Analysis of Fiber Reinforced Prestressed Beams

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Abstract— In recent years, Fiber Reinforced Concrete material has been developed and studied for application to structural members. A property of this material is PseudoStrain- Hardening behaviour caused by the distribution of multiple fine cracks under tensile stress. Fibres have been used to enhance tensile characteristics of concrete by suppressing crack growth and improving mechanical behaviour. In this study, the fiber reinforced prestressed beams are analysed. The prestressed beams with steel and glass fibre reinforcements are compared with the normal prestressed beams. The main scope of this project is to reduce the deflections and control the crack width of the prestressed beams by analysing the fibre reinforced prestresed beams in Concise Beam software.

Keywords: Steel Fibres, Glass Fibres, Prestressed Beams, Concise Beam

I. Introduction

Fibre-reinforced concrete (FRC) is a composite material made of cements, water, fine and coarse aggregate, and short, uniformly dispersed discontinuous fibres. fibres may be of steel, glass, polymeric materials, carbon, cellulose, and so forth, and their lengths vary from 3 to 64 mm (0.12 to 2.52 in.). The diameters may vary from a few µm to about 1 mm (0.04 in.). The sections may be round, oval, polygonal, triangular, crescent shaped or even square depending on the manufacturing process and the raw material used.

The two broad categories of fibres are micro and macro. Microfibers have diameters or equivalent diameters less than 0.3 mm (0.012 in.) and macrofibers have diameters or equivalent diameters greater than 0.3 mm.

Fibres may be used in concrete at volume fractions varying from 0.1% to 5%. The volume fraction is determined by both the ease of mixing and the application. For example, a low fibre dosage in the range of 0.1% to 0.3% is often provided for control of secondary stresses arising from shrinkage and temperature change. At dosage rates above 0.3%, the mechanical response of FRC is substantially different from that of the plain matrix in that it has post cracking load-carrying ability. The ability of FRC to absorb energy beyond matrix cracking is often termed toughness. At significantly higher dosages, in addition to post crack toughening, FRCs can also exhibit strain hardening, i.e., the composite can support stresses beyond the strength of the matrix. In the hardened state, when fibers are properly bonded, they interact with the matrix at the level of micro-cracks and effectively bridge these cracks thereby providing stress transfer media that delays their coalescence and unstable growth. If the fiber volume fraction is sufficiently high, this may result in an increase in the tensile strength of the matrix. Indeed, for some high volume fraction fibre composite, a notable increase in the tensile or flexural strength over and above the plain matrix has been reported. Once the tensile capacity of the composite is reached, and coalescence and conversion of micro-cracks to macro-cracks has occurred, fibres, depending on their length and bonding characteristics continue to restrain crack opening and crack growth by effectively bridging across macro-cracks. This post peak macro-crack bridging is the primary reinforcement mechanisms in majority of commercial fibre reinforced concrete composites.

Prestressed concrete is basically concrete in which internal stresses of a suitable magnitude and distribution are introduced so that the stresses resulting from external loads are counteracted to a desired degree. In reinforced concrete members, the prestress is commonly introduced by tensioning the steel reinforcement.

Fully prestressed beams are prone to excessive upward deflections, especially in structures where dead loads form a major portion of the total service loads and these deflections may increase with time due to the effect of the creep.

The main point in favour of partial or limited prestressing is that untensioned reinforcement is required in the cross section of a prestressed member for various reasons, such as to resist the differential shrinkage, temperature effects and handling stresses.

The advantages of fibre reinforcement in concrete are as follows,

- Crack, Impact and Fatigue Resistance
- Shrinkage Reduction
- Toughness- by preventing or delaying crack propagation from micro-cracks to macro-cracks
- Increases tensile strength and toughness
- Resistance to freezing and thawing
- Reduces surface permeability, dusting and wear
- Increase resistance to plastic shrinkage during curing
- Improve structural strength.

II. Collection of Materials

Materials for the investigation is collected as follows, Cement:	Texas Gold 53 Grade Ordinary Portland Cement
Fine Aggregates:	Locally available clean river sand
Coarse Aggregates:	Locally available well graded crushed granite
Water:	Locally available portable water obtained from source of college campus pore well is used for mixing and curing of concrete
Fly ash:	Obtained from Indian Flyash Bricks, Coimbatore
Superplasticiser:	Master Glenium Sky 8233 bought from Civil Doctor,

	Coimbatore
Fibres:	Steel fibres bought from Jeetmull Jaichandlal (P)

III. CASTING OF SPECIMENS

A nominal mix of M40 grade concrete was casted. Weigh batching and hand compaction methods were adopted. The cube specimen of the size 150 mm x 150 mm x 150 mm, cylindrical specimens of size 150 mm diameter and 300 mm long and prism specimens of size 500 mm x 100 mm x100 mm were used. Initially the moulds were assembled and thinly coated with mould oil to prevent adhesion of concrete with mould. the concrete was placed in the mould in three layers. After 24 hours the specimens were removed from the moulds and kept submerged in clean water until taken out prior to test.

