A Characteristic Study on Strength of Steel fibre Reinforced Cement Concrete

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Abstract **The study presents the behavior of SFRC structural elements. The purpose of this study is to investigate the effects of fibre volume on the compressive, splitting, and flexural behaviors of SFRC, and to compare modes of failure. The properties of fresh concrete have been obtained through Slump test and compaction factor test. Tests on the strength of hardened concrete and flexural behavior of SFRC model beams & slabs under two-point loading were conducted. Failure loads and cracking patterns of beams and slabs with varying percentage of Steel Fibre (non fibrous 0%, 0.5%, 1% and 1.5%) in concrete of M20 grade were compared. Steel fibre-reinforced concrete (SFRC) has been used increasingly in recent years and has a lot of applications. The science and technique of incorporating steel fibres in reinforced cement concrete is getting established through recent research and practice. The addition of steel fibres to conventional reinforced concrete greatly improves the cracking strength. The steel fibres restrict the growth of cracks and reduce the tensile strain in steel reinforcement bars and thereby resulting in smaller crack width. Steel fibre reinforced concrete (SFRC) also has the ability of excellent tensile, flexural strength and shock, fatigue resistance and ductility**

Keywords: Steel fibres, Cement, concrete, Superplasticizer

1. INTRODUCTION

Fibre is a small piece of reinforcing material possessing certain characteristic properties. They can be circular or flat. The fibre is often described by a convenient parameter called “aspect ratio”. The aspect ratio of the fibre is the ratio of its length to its diameter. Typical aspect ratio ranges from 30 to 150. The transformation from a brittle to a ductile type of material would increase substantially the energy absorption characteristics of the fibre composite and its ability to withstand repeatedly applied shock or impact loading. Early steel fibres used as concrete reinforcement were round and smooth [1-4]. They were obtained by cutting or chopping wire. Today, smooth, straight fibres have largely been replaced by fibres that have either rough surfaces, hooked ends, or are crimped or undulated throughout their length. These characteristics improve a fibre resistance to pull out from a cement-based matrix. Tunnel linings, domes, mine linings, rock-slope stabilization, repair and restoration distressed concrete structures etc.

2.EXPERIMENTAL PROGRAMME OBJECTIVE

The objective of this experimental investigation is to study the structural performance of non-fibrous and steel fibre reinforced concrete of two different grades i.e. M20. Experimental program includes the tests carried out to check properties of fresh concrete, and the mechanical properties of hardened concrete like cube compressive strength and split tensile strength.

2.1 General Information about Experimental Programme

The experimental investigation includes casting and testing of 72 cubes, 24 cylinders, the cubes are tested for compression at 7, 14 and 28 days of curing. The cylinders are tested for split tension respectively at 28 days of curing. Among 72 cubes, 18 cubes of non-fibrous concrete, 18 cubes of 0.50% volume fraction of steel fibres (Vf-0.5%), 18 cubes of 1.0% volume fraction of fibres (Vf- 1.0%) and similarly 18 cubes for 1.5% volume fraction of fibres (Vf- 1.5%). The cylinders specimens are cast in four sets, the first set consists of 06 non fibrous (NF) concrete cylinders for two different grade of concrete grade M20. Second set consists of 06 cylinders containing 0.50% volume fraction of steel fibres (Vf- 0.50%), third set consists of 06 cylinders, containing 1% volume fraction of fibres (Vf - 1%), similarly fourth set consists of 06 cylinders, containing 1.5% volume fraction of fibres (Vf - 1%).

