International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 06, June - 2017

Structural Behaviour of Self Compacting Concrete with Basalt Fiber

Satheskumar. K [1],
[1] Assistant Professor,
Department of Civil Engineering,
Jay Shriram Group of Institutions,
Avinashipalayam, Tirupur

Gobinath. R[2],
[2] Associate Professor,
Department of Civil Engineering,
Jay Shriram Group of Institutions,
Avinashipalayam, Tirupur

Ramachandran. V[3]
[3] Post Graduate Student,
Department of Civil engineering,
Jay Shriram Group of Institutions,
Avinashipalayam, Tirupur

Abstract:- **Concrete is the construction material widely used throughout the world. Construction materials used in the industry should be friendly with the environment during its usage. 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, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. The hardened concrete is dense, homogenous and has the same engineering properties and durability as traditional vibrated concrete. In order to obtain the properties of fresh concrete for SCC, proportion of mineral and chemical admixtures to be added. Since its first development in Japan in 1988, SCC has gained wider acceptance in Japan, Europe and USA due to its inherent distinct advantages. The contributing factors to this reluctance appear to be lack of any supportive evidence of its suitability with local aggregates and the harsh environmental conditions. In this study a review is presented based on the development of self-compacting concrete with mineral admixtures- Silica Fume and basalt fiber. On various percentages of Silica Fume and basalt fiber the SCC properties were studied. Silica Fume was added in 10%, 12.5% and 15% by weight of cement and basalt fiber was added in 0.5%, to 3.5% by weight of fine aggregate.**

Keywords: Basalt fiber, cement, viscosity modifying admixtures, super plasticizers, physical properties, concrete properties, self compacting concrete, workability, hardened concrete etc.,

INTRODUCTION:

Current scenario in the building industry shows increased construction of large and complex structures, which often leads to difficult concreting conditions. When large quantity of heavy reinforcement is to be placed in reinforced concrete members it is difficult to ensure that the form work gets completely filled with concrete that is fully compacted without voids or honeycombs. Vibrating concrete in congested locations may cause some risk to labour and there are always doubts about the strength and durability of concrete placed in such locations. One solution for the achievement of durable concrete structures independent of the quality of construction work is the employment of Self Compacting Concrete (SCC). SCC is that concrete which is able to flow under its own weight and completely fill the formwork without segregation, even in the presence of dense reinforcement, without the need of any vibration whilst maintaining homogeneity.

SCC was developed in Japan by Okamura in the late 1980's to be mainly used for highly congested reinforced concrete structures in seismic regions. Since then SCC has generated tremendous interest among the research scholars, engineers and concrete technologists.
Though concrete possesses high compressive strength, stiffness, low thermal and electrical conductivity, low combustibility and toxicity, two characteristics, have limited its use, it is brittle and weak in tension. However the development of fibre-reinforced composites (FRC) has provided a technical basis for improving these deficiencies. Fibres are small pieces of reinforcing material added to a concrete mix which normally contains cement, water and fine and coarse aggregate. Among the more common fibres used are steel, glass, asbestos and polypropylene. When the loads imposed on concrete approach that for failure, cracks will propagate, sometimes rapidly, fibres in concrete provide a means of arresting the crack growth. If the modulus of elasticity of the fiber is high with respect to the modulus of elasticity of the concrete or mortar binder, the fibers help to carry the load, thereby increasing the tensile strength of the material. Fibers improve the toughness, the flexural strength, reduces creep strain and shrinkage of concrete.

Baslt fiber Reinforced Concrete (BFRC) is composed of concrete, reinforced with baslt fibers to produce a thin, lightweight, yet strong material. Though concrete has been used throughout the ages, BFRC is still a relatively new invention. High compressive and flexural strengths, ability to reproduce fine surface details, low maintenance requirements, low coefficients of thermal expansion, high fire resistance, and environmentally friendly made BFRC the ideal choice for civil engineers. The strength of BFRC is determined by glass content, fiber size, fiber compaction, distribution and orientation.

Considering the advantages of SCC and BFRC an attempt has been made to combine these two and to produce Basalt fiber Reinforced Self Compacting Concrete (BFRSCC) and to investigate the and mechanical properties, durability studies and structural behavior of both SCC and BFRSCC.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 06, June - 2017

SCC is cast so that no additional vibration is necessary for the compaction. It has a very smooth surface level after placing. With regard to its composition, SCC consists of the same components as conventionally vibrated concrete, which are cement, aggregates, and water, with the addition of chemical and mineral admixtures. Usually the chemical admixtures used are super plasticizers and viscosity-modifying agents. Mineral admixtures are used as an extra fine material, silica fume and in some cases, they replace cement. Researchers have set some guidelines for mixture proportioning of SCC, which include.

i. Reducing the volume ratio of aggregate to cementitious material,
ii. Increasing the paste volume and water-cement ratio(w/c),
iii. Carefully controlling the maximum coarse aggregate particle size and total volume.

Review of Literature:

(Timo Wustholz et al., 2003)Several methods existing for testing the flowability of self-compacting concrete (SCC). In this article a simple method – based on the so-called J-Ring test – is presented which allows the quantification of the part of the blocked concrete volume. Furthermore some empirical relationships between different test results are presented which were found for the tested SCC mixtures

(Surendra P. Shah et al ., 2007) Fiber-reinforced self-compacting concrete (FRSCC) is a new type of concrete mix that can mitigate two opposing weaknesses: poor workability in fiber-reinforced concrete and cracking resistance in plain SCC concrete. This study focused on earlyage cracking of FRSCC due to restrained drying shrinkage, one of the most common causes of cracking. In order to investigate the effect of fiber on shrinkage cracking of FRSCC, ring shrinkage tests were performed for polypropylene and steel fiber-reinforced SCC. In addition, finite element analyses for those specimens were carried out considering drying shrinkage based on moisture diffusion, creep, cracking resistance of concrete, and the effect of fiber. The analysis results were verified via a comparison between the measured and calculated crack width. From the test and analysis results, the effectiveness of fiber with respect to reducing cracking was confirmed and some salient features on the shrinkage cracking of FRSCC were obtained.

