STUDY ON GLASS FIBER REINFORCED FLY ASH CONCRETE

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ABSTRACT

Cement is the most costly and energy-intensive component of concrete. The unit cost of concrete can be reduced by partial replacement of cement with fly ash. The disposal of fly ash is one of the major issues for environmentalists, as dumping of fly ash as waste material causes severe environmental problems. The utilization of fly ash instead of dumping it as a waste material can be partly used on economic grounds as pozzolana for partial replacement of cement and partly because of its beneficial effects of lower water demand for similar workability, reduced bleeding and lower evolution of heat. The effect of mineral admixture on the strength of concrete varies significantly with its properties and replacement levels. The purpose of this study is to compare the properties of fiber reinforced fly ash concrete with plain concrete

In this experimental investigation the strength properties of concrete for M_{20} grade concrete at various replacement levels of fly ash and glass fibers. Properties studied Include compressive strength, flexural tensile strength and splitting tensile strength of hardened concrete. Fly ash content used was 0%, 15%, 20% and 25% in mass basis, and fiber volume fraction was 0%, 0.5%, 1.0% and 1.5% in volume basis.

Keywords: Glass fiber, flyash, compressive strength, split tensile, flexural strength

1. Introduction

The usage of industrial waste materials in concrete, both in regard to environmental pollution and the positive effect on a country's economy are beyond dispute. Utilization of fly ash in concrete technology is more common. Fly ash causes environmental pollution and the cost of storage of fly ash is very high. When some types of fly ash replaces with cement in concrete mixture, fresh concrete workability is increased, early strength and shrinkage of hardened concrete are decreased, and permeability is decreased due to filling the micro pores of concrete. All these variations on concrete properties, caused by fly ash, depend on the mineralogical composition and fines of fly ash. In addition, fly ash positively affected durability of concrete and mortar like freeze-thaw resistance, sulphate resistance, alkali–silica reaction, and abrasion resistance.

One of the ways to compensate for the early-age strength loss associated with the usage of fly ash is by incorporating fibres, which have been proved very efficient in enhancing the strength characteristics of concrete. The addition of fibres to concrete considerably improves its structural characteristics such as static flexural strength, impact strength, tensile strength, Ductility and flexural toughness. Fibres used in concrete are produced from a wide variety of materials, those being composed of glass, ceramic, steel, organic and some polymer materials. Experimental studies showed that fibres improve the mechanical properties of concrete such as flexural strength, compressive strength, tensile strength, creep behavior, impact resistance and toughness.

2. Literature Review

Okan Karahan, Cengiz Duran Atis [1] (2010) studied the durability properties of polypropylene fibre reinforced fly ash concrete. The Properties studied include unit weight and workability of fresh concrete, and compressive strength, modulus of elasticity, porosity, water absorption, sorptivity coefficient, drying shrinkage and freeze–thaw resistance of hardened concrete. Fly ash content used in concrete mixture was 0%, 15% and 30% in mass basis, and fibre volume fraction was 0%, 0.05%, 0.10% and 0.20% in volume basis. Based on the experimental results they concluded that the inclusion of fly ash improves; however, polypropylene fibre decreases the workability of concrete. Moreover, polypropylene fibre addition, either into Portland cement concrete or fly ash concrete, did not improve the compressive strength and elastic modulus. The positive interactions between polypropylene fibres and fly ash lead to the lowest drying shrinkage of fibrous concrete with fly ash. Freeze–thaw resistance of polypropylene fibre concrete was found to slightly increase when compared to concrete without fibres. Moreover, fly ash increased the freeze–thaw resistance more than the polypropylene fibres did.

