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Experimental Study on Partial Replacement of Fine Aggregate by Lathe Steel Scrap in Concrete

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Abstract: *In this study we had did partial replacement of fine aggregate by metal steel scrap in different percentage in concrete. In this paper, M_{20} and M_{30} grade of concrete is used and lathe metal scrap used as a fiber and added up to 30% by weight, at a gap of 10% (i.e., 0%, 10%, 20%, and 30%). In this investigation, a comparison has been made between plain cement concrete and the fiber reinforced concrete containing lathe metal scrap (metal steel scrap) in various proportions by weight. Analytical comparison is being done between the compressive strength of plain cement concrete and Lathe metal scrap reinforced concrete (LMSRC) M_{20} and M_{30}. The 28 days strength of LMSRC for compressive strength is found to be increased when compared with the 28 days strength of plain cement concrete.*

Keywords: Lathe Machine Steel Scrap, Reuse, Compressive strength, Flexural strength, Split tensile strength Sustainability.

I. Introduction

Concrete is the most widely used material construction worldwide. Generally, concrete is made by mixing the ingredients cement, sand and aggregate together using water as lubricant. Also, use some admixtures and chemicals in concrete to improve its properties. Along with the development of technology in civil engineering, the research conducted to improve the properties of concrete, among others, with the addition of fibres. Nowadays, different wastes such as fly ash, blast furnace slag, quarry dust, brick bats, broken glass waste and its powder, Steel waste, Coconut shells, E-waste, Plastic waste, Marble dust powder, Paper and pulp mill waste, Sugar cane industry waste etc. [7] are using in many developed countries to find out the alternative material in construction.

Due to rapid Industrialization, steel production in industries increasing year and year. These industries produced steel waste and gases as well which are very harmful to the environment. In India steel waste generated from steel industry is high because India expanding their Industries. Also, if we compare the small MIDC from that also every day about 8 to 10 kg of lathe waste is generated by each lathe industries in Wardha city and dumped in the barren soil or may they sale that waste to Bhangarwala. Many constructional industries and construction site waste also dispose there wastes likewise, which include binding wires, nails and other types of scraps. Hence by adopting proper management by recycling and reusing the steel scrap with concrete is considered to be one of the best solutions. Recycling of steel waste generated from workshop and industry reduces the steel waste, but recycling steel has low quality and recycling cost is high. However recycled steel is not using in construction field yet, so we are using steel scrap waste in concrete which reduces the consumption of reinforcement and cost of structure. These industrial steel scrap wastes can effectively be used for making high strength low-cost Fiber Reinforced Concrete. [8]

By experimental study we did to know the compressive, flexural and split tensile strength for steel scrap concrete and plain cement concrete. Then, comparative study on steel scrap concrete and plain cement concrete has been done. We have been checking this scrap waste may also improve or not the properties such as reduction in shrinkage, reduction in cracking, toughness etc.

II. Literature Review

P. Sai Maanvit et. al. (2019); In this experiment entitled "Experimental Examination of Fibre Reinforced Concrete Incorporation with Lathe Steel Scrap", study concludes that the mechanical properties such as compressive, split tensile, bending strength and modulus of elasticity of concrete are increased rapidly at an optimum content of 1.5%. Increase in compressive strength by 10.2%, Increase in bending strength by 45%, Increase in split tensile strength by 30% and modulus of elasticity increases by 250%. Apart from all these properties the usage scrap material in the construction leads to a huge boon to the environment so that it can enhance the properties of concrete same as by using manufactured fibrous material so that we can decrease the cost of construction innovatively. And can save the mother earth from being polluted.[5]

Poorva Haldkar, Ashwini Salunke (2016); In this investigation entitled "Analysis of Effect of Additional of Lathe Scrap on the Mechanical Properties of Concrete", study assesses the effect of addition of lathe scrap on the mechanical properties of concrete. In this paper, M_{30} concrete is used, and lathe scrap fibre 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 has been made between plain cement concrete and the fibre reinforced concrete containing lathe scrap (steel scrap) in various proportions by weight. The fibre used is irregular in shape and with varying aspect ratio. The workability of fresh lathe fibre 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. 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 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%.[2]

Laxmi Kanta Saha et. al. (2018); In this study entitled "Experimental study on properties of concrete by partial replacement of fine aggregates with waste steel chips", an experimental investigation has been done to find the properties of waste steel chips concrete specimens where the flexural strength, compressive strength, split tensile strength have been evaluated. The following conclusions were drawn from experiments conducted on the specimens are as follows: By replacing M-Sand with waste steel chips by 15%, 30% and 60% workability of concrete gets reduced to 15%, 20% and 24% respectively. Hence workability is improved by adding Gluonium as a chemical admixture. By the replacement of M-Sand with waste steel chips, the strength of concrete gradually increases with the increase in the percentage of steel chips. Waste steel chips concrete perform better than Conventional Concrete. For final conclusion, the results obtained shows that the addition of waste steel chips in concrete enhances the strength of concrete without impairing any technical features of normal concrete. Waste steel chips can be used to construct residential building, footpaths, road dividers, parapet wall etc. [3]

