Flexural Behavior of Polyvinyl Alcohol Fiber Reinforced Concrete

Dr.M.Devi[1], Mr.L.Kannan[2], Mr.M.Ganeshkumar[3], Mr.T.S.Venkatachalam[3]
[1]*Principal, Department of Civil Engineering*
[2]*Head of the Department, Department of Civil Engineering,*
[3]*Assistant Professor, Department of Civil Engineering*
Paavai College of Engineering, Namakkal, India

Abstract

The usefulness of fiber reinforced concrete (FRC) in various civil engineering applications is indisputable. Fiber reinforced concrete has so far been successfully used in slabs on grade, shotcrete, architectural panels, precast products, offshore structures, structures in seismic regions, thin and thick repairs, crash barriers, footings, hydraulic structures and many other applications. This report presents a brief state-of-the-art report on flexural behavior of polyvinyl alcohol fiber reinforced concrete. Civil infrastructure around the world the problem is at the apparent lack of tensile strength in our concrete. This paper present data to support the argument that polyvinyl alcohol fiber reinforced concrete is an ideal material for achieving these goals. The research also discusses poly vinyl alcohol fiber reinforced concrete materials properties and mix design. The PVA fiber will be added to the conventional concrete 0%, 0.1%, 0.2%, 0.3% and 0.4% by its cement weight. The optimum level of PVA fiber was determined as 0.3 based on the compressive strength, split tensile strength and modulus of rupture. The beam was casted with size of 125X150X1800mm with 0.3% of PVA Fiber. Then the flexural behavior was studied and compared with conventional concrete.

Keywords *– Polyvinyl alcohol fiber, Flexural Behavior*

I. INTRODUCTION

Concrete is a mixture of Cement, Fine aggregate, Coarse aggregate and Water. In plain concrete and similar brittle materials, structural cracks [micro – cracks] developed even before loading, particularly due to drying shrinkage or other causes of volume change. The width of these initial cracks seldom exceeds a few microns, but their other two dimensions may be higher magnitude.

It has been recognized that the addition of small, closely spaced and uniformly dispersed fibers to concrete would act as a crack arrest and would substantially improve its static and dynamic properties. This type of concrete is known as Fiber Reinforced Concrete.

Fiber reinforced concrete can be defined as a "composite material consisting of mixtures of cement, mortar or concrete and discontinuous, discrete, uniformly dispersed fibers".

Continuous meshes, woven fabric and long wires or rods are not considered to be discrete fibers. The following fibers are could be used as in concrete,

- Steel fibers.
- Polypropylene fibers,
- Nylon fibers.
- Asbestos fibers.
- Coir fibers.
- Glass fibers.
- Carbon fibers.

Fiber is a small piece of reinforcing material possessing certain characteristic properties. They can be circular or flat. The fiber is often described by a convenient parameter called "aspect ratio". The aspect ratio of the fiber is the ratio of its length to its diameter. Typical aspect ratio value ranges from 30 to 150.

II. EXPERIMENTAL PROGRAMME

A. Materials

For this research work Ordinary Portland Cement 53 grade was used. Locally available fine and coarse aggregate was used with specific gravity of 2.75 and 2.8. The maximum size of coarse aggregate was 12.5mm. The Poly vinyl Alcohol fiber was obtained from Spinning King (India) Limited, Gujarat, India. With following Properties.

Table I Properties of Poly Vinyl Alcohol Fiber Reinforced Concrete

Test Item	Tested Value
Material	Poly Vinyl Alcohol
Density	1300 kg/m^3
Diameter	18 μm
Length	6 mm
Modulus of Elasticity	36000 N/mm^2
Tensile Strength	1280 N/mm^2

Fig. 1 Poly Vinyl Alcohol Fiber

B. Mix Design

The Mix design was performed as per IS 10262: 2009. The following mix proportion was obtained from the mix design. The water cement ration for mix is 0.45.

