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UNDERSTANDING THE IMPLICATIONS AND CONSEQUENCES OF THE ASSIMILATION OF STEEL FIBRES FOR CONCRETE PROPERTIES M30

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Abstract

Concrete has comparatively high compressive strength, but significantly lower tensile strength and it is a well established fact that all concrete structures will crack to some extent, due to shrinkage and tension. Concrete which is subjected to long-duration forces is prone to creep. Many researches studies have been carried out to understand the nature of concrete properties and how these properties affect the internal structure of concrete by means of various types of materials so far. However no plausible solutions have been provided to the actual composite use of the fibres with the concrete mixture. This paper represents the Optimum use of the fibres with the concrete mixture and will also help in achieving the desired results. This paper shows the investigation on M30 grade due to incorporation of stainless steel fibres. In this paper we used the stainless steel fibres of diameter 0.50 mm with aspect ratio 80 at various percentages as 0%,0.5,%.1%,1.5%,2% by the volume of concrete on M30 grade of mix proportion (1:1.5:3) with water cement ratio 0.43. SFRC based specimens has been tested for the compressive strength, flexural strength and split tensile strength.

Keywords: *Stainless Steel Fibres, Compressive Strength, Flexural Strength and Split Tensile Strength.*

INTRODUCTION

The poor and unsatisfactory performance of conventional concrete under aggressive environmental conditions has necessitated the researchers and engineers to look for new concrete composites. The innovative use of concrete must contemplate explorations of areas , in use of new shapes, materials and technique of construction. Concrete is such a versatile material that such attempts of contemplation are quite possible. In modern age one cannot think of construction work without concrete. Plain concrete has two major deficiencies; a low tensile strength and allow strain at fracture. The tensile strength of concrete is very low because plain concrete normally contains numerous micro cracks. Hence Fibres are generally utilized in concrete to manage the plastic shrink cracking and drying shrink cracking In FRC, thousands of small fibres are dispersed and distributed randomly in the concrete during mixing, and thus improve concrete properties in all directions. That's why the addition of fibre with concrete improved the concrete properties such as workability, brittleness, strength, corrosion resistance and ultimately increased life of the structure. A major advantage of using fibre reinforced concrete besides reducing permeability and increasing fatigue strength is that fibres addition improves the toughness or residual load carrying ability after the first crack. This concrete is known as steel fibre reinforced concrete (SFRC). Reinforcing capacity and proper functioning of fibre is based on length of fibre, diameter of fibre, the percentage of fibre and condition of mixing, orientation of fibres and aspect ratio. Aspect ratio is ratio of length of fibre to its diameter which plays an important role in the process of reinforcement. SFRC contains only less than 3% of fibres and aspect ratio below 100.

LITERATURE REVIEW

As we know the properties of concrete gets improved due to the incorporation of steel fibre. Large no. of papers have being published which tells about the compressive strength, flexural strength and split tensile strength of concrete according to their opinion. Ahsana fathima k m1 & shibi varghese [1] has investigated the effects of steel fibres and polypropylene fibres on the mechanical properties of concrete.it has been found that SFRC attained higher compressive strength ,flexural strength and split tensile strength with the addition of 0.75% crimped steel fibre by volume of concrete. Fibre reinforced concrete with crimped steel fibre of 25mm length with aspect ratio 50 yields better flexural strength than hooked end steel fibre of 30mm length with aspect ratio 50. Shende.A.M.1 & Pande.A.M [2] has represented the effect of steel fibre reinforcement with different percentage of fibre 0, 1%, 2% and 3% by volume for M-40 grade of concrete with aspect ratio 50, 60 and 67.it has been found that flexural strength of concrete increases gradually upto 3% of fibre content. Vasudev R, Dr. B G Vishnuram [3] has discussed the improved performance of concrete with steel fibres as compared to the concrete M30 with varying percentage of fibres ranging from 0, 0.25, 0.5, 0.75 & 1%.. it has been concluded that splitting tensile strength of concrete increases from 20 to 22 % of the previous sample. Balaguru P. and Jonh Kendzulak [4] in their paper „Flexural behaviour of fibre reinforced concrete" have presented the result of an experimental investigation on the behavior of fibre concrete beam subjected to static and cyclic flexural loading., Nakagawa H., Akihama S., and

