Studies on Flexural Behaviour of M100 Grade Hybrid fibre Reinforced Self compacting concrete beams

S.Sesha Phani [1], Dr.Seshadri Sekhar T [2] Dr P.Srinivasa rao [3]

Abstract *In the present experimental investigation, attempts are made to study the comparative study of flexural behaviour of High Strength hybrid fibre reinforced self compacting concrete beams of M 100 grade with addition of varying percentages of crimped steel fibers varying 0 , 0.5,1.0, 1.5% and Glass fibers 0% , 0.03% . The studies indicated that the addition of glass fibre and steel fibers in certain proportions in High Strength hybrid fibre reinforced self compacting concrete beams had contributed towards development of high performance and high strength concrete which is the need of the hour.*

Key words: Hybrid Fibres , Load Deflection Characteristics, Flexure Behaviour ,

Introduction

Self compacting concrete was first developed in 1986 in JAPAN to achieve durable concrete structures. For several years, the problem of the durability of concrete structures in a major topic of interest for construction engineers to make durable concrete structures. Sufficient compaction is needed for conventional concrete that cause segregation. With plain concrete, it is difficult to ensure uniform material quality in heavily reinforced zone where steel is not correctly surrounded by concrete and which finally leads durability problems. The answer to the problem may be a concrete which can get compacted into every corner of a formwork, purely by means of its own weight and without the need for vibrating compaction. Self Compacting Concrete concept was stated that the concrete meets special performance and uniformity requirements that cannot be used as the ingredients of conventional concrete. To build high rise building by reducing column sizes and increasing available space, to built the super structure of long span bridges and to the durability of bridge decks a high strength is needed. High strength concrete was used in South Wacker in Chicago of 80 Mpa, Baynunah Tower in Abu Dhabi of 80 Mpa and Frankfurt Trianon in Germany of 125 Mpa. If high strength concrete is self-compacting, the production of densely reinforced building element from high strength concrete with high homogeneity would be an easy work.

Literature Review

C. Selvamony et.al(1) involved evaluating the Effectiveness of various percentages of mineral admixtures in producing SCC. Okamura's method, based on EFNARC specifications, was adopted for mixed design. **Ravindrarajaiah et.al (2)**investigated into the development of self-compacting concrete with reduced segregation potential. The fine particle content is increased by replacing partially the fine and coarse aggregates by low-calcium fly ash. **Venkateshwara Rao et.al (3)**aims at developing standard and high strength Self Compacting Concrete (SCC) with different sizes of aggregate based on Nansu's mix design procedure. Also, fly ash optimization is done in study with the graded coarse aggregate. **Youjun**

[1] *Deputy Executive Engineer , Tirumala Tirupathi Devasthanams , Hyderabad*
[2] *Dean , CISC ,NICMAR, Hyderabad, Telangana E: Mail : ss.tirumala@gmail.com*
[3] *Professor , Department of Civil Engineering JNTUH, Hyderabd .*

Xie et.al(4)presented a preparation technology of high-strength self-compacting concrete containing ultra pulverized fly ash and superplasticiser. **Erdogan Ozbay et.al (5)** analyzed mix proportion parameters of high strength self compacting concrete by using the Taguchi's experiment design methodology for optimal

design . Annie peter[6] et.al had compared the structural behaviour such as load- deflection characteristics ,crack-width spacing of crack, numbers of cracks ,crack pattern ,ultimate load carrying capacity, moment curve relation longitudinal strain in both concrete and steel for self compacting concrete and conventionally vibrated concrete .They observed that the crack spacing is same in both the beams. **Ganesh.N [7]** et.al made an attempt has been made to study the effect of steel fibres on the strength and behaviour of Self Compacting Concrete (SCC) flexural elements. **Seshadri sekhar[8] et.al** has discussed the role of mineral admixtures in developing high strength self compacting concrete of grade M 100. **Srinivasa Rao [9]** et.al has discussed the load deflection behaviour of Reinforced glass fibre self compacting concrete beams.

Objectives of Study :

- To Study the load - deflection characteristics of High strength hybrid fibre Reinforced self compacting concrete flexural members of M100 grade concrete.

