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Experimental Study of Steel Fiber Prestressed Concrete Beam for Shear, Bending and Torsion

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Abstract : *In this modern age, civil engineering constructions have their own structural and durability requirements. Fiber Reinforced Concrete (FRC) is a composite material made primarily from hydraulic cements, aggregates and discrete reinforcing fibers. Fiber incorporation in concrete, mortar and cement paste enhances many of the engineering properties of these materials such as fracture toughness, flexural strength, resistance to fatigue, impact, thermal shock and spalling.The FRC is a composite material made of cement, fine and coarse aggregates and discontinuous discrete steel fibers. Recently developed an analytical model to predict the shear, tensional strength and bending torsion behavior of fiber reinforced concrete beam with experimental substantiation. However, very little work has been reported in combined torsion and shear. Similarly to beam with conversional reinforcement, the presence of shear may significance influence on tensional strength of fiber concrete beams. Present paper investigates the mechanical properties like as shear strength, and torsion strength of concrete with different types of steel fiber with constant volume fractions and different aspect ratio.A primary finding emerging from the experimental program was that the placement of fibers, increased load carrying capacity of high strength fiber reinforced concrete [HSFRC] beam. Ductility, toughness significantly improved.*

Keywords: *Aspect ratio, Fatigue, Flexural strength, Fracture toughness, Mechanical properties, Volume fraction, HSFRC, steel fiber, Flexural strength; Load–deflection response; High-strength fiber concrete.*

I. INTRODUCTION

The well-known inherent deficiencies of concrete are its tensile strength and its brittleness. These weaknesses of concrete lead to immediate collapse of plain concrete beams after formation of the first crack and its propagation, at very low values of tensile stress developed in the cross section due to direct (axial) and / or indirect (flexural, shear or torsional) nature of loading. These deficiencies are overcome by fiber reinforced concrete and pre-stressed concrete systems. These systems are not improving the weaknesses of the concrete matrix but are aiding the concrete with tensile reinforcement for sharing almost totally the tensile load on the elements. They and many other investigators have well established that the inclusion of high strength, high elasticity modulus steel fibers of short length and small diameter enhances the tensile strength, ductility and other properties of concrete significantly and also acts as crack arrestors. Concrete with steel fibers is known as steel fiber reinforced concrete (SFRC).

The members of a fiber reinforced concrete structures are subjected to shear forces, axial forces, bending moments and torsional moments. Many researchers carried out tests on reinforced concrete beams under bending-shear-torsion, bending-torsion and shear torsion and proposed modes of failure, empirical formulae and interaction curves. The investigations made in the field of the analysis of behavior of SFRC rectangular beams in combined loading, available in the literature, are fewer as compared with that in the field of pure torsion. In the present investigation 24 fiber reinforced concrete beams with steel fibers were tested under combined torsion-bending-shear.

The objective of this paper is to investigate the mechanical properties like as shear strength, and torsion strength of concrete with different types of steel fiber with constant volume fractions and different aspect ratio.

II. LITERATURE REVIEW

Concrete is a complex material. Innovative structural application is improving performance of concrete. Prestress concrete is also playing major role throughout the world. High performance fiber reinforced prestress concrete beam can prove better on all fronts. The addition of fibers considerably improves the static, flexural strength, impact strength, tensile strength, fatigue strength, ductility, and flexural toughness shear capacity of concrete. The degree of improvement in the above cited parameters depends on many factors including size, type aspect ratio, and volume fraction of fibers.

There is few work done on the torsion to the beam, we at engineeringcivil.com are thankful to Er. Yogesh Ravindra Suryawanshi for submitting this research paper to us. In the beginning all basic tests are conducted on all ingredient material of concrete, viz. cement, fine aggregate, coarse aggregate, water and steel fibers. ACC 43 grade cement conforming to IS 12269 – 1987 is used. River sand is used as fine aggregates, obtained from local river bed. Crushed black trap basalt is used conforming to IS 383 – 1970 of size 10 to 20 mm is used. Sulphonated Naphthalene formaldehyde polymer is used as superplasticizer having brand name as MasterPlast SPL – 9. The dose of superplasticizer is 4% of weight of cement. Three type of steel fibers, hook ended (HK – 80/60) aspect ratio 80, hook ended (HK – 50/30) aspect ratio 50, crimped (CR – 50/30) aspect ratio 50, Round fibers (RD – 50/80) aspect ratio 50 and Round fibers (RD 80/130) aspect ratio 80, all conforming to ASTM A type I are used for the experimental work. The experimental investigation consists of total 36 beam specimens casted and tested for combined shear and torsion. All beams are tested after 28 days of curing. For each type of fiber, the percentage of fiber is kept constant as 2.5%. Out of 36 beams, 6 beams are with 0% fiber content. Total 18 beams are casted with longitudinal reinforcement of 4 numbers of bars, 8 mm diameter, 2 at top and 2 at bottom. The proportioning of concrete is maintained constant throughout the investigation. A concrete mix targeting a compressive strength of 25 MPa is used. Figure 2.1 shows the cross sectional details of the beam loading arrangement. An effective cover of 15 mm is provided for the transverse reinforcement. The cured beams are white washed a day before testing to facilitate the crack identification. One end of the beam is supported on rollers, while the other end is supported on rigid support. This type of test setup facilitates free rotation of roller end and provides stability to the test specimen during testing. Specially made twist arms or twist angles are placed at both supports of the beam having an arm length of 0.60 m. Load on the twist arm is applied through a hydraulic jack and the loading is monitored through a proving ring attached to the jack. Absolute care has taken, such that, the plane of loading and twisting arm are perpendicular to the longitudinal axis of the beam. This avoids any possibility of bending of the beam instead of twisting and as a result the beam between the two supports is subjected to pure torsion. The complete test setup is schematically presented in figure 2.2. Load is applied at an eccentricity of 0.66 m from the center of the beam. For every applied load, the corresponding dial gauge readings are noted which were placed at L/3 distance from ends and considering average value of the two reading.

