Study on Workability and Compressive Strength of Concrete Blended with Steel Fibers

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Abstract - *Concrete is one of the world most widely used construction material. However, since the early 1800's, it has been known that concrete is weak in tension. Weak tensile strength combined with brittle behavior result in sudden tensile failure without warning. This is obviously not desirable for any construction material. Thus, concrete requires some form of tensile reinforcement to compensate its brittle behavior and improve its tensile strength and strain capacity to be used in structural applications. Historically, steel has been used as the material of choice for tensile reinforcement in concrete. Unlike conventional reinforcing bars, which are specifically designed and placed in the tensile zone of the concrete member, fibers are thin, short and distributed randomly throughout the concrete member.*

Fibers are commercially available and manufactured from steel, plastic, glass and other natural materials. Steel fibers can be defined as discrete, short length of steel having ratio of its length to diameter (i.e. aspect ratio) in the range of 20 to 100 with any of the several cross-section, and that are sufficiently small to be easily and randomly dispersed in fresh concrete mix using conventional mixing procedure. The random distribution results in a loss of efficiency as compared to conventional rebar's, but the closely spaced fibers improve toughness and tensile properties of concrete and help to control cracking. In many situations it is prudent to combine fiber reinforcement with conventional steel reinforcement to improve performance.

This study attempts to evaluate the impact of addition of steel fibers on conventional concrete mixes and their performance is analyzed. The experimental work has been carried out as addition of steel fibers of aspect ratio 75-100 in 0%, 0.5%, 1%, 1.5%, and 2% to volume of concrete and observes the change in properties of the concrete.

Key Words: **Fibre reinforcement, Steel Fibre, Aspect ratio**

1. INTRODUCTION

The Usage of SFs in concrete was first suggested in 1910. However, the primary scientific research on fibre reinforced concrete (FRC) in the United States was done in 1963. SFRC is produced the usage of the traditional hydraulic cements, first-class and coarse aggregates, water, and SFs. SFs as discrete, short lengths of metallic having thing ratio (ratio of lenth to diameter) within the range of 20 to one hundred with any of the numerous cross-section which are sufficiently small to be without problems and randomly dispersed in clean concrete mix the usage of conventional blending procedures.

Fig -1: Steel Fiber Reinforced Concrete

To enhance the workability and balance of SFRC, super plasticizers (chemical admixtures) can also be brought into the concrete mix.

The useful influence of Steel Fibers in concrete relies upon on many factors inclusive of type, shape, length, cross section, strength, fiber content, matrix strength, bond strength, mix design, and mixing of concrete.

The addition of Steel Fibers inside the conventional reinforced concrete (RC) individuals has several benefits consisting of

1- Steel Fibers enhances the tensile strength of the matrix, thereby improving the flexural performance of the concrete.
2- The crack bridging mechanism of Steel Fibers and their tendency to redistribute stresses evenly throughout the matrix contribute to the post-cracking strength and restraining of the cracks in the concrete.
3- Increase ductility of the concrete.
4- SFRC is extra durable and serviceable than conventional reinforced concrete.

The only drawback of SFRC would be its reduced workability and expanded stiffening of fresh concrete because of the addition Steel fibers, thereby growing the construction exertions and time because of the excess vibration required to make the SFRC workable. This hassle may be partially overcome with the usage of newly developed high variety super plasticizers which not best enhance the workability of SFRC however also keep the plasticity of the mix for an extended time.

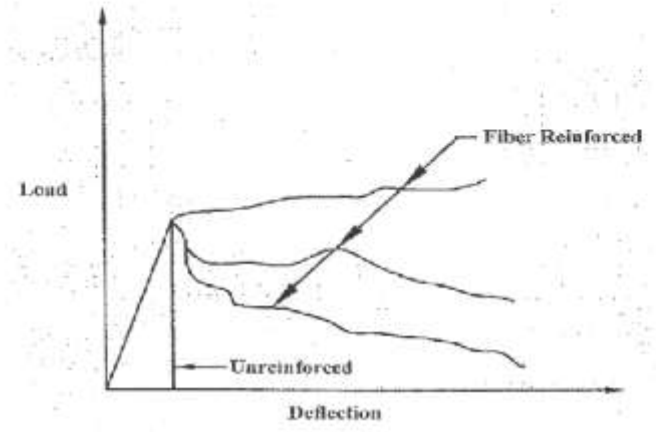

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Fig -2: Load deflection curve

along with the traditional building materials. Incorporation of Nano materials in concrete is a most promising concept for developing concrete having certain desirable properties. The extremely fine size of the particles can alter the specific surface area and hence the properties of concrete. Nano particles added cement composite can increase the workability, strength and durability characteristics.