Eren and Celik [8] (2008) investigated the effect of silica fume and steel fibres on some properties of high-strength concrete. The results show that increase in the amount of silica fume and fibres decrease workability. They reported that while silica fume has an effect on compressive strength, volume percentage of steel fibres has little effect. They used two types of steel fibres with aspect ratios (fibre length/fibre diameter) of 65 and 80 were used in the experiments and volume fractions of steel fibre were 0.5% and 1%. Additions of silica fume into the concrete were 0%, 5%, 10% and 15% by weight of cement content. Water/cement ratio was 0.38 and the reference slump was 120 ± 20 mm. Slump test for workability, air content and unit weight tests were performed on fresh concretes. Compressive strength, splitting tensile strength and flexural strength tests were made on hardened concrete specimens and finally they concluded that the use of silica fume increased both the mechanical strength and the modulus of elasticity of concrete. On the other hand, the addition of steel fibre into concrete improves toughness of high strength concrete significantly. As the steel fibre volume fraction increases, the toughness increases, and high values of aspect ratios give higher toughness. The toughness of high strength steel fibre concrete depends on silica fume content, the fibre volume fraction and the fibre aspect ratio.

Cengiz Duran Atis, Okan Karahan [2] (2007) studied the effects of properties of concrete containing fly ash and steel fibres. The properties studied include unit weight and workability of fresh concrete, and compressive strength, flexural tensile strength, splitting tensile strength, elasticity modulus, sorptivity coefficient, drying shrinkage and freeze–thaw resistance of hardened concrete. Fly ash content used was 0%, 15% and 30% in mass basis, and fibre volume fraction was 0%, 0.25%, 0.5%, 1.0% and 1.5% in volume basis. The laboratory results showed that steel fibre addition, either into Portland cement concrete or fly ash concrete; improve the tensile strength properties, drying shrinkage and freeze–thaw resistance. However, it reduced workability and increase sorptivity coefficient. Although fly ash replacement reduces strength properties, it improves workability, reduces drying shrinkage and increases freeze–thaw resistance of steel fibre reinforced concrete.

Fuat Koksal et al. [5] (2007) studied the Combined effect of silica fume and steel fibre on the mechanical properties of high strength concrete. In this experimental study, the changes on some mechanical properties of concrete specimens produced by using silica fume and steel fibre were investigated. Two types of steel fibres with aspect ratios (fibre length/fibre diameter) of 65 and 80 were used in the experiments and volume fractions of steel fibre were 0.5% and 1%. Additions of silica fume into the concrete were 0%, 5%, 10% and 15% by weight of cement content. Water/cement ratio was 0.38 and the reference slump was 120±20 mm. Slump test for workability, air content and unit weight tests were performed on fresh concretes. Compressive strength, splitting tensile strength and flexural strength tests were made on hardened concrete specimens. Load–deflection curves and toughness of the specimens were also obtained by flexural test performed according to ASTM C1018 standards. Flexural tests on beam specimens were achieved using a closed loop deflection-controlled testing machine.

Ilker Bekir Topcu et al. [3] (2006). Studied the Effect of steel and polypropylene fibres on the mechanical properties of concrete containing class F fly ash, the following are the tests were conducted on the concrete specimens using various replacement levels of fly ash and fibre. Mechanical tests such as compressive, tensile and flexural strength tests, workability test such as slump cone test were conducted on concrete specimen. Fly ash content used was 0%, 10%, 15% and 20% in mass basis, and fibre volume fractions was0%, 0.05%, 0.08% and 0.85% in volume basis the laboratory results showed that addition of steel and polypropylene fibre into the Portland cement concrete or fly ash concrete provide better performance for the concrete, while fly ash in the mixture may adjust the workability and strength losses caused by fibres, and improve strength gain. Fibres are causing a 2–8% decrease in the workability of concrete. However, increment in compressive strength of concrete is observed up to 90%, 18% and 95%for PPI, PPII and steel fibres respectively. In splitting-tensile strength, decrements are also seen for FA concrete; but fibre addition provides increments and finally they concluded that the maximum amount of FA in concretes is limited to 25%.

3. Materials Used

The material properties for cement, fine aggregate, coarse aggregate, glass fibre and fly ash are discussed

3.1 Cement:

In the present study Chittinad Ordinary Portland cement (OPC) 43 grade was used. The specific gravity of cement is 3.14

3.2 Fine Aggregate:

Locally available river sand conforming to grading zone-II as per IS: 383-1970 was used. Average specific gravity of sand=2.65. Fineness modulus of sand= 2.59

3.3 Coarse Aggregate:

In the present study locally available 20 mm size coarse aggregate was used. The specific gravity of coarse aggregate is 2.79

3.4 Glass Fibre:

In this present study Cem-FIL Anti-Crack HD fibres are was used. The following are the properties of Glass fibre.

