International Journal of Engineering Research and General Science Volume 4, Issue 4, July-August, 2016
ISSN 2091-2730

Strength Characteristics Analysis of Concrete Reinforced With Lathe Machine Scrap

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Abstract— The aim of the paper was to study the feasibility of using lathe machine scrap in concrete by checking the compressive strength, splitting tensile strength, flexural strength and load deflection characteristics. All these parameters were found out by varying proportions of lathe machine by 0%, 1 %, 1.5% and 2% by weight in M20 concrete. Thus finding out optimum percentage of lathe machine scrap in concrete up to which its mechanical properties like compressive strength, splitting tensile strength, flexural strength can be increased. All the tests were conducted by following the guidelines set by Indian Standard. The compressive strength was found out to be 25.5N/mm^2, 26.8N/mm^2, 28.4N/mm^2 and 23.33N/mm^2 for 0%, 1 %, 1.5% and 2% lathe machine scrap reinforcement respectively. The splitting tensile strength was 2.85N/mm^2, 3.04N/mm^2, 3.37N/ mm^2 and 2.94N/mm^2, where as flexural strength were 4.33N/mm^2, 5N/mm^2, 5.66N/mm^2 and 4.83N/mm^2 for 0%, 1 %, 1.5% and 2% lathe machine scrap reinforcement respectively. The strength properties of concrete were increasing by adding lathe machine scrap up to 1.5 % by weight in concrete after this slight reduction in strength properties of concrete was noticed. The compressive, split tensile and flexure strengths were increasing by 11.37 %, 18% and 30 % for optimum percentage of lathe machine scrap which was found to be 1.5%. The load carrying capacity of beam at same percentage of lathe machine scrap was found to be 5.66kN and deflection which was also maximum among all percentages was 7mm. Lathe machine scrap was found to be strong and environmental friendly material which can improve structural strength of concrete, decrease steel reinforcements besides, reducing width of cracks when used as reinforced material in concrete.

Keywords— Lathe Machine Scrap, Compressive Strength, Split Tensile Strength, Flexural Strength, Concrete, workability, deflection, Fiber reinforcement,

1. INTRODUCTION

Concrete is considered as the backbone of a modern day structures. Without this it is not possible to build a structure which is strong, durable and capable enough to resist earthquake shocks and other loads like dead load, imposed loads, snow load etc. To resist different types of vibrations a concrete structure has superiority over other structures made up of different materials [1] Concoction of Water, fine and course aggregates along with cement after amalgamating them collectively into a solid stone is described as concrete [2][3]. Once these elements are assorted jointly they outline a liquefied mass, being fresh and impressionable, it can be sorted into any yearned form. Properties like strength, density, chemical and thermal resistance in unsullied and solid state are managed by consequent materials through which concrete is formed [4].Since these ingredients vary in quantity, the properties do not remain same. In order to make sure that freshly obtained concrete is workable and after hardening is capable enough to withstand the weather conditions and the loads the constituents should be correctly mixed [5].

Being strong in compression and weak in tension, concrete is required to be reinforced by materials having higher tensile strength [2][3][6]. To overcome the weakness various researches by using different materials in concrete have been carried out all over the world; one of them has been Fiber reinforced concrete (FRC) which has been very common in the researches carried out in last two decades [7][6][8][9][10][11][12][13][14]. Researchers are also trying to develop high performance concretes by making use of fibers and admixtures in concrete with different proportions [15][16][17][18]. Incorporation of fiber in concrete have found to improve various properties such as cracking resistance, impact, wear resistance, ductility and fatigue resistance besides several other strength properties [19][20][21][22][23]. Besides building structures, concrete pavement is a key part of highway pavement due to increase in ride superiority, minimum maintenance, and extended design life [24] With the use of recycled materials the cost and energy consumption associated with concrete pavements can be lowered down with more effective construction methods [25][26].