Namrata M. Mannade, Prof. A.P.Khatri (2018); The study proves in "An Experimental Investigation on Use of Lathe Scrap Steel Fibres In Rigid Pavement", that the compressive strength, flexural strength and split tensile strength of the concrete is increased by increasing the proportion of the lathe scrap up to 1.5% for 7 days and 28 days. From 1.5 % to 2 %, it shows slight decrease in compressive strength, flexural strength, split tensile strength (28 days).[4]

V. John Sundar Raj et. al. (2021); The rest of the paper entitled, "To Study the Mechanical Properties of Concrete with Addition of Steel Industry Scrap" discusses the Mechanical properties of the different Concrete mix, Control mix, 10kg/cu.m., 20kg/cu.m., and 30kg/cu.m. addition of Steel industry scrap. This paper also focuses on the difference in Strength of the Mixes with aging and comparison among the tests. To minimize the stock pills due to the high accumulation of Steel scrap, at various dump yards located in Tamil Nadu cities. The accrual of the steel scrap also contaminates the Land and the Groundwater due to the Lathe oil in them. The addition of the Steel industry scrap to concrete enhances the strength properties of Concrete. The concrete was casted as four batches, Control mix, 10 kg/m3 addition of the steel industry scrap, 20 kg/m3 addition and 30 kg/m3 addition. The 30 kg addition of Steel scrap showed a higher percentage of Increase in the Compressive, Split tensile and flexural Strengths than the other mixes. There was a 35 – 15 % increase in the compressive strength of the 30 kg addition mix to that of control mix, as the concrete trial aged. There was no substantial increase in the split tensile strength of the Concrete. There was also a small increase in the flexural strength in the batches of 10 kg addition and 30 kg addition of the steel industry scrap. The 20 kg addition of the steel industry scrap had no changes in the flexural strength from the control mix.[6]

G Vijayakumar et. al. (2012); This project work namely "Impact and Energy Absorption Characteristics of Lathe Scrap Reinforced Concrete" emphasis on the study of using lathe scrap as fibre reinforced concrete in the innovative construction industry. Every day about 8 to 10 kg of lathe waste is generated by each lathe industries in the Pondicherry region and dumped in the barren soil there by contaminating the soil and ground water, which creates an environmental issue. Hence by adopting proper management by recycling the lathe scrap with concrete is considered to be one of the best solutions. The following conclusion could be drawn from the present work: The mechanical properties of the concrete are increased by increasing the proportion of the lathe scrap from 0.5% up to 1.5%. From 1.5% to 2.0% it shows slight decrease in the mechanical strength. At 2.0% of lathe scrap proportion there is a considerable reduction in the mechanical strength of LSRC. The compressive strength of LSRC increased by 10% for 7 days strength when compared to Plain Cement Concrete (PCC) for all the tested proportions of lathe scrap and steel fibre. For the 28 days strength the LSRC poses almost the same compressive strength as PCC for all the tested proportion. The addition of lathe scrap has significantly enhanced the performance of beam in flexural nearly 40% when compared with PCC. There is a considerable increase in split tensile strength of about 10% when compared to PCC. The result showed that addition of lathe scrap into PCC mixture enhanced its compressive strength while it decreased the workability of the fresh concrete containing the lathe scrap. In general, from the above study, it was incurred that, the performance of lathe scrap reinforced concrete proves to be better than the normal concrete and very much comparable with steel fibre reinforced concrete regarding its mechanical properties.[1]

2.1 Summary on Literature Review

- The compressive strength is increased with increment of % of steel scrap.
- It is observed that flexural strength and split tensile strength also increase with addition of metal steel scrap till certain percentage.
- Apart from all these properties the usage scrap material in the construction that it can enhance the properties of concrete same as by using manufactured fibrous material so that we can decrease the cost of construction innovatively.
- If lathe scrap dump in barren land it may contaminate land as well as underground water bodies due to the lathe oil in them.
- It is enhanced compressive strength while it decreased the workability of the fresh concrete containing the lathe scrap.

2.2 Gap Finding

- While entire literature survey study found that replacement of Fine aggregate with metal steel scrap is less than 10%.
- The percentage at an interval of 10% not found throughout literature study.
- Also, comparative study of M20 and M30 grade of concrete using metal steel scrap as partial replacing material.

III. AIM AND OBJECTIVES

3.1 Aim

To Examine the Strength of Concrete with Partial Replacement of Fine Aggregate by Metal Steel Scrap in Concrete.

3.2 Objectives

- To use of steel scrap in concrete to increase various strength like compression, flexural and split tensile etc.
- To establish the alternatives of ingredients of concrete.
- To check the feasibility of waste steel scrap in mix design concrete.
- To check viability various tests done on prepared concrete specimen like Compressive strength, Tensile strength, Flexural strength etc.
- To compare test results with conventional concrete and decide optimum percentage of steel scrap for maximum strength of concrete.