An experimental work on the steel fiber reinforced concrete to analyze effective moment of Inertia and flexural rigidity was reported by J Premalatha and R Sundara rajan. In this experimental work eighteen beams with 8mpa compressive strength and having tension and compression reinforcement and deformed steel fibers were tested under two point loading. The flexural rigidity (EI) of cracked rectangular reinforced concrete beams with steel fibers was evaluated experimentally. Considering the steel fibers influence compression and tension reinforcement a change ACI building code method for estimating the effective moment of inertia of the section for the reinforced high strength fibrous concrete beams is proposed. The effective moment of inertia estimated using the changed methods compared with the experimental results. The results of the investigation can be summarized as follows. Addition of steel fibers increases the beam stiffness thus reduces the deflection for a given load. The value of m used in the effective moment of inertia formula equation decreases with increase in fiber volume fraction. Increase in longitudinal reinforcement ratio from 0.01 to 0.03 in tested beams resulted in 17% increase in flexural rigidity. Increase in volume fraction of steel fibers from 0 to 1.5% in tested beams resulted in 21% increase in flexural rigidity.

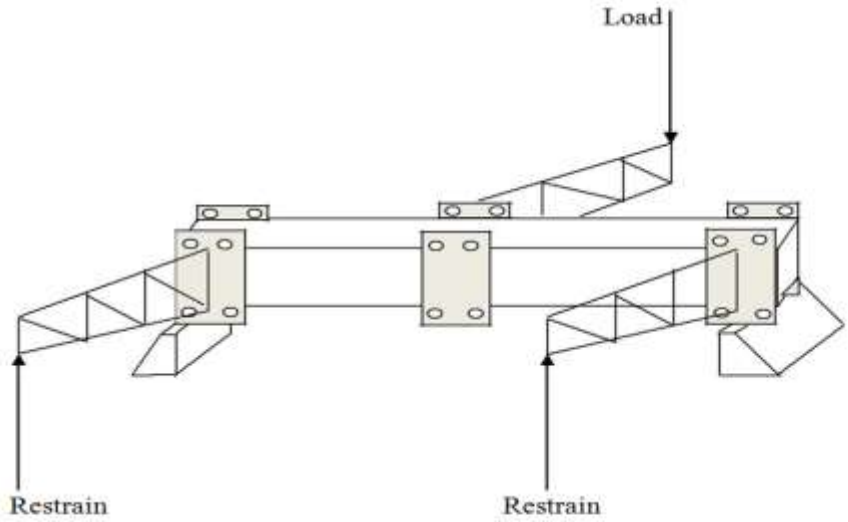
III. Prestress Concrete

Concrete is presently the most widely used construction material. Because of its specialty of being cast in any desirable shape, it has replaced stone and brick masonry. In spite of all this, it has some serious deficiencies which for its remarkable qualities of flexibility, resilience and ability to redistribute stress, would have prevented its use as a building material. Plain, unreinforced concrete is a brittle material, with a low tensile strength and a low strain capacity. Plain concrete is inherently weak in tension and has limited ductility and little resistance to cracking. Micro cracks are inherently present in concrete and because of this low tensile strength; cracks propagate with application of the load, leading to brittle fracture in concrete. The low tensile strength of concrete is being compensated for in several ways and this has been achieved by use of Reinforcing Bars and also by applying Prestressing Techniques.

The prestressing and pre-casting of concrete are inter-related features of the modern building industry. Through the application of imaginative design and quality control, they have, since the 1930's, had an increasing impact on architectural and construction procedures. Prestressing of concrete is the application of a compressive force to concrete members and may be achieved by either pre-tensioning high tensile steel strands before the concrete has set, or by post-tensioning the strands after the concrete has set. Although these techniques are commonplace, misunderstanding of the principles, and the way they are applied, still exists. To avoid this one should have proper knowledge of Prestressing techniques.

IV. TORSION TO THE BEAM

Torsion occurs more frequently in most structure but rarely occurs alone. However, torsion forms one of the basic structural actions besides flexure, shear and axial compression/tension. Torsional failure of concrete member is initiated by the tensile stress developed due to a state of pure shear, which arises due to torsion. Inclusion of steel fibers principally may increase the tensile strength of the matrix to a moderate level but the toughness will be enhanced to a greater extent. This particular advantage of fiber reinforced concrete inspired the different conditions of study its mechanical properties under different conditions of loading. But little information is available on the to behavior of fiber reinforced concrete members under pure torsion. Earlier investigation indicated that the addition of fibers improves the torsional strength and ductility of member. In this investigation an attempt has been made to quantify the effect of fibers in resisting torsional loads. Also a semi empirical formula for predicting the ultimate torsional strength of the SFRC member has been presented.

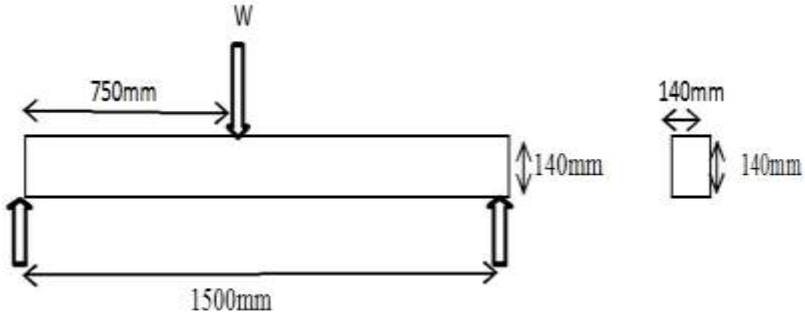


V. FLEXURAL STRESSES IN BEAMS

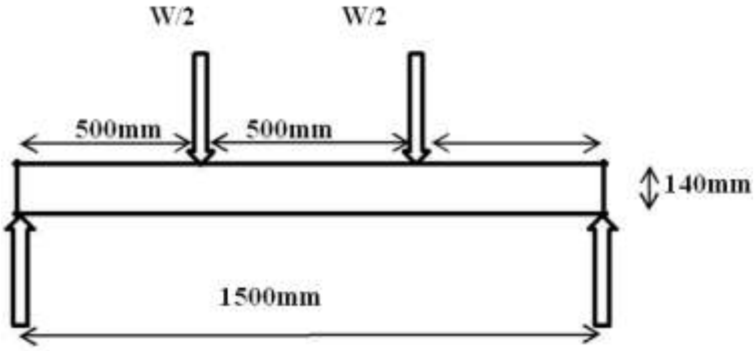
A beam is a structural member whose length is large compared to its cross sectional area which is loaded and supported in the direction transverse to its axis. Lateral loads acting on the beam cause the beam to bend or flex, thereby deforming the axis of the beam into a curved line. In previous chapter prestressing method was discussed. In this chapter flexural behaviour of prestressed beam is discussed.

