"Study in Stress Behaviour of Fibre (Steel & Glass) Reinforced Concrete"

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Abstract - *Construction Company is growing as it has never been before; there is always something under new construction. It is thus very much important to use new materials in construction to improve usability, workability and durability, along with the increase in characteristic strengths of material. Concrete is one such material obtained from mixing of various materials. Concrete is good at compressive strength but shows lesser strength in tensile and flexural. To enhance the tensile properties of concrete, it might be prepared with suitable materials such as admixtures or internal reinforcing agents like fibres.*

Steel and Glass fibre are such two materials which is used in concrete construction technology to rise the tensile, flexural and shear strength and reduce cracks and fatigue. Here by using universal testing machine for results obtaining and sort out any possible cracks. Steel and Glass fibre are used here to the concrete mix proportion in various percentages with respect to cement proportion. The test have been done by me in order to check shear behaviour under load for the fibre reinforced concrete; so obtained, by making cube and prism blocks. Depending upon the tabulated results and graphs that is obtained; during testing of the fibre reinforced concrete the evaluation of conclusion is done.

***Key Words*: Fibres, Flexural Strength, Shear Strength, Concrete mix proportion, Workability & Shear Behaviour of Fibre.**

1. INTRODUCTION

Fibre reinforced concrete results from the addition of either as a short discrete fibres or as a continuous long fibres to the cement based matrix to form concrete during mixing.

Fibre is added as admixture to enhance the properties of concrete, and due to the superior performance characteristics of this category of fibre reinforced concretre, its use by the construction industry has significantly increased in the last two decades. It is predefined by various codes that the development of controlled high strength concrete (used with the fibre addition) are those' achieving a target of minimum compressive strength 35 MPa after 24 hours at room temperature, as measured from 4 x 8 in. (100 x 200 mm) cylinders and 150 x 150 x 150 mm^3 cube.

1.1. Fibres are used for-

2. Main role that fibres plays after addition is to minimize the cracks that develops on the surface of concrete structure and to increase the ductility of concrete elements.
3. There is considerable amount of improvement in the surface post-cracking behavior of concrete containing fibers due to both plastic shrinkage and drying shrinkage.
4. It reduces the permeability of concrete and thus reduce bleeding of water hence, saving mix durability, which is due to interlinkage of fibre within mass.
5. Some types of fibers produces higher abrasion and shatter more resistance in concrete.
6. Imparts more resistance to Impact load.

1.2. Reinforcing Fibres.

The principal fibre in common commercial use for concrete making, civil engineering applications includes glass, carbon, metals and aramid. Fiber orientation in every layer yet because the layed stacking sequence of the varied layers are often controlled for generating a good vary of physical and mechanical properties for the composite mass. The major factors distressing the recital of the fiber matrix composite are: fiber orientation, length, shape and composition of the fibres, the mechanical properties of the type of fibre used in matrix and the adhesion or bond between the fibres and the matrix.

Hence the strength of the fiber reinforced concrete can be measured in terms of its maximum resistance when subjected to either of any compressive, tensile, flexural and shear loads. The strength under each individual type of loading is a useful indicator tool of the fibre reinforecd concrete material's performance and characteristic for design consideration.

1.3. Factors affecting the Properties of FRC.

i. Volume of fibers
ii. Aspect ratio of fiber
iii. Orientation of fiber
iv. Relative fiber matrix stiffness
v. Shape and size of fiber.

1.4. Application of FRC in India & Abroad.

1. More than 400 tons of Steel Fibers have been used in the construction of a road overlay for a project at Mathura (UP).
2. A 3.9 km long district heating tunnel, caring heating pipelines from a power plant on the island Amager into the center of Copenhagen, is lined with SFC segments without any conventional steel bar reinforcement.
3. Steel fibers are used without bars to carry flexural loads at a parking garage at Heathrow Airport. It is a structure with 10 cm thick slab.
4. Precast fiber reinforced concrete manhole covers and frames are being widely used in India.

1.5. Use of different volume of fibers.

1. Low volume fraction(less than 1%) used in slab and pavement that have large exposed surface leading to high shrinkage cracking.
2. Moderate volume fraction(between 1 and 2 percent) used in Construction method such as Short-crete & in Structures which; requires improved capacity against delaminating, sapling & fatigue.
3. High volume fraction(greater than 2%) used in making high performance fiber reinforced composites.

2. LITERATURE SURVEY

Fiber content seems to be the parameter that is of primary importance in determining the first-crack and ultimate strengths under static flexure loading. Fiber aspect ratio and fiber type are of secondary importance in practical concretes where increasing the aspect ratio or changing the type (steel composition, surface area, surface texture, etc.) in a manner that increases water demand may tend to counteract any improvements in strength attributable to changes in these fiber parameters.