(Nayeri.M et al.,2007) Self-compacting concrete (SCC), a new kind of high performance concrete (HPC) have been first developed in Japan in 1986. The development of SCC has made casting of dense reinforcement and mass concrete convenient, has minimized noise. Fresh self-compacting concrete (SCC) flows into formwork and around obstructions under its own weight to fill it completely and self-compact (without any need for vibration), without any segregation and blocking. The elimination of the need for compaction leads to better quality concrete and substantial improvement of working conditions. SCC mixes generally have a much higher content of fine fillers, including cement, and produce excessively high compressive strength concrete, which restricts its field of application to special concrete only. To use SCC mixes in general concrete construction practice, requires low cost materials to make inexpensive concrete.

RESULTS AND DISCUSSION:

The test results for the filling ability (V-funnel flow time , u- box), passing ability (J-ring flow, L- box flow) , Compressive strength, Split tensile strength, Flexural using CTM , and Ultra Sonic Pulse Velocity , Durability of different SCC mixtures are given in below tables and graphs.

S No	Mix ID	Slump dia mm	V- Funnel Sec	J- Ring cm	L- Box h_2/h_1	U- Box mm
1	SCC	650	8	15	0.758	45
2	SCC4	670	8	15.2	0.768	42
3	SCC5	667	7	15.5	0.764	43
4	SCC6	684	6.5	15.8	0.788	42.5
5	SCC7	678	7	16	0.784	42
6	SCC8	665	6	16	0.765	40
7	SCC9	680	7	16.5	0.781	40.5
8	SCC10	685	7	16	0.785	41

