Global Journal of Researches in Engineering: E
Civil And Structural Engineering
Volume 16 Issue 1 Version 1.0 Year 2016
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Effect of Hybrid Fibers on the Strength Characteristics of Slurry Infiltrated Fibrous Ferrocement with Partial Replacement of Steel Fiber by Polypropylene Fiber and with Partial Replacement of Natural Sand by Manufactured Sand

By G. S. Sudhikumar, Ulagadde Chandrashekhara & Chethan Kumar A.C
Chennabasaveshwara Institute of Technology, India

Abstract- The concrete composites play an important role in the field of concrete. The addition of fibers to concrete enhances the strength properties and ductility characteristics. The use of two or more type of different fibers in sustainable combination has potential to improve the mechanical properties of concrete and results in performance synergy. This combination of fibers, often called hybridization of fibers. The inclusion of fibers into concrete not only provides considerably more ductile structure but also improves the structural properties such as tensile strength, static flexural strength, impact strength, flexural toughness and the energy absorption capacity of the high strength concrete. Ferrocement is light weight and versatile material having high cracking, ductility and fatigue resistance and is additionally impermeable to make it far superior than reinforced concrete. It is used for prefabricated residential units, marine and industrial structures. Slurry infiltrated fiber concrete (SIFCON) could be considered as a special type of fiber concrete with high fiber content. The matrix consists of cement slurry or flowing.

Keywords: ferrocement, fibers, fiber reinforced concrete, hybridization; slurry infiltrated fibrous ferrocement (SIFF), welded mesh, chicken mesh, compressive strength, flexural strength, impact strength.

GJRE-E Classification : FOR Code: 090599

EFFECTOFHYBRIDFIBERSONTHESTRENGTHCHARACTERISTICSOFSLURRYINFILTRATEDFIBROUSFERROCEMENTWITHPARTIALREPLACEMENTOFSTEELFIBERBYPOLYPROPYLENEFIBERANDWITHPARTIALREPLACEMENTOF NATURALSANDBYMANUFACTURED SAND

Strictly as per the compliance and regulations of :

Effect of Hybrid Fibers on the Strength Characteristics of Slurry Infiltrated Fibrous Ferrocement with Partial Replacement of Steel Fiber by Polypropylene Fiber and with Partial Replacement of Natural Sand by Manufactured Sand

G. S. Sudhikumar [α], Ulagadde Chandrashekhara [σ] & Chethan Kumar A.C [ρ]

Abstract- The concrete composites play an important role in the field of concrete. The addition of fibers to concrete enhances the strength properties and ductility characteristics. The use of two or more type of different fibers in sustainable combination has potential to improve the mechanical properties of concrete and results in performance synergy. This combination of fibers, often called hybridization of fibers. The inclusion of fibers into concrete not only provides considerably more ductile structure but also improves the structural properties such as tensile strength, static flexural strength, impact strength, flexural toughness and the energy absorption capacity of the high strength concrete. Ferrocement is light weight and versatile material having high cracking, ductility and fatigue resistance and is additionally impermeable to make it far superior than reinforced concrete. It is used for prefabricated residential units, marine and industrial structures. Slurry infiltrated fiber concrete (SIFCON) could be considered as a special type of fiber concrete with high fiber content. The matrix consists of cement slurry or flowing cement mortar. This composite material withstands blast loading and can be used for pre-stressed concrete beams and safe vaults. Slurry infiltrated fibrous ferrocement (SIFF) is a combination of SIFCON and ferrocement and can overcome the limitations of latter. SIFF can be used for the structures like runways in aerodromes, industrial floors etc.

This paper deals with an experimental investigation on the strength characteristics of Slurry infiltrated fibrous ferrocement with partial replacement of 1.5% steel fiber by polypropylene fiber and with 60% replacement of natural sand with manufactured sand.

The results indicated that with 10% replacement of steel fiber with polypropylene fiber improve the compressive strength marginally as compared to mono fibers. Where as, hybridization improves the flexural strength noticeably.

