Increasing Compressive Strength of Concrete Using Fibers

D. Ravi Prakash[1], V. Brahmaiah[2], N. Katamraju[3], Sk. Sadik[4]
[1,2,3,4]*Student, PACE Institute of Technology & Sciences*

Abstract— **Fiber reinforced concrete (FRC) is a popular and effective solution for civil engineering applications, including slabs, architectural panels, precast products, offshore structures, seismic regions, crash barriers, footings, and hydraulic structures. FRC contains short, uniformly distributed fibers, such as steel, glass, synthetic, and natural fibers, which increase structural integrity and reduce micro-cracks. This method improves concrete properties in all directions, increasing toughness, shock resistance, and resistance to plastic shrinkage cracking. This study explores the strength, mechanical properties, and durability of FRC.**

Keywords— **Steel Fibers, Glass Fibers, Water, Fiber Reinforced Concrete.**

I. INTRODUCTION

Concrete is brittle and has poor tensile strength compared to other materials like metals and polymers. Steel is 100 times more resistant to crack growth, making concrete vulnerable to damage. To address this, fiber reinforced concrete (FRC) is being used as a reinforcement material. FRC has improved mechanical characteristics such as fracture strength, toughness, impact resistance, and flexural strength resistance to fatigue. It is widely used in pavements, bridge decks, offshore structures, and machine foundations. The addition of steel fibers improves the post-cracking response, energy absorption capacity, apparent ductility, crack resistance, and crack control. This method also maintains structural integrity and cohesiveness in the material. The development of fiber reinforced concrete has led to a wide variety of material formulations that fit the definition of FRC. SFRC exhibits better performance under static and quasi-static loads, fatigue, impact, and impulsive loading.

Joseph Monnier, a French gardener, invented reinforced concrete in 1849, which is crucial for modern buildings. It enables the production of frames, columns, foundations, beams, and other structures, ensuring smooth load transmission and equal strain between concrete and reinforced material.

Pramod Kawde (2017) et al, This research reveals that ordinary cement concrete has low tensile strength, limited ductility, and less crack resistance, leading to internal micro cracks. To meet structural and durability requirements, modifications in traditional cement concrete are necessary. Steel Fiber Reinforced Concrete (SFRC) has superior resistance to cracking and crack propagation, and this paper explores past studies on SFRC.

J.D. Chaitanya Kumar et al. (2016), A study on M20 grade concrete with varying amounts of glass fiber showed that adding 2% fiber increased its compressive strength by 26.98Mpa, flexural strength by 2.94Mpa, and tensile strength by 3.57Mpa after 28 days of curing. This increased workability reduced cracks under different loading conditions.

Vasudev R, Dr. B G Vishnu ram (2013) et al This paper compares ordinary reinforced concrete and steel fiber reinforced concrete using turn fibers from lathe shops. Experimental investigations showed that composite concrete with varying fiber percentages improved performance compared to conventional steel fibers. The study suggests these sustainable improvements could be easily adopted by the common man in regular constructions.

So, fiber is one of the methods to improve the mechanical properties of the structural concrete. Some important objectives are given below:

1. To study the behavior of the reinforced concrete strengthened with fibers.
2. To improve durability of concrete and reduce crack growth by adding fibers to the concrete.
3. To improve impact strength and resistance against freezing and thawing with the addition of fibers to the concrete.

II. MATERIALS AND METHODOLOGY

A. Steel Fibers

Steel fibers are of three types. They are Straight, Hooked-end and Corrugated fiber, and a type of monofilament polypropylene project is Hooked end steel fibers. fiber are considered. The steel fiber used in this

Diameter: 0. 5 to 1. 0mm;

Length: 25 to 60mm: Aspect Radio: 250; Tensile strength: ≥1000Mpa:

Material: Low carbon steel bar; Coating: Non, Bright.

B. Glass Fibers

Glassmakers throughout history have experimented with glass fibers, but mass manufacture of glass fiber was only made possible with the invention of finer machine tooling.

Diameter: 3.8 and 20 mm;

Length: 12mm;

Material: Silica-based glass fibers.

C. Cement

Locally available Ordinary Portland cement 53 grade are used

D. Coarse Aggregates

Coarse aggregates are particulates that are greater than 4.75mm. The usual range employed is between 9.5mm and 37.5mm in diameter.