Serial No.	Mix Designation	Fiber Content (%)		Remarks
		Steel	Glass	
1	RM	0	0	Reference mix, M40 Grade
2	1S	1	0	M40 concrete with 1% steel fibers
3	2S	2	0	M40 concrete with 2% steel fibers
4	3S	3	0	M40 concrete with 3% steel fibers
5	1G	0	1	M40 concrete with 1% glass fibers
6	2G	0	2	M40 concrete with 2% glass fibers
7	3G	0	3	M40 concrete with 3% glass fibers

Table 1: Designation of specimens

Fig. 1: Casted specimen

Fig. 2: Steel Fibers

Fig. 3: Glass Fibres

Trial No.	1	2	3
Temperature during Test (t °C)	30.5	30.5	30.5
Weight of bottle W1(kg)	0.67	0.67	0.67
Weight of bottle + aggregate W2 (kg)	1.148	1.113	1.043
Weight of bottle + Aggregate + water W3(kg)	1.856	1.84	1.789
Weight of bottle + water W4 (kg)	1.547	1.547	1.547
Specific Gravity Gs at t °C	2.83	2.87	2.85
γ at t °C	0.9957	0.9957	0.9957
γ at 27 °C	0.9966	0.9966	0.9966
α	0.9991	0.9991	0.9991
Specific Gravity Gs at 27 °C	2.83	2.86	2.84
Mean Value of Gs		2.84	

