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EXPERIMENTAL STUDY ON FIBER REINFORCED CONCRETE USING LATHE SCRAP FIBER

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ABSTRACT

Fiber reinforced concrete is a concrete containing fibrous materials that are uniformly distributed and randomly oriented. The fibers include steel fiber, glass fiber, natural fiber and synthetic fiber. The waste steel scrap material which is available from the lathe can be used as steel fiber for innovative construction industry and also in pavement construction. Lathe waste is generated by each lathe industries and dumping of these wastes in the barren soil contaminates the soil and ground water, which creates an unhealthy environment. In addition to get sustainable development and environmental benefits, lathe scrap as recycled fibers with concrete are likely to be used. In this project fiber reinforced concrete using lathe waste is prepared and its fresh and hardened properties are studied. The tests conducted were slump test, compressive strength test, split tensile strength test and flexural strength test. For this concrete cubes, beams and cylinders were casted and cured and tests were done at 7th day and 28th day.

I. INTRODUCTION

The concrete is considered to be the second in consumption by mankind, first being the water. The present day world is witnessing the construction of very challenging and difficult civil engineering structures. Quite often, concrete being the most important and widely used material is called upon to possess very high strength and sufficient workability properties. In terms of strength, compressive strength of concrete has a fairly large, but very low tensile strength of concrete. Provision allowing the concrete to steel reinforcement increases the tensile stress. Along with the development of technology, the research conducted to improve the properties of concrete, among others, with the addition of fiber. Efforts are being made in the field of concrete technology to develop such concretes with special characteristics. Researchers all over the world are attempting to develop high performance concretes by using fibres and other admixtures in concrete up to certain proportions. The effective utilization of locally available lathe waste material is certainly a great have to in the recent years.

The introduction of steel fiber to the cement concrete increases its engineering properties to a high extent and so usage of fiber reinforced concrete is increased day-by-day. The manufacture of one tonne of cement releases approximately one tonne of carbon dioxide to the atmosphere. The steel industry also produces such impacts to the environment. Thus it is high time to think about sustainable development and reduce the wastes generated or reuse it. The available steel fiber of different categories in market is considerably expensive. The lathe scraps produced in local lathes and workshops are in plenty and also are easily available at low cost. Every day about 8 to 10 kg of lathe waste are generated by each lathe industries and dumped in the barren soil there by contaminating the soil and ground water, which creates an environmental issue. The waste steel scrap material which is available from the lathe can be used as steel fiber for innovative construction industry and also in pavement construction. Hence by adopting proper management by recycling the lathe scrap with concrete is considered to be one of the best solutions.

This paper aims to have a comparative study between plain concrete and lathe fiber reinforced concrete. Experimental studies have to be done to know about the fresh and hardened properties of both plain and steel fiber reinforced concrete. These fibers may also contribute to improve properties such as shrinkage reduction, modulus of elasticity, toughness, resistance to cracking and preventing crack propagation.

The main objectives of this paper are-

- To investigate the use of lathe scraps as fiber in concrete.
- To compare the characteristics of strength between ordinary concrete and LSFRC.
- To compare the effects of different percentages of lathe fibers in concrete.
- Perform laboratory investigations in order to verify the workability of lathe fiber reinforced concrete.

II. LITERATURE REVIEW

Concrete is one of the most versatile building materials. It can be cast to fit any structural shape from ordinary rectangular beam or column to a cylindrical water storage tank in a high-rise building. It is readily available in urban areas at relatively low cost. Concrete is strong under compression but weak under tension. As such, a form of reinforcement is needed. The most common type of concrete reinforcement is by steel bars. The advantages in using concrete include high compressive strength, good fire resistance, high water resistance, low maintenance, and long service life. The disadvantages in using concrete include poor tensile strength, and formwork requirement. Other disadvantages include relatively low strength per unit weight. Tensile strength of concrete is typically 8% to 15% of its compressive strength. This weakness has been dealt with over many decades by using a system of reinforcing bars (rebars) to create reinforced concrete; so that concrete primarily resists compressive stresses and rebars resist tensile and shear stresses. The longitudinal rebar in a beam resists flexure (tensile stress) whereas the stirrups, which are wrapped around the longitudinal bar not only holds the longitudinal bars in position but also resist shear stresses. In a column, vertical bars resist compression and buckling stresses while ties resist shear and provide confinement to vertical bars. Cracks in reinforced concrete members extend freely until encountering a rebar and this is where the need for multidirectional and closely spaced reinforcement for concrete arises.

