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Research paper

Experimental study on partial replacement of fine aggregate by lathe steel waste with natural fibre in concrete

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Abstract

This topic focused on bettering concrete properties by replacing traditional materials with waste products, like from the steel industry, and incorporating natural fibres. The aim of this research are to mitigating environmental hazards connected with industrial waste while improving concrete performance. The studies investigated the feasibility of using steel lathe waste as a partial replace for fine aggregate in concrete, along with including coconut Fiber for some reason. Through experimental analysis, the percent of lathe scrap replacement and natural fibre incorporation is determined to achieve the mechanical properties wanted. The research assesses the compressive, tensile, and flexural strengths, as well workability and consistency of the concrete mixes - important stuff. Additionally, durability and resistance to environmental factors are being looked at. Comparative analysis includes figuring out cost-effectiveness with traditional concrete, even though it might be obvious. The project's scope includes a rather comprehensive investigation into the benefits and challenges of these alternative materials, contributing to sustainable construction practices, and minimizing environmental impact.

Keywords: *Engineering; Concrete; Lathe Steel Waste; Fibre; Cement; Lathe Machine Steel Scrap; Reuse; Compressive Strength; Flexural Strength; Split Tensile Strength.*

1. Introduction

Concrete, a fundamental building material, traditionally comprises cement, fine aggregate, and coarse aggregate, with their proportions determined determines the concrete's grade and strength. However, the construction industry's relentless demand for resources has necessitated innovative approaches to enhance concrete properties while addressing environmental concerns. This study explores the efficacy of replacing fine aggregate with lathe steel waste and integrating natural fibre to improve concrete characteristics, aiming to mitigate soil infertility, reduce land filling, and minimize environmental hazards associated with industrial waste

As per the International Concrete Institute (ICI), approximately 1200 million tons of lathe scrap are generated annually, primarily from iron and steel industries. Given that India ranks as the world's third-largest producer of crude steel, an abundant supply of lathe waste is is readily available for utilization in concrete production. By repurposing this industrial by-product, significant energy and time savings can be realized, contributing to both environmental conservation and economic efficiency. Moreover, the integration of natural fibres, particularly coconut fibre, further enhances the sustainability and affordability of concrete construction. Coconut fibre, derived from the husk of mature coconuts, is available in various forms, including decorticated, bristle, and mattress fibres. With approximately 12 million coconut trees cultivated worldwide, yielding 500,000 tons of coconut fibre annually, this renewable resource offers a cost-effective alternative to conventional steel reinforcement in concrete structure

By replacing fine aggregate with lathe steel waste at varying percentages (2%, 4%, 6%, and 8%), this study aims to investigate the impact on concrete properties, including compressive strength and split-tensile strength. Previous experimental studies have demonstrated a notable increase in compressive and flexural strength in lathe scrap reinforced concrete compared to plain cement concrete. Building on these findings, this research aims to elucidate the optimal proportion of lathe waste for enhancing concrete performance while minimizing material costs and environmental footprint. Furthermore, the inclusion of natural fibre in concrete formulations offers additional benefits such as improved ductility, crack resistance, and reduced carbon emissions. in this research we are add 1% of natural fibre into the concrete by the reference of cement . Unlike conventional steel reinforcement, coconut fibre reinforcement not only reduces the overall weight of concrete structures but also mitigates corrosion risks, thereby extending the service life of buildings and infrastructure."

2. Methodology

The methodology of this study involves a comprehensive experimental approach. It includes the collection of lathe scrap, processing it into suitable aggregate sizes, and incorporating it into concrete mixes. Various proportions of lathe scrap and natural fibres will be tested to determine the optimal blend for achieving the desired mechanical properties. The study will encompass a series of laboratory tests, such as compressive strength tests, flexural strength tests, and durability assessments, to evaluate the performance of the modified concrete. By merging innovation, sustainability, and experimental rigor, this project aspires to contribute to the development of eco-friendly and high-performance concrete solutions that align with the demands of modern construction while addressing environmental concerns.