When prestressed concrete members are subjected to bending loads, different types of flexural failures are possible at critical sections, depending upon the principal controlling parameters, such as the percentage of reinforcement in the section, degree of bond between tendons and concrete, compressive strength of concrete and the ultimate tensile strength of the tendons. In the post-cracking stage, the behavior of a prestressed concrete member is more similar to that of a reinforced concrete member and the theories used for estimating the flexural strength of reinforced concrete section may as well be used for prestressed concrete sections.

Flexural testing on beam with single point loading –



Flexural testing on beam with double point loading –



VI. PROJECT EXECUTION WORK

In this project, an attempt will be made to study the effects of steel fibers by fully replacement to steel reinforcement in terms of improved performance in compressive strength and flexural strength of prestressed concrete. Apart from this, the deflection of the prestressed beams also measured etc. In brief, an attempt is to be made to produce high performing prestressed concrete by replacement of steel reinforcement by some percentage of steel fibers to achieve the economy.

The aim of the project is to initiate and provide platform for further studies on following issues:-

- To provide high performance prestressed concrete as economically as possible by incorporating steel fibers by means of suitable mix design for different proportions of fibers.
- For long span of beams/girders the normal construction is difficult and also the cost of steel reinforcement also high, so to reduce this cost of steel reinforcement we can prefer prestressed concrete beam by using steel fibers.

Execution work of the project :-

It involves following work stages:-

- Execution of torsion setup
- Preparation of moulds
- Cube casting.
- Testing of casted cubes at consecutive days.
- Pretensioning of cables.
- Casting of concrete beams by selecting optimum value steel fibers.
- Testing of prestressed concrete beams.

VII. TEEST RESULT

Compressive strength of concrete cubes :-

28 Days Plain cubes test results M40

Date	**Cube**	**Fiber content %**	**Weight (KG)**	**Load (KN)**
	PL1	-	8.723	39.6
11/06/2013	PL2	-	9.045	40.4
	PL3	-	9.189	40.4
Avg comp strength				40.13

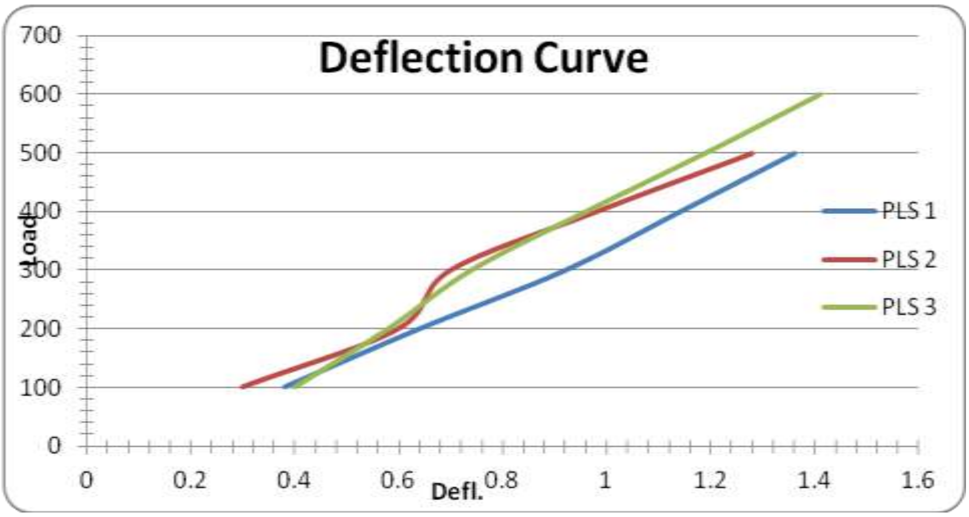
28 Days strength of cubes with fiber proportions M40

Date	**Cube**	**Fiber content %**	**Weight (KG)**	**Load (KN)**
	SF1	1.0%	8.789	51.44
11/06/2013	SF2	1.0%	8.888	49.87
	SF3	1.0%	8.830	49.99
Avg comp strength				**50.43**

Load Vs Deflection Curves :-

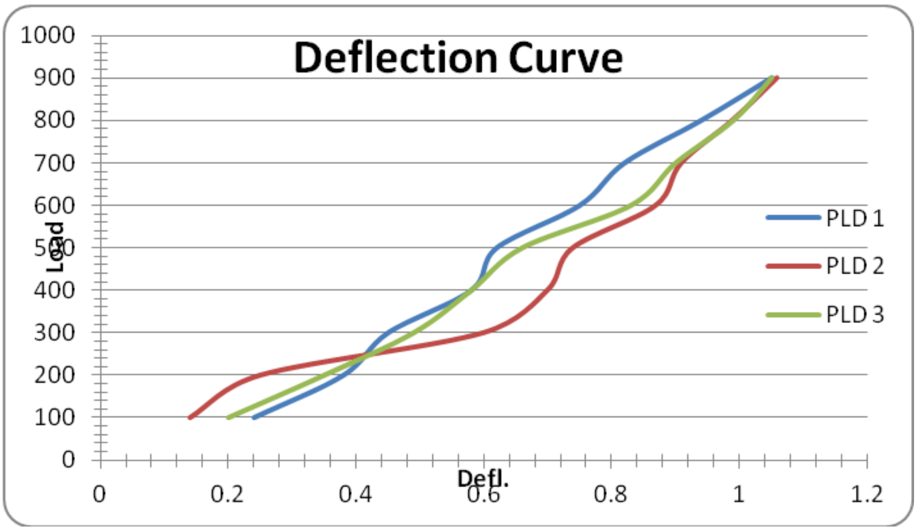
Average Plain Beam with Single Point Load :-

PLS -1		PLS – 2		PLS – 3	
Load (Kg)	Avg. Deflection (mm)	Load (Kg)	Avg. Deflection (mm)	Load (Kg)	Avg. Deflection (mm)
100	0.38	100	0.3	100	0.4
200	0.64	200	0.6	200	0.58
300	0.92	300	0.7	300	0.74
400	1.14	400	0.98	400	0.96
500	1.36	500	1.28	500	1.19
-	-	-	-	600	1.41