2.2 Workability Characteristics:

2.2.1 Slump Cone Test

This is a test used extensively in site work all over the work. The slump test does not measure the workability of concrete although ACI 116R – 90 describes it as a measure of consistency, but the test is very useful in detecting variations in the uniformity of a mix of given nominal proportions. The slump test is prescribed by IS456 (2000), and BS 1881 Part 102:1983. The mould for the slump test is a frustum of a cone, 300 mm high. It is a placed on a smooth surface with the smaller opening at the top and filled with concrete in three layers. Each layer is tamped 25 times with a standard 16mm diameter steel rod, rounded at the end, and the top surface is truck off by means of a sawing and rolling motion of the tamping rod. The mould must be firmly held against its base during the entire operation, this is facilitated by handles or foot rests brazed to the mould. Immediately after filling, the cone is slowly lifted, and the unsupported concrete will now slump hence the name of the test. The decrease in the height of the slumped concrete is called slump and is measured to the nearest 5mm. The decrease is measured to the highest point according to IS456 (2000) BS 1881: Part 102:1983, In order to reduce the influence on slump of the variation in the surface friction, the inside of the mould and its base should be moistened at the beginning of every test, and prior to lifting of the mould the area immediate ly around the base of the cone should be cleaned of concrete which may have dropped accidentally. If instead of slumping evenly all round as in a true slump figure one half of the cone slides down an inclined plane, a shear slump is said to have taken place, and the test should be repeated. If shear slump persists, as may be the case with harsh mixes, this is an indication of lack of cohesion in the mix.

2.2.2 Compaction Factor Test

The degree of compaction, called the compaction factor, is measured by the density ratio i.e., the ratio of the density actually achieved in the test to the density of the same concrete fully compacted. The test, known as the compacting factor test, is described in BS 1881: Part 103:1993 and in ACI 211.3-75 (Revised 1987) (Reapproved 1992), and is appropriate for concrete with a maximum size of aggregate up to 40mm. The apparatus consists essentially of two hoppers, each in the shape of a frustum of cone, and one cylinder, the three being above one another. The hoppers have hinged doors at the bottom, as shown in figure. All inside surfaces are polished to reduce friction. The upper hopper is filled with concrete, this being placed gently so that at this stage no work is done on the concrete to produce compaction. The bottom door of the hopper is then released and the concrete falls into the lower hopper. This is smaller than the upper one and is, therefore, filled to overflowing, and thus always contains approximately the same amount of concrete in a standard state; this reduces the influence of the personal factor in filling the top hopper. The bottom door of the lower hopper is then released and the concrete falls into the cylinder. Excess concrete is cut by two floats slid across the top of the mould. The density of the concrete in cylinder is now calculated, and this density divided by the density of the fully compacted concrete is defined as the compacting factor. The latter density can be obtained by actually filling the cylinder with concrete in four layers, each tamped or vibrated, or alternatively calculated from the absolute volumes of the mix ingredients. The compacting factor can also be calculated from the reduction in volume that occurs when a defined volume of partially compacted concrete (by passing through the hoppers) is fully compacted.

2.3 Materials

Cement, fine aggregate, coarse aggregate, water, steel fibres, superplasticizer SP430 is used throughout the investigation which has the following characteristics.

2.3.1 Cement

Although all materials that go into concrete mix are essential, cement is very often the most important because it is usually the delicate link in the chain. It constitutes only about 20 percent of the total volume of concrete mix; it is the active portion of binding medium and is the only scientifically controlled ingredient of concrete. Portland cement referred as (Ordinary Portland Cement) is the most important type of cement and is a fine powder produced by grinding Portland cement clinker. The OPC is classified into three grades, namely 33 Grade, 43 Grade, 53 Grade depending upon the strength of 28 days. The cement as determined from various tests conforming to Indian Standard IS: 8112:1989 are listed in Table 2.1

Table 2.1 Properties of OPC

S.No	Characteristics	Values obtained
1	Specific gravity	3.15
2	Standard consistency (%)	33
3	Initial setting time	105 (minutes)
4	Final setting time	430 (minutes)

2.3.2 Fine Aggregate

Locally available Bhima River sand from Shahpur taluka is used for the present work. The preliminary tests were conducted in the laboratory and the tests results are tabulated in the table 3.4.

Table 2.2 Properties of fine aggregate

Characteristics	Value
Specific gravity	2.34
Bulk density(kg/m3)	1.3
Fineness modulus	2.62
Water absorption	0.88

2.3.3 Coarse Aggregate

In the present investigation, locally available crushed basalt stone aggregates of 12mm down size is used. The preliminary tests were conducted in the laboratory and the tests results are tabulated in the table 3.5

Table 2.3 Properties of coarse aggregate

Characteristics	Value
Colour	Grey
shape	20mm
size	Angular
Specific gravity	2.74

2.3.4 Water

Water used for both mixing and curing should be free from injurious amounts of deleterious materials therefore Potable water is generally considered satisfactory for mixing and curing of concrete. In the present work potable tap water is used.