Table II Mix Proportion

Cement	Fine Aggregate	Coarse Aggregate	W/C Ratio
1	1.85	2.05	0.45

C. Casting & Curing

The concrete was prepared and the fiber was added based on their percentage then the concrete will be placed on moulds. The following moulds are used to caste the specimens.

1. Cube mould of size 150X150X150mm.
2. Cylinder mould of size 150X300 mm.
3. Prism mould of size 100X100X500 mm.

After casting the specimens left for 24 hours thereafter the mould was removed and specimens were put for water curing till the day of testing.

III. STRENGTH TESTS ON CONCRETE

A. Compressive Strength

Compression test is the most common test conducted on harden concrete, partly because it is an easy test perform, and partly because most of the desirable characteristics properties of concrete are qualitatively related to its compressive strength. To find the compressive strength 150 X 150 X 150mm cube specimens were prepared. The compressive strength of concrete was found by compression testing machine of 2000 kN capacity.

$$\text{Compressive Strength} = \frac{P}{A}$$

Where,

P is the Compressive load.
A is the Area of cube.

B. Split Tensile Strength.

The test is carried out by placing cylindrical specimen horizontally between the loading surface of a universal testing machine and the load is applied until failure of the cylinder along the vertical diameter. To find split tensile strength of concrete cylinder specimen of 150 X 300mm prepared. The split tensile strength of concrete was found by Universal Testing Machine of 400 kN capacity.

$$\text{Split Tension} = \frac{2P}{\pi LD}$$

Where,

P is the compressive load on the cylinder.
L is the length of the cylinder.
D is the diameter of the cylinder

C. Modulus of Rupture

Concrete as we know is relatively strong in compression and weak in tension. To find Modulus of rupture of concrete 100X100X500 mm size prism specimens were prepared. The Modulus of rupture was found by Universal Testing Machine of 400 kN capacity.

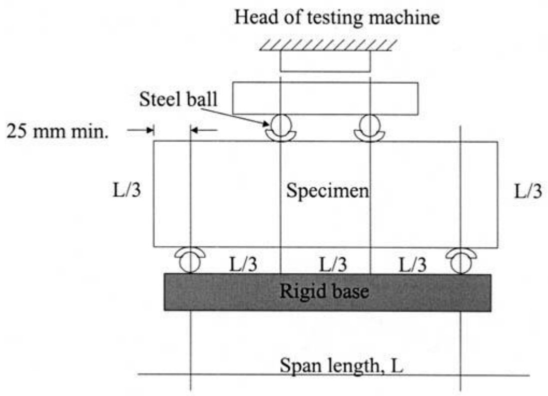

Fig. 2 Third Point Loading

The Modulus of rupture of the specimen is expressed as the moulds of rupture f_b which if ‘a’ equals the distance between the line of fracture and the nearer support, measured on the center line of tensile side of the specimen in cm, is calculated to the nearest 0.05MPa as follows

$$f_b = \frac{Pl}{bd^2}$$

When ‘a’ is greater than 13.3 cm, or

$$f_b = \frac{3Pa}{bd^2}$$

When ‘a’ is less than 13.3 cm but greater than 11.0 cm. If ‘a’ is less than 11.0 cm for 10cm specimen, the result of the test be discarded.

D. *Flexural Behavior of Beams*

Beam was placed over the loading frame with capacity of 500kN and two point load was applied on the beam. LVDT were used to measure the deflection of the beam, one placed on the mid span of the beam and other two are placed under loading point of the beam. Deflection were measured at every interval of 5 kN and it is continued until the failure of the beam occurs. First cracking load, yield load, ultimate load and their corresponding deflection was recorded.

