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Experimental Study of GlassFibrePrestressed Concrete Beam for Shear, Bending

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Abstract— The low tensile strength and limited ductility, the unavoidable deficiency, of concrete can be overcome by the addition of fibers. In this research, an attempt was made to study the effects of flyash and glass fibers on shear,flexuralstrength of high strength prestressed concrete and glassfiberprestressedconcrete beam specimens.
To study the shear, flexural strength behavior, the total 12 beam specimens of size 140mm x140mm x1500mm were castincluding 6 plainprestressedconcrete beam specimens with 20% fly ash replacing to cement by its weight and 6 beam specimens by adding 20% fly ash replacing cement by its weightwith0.25% glass fiber(22) by weight of concrete. A primary finding emerging from the experimental program was that the placement of glass fibers, increased load carrying capacity of high strength fiber reinforced prestressedconcrete beam. Glassfibers enhanced ductility, shear,and flexural strength.
All specimens were tested for single, double pointloading, after 28 days. Deflections were measured. Experimental, analyticalresults were compared.

Keywords: High strength concrete;fly ash;glassfibers;flexural;shear;deflection.

I. INTRODUCTION

A prestressed concrete member is one in which internal stresses are introduced in a planned manner, so that the stresses resulting from the superimposed loads are counteracted to a desired degreePrestressed concrete structures are subjected to large forces and hence by using high strength concrete the sectional dimensions are brought to a minimum(Edward G.Nawy).
Glass fibers present in the concrete arrest the cracks or retard the crack propagation, which improves the tensile strength and energy absorbing property of the basic material (concrete),(S.P.Patil,et.al.,2014).The largest shear stresses occur in the middle of the outside faces or perimeter of the cross section. In this experimental programmethe ductility and shear strength has to improve by adding significant quantity of steel fibers and test for shear,bendingeffect on high strength concrete beamspecimen.

II. OBJECTIVES

The objective of this research program were,
1. To determine the shear, flexuralstrength and deflections of plain and high strength fiber reinforced prestressedconcrete [HSFRPC] beam specimen.
2. Compared actual strength obtained based on experimental results of plain and high strength fiber reinforced prestressed concrete (HSFRPC) beams specimen with analytical results. The research

findings will be help engineers to understand the overall performance of strength of prestressedconcrete with glassfibers for shear, flexuralspecimen.

III. EXPERIMENTAL PROGRAM

The experimental programme was divided in three phases
a)Prestressing tendons and casting of prestressedconcrete beam specimensbyadding Fly Ash.
b)Prestressing tendons and casting of Prestressedconcrete beamsbyadding Fly Ash and glassfibres.
c) Testing of all beam specimens for shear, flexural, and comparison of results.

3.1 CONCRETE PROPERTIES AND MIX PROPORTIONS

Materials for the concrete mixes: Ordinary PortlandCement confirming IS:12269-1976; fine aggregate as river sand confirming IS 2386-Part-I-1963 ; Coarse aggregate consisted of a 20mm maximum size confirming IS:2386-Part-4; the mix proportion was 1:1.30:2.37,Fly Ash of Class-C (IS 3812 Part I– 2003); Glassfibers: Alkali Resistant (AR) type-, Tensile strength=1700MPa,Length of fibers = 12mm, Diameter = 14 µm.
W/c ratio 0.40 and Water reducing admixture (Flowcon-PC 163 JK) 1 % by weight of cement were used for experimentation [30]. Refer table 1.

3.2 TEST SPECIMENS

All 12beam specimens were designed to have the same nominal cross sectional dimensions,width 140mm, depth 140mm and span 1500mm and two prestressing strands having diameter of 4mm each.Average eccentricity was 30 mm.All specimens were designed to have same prestressing force Pu=27156.74N and amount of prestressed steel (25.13mm^2). The cross section details are shown in figure.1.

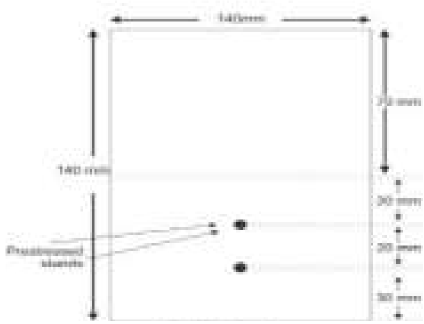


Figure 1 Cross section of Prestressed concrete beam specimen

Two types of beam specimens were design:

a) Prestressedconcrete specimens with 20% fly ash replacing to cement by its weight.
b) Glassfibersprestressed concrete beam specimens with **0.25%**glassfibersby weight of concrete [32] and 20% fly ash replacing to cement by its weight [30].Refer table-1.

