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Durability Studies on Steel Fiber Reinforced Concrete

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Abstract - *Concrete is the most versatile man-made construction material in the world and being extensively used in all types of construction activities. The strength, durability and other characteristics of concrete depend upon the properties of its ingredients, the mix proportions, the method of compaction and other controls during placing, compaction and curing. To enhance these properties, an attempt was made to study the durability property by introducing steel fibers in concrete. In this paper effect of steel fibers on the durability of concrete for M30 grade have been studied by varying percentage of steel fibers in concrete. Fiber dosages of 0.5%, 1%, and 1.5% by volume of concrete were used in the experimental study. Concrete cubes of size 150mmX150mmX 150mm were tested for compressive strength, Resistance to Acid Attack for 28 days, 56 days curing period. Hooked end steel fibers were randomly dispersed in concrete. The results indicated that increasing the volume fraction of fiber showed decrease in compressive strength after subjected to acid attack. High volume SFRC was shown to be more vulnerable to acid attack.*

Key Words: *Fibre reinforced concrete, Steel fibres, Durability properties, Acid Attack.*

1. INTRODUCTION

Concrete is the most widely used construction material in this world. Generally concrete has low ductility and has less resistance to chemical attack, Hence steel fibers are added to concrete mix. Due to an increasing use of *FRC* (fiber-reinforced concrete) in construction like chemical industries against chemical attacks, these concretes have important role in human life. Adding fibers to concrete increases its ductility, tensile strength, flexural strength and resistance against dynamic, impact loads and chemical attacks. The Aspect ratio (L/d) and Volume fraction (VF) are important fibers parameters in FRC.

It was reported that steel fibers were effective in improving strength properties of the concrete [1]. It is evident that addition of fiber dosage has no significant role in enhancing compressive strength of FRC. Attiogbe E.K. [2] studied the effect of acid on different concrete mixes. Parameters such as change in weight and change compressive strength were evaluated. It was found that after acid attack, the specimens showed loss in weight and loss in compressive strength for all types of concrete mixes [2].

Srinivasa Rao et al [3] studied the durability effects on glass fiber reinforced concrete. In this investigation Acid attack is determined by immersion of cubes in 5% of HCL and H_2SO_4 solution respectively of 0.03, 0.06 and 0.10% of glass fiber with M30, M40 and M50 grade of concrete. The results concluded with the reduction in weight loss and also compressive strength with days of 28 and 90 days.

Basavaraj et al [4] studied durability of steel fiber reinforced concrete with M40 grade of concrete of steel content 0.75, 1.0%, and 1.25% by volume of concrete. Experiment was conducted by immersion of cubes in 3% of H_2SO_4 solution by maintaining constant concentration by changing the solution at regular interval of time. Weight of specimens were measured and loss or gain of weight was determined. They concluded that steel fiber reinforced concrete is more resistant when compared with conventional concrete and they observed that 1.25% steel has high resistance [4]. The results showed that the decrease in compressive strength with respect to increase in fiber dosage and also shows most effect on weight loss when immersed in acid curing. The main objective of this project is to study the durability of fiber reinforced concrete with mix proportion of fibers for M30 grade concrete and comparing with the conventional concrete and to know the optimum percentage of addition of fibers to concrete and finding maximum ratios.

2. EXPERIMENTAL STUDY

The experimental investigation was focused on the effect of various fiber dosages to resist the chemical attack. Mix proportion was designed using IS 10262-2009 [5] and IS 456-2000 [6] with mean target strength of 38.25 MPa (M30) for control mix. Ordinary Portland cement *(Type 1)* was used in this study. A coarse aggregate with a maximum nominal size of 19 mm and a fine aggregate with a fineness modulus of 3.4 were used in the experiment. Hooked-end steel fibers were used; their geometry and apparent shape are shown in Fig. 1 and their properties are listed in Table 1. Super plasticizer of SP-430 was used to adjust the workability of mixtures. Crushed granite stones of size 20 mm and 10 mm were used as coarse aggregate and river sand was used as fine aggregate. The bulk specific gravity in oven dry condition and water absorption of the coarse

aggregate 20 mm and 10mm were 2.58 and 0.3% and of sand were 2.62 and 1% respectively.