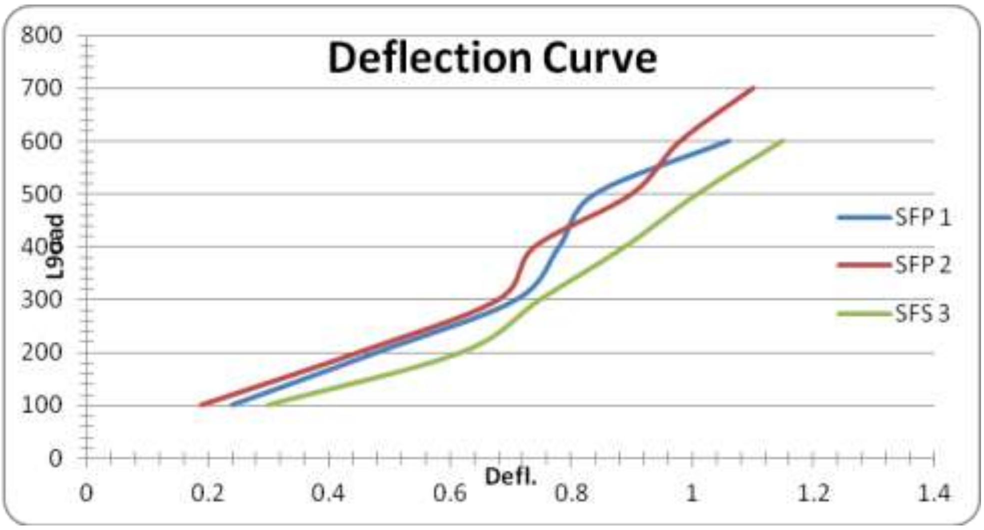
Average Plain Beam with Double Point Load :-

PLD -1		PLD – 2		PLD – 3	
Load (Kg)	Avg. Deflection (mm)	Load (Kg)	Avg. Deflection (mm)	Load (Kg)	Avg. Deflection (mm)
100	0.24	100	0.14	100	0.2
200	0.38	200	0.25	200	0.35
300	0.45	300	0.60	300	0.49
400	0.58	400	0.70	400	0.58
500	0.62	500	0.74	500	0.66
600	0.75	600	0.87	600	0.83
700	0.82	700	0.91	700	0.90
800	0.94	800	0.99	800	0.99
900	1.05	900	1.06	900	1.05



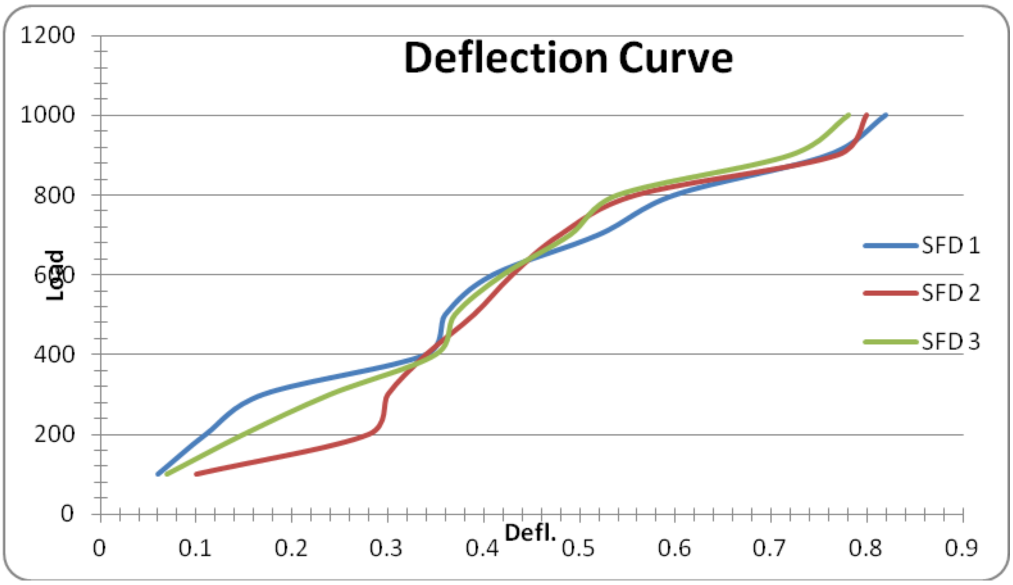
Average Steel Fiber Beam with Single Point Load :-

SFS -1		SFS – 2		SFS – 3	
Load (Kg)	Avg. Deflection (mm)	Load (Kg)	Avg. Deflection (mm)	Load (Kg)	Avg. Deflection (mm)
100	0.24	100	0.19	100	0.3
200	0.48	200	0.45	200	0.62
300	0.71	300	0.68	300	0.75
400	0.78	400	0.74	400	0.89
500	0.84	500	0.9	500	1.01
600	1.06	600	0.98	600	1.15
-	-	700	1.1	-	-



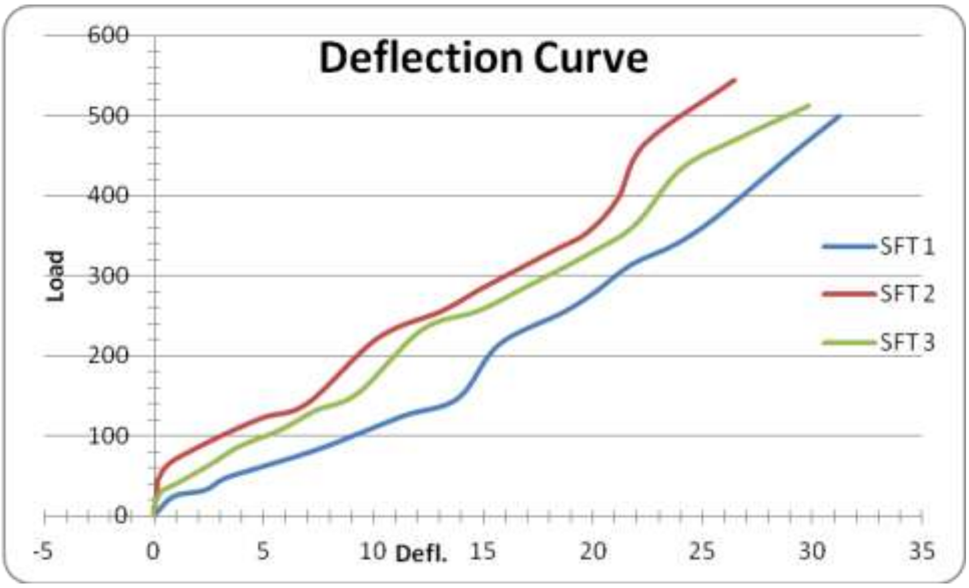
Average Steel Fiber Beam with Double Point Load :-