3.3 SPECIMEN CASTING

All prestressedbeam specimen of size 140mmx140mm x1500mm were cast for specific mix given in table-1 and series of specimen given in table-2 and consolidated using tamping rods.After setting, the beam specimen were covered with wet gunny bags. The burlap was kept for 3 days. At the end of the third day, prestressed force transfer to concrete simultaneously by cutting prestressed tendons , the forms were stripped and beam specimen were kept for curing up to 28days.

Table 1Quantity of materials required per cubic meter [22]

Beam Series	Cement kg/cu.m	Fly Ash kg/cu.m	Glass fibre kg/cu.m	River Sand kg/cu.m	Coarse aggregate kg/cu.m	Water kg/cu.m	Admixture kg/cu.m
Series-1 , and 2	412.8	103.2	--	673.5	1223.89	206.4	5.16
Series-3, and 4	412.8	103.2	6.56	673.5	1223.89	206.4	5.16

Table 2Details of prestressedbeam specimens

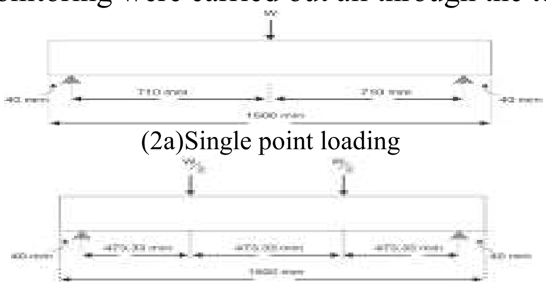
Beam Specimen Series	% Fly Ash	% of GlassFiber	Specimen Type	No. of beam specimens	Point loads adopted for Testing	Specimen Denoted
Series-1	20	0	Plain concrete	3	Single	PL-P-S
Series-2	20	0	Plain concrete	3	Double	PL-P-D
Series-3	20	0.25	Glassfiber concrete	3	Single	GF-P-S
Series-4	20	0.25	Glassfiber concrete	3	Double	GF-P-D

3.4 TEST SETUP AND PROCEDURE

a) Single point load: The beam specimen were simply supported with a concentrated load applied at mid span, as shown in figure-3a.

b) Double point loads: The beam specimen were simply supported with two concentrated load applied at span/3 distance from supports as shown in figure-3b.

Load was applied by using hydraulic jack up to the failure of specimen and the crack pattern were observed. At each load increment, cracks were inspected, marked and the beam specimen were photographed. Continuous monitoring were carried out all through the testing.



(2a)Single point loading

(2b)Double point loading

Figure 2 Test set up

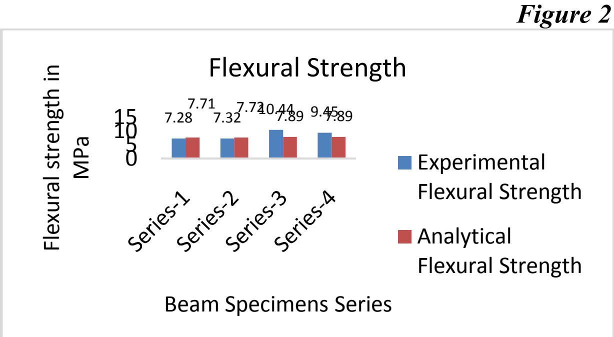


Figure 3Comparison of flexural strength by experimental and analytical results

Table 3 and 4 shown the results comparison of experimental results of plain, glassfibresprestressedconcrete beam specimens with analytically calculated shear force, flexural strength, deflectionsof series-1 to series-4 respectively. The shear force carrying capacities of all beam specimens were including self-weight. The analytical flexural/tensile strength of concrete were calculated as per IS 456-2000.Which were slightly higher than actual experimental results for plain concrete series-1and 2,it may be due to content of fly ash in experimental concrete.Glassfibres increased compressive strength by 5% with respect to plain concrete.

The shear strength of series-3 and 4 were higher than analytical value, it was due to interlocking of high strength glassfibres in concrete. Refer figure 3.

For prestressedplain concrete:

Experimental flexural strength for single and double point loads for prestressed plain concrete beam specimen series-1 and 2 were slightly higher. Calculatedsplit tensile strength of concrete was $0.7\sqrt{f_{ck}} = 4.55MPa$ and experimental split tensile strength of concrete was 4.03MPa.Analytical tensile strength were considered for calculating analytical shear force and flexural strength. The measured experimental vertical deflections were slightly more than analytically calculated deflections of series-1 and series-2.