Table 1 Properties of Glass Fibre

Length	12mm
Diameter	0.014mm
Density	26KN/m3
Modulus of elasticity	73Gpa
Aspect ratio	857.1

3.5 Fly Ash

In this present study Neyvelli F-class fly ash was used. The following are the physical properties of fly ash.

Table 2 Properties of Fly Ash

pH	8.36
Specific gravity	2.323
Loss of ignition	1.85%
Point of zero charge	6.7

3.6 Water

Ordinary potable tap water available in laboratory was used for making concrete specimens and for curing processes. The water quality is conforming to IS: 3025-1964

4. Concrete Mix Design

4.1 Mix Proportion:

In this study, control mix of M20 grade of proportion 1:1.44:2.49 was designated with a water cement ration of 0.4 as per IS10262-2009 to achieve a target compressive strength of 26.6. In this study, we have replaced the cement with flyash (15%, 20% & 30%) and glass fibre (0.5%, 1% & 1.5%) by mass of cement. The mix proportion as per IS-10262-2009 for different mixes are presented in the Table 3 & 4

Table 3 Proportions for Plain Concrete

Cement	450 Kg/m^3
Water	197 Kg/m^3
Fine aggregate	652 Kg/m^3
Coarse aggregate	1123.192 Kg/m^3
Water cement ratio	0.4

Table 4 Proportions For Fly Ash Concrete

Components	**Replacement levels of fly ash**		
	FlyAsh-15%	FlyAsh -20%	FlyAsh -25%
Water	197 Kg/m^3	197 Kg/m^3	197 Kg/m^3
Cement	450 Kg/m^3	450 Kg/m^3	450 Kg/m^3
Fly ash	67.5 Kg/m^3	90 Kg/m^3	112.5 Kg/m^3
Fine aggregate	652.83 Kg	1078.056 Kg	646.58 Kg
Coarse aggregate	1088.47 Kg	1058.96 Kg	635.132 Kg

5. Experimental Program

5.1 Compressive strength

The comprehensive strength of concrete is one of the common performance measure used by the engineer in designing buildings and other structures of concrete. The compressive strength is measured by breaking cube concrete specimens in a compression-testing machine. The compressive strength is calculated from the failure load divided by the cross sectional area resisting the load and reported in units of megapascals (MPa). 100 x 100 x 100 mm size immediately submerged in clean fresh water. After 24 hours, the specimens were demoulded and immediately submerged in clean fresh water. After 28 days of curing, the cubes are then allowed to become dry for some hours. For each system triplicate specimens were cast. The cubes are tested in the compression- testing machine (60T capacity). The load was applied at the rate of 140 KN/min. the ultimate load at which the cube fails was taken.

5.2 Split tensile strength:

The most commonly used tests for estimating the tensile strength of concrete are the ASTM C496 splitting tension test and ASTM C 78 flexural loading test. For this 150 x 300 mm size concrete cylinder were casted. After 24 hours, the specimen were demoulded and immediately submerged in clean fresh water. After 28 days of curing, the cylinders are then allowed to become dry for some hours. Concrete cylinder to compression loads along two axial lines which are diametrically opposite. The load is applied continuously loads until the specimen fails. The compressive stress produces a transverse tensile stress which is uniform along the vertical diameter.

$$T=\frac{2P}{\pi LD}$$

Where T= tensile strength, P=failure load, L=length of the specimen, D=diameter of the specimen

5.3 Flexural strength

In the centre point loading test, 100 x 100 x 500 mm size concrete beam were cast for calculating both flexural strength and flexural elastic modulus. After 28 days of curing, the beams were allowed to become dry for some hours. The arrangement of the flexural strength test and modulus of elasticity was showing in fig. concrete beam was loaded at the rate of0.8 to 1.2 MPa/min. Flexural strength is expressed in terms of the modulus of rupture, which is the maximum stress at rupture computed from the flexure formula

$$R= 1.5\ L/bd^2$$

Where R= modulus of rupture, P=maximum indicated load, L=the span length b=width of the specimen, d=depth of the specimen