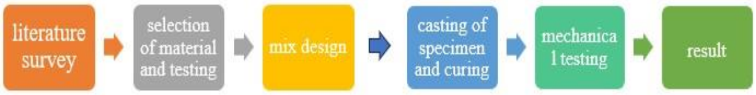


Fig. 1: Methodology Flow Diagram.

2.1. material selection and testing

The following type material to used to make this concrete in traditional way .this all the material test by their own properties with the helping of IS code . also the analysis material physical and chemical characteristics. This process is important for the design mix process.

2.1.1. Cement

The cement used was ordinary Portland cement of 53- grade conforming to is 12269-1987. the cement was check for its freshness and consistency. it was found dry, pure, without any lumps.

Table 1: Properties of Cement

sr no	Description	results
1.	fineness of cement	8%
2.	standard consistency	33%
3.	specific gravity	3.15
4.	initial setting time	30 min
5.	final setting time	10 hrs

Fig. 2: Cement Bag.

2.1.2. Fine aggregate (cursed sand or artificial sand)

Neighbourhood clean waterway sand of Zone I, conforming as per IS 383-1970 were used. The sand was sieved with 4.75 mm. It was free from clay, silt and organic impurities. The aggregate was tested for its physical requirements such as gradation, fineness modulus, specific gravity and bulk modulus in accordance with 15: 2386-1963.

Fig. 3: Fine Aggregate.

Table 2: Properties of Fine Aggregate

Sr no	Description	Results
1.	Specific Gravity	2.43

2.1.3. Coarse aggregate

The coarse aggregate used in this present study was 20 mm and 10 mm down size locally available crushed stone obtained from local quarries. The physical properties have been determined as per is: 2386-1963. The specific gravity of coarse aggregate was found to be 2.87. The water absorption was 0.25%.

Table 3: Properties of Course Aggregate

Sr no	Description	Results
1.	Specific Gravity	2.87

Fig. 4: Course Aggregate

2.1.4. Water

Water Is One Of Important Material For The Pervious Concrete Potable Water With PH Value 6.5 – 8.5 Is Used For Mixing And Curing Throughout The Experiment

2.1.5. Lathe waste

The utilization of industrial waste produced by process has been the main target of waste reduction researched from economic, environmental and technical reasons . Steel slag is a steel waste production lathe industry.

Fig. 5: Steel Lathe.

Table 4: Properties of Lathe Waste

Sr no	Description	Results
1.	Colour	Light To Dark Grey
2.	Shape	Highly Angular
3.	Combustibility's	Non - Combustible
4.	Surface Texture	Rough

2.1.6. Coir fibre

Locally available waste materials were collected from different and property shaped in the form of fibres. uniform length of fibres was obtained by using curing machine. typical properties of fibre shown in table 5

Fig. 6: Coconut Fibre.

Table 5: Properties of Coir Fiber

Sr no	Description	Results
1.	Diameter	0.50 mm
2.	Length of fibre	60mm
3.	Appearance	Brown as thin wire
4.	Deformation	Uneven at both ends

2.1.7. Admixture (superplasticizer)

The type of admixture we used to make the concrete is the superplasticizer the main ingredient on this admixture is POLYTANCRETE NGT. This admixture is Conforms to ASTM C 494 Type F & IS 9103 for chemical admixture . It is Reduce water cement ratio while maintaining workability and Increases strength of the concrete/ mortar by reducing water content.

2.2. Mix design

This project research take for M25 grade of concrete .for preparation of M25 grade concrete. We are first taken the all test on material like ; specific gravity , water absorption , finesse ,sieve analysis ect. that required the prepared mix design of concrete . After that by using is 10262 :2009 prepared the mix design for m25 grade of concrete . the following the mix design ratio of concrete for 1 metric cube

Table 6: Mix Design Ratio of M25 Grade Concrete

Water	Cement	Fine aggregate	Coarse aggregate	Lathe Steel 2%	Lathe Steel 4%	Lathe steel 6%	Coir Fiber 1 %	Admixture (superplasticizer)
0.45	1	2.18	3.01	0.043	0.087	0.130	0.009	0.0199

