Experimental Investigation of Mechanical Properties of Fiber Reinforced Concrete Using Recycled Fiber

Prakhar Duggal[1*]; Ujjwal Bharadwaj[1], Amit Kumar Pandey[2]; Vijit Chaturvedi[3]; Jaya Yadav[3]; Vijay Kumar Dwivedi[4]
[1]Amity School of Engineering & Technology, Amity University Uttar Pradesh, Noida, India
[2]Institution of Management Studies Ghaziabad, India
[3]Amity Business School, Amity University Uttar Pradesh Noida, India
[4]Madan Mohan Malviya Technical University Gorakhpur, India
*Corresponding author: prakharduggal@gmail.com

Abstract-Concrete's propensity to fracture under tensile stress limits its structural performance and life. This study investigates using Recycled Steel filaments (RSF) made from artificial derivations to ameliorate the mechanical rates of concrete. At volumetric rates of 1.5, 2.25 percent, and 3, RSF was added. Compressive strength, flexural strength, and resolve tensile strength trials were carried out. According to the results, rigidity, cargo- bearing capacity, and crack resistance were each markedly bettered by an increase in RSF attention. The results indicate that RSF is a good cover for traditional concrete in terms of strengthening it, as it not only enhances mechanical performance but also encourages provident and environmentally friendly structure styles by recovering artificial waste.

Keywords: Recycled steel fiber, Fiber reinforced concrete , Sustainable construction, Compressive strength, Waste tire recycling, Mechanical properties

1 Introduction

Concrete's low tensile strength and cracking tend to be the main issues when using it for construction due to its durability. Other more resilient materials like fiber glass and synthetic materials are incorporated into concrete to from Fiber Reinforced Concrete (FRC). One innovation that has emerged for tackling this problem uses recycled steel fibers (RSF) from waste tires, increasing the tensile strength, impact resistance, ductility of concrete while reducing environmental pollution. Incorporating steel wires and mesh from used vehicle tires into used concrete increases the strength and durability of concrete making it more cost effective and ecofriendly. In addition to these benefits RSF also improves crack resistance, fire resistance, thermal insulation, as well as energy efficiency. This application is beneficial for the circular economy as it

V. Kumar et al. (eds.), *Proceedings of the International Conference on Advanced Design, Manufacturing, and Sustainable Energy Systems (ICADMSES 2026)*, Atlantis Highlights in Engineering 45,
https://doi.org/10.2991/978-94-6239-750-7_32

promotes the use of unused materials while reducing the carbon footprint of the construction sector.

This study focuses on the sustainability and mechanical properties of RSF reinforced concrete. The goal is to systematically review previously conducted studies and identify important outcomes regarding the performance and the possibility of using recycled steel fibers for other construction applications. This approach not only advances concrete technology but encourages eco-friendly construction methods.

Annual Tire Usage and Wastage in India

As one of the leading countries in both tire consumption and manufacturing, India is currently experiencing a growth in automobile industry, which subsequently increases the environmental challenges associated with tire production and disposal.

According to current data: India generates roughly 200 million tires each year. About 0.6 million tons of obsolete tires are produced each year. Roughly 275,000 tires are thrown away daily in India [1]. Open burning of waste materials leads to uncontrolled release of scrap tires, which further adds waste to the disposal problem. The lack of regulated frameworks for obsolete tires drastically compounds air and water pollution caused by leachates and microplastics, posing severe environmental threats. Using obsolete tires for recycling or repurposing in construction projects such as concrete structures provides opportunities to mitigate waste and pollution in an environmentally conscious manner.

2 Literature Review

2.1 A Comparative Study and Performance of Recycled Steel Fiber

This chapter is concerned with the Construction and structural mining possibilities of the use of recycled steel fibre concrete in construction works and gives some reasons from the above sentences. Different test samples have been addressed with test procedures described in the earlier chapter. The results of the current chapter are related to the mechanical properties as well as environmental effects.

A particularly important conclusion highlights that the recycled steel fibre indicates that RSF may improve flexural strength by as much as seventy percent, while fatigue resistance may be taken to thirty percent, when compared to ordinary concrete. Precisely the utilization of RSF from end-of-life tires not only remarkably increases the toughness but promotes the sustainable endeavor to utilization of waste materials.[1] The experiment further demonstrates the benefits of incorporating Recycled Steel into concrete and enhancing its quality. It is worth noting that the growing concern of pollution in India provides an impetus for RSF Concrete as building material. This is broad scope to sustainable construction. The embedding of recycled steel fibers (RSF) in concrete increases sturdiness and overall acceptability of the material towards global practice in construction. Such outcomes have been noted in compressive strength, flexural strength and toughness which are helpful in the material's load bearing capacity [1].

