss factors are more loss in SCC compared to the SFRSCC in the solution of H_2SO_4 and after that in HCL.

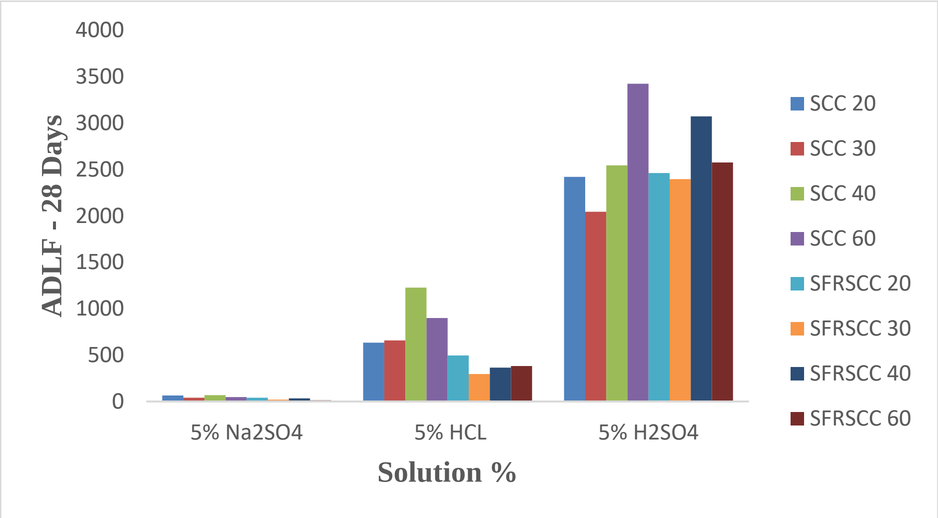


Figure 14: Acid Durability Loss Factors for SCC and SFRSCC at 28 Days of immersion

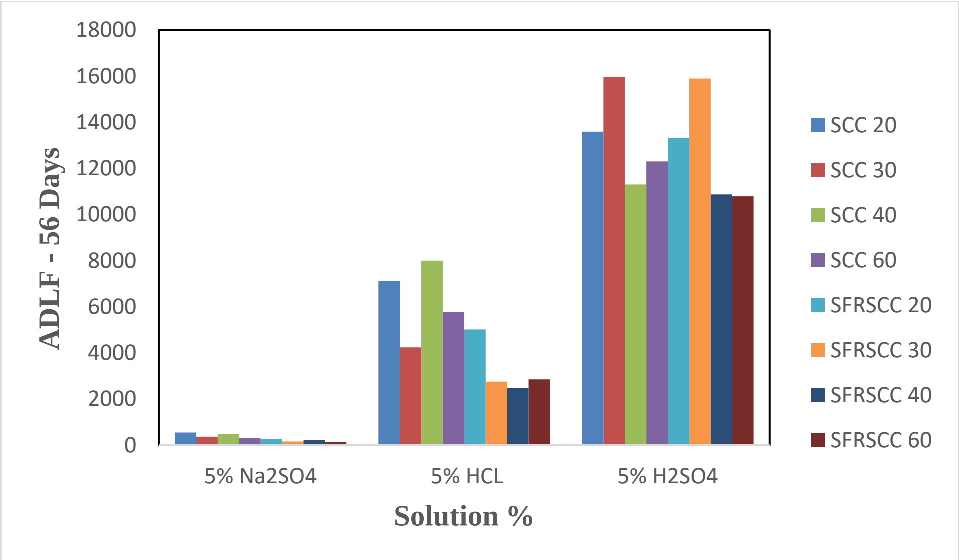


Figure 15: Acid Durability Loss Factors for SCC and SFRSCC at 56 Days of immersion

Sorptivity for SCC and SFRSCC

From the results in figure 16 and 17, the sorptivity of theM20 grade of SCCP mix can be absorption of water is more when compared to the M60 grade of SCCP mix. In case of SFRSCC, the figure 16 and 17 indicates the sorptivity of the

M20 grade of concrete can be water absorption is more compared to the M60 grade of concrete. From the results in both figures clearly indicates that the sorptivity was considerably lower for all the grades of SCC mixes than for the all the grades of SFRSCC mix. Such results would suggest that the near-surface concrete was denser and more resistant to ingress of fluid in the SCC mixes than in the corresponding SFRSCC mixes.