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IV. Methodology

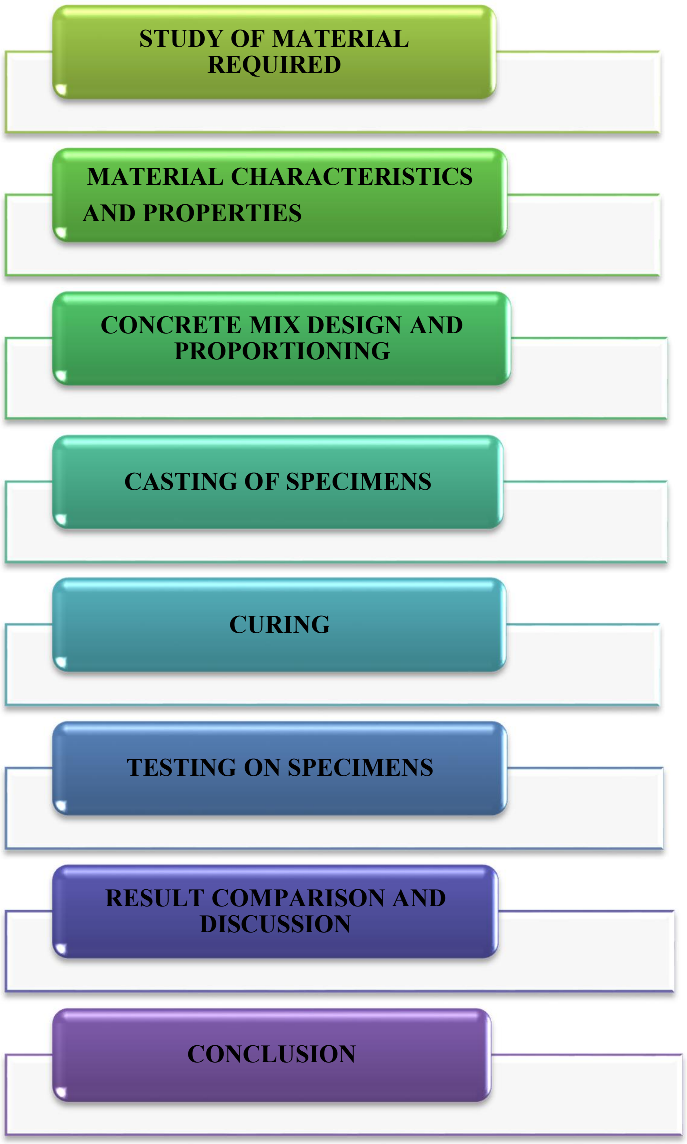

Figure 1: Methodology Flow

IV. Material Characteristics And Properties

4.1 Testing on Ordinary Portland Cement (OPC)

Cement can be described as a material with adhesive and cohesive properties which make it capable of bonding mineral fragment into a compact whole and solid in the presence of water. Cement of 53 grade was purchased and used for this experiment. The properties of the cement used in the experiments are given in the following (Table 1) as per IS 4031.

Table 1: Properties of Cement

Sr. No.	Property	Value	IS Recommendation	Reference
1	Fineness Modulus of Cement	3 %	Less than 10 %	IS:4031 – 1
2	Standard consistency	33%	25 – 35 %	IS:4031 – 4

3	Initial Setting Time	105 min	Not less than 30 min &	IS:4031 – 5
4	Final Setting Time	230 min	not more than 600 min	IS:4031 – 5
5	Soundness of Cement	7mm	not exceed 10 mm for OPC	IS:4031 – 3
6	Specific Gravity of Cement	3.15 g/cc	3.1 – 3.16 g/cc	IS:4031 – 11
7	Bulk Density	1440 kg/m3		IS:4031 – 11

Table 2: Chemical Composition of Cement

Sr. No.	Ingredients	Concentration (%)
1	CaO	66.67
2	SiO2	18.91
3	Fe2O3	4.94
4	Al2O3	4.51
5	SO3	2.5
6	MgO	0.87
7	K2O	0.43
8	Na2O	0.12
9	Loss of Ignition	1.05

4.2 Testing on Fine Aggregate

The purpose of fine aggregate is to fill the voids in the coarse aggregate and to act as a workability agent. Locally available riverbed sand was used as fine aggregate in this experimental work. The size of the sand used is 4.75 mm and downsize. Fine aggregate having properties satisfied the requirement as per IS-383:1970 and it has divided the fine aggregate into four zones (i.e., I, II, III, IV). The properties of the (sand) fine aggregate used in the experiments are given in the following (Table 3) as per IS:383 and IS:2386.

Table 3: Properties of Fine Aggregates

Sr. No.	Property	Value	IS Recommendation	Reference
1	Fineness Modulus	2.75	2.2 – 3.2	IS:383
2	Zone	III	–	IS:383
3	Specific Gravity	2.65 g/cc	2.65 – 2.67 g/cc	IS:2386 – 3
4	Water Absorption	1.2 %	0.3–2.5 %	IS:2386 – 3
5	Silt Content	1%	Not Exceed 8 %	IS:2386 – 2
6	Bulking of Sand	14.29%	Not Exceed 25 %	IS:2386 – 3

4.3 Testing on Coarse Aggregate

The aggregate having size more than 4.75mm is termed as coarse aggregate. Generally, aggregates are angular in shape. Flaky and elongated aggregate should not be used in concrete. It makes concrete porous and more permeable. The aggregates used in concrete should be durable, clean, tough and proper gradation. The average size of 20 mm aggregate used in experimental work. The size of aggregate found out by sieve analysis is 20mm graded nature. The properties of the coarse aggregate used in the experiments are given in the following (Table 4) as per IS:383 and IS:2386.