Compressive Strength- The RSF doesn't only reinforce the concrete bonding but also increases volumetric ratios proportional to increasing form work aspects ratio compressive strength increases up to 3%. Applying silica fume in RSF reinforced concrete has been shown to document modest improvements in compressive strength.

Flexural and Tensile Strength- Observations had shown that depending on the volume of RSF included, the recorded maximum improvement on flexural strength was 6% while the minimum was 2%. RSF incorporation can lead to increased splitting tensile strength by about 8%.

Toughness and ductility- RSF is positively affecting the post-cracking characteristics and toughness of the concrete indicating the ductility is improved, and the brittle fracture risk is lower while the amount of energy absorbed is higher. RSF combined with silica fumes can improve ductility when we use recycled aggregate concrete. Overall, the contribution of RSF into concrete is positive but there is some evidence that still compressive strength of such concreate is less than that of normal concrete and hence more needs to be done at the mix design levels.

2.2 Recycled Fibers for Sustainable Hybrid Fiber Cement Based Material

Mixed Waste Recycled Tire Steel Fiber (WRTSF): Current Literature Trends and Future Prospects. From the title it can be implied that the objective of this document is to map the existing literature on WRTSFs, find the existing research gaps and offer appropriate directions for future research.

This Paper today is useful for the practitioners of WRTSF construction technology as it addresses the changes in WRTSF-reinforced concrete with emphasis on WRTSFs as a green building material. It includes substantial analysis to promote future studies that work towards improving the utilization of WRTSFs in all areas of construction like pavements, tunnel linings, and hydraulic structures [2].

This research indicates that there has been a development in steel fibre reinforced concrete (SFRC)into using more recycled materials with WRTSF as a better substitute for conventional steel fibres. This is very relevant because the world needs sustainable development and waste tires are being manufactured in larger quantities by factories each day.

The WRTSF-reinforced concrete has many applications including pavements, tunnel linings, bridge decks covering, hydraulic structures etc discusses since it identifies all possible areas where the WRTSFs can be improved. These lines are discussed on the processes of improving the performance of the concrete in those applications by using the special properties of WRTSFs [2].

2.3 Investigation Into the Mechanical Properties of Structural Lightweight Concrete Reinforced with Waste Steel Wires

The use of various waste fibres in concrete has gained a lot of popularity recently owing to the economic factors and environmental reasons. This study focused on integrated waste steel wires from used formworks and steel reinforcement into structural lightweight concrete so as to replace the controlled commercial steel fibres with recycled steel fibre.

The compressive, tensile, flexural, and impact strength studies were conducted on the 28 day old concrete specimens cylindrical, reinforced with hybrid waste steels wires, hybrid steel fibres and plain concrete and varying percentages of the steel content were examined in the fibre reinforced concrete (FRC) specimens with specific focus on the three percentages of 0.25%, 0.50%and 0.75% (volume fraction of concrete). While changing the fibre contents, results were obtained in all the types of FRCs that were examined. Waste steel wires were then found to be able to provide an answer to wide industrial challenges as such wires are suitable replacement for industrial steel fibers, in lightweight structural concrete applications [3].

The conclusion suggests that adding waste steel wires (WFRC) or industrial steel fibers (SFRC) up to 0.50% volume fraction improves the compressive strength of lightweight concrete, but more than 0.50% decreases it. Both types of fibers significantly enhance splitting tensile strength, with WFRC performing better. WFRC0.75 shows the highest flexural strength and energy absorption, and an eighteen-fold increase in impact resistance compared to plain concrete, though still lower than SFRC0.75[3]. Overall, waste steel wires are a viable, economical, and environmentally friendly alternative to industrial fiber for certain applications.

2.4 Application of Waste Recycling Tire Steel Fibers as a Construction Material in Concrete

The study highlights the properties of WRTSFs', which include compressive strength (CS), split tensile strength (STS), flexural strength (FS), fracture toughness and energy absorption capacity can be improved due to CSCS[16]. The study specifies optimal the following WRTSF aspect ratio (50–100), tensile strength (>1000 MPa), diameter of 0.2-0.5mm and length 25-50 mm of WRTSF that are connected to better mechanical performance.[4]

A comparative study as per the previous investigation, various WRTSF contents levels (as a percentage of volume) showed different strengths of M30 concrete:

- 0.4% WRTSF: Increase by 29% in the compressive strength.[4]
- 2% WRTSF: Further increases split tensile strength by 149%.[4]
- 3% WRTSF: Increase flexural strength by 157% and energy absorption by 82% and fracture toughness by 110%.[4]

In comparison, the performance of WRTSF-reinforced concrete and conventional steel fiber reinforced concrete performances in many ways have been found to be similar or better improvements in concrete if raw steel fibers are incorporated.