Research significance:

SCC permits constructions of concrete structures with heavy reinforcement as is generally required for resistant designs. It also leads to noise free constructions and results in excellent finishing. In view of the above, SCC is attracting engineers and builders world over . However, poor tensile strength and fracture properties of conventional concrete are present in SCC. Therefore, the need is felt for the development of SCC composites with enhanced tensile strength , improved fracture toughness and post peak-load deflection response of the flexural members. It is clear from the in the past that addition of fibres to conventional concrete improve of many of the engineering properties of conventional concrete. While a number of investigations have been made on the effect of steel fibres on the strength and behaviour of conventional concrete, studies on steel fibre reinforced SCC structural elements such as columns, beams, beam column joints. Comprehension studies which involve tensile strength and fracture properties are not available on High strength self compacting reinforced concrete using hybrid fibres . Hence, considering the gap in the existing literature, an attempt has been made to understand the flexure behaviour of High strength hybrid fibre self compacting reinforced concrete beams .

Materials:

Cement

Ordinary Portland cement of 53 grade having specific gravity of 3.02 and fineness of 3200cm^2/gm was used in the investigation. The Cement used has been tested for various proportions as per IS 4031-1988 and found to be confirming to various specifications of are 12269-1987.

Coarse Aggregate

Crushed angular granite metal of 10 mm size having the specific gravity of 2.65 and fineness modulus 6.05 was used .

Fine Aggregate

River sand having the specific gravity of 2.55 and fineness modulus 2.77 was used .

Viscosity Modifying Agent

A Viscosity modified admixture for Rheodynamic Concrete which is colourless free flowing liquid and having Specific of gravity 1.01$\pm$0.01 @ 25^{0}C and pH value as 8$\pm$1 and Chloride Content nil was used .

Admixture

The Modified Polycarboxylated Ether based superplasticizer which is pale yellow colour and free flowing liquid and having Relative density 1.10$\pm$0.01 at 25^{o}C, pH >6 and Chloride Ion content <0.2% was used .

Fly Ash

Type-II fly ash confirming to I.S. 3812 – 1981of Indian Standard Specification was used .

Micro Silica

The Micro silica having the specific gravity 2.2 was used in the present investigation

Test Specimens:

Glass fibre reinforced with steel fibres of high strength self compacting concrete beams by varying the percentage of crimped steel fibres from 0 % to 1.5 % and glass fibre of 0.03% of sizes 1200 X 150 X 100 mm were cast with reinforcement of 2 nos of 12mm diameter HYSD bars as tension reinforcement and 6mm diameter stirrups spacing at 150 mm c/c as shear reinforcement. To hold stirrups in position two hanger rods of 2 nos of 10mm diameter HYSD bars at top were used. These specimens were cured in water for 90 days and tested for ultimate load, deflections and failure characteristics under one third point loading.

Discussion on Test Results:

Quantities of materials required per 1 cum of Hybrid Fibre High Strength Reinforced Self Compacting Concrete mixes

Table 1 gives the quantities of material required for various trial mixes of High Strength hybrid fibre reinforced Self Compacting mixes . The Trail Mixes were carried by verifying the fresh state properties with EFNARC guidelines.

Table 1 Quantities of Materials for 1m^3 of High Strength Self Compacting Concrete mixes

Grade	Cement (Kg/m^3)	Fly ash (Kg/m^3)	Micro Silica (Kg/m^3)	Water (Kg/m^3)	Coarse Aggregate (kg/m^3)	Fine Aggregate (Kg/m^3)	SP (kg/m^3)	V.M.A (Kg/m^3)
Mix 100	500	125	75	154	774.985	766.195	11.2	0.35

Fresh State properties of Hybrid fibre High Strength Reinforced Self Compacting Concrete mixes

Table 2 provides a summary of the fresh state properties of Strength hybrid fibre reinforced Self Compacting mixes**.** As it is evident, the basic requirements of high flow ability and segregation resistance as specified by guidelines on High Strength Self Compacting Concrete mixes by EFNARC are satisfied. The Rheological properties are maintained by adding suitable quantities of super plasticizers.

Table 2 Fresh Concrete properties of High Strength Self Compacting Concrete Mixes

Grade	Slump flow(mm)	T500 (sec)	V-funnel (sec)	V-funnel T5min(sec)	L-Box (h2/h1)
Mix 100	665.00	4.50	12.00	14.00	0.90

Flexural Behaviour of High Strength Hybrid Fibre Reinforced Self Compacting Concrete Beams of M 100.

