EXPERIMENTAL INVESTIGATION ON STRENGTH AND DURABILITY PROPERTIES OF STEEL FIBRE REINFORCED SELF COMPACTING CONCRETE

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Abstract *The present project investigates the durability studies on Steel Fiber Reinforced Self Compacting Concrete (SFRSCC), with different grades low strength standard grade and high grade concrete i.e., M20, M30, M40 and M60. In addition to compressive strength durability performance of Steel Fiber Reinforced Self Compacting Concrete (SFRSCC) mixes were determined by means of Chemical Resistance, Initial Surface Absorption Test(ISAT).*

In the present study, coarse aggregate with nominal size 10 mm was used. Viscosity Modifying Admixtures (VMA) is used to increase the suspension of power of aggregates and also to eliminate possible segregation. Fine powdered materials like fly ash is also used for eliminating the possible segregation. Super plasticizer is used to enhance flow ofmix.

In the present study, the rational mix design procedure for self-compacting concrete is used. SCC mixes contains large quantity of powder (material whose parcel size is 0.125 mm)to maintain the plastic yield of the properties of fresh concrete as per the general guidelines for design of SCC mixes given in the EFNARC (2005).The present project consists of two phases. In the first phase, SCC mixes for different grades are developed without steel fibers and with steel fibers. The mechanical properties like compressive strength of the different grades were studied. In the second phase, based on the experimental results, durability properties were studied with the using of specimens of size 100 mm × 100 mm × 100 mm. Durability studies like Acid attack factors, Acid-Durability factors, Sulphate attack factors, Sorptivity are studied for the Plain SCC and steel Fiber Reinforced SCC and a comparison is made.

Detailed studies have revealed that the Steel Fiber Reinforced Self Compacting Concrete made with the Steel fibers displays a better performance.

I INTRODUCTION

Self compacting concrete is a self consolidating concrete defined as a Concrete which is able to flow under its self weight and to fill the formwork in complete, 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).
The Professor Hajime Okamura (1997) was the concept of self compacting concrete can be proposed in 1986, but the prototype was first 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 procedures and self compactibility 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 compactibility testing methods have been carried out from the viewpoint of making a standard concrete. When the Self Compacting

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 the 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.

II LITERATURE REVIEW

Gao Peiwei., et al,(2000) The traditional concrete, which is made up of three ingredients cement, aggregates and water, these are used for a long time. In recent years, the 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 aim of the present day concrete is to deduction of cement in the HPC.

Raghu Prasad P.S. 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 report 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. This results in the reduction of corrosion of reinforcement in concrete.

V.M.C.F. Cunha, J.A.O. Barros and J.M. Sena-Cruz(2011) The paper presents the work 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.

III MATERIALS USED IN THE STUDY

Cement

Cement is a material, generally in powered form, which can be made into a paste usually by the addition of water and, when molded or poured, will set into a solid mass. Numerous organic compounds used for an adhering, or fastening materials, are called cements, but these are classified as adhesives, and the term cement alone means a construction material.

In this present investigation, the Ordinary Portland Cement OPC 53 Grade available in the local market was used. To conduct a various test properties according to IS: 4031-1988 and found to confirming to IS: 12269-1987.

OPC 53 Grade cement

Fine aggregates

Fine aggregate/sand is an accumulation of grains of mineral matter derived from disintegration of rocks. It is distinguished from gravel only by the size of the grains or particles, but is distinct from clays which contain organic material.

River sand available in the local market is used as fine aggregate. The fine aggregate (passing through IS Sieve 4.75μm) was tested for its characteristics as per IS: 2386-1963 and found to be confirming to the specifications.

Coarse aggregates

Crushed angular granite material is available from the local market is used as coarse aggregate in this investigation. The coarse aggregate (passing through IS Sieve 12mm and retained at IS Sieve 10mm) was tested for its characteristics as per IS: 2386-1963 and found to be confirming to the specifications.

Coarse aggregates

Fly ash

Fly ash is the one of the most expensively used by-product materials in the construction field resembling Portland cement. It is an inorganic, non-combustible; finely divided residue collected or participated from the exhaust gases of any industrial furnace. Fly ash from a Dirk India Private Limited (A subsidiary of Ambuja Cements Ltd.) in Mumbai was used in this investigation. The physical and chemical properties of the fly ash as used in the investigation confirm to grade I fly ash of IS: 3812-2003.

Fly ash

Super Plasticizer

Super Plasticizer with Sulphonated Napthalene Formaldehyde (SNF) of Conplast SP430 DIS was confirming to IS: 9103-1999 used in this investigation.

Complast SP 430

Viscosity modified admixture

ROOF PLAST VMA2 is ready-to-use, liquid, organic, Viscosity Modifying Admixture (VMA) specially developed for producing concrete with enhanced viscosity and controlled rheological properties. ROOF PLAST VMA2 is used as a Viscosity modifying agent from a standard agency confirming to standard specifications was also used.

ROOF PLAST VMA2

Water

Portable water confirming to IS: 3025-1986 part 22 & 23 and IS: 456-2000 was used in the investigation

Steel Fibers

Hooked end steel fibers of 0.4mm diameter and Aspect ratio of 30 and 12 mm length were used.