Table 7: Quantity of M25 Garde Concrete for 1 M^3

Water (Lit/m^3)	Cement (kg/m^3)	Fine aggregate (kg /M^3)	Coarse aggregate (Kg /m^3)	Lathe Steel 2% (kg /m^3)	Lathe Steel 4% (kg/m^3)	Lathe steel 6% (kg/m^3)	Coir Fiber 1 % (kg/m^3)	Admixture (superplasticizer) (kg/m^3
167.5	372 .22	810	1122	16.2	32.4	48.6	3.72	7.44

2.3. Casting of specimen and mechanical testing

Fig. 7: Cube Specimen.

The following project research the concrete was casted by weight beaching method . we casted 24 number of cube for compressive strength test . also we casted 12 number of beam for flexural strength test and 12 number of cylinder for split tensile strength test . the size of specimen we taken for cube is standard 150 mm X 150 mm X 150 mm for beam size is 150 x 150 x 700 mm and cylinder size is 150 x 300 mm . we study and analysis the material properties and according to that research create the concrete combination . by using that combination we casted specimen . that concrete combination mention below table

Fig. 8: Cylinder Specimen.

Fig. 9: Beam Specimen.

Table 8: Concrete Combination of Lathe Steel with Addition Natural Fibre

Sr no	Concrete combination	Number of specimen cast			
		Cube		Beam	Cylin-der
		7days	28 days	28 days	28 days
1	Cement + fine aggregate + coarse aggregate + water + superplasticizer	3	3	3	3
2	Cement + fine aggregate + coarse aggregate + water + superplasticizer + 2 % lathe steel + 1% coir Fiber	3	3	3	3
3	Cement + fine aggregate + coarse aggregate + water + superplasticizer + 4 % lathe steel + 1% coir Fiber	3	3	3	3
4	Cement + fine aggregate + coarse aggregate + water + superplasticizer + 6 % lathe steel + 1% coir Fiber	3	3	3	3

3. Result

The compressive strength test , flexural strength test and split-tensile strength tests were conducted on prepared concrete specimens. The specimens were cured for 7 days and 28 days before testing. The results have been tabulated in the table and figure below

Fig. 10: Compression Strength Test on Universal Testing Machine

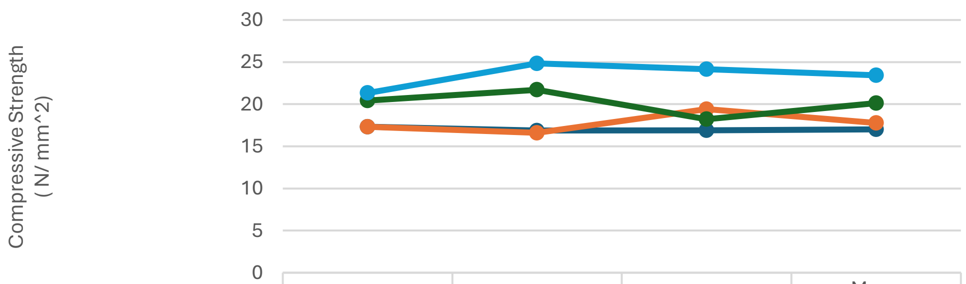
Fig. 11: Split Tensile Strength Test on Compression Testing Machine

Fig. 12: Flexural Strength Test on Universal Testing Machine

3.1. Compressive strength test

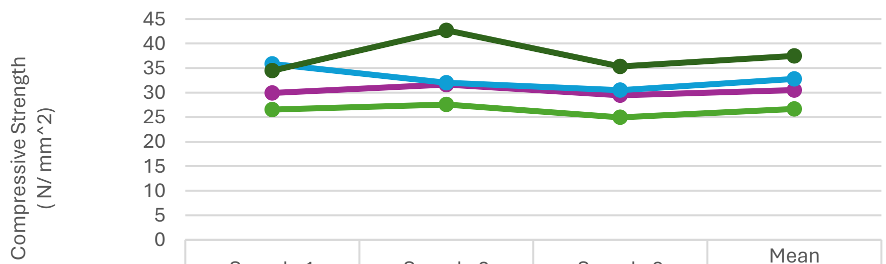
As per the Indian code IS 516:1959, the compression test has the following objective, one can easily judge the concrete strength and quality of concrete produced. Compression tests are used to determine the material behavior under a load. The compressive strength test has been conducted for conventional concrete (i.e., 0% replacement) and fine aggregate replaced by lathe waste. The fine aggregate is replaced by 2% lathe with 1 % coir fiber , 4% lathe with 1 % coir fiber and 6 % lathe with 1 % coir fiber . The test results of 7 days and 28 days are shown in table 9 and figure 2, 3, 4

