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USE OF METAL SCRAP AS PARTIAL REPLACEMENT OF FINE AGGREGATE BY IN CONCRETE

Mrunali Indurkar [*1], G. D. Dhawale [*2], R. S. Kedar [*3], V. A. Kalmegh [*4]

[*1] PG Student, Department of Civil Engineering, Bapurao Deshmukh College of Engineering, Sevagram, Maharashtra, India.

[*2] Professor, Department of Civil Engineering, Bapurao Deshmukh College of Engineering, Sevagram, Maharashtra, India.

[*3] Professor and Head of Department, Department of Civil Engineering, Bapurao Deshmukh College of Engineering, Sevagram, Maharashtra, India.

[*4] Professor, Department of Civil Engineering, Bapurao Deshmukh College of Engineering, Sevagram, Maharashtra, India.

ABSTRACT

In this study we had did partial replacement of fine aggregate by metal steel scrap in different percentage in concrete. In this paper, M20 and M30 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: Metal steel scrap, Reuse, compressive strength, Sustainability etc.

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 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.

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II. LITERATURE SURVEY

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, M30 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

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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]

III. METHODOLOGY

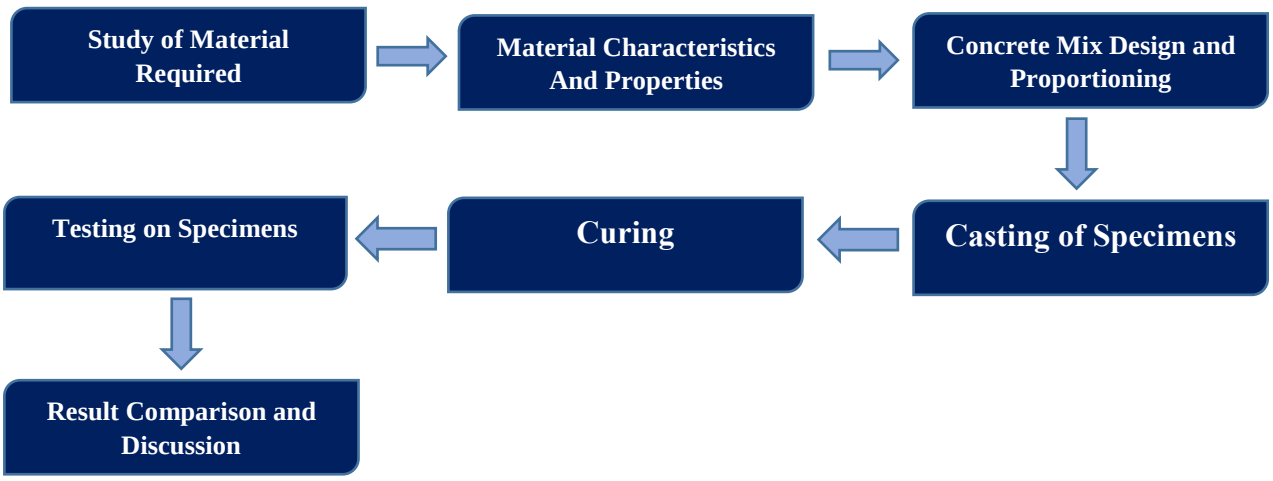

Fig.-1: Methodology Flow

IV. AIM & OBJECTIVE

Aim: Use of metal scrap as partial replacement of fine aggregate by in concrete.

Objective:

- Use of Steel scrap in concrete to increase compressive strength.
- To scan the effect of waste steel scrap in concrete.
- To establishing the alternatives of ingredients of concrete.
- To check the suitability of waste steel scrap in mix design concrete.
- To check feasibility test done on prepared concrete specimen like compressive strength.
- To compare test results with nominal concrete and optimum percentage of steel scrap for maximum strength of concrete.

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V. MATERIAL CHARACTERISTICS AND PROPERTIES

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

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

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5	Silt Content	1%	Not Exceed 8 %	IS:2386 – 2
6	Bulking of Sand	14.29%	Not Exceed 25 %	IS:2386 – 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

VI. CONCRETE MIX DESIGN AND PROPORTIONING

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

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PROPORTIONS:

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

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 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 = 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
358	676	1246	197
1	1.88	3.48	0.55

VII. RESULTS AND DISCUSSION

In this chapter discussion will be focused on compressive strength of concrete cube. All the test method adopted was describing in the previous chapter. The result presented in this chapter is regarding the compressive test different percentage of Lathe Metal Scrap in concrete.

As we all know that concrete is a mixture of sand, cement, and aggregate. The strength of the concrete depends upon many factors like individual compressive strength of its constituents (Cement, Sand, aggregate), quality of materials used, air entrainment mix proportions, water-cement ratio, curing methods and temperature effects. 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.

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- 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.

