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A Study on Effect of Steel Fiber in Fly Ash Based Self-Compacting Concrete

Sheik Jareena Begum
PG Student
Department of Civil Engineering
DNR College of Engg. & Technology, Bhimavaram, Andhra Pradesh, India

P. J. D Anjaneyulu
Assistant Professor
Department of Civil Engineering
DNR College of Engg. & Technology, Bhimavaram, Andhra Pradesh, India

M. K. M. V Ratnam
Assistant Professor
Department of Civil Engineering
DNR College of Engineering & Technology, Bhimavaram, Andhra Pradesh, India

Abstract

Concrete is a versatile widely used construction material. Ever since concrete has been accepted as a material for construction, researchers have been trying to improve its quality and enhance its performance. Recent changes in construction industry demand improved durability of structures. There is a methodological shift in the concrete design from a strength based concept to a performance based design. At present there is a large emphasis on performance aspect of concrete. One such thought has lead to the development of Self Compacting Concrete (SCC). It is considered as "the most revolutionary development in concrete construction". SCC is a new kind of High Performance Concrete (HPC) with excellent deformability and segregation resistance. It can flow through and fill the gaps of reinforcement and corners of moulds without any need for vibration and compaction during the placing process. The features of mix proportion of SCC include low water to cementitious material ratio, high volume of powder, high paste to aggregate ratio and less amount of coarse aggregate. One of the popularly employed techniques to produce Self Compacting Concrete is to use fine materials like Fly Ash, GGBFS etc; in concrete, besides cement, the idea being to increase powder content or fines in concrete. The original contribution in the field of SCC is attributed to the pioneering work of Nan Su etal; who have developed a simple mix design methodology for Self-Compacting Concrete. In this method, the amount of aggregate required is determined first, based on Packing Factor (PF). This will ensure that the concrete obtained has good flowability, self-compacting ability and other desired SCC properties. The European Federation of Producers and Applicators of Specialist Products for Structures (EFNARC) [2005] have also laid down certain guidelines for fresh properties of SCC.

- The present investigation is aimed at developing high strength Self Compacting Concrete of M55 and M65 Grades.
- SCC characteristics such as flowability, passing ability and segregation resistance have been verified using slump flow, L box and V funnel tests.
- To study the Physical Properties of the materials used in our work.
- To study the effect of using Steel Fibers in SCC.
- To study the Mechanical Properties of the obtained SCC & FRSCC.

Keywords: Self-Compacting Concrete, Flyash

I. Introduction

Concrete is the most widely used construction material today. It is all around us; from offices to schools, roads to railways and dams to homes. It is difficult to point out another material of construction which is as versatile as concrete. It is the material of choice where strength, performance, durability, impermeability, fire resistance and abrasion resistance are required. The versatility and mouldability of this material, its high compressive strength, and discovery of the reinforcing and prestressing techniques which helped to make up for its low tensile strength have contributed largely to its widespread use. It is so closely associated now with every human activity that it touches every human being in his day to day living. We can rightly say that we are in the age of concrete.

However, when it comes to considering its sustainable credentials, which will ensure that we balance our current rate of development with the resource requirements of future generations, it is important to look at special concretes like Self-Compacting Concrete(SCC), Fiber Reinforced Self-Compacting Concrete (FR-SCC) and High Performance Concrete(HPC) from several angles, its environmental and lifecycle aspects, its economic impact, its strength and its contribution to our society in general. Taking the environmental aspect first, there is clear evidence that improvements in environmental performance are underway to minimize the impact of concrete production. These changes include actively reducing the emissions associated with the concrete manufacturing process, and lower the reliance on virgin raw materials by increasing the use of by products in concrete.

The greenhouse gas emissions can be significantly reduced by utilizing the fly ash which is a waste product from thermal plants. The use of fly ash will continue to make a significant contribution to reducing the environmental pollution.

