ISSN 2229-5518

MECHANICAL BEHAVIOUR OF SELF COMPACTING CONCRETE WITH HYBRID FIBRE REINFORCED CONCRETE

Guided by

M. RENGANATHAN, M.E

Submitted by

B. FATHIMA JULIET MARY
Student
Structural Engineering (2013-2016)
University College of Engineering , Trichirappalli (BIT – Campus), India.

ABSTRACT

Self compacting concrete(SCC) is able to compact itself without any additional vibration or compaction. SCC provides an efficient solution to the problems of inadequate compaction of concrete which would result in large number of voids, affecting performance and durability of structures. This project involves an experimental study to investigate the properties of stainless steel and polypropylene fibres g and discusses the suitability of those properties to enable stainless steel and polypropylene fibres to be used in the concrete. The test results of fresh and hardened properties of SCC incorporating Stainless Steel and Polypropylene at 0 %, 0.5 %, 0.75 %,1.00 by weight,are compared. Mix proportion of the SCC is determined by fixing the water to powder ratio at 0.55 and the ratio of paste volume to void volume of compacted aggregate phase at 0.5. The flowability or workability of fresh concrete mix are assessed with slump flow test, v-funnel test and L-box tst . The 28th day compressive strength of concrete specimens, in which addition of stainless steel and polypropylene fibres are practiced and compared with that of standard specimen.Still SCC is used as special concrete because of its economical viability. Incorporating stainless steel fibre , the economical SCC is arrived. In a Hybrid Fibre Reinforced Concrete (HFRC), two or more

different types of fibres are rationally combined to produce a cementitious composite that derives benefits from each of the individual fibres and exhibits a synergistic response. The main aim of the present experimental investigation was to combine different fibres namely crimped stainless steel fibre, glass fibre and polypropylene fiber to produce HFRC and thus to evaluate its performance under compression, tension and flexure types of loading. Based on I.S. Code method of mix design, proportion of different ingredients was obtained to get M30 grade concrete. Samples were prepared by varying the volume fraction of fibres from 0 to 1% for each fibres individually and then the optimum percentage of fibres were combined to obtain HFRC. Total 12 different types of FRC matrices were considered for performance evaluation. The experimental test results demonstrated that addition of stainless steel, and polypropylene fibers at 1% ,0.75% and 1% V_f respectively showed considerable gain of strength of 22.12N/mm^2 , 2.45N/mm^2 and 2.78N/mm^2 in compression, tension and flexure at 7 days respectively. The behavior of concrete under loads was found to be consistently improved compared with reference mix design. Thus, the improvement in mechanical properties of a matrix having volume fraction hybridization of 1% stainless steel, and 1% of polypropylene fibres was found to be the best.

KEYWORDS

Self-compacting Concrete; Polypropylene, Stainless Steel Fibre, Admixture CONPLAST SP 430, Mix Design; Fresh Properties; Hardened Concrete Properties; Compressive Strength, Split Tensile Strength , Flexural Strength.

LITERATURE REVIEW

“EXPERIMENTAL NVESTIGATION CARRIED OUT ON HIGH STRENGTH CONCRETE REINFORCED WITH HYBRID FIBRES”

Sivakumar.A, et al (2007)., reported the experimental investigation carried out on high strength concrete reinforced with hybrid fibres (combination of hooked steel and a non-metallic fibre) up to a volume fraction of 0.5%. The mechanical properties, namely, compressive strength, split tensile strength, flexural strength and flexural toughness were studied for concrete prepared using different hybrid fibre combinations steel–polypropylene, steel–polyester and steel–glass. The flexural properties were studied using four point bending tests on beam specimens as per Japanese Concrete Institute (JCI) recommendations. Fibre addition was seen to enhance the pre-peak as well as post-peak region of the load–deflection curve, causing an increase in flexural strength and toughness, respectively. Addition of steel fibres generally contributed towards the energy absorbing mechanism (bridging action) whereas, the non-metallic fibres resulted in delaying the formation of micro-cracks. Compared to other hybrid fibre reinforced concretes, the flexural toughness of steel– polypropylene hybrid fibre concretes was comparable to steel fibre concrete. Increased fibre availability in the hybrid fibre systems (due to the lower densities of non-metallic fibres), in addition to the ability of non-metallic fibres to bridge smaller micro cracks, were suggested as the reasons for the enhancement in mechanical properties.