Fibres are usually used in concrete to control cracking due to both plastic shrinkage and drying shrinkage. They also reduce the permeability of concrete and thus reduce bleeding of water. Some types of fibres produce greater impact, abrasion and shatter resistance in concrete. Generally fibres do not increase the flexural strength of concrete, and so cannot replace structural steel reinforcement. If the modulus of elasticity of the fiber is higher than the matrix (concrete or mortar binder), they help to carry the load by increasing the tensile strength of the material. However, fibres which are too long tend to "ball" in the mix and create workability problems

III. EXPERIMENTAL PROGRAM

3.1 Materials

3.1.1. Cement

Cement acts as a binding agent for materials. Cement is the most expensive materials in concrete and it is available in different forms. When cement is mixed with water, a chemical reaction takes place as a result of which the cement paste sets and hardens to a stone mass. Depending upon the chemical compositions, setting and hardening properties, cement can be broadly divided into two categories such as Portland cement and special cement. Portland pozzolana cement conforming to Indian Standard 1489 (part 1) is used as a binder in this experimental investigation. Portland pozzolana cement produces less heat of hydration and offers greater resistance to the attack of aggressive water than normal Portland cement. The properties of cement that were studied are standard consistency, initial setting time and specific gravity. Table 1 shows the results obtained for various properties of cement.

Table 1: Properties of Cement

Characteristics	Values Obtained
Fineness	390
Specific Gravity	2.85
Moisture Content	0.10

3.1.2. Fine Aggregate

Fine aggregate used in this study is M sand. Fine aggregates are the aggregates whose size is less than 4.75mm. Sand is generally considered to have a lower size limit of about 0.07mm, also free from clay, minerals and salt. The specific gravity of fine aggregate was found out using pycnometer and sieve analysis was carried out using IS sieves of sizes ranging from 4.75mm to 150 microns to find out the grading zone of aggregate. The following table shows the properties of fine aggregate tested in the laboratory.

Table 2: Properties of Fine Aggregate

roperties	Values Obtained
Specific Gravity	2.65
Fineness Modulus	3.28
Grading Zone	Zone I

3.1.3. Coarse Aggregate

The material whose particles are of size as retained on 4.75mm IS sieve is termed as coarse aggregate. The size of coarse aggregate depends upon the nature of work. Coarse aggregate shall consist of crushed or broken stones and be hard, strong, dense, durable, clean or proper gradation. The aggregate shall generally be cubical in shape as far as possible flaky, elongated pieces shall be avoided. Locally available coarse aggregate with maximum size of 20 mm were used in this project. The aggregates should be free from dust before its use in concrete. The properties of coarse aggregates studied were specific gravity, bulk density and water absorption. The results are tabulated in Table 3.

Table 3: Properties of Coarse Aggregate

Properties	Values Obtained
Specific Gravity	2.79
Bulk Density	1.32 g/cc
Water absorption	0.151%

3.1.4. Water

Water to be used in the concrete work should have following properties:

- It should be free from adverse amount of soils, acids, alkalis or other organic or inorganic impurities
- It should be free from iron, vegetable matter or any other type of substances, which are likely to have adverse effect on concrete or reinforcement
- It should be fit for drinking purposes

Potable water available in the premises was used for mixing and curing of concrete.

