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Experimental Investigation on Steel Fiber Reinforced Concrete

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Abstract: *The objective of the study is to analyze systematically the effects of steel fiber reinforcement in concrete. Concrete were prepared using M30 grade concrete and looked end glued steel fiber with aspect ratio of 80 were added at a dosage of 0.75% , 1% , 1.25% volume fraction of concrete. The fiber reinforcement effects were analyzed for different types of distribution in the concrete beam Fibers were dispersed in two different ways either homogeneously in concrete sections or localized in the tension zone or laid parallel the beam axis. The mechanical properties such as the flexural strength using a third point loading and compressive strength property were determined. Load vs deflections were plotted for various fiber concrete specimens and toughness evaluations were made systematically using graph software an order to quantify the energy absorbing mechanism. Test result were compared with that of Plain concrete specimen and the relative improvements on the toughness were measured. Significant conclusions were drawn and comparative analyses on the post elastic deformation capacity of different concrete specimens were measured.*

Key Word: *Steel Fiber, Toughness, Compressive Strength, Split tensile strength.*

I.INTRODUCTION

The advantages of using fibers as reinforcement have been known since ancient times; e.g. 3500 years ago, sun-baked bricks were reinforced with straw. In modern times, in the early 1900s, asbestos cement was the first widely used manufactured composite. In the 1960s, research on fiber-reinforced concrete was already advancing fast, and at the present time, fibersof various kinds are used to reinforce concrete in structural applications. Due to its high stiffness, the steel fiber is probably the most commonly used fiber material. However, synthetic fibers are gaining ground, and new materials are under continuous development. The fiber-reinforced concrete materials may be classified as strain hardening or strain softening, to a large extent depending on the amount of fiber added. Strain hardening is recognized by an increasing tensile stress after the first cracking, and it is accompaniedby multiple cracking; strain-softening materialsexhibit a decreasing tensile stress after the first cracking Strain softening materials are composed of moderate amounts of fiber, typically Vf 1.0% by volume. They have become quite popular in the construction of industrial floors and are frequently used for tunnel linings (as sprayed concrete).The benefits of a strain-softening, fiber- reinforce material, as opposed to plain concrete, is mainly the greater possibility to control the size of the crack widths; thus it may play a major role from the point of view of durability. That is, smaller crack widths will delay the initiation of corrosion of the conventional reinforcement and consequently increase the possibility of a longer life span of the structure. In the past decade, self-compacting, fiber-reinforced concrete (SCFRC), has attracted increased scientific attention. With the use of SCFRC, the concrete is able to fill the mould driven by its own weight, thus avoiding the settling of fibers and aggregates, which may be caused by vibration. Strain hardening may be obtained by increasing the amountof fiber, although this is not quite as straightforwardas it may appear. For the slender fibers that are preferred for improved toughness, the reduced workability at increasing amounts of fiber, limits the maximum amount of fibers that can be incorporatedin the FRC mix. Although this can be overcome by different techniques, e.g. by reducing the aggregatesize, increasing the paste content (water, cement, mineral additions and fine particles) and introducing super-plasticizers, or by pre- placing the fibers, as in SIFCON (slurry infiltrated fiber concrete) and SIMCON (slurry infiltrated mat concrete), these techniques are quite costly. By optimizing the different components of the FRC, strain hardening may be achieved without simply an increase in fiber volume. Methods for obtaining strain-hardening composites with a normal strength matrix and moderate fiber content of about 2 % by volume.

II. EXPERIMENTAL PROGRAM

The experimental work was carried out by casting cubes of size 150 x 150 x 150mm to find the compressive strength cylinder of 100mm diameter and 200mm height were casted to obtain the stress strain curve. The SIFCON specimens (say F1,F2,F3,F4,F5) and without fiber (only slurry, say S1,S2,S3,S4,S5) were casted and TECHNOLOGY 2 compared with the conventional concrete (say C) of grade M30 to study the compressive strength and flexural strength. The edges of the mould were sealed with plaster of paris to prevent the leakage of slurry. The fiber is dispersed in a random manner to the volume fraction. Compaction by table vibrator was used to ensure complete penetration of the slurry into the fiber pack. Twenty four hours after casting, the cubes were demoulded and cured in water for 14 and28 days.