In civil engineering applications most commonly used fibers and waste material includes glass, carbon, cellulose, aramid, steel etc [7]. In many developing countries like India there is a need to look over resource conservation, reducing material cost and using waste products paying much attention towards process of recycling of waste materials. This process of recycling of materials from industrial wastes helps to protect natural resources or environmental profits and results in economy [27]. By using various recycled wastes in concrete it has been found that compressive, flexural, tensile strength and other mechanical properties as well as energy absorption have increased [28][29][30]. The flexural properties of concrete reinforced with glass fibers are found to be more then plain concrete [31]. Use of plastic reinforced fiber in concrete can increase the overall strength of concrete and other mechanical properties [9] Besides plastic incarceration of concrete by fiber reinforced polymer tubes can considerably boost the ductility, strength and energy absorption capacity of concrete [32][16][17]. The shear, bending and serviceability properties of concrete improves when RCC beam is reinforced with textile besides this the crack width also reduces [33] Concrete reinforced with cellulose have shown that width of crack is less as compared to plain concrete beside having less width of crack, cellulose reinforced concrete was found to 40 percent tougher then the unreinforced concrete [34]. Fiber like aramid has been found to improve strength of concrete in an analogous way as that of steel [35]. As far as waste of steel fiber is concerned research done by [36] found that addition of more than 0.5% of the waste wires and steel fibers resulted in considerably higher split tensile strength by about 28 than plain concrete. Beside steel fibers carbon fiber is also being off late as a fiber material in concrete. Carbon fiber reinforced concrete has been found to have piezoelectric activities and can sense large range of loading with soaring compassion beside this it is also scrutinize dynamic loading [37]. By adding 3% of carbon and steel fibers by volume in concrete an increase of 12.1% of original tensile strength have been found [38]. A galvanized iron wire when used in concrete enhances the splitting tensile strength and flexural strength up to 72.65% and 41% [39]. Steel and Polypropylene fiber reinforced concrete of M30 grade results in improvement by 18 % in compressive strength for 28 days [40].[41] made comparative studies on steel fiber reinforced cum control concrete under flexural and deflection and observed that flexural strength increases from 13% to 48 % by utilization of steel fibers .by using 1% steel fibers flexural strength increase from 13.35% to 23.35%. With 2% steel fibers strength increases from 18% to 32%.and by using 3% steel fiber flexural strength increase from 20.80% to 48.35 %. Use of Steel Chords (a byproduct of tire recycling process) reinforced concrete is 18 % more ductile then the plain when 2 % steel chords by volume of concrete are used in it [42]. Recycled aggregate's use in concrete is found to have increase the split tensile strength and besides being workable for a structural use [43]. [44] Conducted tests on C30 and C50 concretes and obtained results which showed improvement in shear strength of concrete reinforced with steel fiber by 2.15 times for C30 and 2.46 times for C 50 then the plain concrete. The shear strength of pre-stressed concrete I beams also increases by using steel fibers in concrete [45].

With increase in population and industrial activities, the quantity of waste fibers generated from various metal industries will obviously increase. These types of industrial waste fibers can effectively be used for making high- strength low cost FRC after exploring their suitability. To overcome wasteful steel fiber, lathe scrap is used as recycle steel fiber which exhibits the property of steel fiber in fiber reinforced concrete.

In this paper an experimental investigation was carried out to study the feasibility of using scrap obtained from lathe machine in concrete by checking the workability, compressive strength, splitting tensile strength, flexural strength and load deflection characteristics of M20 concrete and thus optimizing the fiber proportions. The outcome of this paper shall be useful for many workshop and industries generating scrap from lathe machine. Ultimately the environment and economy of country will be benefited.

2. MATERIALS

The materials used in the study were cement, fine aggregates (sand), course aggregate, Water Lathe machine scrap and Steel fiber. Tests on these materials were conducted as per Indian Standard (IS) guidelines to determine different properties which are explained as follows

a. Cement

Portland Pozzolana Cement (Ambuja cement) shown in figure 1(a) was used in experimental investigation work. Portland Pozzolana Cement was preferred over ordinary Portland cement because it makes concrete more impermeable and denser. Ambuja cement satisfies nearly all the requirements recommended by Indian standard code [46]. Some important physical Properties of cement includes Standard Consistency, Initial and final setting time and Specific Gravity. All these properties were determined by IS guidelines [47]. Table 1 shows some important physical properties of cement.