Table 1 :Fresh concrete properties of self-compacting concrete

Chart 1 : Slump test

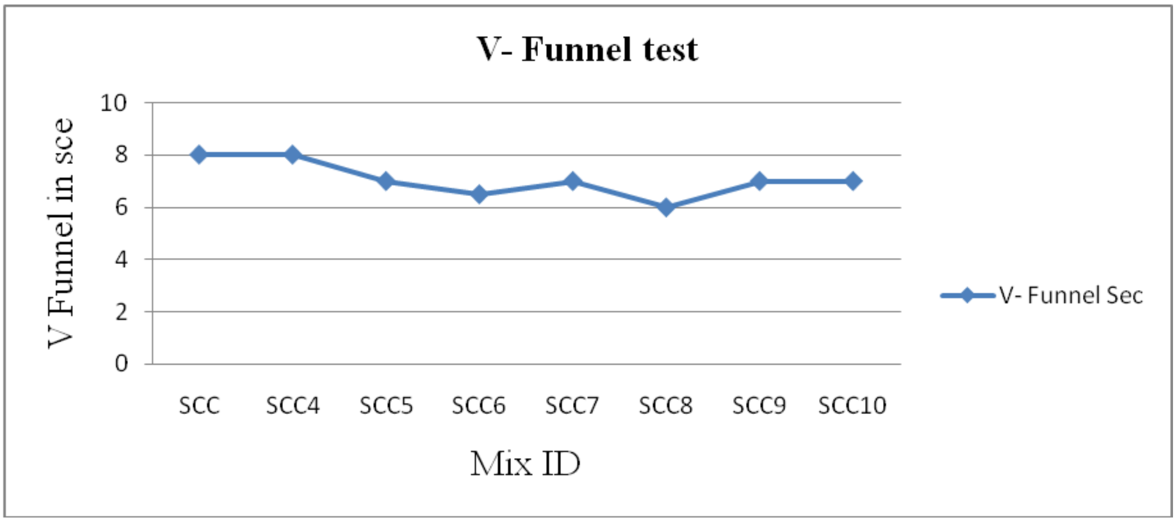

Chart 2: V funnel test

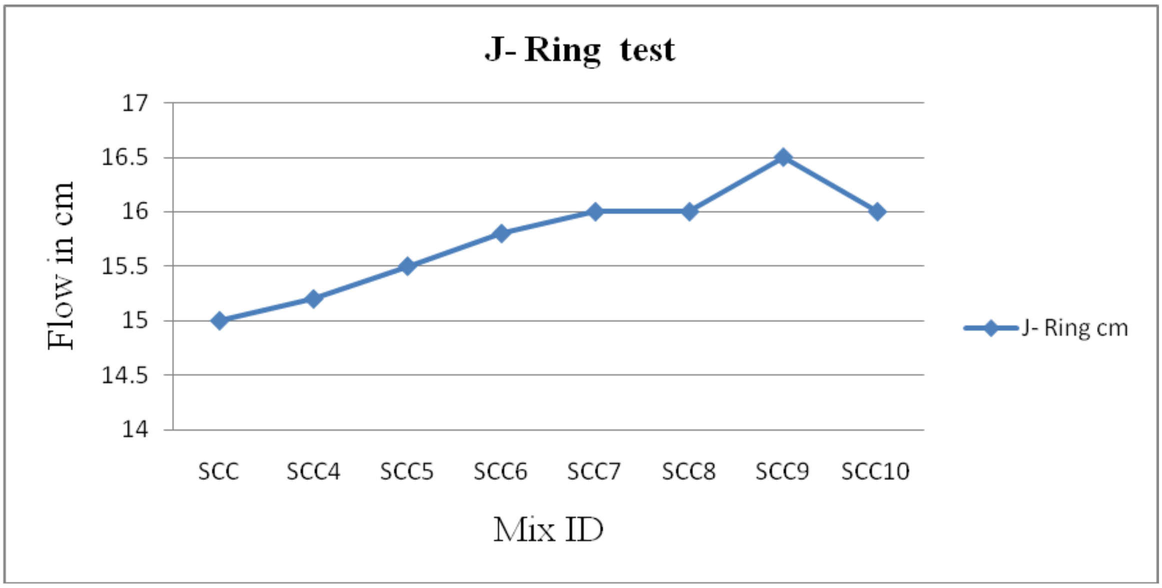

Chart 3: J Ring test

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 06, June - 2017

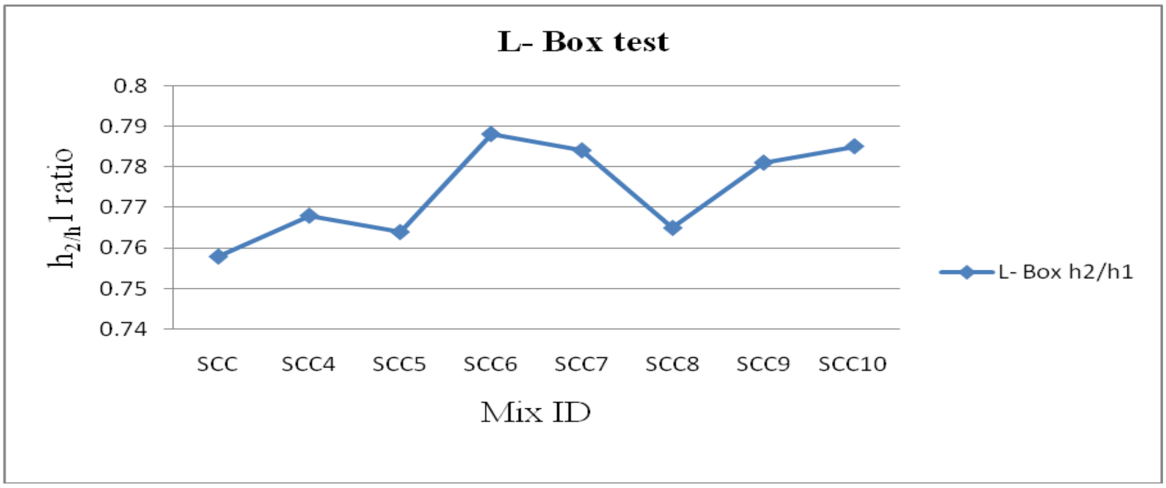

Chart 4: L Box test

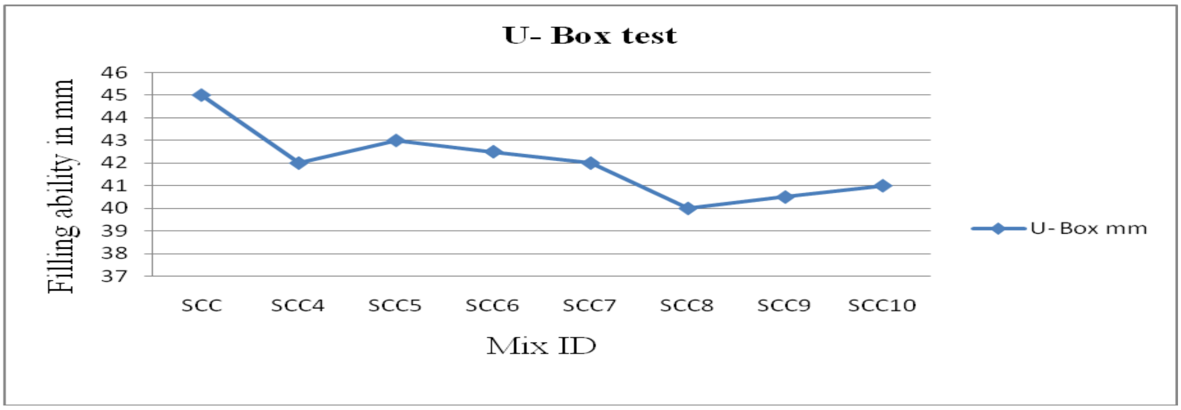

Chart: 5: U Box test

S NO	SCC Km/sec	SCC 4 Km/sec	SCC 5 Km/sec	SCC 6 Km/sec	SCC 7 Km/sec	SCC 8 Km/sec	SCC 9 Km/sec	SCC 10 Km/sec
1	5.53	5.21	5.26	5.42	5.19	5.49	5.92	5.87
2	5.00	5.61	5.35	5.26	5.68	5.42	5.78	5.74
3	5.17	5.12	5.24	5.49	5.76	5.64	5.74	5.47
4	6.67	5.31	5.81	5.29	5.46	5.52	5.68	5.68
5	6.52	5.27	5.63	5.44	5.64	5.42	5.66	5.56
6	5.51	5.45	5.72	5.23	5.47	5.72	5.59	5.71