Author α - Professor, Dept. of Civil Engineering, Channabasaveshwara Institute of Technology, Gubbi – 572 216, Karnataka– India.
e-mail: sudhikumargs@rediffmail.com
Author σ - Student, Dept. of Civil Engineering, Channabasaveshwara Institute of Technology, Gubbi – 572 216,Karnataka – India.
e-mail: chandrashekhara.shashi@gmail.com
Author ρ - Student, Dept. of Civil Engineering, Channabasaveshwara Institute of Technology, Gubbi – 572 216, Karnataka – India.
e-mail: chethanac.smg@gmail.com

Keywords: ferrocement, fibers, fiber reinforced concrete, hybridization; slurry infiltrated fibrous ferrocement (SIFF), welded mesh, chicken mesh, compressive strength, flexural strength, impact strength.

I. Introduction

Today, concrete fiber composite is the most promising and cost effective material used in the construction. Many researchers have shown that the addition of small closely spaced and uniformly dispersed fiber to concrete transforms the brittle cement composite into a more isotropic and ductile material called fiber reinforced concrete (FRC).

In RCC the strength makeup is in the direction of reinforcing bars. In a structure where the tensile stresses are omni-directional, the reinforcing becomes difficult and expensive. FRC which is made up of thin fibers dispersed randomly in all the directions impart strength to its entire volume.

FRC can be used in the preparation of various precast building units such as cladding sheets, window frames, roofing units, floor tiles, manhole covers and advanced applications in highway pavements, air field, machine foundations, industrial floorings, bridge deck overlays, sewer pipes, earthquake resistant structures and explosive resistant structures (like MX missile silos etc).

Even though the performance of FRC in pavement, air fields, industrial floors and machine foundations is satisfactory, it has some limitations. It cannot be employed where high impact, vibration, wear and tear are expected. Many problems have to be faced during the construction of FRC, especially when the quantity of fiber used is more. The fiber should be dispersed uniformly in concrete for being effective. The fibers if put in bulk along with other ingredients do not disperse, but nest together and is called balling effect.

The balling effect can be reduced to some extent by mixing the fibers and other ingredients in dry form and then adding water. The fibers present in the concrete may block the discharge port. Since the flow of FRC is low, the FRC has to be placed near to the place where it is to be used finally. Its spreading with rakes and spades is difficult and laborious. With compaction fibers realign, such that they tend to concentrate more near the surface. Therefore the compaction has to be controlled.

Similar to FRC, Ferro cement – Environmentally sound technologies, according to agenda 21, protect the environment, are less polluting, use all resources in a more sustainable manner [1] has also many advantages and its applications are rapidly increasing in the precast construction industry. Ferro cement make use of different types of steel meshes for its construction. Ferro cement is a form of reinforced mortar wherein the reinforcement is distributed spatially all through the mortar with smaller diameter wire mesh at a very close spacing [2]. Ferro cement also suffer from limitations. It cannot be employed where high impacts, vibrations, wear and tear are expected. The strength of the fibrocement increases with the increase in the number of wire mesh layer and method of confinement [3] and steel content. But when the reinforcement is more, the mortar cannot be easily forced inside without forming voids. Thus strength of fibrocement reduces.

The fibrous fibrocement, which is a combination of fiber reinforced concrete and fibrocement, can overcome all the above said limitations to some extent and can be employed with assurance where high impacts, vibrations, wear and tear are expected. In this new material the advantage of both fibrocement and fiber reinforced concrete are combined. The fibrous cement is becoming a promising material for bridge overlays and industrial floorings where high impacts, high vibrations and high wear and tear are expected. The reinforcements used in fibrous fibrocement are of three kinds. The first type reinforcement is welded mesh where smaller diameter bars (approx. 12 G) are kept closely in both directions and are spot welded. This mesh gives stability and shape to the structure. The second type reinforcement is chicken mesh. This is mesh of similar wires (approx 20G) which are interwoven to different openings. The spacing between the wires of chicken mesh is small. This mesh mainly distributes the stresses evenly and the cracks will be minimized. The third type of reinforcement is fiber. The fibers may be of steel, carbon, glass, polypropylene, GI etc. Experiments have shown that, addition of 1.5% steel fibers with 60% replacement of natural sand by manufactured sand have increased the strength and ductility properties [4]. These fibers act as crack arresters and are randomly distributed in the concrete [5].

