Relationship between Compressive Strength and Flexural Strength of Polyester Fiber Reinforced Concrete

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Abstract *- Fibers are in increasing demand as they improves the tensile resistance and ductility performance of plain concrete thus reducing cracking leading to improved flexural and durability of reinforced concrete structures. In this present investigation a study has been carried out to determine the compressive strength and flexural strength of Polyester Fiber Reinforced Concrete (PEFRC) at different grades M20, M25, M30 and M35. Polyester fibers are used in this experimental investigation in different fractions ranging from 0.2% to 0.8% by addition to weight of cement. In this paper the Compressive Strength and Flexural Strength of PEFRC are studied. From the results it is found that there is a significant improvement in the mechanical and flexural properties by the use of fiber.Relationship between compressive strength and flexural strength of polyester fiber reinforced concrete are used to extrapolate the flexural strength with greater reliability.*

Keywords: *Polyester Fiber Reinforced Concrete, Compressive strength, Flexural strength, Regression Equation*

I. INTRODUCTION

The strength characteristic and economic advantages of fiber reinforced concrete far more appreciable compared to plain concrete. The new concept and technology reveal that the engineering advantages of placing fiber in concrete may improve the flexural strength, compressive strength, fracture toughness, fatigue resistance, impact resistance, thermal crack resistance, rebound loss and shear strength etc. This characteristic of fiber reinforced concrete has led to its large scale acceptance by the construction industry. The magnitude of the improvement depends upon both the amount and the type of fibers used [1]. Polyester fibers are available in monofilament form and belong to the thermoplastic polyester group. Polyester fibers have been used at low contents to control plastic-shrinkage cracking in concrete [2]. In hardened state, polyester fibers reduce micro cracks, and crack propagations [3].An increase of about 15% in compressive strength and a significant improvement in flexural toughness is observed in case of concrete containing Polyester fiber [4].

The primary objectives of this investigation are to determine the benefits of using Polyester fiber in fiber reinforced concrete (PEFRC). A multiple regression analysis also performed to get empirical expression and to establish relation between different strength, based on test results.

II. EXPERIMENTAL INVESTIGATION

A. Materials used

The Ordinary Portland Cement of 53 grade confirming to IS: 12269-1987(9) is used. The specific gravity of cement is 3.15, and the fineness of cement determined is 2950cm^2/g. A chemical admixture in the form of sulphonated Naphthalene polymers (CONPLAST-SP 430) with specific gravity 1.220 – 1.225 complies with IS: 9103-1999 and ASTM 494 type F is used to enhance the workability of concrete. Locally available river sand is used as fine aggregate. The specific gravity and fineness modulus of fine aggregate is found to be 2.57 and 2.28. Crushed aggregates of size 20mm is used as coarse aggregates with specific gravity 2.74 and fineness modulus as 7.20.

B. Mix Proportions and Mix Details

The concrete mix proportions (per cubic meter of concrete) adopted in this investigation is given in Table 1. Mix design is carried out (as per IS10262-2009). Water binder ratio considered for this mixes are 0.5, 0.43, 0.38, and 0.35.Fibers are added in concrete during mixing in weight fractions of 0.2, 0.4, 0.6, 0.8 and details are given in Table 2. Specimens without fibers are cast for reference concrete.

Table 1. Mix proportion for control concrete

Materials required per m^3 of concrete				
Concrete Grade	Cement (Kg)	FA (Kg)	CA (kg)	Water (litre)
M20	383	578	1281.6	191.58
M25	445.53	537.64	1268.10	191.58
M30	487.83	431.65	1367.38	185.4
M35	515	463.5	1501.33	185.15

Table 2. Percentage of Polyester Fiber required for PFRC concrete

Polyester Fiber (%)	Fibers required per m^3 of concrete (kg)			
	M20	M25	M30	M35
0.2	0.77	0.89	0.97	1.03
0.4	1.53	1.78	1.95	2.06
0.6	2.3	2.67	2.92	3.09
0.8	3.06	3.56	3.89	4.12

Fibers are known to significantly affect the workability of concrete. The inclusion of the fibers into the concrete mix, influences its workability, with increasing in the fiber volume and aspect ratio leading to decreased workability [5][6]. However, incorporation of a superplasticizer is essential to achieve medium to high level of workability (120-150mm slump),. Through intercept micro-cracks, many of the mechanical properties of the composite are improved. The level of improvement achieved, compared to plain concrete, depends on the dosage rate and type of fiber [7].

