Analysis of Effect of Addition of Lathe Scrap on the Mechanical Properties of Concrete

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Abstract: ***This paper assesses the effect of addition of lathe scrap on the mechanical properties of concrete. In this paper, M30 concrete is used and lathe scrap fiber is added up to 2% by weight, at a gap of 0.4%(i.e. 0%, 0.4%, 0.8%, 1.2%, 1.6%, 2%). In this investigation, a comparison have been made between plain cement concrete and the fiber reinforced concrete containing lathe scrap (steel scrap)in various proportions by weight. The fiber used is irregular in shape and with varying aspect ratio. The workability of fresh lathe fiber reinforced concrete (LFRC) is restricted to less lathe contents. Analytical comparison is being done between the compressive strength, tensile strength and flexural strength of plain cement concrete and LFRC. The 28 days strength of LFRC for compressive strength, tensile strength and flexural strength, is found to be increased when compared with the 28 days strength of plain cement concrete.***

Keywords: lathe scrap, sustainability, workability, compressive strength, flexural strength, split tensile strength

1. Introduction

The present day, the world is facing the construction of very challenging and difficult civil engineering structures. Concrete, being the most important and widely used material, is called upon to possess very high strength and sufficient workability properties and efforts are made in the field of concrete technology to develop the properties of concrete by using fibers and other admixture in the concrete up to certain proportions. In the view of the global sustainable developments, it is imperative that Fiber Reinforced Concrete (FRC) provide improvements in the tensile strength, toughness, ductility, post cracking resistance, fatigue characteristics, durability, shrinkage characteristics, impact, cavitations, erosion resistance and serviceability of concrete [13]. Due to these benefits, the use of FRC has increased during last two decades. In each lathe industries wastes are available in form of steel scraps are yield by the lathe machines in process of finishing of different machines parts and dumping of these wastes in the barren soil contaminating the soil and ground water that builds an unhealthy environment. Now a day's these steel scraps as a waste products used by innovative construction industry and also in transportation and highway industry. In addition to get sustainable progress and environmental remuneration, lathe scrap as worn-recycle fibers with concrete are likely to be used. When the steel scrap reinforced in concrete it acquire a term; fiber reinforced concrete. The main objectives of this paper are-

- To scrutinize the various physical and mechanical characteristics of the steel (lathe) fibers in concrete.
- To compare the characteristics of strength between ordinary concrete and Lathe Fiber Reinforced Concrete.

In the present experimental investigation, an attempt will be made to analyze the compressive strength, tensile strength and flexural strength of concrete containing the waste lathe scrap material, which is available from the lathe machine, is used as a steel fiber in cement concrete for various construction works and to optimize fiber content. Lathe Fiber Reinforced Concrete (LFRC) is a composite material consisting of hydraulic cement, sand, coarse aggregate, water and fiber (lathe scrap). With the development in industrial activities, the quantity of waste fiber generated from various metal industries will increase in future. These waste fibers can be used to make high-strength low-cost Fiber Reinforced Concrete (FRC).

Plain concrete possess large compressive strength and sufficient workability properties but it possesses a very low tensile strength, limited ductility and little resistance to cracking. Internal micro-cracks are inherently present in the concrete and its poor tensile strength is due to the propagation of such micro-cracks, eventually leading to brittle fracture of the concrete. . The development of such micro-cracks is the main cause of inelastic deformations in concrete. Thus need for multidirectional and closely spaced steel reinforcement arises, which is not possible practically. Fiber reinforced concrete is the solution for this problem.

2. Literature Survey

"Improving concrete properties with fiber addition" [1], E. Mello, C.Ribelloato, E. Mohamdelhassan. They have studied the concrete properties with the addition of cellulose, steel, carbon and PET fibers. Each fiber was added at 4% to the fresh concrete, which was moist cured for 28 days and then tested for compressive, flexural and tensile strength. Results showed that improvement in strength after addition of steel and carbon fibers may justify the extra cost of fibers.