6. Results And Discussions

The result of various tests on fly ash concrete has discussed below and the values are compared with the controlled concrete

6.1 Compressive strength

The results shows the compressive strength of fibre reinforced fly ash concrete with control concrete at different curing period varies from 7 days and 28 days are plotted and shown in fig 1

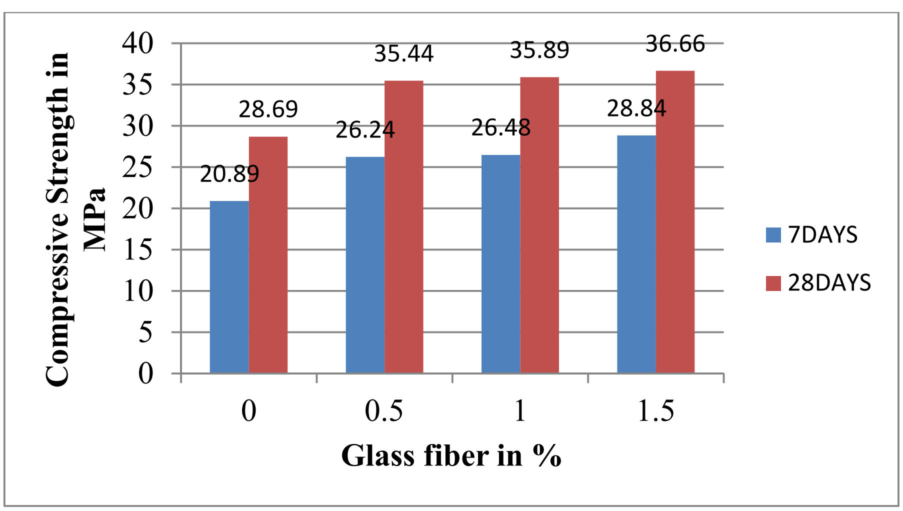

Fig.1 Compressive strength results for M20 grade concrete with 15% fly ash

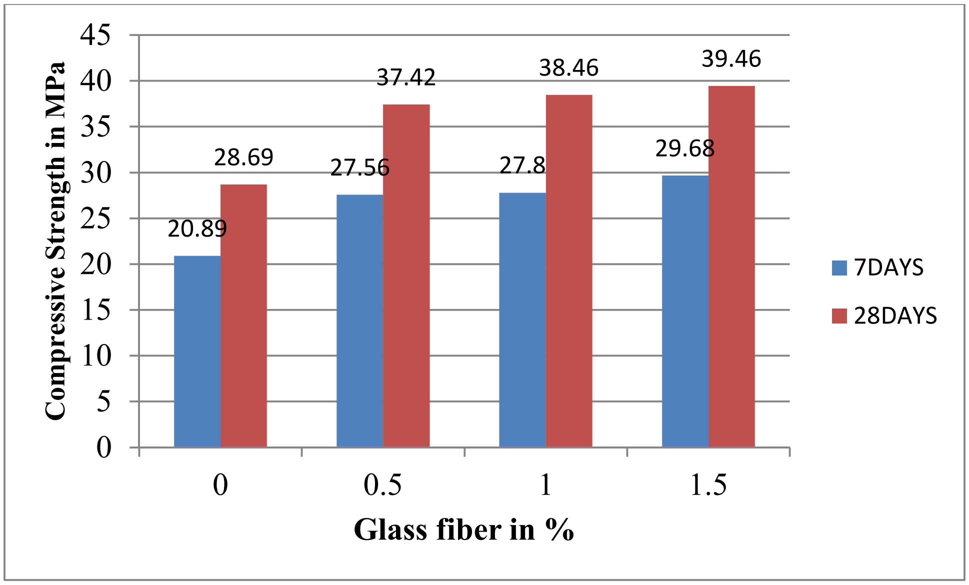

Fig 2 Compressive strength results for M20 grade concrete with 20% fly ash

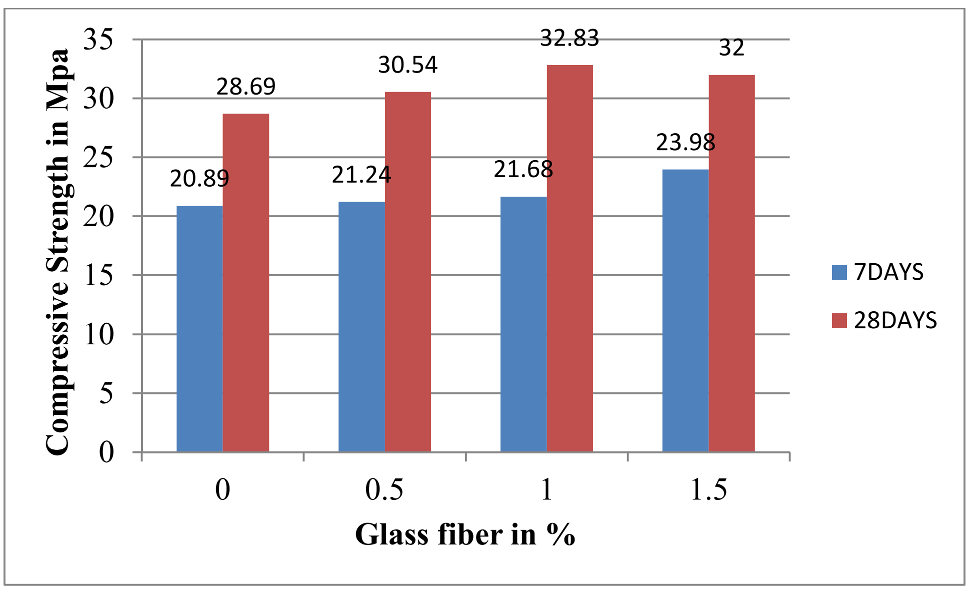

Fig.3 Compressive strength results for M20 grade concrete with 25% fly ash

From this Fig.1 and 2 it can be seen that due to the addition of glass fibre there is significant effect on compressive strength of concrete at 15% replacement of cement with Fly ash. From the Fig. 3 it is observed that there is a decrease of compressive strength at 25% replacement of cement with Fly ash.

6.2 Split Tensile Strength

The results shows the Split Tensile Strength of fibre reinforced fly ash concrete with control concrete at different curing period varies from 7 days and 28 days are plotted and shown in fig 4