Deflections were slightly vary in experimental measurements and analytical calculations.

For glass fibre prestressed concrete: Experimental flexural strength for single and double point loads for plain concrete and glassfibresprestressed concrete beam specimen were higher by 23 % to 34%.Calculated tensile strength of concrete was $0.7\sqrt{f_{ck}} = 4.66MPa$ and experimental split tensile strength of concrete was 5.18MPa.Analytical split tensile strength were considered for calculating analytical shear fore and flexural strength. The experimental vertical deflections were slightly more than analytically calculated deflection of series-3 and vice versa for series-4. Refer table -3

Table 3 Test Results

Experimental Result									Analytical Result			
Beam Specimens Series	Beam Specimen	F_{ck} (MPa)	**Load carrying capacity (KN)**	Avg. Load applied (KN)	Flexural strength (MPa)	Split tensile strength of concrete (MPa)	Vertical Deflection (mm)	Avg. Vertical Deflection (mm)	**Load carrying capacity (KN)**	Flexural strength (MPa)	Tensile strength of concrete= $0.7\sqrt{f_{ck}}\ (MPa)$	Max. vertical deflection (mm)
Series-1	PL-P-S-1	42.35	9.16	9.24	7.28	4.03	0.48	0.70	8.99	7.08	4.55	0.65#
	PL-P-S-2	42.35	9.00				0.90					
	PL-P-S-3	42.35	9.57				0.72					
Series-2	PL-P-D-1	42.35	13.87	13.57	7.32	4.03	2.43	2.27	13.13	7.08	4.55	1.97#
	PL-P-D-2	42.35	13.96				1.03					
	PL-P-D-3	42.35	13.89				3.35					
Series-3	GF-P-S-1	44.50	12	12.38	10.44	5.18	1.00	0.95	9.12	7.84	4.66	0.655#
	GF-P-S-2	44.50	12.65				0.85					
	GF-P-S-3	44.50	12.50				1.02					
Series-4	GF-P-D-1	44.50	16	16.76	9.45	5.18	1.2	1.30	12.63	7.64	4.66	2.022#
	GF-P-D-2	44.50	16.80				1.1					
	GF-P-D-3	44.50	17.50				1.62					

#Analytical deflections were calculated by using strain energy method.