Table 7: Results of Absorbed water per unit area (i) and Time ($t^{1/2}$)

Time ($min^{1/2}$)	**Absorbed water per unit area (i) kg/m^2**			
	SCC M20	**SCC M30**	**SCC M40**	**SCC M60**
0	0	0	0	0
1	0	0	0	0
2.23	0.2	0.1	0	0
3.16	0.3	0.2	0.1	0.1
3.87	0.4	0.3	0.1	0.1
5.47	0.5	0.3	0.2	0.1
7.74	0.5	0.4	0.3	0.2
10.95	0.6	0.4	0.3	0.2
13.41	0.6	0.4	0.4	0.3
15.49	0.6	0.5	0.4	0.3
17.32	0.7	0.6	0.5	0.4
18.97	0.7	0.6	0.5	0.4
37.94	0.8	0.7	0.6	0.5
53.66	0.8	0.7	0.6	0.5
65.72	0.8	0.7	0.6	0.5

Time ($min^{1/2}$)	**Absorbed water per unit area (i) kg/m^2**			
	SFRSCCM20	**SFRSCCM30**	**SFRSCCM40**	**SFRSCCM60**
0	0	0	0	0
1	0.2	0.2	0.2	0.1
2.23	0.3	0.3	0.2	0.2
3.16	0.4	0.3	0.3	0.2
3.87	0.4	0.4	0.3	0.3
5.47	0.5	0.4	0.4	0.3
7.74	0.5	0.5	0.4	0.3
10.95	0.6	0.5	0.5	0.4
13.41	0.7	0.6	0.5	0.4
15.49	0.7	0.6	0.6	0.5
17.32	0.8	0.7	0.6	0.5
18.97	0.8	0.7	0.6	0.5
37.94	0.9	0.8	0.7	0.6
53.66	0.9	0.8	0.7	0.6
65.72	0.9	0.8	0.7	0.6