Suenaga T. [5] in their paper entitled „Mechanical properties of various types of fibre reinforced concrete" have reported the mechanical properties of concrete reinforced with carbon fibre, Aramid fibres, and high strength Vinylon fibres. The authors have carried out flexural test using different types of fibres. Gupta [6] studied the effect of addition of crimped round steel fibres on the splitting tensile strength of concrete. They proposed equations based on linear regression analysis to correlate splitting tensile strength with the fibre reinforcing index. Linear relationship between splitting tensile strength and the flexural strength, split tensile strength and compressive strength were also proposed. Yin et al [7] studied the structural performance of short steel fibre reinforced concrete beams strengthened with externally bonded fibre reinforced polymer sheets. The authors concluded that the strengthened beams exhibit higher load carrying capacity. Ms. K.Ramadevi1, Ms. R. Manju [8] used the Polyethylene Terephthalate (PET) bottles for the reinforcement in concrete with dosage 1%, 2%, 4% and 6% . This paper proved that the replacement of fine aggregates with PET bottles reduces the quantity of river sand and also plastic fibres are proved to be more economical.

MATERIALS USED

CEMENT: Ordinary Portland cement of 43 grade has been used in this experimental work. OPC 43 grade of ULTRATECH cement has been used after investigate the strength of cement at 28 days as per IS 4031-1988. The various properties of the cement are described in Table 1.

FINE AGGREGATES: Locally available river sand passed through 4.75mm IS sieve has been used in the preparation of SFRC. It confirms to IS 383-1970 which comes under Zone I. The physical Properties of sand like Fineness Modulus, Specific Gravity and water absorption are 3.49, 2.67 and 2.31% respectively.

COARSE AGGREGATES: The Coarse aggregate are obtained from a local quarry has been used. The coarse aggregate with a maximum size 20mm having a specific gravity 2.89. In this experimental work coarse gravel of 20mm and crushed aggregate of 10mm are mixed in 60:40. The physical Properties of coarse aggregates like Fineness Modulus, Specific Gravity are 2.31, 2.89 respectively.

STEEL FIBRE: Stainless steel wire of 0.5 mm diameter has been used in the preparation of SFRC. The steel fibre of length 40 mm and of aspect ratio 80 has been used in this experimental work. All the steel fibres are straight in shape.

WATER: - Water used for mixing and curing was clean and free from injurious amounts of oils, acids, alkalis, salts and sugar, organic substances that may be deleterious to concrete. As per IS 456- 2000 Potable water is generally considered satisfactory for mixing and curing of concrete. Accordingly, potable tap water was used for the preparation of all concrete specimens.

Table 1: Properties of cement

Sr. No.	Characteristics	Experimental value	Specified value as per IS:8112-1989
1	Consistency of cement (%)	33%	---
2	Specific gravity	2.98	3.15
3	Initial setting time (minutes)	37	>30 As Per IS 4031-1968
4	Final setting time (minutes)	286	<600 As per IS4031-1968
5	Compressive strength (N/mm^2) (i) 3 days (ii) 7 days (iii)28days	 27.56 40.57 48.96	 >23 >33 >43
6	Soundness (mm)	1.00	10
7	Fineness of Cement	5%	10% As Per IS 269-1976.

EXPERIMENTAL PROGRAMME

In this section, SFRC based specimens has been tested for the compressive strength, flexural strength and split tensile strength.

COMPRESSIVE STRENGTH TEST: To examine the compressive strength of SFRC, cube of 150mmX150mmX150mm has been used in this experimental work 30-40 cubes has been casted to determine the compressive strength. firstly cement and sand are mixed uniformly in dry condition . Secondly coarse aggregates are added in this mixture . Now steel fibres also added according to mix proportion to get the resultant mixture of M30 grade. Required dosage of water was added in the course of mixing. Through mixing was done until concrete appeared to be homogeneous and of desired consistency. Now cube moulds were filled with concrete in three layers and after each layer, concrete was compacted with temping rod . The mould‟s surface level should be plane with trowel . The cube moulds were demoulded after 24 hours then they were placed in water tank containing portable water and were left for curing. After that the specimen are tested at 7 days and 28 days at compression testing machine (CTM) as per IS 516-1959