Table 2: Ultra sonic pulse velocity

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 06, June - 2017

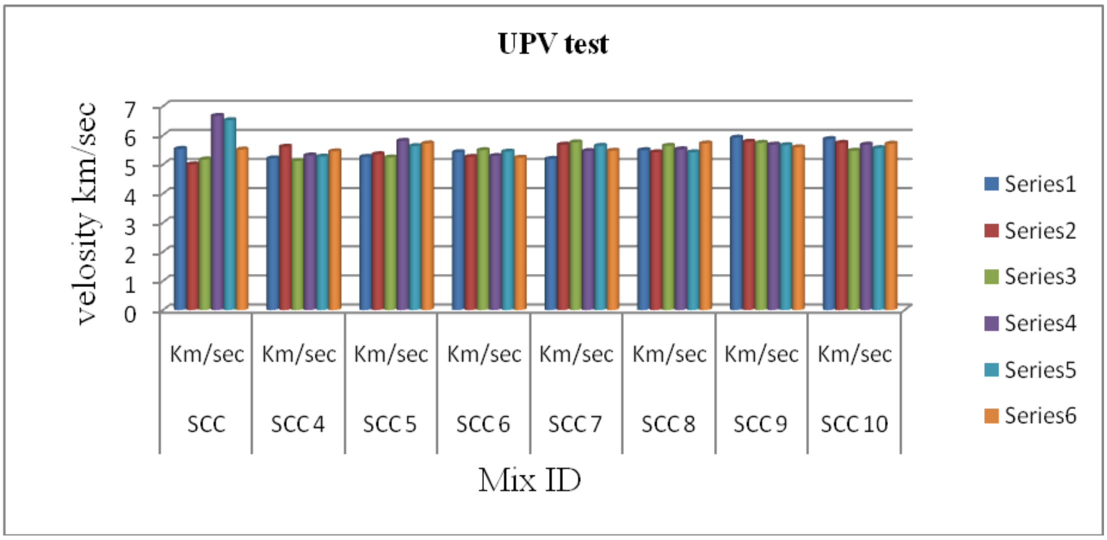

Chart: 6 UPV test

S NO	SCC N/mm^2	SCC 4 N/mm^2	SCC 5 N/mm^2	SCC 6 N/mm^2	SCC 7 N/mm^2	SCC 8 N/mm^2	SCC 9 N/mm^2	SCC 10 N/mm^2
1	20.20	20.82	20.97	20.99	21.21	21.31	21.42	21.46
2	20.12	20.87	20.98	21.05	21.13	21.24	21.38	21.42
3	20.56	20.64	20.95	21.10	21.22	21.56	21.37	21.51
4	19.90	20.47	20.12	21.08	21.13	21.31	21.24	21.29
5	20.26	20.58	20.58	21.05	21.10	21.28	21.35	21.44
6	20.01	20.47	20.89	21.06	21.24	21.34	21.23	21.46
7	20.24	20.89	20.94	20.98	21.16	21.14	21.40	21.43
8	19.87	20.78	20.69	21.12	21.14	21.30	21.36	21.51
9	19.99	20.46	20.88	20.87	21.16	21.19	21.41	21.47

Table 3: Compressive strength test using CTM (28 days)

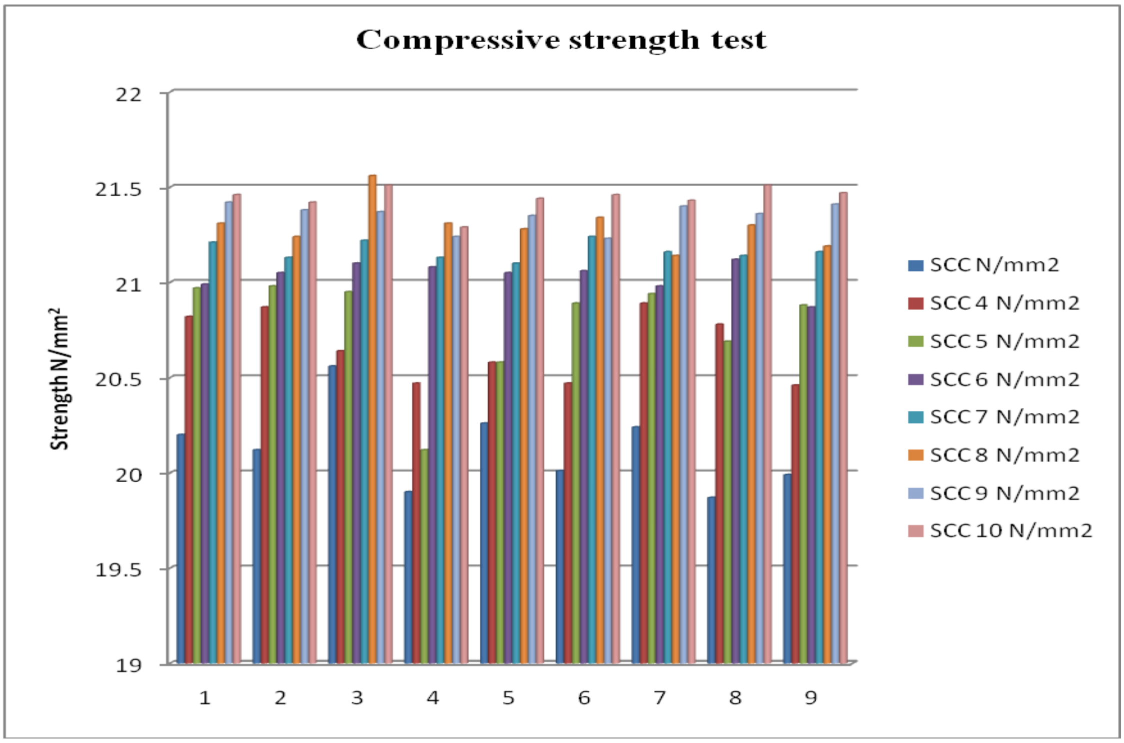

Chart 7: Compressive strength test using CTM (28 days)