"STUDY THE EFFECT OF INCLUSION OF POLYPROPYLENE AND STEEL FIBRES ON THE COMPRESSIVE AND FLEXURE PROPERTIES OF FIBRE REINFORCED CONCRETE"

Abhishek Kumar Singh, et al.(2010), studied the effect of inclusion of polypropylene and steel fibres on the compressive and flexure properties of fibre reinforced concrete. Polypropylene and Steel fibres with different levels of reinforcement index were investigated with pre-designed concrete mixtures consisting of various polypropylene fibres dosages of 0% to 0.45 % and steel fibres of 0% to 2% by volume of concrete. The experimental test results demonstrated that addition of polypropylene and steel fibres at 0.15% and 1% Vf respectively showed considerable gain of strength of 47.10 MPa and 58.20 MPa at 7 and 28 days respectively. The behaviour of concrete under flexural loads was found to be consistently improved compared with reference mix design.

"INVESTIGATE THE FLEXURAL PROPERTIES OF METALLIC-HYBRID-FIBRE-REINFORCED CONCRETE"

Rashid Hameed, et al. (2010), investigated the flexural properties of metallic-hybrid-fibre-reinforced concrete. Two types of fibres were used: amorphous metallic straight fibre characterized as non-slipping fibre due to its rough surface and large specific surface area, and carbon steel hook-ended fibre characterised as slipping fibre. Three types of concrete: control, single-fibre- reinforced and hybrid-fibre-reinforced were prepared. The fibre was incorporated at 20 and 40 kg/m³ for single-fibre reinforced concrete, and at 20, 40 and 80 kg/m³ for hybrid-fibre-reinforced concrete. The flexural properties were studied using three-point bending tests. From the experimental results obtained with fibre-reinforced concrete containing single fibre, addition of high-bonding amorphous metallic fibre delayed the formation of micro-cracks and resulted in high peak load whereas carbon steel hook-ended fibre contributed towards the flexural toughness (energy absorption capacity) by bridging macro-cracks in the post peak region. The test results on hybrid-fibre-reinforced concrete showed that the two metallic fibres when used in hybrid form resulted in superior performance compared to their single-fibre reinforced counterparts. Superior performance as a result of fibre hybridization was interpreted as a positive synergetic effect between the fibres.

EXPERIMENTAL IVESTIGATION THE STRENGTH PROPERTIES OF POLYPROPYLENE FIBRE REINFORCED CONCRETE"

Kolli Ramujee, et al.,(2011) reported the strength properties of polypropylene fibre reinforced concrete. The compressive strength, splitting tensile strength of concrete samples made with different fibres amount varying from 0%, 0.5%, 1%, 1.5%, and 2% were studied. The Reduction of slump was noticed with increase in fibre content, especially beyond 1.5% dosage, the mix became fibrous which resulted in difficulty in handling. The Compressive strength and splitting tensile strength tests revealed that , the strengths were increased proportionately with the increase in volume ratios of Polypropylene Fibers with reference to the controlled mix without fibres and the samples with added polypropylene fibres of 1.5% showed better results with 34% increase in compressive strength and 40% increase in split tensile strength.