The above graph indicates that the compressive strength 7days and 28 days with various percent of lathe waste with coir fiber added to concrete in replacement to fine aggregate (sand). The optimum strength gained after 28 days curing period is at 6% addition and lowest at 0 % addition of lathe waste in replacement to fine aggregate. . The value shows at 2% ,4%, 6% mix of metal steel scrap with 1 % coir fiber in concrete increased the strength by 4.40 % , 18.14 % , 37.63 % than Nominal Mix i.e., 17.78 N/mm^2, 20.12 N/mm^2 , 23.44 N/mm^2 at 7 days at respectively and for 28 days concrete strength increased by by 14.31 % , 22.90 % , 40.55 % than Nominal Mix i.e., 30.5 N/mm^2, 32.79 N/mm^2 , 37.5 N/mm^2 at 28 days at respectively .the strength is constantly increased after increases 4.10 and 14.31 strength gain at 2% mix of metal steel scrap in concrete. So 6% lathe steel with 1% coir fiber is best to used for increasing strength point of view.



	Sample 1	Sample 2	Sample 3	Mean (N/mm^2)
Normal (0%)	17.33	16.88	16.89	17.03
2% (lathe) + 1%(fiber)	17.33	16.61	19.42	17.78
4% (lathe) + 1%(fiber)	20.44	21.71	18.22	20.12
6% (lathe) + 1%(fiber)	21.33	24.85	24.16	23.44

Fig.13: Compressive Strength 7 Days of M25 Grade Concrete.



	Sample 1	Sample 2	Sample 3	Mean (N/MM^2)
Normal (0%)	26.56	27.58	24.96	26.68
2% (lathe) + 1%(fiber)	29.94	31.65	29.46	30.5
4% (lathe) + 1%(fiber)	35.85	32.03	30.5	32.79
6% (lathe) + 1%(fiber)	34.47	42.71	35.33	37.5

Fig. 14: Compressive Strength 28 Days of M25 Grade Concrete.

Table 9: Compressive Strength of M25 Grade Concrete

Percentage of lathe waste and coir fiber	7 - days Compressive Strength (N/mm^2)	28 - days Compressive Strength (N/mm^2)
Normal (0%)	17.03	26.68
2% (lathe) + 1%(fiber)	17.78	30.5
4% (lathe) + 1%(fiber)	20.12	32.79
6% (lathe) + 1%(fiber)	23.44	37.5