Steel fibers

IV DEVELOPMENT 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.

FRSCC

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

Addition of Fibres to SCC mix

STUDY ON SCC

The experimental programme consisted of casting and testing SCC specimens. Although basically the Nan Su method and S V Rao et al method of mix designs (Su et al., 2001) was adopted, several trials were made in producing SCC satisfying the EFNARC specifications (EFNARC, 2005). A total of four grades of concrete was investigated: M20, M30,M40 and M60 grades, representing ordinary, standard and high strength concrete, respectively, according to IS 456-2000 (BIS, 2000). A total of 40 standard cubes of SCC and 40 standard cubes of SFRSCC for acid attack, sulphate attack study studies and eight specimens each for SCC and SFRSCC of size 100mm×100mm for sorptivity studies, was cast and tested. 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 sulphatewith specificgravity of1.464, molecular weight 142.036 g/mol were used in this study at concentrations of both acids and sulphate is 5%.

Mix Design and Trail Mix Proportions of Self Compacting Concrete

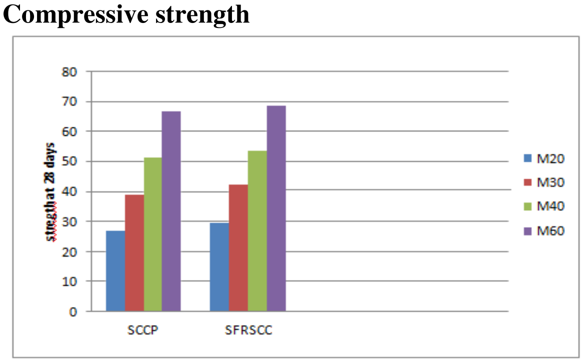
An SCC mixes of M20, M30, M40 and M60 were aimed and the initial mix proportions were obtained using the mix design methods as mentioned above. The mix proportions thus obtained were fine-tuned by incorporating different guidelines available and making various trail mixes to obtain the mix which satisfies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