❖ **Compressive Strength Test of Partial Replacement of Sand with Metal Steel Scrap in M20 Grade of Concrete.**

❖ **Table 5 :**Compressive 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	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

❖ **Graphical Representation**

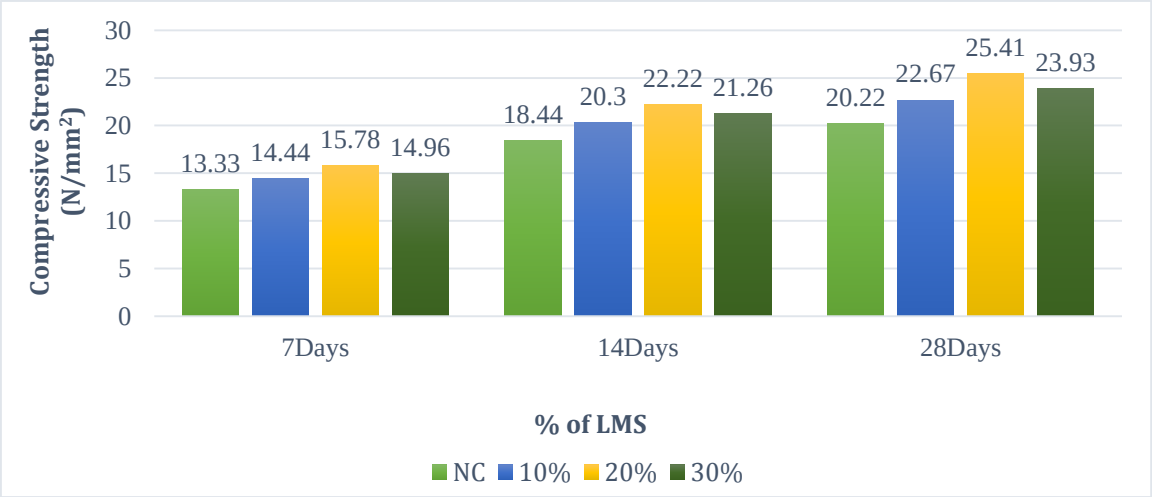

Fig. 2: Graph of Compressive Strength M_{20} Grade of Concrete

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

- This graph interprets that the compressive strength for M20 grade of concrete at 7 days, 14 days and 28 days are observed as follow
- It is compression of compressive strength of Nominal Concrete of M20 grade and percentage of mixing metal steel scrap in it at 10%, 20 % and 30%.
- From the graph maximum compressive strength, we found at 20% mix of metal steel scrap in concrete and at 30% its starts decrease.
- From the graph maximum compressive strength, we found at 20% mix of metal steel scrap in concrete for 7 days it increases 18% as 15.78 N/mm², for 14 days it increases 20% as 22.22 N/mm² and for 28 days it increases 25% as 25.41 N/mm².

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

Table 6: 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	19.85	27.26	30.15

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	Concrete			
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**

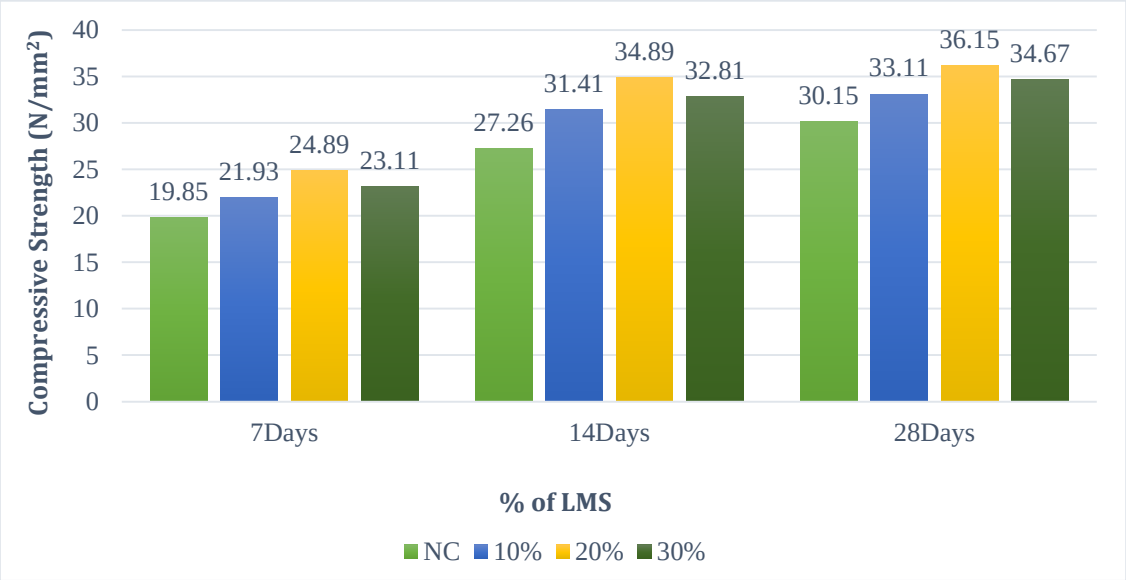

Fig. 3: Compressive Strength M_{30} Grade of Concrete.

❖ **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
- It is compression of compressive strength of Nominal Concrete of M_{20} grade and percentage of mixing metal steel scrap in it at 10%, 20 % and 30%.
- From the graph maximum compressive strength, we found at 20% mix of metal steel scrap in concrete and at 30% its starts decrease.
- From the graph maximum compressive strength, we found at 20% mix of metal steel scrap in concrete for 7 days it increases 25% as 24.89 N/mm², for 14 days it increases 28% as 34.89 N/mm² and for 28 days it increases 20% as 36.15 N/mm².

VIII. CONCLUSION

In this study an experimental investigation has been done to find the properties of waste steel chips concrete specimens where the compressive strength has been evaluated.

➢ The following conclusions were drawn from experiments conducted on the specimens are as follows:

- By the replacement of fine aggregate with waste steel chips, the compression strength of concrete increases at 20% of metal steel scrap mix.
- 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 footpaths, road dividers, parapet wall, this concrete can be used for soil strata stabilization etc.

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