Many of the current applications of fiber reinforced concrete involve the use of fibers ranging around 1.0 percent by volume of concrete. Recently, it has been possible to incorporate relatively large volumes (ranging up to 15 percent) of steel, glass, and synthetic fibers in concrete. et. Al. [1] Shah [1991] and "Effects of FRP Reinforcement Ratio and Concrete Strength on Flexural Behavior of Concrete Beams." Thériault, M. and Benmokrane, B. et. Al. [2] Corrosion of the steel reinforcement in a cold and saline environment leads to the overall deterioration of reinforced concrete structures. To avoid such deterioration, fibre-reinforced polymers (FRP) rebars are used in place of steel reinforcement.

When fibre fractions are increased, it results in a denser and more uniform distribution of fibres throughout the concrete, which reduces shrinkage cracks and improves post-crack strength of concrete. "Properties of steel fibrous concrete containing mixed fibres in fresh and hardened state" by Y. Mohammadi, S.P. Singh and S.K. Kaushikc; et. Al. [3] concluded that Maximum increase in compressive strength of the order of 25% over plain concrete was observed in case of SFRC containing 100% shorter fibres at fibre volume fraction of 2.0%. A 59% increase in split tensile strength of fibrous concrete was observed with respect to plain concrete with a fibre mix ratio of 65% long fibres and 35% short fibres at a fibre volume fraction of 2.0%. In case of static flexural strength tests, a maximum increase in static flexural strength of the order of 100%, centre point deflection corresponding to peak load of the order of 167% and toughness indices were obtained for fibrous concrete with 100% long fibres, at a fibre volume fraction of 2.0%. and by S.H. Alsayed, Y.A. Al-Salloum, and T.H. Almusallam et. Al. [4] The Flexural capacity of concrete beams reinforced by GFRP bars can be accurately estimated using the ultimate design theory (when failure occurs due to crushing of concrete in the compression side) which is also applicable to design of concrete beams reinforced by steel bars (over reinforced sections).

Also it is recived from R. Kumutha, R. Vaidyanathan, and M.S. Palanichamy that et. Al. [5] the Effective confinement with GFRP composite sheets resulted in improving the compressive strength. Better confinement was achieved when the number of layers of GFRP wrap was increased, resulting in enhanced load carrying capacity of the column, in addition to the improvement of the ductility.

"Durability and simulated ageing of new matrix glass fibre reinforced concrete" by P. Purnell and J. Beddows; 8 June 2005. et. Al. [6] the mechanism of degradation of GRC depends on the matrix formulation. The presence or absence of Ca(OH)2 at the fibre–matrix interface is a key factor. The action of Ca(OH)2 is chemical rather than physical. Matrices modified with e.g. sulfo- aluminates and/or metakaolin, which produce little or no Ca(OH)2 on hydration, have an activation energy for the strength loss process of 57–59 kJ/mol; traditional OPC matrix gfrc has an activation energy of 94–97 kJ/mol.

"Effect of Glass Fibres on Ordinary Portland cement Concrete". by Deshmukh S.H, Bhusari J. P, and Zende A. M.; June. 2012. et. Al. [7] The glass fibers used in concrete suppressed the localization of micro cracks in to macro cracks hence tensile strength increase. It improves durability of concrete by increasing the strength of concrete. The 0.1% addition of glass fibers into the concrete shows better result in mechanical properties and durability.

2.1. Objective of Study:

Many researchers and scholars have started using steel fibres and glass fibres in there experimental setup with the understanding that the longer fibres are more effective in arresting macro-cracks whereas, shorter fibres are effective in arresting micro-cracks, and arrived at specified results depending upon tests. This investigation was, therefore, planned to study the properties of fresh concrete as well as hardened concrete containing mixed steel fibres wrt glass fibres. It is tried in this experiment for getting stress behavior analysis based on cyclic loading for high strength fibre reinforced concrete.

3. EXPERIMENTAL SETUPS

The details of experimental setup is given below and it is tried here to get better result and minimum deviation in the concrete testing results as per IS: 456 – 2000, IS: 10260 – 2000 and Steel fabric shall be hard-drawn steel wire conforming, in all respects, to the requirements of IS: 432 (Part II)-1982* and suitable for welding. Aggregates shall comply with the requirements of IS: 383 - 1998. The Glass Fibers are of Cem-FIL Anti - Crack having higher durability with E = 72 GPa, Filament diameter 14 microns. Specific Gravity is 2.68, length 12 mm and having the aspect ratio of 857.1.