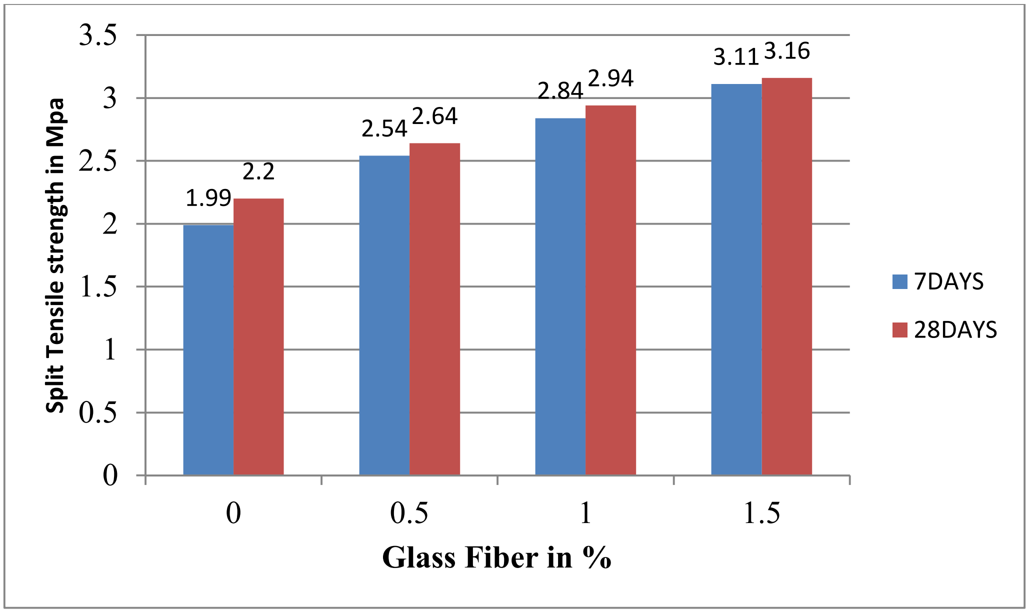

Fig.4 Split Tensile strength results for M20 grade concrete with 15% fly ash

From Fig.4 it is observed that there is an increase in split tensile strength of 44% for 15% replacement of cement with Fly ash. At 20% replacement level there is no significant effect on split tensile strength. For 25% replacement level there is a decrease in split tensile strength of about 10.5%