3.1.5 Fiber

Lathe wastes are materials which are collected from workshops and other steel industries at a very minimum cost. They are similar to the steel fiber but they don't have any regular shape and size. The dimension varies with nature of source which depends upon the type of industries. Scrap Steel Fibers obtained from the lathe machines of length 20-30 mm, width 1.5-2 mm and thickness 0.3-0.6 mm are used here to reinforce the concrete matrices. Aspect ratio varies from 50-70 with high modulus of elasticity about 200 GPa. The shape of scrap fibers cross section may be rectangular, twisted and metallic bight appearance. Lathe scraps are added to concrete at a varying percentage such as 0%, 0.5%, 1%, 1.5%, 2%, 2.5% and 3% by weight of cement. Fig 1 shows the sample of lathe scrap used for the work.

Fig 1: Lathe Scrap

3.2 Laboratory Work

3.2.1 Mixing

For mixing the concrete, a drum mixer was used. The aggregates were prepared in saturated surface dry condition. The materials were loaded into the drum dry mixed for about 3 minutes. Calculated quantity of water was then added and mixed thoroughly mixed until a uniform mixture is obtained. After obtaining a uniform mix calculated amounts of lathe scrap fibers were added uniformly and mixed again till the fiber is uniformly distributed. Care should be taken to prevent clumping of lathe fibers.

Cubes with 15 cm × 15 cm × 15 cm sizes were casted. Cubes were casted with a fiber content of 0 %, 0.5 %, 1 %, 1.5 %, 2 %, 2.5 % and 3 % by weight of cement. Compaction of the specimens was done on table vibrator.

3.2.2 Curing

After casting the specimens, as per literature studies, a 24 hour rest period was given to the specimens. After 24 hours the specimens were demoulded and were subjected to water curing. The specimens were cured in a water tank till test dates.

3.3 Mix Proportion

Mix proportioning is defined as the process of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible. The mix design must consider the environment that concrete will be in exposure to sea water, trucks, cars, forklifts, foot traffic or extremes of hot and cold. The mix design was done for a concrete of grade M30. The mix proportion of the concrete mix was designed based on Indian standard code IS: 10262 - 2009

- Cement - 384 kg/m^3
- Fine Aggregate - 708.504 kg/m^3
- Coarse Aggregate - 1118.9 kg/m^3
- Water - 192 kg/m^3

The mix ratio obtained was **1: 1.85: 2.91**

3.4 Workability

The concrete slump test is an empirical test that measures the workability of fresh concrete. It measures the consistency of the concrete in that specific batch. This test is performed to check the consistency of freshly made concrete.

A shortcoming of using fibers in concrete is reduction in workability. As the fiber content increases, workability decreases. The concrete was workable at the initial mixes but its workability reduced when percentage of lathe scrap added was increased. The following table shows the slump values of concrete mixes containing different percentages of lathe scrap fiber.

Table 4: Slump Values for Different Percentages of Fiber

Sl. No.	w/c ratio	Percentage of fiber added	Slump value (mm)
1	0.5	0	55
2		0.5	55
3		1	50
4		1.5	40
5		2	25
6		2.5	20
7		3	15

3.5 Compressive Strength

To estimate the strength of concrete, cubes of size 150 mm × 150 mm × 150 mm were casted for carrying out compression strength test. 7 day, 28 day and 56 day strength of the specimens were measured. The specimens were tested on a compression testing machine with capacity of 3000 kN. The results are as follows:

3.5.1 7 Day Compressive Strength

The maximum 7 day compressive strength of the sample obtained is 21.185 N/mm^2. The 7 day maximum strength was obtained for a fiber content of 1%. It should be noted that as the fiber content increases the strength increases but only up to a certain limit and beyond that strength decreases.