3.1. Concrete Mix design:- M60 grade

Before starting the concrete mix design we have to need some aggregate properties:

1. Specific gravity of Cement = 3
2. Specific gravity of Coarse aggregate = 2.61
3. Specific gravity of Fine Aggregate = 2.44
4. Compaction factor = 0.9
5. Size of the aggregate = 20mm
6. Grading of fine aggregate =
7. Super Plasticizer (CONPLAST SP 337)

4. RESULTS & OBSERVATIONS

Table No. - 1, Mix proportions of concrete used

S. No	W/C ratio	Sand /cemet ratio	CA / cement ratio	% fibre content	Type of fibre
1	0.3	1.25	1.8	0, 0.4, 0.8, 1.2	Steel Fibre
2	0.3	1.25	1.8	0, 0.4, 0.8, 1.2	Glass Fibre

Table No. - 2, Designation of the prisms.

For SFRC & GFRC.

Designation of the Beam	Concrete Compressive Strength	% fibre reinforcement	No of beams	Section Dimensions		
				B (mm)	D (mm)	L (mm)
60	60	0	8	100	100	400
M60	60	0.4	8	100	100	400
M60	60	0.8	8	100	100	400
M60	60	1.2	8	100	100	400

Table No. - 3, Details of standard prisms used for experimentation.

Designation of the Beam	**Mix proportions**	**% Steel and Glass fibre reinforcement**	**No of beam**
M 60	1:1.25:1.8:0.3	0	8
M60	1:1.25:1.8:0.3	0.4	8
M60	1:1.25:1.8:0.3	0.8	8
M60	1:1.25:1.8:0.3	1.2	8

Table No. - 3.1, Details of mix proportion and prisms.

a. For Steel fibre reinforced concrete.

Prism Type	Compressive Strength of Concrete	Notch Depth Ratio	Mix Proportions (Kgs per cubic meter of concrete)				Dimensions of prism specimen (lXbXd)
% Steel Fibre		(a/d)	Cement	Fine aggregates	Coarse aggregates	Water	mm *mm *mm
0% Fibre	61.33	0.10	769.23	923.	1307.6	230.	400X100X100

				07	9	77	
	61.33	0.15	769.23	923.07	1307.69	230.77	400X100X100
	61.33	0.20	769.23	923.07	1307.69	230.77	400X100X100
	61.33	0.25	769.23	923.07	1307.69	230.77	400X100X100
0.4% Fibre	64.27	0.10	769.23	923.07	1307.69	230.77	400X100X100
	64.27	0.15	769.23	923.07	1307.69	230.77	400X100X100
	64.27	0.20	769.23	923.07	1307.69	230.77	400X100X100
	64.27	0.25	769.23	923.07	1307.69	230.77	400X100X100
0.8% Fibre	65.68	0.10	769.23	923.07	1307.69	230.77	400X100X100
	65.68	0.15	769.23	923.07	1307.69	230.77	400X100X100
	65.68	0.20	769.23	923.07	1307.69	230.77	400X100X100
	65.68	0.25	769.23	923.07	1307.69	230.77	400X100X100
1.2% Fibre	60.24	0.10	769.23	923.07	1307.69	230.77	400X100X100
	60.24	0.15	769.23	923.07	1307.69	230.77	400X100X100
	60.24	0.20	769.23	923.07	1307.69	230.77	400X100X100
	60.24	0.25	769.23	923.07	1307.69	230.77	400X100X100

b. For Glass fibre reinforced concrete.

Prism Type	Compressive Strength of Concrete	Notch Depth Ratio	Mix Proportions (Kgs per cubic meter of concrete)				Dimensions of prism specimen (l × b × d)
% Glass Fibre		(a/d)	Cement	Fine aggregates	Coarse aggregates	Water	mm × mm × mm
0% Fibre	61.33	0.10	769.23	923.07	1307.69	230.77	400X100X100
	61.33	0.15	769.23	923.07	1307.69	230.77	400X100X100
	61.33	0.20	769.23	923.07	1307.69	230.77	400X100X100
	61.33	0.25	769.23	923.07	1307.69	230.77	400X100X100
0.4% Fibre	62.87	0.10	769.23	923.07	1307.69	230.77	400X100X100
	62.87	0.15	769.23	923.07	1307.69	230.77	400X100X100
	62.87	0.20	769.23	923.07	1307.69	230.77	400X100X100
	62.87	0.25	769.23	923.07	1307.69	230.77	400X100X100
0.8% Fibre	61.33	0.10	769.23	923.07	1307.69	230.77	400X100X100
	61.33	0.15	769.23	923.07	1307.69	230.77	400X100X100
	61.33	0.20	769.23	923.07	1307.69	230.77	400X100X100
	61.33	0.25	769.23	923.07	1307.69	230.77	400X100X100
1.2% Fibre	60.28	0.10	769.23	923.07	1307.69	230.77	400X100X100
	60.28	0.15	769.23	923.07	1307.69	230.77	400X100X100