Fig 1: Steel Fibers

Table 1: Physical Properties of steel fibers

Fiber	Diameter (µm)	Specific Gravity	Modulus of Elasticity
Steel	5-500	7.84	200

To study the acid resistance of specimens immersed in the 3% of H_2SO_4 solution at 28 and 56 days curing period.

3. MIX DESIGN

In this study, water cement ratio of 0.5 was adopted for M30 grade concrete and steel of 0.5%, 1%, 1.5% volume fractions were used

Table 2: Content of mix proportions used

Constituents	Content KG/ m^3 of concrete
Cement	394.32
Fine aggregate	623.45
Coarse aggregate	1097.81
Water content	197.16
Fibers	
0.5%	11.56
1%	23.12
1.5%	34.69
Super plasticizer	9.38

4. METHODOLOGY

In the course of investigation, normal fine aggregate for the study of various properties, different specimens have been cast and tested. Tests were conducted on acid attack resistance for conventional concrete and steel fiber reinforced concrete. Acid attack was determined by immersing test specimens of 150X150X150mm cubes in 3% H_2SO_4 solution respectively.

The deterioration of conventional concrete and steel fiber reinforced concrete specimens are presented in the form of percentage reduction in weight of concrete of specimens at 28 and 56 days.

4.1 Compressive Strength test

Compressive strength of the FRC specimens were evaluated after immersing them in acid for 28 days and 56 days respectively.

Fig 2: Testing of cubes for Compressive strength

4.2 Acid Attack

Resistance against external acid attack is evaluated as per ASTM C 267-01. Cubes of size 150 x 150 x 150 mm were casted and cured in water for 28 days. Samples were taken out from water, cleaned with a cloth and initial weight is taken and compressive strength was evaluated for one set of specimens. Second sets of specimens were immersed in 3% Sulphuric acid solution for a further curing period of 28 days. Properties such as Weight of the specimen and compressive strength of the specimen were recorded at the age of 28 days.

Fig 3: Immersion of specimens in acid tank

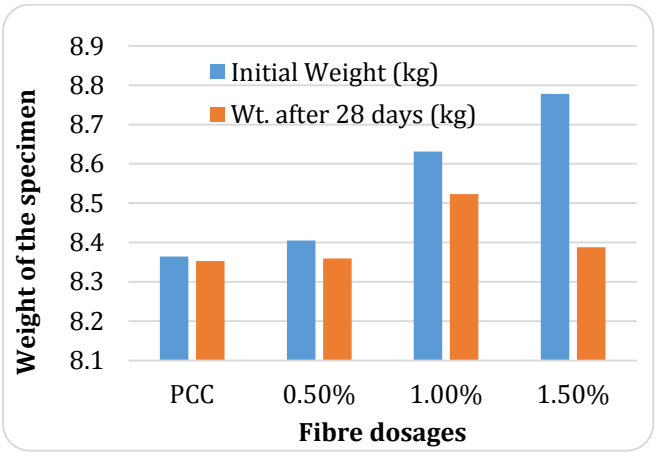
5. RESULTS AND DISCUSSIONS

Acid attack test was conducted on different volume of steel FRC. Parameters such as loss in weight and loss in compressive strength were evaluated after immersing the specimens in the acid.