2.3.5 Steel Fibres

The steel fibres used are already described in section. A varying volume fraction i.e., 0.50%, 0.1% & 1.5% of fibres are used in this investigation. In this present investigation, the fibres used are round crimped steel fibres of diameter 0.45 mm and length 36mm (aspect ratio 80) the steel fibres are uniformly dispersed inside the entire mass of concrete.

2.3.6 Superplasticizer

Super plasticizers constitute a relatively new category and improved version of plasticizer. Only thing is that the super plasticizers are more powerful as dispersing agents and they are high range water reduce. It is the use of superplasticizer which has made it possible to use W/c as low as 0.25 or even lower and yet to make flowing concrete to obtain strength of the order 120 MPa or more.

2.3.7 Properties [As per manufacturer]

Strength: steel fibres fully satisfy the requirement of ASTM-A820:90 in respect of shape bend ability and minimum ultimate tensile strength as confirmed by the test conducted at IIT Chennai and other reputed Engineering institutions.

3. RESULTS & DISCUSSIONS

Table 3.1 Results of Slump Cone Test and Compaction Factor Test for M20 Grade Concrete

Specimen type M20 Grade Concrete	Slump (mm)	Compaction Factor
N.F	55	0.89
Vf – 0.50%(A1)	44	0.87
Vf – 1%(A2)	37	0.80
Vf – 1.5%(A3)	30	0.75

Table 3.2 Results of Slump Cone Test and Compaction Factor Test for M20 Grade Concrete

Specimen type M30 Grade Concrete	Slump (mm)	Compaction Factor
N.F	62	0.90
Vf – 0.50%(B1)	50	0.89
Vf – 1%(B2)	41	0.82
Vf – 1.5%(B3)	35	0.74

Table 3.3 Description of ingredient in M20 grade concrete

Water	Cement	Fine aggregate	Coarse aggregate
0.4	1	1.42	3.09

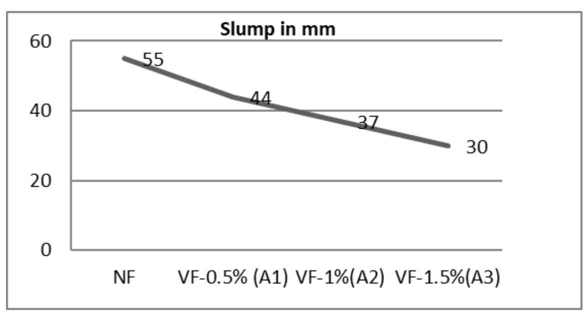

Figure 3.1 Slump values for various mixes of M20 grade concrete

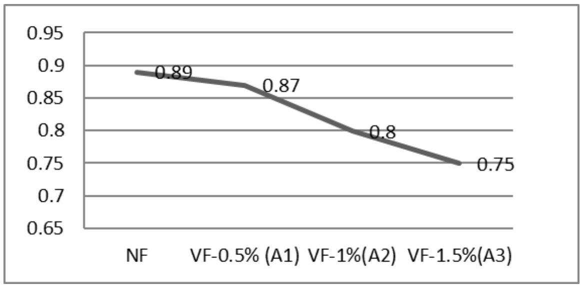

Figure 3.2 Compaction factor test for various Mixes of M20 grade

Table 3.4 Compressive Strength Test Results at 7 days for M20 grade mixes

Mix designation	Specimen	Compressive strength N/mm2	Avg compressive strength N/mm2
CVC (NF)	C1	27.34	28.123
	C2	28.08	
	C3	28.95	
A1 vf=0.5%	C1	30.70	30.03
	C2	30.00	
	C3	29.39	
A2 vf= 1.0%	C1	34.75	35.24
	C2	35.06	
	C3	35.93	
A3 vf = 1.5%	C1	30.44	30.75
	C2	31.57	
	C3	30.26	