SFD -1		SFD – 2		SFD – 3	
Load (Kg)	Avg. Deflection (mm)	Load (Kg)	Avg. Deflection (mm)	Load (Kg)	Avg. Deflection (mm)
100	0.06	100	0.1	100	0.07
200	0.11	200	0.28	200	0.15
300	0.17	300	0.30	300	0.24
400	0.34	400	0.34	400	0.35
500	0.36	500	0.39	500	0.37
600	0.41	600	0.43	600	0.42
700	0.52	700	0.48	700	0.49
800	0.60	800	0.56	800	0.54
900	0.76	900	0.77	900	0.72
1000	0.82	1000	0.80	1000	0.78



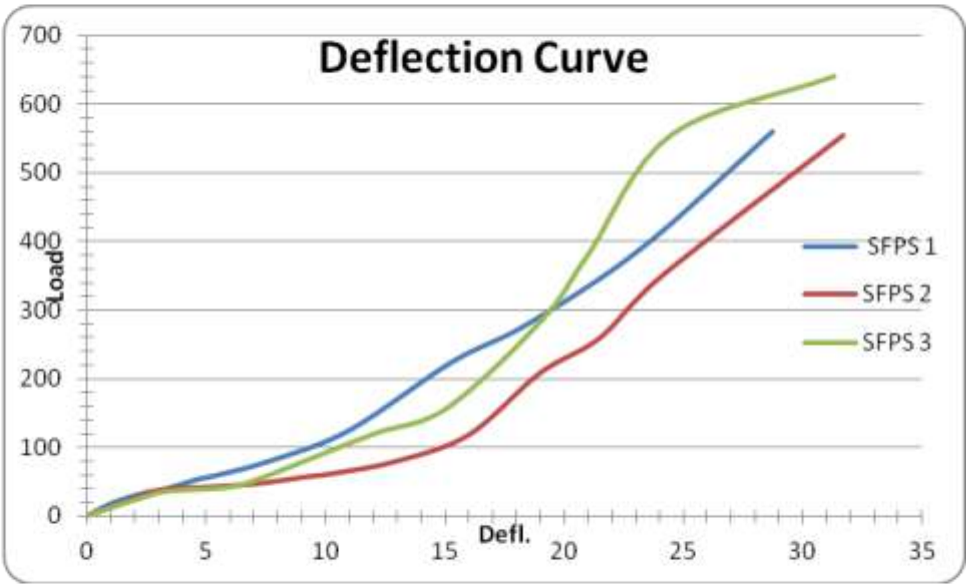
Average Steel Fiber Torsion Table :-

SFT -1		SFT – 2		SFT – 3	
Load (Kg)	Avg. Deflection (mm)	Load (Kg)	Avg. Deflection (mm)	Load (Kg)	Avg. Deflection (mm)
0	0	0	0	0	0
24	0.875	8	0	12	0
32	2.3125	33.6	0.125	30.4	0.34375
46.4	3.1875	46.4	0.1875	41.6	1.125
57.6	4.46875	65.6	0.6875	64	2.5625
75.2	6.59375	84.8	1.9375	86.4	3.875
89.6	8.125	107.2	3.625	107.2	5.75
124.8	11.375	123.2	5.03125	131.2	7.34375
147.2	13.875	140.8	7	153.6	9.3125
214	15.71875	222	10.1875	232	12.1875
254	18.625	256	13.125	256	14.78125
280	20.125	284	14.9375	284	16.8125
314	21.75	330	18.125	328	19.875
340	23.8125	354	19.75	364	21.9375
376	25.75	396	21.125	433.07	24
450	28.96875	465.06	22.375	471.47	26.625
500	31.25	544	26.4375	512	29.8125



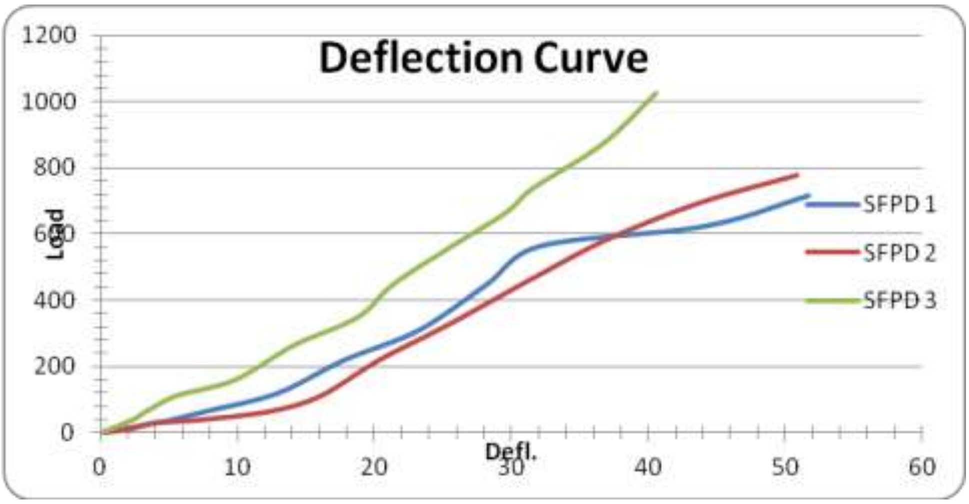
Average Steel Fiber Prestress Concrete Single Point Load :-

SFP - S -1		SFP - S – 2		SFP - S – 3	
Load (Kg)	Avg. Deflection (mm)	Load (Kg)	Avg. Deflection (mm)	Load (Kg)	Avg. Deflection (mm)
0	0	0	0	0	0
19.2	1.083333	16	1.25	17.6	1.5
33.6	2.416667	36.8	2.916667	33.6	3
36.8	3	41.6	4.833333	36.8	3.833333
44.8	3.833333	46.4	7	41.6	5.916667
52.8	4.583333	56	9	51.2	7
57.6	5.25	62.4	10.41667	81.6	9.25
80	7.666667	80	13	120	12.08333
124.8	11	118.4	16	156.8	15.08333
224	15.29167	208	18.95833	284	19.04167
280	18.5	260	21.5	380	21
390	23.25	350	24.08333	554.67	24.5
560	28.75	554.67	31.66667	640	31.33333