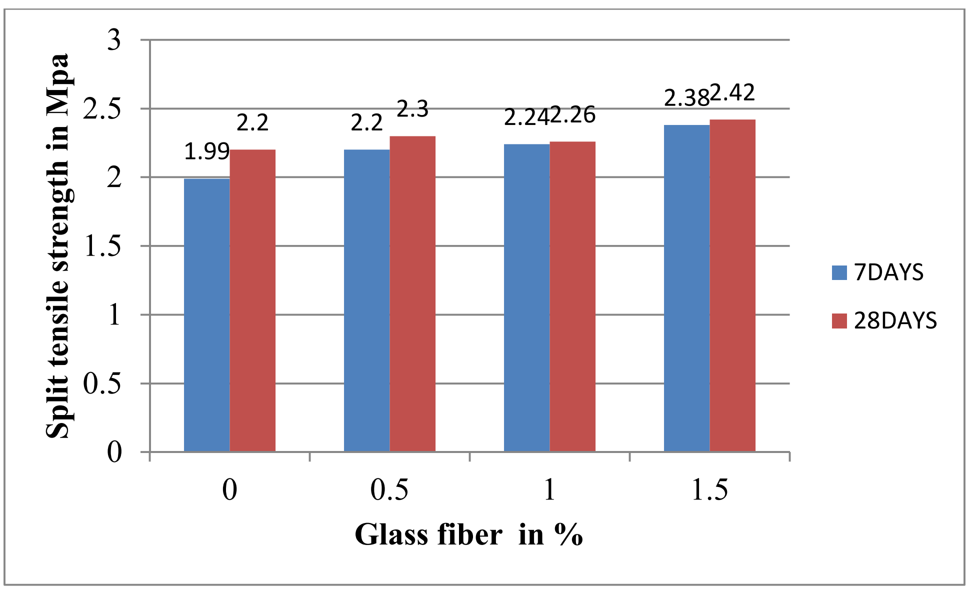

Fig.5 Split Tensile strength results for M20 grade concrete with 20% fly ash

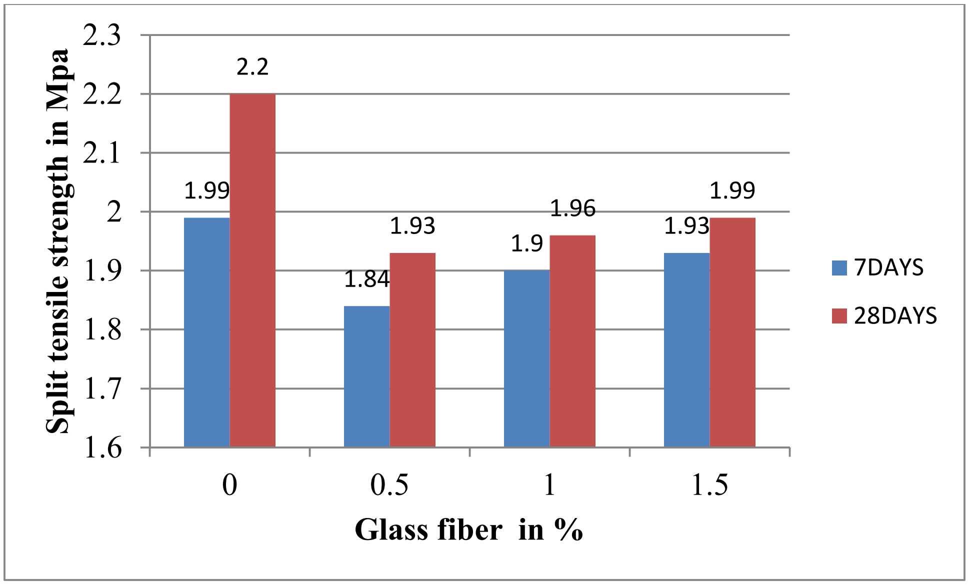

Fig.6 Split Tensile strength results for M20 grade concrete with 25% fly ash

6.3 Flexural tensile strength

The results shows the flexural Tensile Strength of fibre reinforced fly ash concrete with control concrete at different curing period varies from 7 days and 28 days are plotted and shown in fig 7