TABLE 2: Compressive Strength Results

Mix Designation	Percentage of Steel Fibre	Compressive Strength After 7 Days (N/mm^2)	Compressive Strength After 28 Days (N/mm^2)
MX0	0	16.25	29.33
MX1	0.5	18.92	30.93
MX2	1	21.25	33.21
MX3	1.5	19.12	31.78
MX4	2	17.67	30.21

From the above results, we observe that compressive strength of concrete increases due to incorporation of steel fibres. From the plot we can say that compressive strength of concrete increases upto 30 % with 1 % steel fibres at the end of 7 days and 12% at the end of 28 days.

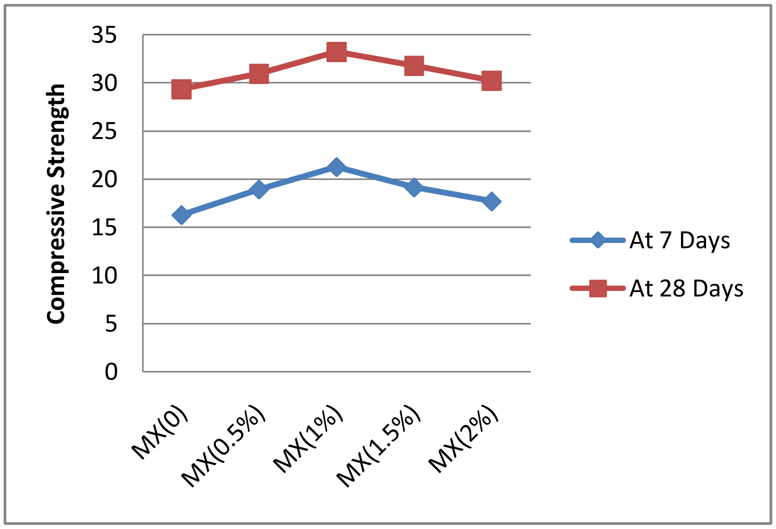

Fig. 4 Variation of Compressive Strength at Different Ages

FLEXURAL STRENGTH TEST:- To examine the flexural strength of SFRC, cylinder of size 150mmX150mmX70mm has been used in this experimental work. 30-40 beams has been casted to determine the tensile strength. The beams specimens of different proportions were demoulded after 24 hours and transferred to the curing tank for 28 days . After that, beams were placed to the two point loading machine on which we apply the load manually. Note down the load value at which cracks starts developing on the beam.

TABLE 3: Flexural Strength Results

Designation	Percentage of Steel Fume	Flexural Strength After 7 Days (N/mm^2)	Flexural Strength After 28 Days (N/mm^2)
MX0	0	1.37	2.56
MX1	0.5	1.81	2.82
MX2	1	2.05	2.98
MX3	1.5	1.85	2.53
MX4	2	1.72	2.49

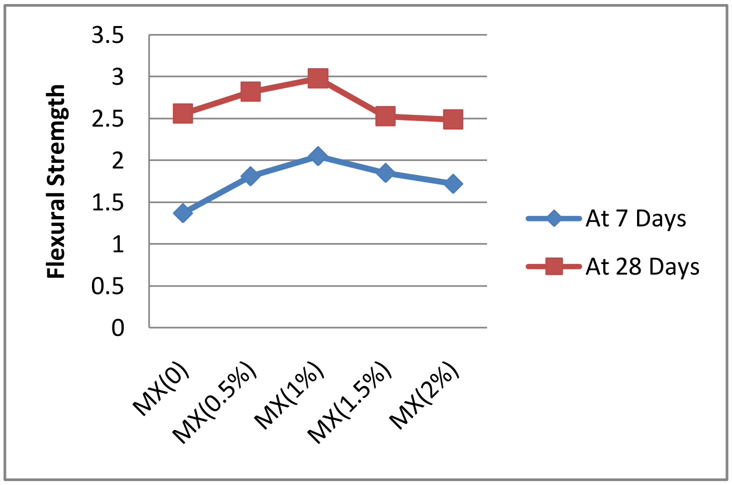

Fig. 5 Variation of Flexural Strength at Different Ages

The results obtained from the experiment showed that flexural strength of the SFRC increased upto 16 % as compared with plain concrete.