II. Review of Literature

Jagadish Vengala et al (2003)[37] developed a sequential procedure for achieving SCC. Fifteen mixes were investigated, maintaining w/c ratio and super-plasticizer dosage constant for all excepting for the initial mixes. To obtain the required flow in SCC fly ash replacement of 5, 10, 15, 20 and 25 percent respectively of coarse aggregate was adopted. A VMA was also tried in different dosages to stabilize the mix. Slump flow test and L-box tests as recommended in literature were carried out to obtain the properties of flow ability and workability of fresh concrete. The mechanical properties of hardened concrete were also investigated in terms of compressive strength. The results indicated that using the sequential procedure developed, SCC could be achieved successfully. It was reported that VMA may not be strictly necessary for making SCC.

Lachemi M. et al(2004)[51] presents the performance of four new polysaccharide-based VMAs in enhancing the rheological and consistency properties of cement paste. The study of the rheological properties and consistency of cement paste to screen the dosage and type of new VMA to be used in SCC is reported. Investigation was carried out on cement pastes with combinations of various dosages of new VMAs and of a super-plasticizer (SP) to study the influence on rheology, consistency and washout mass loss. A commercial VMA designated as ‘‘COM’’ was tested for comparison. The study on new VMAs was found to be encouraging and confirmed that pastes with satisfactory rheological and consistency properties comparable with or even better than commercial VMA can be developed. The combined use of proper dosages of VMA and SP is shown to clearly contribute to securing high-performance cement pastes that is highly fluid yet cohesive enough to reduce water dilution and enhance water retention. Attempt was made to correlate rheological properties (yield stress) to consistency (slump) of pastes.

Burak Felekoglu and Hasan Sarikahya (2008)[12] investigated and reported about the effect of the three synthetic polycarboxylate-based super-plasticizers (PC-based SPs) on setting time of cement pastes and time dependent workability and strength development of SCCs. It was shown that

- Effective slump-flow loss control of SCC is possible by employing a PC-based SP with a modified bond structure between side-chains and main backbone of copolymer.
- The SP dosage and w/p ratio were also important parameters to improve the workability retention performance of copolymers
- In addition to high early strength and shorter setting times, the comparatively high initial water reducing capacity of ester bonded super plasticizer, makes the proposed admixture more suitable for precast industry.

III. Experimental Study

A. Materials:

1) Cement:
Ordinary Portland Cement (OPC) of 53 grade confirming to IS: 12269 – 1987 was used for the present experimental investigation

2) Fine Aggregate:
Clean river sand conforming to IS 383:1970 was used

3) Coarse Aggregate:
Crushed granite coarse aggregate of particle size passing through 10mm and retained on 4.75mm sieve having “rounded” shape and confirming to IS: 2386 – 1963 was used for the present investigation.

4) Water:
Potable tap water free from any injurious amounts of oils, acids, alkalies, sugar, salts and organic materials available in the laboratory with PH value of 7.0±1 and confirming to the requirements of IS: 456 -2000 was used for mixing concrete and curing the specimens as well

5) Fly Ash:
The fly ash obtained from Vijayawada Thermal Power Station (VTPS), Krishna district in Andhra Pradesh state confirming to IS: 3812 – 1981 was used in the present investigation

6) Steel Fiber:
Binding wire commercially available in the local market was used as fiber in the present investigation. The diameter of the wire was found to be 0.925mm and a constant aspect ratio of 40 was used throughout the work. The properties of fibers used for making SFR-SCC are reported in Table 3.10. The strength of fibers is approximately 960 N/mm2.

7) Super Plasticizer (SP)
GLENIUM B233 is an admixture of a new generation, based on modified polycarboxylic ether. The product has been primarily developed for applications in high performance concrete where the highest durability and performance is required. GLENIUM B233 is free of chloride & low alkali. It is compatible with all types of cements.