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	-

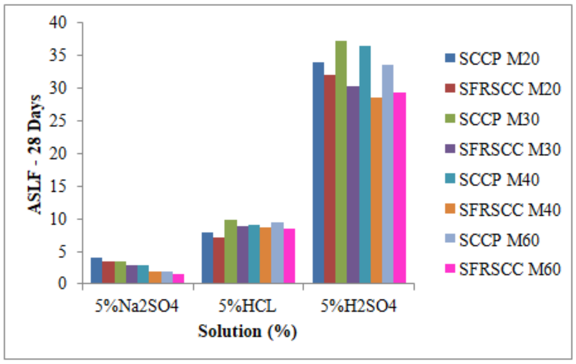
V RESULTS AND ANALYSIS

Compressive strength

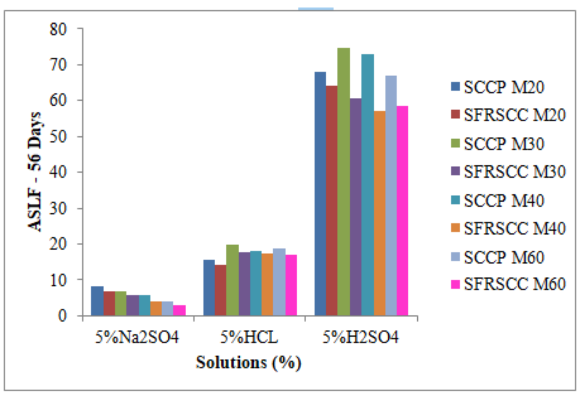


Variation of Cube Compressive Strengths for SCCP and SFRSCC for 28 days

Durability of concrete

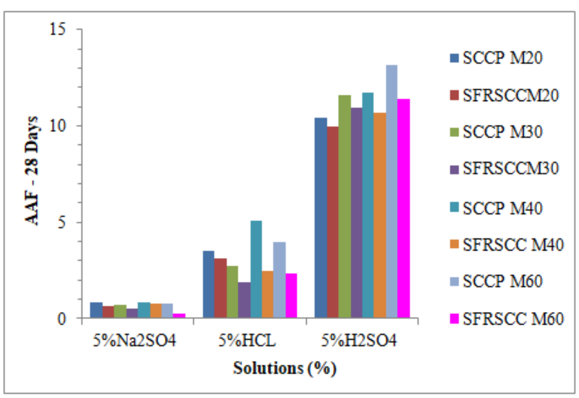


Acid Strength Loss Factors (ASLF) for SCCP and SFRSCC at 28 Days

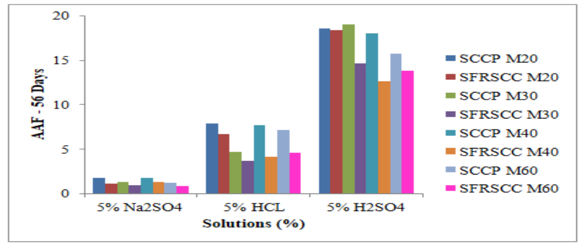


Acid Strength Loss Factors (ASLF) for SCCP and SFRSCC at 56 Days

Acid Attacking Factor

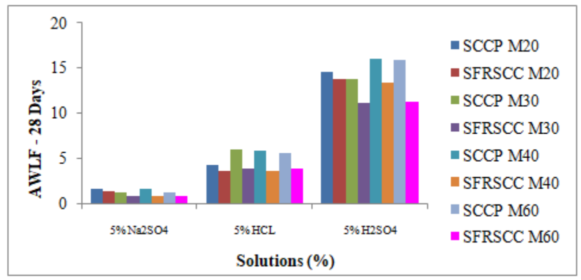


Acid Attack factors (AAF) for SCC and SFRSCC at 28 days of immersion

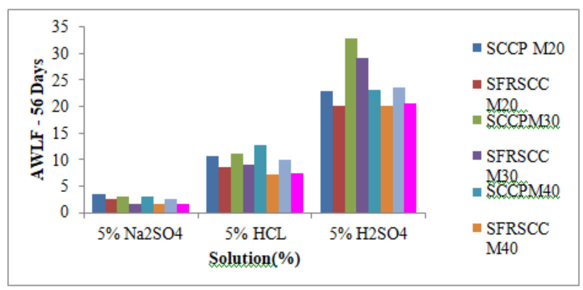


Acid Attack Factors (AAF) for SCC and SFRSCC at 56 days of immersion

Acid Weight Loss Factor

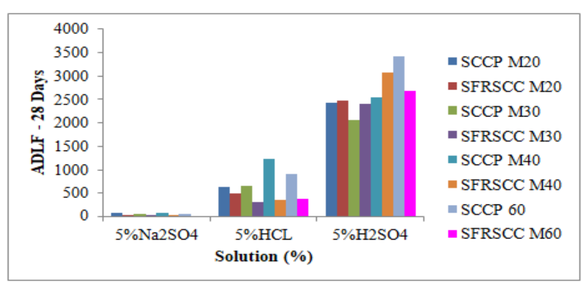


Acid weight loss factors (AWLF) for SCC and SFRSCC at 28 days of immersion

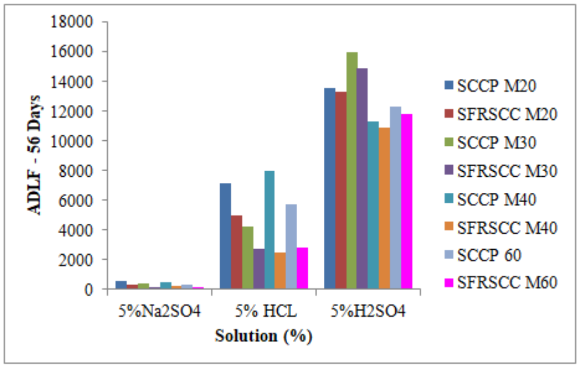


Acid weight loss factors (AWLF) for SCC and SFRSCC at 56 days of immersion

Acid Durability Loss Factor

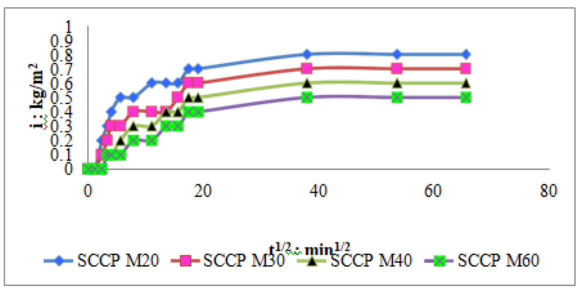


Acid Durability Loss Factors (ADLF) for SCCP and SFRSCC at 28 Days of immersion

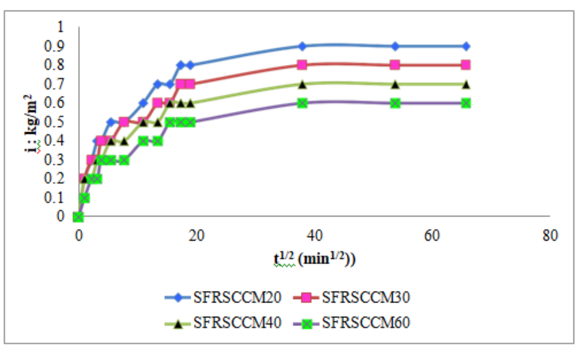


Acid Durability Loss Factors (ADLF) for SCCP and SFRSCC at 56 Days of immersion

Sorptivity Study on SCC and SFRSCC



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



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

VI 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-compactingconcrete.

2 Aspect ratio is very important and found that shorter fibres with 12mm long and aspect ratio 30 gives betterperformance.

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 ofadmixtures.

4 In different grades of the concrete i.e., M20, M30, M40 and M60. The compressive strength of the Steel fibre reinforced Self-compacting concrete was found to be more ranging from 2% to 10%. When compared to plain self- compactingconcrete.

5 With increase of fibre 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.

9 With increase in period of immersion of the concrete in 5% concentration ofacids 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

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