The replacement of cement with RSF in Concrete blocks leads to a reduced demand for cement, ultimately cutting down manufacturing costs and CO2 emissions associated with cement production. The report underscores the eco-friendliness and cost-effectiveness of RSF, which reduces costs and contributes to environmental improvement.

In conclusion, the report strongly advocates that the use of RSF in Concrete makes a superior and cost-effective alternative to traditional steel, highlighting their enhanced strength, diverse properties, and environmental benefits Furthermore, WRTSF reinforced concrete is an environmentally eco-friendly.

2.5 Behavior of Lightweight Self-Compacting Concrete with Recycled Tire Steel Fibers

This study aims at evaluating the viability of Lightweight Self-Compacting Concrete (LWSCC) reinforced with Recycled Tire Steel Fibers (RTSFs). LWSCC, with excellent light weight and workability, typically possesses low mechanical strength to normal concrete due to use of lightweight aggregates (LWA). The study concentrates on the properties of LWSCC beams after each application of RTSFs, with emphasis on cracking, deflection, ductility, and load carrying capacity. The experimental values are compared with ACI predictions. The outcome of this investigation shows that the LWSCC containing RTSFs has better tensile strength behavior which leads to higher performance in repairing construction rather than conventional type of construction. It can be assessed based on the outcomes of the study that using RTSFs in LWSCC mixtures has the following advantages: It was found that the use of RTSFs decreased the deflection at the midspan and the width of cracking at service load levels by 25% and 45% respectively which improved the ductility index between 12% and 16% when compared to non-fibrous control beams .[5] The load at which the beams without RTSFs initiated cracking was increased by 52.5% and 63.8% for 0.5% and 1.0% contents respectively and also the ultimate load also improved [5]. A bit of slump flow of the mixture was lost with the use of RTSFs but none of the formulations were below the EFNARC specified lower limits which provided enough flowability for the SCC. The research focuses on the need for making studies on the performance and durability of the LWSCC reinforced with RTSFs after different exposure periods and conditions, and further studies will take Roberts to the regions for practical investigation to support the laboratory results.

2.6 Mechanical and Durability Performance of Concrete with Recycled Tire Steel Fibers

The focus of this paper is to investigate the use of recycled tire steel fibers (RTSF) in replacing the industrial steel fibers (ISF) at a lower cost in the making of concrete. This study also attempts to mitigate global issues stemming from the disposal of waste tires. The study will seek to compare the mechanical properties, workability, and durability of RTSF reinforced concrete (RSC) against ISF reinforced concrete (ISC).[6] The literature review provides an overview of the results of Study on Strength and initial surface of concrete. The main objective of the study is to determine the strength and initial surface absorption of concrete with the addition of recycled steel fibers. This paper seeks to understand the added benefits of these fibers in improving tensile and compressive strength of concrete while assessing its permeable and water absorption features.[8] The review paper focuses on the impacts of waste tires in the environment especially in India and their classification problem, which is somehow related to health hazards. Most studies have been conducted on the addition of steel fibers which are usually produced in industries to improve the mechanical properties of Concrete. Past research findings demonstrate that use of steel fibers improves the tensile and compressive strength of concrete and considerably lowers its water absorption [8] previous research regarding important facts of fiber reinforcement in concrete such as enhanced tensile strength with increase in fiber length and better adhesion with certain fiber shape. Still, when excessive number of fibers is used, performance may decline and RTSFs may have deleterious effects on freeze-thaw endurance. The study results show that RTSFs enhance the workability of concrete and provide flexural strength similar to industrial steel fibers. The properties of the concrete with RTSF reinforcement are more flowable, possess 15.4% higher tensile strength, and have improved durability with less shrinkage and freeze-thaw cycles. All in all,', RTSF has economic and eco-friendly benefits by replacing waste tires but does not compromise the working of concrete.[6]