Depending upon the shape required, the cage is prepared out of welded mesh and chicken mesh. The cage can be prepared by tying the chicken mesh over the welded mesh at regular intervals by using binding wires. The calculated quantities of fibers are placed in the mould. The mortar is then infiltrated into the mould to form SIFF.

II. Materials and Method

Main objective of this experimentation is to study the strength characteristics of slurry infiltrated fibrous fibrocement with varying percentage replacement of 1.5% steel fiber with polypropylene fiber with 60% replacement of natural sand by manufactured sand. The aspect ratios of steel fiber used was 25, and that of polypropylene fiber was 1600. Different strength parameters considered for study are compressive strength, flexural strength and impact strength.

Ordinary Portland cement of 43 grade and locally available sand (passing 1.18 mm and retained on 150 micron IS sieve) with specific gravity 2.64 was used in the experimentation. To impart additional workability a super plasticizer (Conplast SP 430), 1% by weight of cement was used. The welded mesh (WM) used in the experimentation was square opening of 25 mm x 25 mm of 20 gauge. The chicken mesh (CM) used was having a hexagonal opening with 0.5 mm diameter. The cement mortar with a proportion of 1:1 was used with a water cement ratio of 0.45.

The required size of welded mesh and chicken mesh were first cut according to the mould sizes for compression, flexural and impact tests. The chicken mesh was tied to the welded mesh using binding wires at regular intervals. This forms the cage (1WM + 1CM). Cages were prepared by tying the chicken mesh layer to welded mesh at regular intervals by using binding wire. The prepared cages were placed in the moulds which were oiled. Cement –sand slurry was prepared with a mix proportion of 1:1 with a w /c ratio of 0.45, and a super plasticizer dosage of 1% (by weight of cement).

For steel fibers, initially a small quantity of slurry (10 mm) was poured into the mould and then the respective cages were placed in the mould and then the fibers were placed in the mould and later on the slurry was infiltrated up to the brim level and was lightly compacted using the table vibrator. Whereas for polypropylene fibers, fibers were initially dispersed in the dry cement-sand mortar and then water of required amount was added, after placing the cages, slurry was filled into the mould and then lightly compacted. Then the moulds were covered with wet gunny bags for 12 hours. After 12 hours, the specimens were demoulded and kept in water for 28 days curing. For compressive strength, specimens of dimensions 150 x 150 x 150 mm were cast. For flexural strength, specimens of dimensions 100 x 100 x 500 mm were cast. For impact strength, specimens of diameter 152 mm and thickness 63.5 mm were casted. The specimens were demoulded after 24 hours of casting and specimens were transferred to curing tank for 28 days. After 28 days of curing, they were taken out of water and were tested for their respective strengths.

III. Test Results

a) Test Results of Compressive Strength

Following table 1 gives the overall results of compressive strength of slurry infiltrated fibrous errocement with partial replacement of 1.5% of steel fiber by polypropylene fiber and with 60% replacement of natural sand by manufactured sand. The variation in the compressive strength is represented graphically in figure1.

Table 1 : Compressive strength of slurry infiltrated fibrous ferrocement with partial replacement of steel fiber by polypropylene fiber.

Percentage replacement of steel fiber by polypropylene fiber	Compressive strength (MPa)	Percentage increase / decrease of compressive strength w.r.t ref mix
0 (Ref.mix)	40.20	-
10	41.77	03..90
20	35.42	-11.89
30	33.51	-16.66
40	30.53	-24.05
50	30.40	-24.37
60	26.40	-34.32
70	20.10	-50.00
80	19.86	-51.59
90	19.33	-51.91
100	18.53	-53.90