Table 1: Some Physical properties of cement

S.No	Description	Values obtained	Requirements as per IS-1489, 1991
1	Standard consistency (using vicat apparatus)	28%	-
2	Initial setting time, min	50	>30min
3	Final setting time, min	7 hours 3min	<10hrs
4	Specific gravity	3.0	3.0-3.15

b. Fine Aggregates (Course sand)

Locally available Sand confirming to zone IV was used in the experiment work. As per [48] sieve analysis of the fine aggregates was carried out in the laboratory. The material whose particles are of size as are retained on IS sieve no 480(4.75mm) is termed as coarse sand [48] Fineness modulus of sand was found to be as 2.91. It was found out by carrying sieve analysis [48]. Specific gravity determined by pycnometer method [49] found to be 2.6.

c. Coarse Aggregates

Tests were carried out on locally available crushed coarse aggregates of 20mm in size and angular in shape. The fineness modulus was found to be 6.3 and specific gravity of coarse aggregate was 2.64. Both the properties were determined by sieve analysis [48] and [49] respectively.

d. Water

According to IS code [50], the pH value of water should not be less than 6. Water used for expermimental work was portable.

e. Lathe machine scrap

Scrap from lathe machine is produced from different manufacturing processes which are carried out by lathe machine. Scrap which is a waste can be used as a reinforcing material in concrete to enhance the various properties of concrete

All the materials except water are shown in figure 1.

Fig 1: Cement, Course Sand, Course Aggregate and Lathe machine scrap from left to right respectively

The lathe scrap which was used for cost sensitivity analysis was tested in production laboratory with the help of universal testing machines (UTM). The universal testing machine in production engineering lab consists of computer attached to it. The properties of Scrap and steel fiber both were displayed on screen. Some of the important properties which were determined include breaking strength, breaking load, elongation and modulus of elasticity. Table 2 shows some important properties of lathe machine scrap.

Table 2: Properties of Lathe Machine Scrap

S. No	Property	Lathe machine Scrap (LMS)
1	Type	Turned and deformed
2	Length	40-60 mm
3	Diameter	0.4-0.8 mm
4	Aspect ratio	70-100
4	Tensile strength	0.02-0.08N/mm^2
5	Young’s modulus	0.04-0.06N/mm^2

3. EXPERIMENTAL PROGRAM

The properties of Unreinforced and Lathe machine scrap reinforced concrete (LMSRC) which includes Workability, Compressive Strength, Tensile Strength, Flexural Strength, deflection were all determined by following the Indian Standard guidelines. The Mix design of Concrete was also done by following the Indian Standard guidelines.

a. Workability

Slump test was conducted to check the workability of unreinforced concrete and the concrete reinforced with lathe machine scrap at percentages 1 %, 1.5% and 2 % by weight. Test was conducted by following the specifications recommended by Indian Standard [51]

b. Compressive strength

A total of 12 specimens’ cubes of concrete were casted having size of 150x150x150mm for different proportions (0%, 1%, 1.5%, 2%) by weight of Lathe machine scrap and 3 cubes were used for taking average value. Figure 2(a) shows the Cube Moulds. UTM was used for determining compressive strength. [52] was followed while determination of compressive strength was done.

c. Tensile Strength

12 cylinders specimens were casted for different percentages of lathe machine steel scrap of size 150mm dia. and 300mm in height. Figure 2 (b) shows the cylindrical mould. Split tensile test confirming to Indian Standard code [53] was used. The tensile strength of concrete cylinders reinforced with 0%, 1%, 1.5%, 2% of Lathe machine scrap by weight in concrete was determined.

d. Flexural Strength

In flexural strength test of beam, the specimen of size 100x100x500mm was placed over three point loading arrangements and stress produced during breakage of specimen was determined. This breakage stress is known as Modulus of rupture or the flexural strength. The test was done by following Standard set by [54]. The flexural strength of beams reinforced with lathe machine scrap 0%, 1%, 1.5%, 2% by weight of concrete was determined. Figure 2 (c) shows the beam mould

Figure 2 (a) Cube Moulds

Figure 2 (b) Cylindrical Moulds

Figure 2(c) Beam Moulds

e. Deflection

Deflection was measured by dial gauges with stand having magnetic base. The least count of the gauge was 0.01mm. The deflection and corresponding maximum load carrying capacity of the beam specimen for different proportions (0%, 1%, 1.5%, 2%) by weight of Lathe machine scrap in concrete were determined and load deflection curve has also been plotted.

f. Mix design and Mixing of Concrete

M-20 concrete mix was used with coarse aggregates of size 10mm.Mix design was carried out as per Indian Standard IS guidelines [55]. After mix design it was found that the final Mix proportions were 1:1.88:2.86 (Cement: Fine aggregates: Course Aggregates), W/C ratio was 0.52. Electrically operated concrete mixer was used for mixing of concrete. Proper care was taken for prevention of formation of concrete balls.

e. Batching

Weight batching was used in our experimental program as it is considered to be superior than volume batching [2][3][4].