2. LITERATURE REVIEW

Experimental investigation were carried out O.Kayali et al. on the effect of polypropylene and steel fibres on high strength light weight aggregate concrete. Sintered fly ash aggregates were used in the light weight concrete. By adding polypropylene fibres at 0.56% by volume of the concrete caused a 90% increase in the indirect tensile strength and a 20% increase in the modulus of rupture, whereas addition of steel fibres at 1.70% of volume of concrete increased the indirect tensile strength by about 118% and 80% increase in modulus of rupture. Finally there is a significant gain in ductility when steel fibres are used.

Kaushik S.K., et al. carried out experimental investigation on the mechanical properties of reinforced concrete by adding 1.0% volume fraction of 25mm and 50 mm long crimped type flat steel fibres. It was observed that short fibres acts as crack arrestors and enhances the strength, where as long fibres contributed to overall ductility. They concluded that best performance was observed with mixed aspect ratio of fibres. Song, Hwang and Shou carried out experimental investigations to study the impact resistance of steel fibre reinforced concrete using drop weight test method. They used hooked end fibres with 0.55mm in diameter and 35mm long. They concluded that steel fibrous concrete improved to various degrees to first crack and failure strengths and residual impact with standing capacity over the non-fibrous concrete.

2.1 Aim & Objectives

- To contribute towards the information data base of the properties and performance of steel fiber reinforced concrete and plain concrete with various percentages of steel fibers have been analyzed in extensive experiment.
- A study on these steel fibers will reveal the improvement in the various properties of hardened concrete.
- To maintain a good indoor environmental quality & performance of the building all through.
- To conduct the compressive test and study workability.

3. MATERIALS AND METHODOLOGY

3.1 Materials used

Cement:

43 Grade
Fineness: 5.4%
Consistency: 28.5%
Initial setting time: 46min
Avg compressive strength: 48.33 N/mm^2 (28 days).
Aggregates: Locally available coarse and fine aggregate were used.
Grade of concrete: M15 (1:2:4)
Water Cement ratio: 0.4 to 0.5
Temperature: 32^{0}C
Volume of fibers: 0-2%
Aspect ratio: 75-100

3.2 Method Adopted

1. Properties of various constituents of concrete viz, Cement, fine aggregates, coarse aggregates were determined, by carrying out various tests.
2. Grade M15 concrete was designed as per IS: 10262-2009 which is used as reference mix.
3. Steel fibers were added in 0%, 0.5%, 1%, 1.5%, and 2%, by weight of Concrete.
4. Cube and cylinders was casted and curing was done.
5. Compressive strength test, Workability analysis was done.

4. EXPERIMENTAL PROGRAMME

Mix Proportions for M15 grade of Concrete
Cement = 312 kg/m^3
Water = 161 liters for 1m^3
Fine aggregate(M sand) = 624 kg/m^3
Coarse aggregate 20mm =1248 kg/m^3

The specimens of standard sizes and required shapes of different mix proportions were casted for 7, 14, 28, days and curing process is carried out after 24hrs from casting time.

5. RESULTS AND DISCUSSIONS

All the tests have been performed in standard procedures and the results and load values obtained were tabulated and calculated in following sections.

5.1 Slump flow

Slump cone values for concrete mixes are given in table 5.1 below

Test Results of Slump Cone Test	
M-15 Mix With 0% Steel Fibers	
Sample	**Slump**
Water Cement Ratio = 0.4 with no plasticizers	66mm
Water Cement Ratio = 0.45 with no plasticizers	96mm
Water Cement Ratio = 0.5 with no plasticizers	124mm
M-15 Mix With 0.5% Steel Fibers	
Water Cement Ratio = 0.4 with no plasticizers	56mm
Water Cement Ratio = 0.45 with no plasticizers	88mm
Water Cement Ratio = 0.5 with no plasticizers	106mm
Water Cement Ratio = 0.45 with 0.5% plasticizers	156mm
M-15 Mix With 1% Steel Fibers	
Water Cement Ratio = 0.4 with no plasticizers	31mm
Water Cement Ratio = 0.45 with no plasticizers	65mm
Water Cement Ratio = 0.5 with no plasticizers	95mm
Water Cement Ratio = 0.45 with 0.5% plasticizers	135mm
M-15 Mix With 1.5% Steel Fibers	
Water Cement Ratio = 0.4 with no plasticizers	Even mixing was not seen
Water Cement Ratio = 0.45 with no plasticizers	30mm Harsh Mix
Water Cement Ratio = 0.5 with no plasticizers	63mm
Water Cement Ratio = 0.45 with 0.5% plasticizers	92mm
Water Cement Ratio = 0.45 with 1% plasticizers	124mm
M-15 Mix With 2% Steel Fibers	
Water Cement Ratio = 0.4 with no plasticizers	Even mixing was not seen
Water Cement Ratio = 0.45 with no plasticizers	28mm Harsh Mix
Water Cement Ratio = 0.5 with no plasticizers	48mm
Water Cement Ratio = 0.45 with 0.5% plasticizers	64mm
Water Cement Ratio = 0.45 with 1% plasticizers	80mm
Water Cement Ratio = 0.45 with 1.5% plasticizers	134mm

Table -5.1: Slump Flow values

5.2 Compressive Strength

Compressive strength tests were conducted on cured cube specimen at 7 days and 28 days age using a compression testing machine of 200 kN capacity. The cubes were fitted at center in compression testing machine and fixed to keep the cube in position. The load was then slowly applied to the tested cube until failure.