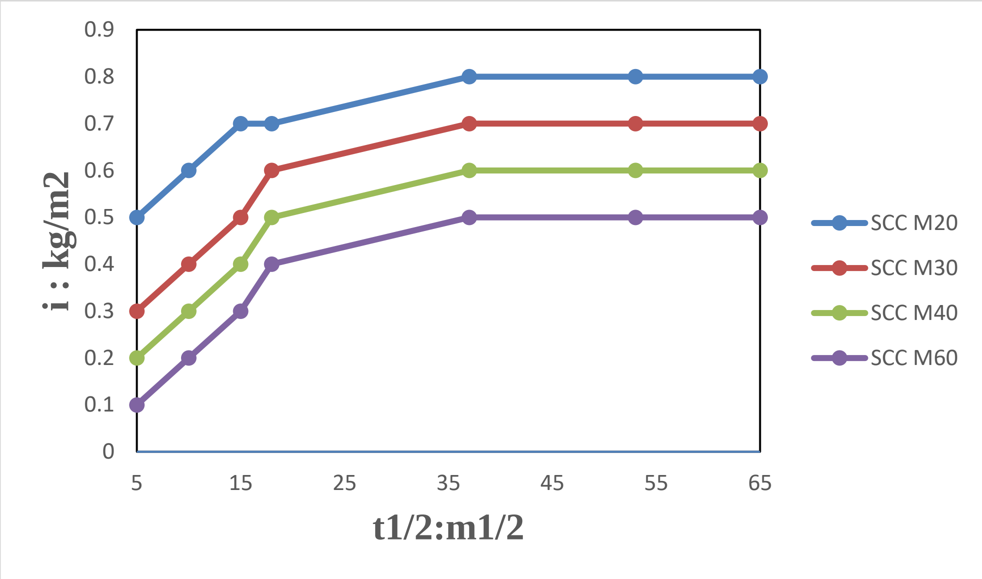


Figure 16: Absorbed water per unit area (i) against time ($t^{1/2}$) for SCC

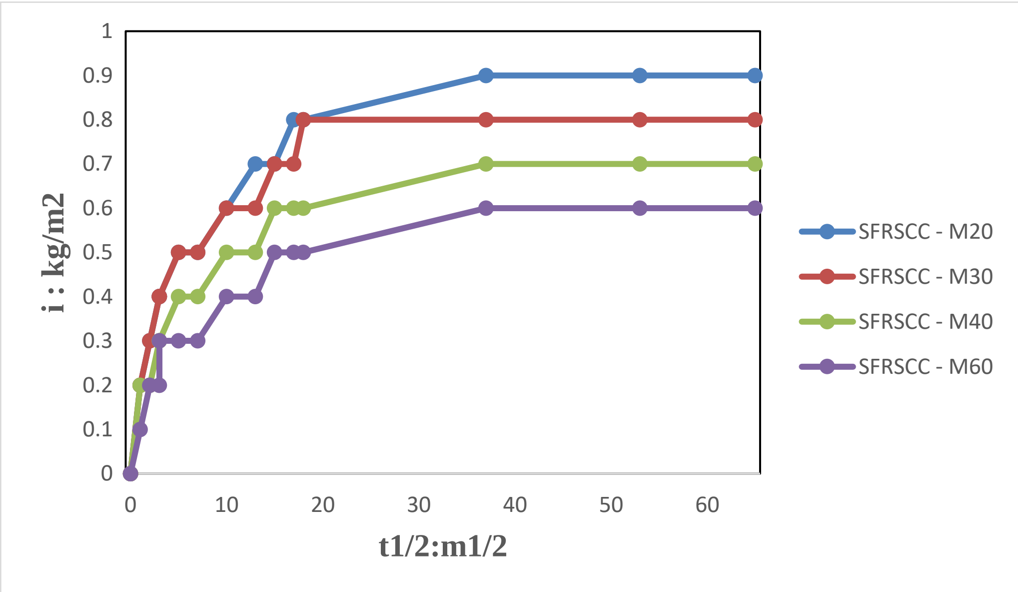


Figure 17: Absorbed water per unit area (i) against time($t^{1/2}$) for SFRSCC

CONCLUSIONS

Based on the experimental work conducted on SCC mixes and SFRSCC mixes of different grades are to aim the study the durability properties.

The following specific conclusions are drawn from this experimental study:

1. Fibre reinforced self-compacting concrete can be produced by incorporating Steel fibres to improve its performance. However, the use of appropriate dosage of super plasticizer and viscosity modifying agent is essential to maintain the fresh properties of self-compacting concrete.
2. Aspect ratio is very important and found that shorter fibres with 12mm long and aspect ratio 30 gives better performance.
3. In the case of Steel fibres, a dosage of 31 kilo grams of fibres/m^3 of concrete is used as optimum dosage by suitably adjusting the dosage of admixtures.
4. In different grades of the concrete i.e., M20, M30, M40 and M60. The compressive strength of the Steel fiber reinforced Self-compacting concrete was found to be more ranging from 2% to 10%. When compared to plain self- compacting concrete.
5. With increase of fiber dosage, the workability decreases. This problem of workability and flow proprieties of concrete can be overcome by adding

super plastizers and VMA.

6. With the increase in the grade of concrete the sorptivity of Steel Fibre Reinforced SCC was found to be lower similarly in plain SCC also.
7. In SFRSCC the amount of water absorption per unit area decreases with increase in the grade of concrete.
8. With the increase in duration of exposure to the acidic environment the ASLF increased. This was true for both SCCP and SFRSCC. SCCP and SFRSCC showed more or less similar percentage loss in strength for the same grade of concrete. With increase in period of immersion of the concrete in 5% concentration of acids like Na_2SO_4, HCl and H_2SO_4, there was a damage of concrete near the corners of the standard cube and such disruption in SFRSCC was less than in SCCP, indicating superior durability of SFRSCC