4. RESULTS AND DISCUSSION

The results which were obtained after carrying out tests on different properties of both unreinforced and reinforced Lathe machine scrap concrete (LMSC) are presented and discussed in this section.

a. Workability

Workability of concrete is defined as the capability to work alongside concrete. Concrete is said to be workable if it can be taken care of without isolation and loss of uniformity [55]. Slump Value was obtained to check the workability of concrete. The slump value of M20 concrete grade having mix of 1:1.88:2.86 (Cement: Fine aggregates: Course Aggregates), W/C ratio was 0.52 and having no lathe machine scrap in it was found to be 30 mm. When the same mix of concrete was added by 1 % of lathe machine scrap by weight, the slump value decreased to 22mm. For 1.5 % and 2 % lathe machine scrap by weight in the same mix slump values were found out to be 16mm and 10mm respectively. With increase in percentage content of Lathe machine scrap, the slump value decreases. The less is the slump value, more workable is the concrete [18][56][57]. Thus addition of lathe machine steel scrap in concrete was found to be beneficial to make it more workable.

b. Compressive strength, split tensile strength and flexural strength of plain and lathe machine scrap reinforced concrete

The compressive, split tensile and flexural strength were all determined by using M20 mix of 1:1.88:2.86 (Cement: Fine aggregates: Course Aggregates), W/C ratio 0.52. The percentage of lathe machine scrap for each parameter was kept at 0 %, 1 %, 1.5 % and 2 percent by weight of concrete**.** Compressive strength is the ability of a material to bear up loads having tendency to decrease size of material [58]. A total of 12 cube moulds of concrete were tested to determine the load at which failure will occur. The compressive strength of both plain and LMSRC were determined corresponding to average of failure loads of three specimens at different percentages of Lathe machine scrap. It was observed that addition of lathe machine scrap in concrete increases the compressive strength of concrete. For 0%, 1% and 1.5% lathe machine scrap content by weight in concrete the compressive strength obtained was 25.5N/mm^2, 26.8N/mm^2 and 28.4N/mm^2 respectively, however at 2% scrap content by weight the compressive strength decreases and was found to be 23.33N/mm^2. The addition of Lathe machine scrap in concrete the Compressive strength of concrete increases by about 11.37% for 1.5 % scrap as compare to conventional concrete. Thus the optimum percentage for lathe machine scrap in M20 concrete up to which Compressive strength can be increased is 1.5 % by weight and corresponding compressive strength was 28.4 N/mm^2.

Tensile strength is the ability of a material to bear up loads in tension [59]. A total of 12 cylinders specimens of size 15mm diameter and 300mm height were casted for different percentages of lathe steel scrap. The compression load was applied diametrically and along the length of cylinder until the failure of the cylinder along vertical diameter occurs. The split strength of both plain and LMSRC were determined corresponding to average of failure loads of three specimens at different percentages of LMS. It was observed that addition of lathe machine scrap in concrete increases the tensile strength of concrete cylinder. For 0%, 1% and 1.5% lathe machine scrap content by weight in concrete the tensile strength obtained was 2.85N/mm^2, 3.04N/mm^2 and 3.37N/mm^{2}respectively, however at 2% scrap content by weight the tensile strength decreases and was found to be 2.94N/mm^2. The addition of Lathe machine scrap in concrete increases the tensile strength of concrete cylinder by about 18% for 1.5 % scrap as compare to conventional concrete cylinder. Thus the optimum percentage for lathe machine scrap in M20 concrete up to which tensile strength can be increased was found to be 1.5 % by weight in concrete cylinder and corresponding compressive strength is 3.37 N/mm^2.

Flexural strength or modulus of rupture is mechanical property of brittle material at which it defies bending under load [60]. A total of 12 beam specimens of the specimen of size 100x100x500mm were placed over three point loading arrangements for different percentages of lathe machine scrap to determine the load at which failure will occur. The flexural strength of both plain and LMSRC were determined corresponding to average of failure loads of three specimens at different percentages of LMS. It was observed that addition of lathe machine scrap in concrete increases the flexural strength of concrete beam. For 0%, 1% and 1.5% lathe machine scrap content by weight in concrete the flexural strength obtained was 4.33N/mm^2, 5N/mm^2 and 5.66N/mm^{2}respectively, however at 2% scrap content by weight the tensile strength decreases and was found to be 4.83N/mm^2. The addition of Lathe machine scrap in concrete increases the flexural strength of concrete beam by about 30% for 1.5 % scrap as compare to conventional concrete beam. Thus the optimum percentage for lathe machine steel scrap in M20 concrete up to which flexural strength can be increased is 1.5 % by weight and corresponding compressive strength is 5.66 N/mm^2. Figure 3 shows the compressive, split tensile and flexural strength at different percentages of lathe machine scrap by weight in concrete.