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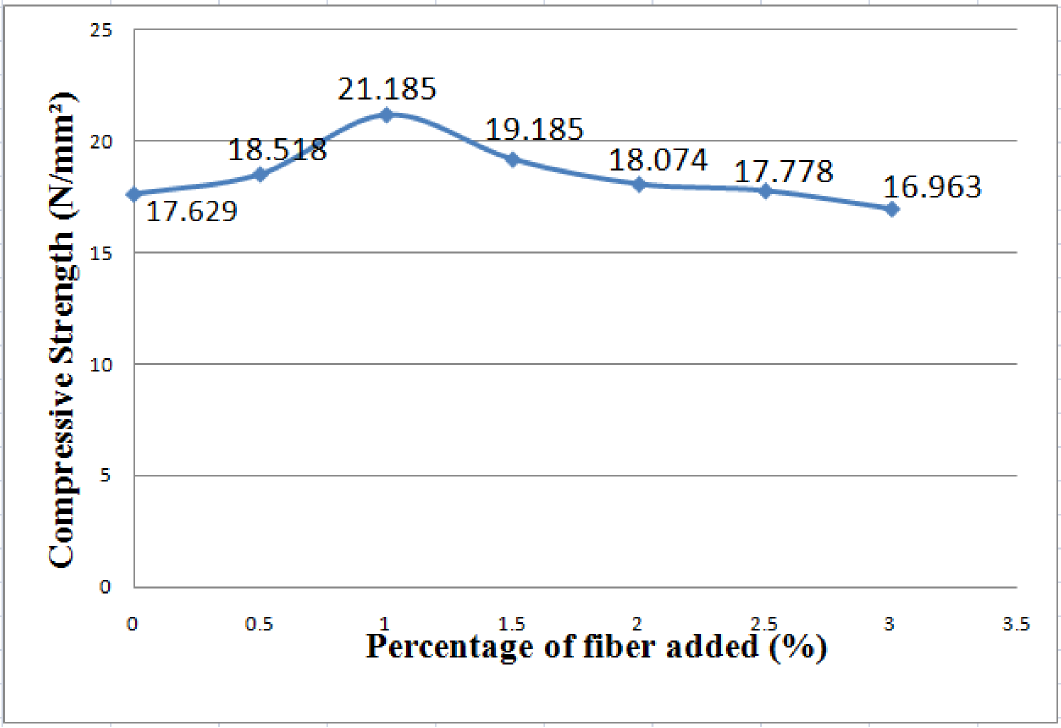

Fig 2: 7 Day Compressive Strength

3.5.2 28 Day Compressive Strength

The 28 day compressive strength was also maximum for 1% addition of lathe scrap fiber.