8) Viscosity Modifying Admixture (VMA)
GLENIUM STREAM 2 is a premier ready-to-use, liquid, organic, viscosity-modifying admixture (VMA) specially developed for producing concrete with enhanced viscosity and controlled rheological properties. Concrete containing GLENIUM STREAM 2

admixture exhibits superior stability and controlled bleeding characteristics, thus increasing resistance to segregation and facilitating placement.

B. Mix Proportion:

S.No.	*Mat. Mix*	*Cement (kg)*	*Fly ash (kg)*	*Powder (Kg)*	*FA (kg)*	*CA (kg)*	*Water (litrs)*	*W/P Ratio*	*SP 1% of P*	*VMA 0.07% of P*
1	*M55*	*360*	*240*	*600*	*670*	*755*	*180*	*0.30*	*6.00*	*0.420*

IV. EXPERIMENTAL TEST RESULTS

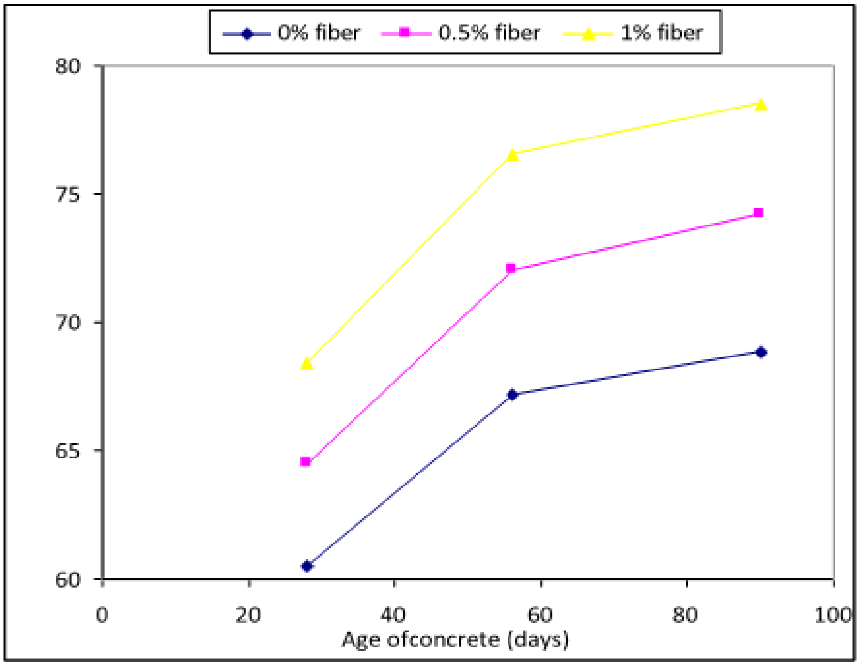

Fig. 1: Compressive strength of M55 Grade concrete mix at 28, 56 and 90 days

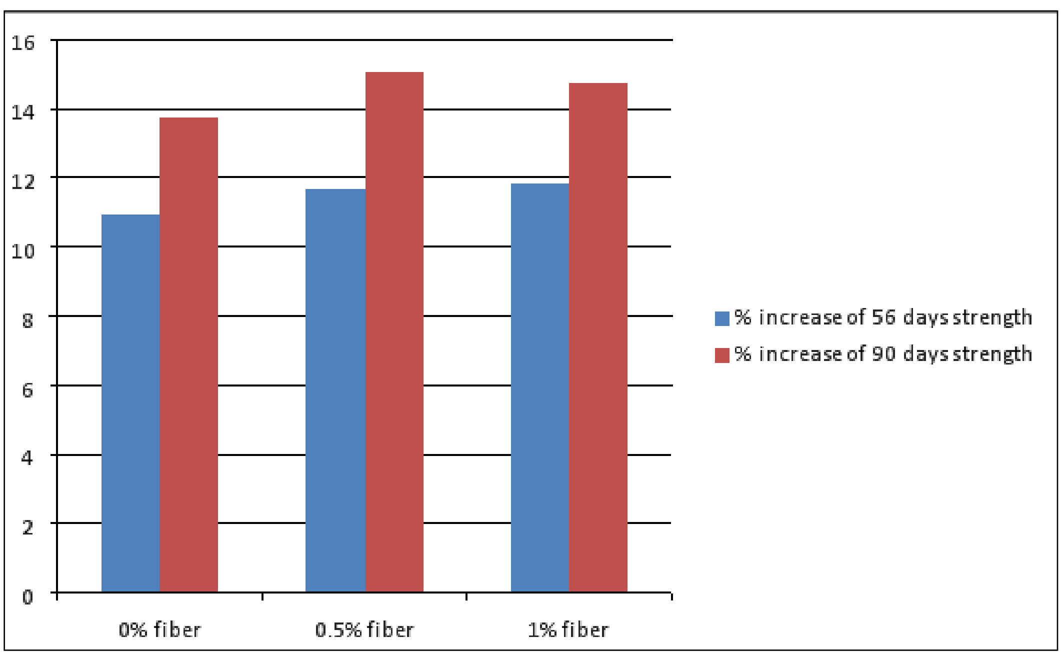

Fig. 2: Percentage increase in compressive strength of M55 Grade concrete mix in comparison with 28days strength

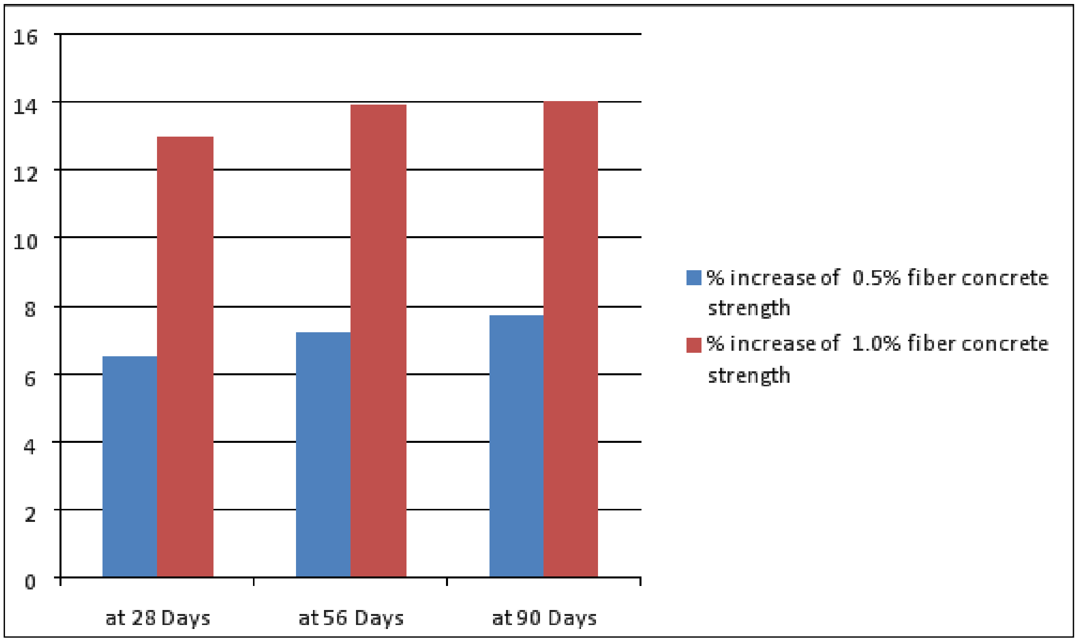

Fig. 3: Percentage increase in compressive strength of M55 Grade concrete mix in comparison with 0% fiber strength