Compressive strength (N/mm^2)		
Concrete Age Tested, days	**7**	**14**
Specimen 0% Steel Fibers		
Sample -1	16.35	20.44
Sample -2	17.96	21.64
Sample -3	17.19	21.22
Average Compressive Strength	17.17	21.10
Specimen 0.5% Steel Fibers		
Sample -1	17.99	22.48
Sample -2	20.12	24.24
Sample -3	18.56	22.92
Average Compressive Strength	18.89	23.21
Specimen 1% Steel Fibers		
Sample -1	18.90	23.63
Sample -2	20.83	25.10
Sample -3	19.77	24.40
Average Compressive Strength	19.83	24.38
Specimen 1.5% Steel Fibers		
Sample -1	19.79	24.73

Sample -2	21.91	26.40
Sample -3	21.14	26.10
Average Compressive Strength	20.95	25.74
Specimen 2% Steel Fibers		
Sample -1	20.93	26.16
Sample -2	22.81	27.48
Sample -3	22.00	27.16
Average Compressive Strength	21.91	26.94

Table -5.2: Compressive Strength values

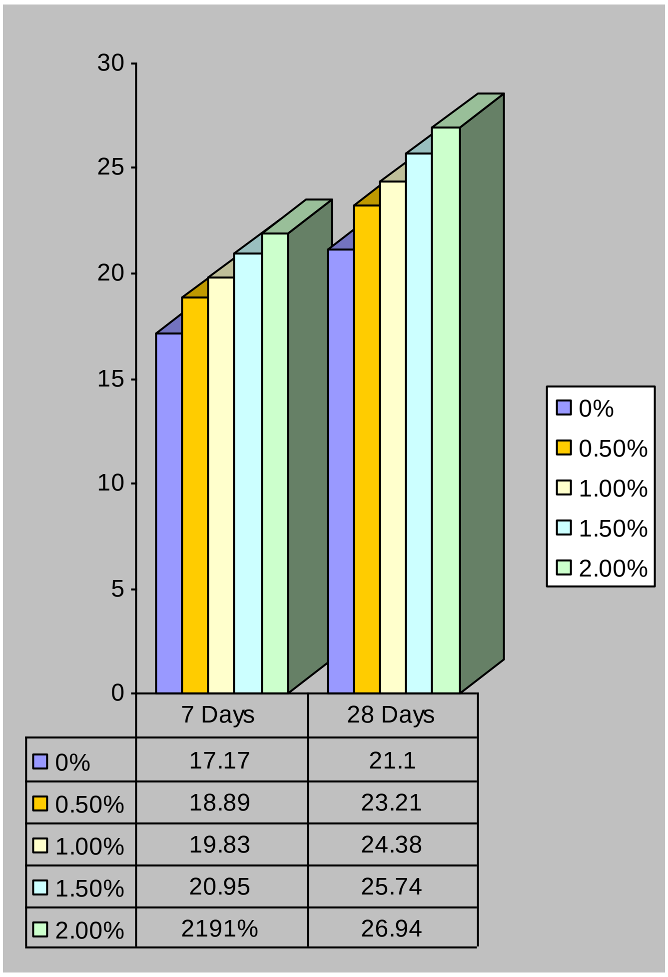

Chart -5.2: Compressive Strength

6. SUMMARY AND CONCLUSIONS

The main objective of this study is to analyze the performance of steel fiber reinforced concrete and plain concrete with various percentages of steel fibers. The following conclusions were obtained as a result and performance for the tests conducted.

- A shortcoming of using fibers in concrete is reduction in workability.
- As Fiber content increases, workability decreases.
- This study is limited to volume of fibers 2% and aspect ratio l/d to 100 to avoid unworkable mixes 1,5% of plasticizers were added to the mix.
- The conventional mix with 0% steel fibers achieves a compressive strength of 17.17 N/mm2 and 21.10 N/mm2 for 7 and 28 days of curing respectively.
- A concrete with 2% volume of fibers achieves a compressive strength of 21.91 N/mm2 and 26.94 N/mm2 for 7 and28 days of curing respectively.
- Considerable increase in compressive strength (27.67%) of steel fiber reinforced concrete at volume of fiber 2% water cement ratio 0.45 and 1.5% plasticizers was observed.

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