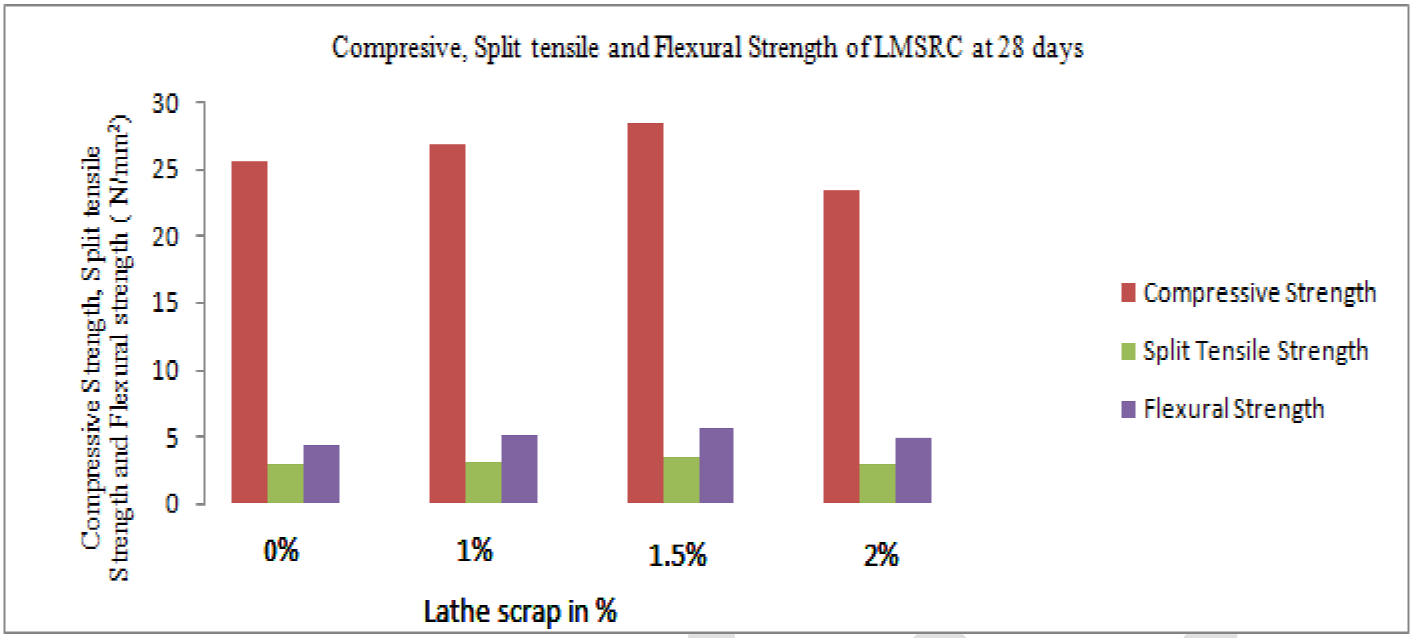

Fig 3: Compressive, Split tensile and flexural strength of concrete at different percentages of Lathe Machine Scrap

c. Load deflection Characteristics

The load deflection characteristics of the beam specimens were studied because it helps us to know how much load a structure or material can bear and how much deformation it is undergoing corresponding to that load, besides this it also enables us to know how much deflection a beam can undergo. For that the load deflection curve was plotted.. The load-deflection curve for conventional beam without any Lathe machine scrap has shown maximum deflection of 6mm at failure and maximum load carrying capacity of 4.33KN. Concrete beam reinforced with 1 % LMS by weight showed maximum deflection of 6mm at failure and maximum load carrying capacity of 5kN. Beams with 1.5% and 2% LMS reinforcement by weight showed maximum deflection of 7mm and 6mm at failure respectively where as maximum load carrying capacity of 5.66kN and 4.83kN was noticed at 1.5% and 2% LMS reinforcement by weight in concrete respectively. The detailed load deflection curve and the comparison between the load carrying capacity and deflection of the beam specimen of both unreinforced and reinforced concrete with lathe machine scrap is shown in figure 9. It was clearly observed that the load carrying capacity of 1.5% lathe machine scrap content beam is maximum compared to other beams. It has also been observed that deflection is maximum in case of 1.5% Scrap. Hence beam with 1.5% lathe machine scrap content was found to be more ductile than other beams.

