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EVALUATION OF EFFECTIVENESS OF PFRC DEEP BEAM IN SHEAR

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ABSTRACT

Polypropylene Fiber Reinforced Concrete plays an important role in bridging the cracks developed in concrete and thus, increases the overall strength of concrete. To improve the post cracking behavior, short discontinuous PP fibers are used. Behavior of normal reinforced concrete deep beams and pp fiber reinforced concrete deep beams subjected to predominant shear with or without stirrups and web reinforcement is presented to evaluate the effectiveness of PFRC Deep Beam. Plain, 0.5% PFRC & 1% PFRC cubes, cylinders & deep beams were cast of grade M40 & M60. The experimental results shows that the inclusion of pp fibers in reinforced deep beams results in enhancing their deformation characteristics at all stages of loading up to failure as well as improving their shear resistance.

Keywords: Deep Beams, Polypropylene Fibers, Polypropylene Fiber Reinforced Concrete, shear Failure.

I. INTRODUCTION

Concrete is a homogeneous mixture of cement, fine aggregate coarse aggregate and water is prone to cracks. These cracks make concrete into permeable elements which are having high risk of corrosion and further it leads to failures which are hazardous as it causes loss of life and property. By adding fibers these cracks can be controlled. Poly-propylene fibers, when added to concrete bridges, then there is no further development of cracks. Deep beams are structural element whose effective span to depth ratio is less than 2 for simply supported beams and less than 2.5 for continuous beam. In deep beams loaded as simple beams the significant amount of load is carried to the supports by a compression force combining the load and reaction. Normally the shear action which is very significant in deep beams leads to compression failure along compressive arch connecting point of loading and supports, especially for the beam failed in shear compression mode.

II. MATERIAL & METHODOLOGY

2.1 Polypropylene Fibers

The use of these fibers has increased tremendously in construction of structures because addition of fibers in concrete improves the toughness, flexural strength, tensile strength and impact strength as well as failure mode of concrete. Polypropylene fibers are new generation chemical fibers. They are manufactured in large scale and have fourth largest volume in production after polyester, polyamides and acrylics. About 4 million tonnes of polypropylene fibers are produced in the world in a year.

2.2 Properties of Polypropylene Fibers

Because of its low specific gravity, polypropylene yields the greatest volume of fiber for a given weight. This high yield means that polypropylene fiber provides good bulk and cover, while being lighter in weight. Polypropylene is the lightest of all fibers and is lighter than water. It is 34% lighter than polyester and 20% lighter than nylon. It provides more bulk and warmth for less weight.

1. **Environmental Effect**

   Recyclable, ecologically friendly. Incinerates to trace ash with no hazardous volatiles.

2. **Thermal Conductivity:**

   Lowest thermal conductivity of any natural or synthetic fiber. Polypropylene fibers retain more heat for a longer period of time, have excellent insulating properties in apparel, and combined with its hydrophobic nature keeps wearer dry and warm. Warmer than wool.

3. **Resistant to Bacteria and Micro-organisms:**

   Like other synthetic fibers – nylon, acrylic and polyester – polypropylene fibers are not attacked by bacteria or micro-organisms; they are also moth-proof and rot-proof and are inherently resistant to the growth of mildew and mold.

4. **Effect of Extreme Cold:**

   Remains flexible at temperatures in the region of -55°C.

5. **Flammability:**

   Polypropylene fiber burns and presents much the same risks as most other man-made textile fibers. It is difficult to ignite, and is defined as combustible but not highly inflammable. It can, however, be rendered flame-retardant by the incorporation of additives.

6. **Water Absorption:**

   The water absorption of polypropylene fiber is about 0.3% after 24 hours immersion in water, and thus its regain – the amount of water absorbed in a humid atmosphere – is virtually nil (0.05% at 65% RH, 21 °C.)

7. **Effect of Acids:**

   Excellent resistance to most acids except chlorosulphonic and concentrated sulfuric acid.

8. **Effect of Alkalis:**

   Excellent resistance with the exception of some oxidizing agents.

9. **Abrasion Resistance:**

   The abrasion resistance of fibers, unlike some other properties such as tenacity or modulus, is not a fundamental property and hence comparisons between the abrasion resistances of fibers are only useful if they truly represent performance in the application in question and are carried out on fabrics of identical construction..