Stone: Crushed stone, Size: 15mm, 20mm and 25mm Specific gravity: 2.76, Density: 1100-1750kg/m³

Code:IS-393-1970

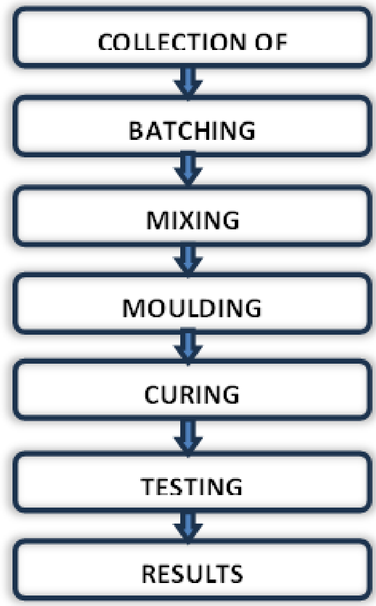
E. Fine Aggregates

Sand occurs naturally and is composed of fine rock material and mineral particles. Its composition is variable depending on the source. It is defined by size, being finer than gravel and coarser than silt. Locally available zone-2 sand.

Specific gravity: 2.6, Is code: IS-393-1970

F. Water

The water used for preparation of Fiber reinforced concrete is portable water. PH range between 6 to 8 is used



G. Procedure For Casting Cubes
150mmx150mmx150mm

Clean the cube mould properly with a cloth and apply a coat of firm oil on the inner surfaces of the mould. No excess oil should be visible on the inner surfaces. Fix the nuts & bolts tightly with base plate and side plates, no gaps should be seen within the parts of cube mould. It is necessary that the cube mould should be placed on a clean, level & firm surface for filling the concrete in it.

H. Procedure For Casting Prism
150mmx150mmx700mm

Clean the prism mould properly with a cloth and apply a coat of firm oil on the inner surfaces of the mould. No excess oil should be visible on the inner surfaces. Fix the nuts & bolts tightly with base plate and side plates, no gaps should be seen within the parts of prism mould. It is necessary that the mould should be placed on a clean, level & firm surface for filling the concrete in it.

I. Compression Test

Compressive strength of concrete measures its ability to resist compressive loads, measured by crushing cube specimens in compression testing machines, ranging from 17 MPa for residential to 70 MPa for commercial structures. For cube test two types of specimens either cubes of 150mm X 150mm X 150mm or 100mm X 100mm x 100mm depending upon the size of aggregate are used. For most of the works cubical moulds of size 150mm x 150mm x 150mm are commonly used.

$$\text{Compressive strength of concrete} = \frac{\text{Load at which specimen fails}}{\text{Cross section area of cube}}$$

J. Flexural Test

Flexure tests measure material's flexural modulus or strength, using a more affordable method. They involve tamping concrete layers, ensuring uniform distribution of force at failure. Clean the bearing surfaces of the supporting and loading rollers, and remove any loose sand or other material from the surfaces of the specimen where they are to contact the rollers. the load shall be applied at a rate of loading of 400 kg/min for the 15.0 cm specimens and at a rate of 180 kg/min for the 10.0 cm specimens.

III. RESULT AND DISCUSSION

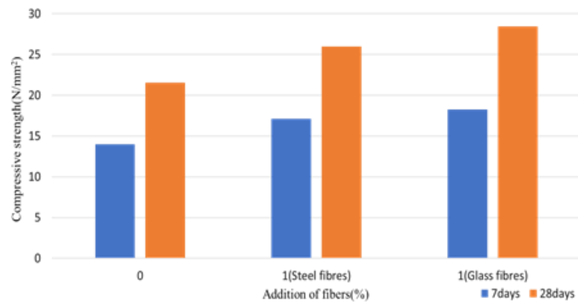
Results for the compressive strength test and flexural strength test measurements are presented in graphical forms

A. Compression Strength Test:

Size 150 x 150 x 150mm were casted and tested for 7 days and 28 days testing of the specimens for each percentage after conducting the workability tests. The results are tabulated below.