S NO	SCC N/mm²	SCC 4 N/mm²	SCC 5 N/mm²	SCC 6 N/mm²	SCC 7 N/mm²	SCC 8 N/mm²	SCC 9 N/mm²	SCC 10 N/mm²
1	4.60	4.68	4.74	4.89	4.99	5.21	5.24	5.46
2	4.48	4.67	4.72	4.87	4.95	5.06	5.26	5.48
3	4.56	4.60	4.76	4.91	4.84	5.10	5.50	5.44
4	4.82	4.65	4.54	4.89	4.76	5.02	5.32	5.34
5	4.22	4.70	4.76	4.68	4.47	5.23	5.27	5.56
6	4.27	4.69	4.73	4.73	4.88	5.12	5.24	5.38
7	4.23	4.82	4.81	4.85	4.91	5.18	5.17	5.51
8	4.67	4.53	4.73	4.99	4.97	5.11	5.51	5.52
9	4.53	4.54	4.76	4.85	4.96	5.16	5.13	5.48

Table 4: Flexural strength test (28 days) (Two point load)

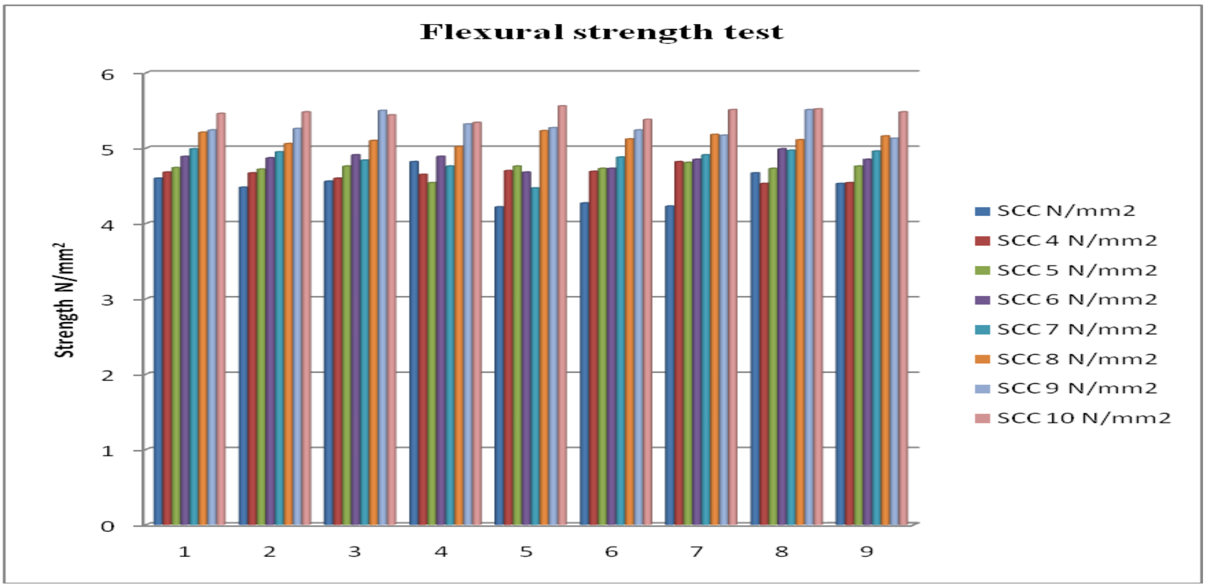

Chart 8: Flexural strength test (28 days) (Two point load)

S NO	SCC N/mm²	SCC 4 N/mm²	SCC 5 N/mm²	SCC 6 N/mm²	SCC 7 N/mm²	SCC 8 N/mm²	SCC 9 N/mm²	SCC 10 N/mm²
1	4.27	4.52	4.23	4.66	4.44	4.82	4.99	5.21
2	4.56	4.47	4.57	4.65	4.78	4.77	5.01	5.31
3	4.34	4.64	4.54	4.68	4.72	4.83	5.12	5.24
4	4.54	4.62	4.58	4.56	4.73	4.84	5.21	5.28
5	4.67	4.62	4.52	4.23	4.79	4.87	5.13	5.44
6	4.24	4.44	4.59	4.27	4.64	4.89	5.14	5.45
7	4.78	4.62	4.61	4.58	4.77	4.91	5.16	5.51
8	4.64	4.24	4.67	4.67	4.83	4.88	5.13	5.60
9	4.12	4.56	4.68	4.70	4.78	4.83	5.17	5.48

Table 5: Splitting tensile strength test (28 days)