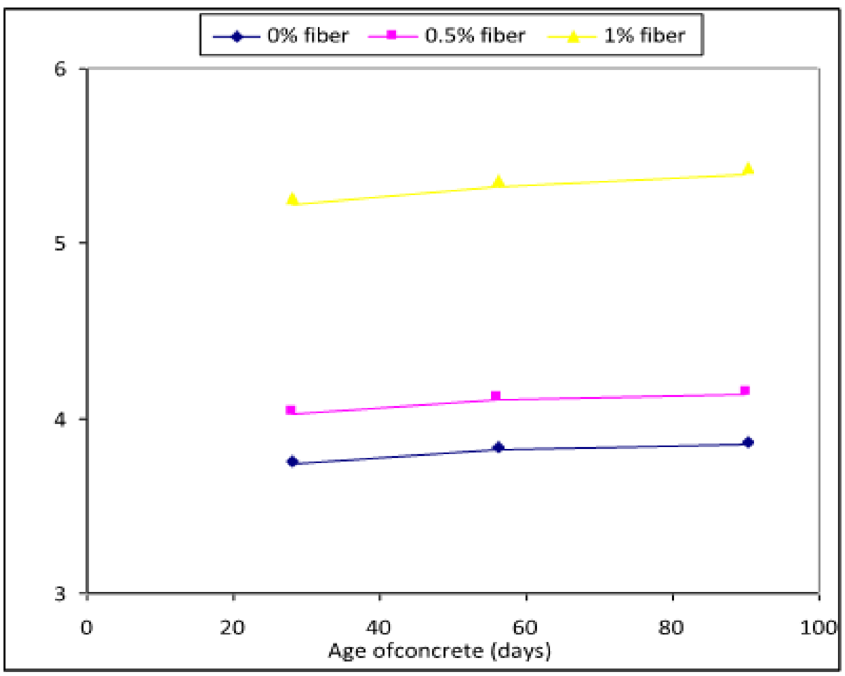

Fig. 4: Split Tensile strength of M55 grade concrete Mix at 28, 56, 90 days strength

V. DISCUSSIONS ON RESULTS

A. Discussion on Compressive Strength Results of SFR-SCC Mix of M55 Grade

- The percentage increase in compressive strength with respect to the age of the mix is worked out and presented in the Table 4.3. It is noted that the percentage increase varies from 10.94 to 15.05.
- The percentage increase in compressive strength with respect to the fiber content is worked out and presented in the Table 4.4. It is noted that the percentage increase varies from 6.51 to 14.02.

B. Discussion on Split Tensile Strength Results of SFR-SCC Mix of M55 Grade

- The percentage increase in split tensile strength with respect to the age of the mix is worked out and presented in the Table 4.6. It is noted that the percentage increase varies from 1.90 to 3.23. The percentage increase in split tensile strength with respect to the fiber content is worked out and presented in the Table 4.7. It is noted that the percentage increase varies from 7.51 to 40.67.

VI. CONCLUSIONS

- The mix maintains self-compactability for fiber content up to 1% with an aspect ratio of 40.
- High volume of fly ash (35-50% of powder) is proposed to be used as a binder replacing cement partially. The fly ash thus proposed enhances the fines (paste content) and improves the flow-ability and durability of the concrete. The usage of such a high volume of fly ash reduces the pollution level thereby protecting the environment from pollution.
- The usage of high volume of fly ash reduces the requirement of super plasticizer in developing the SCC mixes.
- The quantity of cement required is less due to the usage of fly ash as a replacement for cement. This reduces the energy required in the manufacturing of cement, thus saving lot of energy which is in scarce now.
- Water required for fly ash based SCC is at its minimal and is noted to be around 180 liters per cubic meter of concrete.
- Strength increases noticeably with increase in fiber content and age
- Compressive strength increases from 10.94 to 13.73%, 11.68 to 15.05%, and 11.84 to 14.75% in case of mixes with 0, 0.5 and 1% fiber content respectively with respect to their 28 days strength.
- Split tensile strength increases from 2.13 to 2.93%, 1.98 to 2.72%, and 1.90 to 3.23% in case of mixes with 0, 0.5 and 1% fiber content respectively with respect to their 28 days strength.

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