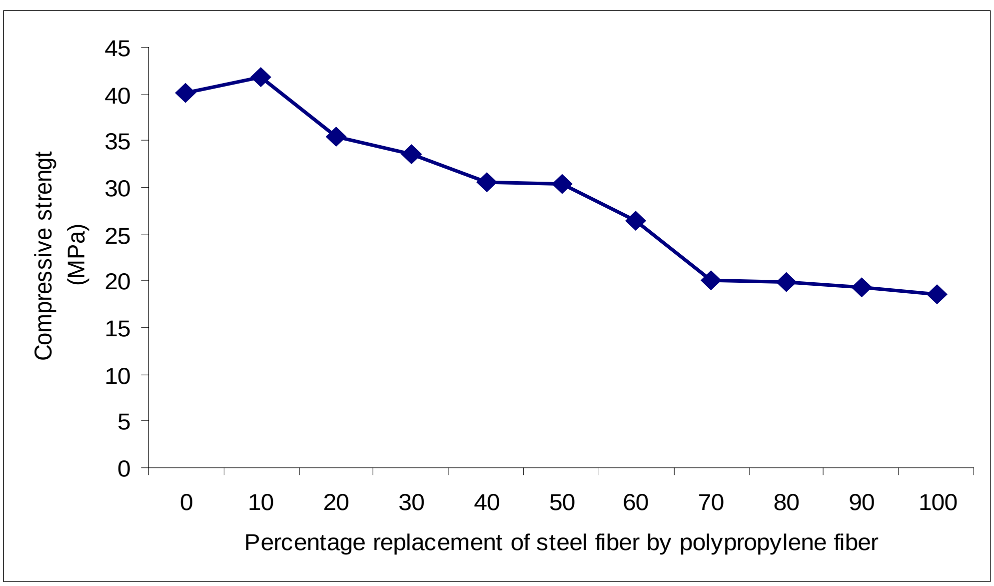

Figure 1 : variation of Compressive strength of slurry infiltrated fibrous fibrocement with partial replace mentof steel fiber by polypropylene fiber.

b) Test Results of Flexural Strength

Following table 2 gives the overall results of flexural strength of Slurry infiltrated fibrous fibrocement with partial replacement of 1.5% of steel fiber by polypropylene fiber and with 60% replacement of natural sand by manufactured sand. The variation in the flexural strength is represented graphically in figure1.

Table 2 : Flexural strength of slurry infiltrated fibrous ferrocement with partial replacement of steel fiber by polypropylene fiber.

Percentage replacement of steel fiber by polypropylene fiber	Flexural strength (MPa)	Percentage increase / decrease of flexural strength w.r.t ref mix
0(Ref. mix)	4.00	-
10	7.30	81.65
20	6.20	55.00
30	5.60	40.00
40	5.40	35.00
50	5.00	25.00
60	4.20	05.00
70	2.70	-33.33
80	2.60	-35.00
90	2.48	-38.00
100	2.40	-41.60

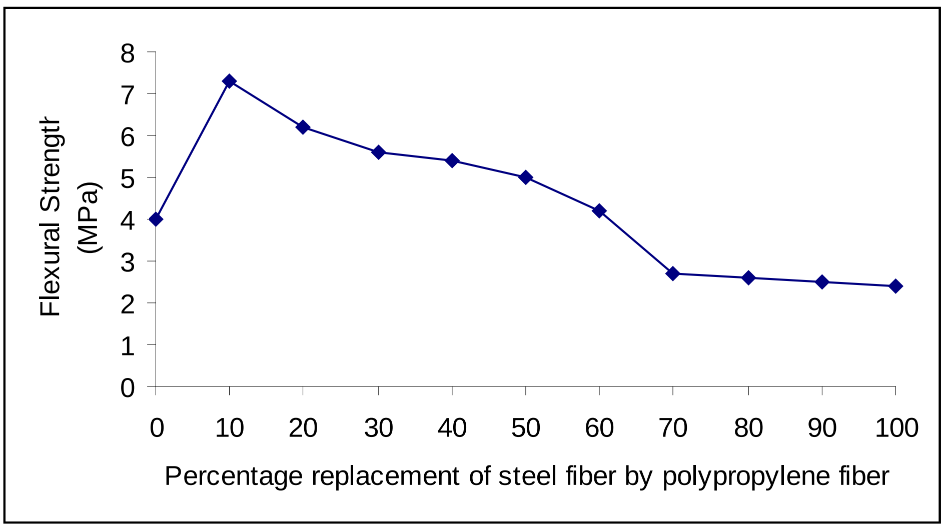

Figure 2 : Variation of Flexural strength of slurry infiltrated fibrous ferrocement with partial replacement of steel fiber by polypropylene fiber.

c) Test Results of Impact Strength

Following table 3 gives the overall results of impact strength of Slurry infiltrated fibrous ferrocement with partial replacement of 1.5% of steel fiber by polypropylene fiber and with 60% replacement of natural sand by manufactured sand. The variation in the impact strength is represented graphically in figure3.