"Study on the properties of high strength concrete using glass powder and lathe scrap" [2], T. Sezhiyan, R.Rajkumar They have aimed to use glass powder as a replacement of cement to assess the pozzolonic activity of fine glass powder in concrete and study the properties of concrete. Lathe scraps are the waste materials which are collected from workshops and other steel industries at very minimum cost. Scraps considered in this work are 0.5mm thick. 30% concentration of glass powder replacement in concrete is found to be the optimum dosage for their project work.

"Study of utilization of waste lathe scrap on increasing compressive strength and tensile strength of concrete" [3], Irwan lie keng Wong

In this research method, they have mixed the lathe waste in three proportions, i.e. 0.5, 1 and 2%. The results show that the compressive strength increased by 16.4% and tensile strength increased by 25.3% due to addition of waste lathe by 2% as compared to plain cement concrete.

"Reuse of steel scrap from lathe machine as reinforce material to enhance properties of concrete" [4], Shirule Pravin, Swami Suman, Nilesh Chincholkar

In this study, a comparison has been made between plain cement concrete and steel scrap (i.e. 0.5%, 1%, 1.5%, 2%) by weight of cement has been taken into account. Compressive strength, tensile strength and flexural strength of SSFRC is found to be maximum for volume fraction of 1.5% steel scrap fiber.

"Impact and energy absorption characteristics of lathe scrap reinforced concrete" [5], G. Vijayakumar, P. Senthilnathan, K Panduangan, G Ramakrishna

In this research paper, the addition of lathe scrap in concrete has increased the performance of beams in flexural by 40% as compared to PCC. There is only considerable increase in split tensile strength of concrete with lathe scarp as compared with PCC. The result shows that addition of lathe scraps into PCC mixture enhance its compressive strength while it decreases the workability of fresh concrete containing the lathe scrap. The impact strength of concrete mixed with lathe scrap shows increased impact strength as compared with PCC.

"Experimental study on steel fiber reinforced concrete for M40 Grade" [6], A.M Shende, A.M Pande, M. Gulfam Pathan

In this paper, authors 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. All the strength properties are observed to be on higher side for aspect ratio of 50 as compared to those for aspect ratio 60 and 67.It is observed that compressive strength increases from 11 to 24% with addition of steel fibers. It is observed that flexural strength increases from 12 to 49% with addition of steel fibers .It is observed that split tensile strength increases from 3 to 41% with addition of steel fibers.

"Effect of different types of steel fiber at aspect ratio on mechanical properties of self compacting concrete" [7], Kishor S Sable, Madhuri K Rathi

This research paper shows that it is possible to design a steel fiber reinforced self-compacting concrete incorporating fly ash. The SCC developed compressive strengths range from 17.98 to 22.60 Mpa at the end of 3 days, from 23.99 to 29.70 Mpa at the end of 7 days and from 32.50 to 46.00 Mpa, at the end of 28 days. The SCC developed split tensile strengths range from3.82 to7.59 Mpa at the end of 28 days. The SCC developed flexural strengths range from 4.98 to 6.92 Mpa at the end of 28 days.

"Experimental studies of the applications of turn steel scraps as fibers in concrete– A Rehabilitative Approach"[8], Vasudev R, Dr. B. G. Vishnuram.

The authors concluded that HSC consistently meets requirements for workability and strength development places more stringent requirements on material selection than that for lower strength concrete. Therefore, the production of HSC may or may not require the special materials, but it definitely requires materials of highest quality and their optimum proportions. In the production of HSC, use of strong, sound and clean aggregates is essential. The addition of steel fibers which is commercially available in market increases the budget of the project. But, by rehabilitating the scraps extracted from the steel lathe shops, improved the tensile properties of concrete in the order of 20 to 35 % in both the grades of concrete. This is very much encouraging as the use of such scraps is affordable by the common man.