Table 4: Properties of Coarse Aggregates

Sr. No.	Property	Value	IS Recommendation	Reference
1	Sieve Analysis	Size 20mm Graded	–	IS:383
2	Specific Gravity	2.87 g/cc	2.5 to 3 g/cc	IS:2386 – 3
3	Water Absorption	0.9 %	0.1 – 2 %	IS:2386 – 3
4	Impact Value	18.6 %	10 – 20 (Strong)	IS:2386 – 4
5	Crushing Value	18.10 %	–	IS:2386 – 4

V. Concrete Mix Design And Proportioning

5.1 Concrete Mix Design for M_{20}

Grade for proportioning M_{20}

1. Type of cement: OPC (Ordinary Portland Cement) of grade 53 confirming to IS 12269 – 2013
2. Maximum nominal size aggregate: 20 mm
3. Minimum cement content: 300 kg/m3 IS 456:2000
4. Maximum water cement ratio: 0.55
5. Workability: 75-100 mm (slump)
6. Exposure condition: Mild
7. Degree of supervision: Good
8. Type of aggregate: Crushed angular aggregate
9. Maximum cement content: 450 kg/m3

Test Data for Materials

1. Cement used: OPC (Ordinary Portland Cement) of grade 53 confirming to IS 12269 – 2013
2. Specific gravity of cement: 3.15
3. Specific gravity of coarse aggregate: 2.87
4. Specific gravity of fine aggregate: 2.65

Summary

- Cement = 358 kg/m
- Water = 197 kg/m^3
- Fine Aggregate = 676 kg/m^3
- Coarse Aggregate = 1246 kg/m^3
- Water – cement ratio = 0.55 kg/m^3

Proportions

Cement	Fine Aggregate	Coarse Aggregate	Water
358	676	1246	197
1	1.88	3.48	0.55

5.4 Concrete Mix Design for M_{30}

Grade for proportioning: M_{30}

1. Type of cement: OPC (Ordinary Portland Cement) of grade 53 confirming to IS 12269 – 2013
2. Maximum nominal size aggregate: 20 mm
3. Minimum cement content: 320 kg/m3 IS 456:2000
4. Maximum water cement ratio: 0.45
5. Workability: 75-100 mm (slump)
6. Exposure condition: Severe
7. Degree of supervision: Good
8. Type of aggregate: Crushed angular aggregate
9. Maximum cement content: 450 kg/m3

Test Data for Materials

1. Cement used: OPC (Ordinary Portland Cement) of grade 53 confirming to
2. IS 12269 – 2013
3. Specific gravity of cement: 3.15
4. Specific gravity of coarse aggregate: 2.87
5. Specific gravity of fine aggregate: 2.65

Summary

- Cement = 438 kg/m
- Water = 197 kg/m^3
- Fine Aggregate = 616 kg/m^3
- Coarse Aggregate = 1240 kg/m^3
- Water – cement ratio = 0.45 kg/m^3

Proportions

Cement	Fine Aggregate	Coarse Aggregate	Water
438	616	1240	197
1	1.40	2.83	0.45

VI. Experimental Setup

6.1 Preparation of Concrete for Casting of Specimens

Concrete is a composite material made up of cement, sand, coarse aggregates, water and chemical admixtures (if required). It is the primary construction material. It plays a significant role in the structure's serviceability and durability. Not only the concrete but the process of concreting such as batching, mixing, transporting, compacting and finishing etc. also plays a significant role. Though making concrete is very easy, the proper concreting process is quite difficult and requires extra care specially the process of mixing of concrete ingredients.

6.2 Methods for Mixing Concrete

When it comes to mixing concrete, following three mixing methods are used for the production of effective and good quality concrete.

- Hand Mixing of Concrete (Mixing concrete manually without a mixer machine)
- Machine Mixing of Concrete (Mixing concrete with a mixer machine)
- Ready Mix Concrete (Mixing in automatic or semi-automatic batching plant)

Different constructions require different type of concrete mixing. For the efficient result, using appropriate method of mixing of concrete for the specific use and application is essential. Several factors affect the method of concrete mixing such as,

- Location of the construction site with sufficient land for construction activities e.g., highly congested urban areas
- Available space for concrete batching and mixing and storage of aggregates
- Volume of concrete needed
- The construction schedule like the volume of concrete required per hour or per day
- Height at which concrete is to be placed
- Cost

We have adopted hand mixing method for mixing concrete to make project testing specimen's

6.3 Hand Mixing of Concrete

Hand mixing is the process of mixing the ingredients of the concrete manually without a mixer machine. Mixing concrete without a mixer is used only for small works. According to 'M. M. Goyal' (Author of Construction Handbook for Civil Engineers and architects), 10% extra cement shall be added to the nominal mix concrete proportion in case of hand mixing.

Figure 2: Hand Mixing of Concrete

Table 5: Percentage of Mixing

Sr. No.	Cement (%)	Sand (%)	Metal Steel Scrap (%)	Coarse Aggregate (%)
1	100	100	Nominal Mix	100
2			10	
3			20	
4			30	

6.3 Concrete Placing and Compacting

- It is very important that the concrete must be placed in position in a proper manner as early as possible within the initial setting time of cement.
- Once the concrete has been adequately mixed, it must be placed into the formwork that defines its final position and shape. If the concrete is to be reinforced, the rebar must already be in place so the concrete can flow around it.
- It is the process of consolidating concrete mix after placing it in position. The main aim of consolidation of concrete is to eliminate air bubbles and thus to give maximum density to concrete.
- The proper consolidation ensures intimate contact between the concrete and the surface of reinforcement. The compaction of concrete may be carried out either manually or mechanically.

