EXPERIMENTAL INVESTIGATION ON UNDULATED AND HOOKED STEEL REINFORCED CONCRETE

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Abstract— In this project, effect of fibers on the strength of concrete for M30 grade have been studied by varying the % of fibers in the concrete. Fiber content were varied by 3%, 6% and 9% by weight of cement. Fibers are generally used as resistance of cracking and strengthening of concrete. Admixtures are used in the concrete to improve the strength of the concrete and to reduce the water cement ratio. Steel fiber reinforced concrete is subjected to check the influence of fibers on tensile strength, compressive strength and flexural strength of concrete. Cubes of size 150mm x 150mm x 150mm is used to check the compressive strength , cylinders of diameter 150mm and height 300mm is used to check the splitting tensile strength of the concrete and beams of size 500mm x 100mm x100mm for checking flexural strength of the concrete. All the specimens were cured for the period of 14days and 28days before crushing. The results of fiber reinforced concrete for 14 days and 28 days curing with varied % of fibers were studied and it has been found that there is the significant strength improvement in the steel fiber reinforced concrete. Finally it has been observed that with the increase in fiber content up to the optimum value increases the strength of concrete.

Keywords—Steel fibre; mechanical properties; normal weight concrete .

1.INTRODUCTION

Concrete is the most extensively used construction material in the world. The reason for its extensive use is that it provides good workability and can be moulded to any shape. It also replaces old construction materials such as brick and stone masonry. Hence concrete is very suitable for a wide range of applications. However concrete has some deficiencies as listed below:

- Low Tensile strength
- Low post cracking capacity
- Brittleness and low ductility
- Limited fatigue life

Therefore it is necessary to increase the mechanical properties, durability and crack resistance of the concrete. It has been found that different type of fibers added in specific percentage to concrete increases the tensile strength.

Fiber reinforced concrete may be defined as composite materials made with Portland cement, aggregate, and incorporating discrete discontinuous fibers. In FRC, thousands of small fibers are dispersed and distributed randomly in concrete during mixing, and thus improve concrete properties in all directions. These fibers are also used as a replacement to reinforcing steel. Fibers in the form of mat are also

being used in the development of high performance structural composite. Because of the vast improvements achieved by the addition of fibers to concrete, there are several applications where Fiber Reinforced Concrete (FRC) can be intelligently and beneficially used.

2. LITERATURE REVIEW

Performance of steel fiber reinforced concrete
Milind V. Mohod, Assistant Professor, Department of Civil Engineering, P.R.M.I.T. & R., Badnera. In his project he concluded that the workability of steel fiber reinforced concrete gets reduced as the percentage of steel fiber increases. Compressive strength and tensile strength goes on increasing by increase in steel fiber percentage upto the optimum value. The optimum value was found to be 1% and 0.75% respectively.

Experimental study on steel fiber reinforced concrete for M40 grade
A.M.Shende, A.M.Pande, M.Gulfam Pathan. Maharashtra, India. In this project it is observed that compressive strength, split tensile strength and flexural strength are on higher side for 3% fibers as compared to that produced from 0%, 1%, and 2% fibers. Compressive strength increases from 11 to 24% with addition of steel fibers. Flexural strength increases from 12 to 49% and split tensile strength increases from 3 to 41% with addition of steel fibers.

Some Studies on Steel Fiber Reinforced Concrete *Amit Rana, Adhoc Lecturer, Sarvajanik College of Engineering & Technology, Surat – 395001, Gujarat, India.* According to this project the flexural strength increases as percentage of fiber increases. The optimum value is founded as 6%. The grade of concrete used is M25. Beam size of 700mm x 150mm x 150mm is used.

Laboratory Characterisation of Steel Fiber Reinforced Concrete for varying Fiber Proportion and Aspect ratio
Mohammad Adnan Farooq, Dr.Mohammad Shafi Mir, N.I.T Srinagar, J&K, India. The conclusions drawn from the study are the workability was found to decrease with an increase in the fiber content. The optimum fiber value for compressive strength is founded as 1% for aspect ratio 63.