3. Approach

3.1. Concrete Mix Design

In the present study M30 grade concrete mix design as per IS: 10262-2009 is carried out. The concrete mix proportion was1:1.73:3.3:0.45 and water content was 170l/m3

Table 1: Concrete Mix

Sr. No.	*Items*	*Per m^3 of concrete*
1	Cement	377.8 kg
2	Fine Aggregate	655 kg
3	Coarse Aggregate	1246 kg
4	Water	170 L

3.2. Casting and Testing

Total 54 cubes, 18 beams and 18 cylinders were casted. Scrap Steel Fiber was added in concrete in 5 different percentages starting from 0.0% at a gap of 0.4% up to 2%. For each percent of scrap steel fiber addition, 3 cubes, 3 beams and 3 cylinders were casted. Final compressive strength of cubes was tested after 14, 28 and 90 days curing. Flexural strength of beams were tested after 28 days curing and split tensile strength was tested for cylinders after 28 days curing. Compression testing machine is used for determining the compressive strength and split tensile strength of concrete and Flexural Testing machine was used to determine the flexural strength of concrete. The crushing loads were noted and average strengths for three specimens tested were determined for each percentage of fiber added (i.e. 0%, 0.4%, 0.8%, 1.2%, 1.6%, and 2%).

3.3. Methodology

Compressive strength test

For compressive strength test, cube specimens of dimensions 150 x 150 x 150 mm were cast for M30 grade of concrete. Super-plasticizer (0.6% to 0.8% by weight of cement) was added to this. The moulds were filled with 0%, 0.4% 0.8%, 1.2%, 1.6% and 2% fibers. Vibration was given to the moulds using table vibrator. The top surface of the specimen was levelled and finished. After 24 hours the specimens were demoulded and were transferred to curing tank where in they were allowed to cure for 14 days, 28 days and 90 days. After 14, 28 and 90 days curing, these cubes were tested on digital compression testing machine as per I.S. 516-1959. The failure load was noted. In each category three cubes were tested and their average value is reported. The compressive strength was calculated as follows. Compressive strength (MPa) = Failure load / cross sectional area.

Flexural strength test

For flexural strength test beam specimens of dimension 150x150x700 mm were cast. The specimens were demoulded after 24 hours of casting and were transferred to curing tank where in they were allowed to cure for 28 days. These flexural strength specimens were tested under two point loading as per I.S. 516-1959, over an effective span of 600 mm on Flexural testing machine. Load and corresponding deflections were noted up to failure. In each category three beams were tested and their average value is reported. The flexural strength was calculated as follows.

Flexural strength (MPa) = $(P \times L) / (b \times d^2)$,

Where, P = Failure load, L = Centre to centre distance between the support = 600 mm, b = width of specimen=150 mm, d = depth of specimen= 150 mm.

Split Tensile strength:

For Split tensile strength test, cylinder specimens of dimension 150 mm diameter and 300 mm length were cast. The specimens were demoulded after 24 hours of casting and were transferred to curing tank where in they were allowed to cure for 28 days. These specimens were tested under compression testing machine. In each category three cylinders were tested and their average value is reported. Split Tensile strength was calculated as follows as split tensile strength:

Split Tensile strength (MPa) = $2P / \pi DL$, Where, P = failure load, D = diameter of cylinder, L = length of cylinder.

4. Results and Discussion

4.1. Workability

The workability of fresh LFRC is a measured of its ability to be mixed, handled, transported and importantly place and consolidated. Slump test is a common, convenient and inexpensive test but refer only for small fiber contents, for high volume contents inverted cone or vebe test is referred (IS 1199-1959).