5.1 Weight Loss

Table 3: Weight loss after 28 and 56 days

Fiber dosage	Initial Weight (kg)	Wt. after 28 days (kg)	% wt. loss for 28 days acid curing	Weight after 56 days (kg)	% wt. loss for 56 days acid curing
PCC	8.364	8.353	-0.13	8.092	-3.25
0.50%	8.405	8.359	-0.55	8.097	-3.67
1.00%	8.631	8.523	-1.25	8.218	-4.79
1.50%	8.778	8.388	-4.44	8.188	-6.72



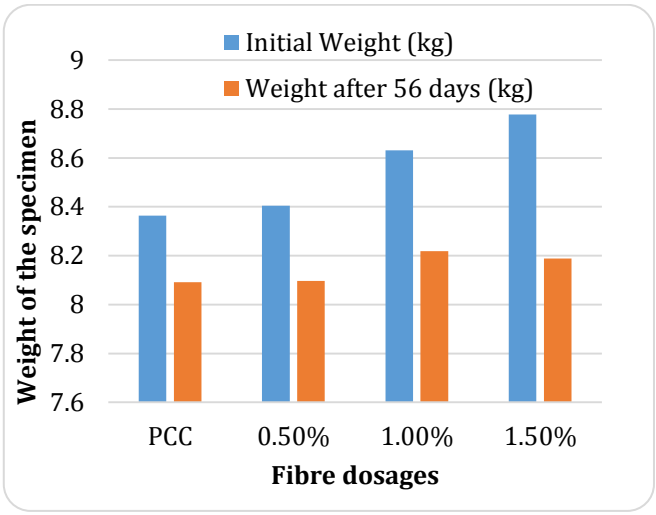


Fig 4: Comparison of weight before and after immersing in acid for 28 and 56 days curing

Weights of the specimens before and after immersing in acid for 28 and 56 days were evaluated and results are presented in Table 3. Weight of the specimen increased with fiber dosage for SFRC before immersing in acid. On the contrary, weight of the specimens reduced after curing in acid.

5.1.1 Percentage loss of weight

Percentage loss of weight of FRC specimens as compared to initial weight are analyzed and presented in Figure 5.

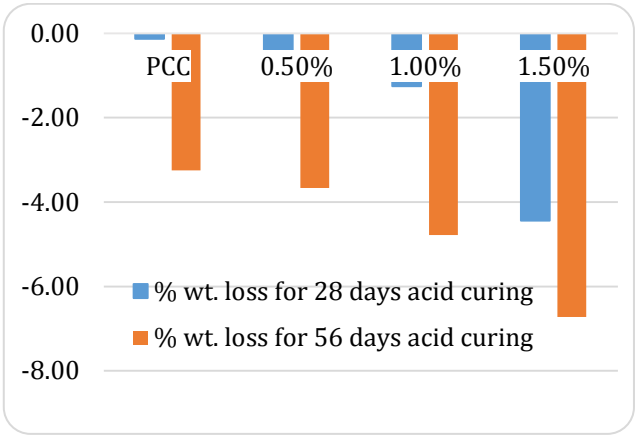


Fig 5: Percentage change in weight of the specimen

Here cleanly we observed that the for increase in fiber dosage, weight loss is more when compared to conventional concrete

5.2 Compressive strength

Compressive strength of the FRC specimens were evaluated after immersing them in acid for 28 and 56 days and the results are presented in Table 4 and 5. Compressive strength decreased with fiber dosage for FRC

and conventional concrete after immersing in acid for 28 days and 56 days as shown in Figure 6.

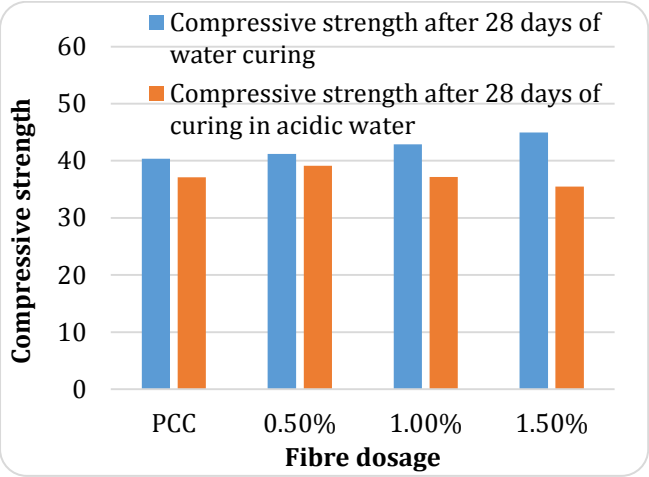
Table 4: Compressive strength of 28 days