"STUDIED THE STRENGTH OF CONCRETE CUBES, CYLINDERS AND PRISMS CAST USING M30 GRADE CONCRETE REINFORCED WITH STEEL AND POLYPROPYLENE FIBRES"

Tamilselvi.M, et al (2013)., studied the strength of concrete cubes, cylinders and prisms cast using M30 grade concrete reinforced with steel and polypropylene fibres. Also, hybrid fibres with crimped steel and polypropylene were used in concrete matrix to study its improvement in strength and durability properties. The steel, polypropylene and hybrid polypropylene and steel fibres of various proportion i.e., 4% of steel fibre, 4% of polypropylene fibre and 4% of hybrid polypropylene and steel fibres each of 2% by volume of cement were used in concrete mixes. Besides cubes, cylinders of 150 mm x 300 mm of M30 grade concrete were cast with 4% of steel fibre and polypropylene fibre, respectively, by volume of cement. The rapid chloride permeability test and water absorption test were conducted on 7, 28, 56 and 90 days and the test results showed that the addition of steel and polypropylene fibres to concrete exhibited better performance. Totally 160 specimens were cast and tested including conventional concrete for comparison. The test results show that use of steel fibre reinforced concrete improves compressive strength and split tensile strength. In addition to this, concrete with shorter fibre has better workability as compared to longer fibre. The concrete mix with 4% Endura-600 Macro synthetic Polypropylene fibre showed that concrete was more slippery and difficult to compact. Increase in compressive strength of SFRC was observed to be in range of 3 per cent to 60 per cent between 7 and 28 days. The compressive strength of PPFRC was observed to increase between 10 per cent and 18 per cent for 7 and 28 days.

Corresponding values for Hybrid concrete was increased by 3 per cent to 22 per cent for 7 to 28 days when compared to conventional concrete. In conventional concrete, specimen splits into two halves exactly under the loaded area, but using SFRC, PPFRC, Hybrid fibres cylinders did not split into halves under the loaded area. Because of toughness it did not yield to sudden breakage. An increase in ductility of the specimens by the introduction of fibres was observed in this investigation. Chloride Permeability for conventional concrete and Hybrid specimens was low and a SFRC and PPFRC specimen was medium according to ASTMC 1202 criteria. Water absorption results of SFRC and Hybrid specimens were equal to conventional concrete. But in the case of PPFRC it was 4% increase than conventional concrete.

Introduction

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, homogeneous and has the same engineering properties and durability as traditional vibrated concrete.

Concrete is a rigid material with high compressive strength and low tensile strength with little resistance to cracking. Internal micro cracks are inherently present in the concrete and its poor tensile strength is due to the propagation of such micro cracks, eventually leading to brittle fracture of the concrete. Reinforcing bars are used to improve the tensile strength. In addition to that fibres can make the concrete more homogeneous and can improve the tensile response, particularly the ductility. The various types of fibres added to concrete are steel and polypropylene Fibre have been successfully used in the construction of new structures and in rehabilitation of existing structures.

Although much research exists on the structural applications of steel fibres

ISSN 2229-5518

in concrete, the potential of using hybrid stainless steel and polypropylene fibres is yet to gain wide acceptance. This experimental program is to gain a better understanding of the performance of these fibres in the structural elements. The stainless steel fibre proposed to use is crimped round stainless steel fibre and is purchased from Stewols castings pvt.ltd. The polypropylene fibre from Microwave Agencies.

FIBER REINFORCED CONCRETE

Concrete is acknowledged to be a relatively brittle material when subjected to normal stresses and impact loads, where tensile strength is only approximately one tenth of its compressive strength. As a result of these characteristics, concrete member could not support such loads and stresses that usually take place, majority on concrete beams and slabs. Historically, concrete member reinforced with continuous reinforcing bars , withstand tensile stresses and compensate for the lack of ductility and strength. Furthermore, steel reinforcement is adopted to overcome high potentially tensile stresses and shear stresses at critical location in concrete member. The additional of steel reinforcement significantly increase the strength of concrete, but to produce concrete with homogenous tensile properties, the development of micro cracks is a must to suppress. The introduction of fibres was brought in as a solution to develop concrete in view of enhancing its flexural and tensile strength, which are a new form of binder that could combine Portland cement in the bonding with cement matrices. Fibres are most generally discontinuous, randomly distributed throughout the cements matrices. The term 'Fibre Reinforced Concrete' (FRC) is made up with cement, 20mm sizes of aggregate, which incorporate with discrete, discontinuous fibres .