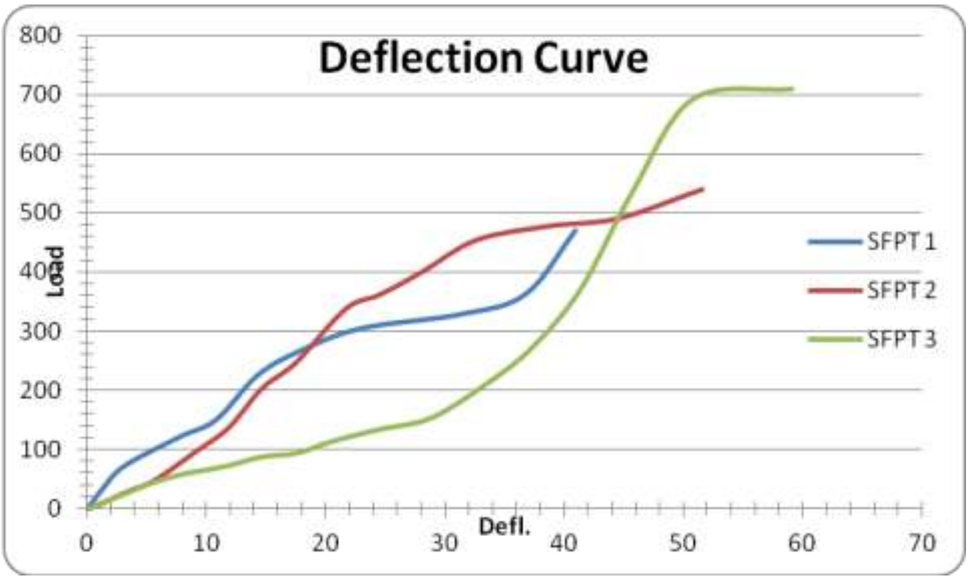
Average Steel Fiber Prestress Concrete Double Point Load :-

SFP - D -1		SFP - D – 2		SFP - D – 3	
Load (Kg)	Avg. Deflection (mm)	Load (Kg)	Avg. Deflection (mm)	Load (Kg)	Avg. Deflection (mm)
0	0	0	0	0	0
6.4	1	11.2	2.083333	16	1
32	4.166667	30.4	4.083333	41.6	2.458333
36.8	4.916667	40	7.416667	56	3
65.6	7.75	65.6	12.41667	73.6	3.708333
120	12.95833	112	16.08333	113.6	5.666667
220	17.79167	220	20.33333	160	9.833333
310	23.25	326	25.33333	264	14.125
448	28.20833	473.6	31.83333	350	18.83333
565.33	32.16667	586.67	37.08333	448	21.375
625.25	44.16667	697	43.83333	565.33	25.75
717.5	51.75	779	50.83333	666.25	29.66667
-	-	-	-	738	31.58333
-	-	-	-	871.25	36.66667
-	-	-	-	1025	40.58333



Average Steel Fiber Prestress Concrete Torsion Load :-

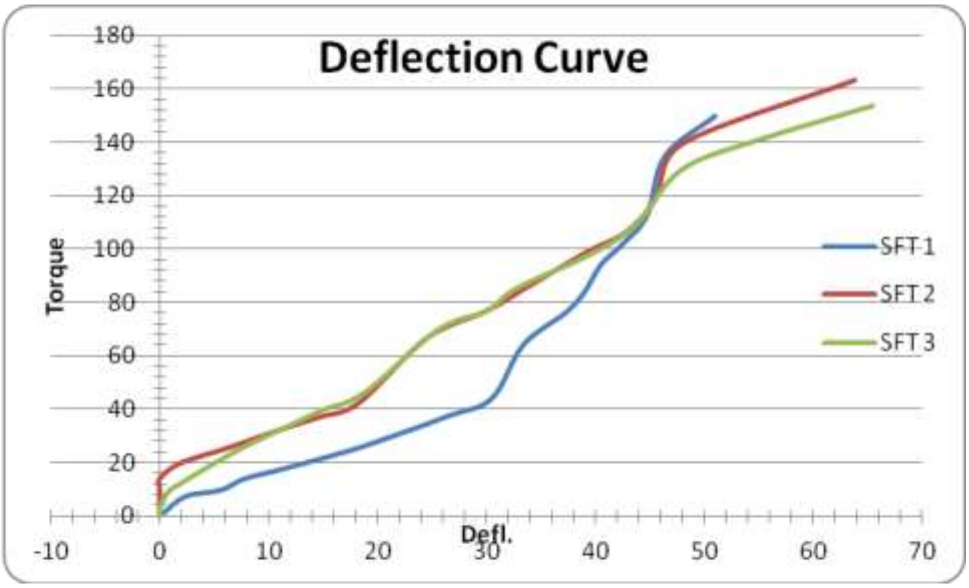
SFP - T -1		SFP - T – 2		SFP - T – 3	
Load (Kg)	Avg. Deflection (mm)	Load (Kg)	Avg. Deflection (mm)	Load (Kg)	Avg. Deflection (mm)
0	0	0	0	0	0
33.6	1.2625	8	1.0625	8.8	1.0625
72.8	3.13125	30.4	3.5	24	2.9375
121.6	7.7625	48	5.625	44.8	5.5625
150.4	10.8	97.6	9.15625	59.2	8.09375
224	14.2	137.6	11.875	72	11.5625
264	17.575	204	14.6875	88	14.625
304	22.875	248	17.5625	94.4	17.59375
328	31.3	338	21.6875	113.6	20.4375
362	36.75	362	24.5625	134.4	24.5
469.33	40.9375	400	28.0625	153.6	28.8125
-	-	454.4	32.6875	212	33.5
-	-	477.87	38.8125	272	37.25
-	-	490.67	44.5625	372	41.375
-	-	539.73	51.625	535.47	45.6875
-	-	-	-	692.9	50.8125
-	-	-	-	709.3	59.0625