Flexural strength of high strength 0% hybrid fibre reinforced self compacting concrete beams of M 100 grade.

The beam 1 failed at a load of 118KN and the first crack observed to be at 33KN. The beam2 failed at a load of 93KN and the first crack observed to be at 35KN.

Flexural strength 0.03% of glass fibre reinforced with 0.5% of steel fibre of high strength self compacting concrete beams of M100 grade

The beam 1 failed at a load of 98KN and the first crack observed to be at 37KN. The beam2 failed at a load of 106KN and the first crack observed to be at 40KN.

Flexural strength 0.03% of glass fibre reinforced with 1.0% of steel fibre of high strength self compacting concrete beams of M100 grade

The beam 1 failed at a load of 115KN and the first crack observed to be at 30KN. The beam2 failed at a load of 111KN and the first crack observed to be at 40KN.

Flexural strength 0.03% of glass fibre reinforced with 1.5% of steel fibre of high strength self compacting concrete beams of M100 grade

The beam 1 failed at a load of 142KN and the first crack observed to be at 60KN. The beam2 failed at a load of 115KN and the first crack observed to be at 50KN.

Table 3 Ultimate flexural strength and Deflection at Ultimate flexural strength of high strength hybrid fibre reinforced self compacting concrete beams of M 100 Grade

M100 Grade of Concrete	Ultimate Flexural Strength of High Strength Self Compacting Concrete Beams	Deflections at Maximum Strength of Glass Fibre Self Compacting Concrete Beams
0%	93	4.8
0.03 %GF + 0.5 %SF	106	7.6
0.03 %GF + 1.0% SF	111	9.1
0.03 %GF + 1.5 %SF	115	10.1

Table 4 Percentage increase of Ultimate flexural strength and Deflection at Ultimate flexural strength of high strength hybrid fibre reinforced self compacting concrete beams of M 100 grade with respect to 0% fibres

M100 Grade of Concrete	% increase	% increase
0.03 %GF + 0.5% SF	14	58
0.03% GF + 1.0 %SF	19	89

0.03% GF + 1.5 %SF	24	110

Load Deflection characteristics of high strength hybrid fibre reinforced self compacting concrete beams of M 100 grade.

Table 3 gives ultimate load and deflections at maximum load forM100 grade of high strength self compacting concrete beams with glass fibre reinforced with steel fibres for beams. By observing the behaviour of cracks it can be seen that the load carrying capacity of high strength self compacting beams at 0.03 % glass fibres reinforced with 0.5%, 1% and 1.5% of steel fibres are on higher side when compared with other beams without hybrid fibres. This is true almost up to the failure even though at certain loads identical deflection is observed. The failure patterns of the beams are shown in Photographs in plate no 1, Load Vs Deflection curves for the beams over full depth are shown in the fig 1. It can be seen that the presence of glass fibres in reinforced ordinary concrete beams is no more advantage in respect of ductility. The ultimate load carrying capacity of glass fibre reinforced high strength self compacting concrete beams are more than reinforced high strength self compacting concrete beams with 0.03% glass fibres. However development of multiple cracks and micro cracks is prevented with the use of glass fibre. Due to the presence of higher percentage of crimped steel fibres with higher aspect ratio, the formation of first crack and subsequent cracks has been delayed. Hence in the present case, it may be concluded that the presence of high percentage of steel fibres with higher aspect ratio along with Micro silica has helped in imparting ductile behaviour to beams.