2.3 Properties of Polypropylene fiber reinforced concrete

Before mixing the concrete, the fiber length, amount and design mix variables are adjusted to prevent the fibers from balling. Good FRC mixes usually contain a high mortar volume as compared to conventional concrete mixes. The aspect ratio for the fibers are usually restricted between 100 and 200 since fibers which are too long tend to "ball" in the mix and create workability problems. As a rule, fibers are generally randomly distributed in the concrete; however, placing of concrete should be in such a manner that the fibers become aligned in the direction of applied stress which will result in even greater tensile and flexural strengths. There should be sufficient compaction so that the fresh concrete flows satisfactorily and the PP fibers are uniformly dispersed in the mixture. The fibers should not float to the surface nor sink to the bottom in the fresh concrete.

Polypropylene fibers reinforced concrete is an embryonic construction material which can be described as a concrete having high mechanical strength, stiffness and durability. By utilization of polypropylene fibers in concrete not only optimum utilization of materials is achieved but also the cost reduction is achieved.

Concrete has better resistance in compression while steel has more resistance in tension. Conventional concrete has limited ductility, low impact and abrasion resistance and little resistance to cracking. A good concrete must possess high strength and low permeability. Hence, alternative composite materials are gaining popularity because of ductility and strength hardening. To improve the post cracking behavior, short discontinuous and discrete fibers are added to the plain concrete. Addition of polypropylene fiber to concrete improves the post peak ductility performance, pre-crack tensile strength, fracture strength, toughness, impact resistance, flexure strength resistance, fatigue performance, etc. The ductility of fiber reinforced concrete depends on the ability of the fibers to bridge cracks at high levels of strain. Addition of polypropylene fibers decreases the unit weight of concrete and increases its strength

2.4 Properties improved by polypropylene fiber in concrete

1. Improves concrete resistance to plastic shrinkage cracking.
2. Improves durability and reduces permeability.
3. Decreases risk of plastic settlement.
4. Increases cohesion of the mix, hence reduces settlement and gives easier finishing.
5. No requirement for crack control steel mesh, hence no need to purchase additional material.
6. Concrete placement and crack control is done simultaneously in one operation, hence reduce site labour requirement.
7. Reduces bleeding, hence easier finish of concrete.
8. Harder, more durable surface with better abrasion resistance.
9. More weather resistant, hence more durable.
10. Reduce absorption of water, chemical and dirt.
11. Tougher surface with fewer bleed holes.

III. RESULTS & DISCUSSION

3.1 Test Material

Ordinary Portland cement of 53 grade was used having fineness modulus of 7.3 and crushed aggregate of maximum size 20mm were used. The grade of concrete is M40 with mix proportion of 1:2.38:3.89 by weight with water cement ratio of 0.40 was kept constant for every specimen. The monofilament polypropylene fibers of 24mm length and 32 µm diameter were used

Testing procedure

1. Three deep beams of each proportion were tested. All these beams were of rectangular cross section, of size 700mm x 350mm x 100mm.
2. Three cubes of each proportion were tested. All these cubes were of size 150mm x 150mm x 150mm.
3. Three cylinders of each proportion were tested. All these cylinders were of size 300mm height and 150mm diameter.
4. Both the surfaces of beams were white washed to clearly observe the crack development during testing. The beams were tested to failure under point top loading and simply supported in compressive testing machine of capacity 1000 tones. The first crack load and the ultimate load were determined.