Fiber dosage	Compressive strength after 28 days of water curing	Compressive strength after 28 days of curing in acidic water	% loss in compressive strength for 28 days acid curing
PCC	40.36	37.11	-8.05
0.50%	41.19	39.14	-4.98
1.00%	42.89	37.18	-13.31
1.50%	44.93	35.47	-21.05

Table 5: Compressive strength of 56 days

Fiber dosage	Compressive strength after 56 days of normal curing	Compressive strength after 56 days of curing in acidic water	% loss in compressive strength for 56 days acid curing
PCC	41.62	26.36	-57.90
0.50%	43.21	33.19	-30.18
1.00%	44.58	30.92	-44.17
1.50%	45.93	28.47	-61.32

Comparatively, SFRC at lower fiber dosages showed better performance at 28 days and 56 days as compared to other combinations. SFRC showed better performance at lower fiber dosage. However, with increase in fiber dosage, the compressive strength dropped drastically.



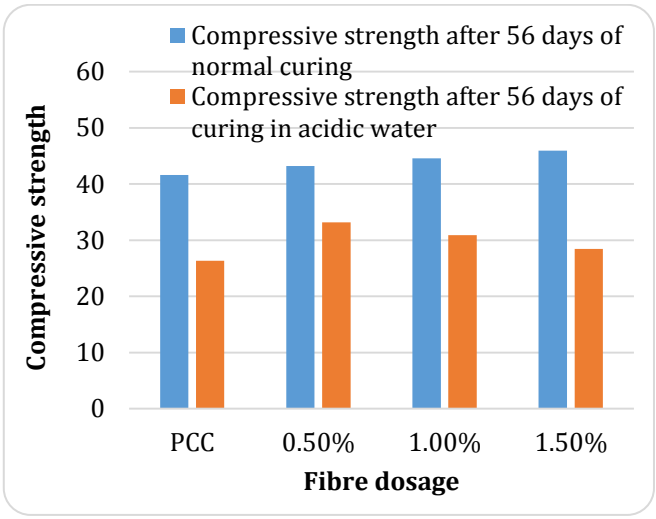


Fig 6: Comparison of strength between acid curing and normal curing after 28 and 56 days

5.2.1 Percentage loss in strength

When compare to conventional concrete SFRC with 0.5% dosage shows better results and resistance to acid attack. Increase in fiber dosage there is increase in percentage loss.

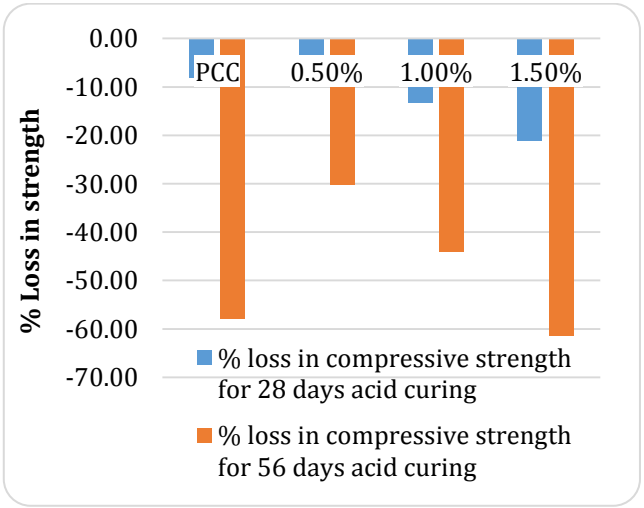


Fig 7: Percentage loss in strength

6. CONCLUSIONS

Based on the results of this experimental investigation, the following conclusions can be drawn:

1. Steel fibers were found to be effective to acid resistance.
2. Compressive strength decreased with increase in fiber dosage respectively subjected to acid curing compare to normal curing
3. Percentage loss of weight was increased with increasing in fiber dosage subjected to acid curing.

4. Fiber dosage of 0.5% shows better results

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