Where C1, C2, C3, are number of cube specimen

Table 3.5 Compressive Strength Test Results at 14 days for M20 grade mixes

Mix designation	Specimen	Compressive strength N/mm2	Avg compressive strength N/mm2
CVC (NF)	C1	28.21	28.91
	C2	29.39	
	C3	29.13	
A1 vf=0.5%	C1	34.75	35.24
	C2	35.06	
	C3	35.93	
A2 vf= 1.0%	C1	36.24	36.87
	C2	36.62	
	C3	37.75	
A3 vf = 1.5%	C1	37.11	36.75
	C2	36.80	
	C3	36.36	

Table 3.6 Compressive Strength Test Results at 28 days for M20 grade mixes

Mix designation	Specimen	Compressive strength N/mm2	Avg compressive strength N/mm2
CVC (NF)	C1	34.31	35.07
	C2	35.42	
	C3	35.49	
A1 vf=0.5%	C1	42.73	41.83
	C2	41.60	
	C3	41.16	
A2 vf= 1.0%	C1	45.07	46.18
	C2	46.83	
	C3	46.65	
A3 vf = 1.5%	C1	44.21	44.86
	C2	45.72	
	C3	44.65	

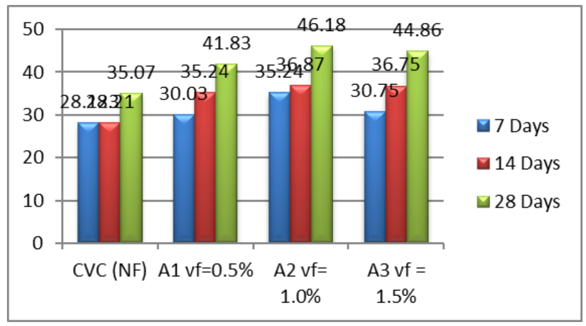

Figure 3.3 Comparison of Compressive Strength [Mix CVC (NF) A1, A2, A3, equivalent to M20 grade

Table 3.7 Split Tensile Strength Test Results at 28 days for M20 grade mixes

Mix designation	Specimen	Load (tons)	Split Tensile strength	Avg. Split Tensile strength N/mm2
CVC (NF)	C1	6	0.63	0.7
	C2	7	0.77	
	C3	6.5	0.70	
A1 vf=0.5%	C1	10	1.18	1.04
	C2	9	1.04	
	C3	8	0.90	
A2 vf= 1.0%	C1	10	1.18	1.45
	C2	12	1.45	
	C3	14	1.73	
A3 vf = 1.5%	C1	11	1.31	1.31
	C2	10	1.18	
	C3	12	1.45	

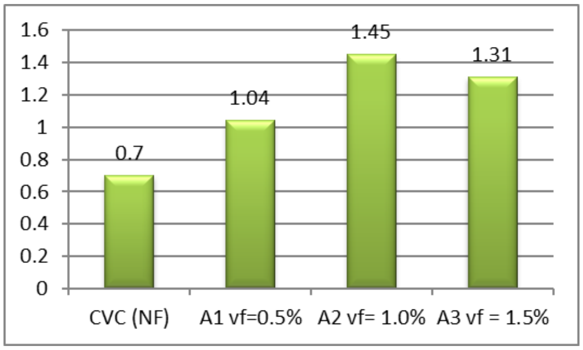

Figure 3.4 Split Tensile Strength for various Mixes of M20 Grade at 28 day

4.CONCLUSION

- In comparison with three percent of fibre, 1.0% was recognized as the best fibre volume for both economical and strength aspects
- The compressive strength had been increased for fibre content up to 1.0%.
- The maximum compressive strength for 28days attained was 46.18 N/mm2 & 51.95 N/mm2 with 1.0% volume fraction of fibres for M20 grade of concrete
- The Split tensile strength had been increased for fibre content up to 1.0%.
- The maximum Split tensile strength for 28days attained was 1.45 N/mm2 & N/mm2 with 1.0% volume fraction of fibres for M20 grade of concrete

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