Enhancement on strength properties of steel fiber reinforced concrete
Noor Nabilah Sarbini, Izni Syahrizal Ibrahim, and A Aziz Saim, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia. In this project they concluded that addition of steel fibers increases the tensile, compressive and flexural strength. The optimum value of fiber content is $1.00 \leq vf \leq 1.50$ for STAHLCON®HE0.75/60 type of steel fiber

Steel Fiber Reinforced Concrete
Abdul Ghaffar1 Assistant Professor, Jawaharlal Darda institute of Engineering and Technology, Yavatmal, The purpose of this research is based on the investigation of the use of steel fibres in structural concrete to enhance the mechanical properties of concrete. The objective of the study was to determine and compare the differences in properties of concrete containing without fibres and concrete with fibres. This investigation was carried out using several tests, compressive test and flexural test. A total of eleven mix batches of concrete containing 0% to 5% with an interval of 0.5% by wt. of cement. „Hooked" steel fibres were tested to determine the enhancement of mechanical properties of

concrete. The workability of concrete significantly reduced as the fibre dosage rate increases. Key words: Steel fibres, FRC, Workability, Strengths.

Compressive behavior of steel fibre reinforced concrete R. D. Neves and J. C. O. Fernandes de Almeida, An experimental study to investigate the influence of matrix strength, fibre content and diameter on the compressive behaviour of steel fibre reinforced concrete is presented. Two types of matrixand fibres were tested. Concrete compressive strengths of 35 and 60 MPa, 0,38 and 0,55 mm fibre diameter, and 30 mm fibre length, were considered. The volume of fibre in the concrete was varied up to 1.5%. Simpie expressionsare proposed to estimate the Young's modulus and the strain at peak stress, from the compressive strength results, knowing fibre volume, length and diameter. An analyticalmodel to predict the stress-strain relationship for steel fibre concrete in compression is also proposed. The model results are compared with experimental stress-strain curves

A REVIEW STUDY ON USE OF STEEL FIBER AS REINFORCEMENT MATERIAL WITH CONCRETE

Er Gulzar Ahmad 1 , Er kshipra Kapoor Fibers are generally used as resistance of cracking and strengthening of concrete. In this project, I am going to carry out test on steel fiber reinforced concrete to check the influence of fibers on strength of concrete. According to various research papers, it has been found that steel fibers give the maximum strength in comparison to glass and polypropylene fibers. Now a days there exists many reinforcement techniques for improving the strength of those materials which lacks load carrying and less durable capacity. Use of steel fiber to enhance the strength and reduce maintenance is an ef ective technology established in recent times. Fiber reinforced concrete has been successfully used in slabs on grade, shotcrete, architectural panels, precast products, offshore structures, structures in seismic regions, thin and thick repairs, crash barriers, footings, hydraulic structures and many other applications. The usefulness of fiber reinforced concrete in various Civil Engineering applications is thus indisputable. This review study is a trial of giving some highlights for inclusion of steel fibers especially in terms of using them with new types of concrete.

STEEL FIBER REINFORCED CONCRETE A REVIEW

Abhijit Warudkar, Extensively used material in construction industry is concrete this is because of good workability and ability to be moulded to any shape. Ordinary cement concrete possesses very low tensile strength, limited ductility and less resistance to cracking. The concrete shows the brittle behaviour and fails to handle tensile loading hence leads to internal micro cracks which are mainly responsible for brittle failure of concrete. In this era, RCC constructions have their own structural and 14
durability requirements, every structure has its own intended purpose and hence to meet this purpose, modification in traditional cement concrete has become mandatory. It has been proved that different type of fibers added in specific percentage to concrete improves the mechanical properties, durability and serviceability of the structure. As compared to other fibers it is now established that one of the important properties of Steel Fiber Reinforced Concrete (SFRC) is its superior resistance to cracking and crack propagation. In this paper Past studies based on the Steel fiber concrete is studied in detail.

Ronald F. Zollo (1997) presented an overview regarding the history and development of Fibre Reinforced Concrete

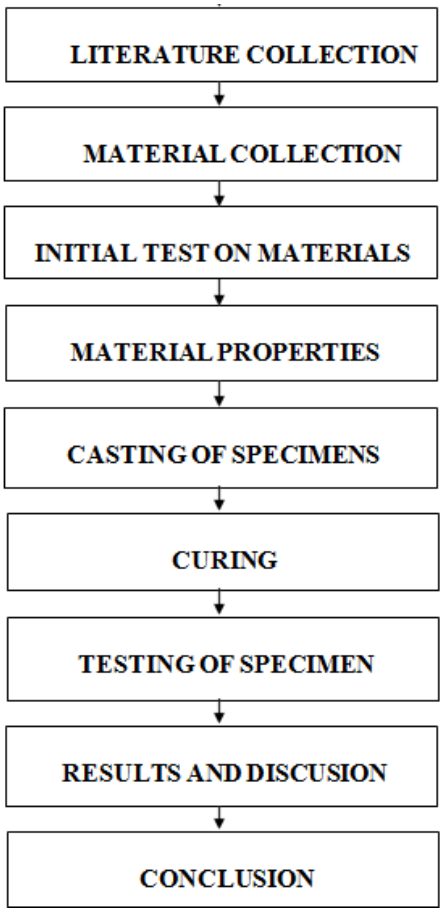
30 years ago. According to this report, in the early 1960s, the works on fibre reinforced concrete had been started. A lot of research work has been conducted by many researchers on different fashions. But these projects have studied about steel fibres alone. So far, there were only a few works which have studied the other fibres like nylon, plastic, rubber and natural fibres. But those researches are completely 11 different from the current study, since they have concentrated along the material strength properties not on their strucutral behavior