Figure 3: Finished Testing Specimens

6.4 Curing of Specimens

- It is the process of hardening the concrete mixes by keeping its surface moist for a certain period, in order to enable the concrete to gain more strength.
- The object of curing is to prevent the loss of water by evaporation; to reduce the shrinkage of concrete and to preserve the properties of concrete.

Figure 4: Curing of Testing Specimens

VII. Results And Discussion

In this discussion will be focused on compressive, flexural and split tensile strength of concrete. All the test method adopted were describing in this chapter. The result presented in this chapter is regarding the compressive, flexural different percentage of Lathe Metal Scrap in concrete.

7.1 Compressive Strength Test

As per the Indian code IS 516:1959, the compression test has the following objective, one can easily judge the concrete strength and quality of concrete produced. Compression tests are used to determine the material behaviour under a load. The maximum stress a material can sustain over a period under a load (constant or progressive) is determined. Compression testing is often done to a break (rupture) or to a limit.

- The compressive strength is calculated for 7 days, 14 days and 28 days for the various percentage of mixture of metal steel scrap partially replaced with sand in concrete.
- There were 3 samples of each test and the results would be taken as an average of these 3 samples. The following result are calculated by the average of 3 samples of 10%, 20% and 30% of metal steel scrap materials used in concrete.
- The compressive strength of concrete is the most common measure for judging not only the ability of the concrete to withstand load but also the quality of the hardened concrete. The compressive strength of concrete is given in terms of the characteristic compressive strength of 150 mm size cubes tested at 28 days (fck).

Compressive Strength = P/A

Where, P = Applied Load and A = Area of the Specimen

Compressive Strength Test of Partial Replacement of Sand with Metal Steel Scrap in M_{20} Grade of Concrete.

Table 6: Compressive Strength M_{20} Grade of Concrete

Sr. No.	Concrete Mix	Avg. Strength (N/mm^2) 7 Days	Avg. Strength (N/mm^2) 14 Days	Avg. Strength (N/mm^2) 28 Days
1.	Nominal Concrete	13.33	18.44	20.22
2.	10%	14.44	20.30	22.67
3.	20%	15.78	22.22	25.41
4.	30%	14.96	21.26	23.93

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Graphical Representation

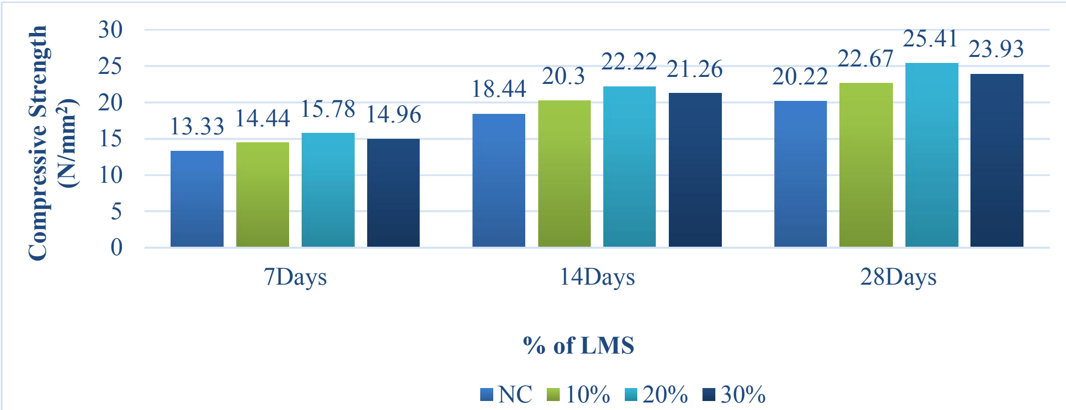

Figure 5: Compressive Strength M_{20} Grade of Concrete.

Interpretation of graph for Compressive Strength M_{20} Grade of Concrete

This graph interprets that the compressive strength for M_{20} grade of concrete at 7 days, 14 days and 28 days are observed as follow:

- From graph comparison of compressive strength of Nominal Concrete of M_{20} grade and percentage of mixing metal steel scrap in it at 10%, 20 % and 30% we can observe.
- The compressive strength for 10% mix of metal steel scrap in concrete which is increased by 12% than Nominal Mix i.e., 22.67 N/mm^2
- From the graph maximum compressive strength, we found at 20% mix of metal steel scrap in concrete which is increased by 25% than Nominal Mix i.e., 25.41 N/mm^2
- The compressive strength for 30% mix of metal steel scrap in concrete which is increased by 18% than Nominal Mix i.e., 23.93 N/mm^2

Compressive Strength Test of Partial Replacement of Sand with Metal Steel Scrap in M_{30} Grade of Concrete.

Table 7: Compressive Strength M_{30} Grade of Concrete.