Table 2: Slump for LFRC

Sr. No.	*Lathe scrap Fiber (%)*	*Values*
1	0	80
2	0.4	75
3	0.8	73
4	1.2	71
5	1.6	70
6	2	70

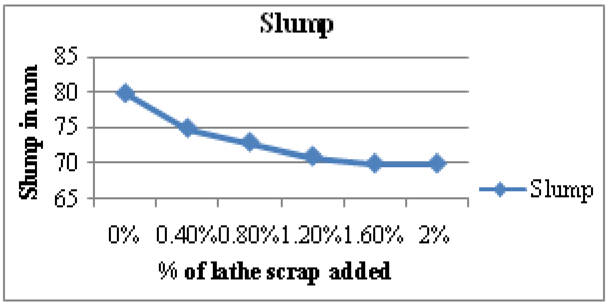

Figure 1: Workability variations

4.2. Compressive Strength: (IS 516-1959)

The compressive strength of concrete with different proportions of concrete are determined for 14 days, 28 days and 90 days. The strengths appear to increase gradually and then decrease gradually after a certain proportion of fiber added.

Table 2: Compressive strength (14 days)

Lathe scrap Fiber (%)	*Sr. No.*	*Load at failure (KN)*	*Strength at 14 days(N/mm²)*	*Average Strength at 14 days(N/mm²)*
0	1	750	33.33	33.33
	2	740	32.88	
	3	760	33.77	
0.4	1	780	34.66	34.66
	2	770	34.22	
	3	790	35.11	
0.8	1	830	36.89	36.44
	2	810	36.00	
	3	820	36.44	
1.2	1	790	35.11	34.66
	2	780	34.66	
	3	770	34.22	
1.6	1	750	33.33	34.07
	2	790	35.11	
	3	760	33.7	
2	1	700	31.11	32.74
	2	710	31.55	
	3	720	32.00	

Table 3: Compressive strength (28 days)

Lathe scrap Fiber (%)	*Sr.No.*	*Load at failure(KN)*	*Strength at 28 days (N/mm²)*	*Average Strength at 28 days(N/mm²)*
0	1	930	41.33	42.07
	2	950	42.22	
	3	960	42.67	
0.4	1	1030	45.78	45.18
	2	1000	44.44	
	3	1020	45.33	
0.8	1	1060	47.11	45.92
	2	1000	44.44	
	3	1040	46.22	
1.2	1	1100	48.88	46.66
	2	1000	44.44	
	3	1050	46.67	
1.6	1	1000	44.44	43.26
	2	950	42.22	
	3	970	43.11	
2	1	880	39.11	39.70
	2	920	40.88	
	3	880	39.11	

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Table 4: Compressive strength (90 days)

Lathe scrap Fiber (%)	*Sr. No.*	*Load at failure(KN)*	*Strength at 90 days (N/mm^2)*	*Average Strength at 90 days(N/mm^2)*
0	1	800	35.56	35.55
	2	810	36.00	
	3	790	35.11	
0.4	1	900	40.00	40.44
	2	910	40.44	
	3	920	40.89	
0.8	1	840	37.33	37.78
	2	850	37.78	
	3	860	38.22	
1.2	1	820	36.44	37.92
	2	900	40.00	
	3	840	37.33	
1.6	1	800	35.56	38.37
	2	890	39.56	
	3	900	40.00	
2	1	800	35.56	35.11
	2	780	34.67	
	3	789.50	35.09	

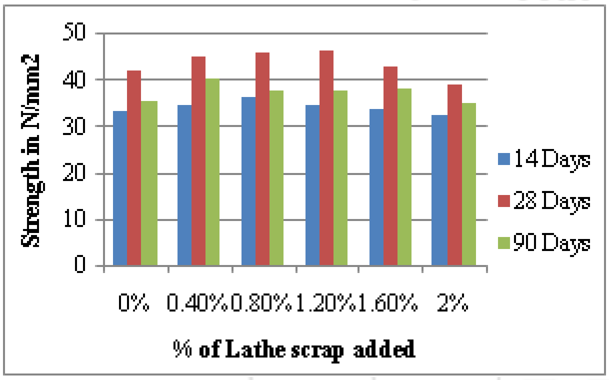

Figure 2: Compressive Strength

4.3. Flexural strength (I.S. 516 - 1959)

The flexural strength of the beams tested for different proportion shows a gradual increase in flexural strength up to 1.2% of fiber added concrete and then a gradual decrease in the strength up to 2%.