From each mix, three cube specimens are cast with four different grades of concrete with varying percentage of polyester fibers. The mixing procedure and time are kept constant for all the concrete mixes investigated [8]. Cube specimens of size 150 x 150 x 150 mm^3 are used for to determine the 28 days compressive strength. Cube and Beam specimens of size 150 x 150 x 150 mm^3 and 150 x 150x 750 mm^3 are used for the compressive and flexural strength calculation of PEFRC. All the specimens are cured by immersion in water for a normal period of 28 days before testing. The average strength of three specimens is taken for each strength value. A correlation between Compressive strength and Flexural strength of PEFRC in the form simple Regression equation has been proposed to study the behaviour of fiber reinforced concrete. The experimental study in this research paper mainly focused on the compressive strength and flexural strength of the PEFRC and to develop the relationship between Compressive strength and flexural strength of polyester fiber reinforced concrete.

III. RESULTS AND DISCUSSIONS

A. Compressive Strength of Polyester Fiber Reinforced Concrete

The compressive strength of concrete mixes with varying percentage of Polyester fiber is measured at the age of 28 days. The result for different grades of concrete is shown in figure 1. From the figure it is seen that there is an increases in strength with increase in Fiber. This trend is more obvious between 0.4% to 0.6% percentages of addition of polyester fibers into concrete. However maximum compressive strength is at 0.4% of PFRC. This may be due to large pozzalanic reaction and improved interfacial bond between paste and aggregate. For all grades of concrete with incorporation of 0.4% of fiber the compressive strength is found as 32.79 MPa, 38.01 MPa, 43.54 MPa and 46.54 MPa. Fiber addition improves the compressive strength it is keenly observed that when fiber is added to the concrete the compressive strength increased marginally and this may be due to the interfacial bond between paste and aggregate.

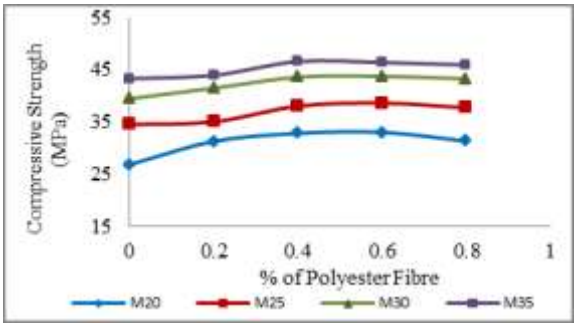


Fig 1: Compressive Strength Vs Percentage of Polyester Fiber Reinforced Concrete

B. Flexural Strength of Polyester Fiber Reinforced Concrete

The result for flexural strength of M20, M25, M30 and M35 grades of PFRC is plotted against various percentages of fiber volumes in Fig 2. From figure it can be seen that when OPC is mixed with polyester fiber a significant increase in flexural strength is obtained. The predominant increase in flexural strength is found at 0.4% of Polyester fiber. The percentage of increase in flexural strength is found to be 3% to 6% compared to control concrete.

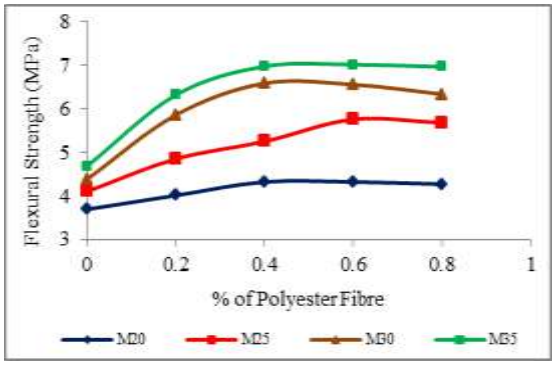


Fig 2: Flexural Strength Vs Percentage of Polyester Fiber Reinforced Concrete

C. Relationship between Compressive Strength and Flexural Strength of Polyester Fiber Reinforced Concrete

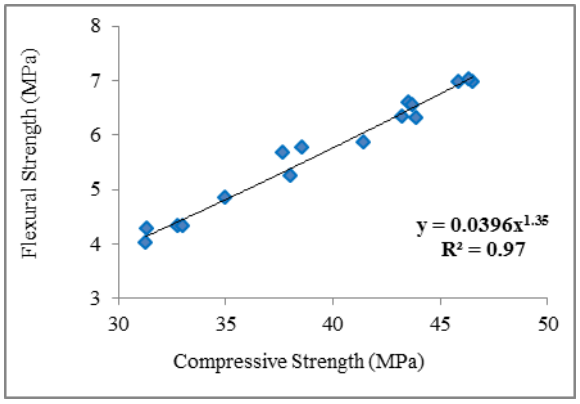
The relationship between compressive strength and flexural strength of Polyester fibre reinforced concrete are shown in Fig 3. The relationship equation is $f_t = 0.039(f_{ck})^{1.35}$ with the value of correlation coefficient (R^2) of 0.97.

Where

f_t - represents the flexural strength in MPa

f_{ck} the compressive strength in MPa.

The intercept constant of the relationship is found to be varied and it is also found that the 0.5 power law is not fit for fibre reinforced concrete and varies with respect to the type of concrete.



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