Sr. No.	Concrete Mix	Avg. Strength (N/mm^2) 7 Days	Avg. Strength (N/mm^2) 14 Days	Avg. Strength (N/mm^2) 28 Days
1.	Nominal Concrete	19.85	27.26	30.15
2.	10%	21.93	31.41	33.11
3.	20%	24.89	34.89	36.15
4.	30%	23.11	32.81	34.67

Graphical Representation

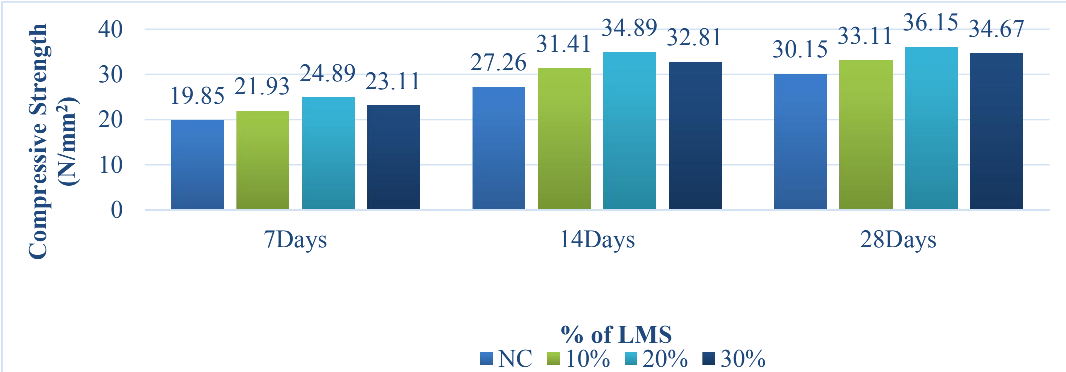

Figure 6: Compressive Strength M_{30} Grade of Concrete.

Interpretation of graph for Compressive Strength M_{30} Grade of Concrete

This graph interprets that the compressive strength for M_{30} grade of concrete at 7 days, 14 days and 28 days are observed as follow:

- Graph shows comparison of compressive strength of Nominal Concrete of M_{30} grade and percentage of mixing metal steel scrap in it, at 10%, 20 % and 30%.
- The compressive strength for 10% mix of metal steel scrap in concrete which is increased by 10% than Nominal Mix i.e., 33.11 N/mm^2
- From the graph maximum compressive strength, we found at 20% mix of metal steel scrap in concrete which is increased by 20% than Nominal Mix i.e., 36.15 N/mm^2
- The compressive strength for 30% mix of metal steel scrap in concrete which is increased by 15% than Nominal Mix i.e., 34.67 N/mm^2

7.2 Flexural Strength Test

For flexural strength test beam specimens of dimension 150x150x700 mm were cast. These flexural strength specimens were tested under two-point loading as per IS 516 – 1959, over effective span of 600 mm on flexural testing machine. Load and corresponding deflections were noted up to failure. In each category their beams were tested and their average value is flexural strength was calculated as follows,

Flexural strength (MPa) = (P x L)/ (b x d2)

Where, P = failure load,

L= centre to centre distance between the support= 600 mm,

b = width of specimen=150 mm,

d = depth of specimen =150mm

Flexural Strength Test of Partial Replacement of Sand with Metal Steel Scrap in M_{20} Grade of Concrete

Table 8: Flexural Strength M_{20} Grade of Concrete

Sr. No.	Concrete Mix	Avg. Strength (N/mm^2) 7 Days	Avg. Strength (N/mm^2) 14 Days	Avg. Strength (N/mm^2) 28 Days
1.	Nominal Concrete	3.15	3.96	4.24
2.	10%	3.60	4.27	4.57
3.	20%	3.44	4.21	4.45
4.	30%	3.20	4.14	4.38

Graphical Representation

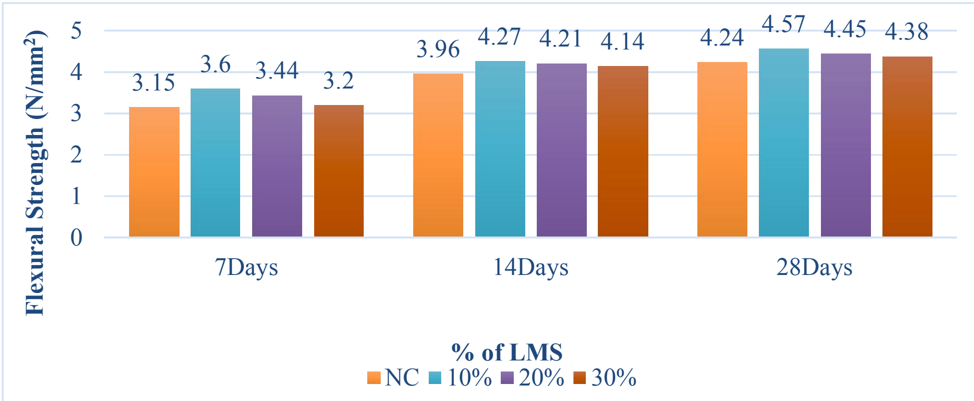

Figure 7: Flexural Strength M_{20} Grade of Concrete

Interpretation of graph for Flexural Strength M_{20} Grade of Concrete

This graph interprets that the flexural strength for M20 grade of concrete at 7 days, 14 days and 28 days are observed as follow:

- From above graph we can observe comparison of flexural strength of Nominal Concrete of M20 grade and various percentage of mixing metal steel scrap in it as 10%, 20 % and 30%.
- From the graph maximum flexural strength, we found at 10% mix of metal steel scrap in concrete and after that it starts decrease.
- Graph shows at 10% mix of metal steel scrap in concrete increased the strength by 8% than Nominal Mix i.e., 4.57 N/mm2 at 28 days
- The strength is gradually decreased after increases 8% strength gain at 10% mix of metal steel scrap in concrete.