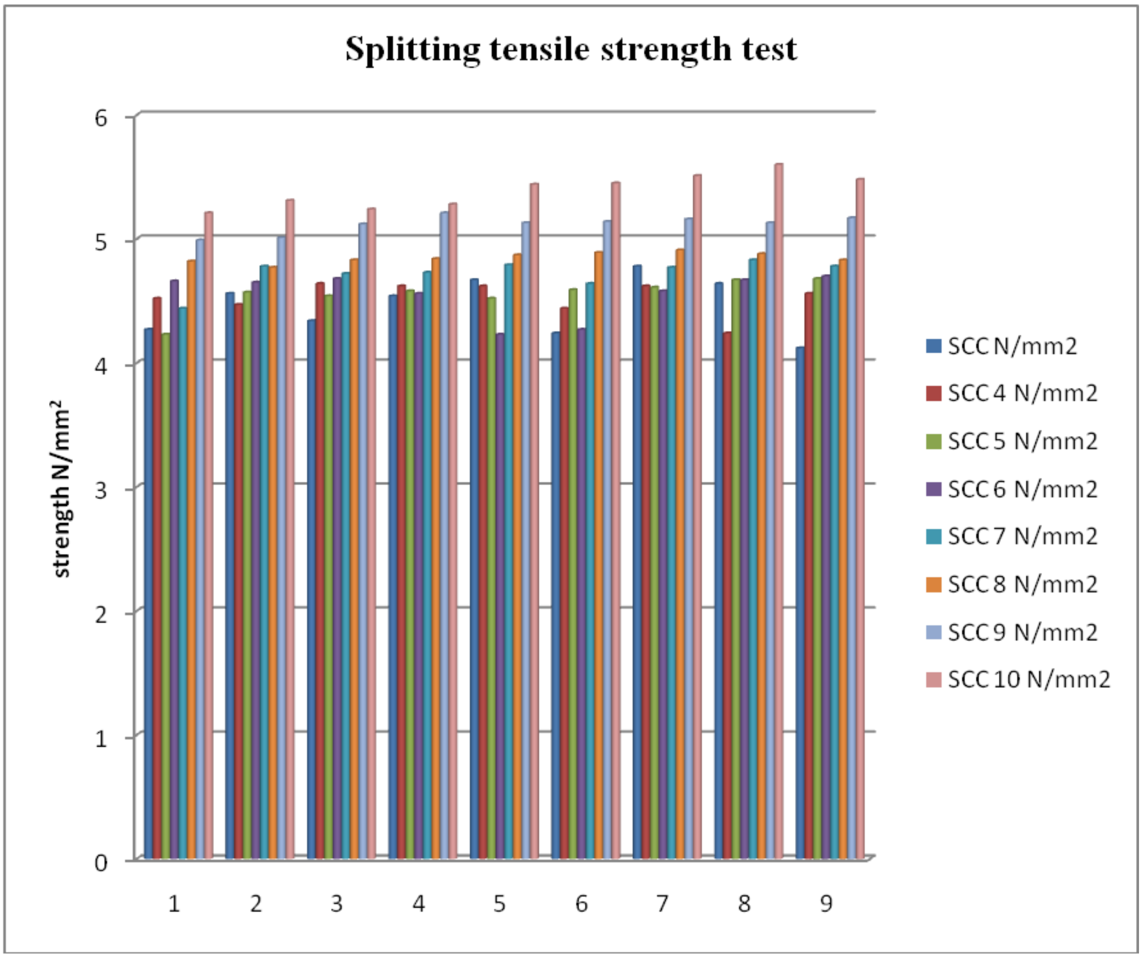

Chart 9: Splitting tensile strength test (28 days)

Chemical	Initial Weight (Kg)	1st(Day) Weight (Kg)	2nd Day Weight (Kg)	3rd(Day) Weight (Kg)	4th(Day) Weight (Kg)	5th(Day) Weight (Kg)	6th(Day) Weight (Kg)
H2SO4	8.640	8.610	8.610	8.590	8.580	8.560	8.470
Al2SO4	8.620	8.620	8.600	8.580	8.560	8.540	8.380
Nacl	8.810	8.810	8.800	8.790	8.770	8.740	8.690
HCl	8.720	8.720	8.700	8.680	8.660	8.640	8.560
NaOH	8.710	8.710	8.700	8.690	8.680	8.640	8.560
CaCl2	8.680	8.680	8.660	8.650	8.640	8.610	8.550

Table 6: Weight Loss of SCC and BFRSCC Mixes After Immersed in Different Solutions

Chemical	SCC	SCC4	SCC4	SCC6	SCC7	SCC8	SCC9	SCC10
H2SO4	16.23	16.34	16.54	17.02	17.12	17.34	17.41	17.58
Al2SO4	17.45	17.24	17.41	17.84	17.96	18.12	18.32	18.42
Nacl	17.85	17.91	17.86	17.54	17.67	17.84	17.94	18.01
HCl	17.02	17.12	17.44	17.57	17.89	17.96	17.90	18.14
NaOH	18.78	18.46	18.56	18.74	18.86	18.80	18.54	18.54
CaCl2	18.24	17.94	17.87	17.94	17.90	18.01	18.12	18.34

Table 7: Compressive strength of SCC and BFRSCC Mixes after Immersed in Different Solutions