EFFECT OF FIBRES IN CONCRETE

Fibre reinforced concrete is a composite material comprised of Portland cement, aggregate and fibres. Normal unreinforced concrete is brittle with a low tensile strength and strain capacity. The function of the irregular fibres distributed randomly is to fill the cracks in the composite. Fibres are generally utilized in concrete to manage the plastic shrinkage cracking and drying shrinkage cracking. They also lower the permeability of concrete and therefore reduce the flow of water. Some types of fibres create greater impact, abrasion and shatter resistance in the concrete. Usually fibres do not raise the flexural strength of concrete. The quantity of fibres required for a concrete mix is normally determined as a percentage of the total volume of the composite materials. The fibres are bonded to the material and allow the fibre reinforced concrete to withstand considerable stresses during the post- cracking stage. The actual effort of the fibres is to increase the concrete toughness.

HYBRID FIBRE REINFORCED CONCRETE

A composite can be termed as hybrid, if two or more types of fibres are rationally combined in a common matrix to produce a composite that derives benefits from each of the individual fibres and exhibits a synergetic response. The advantages of hybrid fibre systems can be listed as follows

1. To provide a system in which one type of fibre, which is stronger and stiffer, improves the first crack stress and the ultimate strength, and the second type of fibre, which is more flexible, and ductile leads to improved toughness and strain in the post-cracking zone.

2. To provide a hybrid reinforcement in which one type of fibre is smaller, so that it bridges the micro cracks of which growth can be controlled. This leads to a higher tensile strength of the composite. The second type of fibre is larger, so that it arrests the propagating macro cracks and can substantially improve the toughness of the composite.

3. To provide a hybrid reinforcement, in which the durability of fibre types is different. The presence of the durable fibre can increase the strength and/or toughness relation after age while the

ISSN 2229-5518

other type is to guarantee the short-term performance during transportation and installation of the composite elements.

In the present approach the strengthening and toughening mechanisms for cement based composites are viewed on two different scales. To strengthen the matrix, the specific fibre spacing must be decreased in order to reduce the allowable flow size. This may be achieved through the use of short discrete fibres. These fibres can provide bridging of micro cracks before they reach the critical flaw size. To provide the toughening component, fibres of high ultimate strain capacity are required so that they can bridge the macro cracks in the matrix.

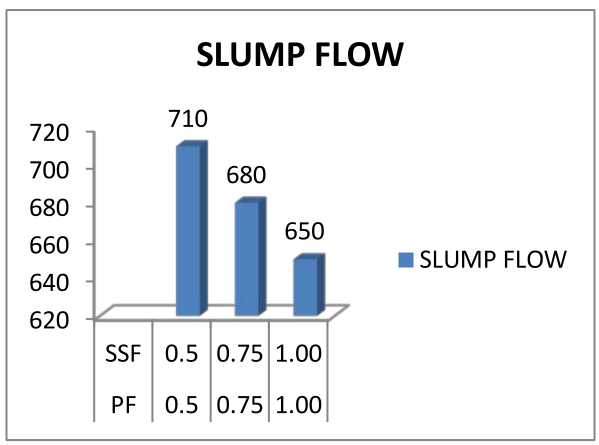
The concept of hybridization was developed in conjunction with asbestos replacement, where it was difficult to produce synthetic fibres that would provide simultaneously a reinforcing effect and the filtering and solid retention characteristics, which are needed in the Hatschek process. The combination of different types of fibres to optimize the performance in the hardened state, with respect to strength and toughness, has been studied by various researchers, using asbestos, carbon, and steel to achieve strength, and polypropylene to improve toughness.