Flexural Strength Test of Partial Replacement of Sand with Metal Steel Scrap in M_{30} Grade of Concrete.

Table 9: Flexural Strength M_{30} Grade of Concrete

Sr. No.	Concrete Mix	Avg. Strength (N/mm²) 7 Days	Avg. Strength (N/mm²) 14 Days	Avg. Strength (N/mm²) 28 Days
1.	Nominal Concrete	3.63	4.70	5.08
2.	10%	4.76	5.68	6.16
3.	20%	4.25	5.42	5.74
4.	30%	3.87	5.17	5.52

Graphical Representation

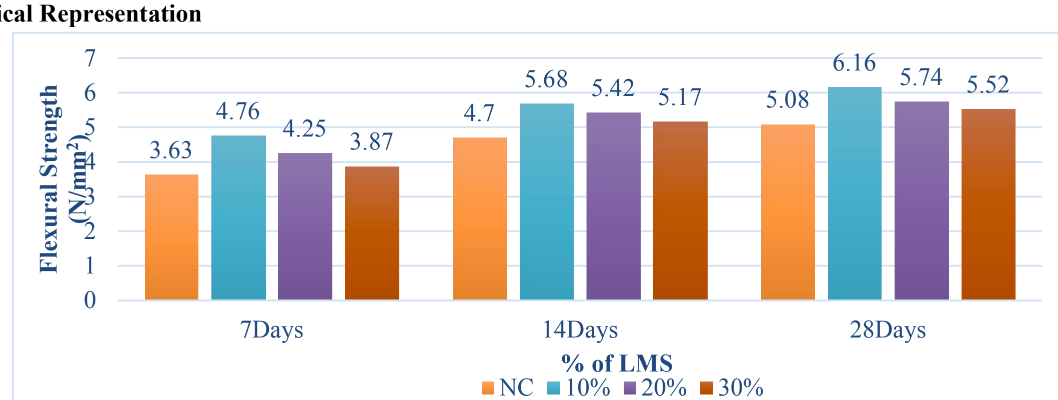

Figure 8: Flexural Strength M_{30} Grade of Concrete

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Interpretation of graph for Flexural Strength M_{30} Grade of Concrete

This graph interprets that the flexural strength for M_{30} grade of concrete at 7 days, 14 days and 28 days are observed as follow:

- From above graph we can observe comparison of flexural strength of Nominal Concrete of M_{30} grade and various percentage of mixing metal steel scrap in it as 10%, 20 % and 30%.
- From the graph maximum flexural strength, we found at 10% mix of metal steel scrap in concrete and after that it starts decrease.
- Graph shows at 10% mix of metal steel scrap in concrete increased the strength by 21% than Nominal Mix i.e., 6.16 N/mm2 at 28 days
- The strength is gradually decreased after increases 21% strength gain at 10% mix of metal steel scrap in concrete.

7.3 Split Tensile Strength Test

For split tensile strength test, cylinder specimens of dimension 150mm diameter and 300 mm length were cast. 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.

Split Tensile Strength Test of Partial Replacement of Sand with Metal Steel Scrap in M_{20} Grade of Concrete.

Table 10: Split Tensile Strength M_{20} Grade of Concrete

Sr. No.	Concrete Mix	Avg. Strength (N/mm²) 7 Days	Avg. Strength (N/mm²) 14 Days	Avg. Strength (N/mm²) 28 Days
1.	Nominal Concrete	1.34	1.86	2.15
2.	10%	1.67	2.34	2.57
3.	20%	1.96	2.52	3.09
4.	30%	1.75	2.45	2.95

Graphical Representation

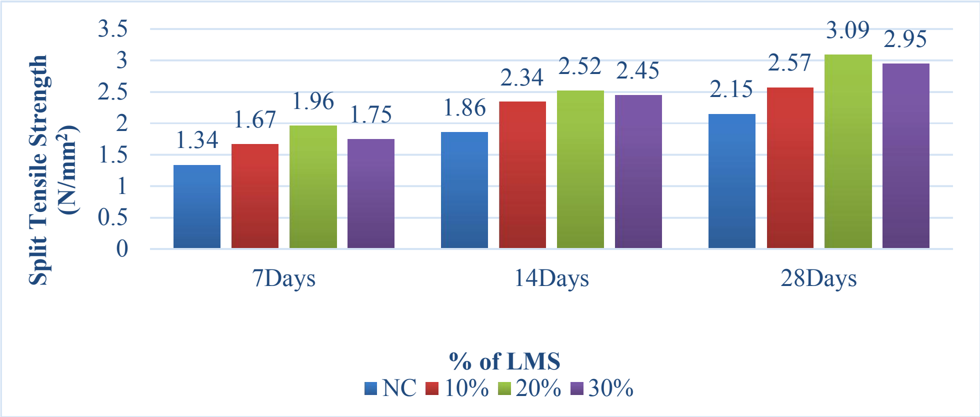

Figure 9: Split Tensile Strength M_{20} Grade of Concrete

Interpretation of graph for Split Tensile Strength M_{20} Grade of Concrete

This graph interprets that the split tensile strength for M_{20} grade of concrete at 7 days, 14 days and 28 days are observed as follow:

- It is comparison of split tensile strength of Nominal Concrete of M_{20} grade and various percentage of mixing metal steel scrap in it as 10%, 20 % and 30%.
- From the graph we can observe that maximum split tensile strength, we found at 20% mix of metal steel scrap in concrete.
- The split tensile strength for 10% mix of metal steel scrap in concrete which is increased by 19.5% than Nominal Mix i.e., 2.57 N/mm2
- The split tensile strength, we found at 20% mix of metal steel scrap in concrete which is increased by 43.5% than Nominal Mix i.e., 3.09 N/mm2
- Graph shows split tensile strength at 30% mix of metal steel scrap in concrete is 37% increased than Nominal Mix i.e., 2.95 N/mm2

Split Tensile Strength Test of Partial Replacement of Sand with Metal Steel Scrap in M_{30} Grade of Concrete.

Table 10: Split Tensile Strength M_{30} Grade of Concrete

Sr. No.	Concrete Mix	Avg. Strength (N/mm^2) 7 Days	Avg. Strength (N/mm^2) 14 Days	Avg. Strength (N/mm^2) 28 Days
1.	Nominal Concrete	1.49	2.48	2.76
2.	10%	1.56	2.67	2.88
3.	20%	2.26	3.18	3.49
4.	30%	1.93	2.97	3.16

Graphical Representation

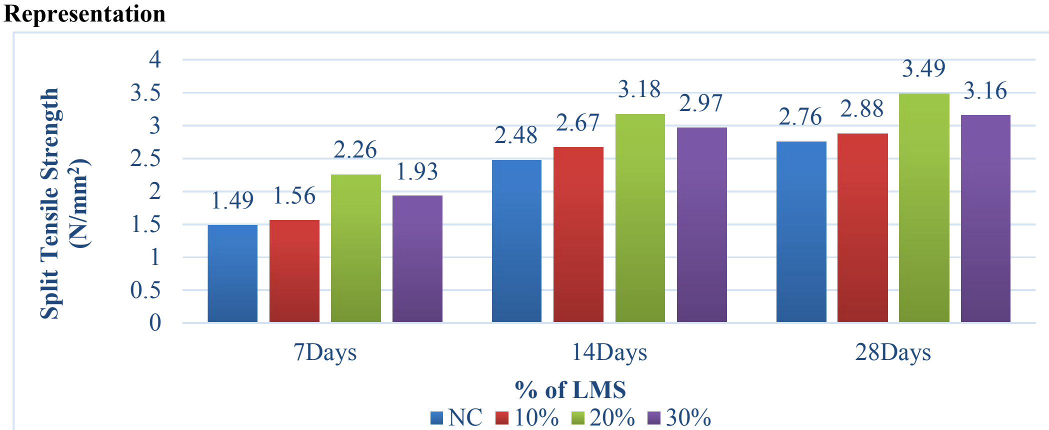

Figure 10: Split Tensile Strength M_{30} Grade of Concrete

Interpretation of graph for Split Tensile Strength M30 Grade of Concrete

This graph interprets that the split tensile strength for M30 grade of concrete at 7 days, 14 days and 28 days are observed as follow:

- It is comparison of split tensile strength of Nominal Concrete of M30 grade and various percentage of mixing metal steel scrap in it as 10%, 20 % and 30%.
- From the graph we can observe that maximum split tensile strength, we found at 20% mix of metal steel scrap in concrete.
- The split tensile strength for 10% mix of metal steel scrap in concrete which is increased by 4.5% than Nominal Mix i.e., 2.88 N/mm2

- The split tensile strength, we found at 20% mix of metal steel scrap in concrete which is increased by 33.5% than Nominal Mix i.e., 3.49 N/mm2
- Graph shows split tensile strength at 30% mix of metal steel scrap in concrete is 14.5% increased than Nominal Mix i.e., 3.16 N/mm2

VIII. Conclusion

In this study an experimental investigation has been done to find the properties of waste metal steel scrap concrete specimens where the compressive strength, flexural strength and split tensile strength have been evaluated. The following conclusions were drawn from experiments conducted on the specimens are as follows:

- By the replacement of fine aggregate with waste metal steel scrap, the compression strength of concrete increases at 20% of metal steel scrap mix by 25% in M20 and 20% in M30 respectively.
- From test result we found that flexural strength of concrete increases at 10% of metal steel scrap mix by 8% in M20 and 21% in M30 respectively.
- Result shows that split tensile strength of concrete increases at 20% of metal steel scrap mix by 43.5% in M20 and 26.5% in M30 respectively.
- Waste metal steel scrap concrete perform better than Conventional Concrete.
- For final conclusion, the results obtained shows that the addition of waste metal steel scrap generated from lathe machine in concrete enhances the strength of concrete without impairing any technical features of normal concrete. Waste metal steel scrap can be used to construct residential building, footpaths, road dividers, parapet wall etc.

Future Scope

- Study the behavior of structural elements using waste metal steel scrap in concrete.
- To overcome the problems related to use of waste steel chips concrete in structural elements.
- 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.
- This metal steel scrap concrete can be used in soil strata stabilization.

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