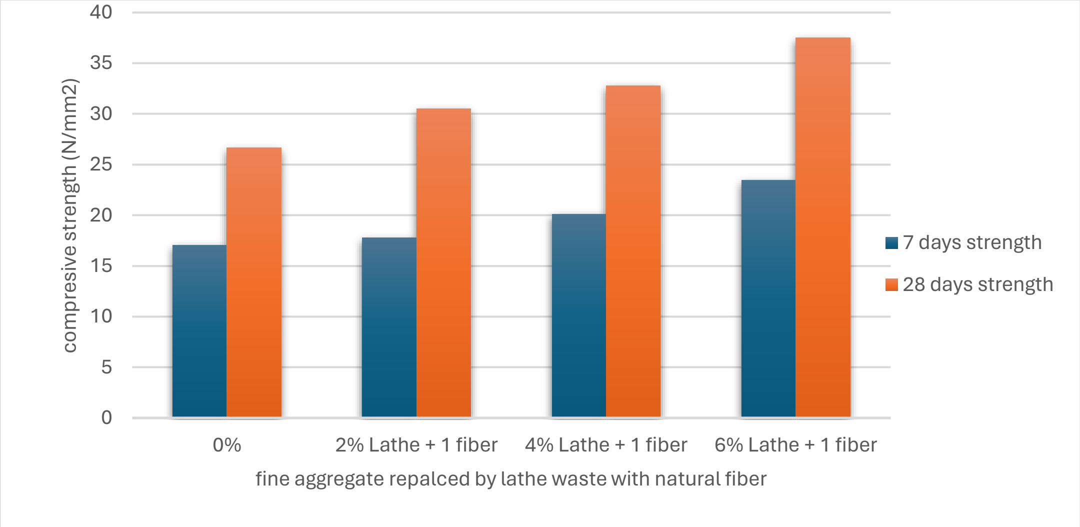
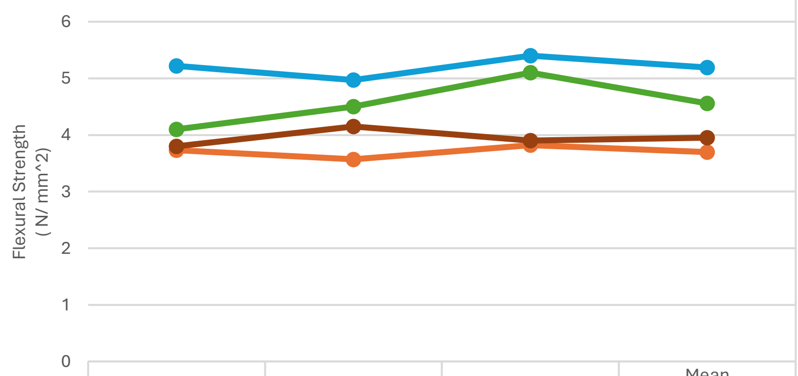


Fig. 15: Compression Between Tradition (0%) Concrete and Percentage of Lathe Steel Concrete.

3.2. Flexural strength test

For flexural strength test beam specimens of dimension 150x150x700 mm were cast. These flexural strength specimens were tested under one-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 The test results of 28 days are shown in table 10 and figure 5.
This graph interprets that the flexural strength for M25 grade of concrete at 28 days are observed as the above graph we can observe comparison of flexural strength of Nominal Concrete of M25 grade and various percentage of mixing lathe steel scrap in it as 2%, 4 % and 6%.with 1 % coir fiber common all concrete .The optimum strength gained after 28 days curing period is at 2% addition and lowest at 0 % addition of lathe waste in replacement to fine aggregate. From the graph maximum flexural strength, we found at 2% mix of metal steel scrap with 1 % coir fiber in concrete and after that it starts decrease. Graph shows at 2% mix of metal steel scrap in with 1% coir fiber in concrete increased the strength by 40% than Nominal Mix i.e., 5. 19N/mm^2 at 28 days So 2% lathe steel with 1% coir fiber is best to used for economical point of view.



	Sample 1	Sample 2	Sample 3	Mean (N/MM^2)
Normal (0%)	3.73	3.57	3.82	3.7
2% (lathe) + 1%(fiber)	5.22	4.97	5.4	5.19
4% (lathe) + 1%(fiber)	4.1	4.5	5.1	4.56
6% (lathe) + 1%(fiber)	3.8	4.15	3.9	3.95

Fig. 16: Flexural Strength 28 Days of M25 Grade Concrete.

Table 10: Flexural Strength of M25 Grade Concrete

Percentage of lathe waste and coir fiber	28 - days flexural Strength (N/mm^2)
Normal (0%)	3.70
2% (lathe) + 1%(fiber)	5.19
4% (lathe) + 1%(fiber)	4.56
6% (lathe) + 1%(fiber)	3.95

3.3. 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. The split-tensile strength test has been conducted for conventional concrete (i.e., 0% replacement) and fine aggregate replaced by lathe waste with coir fibre . The fine aggregate is replaced by 2%, 4%, 6% . The test results of 28 days are shown in table 11 and figure 6.