Materials Used

- Cement
- Fine Aggregate (M Sand)
- Coarse Aggregate
- Steel Fiber

Cement

Cement is made by heating limestone (calcium carbonate) with small quantities of other materials (such as clay) to 1450 °C in a kiln, in a process known as calcinations, whereby a molecule of carbon dioxide is liberated from the calcium carbonate to form calcium oxide, or quicklime, which is then blended with the other materials that have been included in the mix. The resulting hard substance, called 'clinker', is then ground with a small amount of gypsum into a powder to make 'Ordinary Portland Cement', the most commonly used type of cement (often referred to as PPC). Portland cement is a basic ingredient of concrete, mortar and most non-specialty grout. The most common use for Portland cement is in the production of concrete.

Fine Aggregate

The M sand is manufactured by crushing the quarry stones into required grain in size & after washing, grading the crushed cubical shape with rounded edges, it turned as construction material. The cleaned aggregates are placed into the primary crusher to crush the aggregates into fine aggregate. It passes through 4.75mm sieve. In fact utilization of M sand in construction is appreciated because it is eco- friendly. The type of sand used in this project is M sand.

Coarse Aggregate

Aggregates are the most mined materials in the World. The coarse aggregate is the important material to be added in concrete. The aggregates of size greater than 4.75mm are generally termed as coarse aggregates. The types of coarse aggregates are, • Crushed Aggregates • Uncrushed Aggregates Mostly uncrushed aggregates are not used in concrete due to their smooth surface. The strength value decreases with the usage of this aggregate. The crushed aggregates have high strength compared to uncrushed aggregates. Workability of Crushed aggregate is verymuch lesser compared to uncrushed aggregate. The size of the aggregate used in this project is 20mm.

Steel Fiber (Hooked)

Steel fibers are added to concrete to improve the structural properties, particularly tensile and flexural strength. The extent of improvement in the mechanical properties achieved with SFRC over those of plain concrete depends on several factors, such as shape, size, volume, percentage and distribution of fibers. Plain, straight and round fibers were found to develop very weak bond and hence low flexural strength. For a given shape of fibers, flexural strength of SFRC was found to increase with aspect ratio (ratio of length to equivalent diameter).

III.TESTING ON MATERIALS

Cement

In this project, Pozzalonic Portland Cementof 43 Grade conforming to Indian standards available in local market of standard brand is used for casting cubes, cylinders for M30 concrete mixes. The cement used was fresh, uniform color and without any hard lumps. . Testing of cement was done as per IS: 12269-1987.

Fine Aggregate

The locally available M sand was used asfine aggregate in the present investigation. The sand should be devoid of impurities like clay matter, salt and organic matter and is tested for different properties as per IS383-1970 such as specific gravity, fineness modulus, water absorption etc., Sieve analysis is carried out and it is passing through 4.75 mm sieve.

Coarse Aggregate

Machine crushed angular granite metal of 20mm size from a local source was used as coarse aggregate. It is from impurities such as dust, clay particles and organic matter etc., The coarse aggregate is also tested for its various properties. The aggregates of size greater than 4.75mm are generally termed as coarse aggregate. Testing of coarse aggregate is done as per IS: 383-1970.

Steel Fiber

The steel fiber used in this concrete as volume fraction the steel fiber increases tensile strength of the concrete. The test results are tabulated below.

Water

Water is the least expensive but most important ingredient of the concrete. The water used for making concrete should be clean and free from deleterious impurities like oil, alkalinities, acids etc., In general, the water fit for drinking is ideal for concrete making. In this project, potable tap water in the laboratory was used for the concrete preparation and for the curing of specimens.

Fresh Concrete Test

Though fresh state is transient, its condition seriously affects the behavioral properties of the final product. Poor compaction and improper curing will lead to porous concrete with low strength and high permeability. Fresh concrete is freshly mixed material which can be moulded into any shape. The relative quantities of cement, aggregate and water mixed together control the properties of concrete in wet state as well as in hardened state.

Properties of Fresh Concrete

- Compatibility
- Mobility
- Stability
- Consistency
- Segregation
- Bleeding
- Curing
- Workability

Workability

Workability is defined as the ease to placement with resistance to segregation. According to ACI:116R-90 workability is defined as the property of freshly mixed concrete or mortar which determines the case and homogeneity with which it can be mixed, placed, consolidated and finished. According to ASTM: C125 workability is the property of determining the effort required to manipulate a fresh mixed quantity of concrete with minimum loss of homogeneity. Therefore, the workability of concrete is associated with terms such as flow ability, mobility, stability, resistance to segregation, and palpability. Workability is necessary to compact concrete to the maximum possible density.