TORQUE VS DEFLECTION CURVE :-

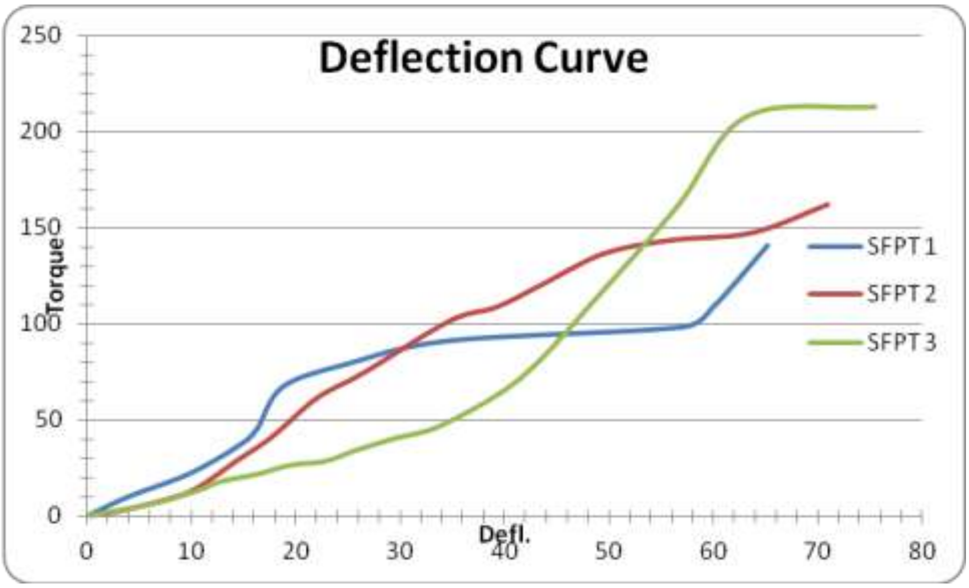
Steel Fiber Torsion : Torque vs Center Deflection Curve :-

SFT – 1			SFT - 2			SFT – 3		
Load (Kg)	Torque = 0.3 X Load (Kg m)	Center Deflection (mm)	Load (Kg)	Torque = 0.3 X Load (Kg m)	Center Deflection (mm)	Load (Kg)	Torque = 0.3 X Load (Kg m)	Center Deflection (mm)
0	0	0	0	0	0	0	0	0
24	7.2	2.25	8	2.4	0	12	3.6	0
32	9.6	5.5	33.6	10.08	0	30.4	9.12	0.75
46.4	13.92	7.75	46.4	13.92	0	41.6	12.48	2
57.6	17.28	11	65.6	19.68	1.875	64	19.2	4.75
75.2	22.56	15.75	84.8	25.44	6.25	86.4	25.92	7.75
89.6	26.88	19.25	107.2	32.16	11	107.2	32.16	11
124.8	37.44	26.5	123.2	36.96	14.625	131.2	39.36	14.75
147.2	44.16	30.5	140.8	42.24	18.25	153.6	46.08	18.75
214	64.2	33.375	222	66.6	24.5	232	69.6	25.5
254	76.2	37.25	256	76.8	30	256	76.8	30
280	84	39	284	85.2	33.5	284	85.2	32.75
314	94.2	40.5	330	99	39.25	328	98.4	39.75
340	102	42.5	354	106.2	42.75	364	109.2	43.75
376	112.8	44.75	396	118.8	45.5	433.07	129.921	48
450	135	46.375	465.06	139.518	48	471.47	141.441	55.5
500	150	51	544	163.2	63.75	512	153.6	65.5



Steel Fiber Prestress Torsion : Torque vs Center Deflection Curve :-

SFP - T - 1			SFP - T - 2			SFP - T – 3		
Load (Kg)	Torque = 0.3 X Load (Kg m)	Center Deflection (mm)	Load (Kg)	Torque = 0.3 X Load (Kg m)	Center Deflection (mm)	Load (Kg)	Torque = 0.3 X Load (Kg m)	Center Deflection (mm)
0	0	0	0	0	0	0	0	0
33.6	10.08	4	8	2.4	3	8.8	2.64	2.75
72.8	21.84	9.75	30.4	9.12	8	24	7.2	7
121.6	36.48	14.5	48	14.4	10.5	44.8	13.44	10.75
150.4	45.12	16.25	97.6	29.28	14.5	59.2	17.76	12.75
224	67.2	18.75	137.6	41.28	17.75	72	21.6	16.25
264	79.2	25	204	61.2	22	88	26.4	19.5
304	91.2	34.75	248	74.4	26.5	94.4	28.32	22.75
328	98.4	57.25	338	101.4	34.75	113.6	34.08	25.75
362	108.6	60	362	108.6	39.25	134.4	40.32	29.5
469.33	140.799	65.25	400	120	43.5	153.6	46.08	33.5
-	-	-	454.4	136.32	49.5	212	63.6	39.5
-	-	-	477.87	143.361	56	272	81.6	43.5
-	-	-	490.67	147.201	63.75	372	111.6	48.5
-	-	-	539.73	161.919	71	535.47	160.641	56.5
-	-	-	-	-	-	692.9	207.87	63.25
-	-	-	-	-	-	709.3	212.79	75.5