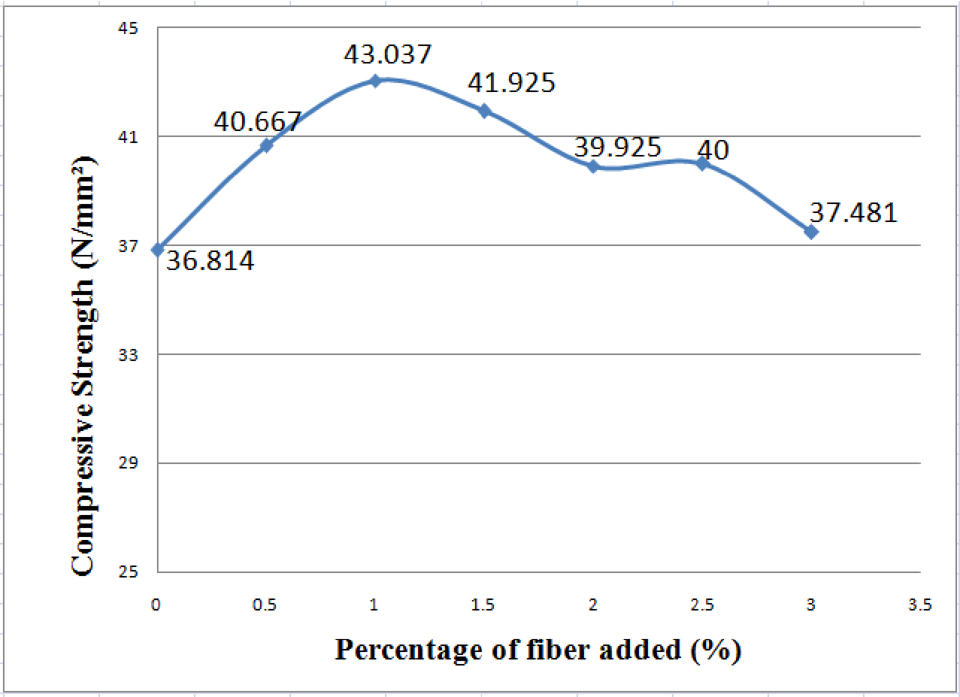

Fig 3: 28 Day Compressive Strength

3.5.3 56 Day Compressive Strength

The compressive strength after 56 days of curing in water was tested. The maximum strength obtained was 54.66 N/mm^2 and this value was obtained for a fiber content of 1%.

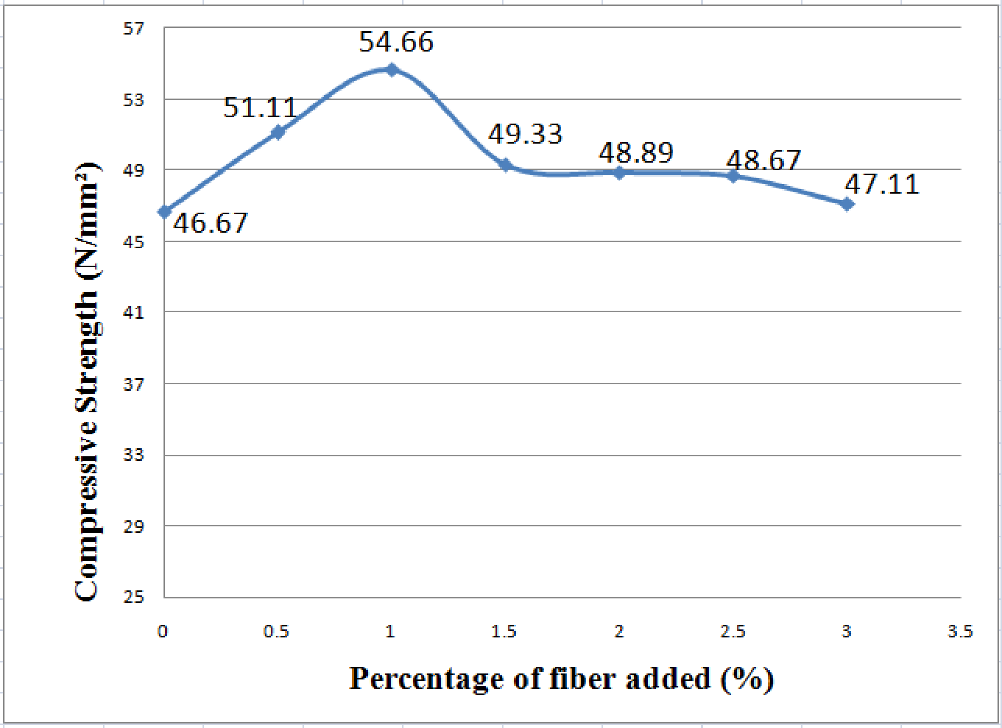

Fig 4: 56 Day Compressive Strength

IV. DISCUSSION

It was observed from the results that the addition of steel fibers to the concrete increases the properties of concrete up to a certain limit. From the investigation, it was clear that 1% fiber content has a noticeable effect on the properties of concrete. Further increase in fiber content tends to be ineffective. Fibers added in higher volume fraction reduces workability of mixes as they clump together and tend to “ball”. It results in higher presence of voids. Hence an optimum percentage of fiber content is always preferable.

V. CONCLUSION

The waste steel scrap material which is available from the lathe can be used as steel fiber for innovative construction industry.

- An optimum of 1% of lathe scrap as an addition can be used to improve the strength of fiber reinforced concrete
- Compressive strength increases up to 20.171 % at 7 days when compared to control specimen
- 16.904 % increase in compressive strength at 28 days when compared to control specimen
- 17.12 % increase in 56 day strength at 1% fiber content

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