Slump Test

Slump is a measure indicating the consistency or workability of cement concrete. It gives an idea of water content needed for concrete to be used for different works. A concrete is said to be workable if it can be easily mixed and placed, compacted and finished. A workable concrete should not show any segregation or bleeding. Segregation is said to occur when coarse aggregate try to separate out from the finer material and a concentration of coarse aggregate at one place occurs. This results in large voids, less durability and strength. Bleeding of concrete is said to occur when excess of water comes up at the surface of concrete. This causes small pores through the mass of concrete and is undesirable.

Result:

Type of collapse: shear slump Slump value : 50 mm from top.

Compaction Factor Test

It gives an idea of degree of compaction and can be defined as the ratio of the density actually achieved in the test to the density of fully compacted concrete. The degree of compaction in this test is high. The degree of compaction in this test isachieved by allowing the concrete to fall fromstandard height to the container. This test is more sensitive and precise when compared to slump testand particularly useful for concrete mixes of very low workability as are normally used when concrete are insensitive to slump flow.

Workability Value

Compaction factor = 0.88 Compaction type =Medium

Mix Design

Concrete mix has been designed based on Indian Standard Recommended Guidelines IS10262:2019.

WATER lit/m^3	**CEMENT** kg/m^3	**FINE AGGREGATE** kg/m^3	**COARSE AGGREGATE** kg/m^3	**CHEMICAL ADMIXTURE** kg/m^3
153.6	342	612.7	1241	3.42
0.45	1	1.78	3.62	0.01

Test on Hardened Concrete

The following tests are conducted

- Compressive strength test
- Split tensile strength test

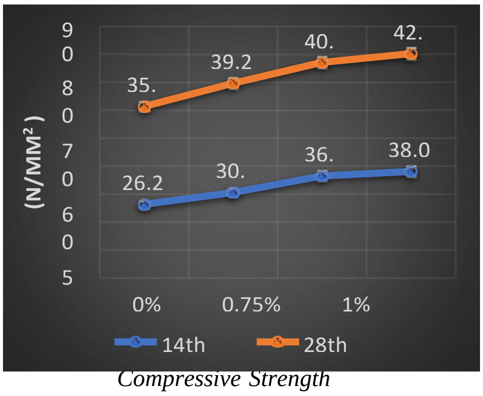
Compressive Strength Test

For compressive strength test cube specimens of dimensions 150 x 150 x 150 mm are cast using M30 grade of concrete with different percentage of polypropylene and steel fibers taken the volume of concrete. The top surface of the specimen was leveled and finished. After 24 hours, the specimens were de moulded and transferred to curing tank where in they were allowed to cure for 14 and 28days. After curing, these cubes were tested on compression testing machine. The failure load was noted. In each category, three cubes were tested and their average value is reported.

Then compressive strength determined by

= Load / Area.

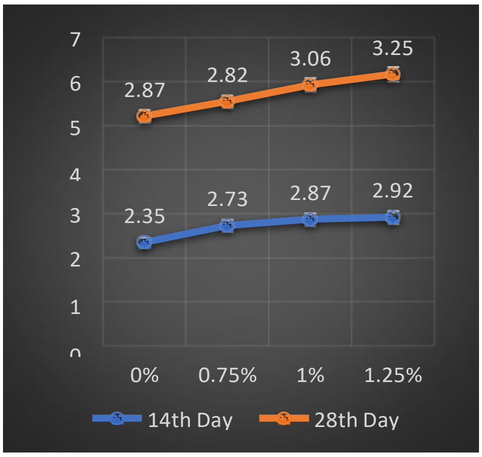
= P/A (N/mm2).



Compressive Strength

Split Tensile Strength Test

For 3 specimens of cylindrical shape of diameter 150 mm and length 300 mm were tested under a compression testing machine of 2000 kN capacity under a compressive load across the diameter along its length till the cylinder split tensile strength. The tension develops in a direction at right angles to the line of action of the applied load. The split tensile strength was calculated as follows



Split Tensile Strength

IV.CONCLUSION

The following conclusions could be drawn fromthe present investigation.

1. It is observed that compressive strength and splittensile strength are on higher side for 1.25% fibers as compared to that produced from 0%, 0.75%, 1% and 1.25% fibers.
2. It is observed that compressive strength increasesfrom 11 to 24% with addition of steel fibers.
3. It is observed that split tensile strength increases from 3 to 41% with addition of steel fibers

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resistance of steelfiber reinforced concrete.