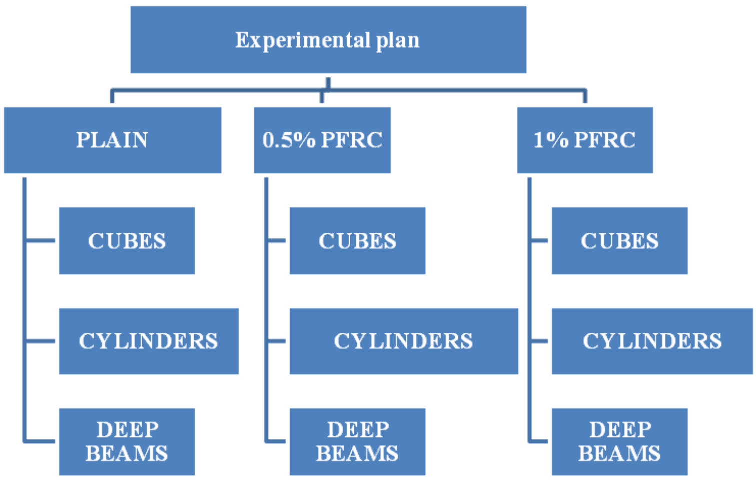
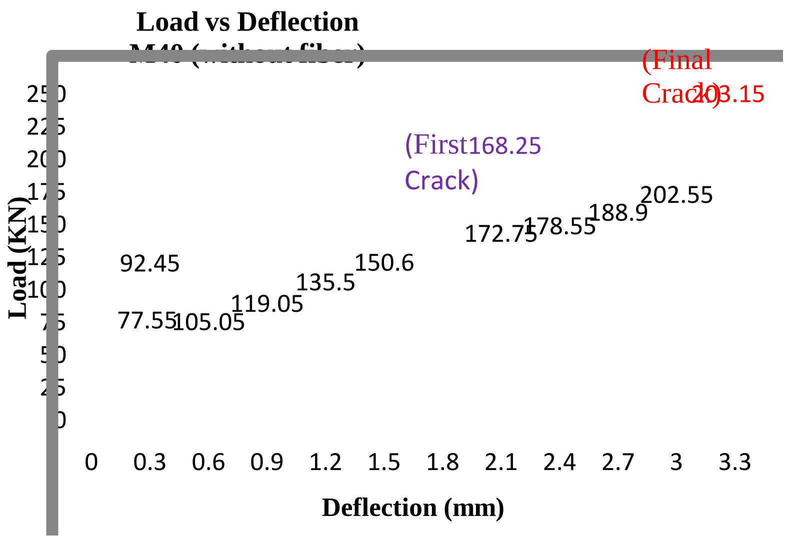


Fig.1. Flow Chart of Experimental Work

3.2 Result and Discussion

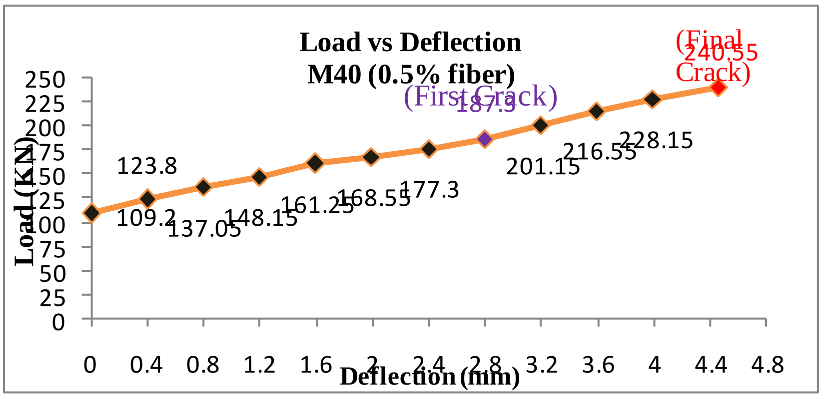
3.2.1 Plain Deep Beam of M40 Grade



Graph 1: Load v/s Deflection of M40 Grade Plain Beam

Discussion:. It was observed that the first crack occurs at load 168.25 kN, deflection 1.9 mm and the ultimate load was 203.15 kN with deflection 3.09mm.