RESULTS FROM EXPERIMENT

Slump flow test

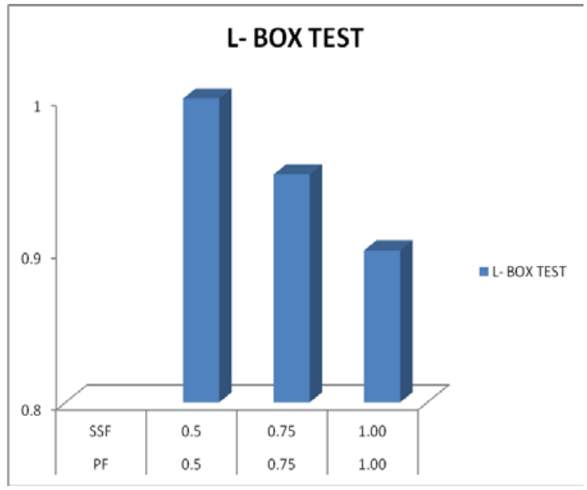
Test Results of Slump Flow at various proportion of PF & SSF

PF%	SSF %	Slump flow test (mm)
0.5	0.50	750
0.75	0.75	695
1.00	1.00	660



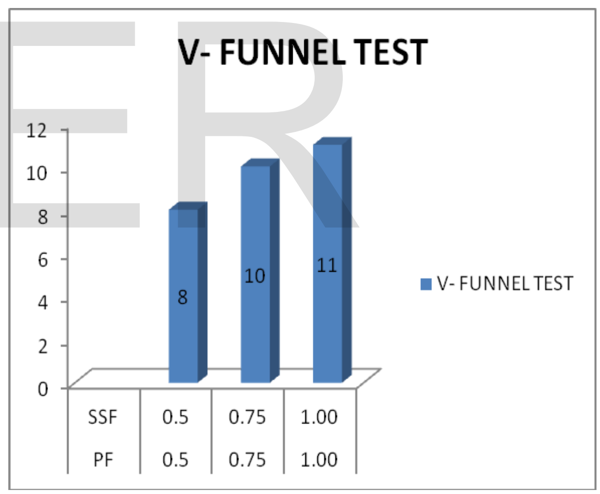
Test Results of L-Box test at various proportion of PF & SSF

PF%	SSF	L-box test
0.5	0.50	1.0
0.75	0.75	0.95
1.00	1.00	0.9



Test Results of V-funnel at various proportion of PF & SSF

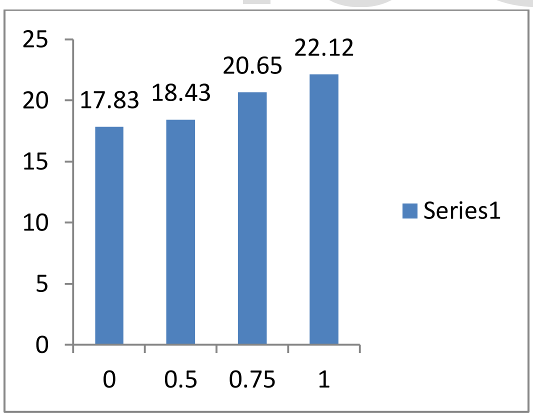
PF%	SSF	V-funnel test(sec)
0.5	0.50	8
0.75	0.75	10
1.00	1.00	11



Compressive Strength for various proportion of SSF and PF @ 7 days

% of Addition of SSF	% of Addition 0f PF	Compressive Strength @ 7 Days N/mm^2	Average Compressive Strength @ 7 days N/mm^2
0(CCC)	0(CCC)	19.13	17.82
		17.81	
		16.51	
0.50	0.50	18.35	18.43
		18.88	
		18.08	
0.75	0.75	20.53	20.65
		20.46	
		20.98	
1.00	1.00	22.37	22.12
		21.22	
		22.78	

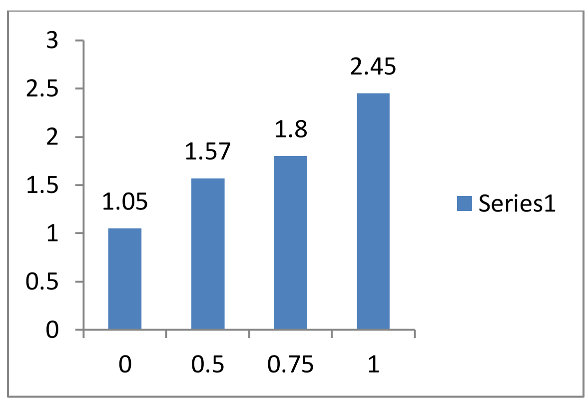
Compressive strength for SSF & PF @7 days