Kukreja et al (1980) conducted some experiments and reported that, based on the results of three methods such as split tensile test, direct tensile test and flexural test, split tensile strength test was recommended for fibrous concrete. Also increase in tensile strength and post cracking strength, toughness were reported.

Goash et al (1989) studied tensile strength of SFRC and reported as inclusion of suitable short steel fibres increases the tensile strength of concrete even in low volume fractions. Optimum aspect ratio was found as 80 and the maximum increase in tensile strength was obtained as 33.14% at 15 a fibre content of 0.7% by volume. Also it was reported that cylinder split tensile strength gave more uniform and consistent results than the modulus of rupture test and direct tension test.

Balaguru and Shah (1992) have reported that the fibres that are long and at higher volume fractions were found to ball up during the mixing process. The process called „balling" occurs and causes the concrete to become stiff and a reduction in workability with increase volume dosage of fibres. This has a tendency to influence the quality of concrete and strength.

3. METHODOLOGY



4. PRELIMINARY TEST

4.1 Cement

In this section, the Specific Gravity, Initial and Final Setting Time of cement to be tested as per IS Standard and results are as follow.

Table 4.1 Properties of OPC

Test	Result	As per IS Std.
Initial setting time	37 min	Not < 30 min.
Final setting time	475 min	Not > 600 min
Specific gravity	3.15	2.5 – 3.15

4.2 Fine Aggregate

In this section, the Water Absorption, Specific Gravity and Sieve Analysis of fine aggregate to be carried out as per IS383 standard and results are as follow.

Table 4.1 Properties of Fine Aggregate

Test	Value	As per IS Std.
Water absorption	1.42	IS:2386 (Part III)
Specific Gravity	2.60	2.6-2.8

4.3 Coarse Aggregate

In this section, the Water Absorption, Specific Gravity and Sieve Analysis of coarse aggregate to be carried out as per IS383 standard and results are as follow.

Table 4.3 Properties of Coarse Aggregate

Test	Value	As per IS Std.
Water absorption	0.66%	IS:2386 (Part III)
Specific Gravity	2.76	2.6-2.85

4.4 Steel Fiber

Table 4.4 Physical Properties of Steel Fibre

S.NO	**Physical Properties**	**Values**
1	Tensile strength (Mpa)	1050Mpa
2	Modulus of Elasticity	200Gpa
3	Diameter	0.45mm

Mix Design and Batching

We designed a mix for M30 grade concrete for the following datas.

a) Grade designation : M30
b) Type of cement : OPC 53 grade
c) Minimum cement content : 320 kg/m3
d) Maximum water-cement ratio : 0.50
e) Exposure condition : Moderate
f) Method of placing : Manual
g) Degree of supervision : Good
h) Type of aggregate : fine aggregate
i) Maximum cement content : 450 kg/m3

4.5 Fresh Concrete

Fresh concrete is that stage of concrete in which concrete can be moulded and it is in plastic state. The potential strength and durability of concrete of a given mix proportion is very dependent on the degree of its compaction. In this project, we have conducted two tests on fresh concrete.

(a) Slump cone test

(b) Compaction factor test

Table 4.5 Physical Properties of Fresh Concrete

S.NO	Test	Value	As Per IS Std.
1	Slump Cone	90mm	Medium
2	Compaction Factor	0.93	Medium

5. RESULT AND DISCUSSION

5.1 COMPRESSION TEST

Comparison of compressive strength of SFRC 0%, 3%, 6% & 9% undulated and hooked steel fibers

Table 5.1 Results of compressive strength

Steel Fiber	Days	Compression strength(N/mm^2)			
		% of Steel Fiber			
		0%	3%	6%	9%
Undulated	7	25.5	32.4	28	26.2
	14	31.1	40.5	35	33.4
	28	37.7	47.7	42.1	38.8
Hooked End	7	25.5	25.3	30.2	33.8
	14	31.1	33.0	40.6	46.5
	28	37.7	39.0	46.9	52