Table 3 : Impact strength of slurry infiltrated fibrous ferrocement with partial replacement of steel fiber by polypropylene fiber.

Percentage replacement of steel fiber by polypropylene fiber	Impact strength required to cause (N-m)		Percentage increase / decrease of impact strength w.r.t ref mix	
	First crack	Final failure	First crack	Final failure
0(Ref.mix)	15695.00	18644.04	--	--
10	16967.50	19633.82	8.10	05.30
20	13089.20	17916.90	-16.60	-03.90
30	12887.20	15645.53	-10.00	-16.08
40	12584.22	13352.00	-19.82	-28.38
50	12422.63	13271.00	-20.84	-28.81
60	11897.44	13210.40	-24.19	-29.14
70	11635.00	13150.00	-25.86	-29.46
80	10584.50	12665.00	-32.56	-32.12
90	9453.32	11453.00	-39.76	-38.57
100	7857.60	9776.50	--50.00	-47.56

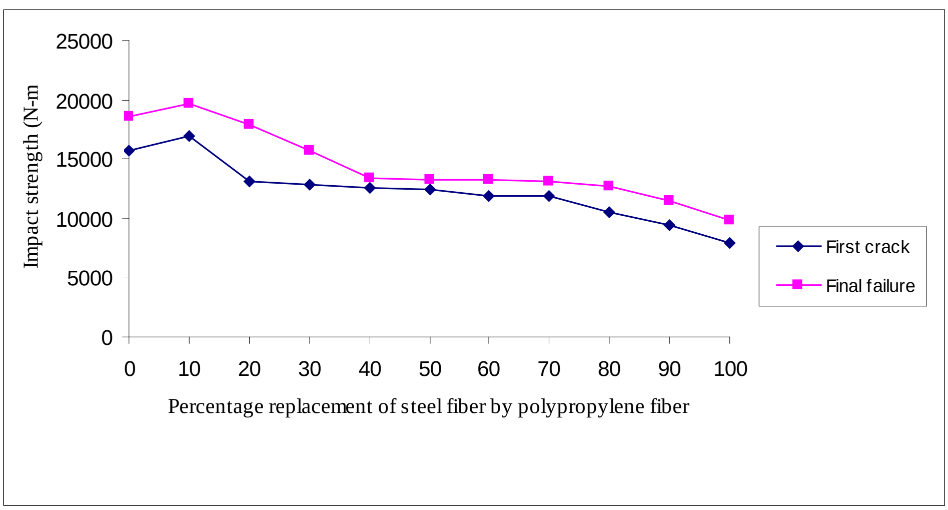

Figure 3 : Variation of impact strength of slurry infiltrated fibrous ferrocement with partial replaceme of steel fiber by polypropylene fiber.

IV. Discussion on Test Result

Following observation were made with reference to partial replacement of 1.5% of steel fiber by polypropylene fiber and with 60% replacement of natural sand by manufactured sand.

It is clear from the test result that the compressive strength, flexural strength and impact strength of slurry infiltrated fibrous ferrocement with partial replacement of 1.5% of steel fiber by polypropylene fiber and with 60 % replacement of natural sand by manufactured sand goes on increasing upto 10% replacement of steel fiber by polypropylene fiber, there after strength decreases. A higher compressive strength of 41.77 Mpa (Table 1), flexural strength of 7.3 Mpa (Table 2) and impact strength of 16967.50N-m, 19633.82 N-m and (Table 3) for the first crack and final failure respectively. In other words, the percentage increase in compressive strength were to be 03.90 %, (Table 1), flexural strength were to be 81.65% , (Table 2) and impact strength were to be 8.10% and

The reason for this can be attributed that 10 percent replacement of steel fiber by polypropylene fiber will certainly increase the microcrack resisting capacity of slurry infiltrated fibrous ferrocement and with 60% replacement of natural sand by manufactured sand, thus resulting in higher compressive, flexural and impact strength.

V. Conclusions

Following conclusions can be drawn based on the study conducted on the effect on the strength characteristics of Slurry infiltrated fibrous ferrocement with partial replacement of 1.5% steel fiber by polypropylene fiber and with 60% replacement of natural sand with manufactured sand.