SPLIT TENSILE STRENGTH TEST:-

To examine the tensile strength of SFRC, cylinder of size 150mmX300mm has been used in this experimental work . 30-40 cylinders has been casted. The cylinder moulds were demoulded after 24 hours and transferred to curing tank for 28 days.After that cylinders were tested horizontally under compression testing machine (CTM). Split tensile strength of concrete mixtures was measured at the ages of 7 and 28 days as shown in Table 4. The results shows that in general, there is an increase in splitting tensile strength of cylinder concrete specimens with the addition of fibres to the concrete at 28 days age.

TABLE 4: Split Tensile Strength Results

Mix Designation	Percentage of Silica Fume	Split Tensile Strength After 7 Days (N/mm2)	Split Tensile Strength After 28 Days (N/mm2)
MX0	0	1.49	2.5
MX1	0.5	1.58	2.42
MX2	1	1.84	2.49
MX3	1.5	1.62	2.82
MX4	2	1.51	2.43

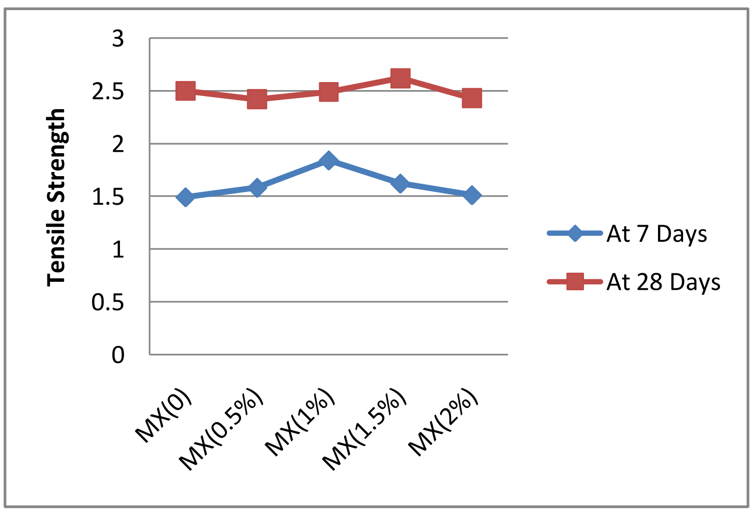

Fig. 6 Variation of Split Tensile Strength at Different Ages

From the above results, we observe that Split Tensile Strength of concrete increases due to incorporation of steel fibres. From the plot we can say that Split Tensile strength of concrete increases upto 13 % with 1.5% steel fibres as compared to plain concrete.

CONCLUSION

The following conclusions could be drawn from the present investigation.

1. The Experimental work shows that properties of concrete M30 gets improved due to incorporation of steel fibres
2. The Experimental work shows that workability of SFRC gets reduced as we increased the fibre amount.
3. It can be concluded that the compressive strength of SFRC gets increased upto 30 % with 1% steel fibres as compared to plain concrete.
4. It can also be concluded that optimum dosage amount of fibre for M30 is 1 % by weight of concrete.
5. It is observed that the compressive strength of steel fibre reinforced concrete gets increased upto 1 % dosage amount after that it starts decreases.
6. It is observed that the Flexural strength of steel fibre reinforced concrete gets increased upto 16 % as compared to plain concrete.
7. It can be concluded that Flexural strength of the SFRC gets increased continuously but after 1% gets decreased.
8. It is also observed that the Split Tensile strength of steel fibre reinforced concrete gets increased increases up to 13 % with 1.5% steel fibres as compared to plain concrete.
9. While testing the specimens, the plain cement concrete specimens have shown a typical crack propagation pattern which leaded into splitting of beam in two-piece geometry. But due to addition of steel fibres in concrete cracks gets ceased which results into the ductile behaviour of SFRC.
10. It is also observed that during testing the specimens, the SFRC specimens does not collapse as compared to plain concrete.

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