REFERENCES

1. Borsoi. A, Collepardi. M, Collepardi. S, Croce. E.N., Passuelo. A "Influence of Viscosity Modifying Admixture on the Composition of SCC" Supplementary volume of Eighth CANMET/ACI International Conference on Superplasticizers and other Chemical Admixtures in Concrete, October 29-November 1, 2006, Sorrento, Italy pp253-261.
2. Chandrasekhar M, Seshagiri Rao M V, Janardhana Maganti "Structural Behaviour Of Glass Fibre Reinforced Self Compacting Concrete Wall Panels" BEFIB2012 – Fibre reinforced concrete, 2012.
3. Gao Peiwei, Deng Min and Feng Naiqui" The Influence of SP and Superfine Mineral Powder on the Flexibility, Strength and Durability of HPC". Cement and Concrete Research. 2000, Vol.31, pp703-706.
4. Giri Prasad. G, Seshagiri Rao M.V. and Rama Rao G.V. "Computation of Stress-Strain Behaviour of Self-Compacting Concrete in Higher Grade" International Journal of Scientific Computing, Vol.3, No.2 July-December 2009 pp193-197.
5. K. Rajesh Kumar, N. Mahendran "Experimental Studies on Strength, Durability And Behaviour of Beam Using S.C.C. with E-Glass Fiber Strands" International Journal of Engineering Research & Technology (IJERT) Vol. 2 Issue 4, April – 2013.
6. Lachemi M and Hossain K. M. A. "Self-Consolidating Concrete incorporating New Viscosity Modifying Admixtures" Cement & Concrete Research 34 (2004), pp185-193.
7. Mallesh M, Shwetha G C, Reena K, Madhukaran" Experimental Studies on M30 Grade Self Compacting Concrete" International Journal of Science, Engineering and Technology Research (IJSETR), Volume 4, Issue 9, September 2015.
8. Miao Liu "Wider Application of Additions in Self-Compacting Concrete" Ph.D Thesis, University of London, July2009.
9. Nan Su, Kung-Chung Hsu, His-Wen Chai "A Simple Mix Design Method for Self-Compacting Concrete" Journal of Cement and Concrete Research 31(2001) pp 1799-1807.
10. Nishant Singh, Aditya R, Sri Rama Chand M and Rathish Kumar P "Strength and Durability Properties of Eco-SCC Using Recycled Aggregate from Building Demolished Waste (BDW)"Journal of Civil Engineering and Environmental Technology p-ISSN: 2349-8404; e-ISSN: 2349-879X; Volume 3, Issue 5; April-June, 2016, pp. 410 415.
11. N. Venkat Rao, M. Rajasekhar, Mohd Mujeebuddin ahmed"An Experimental Study on Durability of High Strength Self Compacting Concrete (HSSCC)" IJRET: International Journal of Research in Engineering and Technology eISSN: 2319-1163 | pISSN: 2321-7308, 2013.
12. Ouchi M. and Okamura H. "Effect of Super Plasticizer on Self- Compactability of Fresh Concrete", Journal of the Transportation Research Board, 1997, pp37-40.
13. Prasad. M.L.V, Rathish Kumar. P. and Toshiyuki Oshima "Development of Analytical Stress-Strain Model for glass Fiber Reinforced Self Compacting Concrete", International Journal of Mechanics and Solids, ISSN:0973- 1881,Vol.4, No.1(2009),pp.25-37.
14. Rizwan A. Khan, Atul Sharma "Durability Properties Of Self Compacting Concrete Containing Fly Ash, Lime Powder And Metakaolin" Journal of Materials and Engineering Structures, 2 (2015) 206–212.
15. Raghuprasad P. S. et. al. "Comparative Study on Different types of Blended Cement with Different Grade O.P.C Concrete – An Experimental Approach", ICACC-2004. Proceedings of International Conference on Advances in Concrete and Construction. 16-18 December 2004, Hyderabad, Vol.II, pp637- 646.
16. Seshadri Sekhar.T, Sravana. P and Srinivasa Rao.P,

"Some Studies on the Permeability Behaviour of Self Compacting Concrete" AKG Journal of Technology, Vol.1, No.2.(2005)

17. Suresh Babu. T, Seshagiri Rao. M.V. and Ramseshu. D "Mechanical Properties and Stress-Strain Behaviour of SelfCompacting Concrete with and without Glass Fibres", Asian Journal of Civil Engineering (Building and Housing) Vol.9, No.5(2008),pp457-472.
18. S Venkateswara Rao, M V Seshagiri Rao, D Ramaseshu, P Rathish Kumar "A Rational Mix Design Procedure for Self Compacting Concrete" 2010.
19. S Venkateswara Rao, M V Seshagiri Rao, D Ramaseshu, P Rathish Kumar "Durability performance of selfcompacting Concrete" Magazine of Concrete ResearchVolume 64 Issue 11 2012.
20. S Shrihari and Seshgiri Rao M V "Strength and Durability properties ofSCC with GBFS and MetaKaolin" Journal of Chemical and Pharmaceutical Sciences ISSN: 0974-2115, JCHPS Special Issue 2: August 2016.
21. V Karthik and G Baskar (2015) "Study On Durability Properties Of Self Compacting Concrete With Copper Slag Partially Replaced For Fine Aggregate" International Journal Of Civil Engineering And Technology (Ijciet)Volume 6, Issue 9, Sep 2015, pp. 20-30, Article ID:IJCIET_06_09_003.
22. Veera Reddy. M. and Seshagiri Rao. M.V "Computation of the Complete Stress-Strain Curve for Steel Fibre Reinforced High Strength Concrete", International Journal of Computational Intelligence Research andApplications. 1(2) July-December 2007, pp123 129.
23. W Zhu J Quinn & PJM Bartos "Aspects Of Durability Of Self Compacting Concrete" Advanced Concrete and Masonry Centre, University of Paisley, Scotland, UK 2002.
24. Kopparthi, P. K., Gemaraju, S., Pathakokila, B. R., & Gamini, S. (2021). Experimental investigations on flexural behaviour of delaminated carbon/epoxy composite using three dimensional digital image correlation. Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science, 235(12), 2265-2275.
25. Srikar, G., & Javeed, S. (2022). Mechanical Characterization of Carbon Fabric Reinforced Polymer Composites. Mathematical Statistician and Engineering Applications, 71(2), 425-429.
26. Srinivasababu, N., Kumar, K. P., & Srikar, G. (2015). Mechanical performance of polycarbonate/ABS, glass filled polycarbonate blends–review. Applied Mechanics and Materials, 766, 27-33.