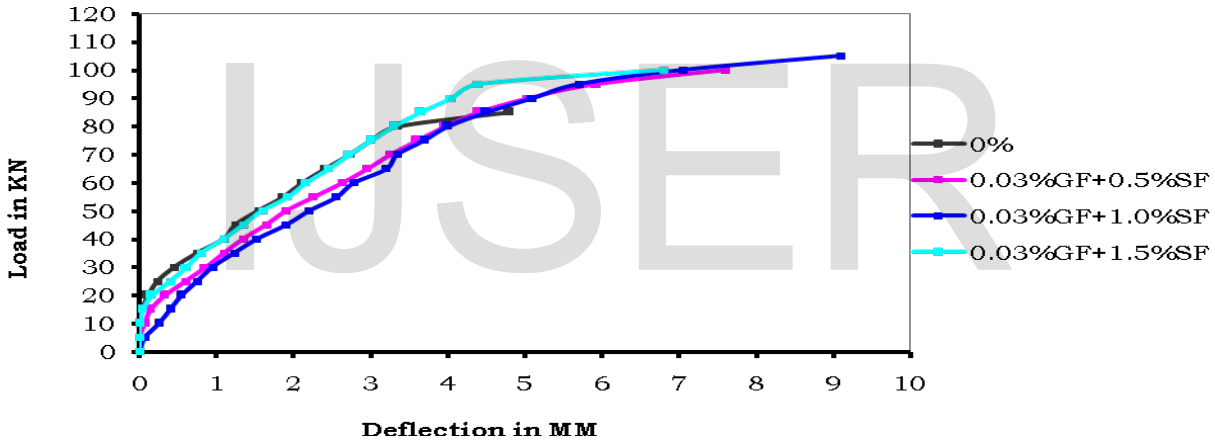

Fig 1 Load Deflection Characteristics of high strength hybrid fibre reinforced self compacting concrete beams of M 100 grade.

Plate No 1 : Failure modes of Hybrid fibre High Strength Reinforced Concrete Self Compacted Beams

Conclusions

- The workability of High Strength Self Compacting Concrete mix is reduced as the % of steel and glass fibers increased.
- The presence of fibers contributed towards improvement in the ductility characteristics
- 1.5% steel fibers and 0.03% glass fibers gives Ultimate strength it may be considered as optimum.
- The Ultimate load of HSSC with 0.5% steel fibers and 0.03% glass fibers is increased by 2% and the deflection by 5% than self compacting concrete beams
- The Ultimate load of HSSC with 1% steel fibers and 0.03% glass fibers is increased by 7.63% and deflection by 15% than self compacting concrete beams
- The Ultimate load of HSSC with 1.5% steel fibers and 0.03% glass fibers is 22.42% and deflection by 40% than self compacting concrete beams
- The presence of steel fibers reduces the crack propagation in concrete beams .it enhances the flexural rigidity resulting in better deflection control.

References:

1. Selvamony C. , Ravikumar M.S. , Kannan S.U. , Basil Gnanappa S., “Development of high strength self compacted self curing concrete with mineral admixtures” International Journal Design and manufacturing Technologies, Vol.3, No.2, July 2009,pp 103 -108.

2. Dr. R. Sri Ravindrarajah, D. Siladyi and B. Adamopoulos “Development of high strength self compacting concrete with reduced segregation potential “,Proceedings of the 3rd International RILEM Symposium , Reykjavik, Iceland, 17-20 August 2003, Edited by O. Wallevik and I. Nielsson , (RILEM Publications), 1 Vol., 1048 pp., ISBN: 2-912143-42-X, soft cover.

3. S. Venkateswara Rao, M.V. Seshagiri Rao, P. Rathish Kumar,” Effect of Size of Aggregate and Fines on Standard And High Strength Self Compacting Concrete”, Journal of Applied Sciences Research, 6(5): 433-442, 2010.

4. Youjun Xie*, Baoju Liu, Jian Yin, Shiqiong Zhou," Optimum mix parameters of high-strength self-compacting concrete with ultrapulverized fly ash", Cement and Concrete Research 32 (2002) 477–480.

5. Erdogan Ozbay, Ahmet Oztas , Adil Baykasoglu , Hakan Ozbebek," Investigating mix proportions of high strength self compacting concrete by using Taguchi method", Construction and Building Materials 23 (2009) 694–702.

6. Annie peter, J. Lakshman, N. Devdas Manoharan, P.Rajamane N.P and Gopalakrishna Flexural behaviour of reinforced concrete beans using self, compacting concrete". Indian concrete Journal June 2004, PP 66-72.

7.Ganesh.N, Indra.P.V. and santhosh Kumar.P.T Strength and behaviour of Steel Fibre Reinforced Self Compacting Concrete in Flexure. International conference in advance in concrete, composite structures, held at SERC, Chennai 6-8 January 2005 PP475-484.

8. Seshadri sekhar , Dr P. Srinivasa Rao and Seshaphani High Strength self compacting concrete using mineral admixtures, Indian Concrete Journal March 2013 PP 42-48.

9. Dr Srinivasa Rao , Seshadri sekhar T Flexural Behaviour of Reinforced Concrete Beams using Self Compacting Concrete our world concrete organized by Ci-Premier at Singapore on 16-18 Aug 2009, PP 329-336.