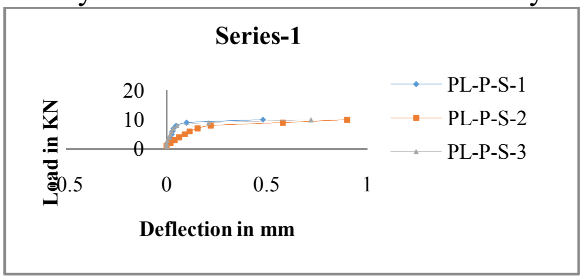


Figure 4 Load Vs deflection for Series-1 beam specimens

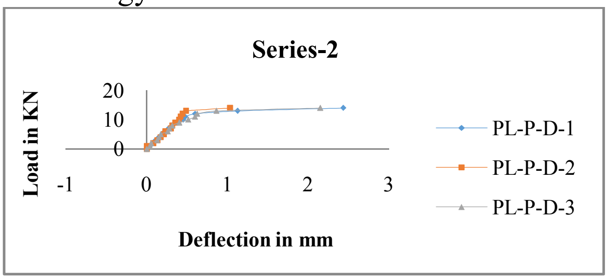


Figure 5 Load Vs deflection for Series-2 beam specimens

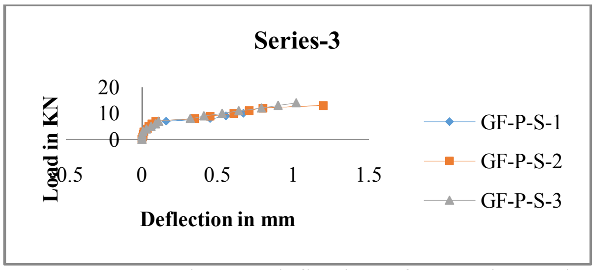


Figure 6 Load Vs deflection for Series-3 beam specimens

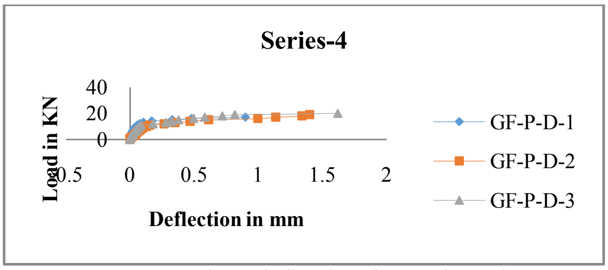


Figure 7 Load Vs deflection for Series-4 beam specimens

Glassfibresprestressed concrete beams having more strength as compared to fly ash plain concrete beam specimens.
There were various factors which may influence the strength of concrete. The strength may affect due to addition of fly ash, the dimension of the beam element as well as the local available materials used in the experimentation.
Concrete was very complex material and it was very difficult to exact formulate in mathematical model.

Figure-4 shows load vs deflection of series-1.Specimen-PL-P-S-1 was having slightly more load carrying capacity than specimen PL-P-S-2.Specimen PL-P-S-3 was having more load carrying capacity than another two specimen and average load carrying capacity of all specimen was 9.24KN.The vertical deflection of specimen PL-P-S-1 was less than another two specimen in series-1 and average verical deflection was 0.70mm,which was slightly more than analytical deflection.Refer table-3.

Figure-5 shows load vs deflection of series-2.All Specimen of series-2 were having aproximatly same load carrying capacity and average load carrying capacity was 13.57 KN,which was slightly less than analytical strength.Specimen PL-P-D-2 was having less deflection than another two specimen and average deflection of all specimen of series-2 was 2.27mm,which was slightly more than analytical deflection.Refer table-3.

Figure-6 shows load vs deflection of series-3.All specimen of series-3 were having aproximatly same load carrying capacity. The average load carrying capacity of all specimen was 12.38 KN. Specimen GF-P-S-1 was having less deflection than another.The average deflection of all specimen was 0.95mm.Refer table-3.

Figure-7 shows load vs deflection of series-4.All specimen of series-4 were having aproximatly same load carrying capacity,although specimen GF-P-D-3,was having slightly more load carrying capacity and specimen GF-P-D-1 was having slightly less load carring capacity.The average load carrying capacity of all specimen was 16.76KN,it was more than analytical load carrying capacity.Specimen GF-P-D-2 was having less deflection than another specimen and GF-P-D-3 was having maximum deflection than another specimen.The average deflection of all specimen was 1.30 mm,it was less than analytical deflection.Refer table-3.

3.5 TEST RESULT AND DISCUSSIONS

Following points after reviewing and analyzing the results:-
1) As observed from the experimental testing results for M40 grade of concrete without steel fibres, the actual characteristic compressive strength was 42.35MPa and split tensile strength was 4.03MPa were used for series 1, and 2.Concrete with glass fibres having characteristic compressive strength

was 44.50 MPa and split tensile strength was 5.18 MPa were used for series 3, and 4.(30) Refer table-1.

2) The use of glass fibers in concrete mix was found to increase the crack resistance of the beams. This was due to the fact that the presence of fibers throughout the cross section of beam and especially at the surface entraps the cracks developed at the surface and
prevents the further propagation of crack through the depth of beam.

3) Shear, Flexural strength of concrete increased for glass fiber reinforced prestresed concrete beam specimen. Load carrying capacity increased approximately by 25 to 30 % than plain prestressed concrete beam.

4) In case of double point loading flexural strength was observed greater than single point loading. Failure in case of single point load was flexure type in initial stages and shear-flexure failure at later stage of loading. While in case of two point load testing program diagonal cracks were developed below loads concluding shear failure.

5) It was observed that development of first crack for fiber reinforced prestrssed concrete beam was at higher loads than plain prestressed concrete beam. It was also noted that deflection was satisfactory. Crack width was not more than 4 mm in case of any of the beam specimens.

CONCLUSIONS

The present investigation was undertaken to explore the potential benefits occurring from the use of glass fiber reinforced prestressedconcrete beams in flexure. Following were some of the broad conclusions drawn from the present study:

Use of glassfibres in concrete beams improves the flexural capacity, shear strength, crack resistance and ductility of beams.With the use of admixtures, glassfibres in concrete beams can be safely made maintaining the required level of ductility.The bridging mechanism of fibers and its tendency to redistribute stress evenly throughout the matrix contribute to post-cracking resistance, restrain crack growth and impart ductility to concrete.The flexural and shear capacity of concrete beams increases with the use of glassfibres, maintaining the optimum content of fibres to be added in the mix.

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