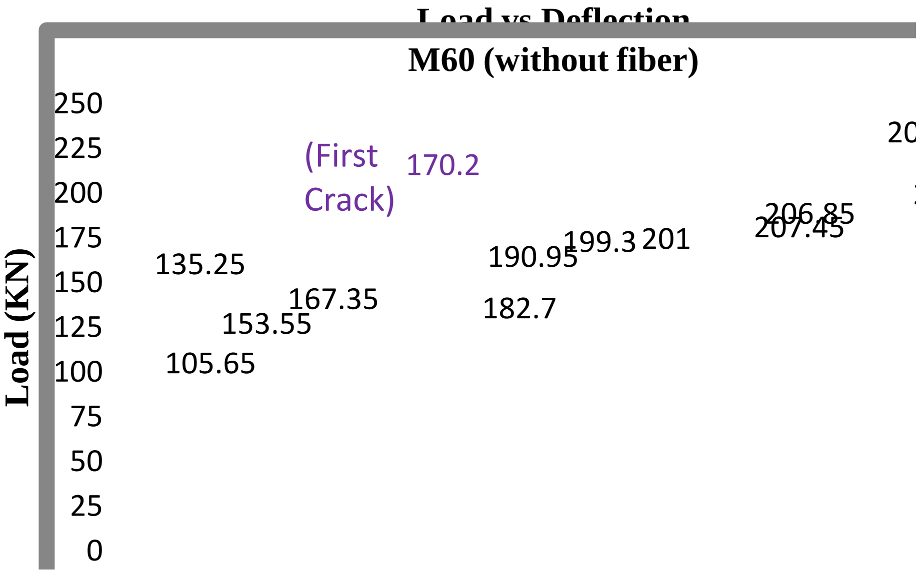
3.2.2 Deep Beam of M 40 Grade with addition of 0.5% Polypropylene fiber



Graph 2 :M40 Grade Beam with 0.5% fiber

Discussion: It was observed that the first crack occurs at load 187.3 kN, deflection 2.8mm and the ultimate load is 240.55 kN with deflection 4.46mm.

3.2.3 Plain Deep Beam of M60 Grade



Graph 3: M60 Grade Plain Beam

Discussion: It was observed that the first crack occurs at load 170.2 kN, deflection 0.7mm and the ultimate load is 209.6 kN with deflection 2.59mm.

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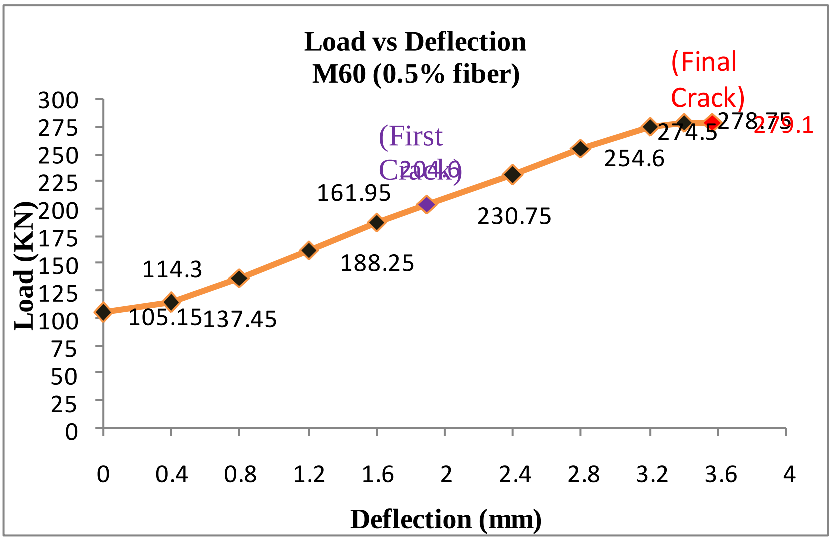
3.2.4 Deep Beam of M 60 Grade with addition of 0.5% Polypropylene fiber



Graph4: M60 Grade Beam with 0.5% fiber

Discussion: It was observed that the first crack occurs at load 204.6 kN, deflection 1.9mm and the ultimate load is 279.1 kN with deflection 3.57mm.

IV. CONCLUSION

1. Maximum increase of 18.41% in first cracking load for beam containing 0.5 % of fiber was observed when compared with beam containing no web reinforcement for M40 grade.
2. Maximum increase of 33.15% in first cracking load for beam containing 0.5 % of fiber was observed when compared with beam containing no web reinforcement for M60 grade.
3. After comparing plain deep beam and 0.5% addition of polypropylene fiber deep beam there was increase in the strength and load carrying capacity.
4. The first crack load is greater for deep beams with 0.5% polypropylene fiber rather than plain deep beams.
5. The inclusion of polypropylene fiber in concrete mix provides effective shear reinforcement in deep beams and provides better crack control in beams.
6. Both the first crack strength and ultimate strength in shear increase for 0.5% polypropylene fiber reinforced beam because of their increase resistance to propagation of cracks.

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