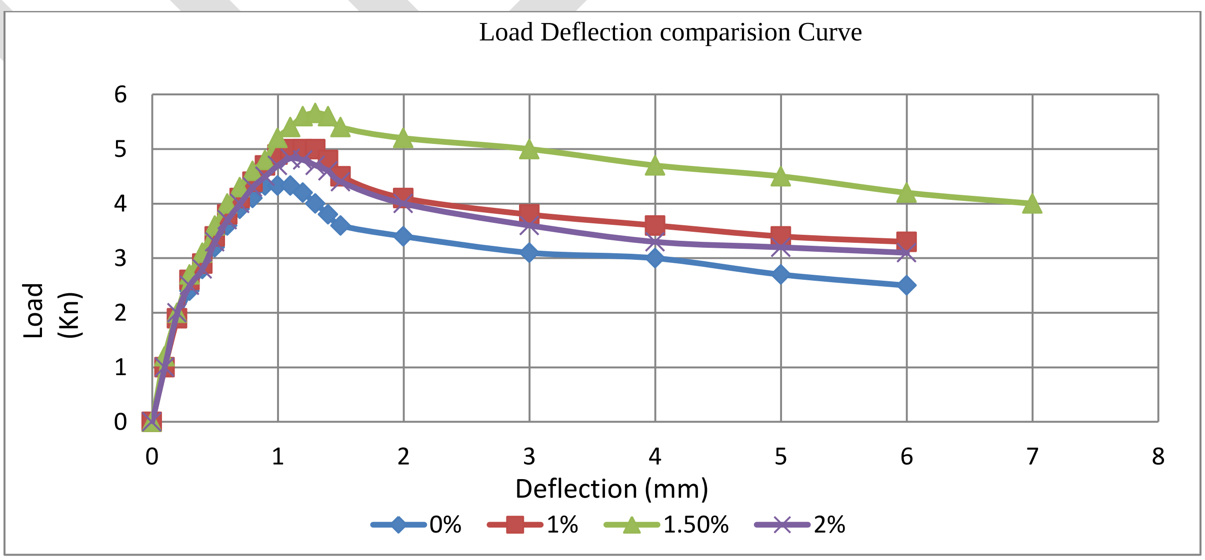

Figure 4: Comparison Load-deflection curve for beams with varying percentages of scrap

5. CONCLUSION

The slump value, compressive, split tensile and flexure strengths of M20 concrete grade were obtained at varying percentages of lathe machine scrap by weight in concrete. Slump Value decreased from 30mm to 10mm for concrete with no reinforcement and concrete with 2 % LMSR. The compressive strength was found out to be 25.5N/mm^2, 26.8N/mm^2, 28.4N/mm^2 and 23.33N/mm^2 for 0%, 1 %, 1.5% and 2% lathe machine scrap reinforcement respectively. The splitting tensile strength was 2.85N/mm^2, 3.04N/mm^2, 3.37N/ mm^2 and 2.94N/mm^2, where as flexural strength were 4.33N/mm^2, 5N/mm^2, 5.66N/mm^2 and 4.83N/mm^2 for 0%, 1 %, 1.5% and 2% lathe machine scrap reinforcement respectively. It was observed that strength properties of concrete are increased by adding lathe machine scrap up to 1.5 % and it was found to be the optimum percentage for compressive, split tensile and flexure strengths after this percentage there was reduction in strength of concrete slightly. Deflection of the beam was also found to be maximum in case of 1.5 % lathe machine scrap i.e 7mm and load bearing capacity of the beam was 5.66kN. All in all it is concluded that lathe machine scrap is a strong and environmental friendly material which can improve structural strength of concrete, lessen steel reinforcements besides reducing width of cracks when used as reinforcement in concrete. It can also be used in future also in various concrete works, which includes determining shear strength parameters, durability properties.

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