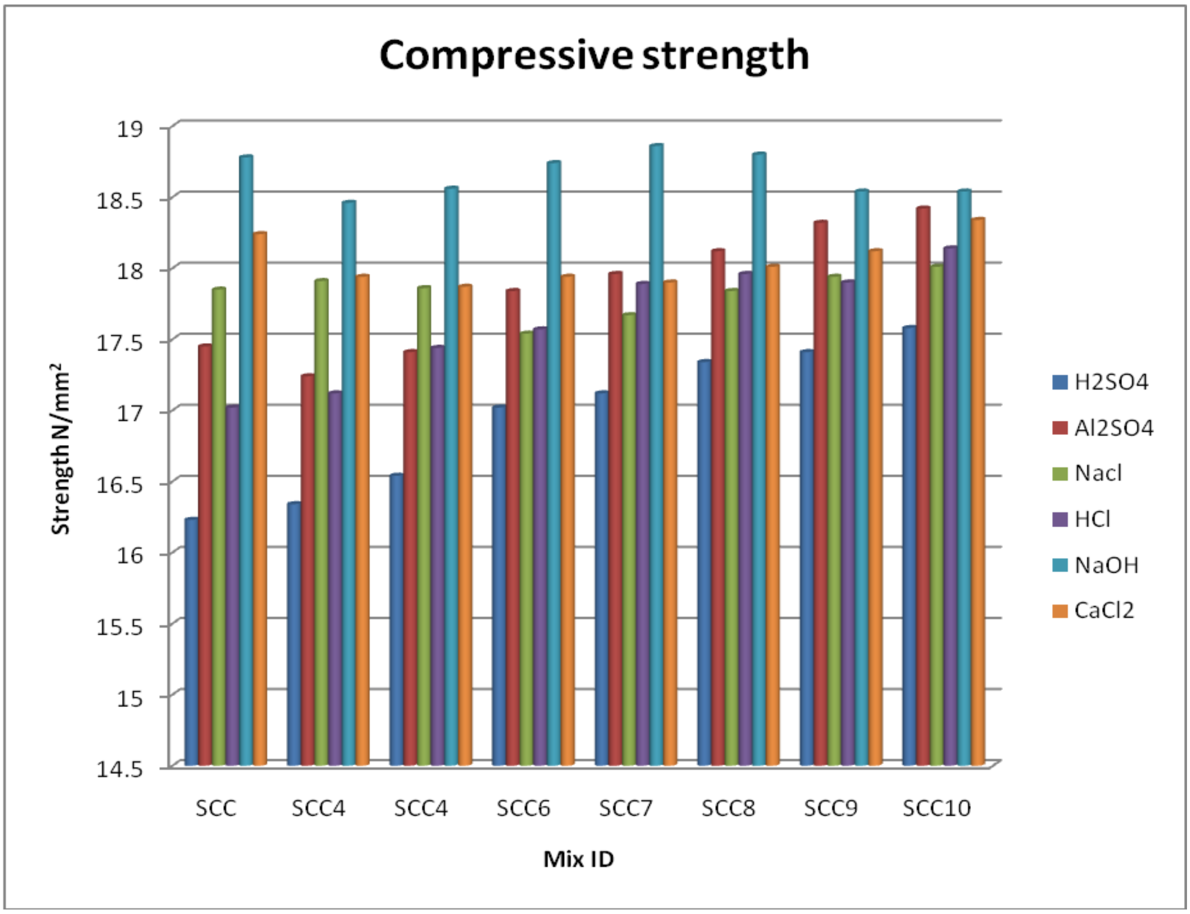

Chart 10: Compressive strength of SCC and BFRSCC Mixes after Immersed in Different Solutions

Discussion of Test Results:

Results of experimental investigations are discussed in the following sections with respect to the characteristics of SCC and BFRSCC mixes in the fresh and hardened states.

Characteristics of SCC Mixes In Fresh State:

The filling ability, passing ability & segregation resistance values of BFRSCC mixes compared to SCC mixes indicate that the presence of basalt fibers did not have any pronounced effect up to 0.5% this may be due to the low dosage of fibre addition (0.5%) and also may be due to the high dispersing nature of the fibers and some effect have appeared when 3.5% of basalt fibre added.

Characteristics of SCC Mixes In Hardened State:

Compressive strength:

The compressive strength values obtained by testing standard cubes made with different SCC and BFRSCC mixes. All the mixes have shown strength above 20 MPa, which is the required strength. The mix, without basalt fibers, containing the mineral admixture of silica fume (15%) has shown lower compressive strength compared to other BFRSCC mixes. The mix with 3.5 % basalt fibers, containing the mineral admixture of silica fume (15%) has shown higher compressive strength compared to other SCC & BFRSCC (0.5%) mixes. Further the BFRSCC mixes compared to normal SCC mixes have shown an improvement in compressive strength by 1.5 to 3.0%.

Tensile strength:

The tensile strength of mixes is obtained (i) by conducting split tensile test on standard cylindrical specimens and also by (ii) by conducting two point bend test on standard prisms. The results indicated that the incorporation of basalt fibers in to the SCC mixes increased the split tensile strength and flexural strengths by 14.2 to 23.33 % and 18.85 to 25.75 % respectively. The increase is significant and it may be due to high tensile strength of basalt fibers.

Durability:

The durability of mixes is obtained by conducting acid attack test on standard cube specimens of size 150x150x150mm. The results indicated that the incorporation of basalt fibers in to the SCC mixes increased the durability by 13.8 to 22.0 %. The increase is significant and it may be due to incorporation of basalt fibers.

CONCLUSION:

The application of silica fume in concrete mixture has significantly increased and enhanced the properties of the concrete whether it is in wet stage or in harden condition. Silica fume is a viable secondary mineral material. It leads to higher than usual modulus value and from the mixes studied, it is suggested that no more than 10% silica be replaced by mass. Rheological tests chosen and performed were sufficient to ascertain whether the mix will have all the attributes of SCC or not, i.e. the fresh concrete test used were sufficient to measure the filling ability and passing ability. SCC provides good resistance to corrosion, freeze and thaw cycles, and sulphate attack due to reduced porosity and decreased transport properties. SCC provides reduced drying shrinkage, low transport properties, high electrical resistivity and stable air-voids, which improve concrete durability. Sufficient segregation resistance must be maintained in SCC to decrease the transport properties, and thus to improve the durability of concrete. Comprehensive research is needed to examine the effect of electrical resistivity and segregation resistance on the durability of SCC. All the SCC and BFRSCC mixes developed satisfied the requirements of self compacting concrete specified by EFNARC. From above discussion of test results, it can be observed that addition of the Basalt fibers tested improves the compressive strength, tensile strength, durability load carrying capacity of ordinary reinforced cement concrete in flexure even with small dosage levels of 0.5% and 3.5 %. With the above discussion we found out that the results obtained in 3.5% is more when compared to the results obtained for 0.5%. Hence we conclude that the results may be higher when Basalt fibre is added at the percentage more than 3.5%. So we have ideas to continue our project in future with higher percentage of basalt fibers.