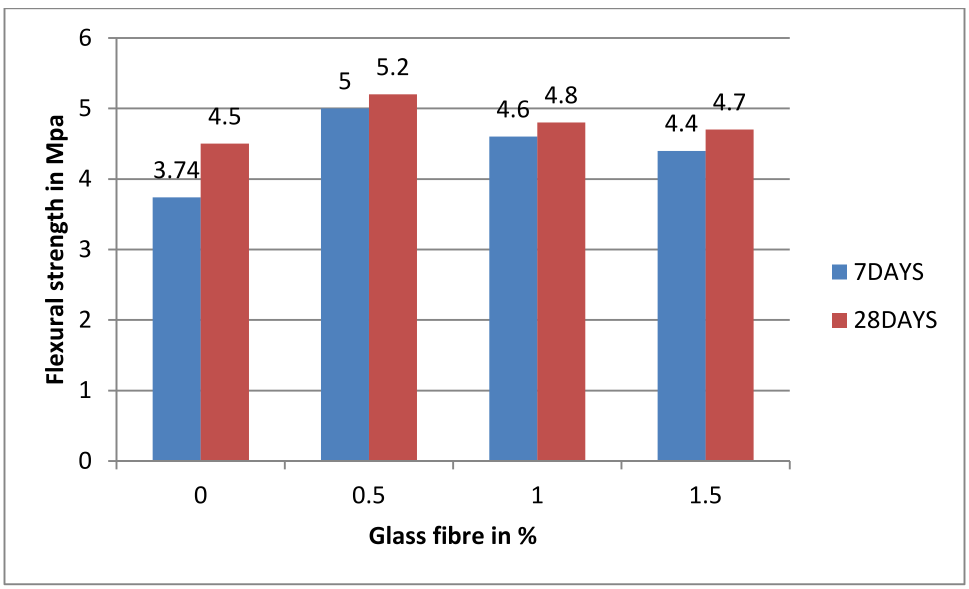

Fig.7 Flexural Tensile strength results for M20 grade concrete with 15% fly ash

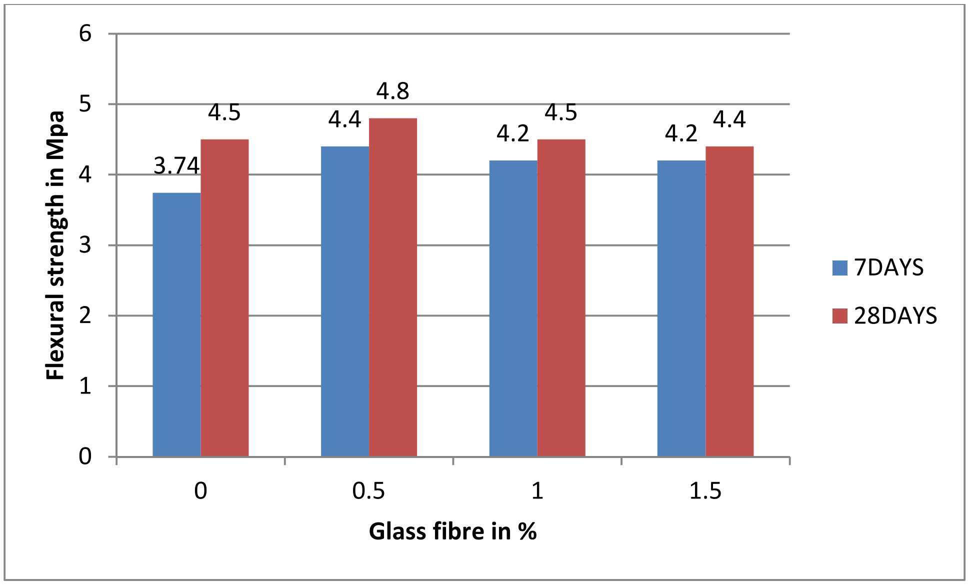

Fig.8 Flexural Tensile strength results for M20 grade concrete with 20% fly ash

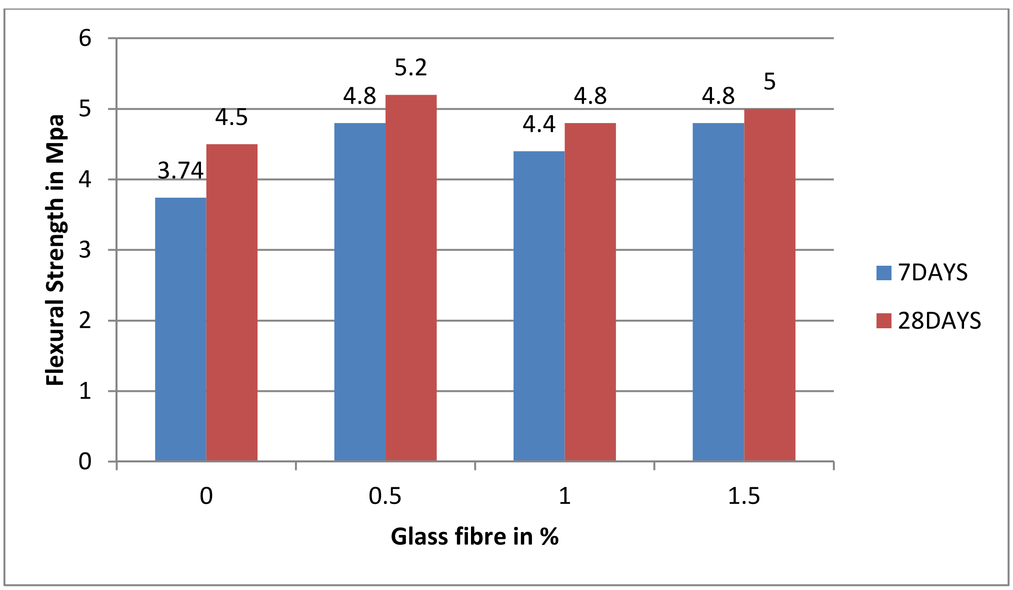

Fig.9 Flexural Tensile strength results for M20 grade concrete with 25% fly ash

From fig. 7, 8 and 9 it is observed that there is an increase in flexural strength at 0.5 % use of Glass fibre. Due to addition of Glass fibre more than 0.5% at there is a decrement in flexural strength.

7. Conclusions

Based on the extensive experimental investigations carried out on Glass Fibre reinforced Fly ash concrete the following conclusion has been drawn.

a) It is observed that Replacement of cement with Fly ash and addition of steel fibres increases the compressive strength of concrete about 27%, 37.5%, 14% for 15%,20% and 25% respectively.

b) It is observed that Replacement of cement with Fly ash and addition of steel fibres increases the split tensile strength of concrete about 43.5% and 10%, for 15% and 20%. There is decrease in split tensile strength of about 10.5% at 25% replacement of cement with Fly ash.

c) It is observed that Replacement of cement with Fly ash and addition of steel fibres increases the flexural strength of concrete about 15.5%, 6%, 15.5% for 15%,20% and 25% respectively.

8. References

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