Compressive strength results at 7 days& 28 days

S. No	Addition of Fibers (%)	Compressive Strength(N/mm^2) (at 7 days)	Compressive Strength(N/mm^2) (at 28 days)
1	0	14.00	21.16
2	1(S.F)	16.52	26.00
3	1(G.F)	18.24	28.46

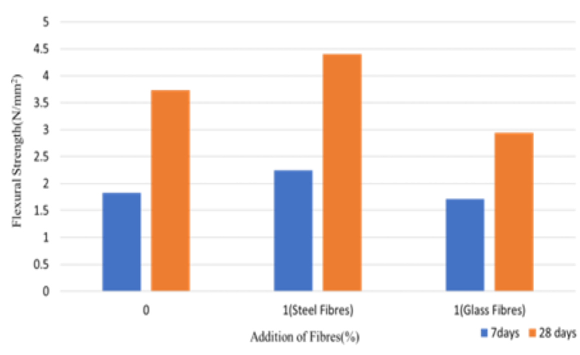


Compressive strength of normal concrete is 14.00 N/mm^2 At 7 days and 21.16N/mm^2 at 28 days and compressive strength of steel fibres 16.52 N/mm^2 at 7 days and 26.00 N/mm^2 at 28 days and compressive strength of glass fibres 18.24 N/mm^2 at 7 days and 28.46 N/mm^2 at 28 days.

B. Flexural Strength Test

Flexural strength results at 7 days & 28 days

S. No	Addition of Fibers (%)	Flexural Strength(N/mm^2) (at 7 days)	Flexural Strength(N/mm^2) (at 28 days)
1	0	1.83	3.73
2	1(S.F)	2.12	4.46
3	1(G.F)	1.71	2.94



Flexural strength of normal concrete is 1.83 N/mm2 at 7 days and 3.73N/mm2 at 28 days and flexural strength of steel fibres 2.12 N/mm2 at 7 days and 4.46 N/mm2 at 28 days and flexural strength of glass fibres 1.71 N/mm2 at 7 days and 2.94 N/mm2 at 28 days.

IV. CONCLUSION

1) It has been reported that the concrete containing steel and glass fibers have achieved 18 – 20% and 30 -32% more compressive strength respectively at 7days and 28 days tests.
2) It has also been reported that the concrete containing steel fibers have achieved 15 -17% more flexural strength at 7 days and 28 days test.
3) It is concluded that compressive strength can be increased by adding glass fibers and flexural strength can be increased by adding steel fibers to the concrete.
4) Fibers increases the concrete's durability.
5) It reduces crack growth and increases impact strength.
6) Fiber-reinforced concrete improves resistance against freezing and thawing.
7) This is crucial for an outside environment application for weather that experience tremendous amount of moisture, wet and dry through rain and dry season.
8) Fiber-reinforced concrete also have high fire-resistant properties thus reducing the loss of damage during fire accidents.

REFERENCE

[1] R.N. Swamy, "Testing and Test methods of Fibre Cement Composites", Published 1978, (pp 42- 43).

[2] Surendra P. Shah, James I. Daniel, DarmawanLudirdja, "Toughness of Glass Fiber reinforced concrete panels subjected to accelerated aging", PCI Journal, September-October 1987, (pp 83-88).

[3] ArnonBentur and Sidney mindess , " Fiber reinforced cementetious composites" , Second edition 2007, chapter 8

[4] Amit rana " some studies on steel fibre reinforced concrete" , Vol 3, 2013.

[5] Abdul Ghaffar, Amit S.Chavan, Dr.R.S. Tatwawadi, " Steel Fibre Reinforced Concrete ", International Journal of Engineering Trends and Technology (IJETT).

[6] Alan J,Bookes, " Cladding of Buildings", Third Edition

[7] Chandramouli, K. Srinivasa Rao P. Pannirselvam N., Seshadri Sekhar T. And Sravana P. (2010) "Strength Properties Of Glass Fiber Concrete" Asian Research Publishing Network VOL.5, NO. 4, APRIL 2010.

[8] Johnston, C.D, Colin, D. (1982). "Fibre Reinforced Concrete." Progress in Concrete Technology CANMET, Energy, Mines and Resources, Canada, pp 215-236.

[9] Johnston, C. D. 1974. Steel fiber reinforced mortar and concrete: a review of mechanical properties. Special Publication, 44, 127-142.

[10] Mangat, P. &Gurusamy, K. 1987. Permissible crack widths in steel fibre reinforced marine concrete. Materials and structures, 20, 338-347.

[11] Naaman, A. E. 1985. Fiber reinforcement for concrete. Concrete International, 7, 21-25.

[12] Steel Fiber-Reinforced Concrete. Technical Report No.115, National Institute of Statistical Sciences (NISS),Research Triangle Park,NC, USA

[13] ACI Committee 544, "State-of-the-Art Report on Fiber Reinforced Concrete", May 1982, pp 2-3