5.2 SPLIT TENSILE STRENGTH TEST

Comparison of Split tensile strength of SFRC 0%, 3%, 6% & 9% undulated and hooked steel fibers

Table 5.2 Results of Split Tensile Strength

Types of Steel Fiber	Days	Tensile strength(N/mm^2)			
		% of Steel Fiber			
		0%	3%	6%	9%
Undulated	7	2.5	4.6	4.3	4.1
	14	3.2	6.4	6.3	5.5
	28	3.9	7.2	6.8	6.4
Hooked End	7	2.5	3.8	4.3	4.5
	14	3.2	5.7	6.3	6.7
	28	3.9	6.4	7.0	7.3

5.3 FLEXURAL STRENGTH TEST

Comparison of flexural strength of SFRC 0%, 3%, 6% & 9% undulated and hooked steel fiber Table 5.3 Flexural Strength

Types of Steel Fiber	Days	Flexural Strength(N/mm^2)			
		% of Steel Fiber			
		0%	3%	6%	9%
Undulated	7	3	4.9	3.8	3.4
	14	4.8	5.7	5.1	4.9
	28	5.0	7.8	6.2	5.4
Hooked End	7	3	3.75	5.1	5.5
	14	4.8	5.1	5.8	7.5
	28	5.6	6.0	8.0	8.7

6.Durability test

Quantity of chemicals used for different chemical attacks as percentage of volume are:

1. Acid Attack: 5% Conc. Sulphuric Acid (H2SO4)
2. Chloride Attack: 10% Sodium Chloride (NaCl)
3. Sulphate Attack: 5% Magnesium Sulphate (MgSO4)

Table 6.1 WEIGHT REDUCTION AFTER ACID ATTACK.

Types of Steel fiber	% of Fiber	Initial Weight (Kg)	Weight After Acid Attack (Kg)	Weight Reduction (%)
Undulated	0	8.15	7.55	7.36
	3	8.3	7.95	4.21
	6	8.42	7.93	5.81
	9	8.5	7.95	6.47
Hooked End	0	8.15	7.55	7.36
	3	8.3	7.7	6.62
	6	8.42	7.95	5.58
	9	8.5	8.15	4.11

Table 6.2 WEIGHT REDUCTION AFTER CHLORIDE ATTACK.

Types of Steel fiber	% of Fiber	Initial Weight (Kg)	Weight After Chloride Attack (Kg)	Weight Reduction (%)
Undulated	0	8.2	8.11	1.09
	3	8.28	8.25	0.36
	6	8.33	8.29	0.48
	9	8.5	8.42	0.94
Hooked End	0	8.2	8.11	1.09
	3	8.25	8.18	0.84
	6	8.3	8.24	0.72
	9	8.45	8.41	0.47

Table 6.3 WEIGHT REDUCTION AFTER SULPHATE ATTACK.

Types of Steel fiber	% of Fiber	Initial Weight (Kg)	Weight After SULPHATE Attack (Kg)	weight Reduction (%)
Undulated	0	8.21	8.1	1.33
	3	8.25	8.21	0.48
	6	8.35	8.29	0.71
	9	8.4	8.33	0.83
Hooked End	0	8.21	8.1	1.33
	3	8.25	8.18	0.84
	6	8.3	8.24	0.72
	9	8.45	8.40	0.59

7. CONCLUSION

The following conclusions were drawn from the work carried out:

- It is observed that the workability of steel fiber reinforced concrete gets reduced as the percentage of steel fiber increases.
- In this project work, it is observed that the increase of 26% of compressive strength, 85% of split tensile strength and 56% flexural strength in undulated fiber when compared with conventional concrete.
- In this project work, it is observed that the increase of 38% of compressive strength, 87% of split tensile strength and 55% flexural strength in hooked fiber when compared with conventional concrete.
- In case of undulated fibers it is noted that the compressive strength, split tensile strength and flexural strength are on higher side for 3% fibers as compared to that produced from 0%, 6% and 9% fibers.
- It is observed that the compressive strength, split tensile strength and flexural strength are on higher side for 9% hooked end fibers as compared to that produced from 0%, 3% and 6% hooked end fibers.
- In case of undulated fibers it is noted that Percentage of weight reduction is less for 3% fibers as compared to that produced from 0%, 6% and 9% fibers.
- In case of hooked fibers it is noted that Percentage of weight reduction is less for 9% fibers as compared to that produced from 0%, 3% and 6% fibers.

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