Table 5: Flexural Strength (28 days)

Lathe scrap Fiber (%)	*Sr.No.*	*Load at failure (KN)*	*Strength at 28 days (N/mm^2)*	*Average Strength at 28 days(N/mm^2)*
0	1	24.7	4.39	4.47
	2	25	4.44	
	3	25.8	4.59	
0.4	1	20.9	3.72	3.76
	2	21	3.73	
	3	21.6	3.84	
0.8	1	21.9	3.89	3.96
	2	22	3.91	
	3	23	4.09	
1.2	1	32	5.69	5.68
	2	31	5.51	
	3	32.8	5.83	
1.6	1	27	4.8	4.89
	2	27.5	4.89	
	3	28	4.98	
2	1	24	4.27	4.36
	2	24.6	4.37	
	3	25	4.44	

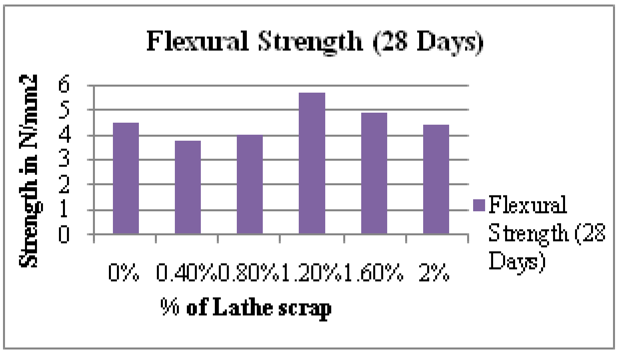

Figure 3: Flexural Strength

4.4. Split Tensile strength (I.S. 5816 - 1999)

The split tensile strength of the concrete varies with the proportion of fiber added in concrete. The maximum strength is observed for 1.2% of fiber added concrete.

Table 6: Split Tensile Strength (28 Days)

Lathe scrap Fiber (%)	*Sr.No.*	*Load at failure(KN)*	*Strength at 28 days(N/mm^2)*	*Average Strength at 28 days(N/mm^2)*
0	1	197	2.71	2.78
	2	198.5	2.81	
	3	199	2.82	
0.4	1	198	2.8	2.79
	2	197.7	2.79	
	3	197	2.78	
0.8	1	235	3.32	3.3
	2	233.7	3.31	
	3	232	3.28	
1.2	1	266	3.76	3.76
	2	266.1	3.76	
	3	266.5	3.77	
1.6	1	221	3.13	3.13
	2	220.82	3.12	
	3	222	3.14	
2	1	200	2.83	2.82
	2	199.28	2.82	
	3	199	2.82	

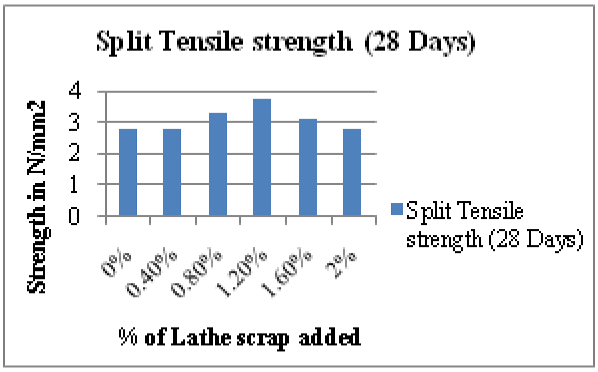

Figure 4: Split Tensile Strength (28 days)

5. Conclusion

The experimental work shows that the compressive strength, flexural strength and split tensile strength appear to increase gradually till 1.2% of lathe scrap added concrete and then a gradual decrease in the strength is observed. The compressive strength is increased by 11%. The flexural strength is increased by 19% - 32.3%. The split tensile strength is increased by 25.7%.

6. Future Scope

The effect of rusting of the steel lathe scrap on the strengths of concrete can be determined. Also, the effect of addition of lathe scrap on the reinforcement provided in R.C.C structure can be determined.

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