Table 2: Specific gravity for Coarse Aggregate

A. Marsh Cone Test

Fig. 4: Marsh Cone

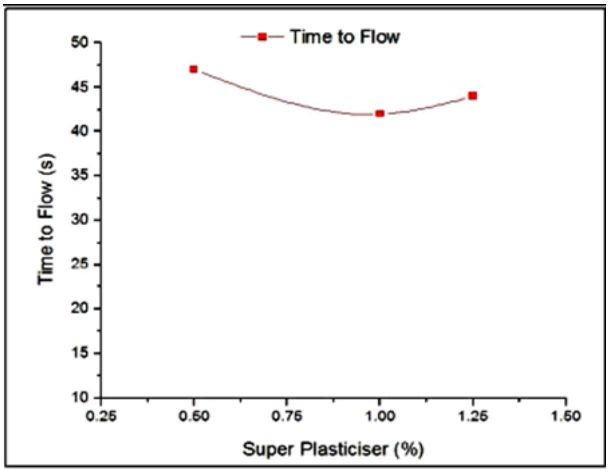

Fig. 5: Time to Flow

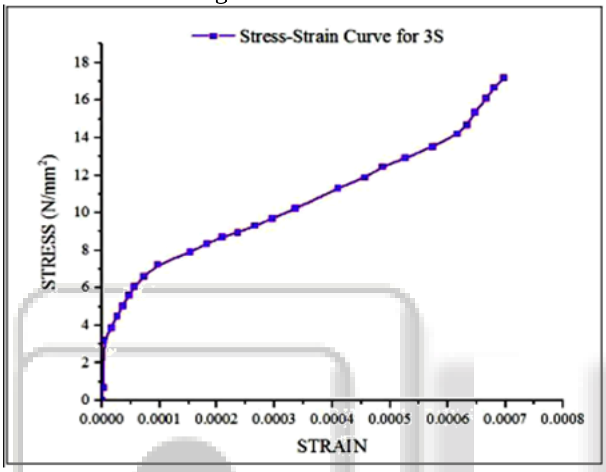

Fig. 6: stress-strain curve

IV. Results and Conclusion

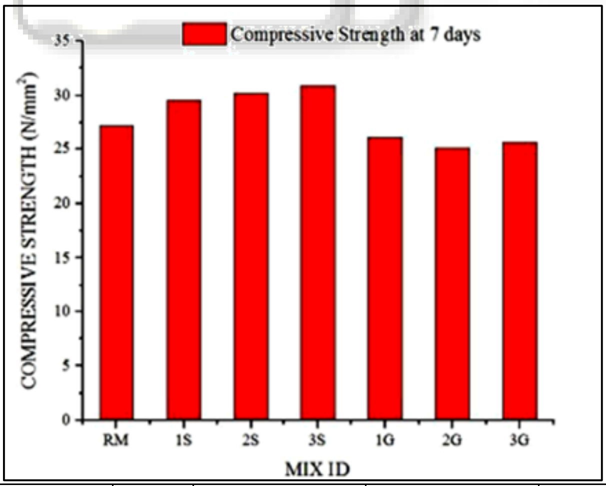

Fig. 7: Compressive strength

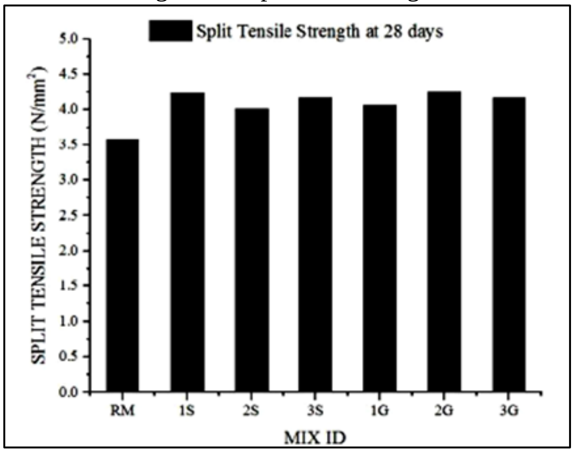

Fig. 8: Split tensile strength of concrete at 28 days

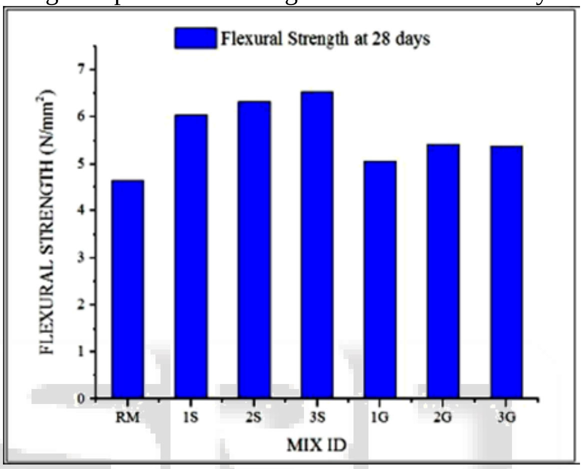

Fig. 9: Flexural strength of concrete at 28 days

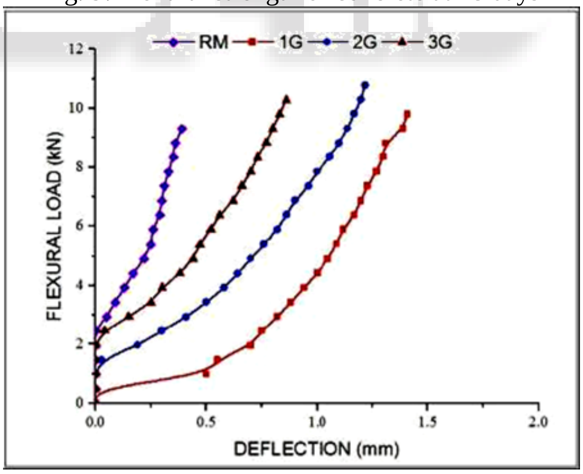

Fig. 10: Load vs defection curve

Serial No.	MIX ID	Deflection on erection (mm)	Deflection on completion (mm)	Final DL+LL Deflection (mm)	% Decreas e in crack width	Crack width (mm)	% Decreasein crack width
1	RM	3.812	-7.94	-24.41	-	0.264	-
2	3S	3.406	-7.197	-18.89	22.73	0.173	34.5
3	2G	3.242	-6.863	-18.3	25	0.171	35

Table 3: Results from Concise Beam Software

V. Conclusions

From the tests conducted with the control and fibre reinforced specimens, it is clear that the addition of fibres in to the concrete improves the properties of concrete such as compressive strength, flexural strength and split tensile strength. Also from the results, it is observed that steel fibre has better performance in concrete when compared to that of glass fibre.

By analysing the prestressed beam model in Concise beam software with steel and glass fibre reinforced concrete, it had less deflection and crack width than the prestressed beam with normal concrete.

Therefore, from the analysis of fibre reinforced prestressed beams, it is clear that durability of the beams will be much durable with less crack width and deflection and corrosion of prestressing strands and steel bars will be prevented even in the slender sections.

References

[1] Khadake S.N., Konapure C.G., (2013), " An Experimental Study of Steel Fiber Reinforced Concrete with Fly Ash for M35 Grade", International Journal of Engineering Research and Applications (IJERA), Vol. 3, Issue 1, pp. 950-953
[2] Eng. Pshtiwan N. Shakor, S.S. Pimplikar, (2011), "Glass Fibre Reinforced Concrete Use in Construction", International Journal of Technology and Engineering System(IJTES), Vol. 2, No. 2
[3] Falah A. Almottiri, (2011), "Physical Properties of Steel Fiber Reinforced Cement Composites Made with Fly Ash", Jordan Journal of Civil Engineering, Vol. 5, No. 2.