It was observed that the compressive, flexural and impact strength increases upto 10 percent replacement of steel fiber by polypropylene fiber and with 60% replacement of natural sand by manufactured sand, thereafter the strength decreases. This may be due to the fact that, 10 percent replacement of polypropylene fiber may arrest the micro cracks which can contribute to the strength of concrete.

VI. Acknowledgements

The authors would like to thank Dr. D S Suresh kumar, Director, for their encouragement throughout the work. Authors are also indebted to management authorities of the college for their whole hearted support, which boosted the moral of the authors. The authors are also grateful to all the staff for their encouragement.

References Références Referencias

1. Robles-Austriaco. L. “Ferrocement: Environmentally Sound Technology”, Journal of Ferrocement, Vol. 29, No.3, pp 207 – 213, July 1999.
2. Seshu D R and Kamasundara Rao A. “ Ferrocement for Confinement of Reinforced Concrete – A Review”, National Conference on Materials and Structures 23 – 24, January 2004, NIT Warangal, pp 189 – 192.
3. Waliuddin A. M. and Rafeeqi S.F.A. “Study of the Behavior of Plain concrete Confined with Ferrocement”, Journal of Ferrocement, Vol. 24, No.2, pp 139 – 151, April 1994.
4. Rajarajeshwari B Vibuti, Radhakrishna and Arvind N. “Mechanical properties of Hybrid fiber reinforced Concrete for pavements”, International Journal of Research in Engineering and Technology, eISSN: 2319-1163 / pISSN: 2321 – 7308, IC-RICE Conference Issue / Nov-2013,pp 244-247.
5. Bin Mu and Christian Meyer “Flexural Behavior of Fiber Mesh-Reinforced Concrete with Glass Aggregate” ACI Materials Journal, Title no. 99-M42, pp 425-433, September-October 2002.
6. Prakash K B and Sudhikumar G S “An Experimental Investigation on the Strength Properties of Fibrous Ferrocement” Proceedings of the International conference on Recent Advances in Concrete and Construction Technology, December 7-9, 2005 SRMIST, Chennai, India, pp 35-42.
7. Sudhikumar G.S, Prakash K B, and Seshagiri Rao M. V. “Effect of Freezing and thawing on the strength characteristics of slurry infiltrated fibrous fibrocement”, International journal of Global Journal of Research in Engineering-E Civil & Structural engineering, volume 14, issue 5, version 1.0, Print ISSN: 0975-5861, pp 25-28, 2014.
8. Hudson B. P. “Manufactured Sand for Concrete”, the Indian Concrete Journal. 71(5): 237-240 (1997).
9. Sahu A. K., Kumar Sunil and Sachin A. K. “Crushed Stone Waste as Fine Aggregate for Concrete”, The Indian Concrete Journal. 77(1): 845-847 (2003).
10. Chitlange M. R., Dr. Pajgade P. S., Dr. Nagarnaik P. B. “Artificial Sand as Fine Aggregate for Concrete”, Civil Engineering and Construction Review. 21(12): 64-67 (2008).
11. Kode V. R., Murty D. S. R., Swarna Kumar P. “Appraisal of Crushed Stone Dust, as Fine Aggregate in Structural Concrete”, Civil Engineering and Construction Review. 20(7): 52-58 (2007).
12. Ahmed E. Ahmed and Ahemed A. El-Kourd. “Properties of Concrete incorporating Natural and Crushed Stone very Fine Sand”, ACI Material journal 86(4): 417- 424 (1989).
13. Tahir Celik and Khaled Marar. “Effects of Crushed Stone Dust on Some Properties of Concrete”, Cement and concrete research. 26(7): 1121-1130 (1996).
14. G. Sreenivasa, Head Manager (Business Development) “Use of manufactured sand in concrete and construction an alternate to sand”, Ultra tech Cement Ltd., Bangalore.
15. IS 383: 1970. “Specification for coarse and fine aggregates from natural sources for concrete, New Delhi, India: Bureau of Indian Standards.
16. IS 516:1959. Indian Standard Code of practice, Methods of test for strength of concrete New Delhi, India: Bureau of Indian Standards.