Final Result Table :-

	Beam Specimen	Size (Width x Depth x Length) in mm	Point loads	Moment of Inertia in mm^4	F_{ck} in MPa	E_c of Concrete in Mpa= 5000√Fck	Torque	Hoz. Deflection	Ver. Deflection
Series-I	PLS – 1	140x140x1500	Single	32013333	**40.13**	31674.12	-	-	-
	PLS – 2	140x140x1500	Single	32013333	**40.13**	31674.12	-	-	-
	PLS – 3	140x140x1500	Single	32013333	**40.13**	31674.12	-	-	-
Series-II	PLD – 1	140x140x1500	Double	32013333	**40.13**	31674.12	-	-	-
	PLD – 2	140x140x1500	Double	32013333	**40.13**	31674.12	-	-	-
	PLD – 3	140x140x1500	Double	32013333	**40.13**	31674.12	-	-	-
Series-III	SFS – 1	140x140x1500	Single	32013333	**50.43**	35507.04	-	-	-
	SFS – 2	140x140x1500	Single	32013333	**50.43**	35507.04	-	-	-
	SFS – 3	140x140x1500	Single	32013333	**50.43**	35507.04	-	-	-
Series-IV	SFD – 1	140x140x1500	Double	32013333	**50.43**	35507.04	-	-	-
	SFD – 2	140x140x1500	Double	32013333	**50.43**	35507.04	-	-	-
	SFD – 3	140x140x1500	Double	32013333	**50.43**	35507.04	-	-	-
Series-V	SFT – 1	140x140x1500	Torsion	32013333	**50.43**	35507.04	150	37.5	51
	SFT – 2	140x140x1500	Torsion	32013333	**50.43**	35507.04	163.2	20	63.75
	SFT – 3	140x140x1500	Torsion	32013333	**50.43**	35507.04	153.6	27.25	65.5
Series-VI	SFP – S – 1	140x140x1500	Single	32013333	**50.43**	35507.04	-	-	-
	SFP – S – 2	140x140x1500	Single	32013333	**50.43**	35507.04	-	-	-
	SFP – S – 3	140x140x1500	Single	32013333	**50.43**	35507.04	-	-	-
Series-VII	SFP – D – 1	140x140x1500	Double	32013333	**50.43**	35507.04	-	-	-
	SFP – D – 2	140x140x1500	Double	32013333	**50.43**	35507.04	-	-	-
	SFP – D – 3	140x140x1500	Double	32013333	**50.43**	35507.04	-	-	-
Series-VIII	SFP – T – 1	140x140x1500	Torsion	32013333	**50.43**	35507.04	140.799	51.25	65.25
	SFP - T - 2	140x140x1500	Torsion	32013333	**50.43**	35507.04	161.919	61	71
	SFP – T -3	140x140x1500	Torsion	32013333	**50.43**	35507.04	212.79	67	75.5

Beam Specimen		**Experimental**					**Analytical**		
Series		**Strength in (N)**	**Avg. strength in (N)**	**Flexural strength in MPa**	**Deflection in mm**	**Avg. deflection in mm**	**Strength in (N)**	**Flexural strength in MPa**	**Deflection in mm**
Series-I	PLS – 1	5000	5333.33	7.65E-06	1.36	1.35	5333.33	4.56	0.36
	PLS – 2	5000			1.28				
	PLS – 3	6000			1.41				
Series-II	PLD – 1	9000	9000	1.05E-05	1.05	1.053	9000	6.75	0.66
	PLD – 2	9000			1.06				
	PLD – 3	9000			1.05				
Series-III	SFS – 1	6000	6333.33	9.09E-06	1.06	1.10	6333.33	5.38	0.45
	SFS – 2	7000			1.1				
	SFS – 3	6000			1.15				
Series-IV	SFD – 1	10000	10000	1.16E-05	0.82	0.8	10000	7.48	1.46
	SFD – 2	10000			0.8				
	SFD – 3	10000			0.78				
Series-V	SFT – 1	5000	5186.67	-	51	60.08	5186.67	-	-
	SFT – 2	5440			63.75				
	SFT – 3	5120			65.5				
Series-VI	SFP – S – 1	5600	5848.9	8.39E-06	45.25	47.83	5848.9	4.98	0.41
	SFP – S – 2	5546.7			50.25				
	SFP – S – 3	6400			48				
Series-VII	SFP – D – 1	7175	8405	1.21E-05	73.5	68.83	8405	6.31	1.23
	SFP – D – 2	7790			67				
	SFP – D – 3	10250			66				
Series-VIII	SFP – T – 1	4693.3	5727.87	-	65.25	70.58	5727.87	-	-
	SFP - T - 2	5397.3			71				
	SFP – T -3	7093			75.5				

VIII. CONCLUSION

The purpose of this research project is to study the behaviour of Prestressed Steel Fiber Concrete (PSFC) beams under shear, bending and torsion. The following conclusions were made from this research:

1. From above discussion it is conclude that, shear strength and Torsional strength are improved by addition of fibers irrespective of fiber type and aspect ratio. There is marginal improvement in torsion and shear strength of concrete with change in aspect ratio.
2. Based on the flexural test results of small beam specimens, the recommended maximum Dosage of Dramix steel fibers to be used in full-scale PSFC beams considering strength and good workability of concrete mix is as below:
   Dramix Long Fibers - Dosage of 1.0% by volume of concrete
3. Torsional concrete beams strengthened with fiber reinforced concrete exhibited significant increase in their cracking and ultimate strength as well as ultimate twist deformations.
4. PSFC beam tests showed that the tensile stiffness and concrete softening characteristics of PSFC improves with an increased Fiber-Factor.
5. The results obtained from deflection curve, it is find that, the deflection of the middle section of the beam is very high and that's why Every time there is a failure occurs at the center of the beam. This failure is torsion shear failure forms.

So, it is conclude that, the without reinforcement beam is very weak. As we added the steel fiber the strength of beam at the meddle increases and prestressed concrete beam is getting very high ultimate strength and twisting strength with compare to plain beam.

6. From the last result table, it is observed that experimental deflection is much higher than the analytical deflection that was calculated.

7. The flexural behaviour of PSFC beams was critically examined by full-scale tests on three beams flexural-shear failure modes.
8. From the experimental results of three PSFC beams, steel fibers were found very effective in resisting the deflection and mild steel shear reinforcement can be completely replaced with steel fibers.
9. From the test results of all three PSFC beams it was found that 1% by volume of Dramix short steel fibers was an optimum dosage in prestress concrete beams as shear and torsion reinforcement.
10. Using the constitutive laws of PSFC established in this research, an analytical model was developed and implemented in a finite element program framework (Open Sees) to simulate the shear behaviour of the PSFC beams. Using this computer program, the load-deflection curves of all the beams are simulated with acceptable accuracy.
11. Addition of steel fibers in concrete increased the load carrying capacity, ductility and energy absorption capability (i.e. flexural toughness) of the beam.
12. An increase of 30% to 120% was observed in the ultimate flexural capacities of beam specimens, when steel fiber content was increased from 0.5% to 1.5% by volume of concrete.
13. In the beam specimens with 0.5% dosage of Dramix fibers, an increase in the fiber Length (i.e. from short to long fibers) attributed to a significant increase (of about 30%) in the flexural toughness values. The beneficial effect of fiber length on flexural toughness became less significant at higher dosage of steel fibers in the beam Specimens.

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