	60.28	0.20	769.23	923.07	1307.69	230.77	400X100X100
	60.28	0.25	769.23	923.07	1307.69	230.77	400X100X100

4.1. RESULT DISCUSSION:

The result analysis is done on the basis of various tables and graphs obtained from test result of fibres reinforced concrete on universal testing machine. As it is evident that whenever a force will act on an area of mass stress will be generated due to force applied and strain or deflection in shape and size is obvious.

The load causes deflection and it causes fatigue in diagonal cross-section and breakage or crack get develops which is puerly due to shear generation in the cncrete prism and cube tested.

The fiber reinforced prism resist better cracks developing diagonally and enhance tensile and flexural strength. Used model of prism with different proportion percentage of fibrein mix, shows different behaviour towards different loads and resistant to it via; shear failure at varous loads.

Table No. - 4 Shear value for Fibre reinforced Concerete.

S. No	Type of Fibre	Percent proportion	Interlaminar Shear Value (28 day) MPa	In-Plane Shear Value (28 day) MPa
1	Steel fibre	0.0 %	4.28	4.63
		0.4 %	8.28	9.57
		0.8 %	8.76	11.73
		1.2 %	4.86	6.67
2	Glass fibre	0.0 %	4.28	4.63
		0.4 %	5.88	8.45
		0.8 %	6.65	10.34
		1.2 %	4.35	5.12

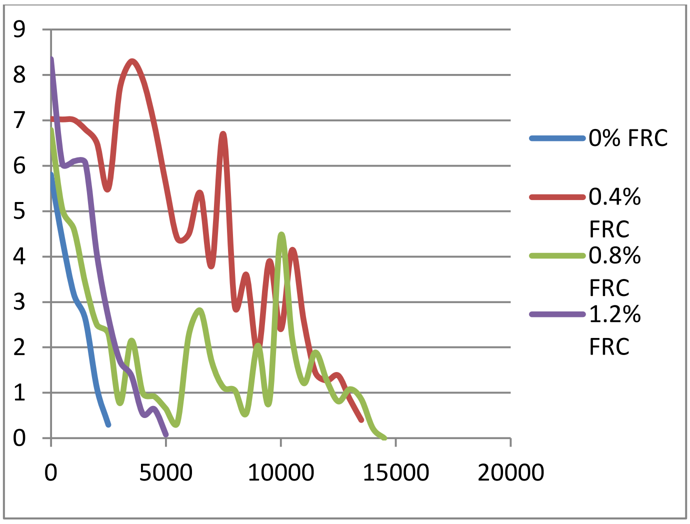

Figure No - 1 Stress behaviour of Steel fibre reiforced concrete.

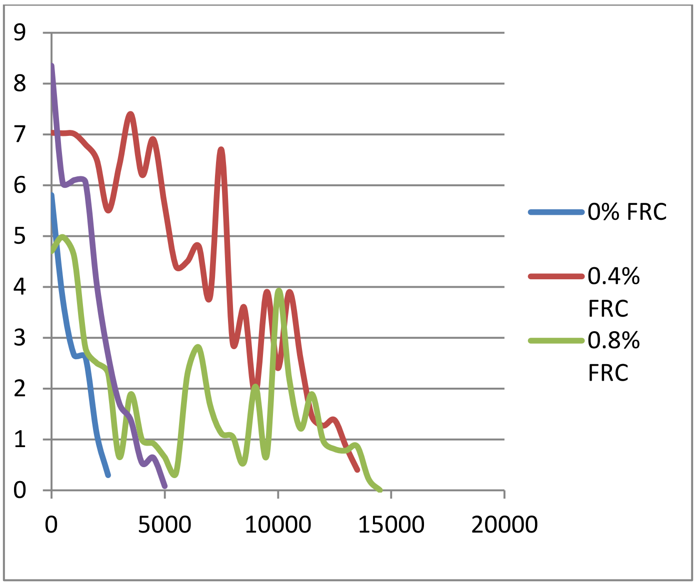

Figure No - 2 Stress behaviour of Glass fibre reiforced concrete.