Split Tensile Strength for SSF & PF @ 7days

% of Addition of SSF	% of Addition of PF	Split Tensile Strength @ 7 Days N/mm^2	Average Split Tensile Strength @ 7 days N/mm^2
0(CCC)	0(CCC)	1.02	1.05
		1.06	
		1.09	
0.50	0.50	1.65	1.57
		1.50	
		1.58	
0.75	0.75	1.80	1.80
		1.75	
		1.85	
1.00	1.00	2.25	2.45
		2.50	
		2.60	

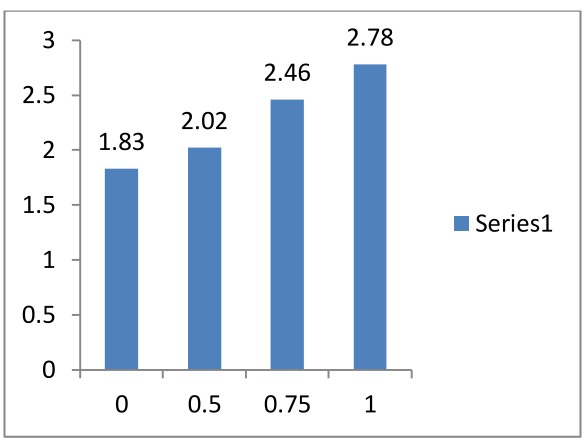
Split Tensile Strength for SSF & PF @ 7days



Flexural Strength for various % of SSF & PF @ 7days

% of Addition of SSF	% of Addition of PF	Flexural Strength @ 7 Days N/mm^2	Average Flexural Strength @ 7 days N/mm^2
0(CCC)	0(CCC)	1.85	1.83
		1.80	
		1.85	
0.50	0.50	1.95	2.02
		1.92	
		2.20	
0.75	0.75	2.45	2.46
		2.38	
		2.55	
1.00	1.00	2.68	2.78
		2.78	
		2.88	

Flexural Strength for various % of SSF & PF @ 7days



CONCLUSION

- Based on the experimental results by using two types of fibres, namely stainless steel and polypropylene the following conclusions are drawn. Based on the experiment results
- I concluded that when increaing the dosage of fibres (PF & SSF) from 0.5 to 1.0% the slump flow and L- Box test of the SCC is decreased but the dosage of fibres (PF & SSF) from 0.5 to 1.0 % in V- funnel test the time range is increased and then all the properties of conventional cement concrete is determined in Phase -I

REFERENCE

1. IS 10262:2009- Recommended Guidelines for Concrete Mix Design.
2. Shetty.M.S (2012), “Concrete Technology”, S.Chand and Publications Pvt Ltd.
3. EFNARC (European Federation of National Trade Associations representing producers and applicators of specialist building products), *Specification and Guidelines for self-compacting*

concrete, February 2002, Hampshire, U.K.

4. IS 10262-1982, Recommended guide lines for concrete mix design,

5. IS 456 -2000 Design of plain cement concrete Abhishek Kumar Singh, Anshul Jain and Deependra Singh, “Evaluation Of Mechanical Properties For Polypropylene And Steel Fibre Reinforced Concrete ”, International Journal of Engineering Research & Technology, Vol. 2, pp.2278-0181.

6. Naveen Hooda, Jyoti Narwal, Bhupinder Singh, Vivek Verma and Parveen Singh, “An Experimental Investigation on Structural Behaviour of Beam Column Joint”, International Journal of Innovative Technology and Exploring Engineering , Vol.3, 2013.

7. Patodi.S.C and Kulkarni.C.V, ‘Perfomance Evaluation Of Hybrid Fibre Reinforced Concrete Matrix’, International Journal of Engineering Research and Application, Vol.2, No.5, PP.1856-1863, 2012.

8. Perumal.P and Thanukumari.B, ‘Seismic Performance Of Hybrid Fibre Reinforced Beam - Column Joint’, International Journal Of Civil And Structural Engineering, Vol.1, No.4, 2012.