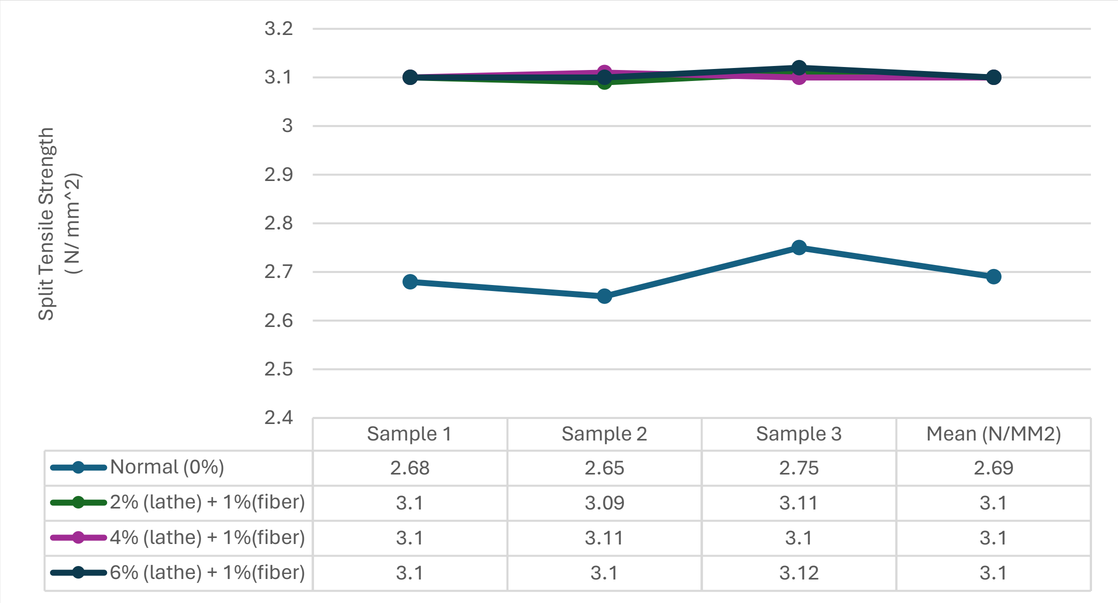


Fig. 17: Split Tensile Strength 28 Days of M25 Grade Concrete.

This graph interprets that the Split Tensile Strength Test for M25 grade of concrete at 28 days are observed as the above graph we can observe comparison of flexural strength of Nominal Concrete of M25 grade and various percentage of mixing lathe steel scrap in it as 2%, 4 % and 6%.with 1 % coir fiber common all concrete. From the graph we can observe that maximum split tensile strength, we found at 2% mix of metal steel scrap with the 1 % fiber in concrete strength get started increasing and after that 4 % and 6% strength get constant. Graph shows at 2% mix of metal steel scrap in with 1% coir fiber in concrete increased the strength by 15% than Nominal Mix i.e., 3.1N/mm^2 at 28 days . So 2% lathe steel with 1% coir fiber is best to used for economical point of view

Table 11: Split Tensile Strength of M25 Grade Concrete

Percentage of lathe waste and coir fiber	28 - days split tensile Strength (N/mm^2)
Normal (0%)	2.69
2% (lathe) + 1%(fiber)	3.1
4% (lathe) + 1%(fiber)	3.1
6% (lathe) + 1%(fiber)	3.1

4. Conclusion

Based on the results obtained from the experimental study on the partial replacement of fine aggregate by lathe steel waste with natural fiber in concrete, several conclusions can be drawn:

- Compressive Strength:The addition of 2%, 4%, and 6% of metal steel scrap with 1% coir fiber in concrete resulted in significant improvements in compressive strength compared to the nominal mix. The highest increase in strength was observed at 6% replacement, indicating that this combination is optimal for enhancing compressive strength.
- Flexural Strength: The maximum flexural strength was achieved with 2% addition of lathe steel waste and 1% coir fiber in concrete. Beyond this point, the strength began to decrease. This suggests that 2% lathe steel with 1% coir fiber is the most economically viable option for enhancing flexural strength.
- Split Tensile Strength: Similar to flexural strength, the maximum split tensile strength was observed with 2% addition of metal steel scrap and 1% coir fiber in concrete. This combination resulted in a 15% increase in strength compared to the nominal mix.