5. CONCLUSIONS

From the above result analysis Table and Graphs assembly that is attached here in this helps to conclude the following points for the Steel and Glass fibres reinforced.

a. The shear strength depends upon the fracture and cracks that is likely to occur due to loads, fibre reinforced concrete shows better resistance against such failure.
b. After the static test we find that it is clear that the 0.08% for Steel fibre & 0.04% Glass fibre reinforcement increases the max load carrying capacity, but reduces shear capacity.
c. Increase in the notch ratio (a/d) increases the brittleness of the member, in other words, increase in crack length in a structure allows the structure to behave in a brittle manner, hence; reduces In-plane shear
d. The fibre reinforced concrete help to increase the strength ultimate load capacity of concrete.
e. The addition of fibres improves the static flexural strength, flexural fatigue strength, impact strength, shock resistance, ductility, and flexural toughness of concrete.
f. The Steel fibre reinforced concrete resist equally shear in all direction rather than Glass fibre reinforced concrete, later one resist better Inter-laminar shear with higher impact resistance.
g. The Steel fibre & Glass fibre or any other fibre to may be used as aggregate supplement to reduce crackrs and increase shear and flexural strength.

REFERENCES

[1] "Mechanical properties of high strength concrete reinforced with metallic and non-metallic fibres." by A. Sivakumar, and Manu Santhanam in ELSEVIER Volume 29, Issue 8, Sep 2007.
[2] "Effects of FRP Reinforcement Ratio and Concrete Strength on Flexural Behavior of Concrete Beams." By Thériault, M. and Benmokrane, B.
[3] "Properties of steel fibrous concrete containing mixed fibres in fresh and hardened state" by Y. Mohammadi, S.P. Singh and S.K. Kaushikc; Volume 22, Issue 5, May 2008.
[4] "Performance of glass fiber reinforced plastic bars as a reinforcing material for concrete structures" by S.H. Alsayed, Y.A. Al-Salloum, and T.H. Almusallam, published journal paper in Elsevier, 'Part B 31 (2000).
[5] Behaviour of reinforced concrete rectangular columns strengthened using GFRP R. Kumutha, R. Vaidyanathan, and M.S. Palanichamy. published paper in Elsevier, 18 April 2007.

[6] "Durability and simulated ageing of new matrix glass fibre reinforced concrete" by P. Purnell and J. Beddows; 8 June 2005
[7] "Effect of Glass Fibres on Ordinary Portland cement Concrete" by Deshmukh S.H. , Bhusari J. P , and Zende A. M. IOSR Journal of Engineering June. 2012, Vol. 2(6) pp: 1308-1312
[8] Mechanical properties of glass and steel fibre reinforced mortar. ACI J 1976; 73(1) by Shah S.P. and Naaman.
[9] Toutaji and Bayasi et. Al. [8] investigated the effect of manufacturing techniques on the mechanical properties of steel fibre reinforced concrete. The effect of curing environmen
[10] IS:10262-2009. Recommended guidelines for concrete mix design, Bureau of Indian Standards (Reaffirmed), New Delhi, 2000.
[11] IS:456-2000. Indian standard recommended guidelines for concrete mix design, Bureau of Indian Standards.
[12] IS:8112-1989. Specifications for 43-Grade Portland cement, Bureau of Indian Standards, and New Delhi, India.
[13] IS:516-1959. Method of test for strength of concrete, Bureau of Indian Standards, New Delhi, 1959.
[14] IS:2386 (Part I, IV, VI)-1988. Indian standard Method of test for aggregate for concrte, Bureau of Indian Standards, Reaffirmed, New Delhi, 2000.
[15] IS:1199-1959. Indian Standards Methods of Sampling and Analysis of Concrete, Bureau of Indian Standards, New Delhi, India.
[16] P.K. Mehta and P.J.M. Monteiro, Concrete: Microstructure, Properties, and Materials, Third Edition, Fourth Reprint 2011, pp 502-522
[17] ACI Committee 544, Report 544.IR-82, Concr. Int., Vol. 4, No. 5, p. 11, 1982
[18] Hanna, A.N., PCA Report RD 049.01P, Portland Cement Association, Skokie, IL, 1977
[19] Ezio Cadoni ,Alberto Meda ,Giovanni A. Plizzari, Tensile behaviour of FRC under high strain-rate,RILEM, Materials and Structures (2009) 42:1283–1294
[20] Marco di Prisco, Giovanni Plizzari, Lucie Vandewalle, Fiber Reinforced Concrete: New Design Prespectives, RILEM, Materials and Structures (2009) 42:1261-1281.
[21] Federal Highway Administration Research and Technology Coordinating, Developing, and Delivering Highway Transportation Innovations.
[22] Neville AM. Properties of concrete. Eyrolles Editions; 2000.
[23] Google Scholar.

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