Scope for Further Study:

Since a rational mix design method and an appropriate acceptance testing method at the job site have both largely been established for self-compacting concrete, the main obstacles for the wide use of self-compacting concrete can be considered to have been solved. The next task is to promote the rapid diffusion of the techniques for the production of self-compacting oncrete and its use in construction. Rational training and qualification systems for engineers should also be established. In addition, new structural design and construction systems making full use of the self-compacting concrete should be introduced. When self-compacting concrete becomes so widely used that it is seen as the "Standard concrete" rather than a "Special concrete", we will have succeeded in creating durable and reliable concrete structures that require very little maintenance work.

REFERENCES:

[1] Ahmadi. M. A, Alidoust. O, Sadrinejad. I, and Nayeri. M, (2007), 'Development of Mechanical Properties of Self Compacting Concrete Contain Rice Husk Ash', World Academy of Science, Engineering and Technology, Vol. 10.

[2] AkhmadSuryadiQomariahSarosa R. M, (2012), 'Investigation of the Chemical Admixture Influence on the Performance of Self Compacting Concrete', Natural & Applied Sciences, Vol. 3, No. 3.

[3] Ali Nazari, ShadiRiahi, ShirinRiahi, SeyedehFatemehShamekhi and Khademno.A, (2010), 'Benefits of Fe2O3 nanoparticles in concrete mixing matrix', Journal of American Science, Vol. 6, No. 4.

[4] Ali Nazari, ShadiRiahi, ShirinRiahi, SeyedehFatemehShamekhi and Khademno.A, (2010), 'Influence of Al_2O_3 nanoparticles on the compressive strength andworkability of blended concrete', Journal of American Science, Vol. 6, No. 5.

[5] Ali Nazari, ShadiRiahi, ShirinRiahi, SeyedehFatemehShamekhi and Khademno.A, (2010), 'An investigation on the Strength and workability of cement based concrete performance by using ZrO_2 nanoparticles',Journal of American Science, Vol. 6, No. 4.

[6] Ali Nazari, ShadiRiahi, ShirinRiahi, SeyedehFatemehShamekhi and Khademno.A, (2010), 'Assessment of the effects of the cement paste composite in presence TiO_2 nanoparticles', Journal of American Science, Vol. 6, No. 4.

[7] Anand.N, Prince Arulraj.G, (2011), 'The effect of elevated temperature on concrete materials - A literature review', International Journal Of Civil And Structural Engineering, Vol. 1, No. 4.

[8] Aravindhan.CAnand.N Prince Arulraj.G, (2012), 'Development of Self Compacting Concrete with Mineral and Chemical Admixtures State of the Art', Engineering Science and Technology: An International Journal, Vol. 2, No, 6.

[9] Ashok Pareek, Trilok Gupta and Ravi K Sharma, (2012), 'Performance Of Polymer Modified Bitumen For Flexible Pavements', International Journal of Structural and Civil Engineering Research, Vol. 1, No. 1.

[10] Bhikshma.V and Annie Florence.G, (2013), 'Studies on Effect of Maximum Size of Aggregate in Higher Grade Concrete with High Volume Fly Ash', Asian Journal Of Civil Engineering (BHRC) Vol. 14, No. 1.

[11] CHEN Yu, WANG Ke-jin, ZHAO Xiao-long, (2012), 'Cracking behaviors and crack control of self-consolidating concrete a review of literature', Journal of Chongqing University, Vol. 11 No. 3.

[12] Dimitri Feys, Ronny Verhoeven, Geert De Schutter, (2007), 'Evaluation of Time Independent Rheological Models Applicable to Fresh Self-Compacting Concrete', Rheol, Vol.17, No.5.

[13] Dr. Sri Ravindrarajah. R, Siladyi. D and Adamopoulos. B, (2003), 'Development of High-Strength Self-Compacting Concrete with Reduced Segregation Potential', Reykjavik, Vol. 1.

[14] Dr.HemantSood, Dr.Khitoliya. R. K, and Pathak. S. S, (2009), 'Incorporating European Standards for Testing Self-Compacting Concrete in Indian Conditions', International Journal of Recent Trends in Engineering, Vol. 1, No. 6.

[15] Dr.Vaishali. G. Ghorpade, Dr.Sudarsana Rao, H, B.V. Ramana Prasad, (2013), 'Deriving Mix Proportions For Different Grades Of Phosphogypsum Based Self Compacting Concrete',International Journal of Engineering Research and Applications, Vol. 3, No.3.

[16] Ernestas IVANAUSKAS, ZymantasRudzionis, ArunasAleksandrasNavickas, MindaugasDauksys, (2008), 'Investigation of Shale Ashes Influences on the Self-Compacting Concrete Properties', MATERIALS SCIENCE, Vol. 14, No.3.

[17] Foroughi-Asl. A, Dilmaghani. S, Famili. H, (2008), 'Bond strength of reinforcement steel in self-compacting concrete', International Journal of Civil Engineerng. Vol. 6, No. 1.

[18] HanifiBinici, Hasan Kaplan and Salih Yilmaz, (2007), 'Influence of marble and limestone dusts as additives on some mechanical properties of concrete', Scientific Research and Essay, Vol. 2, No. 9.