IV. RESULTS AND DISCUSSIONS

A. *Compressive Strength Result*

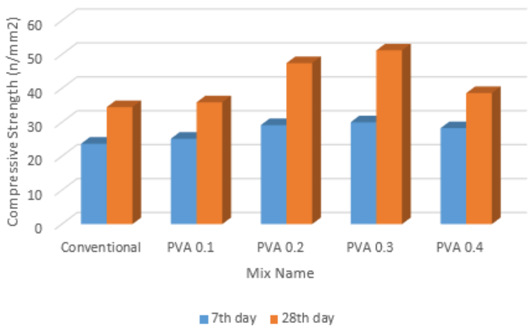

Fig.3 Compressive Strength Result

B. *Split Tensile Strength Result*

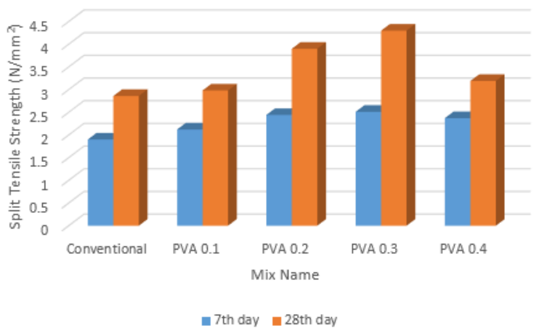

Fig.4 Split Tensile Strength Result

C. *Modulus of Rupture Result*

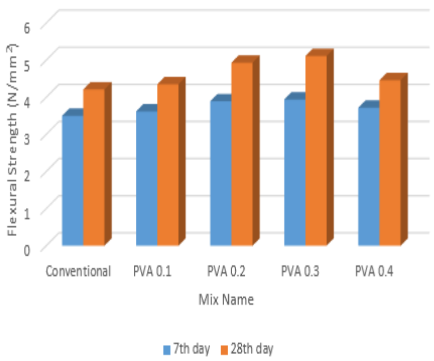

Fig.5Modulus Of Rupture Result

D. *Load Deflection Curve*

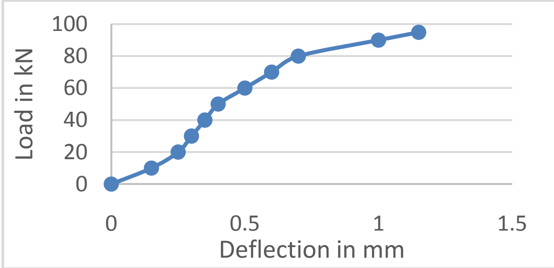

Fig. 6 Load Deflection Curve for Conventional Beam

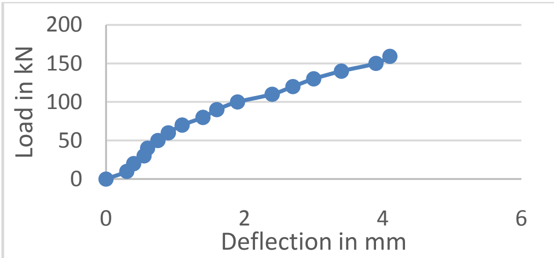

Fig. 7 Load Deflection Curve For 0.3% Of PVA Fiber

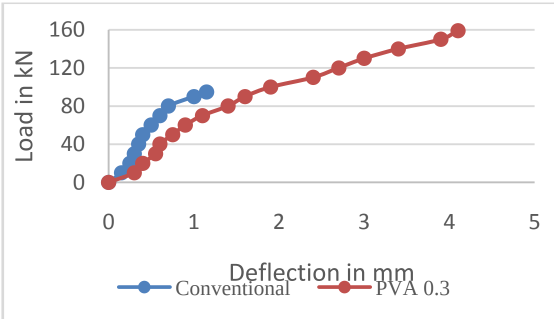

Fig. 8 Load Deflection Curve (Conventional And PVA Fiber)

Figure.6 shows the load deflection curve of reinforced conventional concrete, Figure. 7 shows that load deflection curve of PVA fiber reinforced concrete and Figure.8 shows that combined load deflection curve for conventional concrete and PVA fiber reinforced concrete. When 0.3% of poly vinyl alcohol fibers were added, the ultimate load increased when compared to 0% of steel fiber. The ultimate load of beams with 0.3% of poly vinyl alcohol fiber increased by 68% when compared with that of beam with 0% of steel fiber. Initially flexural cracks were observed when the load in flexure increased; further, the propagation of diagonal cracks and shear failure were also observed.