So the findings indicate that incorporating lathe steel waste and natural fiber in concrete can lead to significant improvements in mechanical properties such as compressive, flexural, and split tensile strengths. The optimal combination for enhancing these properties while considering cost-effectiveness is 2% lathe steel waste with 1% coir fiber. This research contributes to sustainable construction practices by utilizing waste materials and minimizing environmental impact. Further studies could explore additional parameters and long-term durability to validate these findings comprehensively.

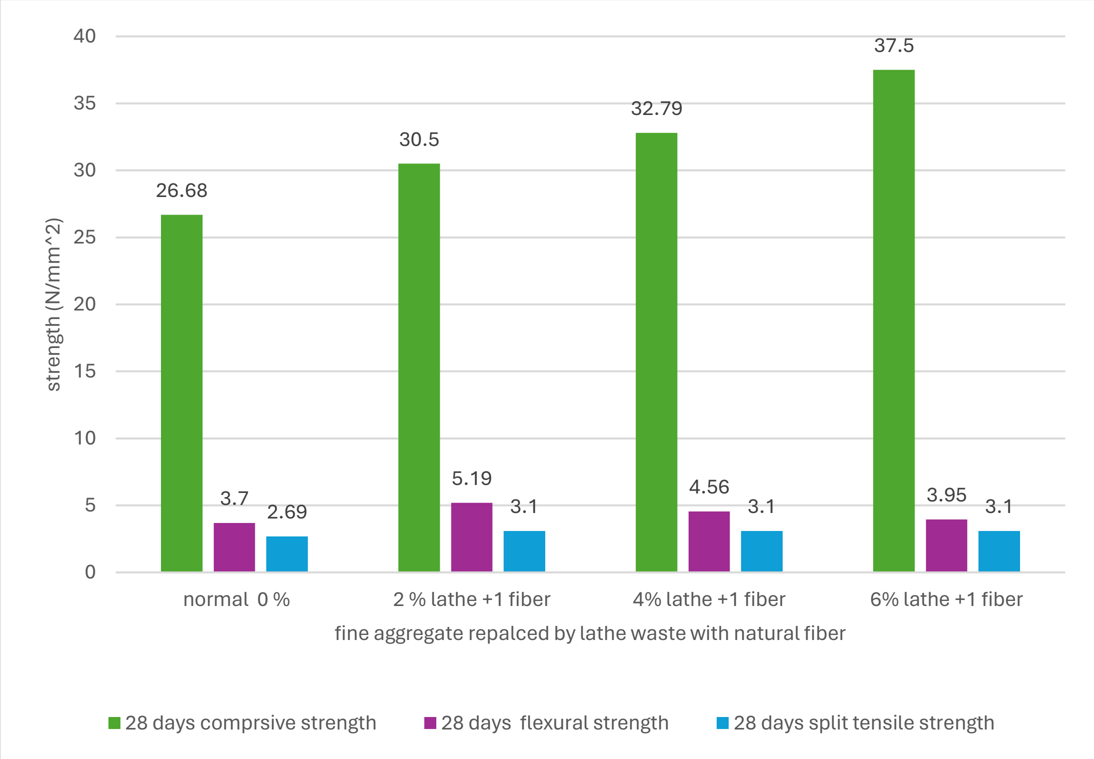


Fig. 18: Combined Strength of M25 Grade Concrete.

5. Future scope

- Examine how different curing conditions affect the strength and durability of concrete with lathe steel waste and natural fiber.
- Explore additives or chemical treatments to improve the bond between lathe steel waste and the concrete matrix.
- Assess the suitability of using lathe steel waste and natural fiber concrete for road pavement or precast construction elements.
- test the performance of the concrete mixture under extreme environmental conditions like freeze-thaw cycles or exposure to aggressive chemicals.

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