Ductility of structure can be defined as its ability to absorb energy without critical failure. Ductility generally refers to the amount of inelastic deformation which a material or structure experience before complete failure. This deformation can be measured in terms of displacement, strain or curvature. Ductile behavior allows a structure to undergo large plastic deformations with little decrease in strength and hence prevents brittle failure. Conventional steel reinforced beams have a distinct elastic and inelastic phase of deformation before and after yielding of steel. Hence for these structures, ductility can be defined quantitatively as the ratio of the total deformation at failure divided by the deformation at the elastic limit.

Ductility index (μ) is conventionally defined as the ratio between $\delta_u$and $\delta_y$where δ_u is the mid span deflection at the beam ultimate load and δ_y is the mid span deflection at the yield load of the tensile steel reinforcement at the central support. Table 3 shows the ductility index (μ) values. Ductility index increased 25% when poly vinyl alcohol fiber increased from 0% to 0.3%.

Table III Ductility Index

Sl.No.	Beam ID	Ductility Index.
1	Conv.	1.16
2	PVA 0.3	1.45

V. CONCLUSION

From the results of this experimental investigation, the following conclusions are drawn on concrete without and with poly vinyl alcohol fiber.

1. With the addition of poly vinyl alcohol fibers leads to increase in compressive strength, split tensile strength and modulus of rupture with age and with the increase of poly vinyl alcohol fiber content up to 0.3% compared to control concrete at 28 day.
2. Compared to conventional concrete poly vinyl alcohol fiber reinforced concrete specimens attains 48.5% higher compressive strength, 50.4% higher split tensile strength, 21.4% higher modulus of rupture.
3. Based on the compressive strength, split tensile strength and modulus of rupture, the optimum level of poly vinyl alcohol fiber content was 0.3%.
4. The ultimate loads of poly vinyl alcohol fiber reinforced concrete were increased by 68% of conventional concrete beam.
5. The ductility index of poly vinyl alcohol fiber reinforced concrete increased by 25% of conventional concrete.
6. Based on the above research we came to know if 0.3% of poly vinyl alcohol fiber were added to the concrete then the concrete properties will be better than the conventional concrete.

REFERENCE

[1] SagarGadhiya, T N Patel and Dinesh Shah, Bendable Concrete : A Review, International Journal of Structural and Civil Engineering Research,Vol. 4, No.1, February 2015.

[2] M.M.Kamal, M.A.Safan, Z.A.Etman and R.A.Salama, Behaviour and strength of beams cast with ultra high strength concrete containing different types of fibers, HBRC Journal, 2014.

[3] SagarGadhiya, Prof.T.N.Patel and Dr.Dinesh Shah, Parametric Study on Flexural Strength of ECC, International Journal for Scientific Research and Development, Vol. 3, No.4, 2015.

[4] A.Sofi, B.R.Phanikumar, An experimental investigation on flexural behavior of fiber reinforced pond ash modified concrete, Ain Shams Engineering Journal.

[5] Dhillon, Ramandeep, Sharma, Shruti and Kaur, Gurbir, Effect of Steel and Polypropylene Fibers on Strength Characteristics of Fly ash Concrete, International Journal of Research in Advent Techbology,Vol.2, No.3, March 2014.

[6] Khadake S.N, Konapure C.G, An Experimental Study of Steel Fiber Reinforced Concrete with Fly ash for M35 Grade, International Journal of Engineering Research and Application, Vol.3, Issue1, 2013.

[7] Amar R Dongapure, Brijbhushan S, D K Kulkarni, A Study on Strength Properties of Hybrid Fiber Reinforced Concrete, International Research Journal of Engineering and Technology, Vol. 2, Issue 6, 2015.