2.7 Technical and Environmental Potentialities of Recycled Steel Fiber Reinforced Concrete for Structural Applications

The main objective of the study was to analyze the environmental performance of the Recycled Steel Fiber Reinforced Concrete (RSFRC) in comparison to the Industrial Steel Fiber Reinforced Concrete (ISFRC) through Life Cycle Assessment (LCA). This evaluation was based on ISO 14,040-44:2006 and EN 15804:2012+A1 documents and looked at the ecologists focus of concrete with 1 percentage volume of RSF harvested from waste tires.[7]

As seen in the literature, there is increasing number of studies towards the implementation of recycled material or utilization of construction waste as a viable material for cement based composites in structural applications. This reduction in environmental footprints has been observed in previous research whenever construction waste materials have been incorporated particularly in concrete. The Objective of the research tasks also consisted of numerical simulations to retrieve the post cracking constitutive laws of RSFRC and ISFRC, which were in turn compared to the experimental results derived from a number of tests. Such an investigation generated a more adequate picture of the large scale properties and exposure risks of both types of concrete.[7] Results showed that RSFRC has less environmental impacts than the ISFRC in several categories like Global Warming Potential, Primary Energy Demand Renewable and Non-renewable, Photochemical Ozone Creation Potential POCP, and Abiotic Depletion Potential ADP for fossil fuels, among other impact categories. In particular, these categories registered a decrease of RSFRC88 by 17%, 20%, 28%, 34%, and 34% respectively, when compared to ISFRC with similar concrete matrix.

3 Objectives

- **Evaluate Mechanical Properties:** Examine the concrete compressive strength using recycled fibers.
- **Optimize Fiber Content and Type:** To achieve the best strength and durability
- **Compare Recycled vs. Virgin Fibers:** Examine the differences in performance between virgin and recycled fibers in reinforced concrete.
- **Assess Durability and Crack Control:** Examine how recycled fibers increase concrete's durability and reduce cracking.
- **Evaluate Sustainability Benefits:** Calculate environmental benefits such as reduced carbon emissions and waste.

4 Methodology

1. OPC Cement- Ordinary Portland Cement (OPC) 53 is a type of hydraulic cement widely used in the construction industry. The "53" in its name refers to the compressive strength of the cement after 28 days of curing. OPC 53 has a minimum strength of 53 MPa (megapascals) or approximately 6,200 pounds per square inch (psi).
2. Fine Aggregates- Fine aggregate refers to the natural sand or crushed stone that passes through a 4.75 mm IS sieve and is used to fill the voids between coarse aggregates and provide workability to concrete.
3. Coarse Aggregates- Coarse Aggregates are fundamental construction material commonly used in a wide range of building and infrastructure projects. These aggregates play a crucial role in providing structural stability and durability to concrete and other construction materials

Specific gravity of 10 mm aggregate is 2.7 whereas specific gravity of 20 mm aggregate stands at 2.85

4. Recycled Steel Fiber- RSF is an eco-friendly material utilized in fiber-reinforced concrete. These fibers are often obtained from industrial waste, including worn-out tires and razor- edged steel that remain after manufacturing. RSF can positively impact the concrete's mechanical properties by increasing its tensile capacity, crack resistance, and overall durability. Fig 1 represent the RSF sample.

(a) Preparing RSFs to be added to the mix (b) The representation of RSFs with scale

Fig. 1. Recycled steel Fiber [1]

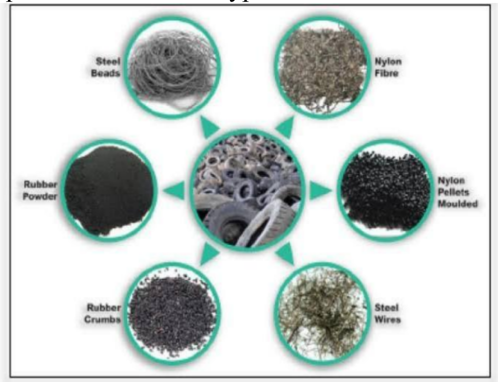
4.1 Type Of Steel Fiber

1)Straight Steel Fibers: Shape: Fibers are uniform and straight. Properties: They are basic and most common where moderate tensile strength of the concrete is required but no good bonding is experienced as compared to the other types. Applications: Appropriate for general reinforcement of concrete that has not been designed for high stresses.

2)Hooked-End Steel Fibers: Shape: Straight fibers with hooked tips Properties: Due to the protruded hooked ends, better anchorage of matrix material is achieved and hence improved bonding as well as resistance to cracks.

4.2 Recycled Steel fiber From Tires (Material for Literature Review)

Recycled steel fiber (RSF), specifically Tire-Derived Steel Fiber (TDSF), is mainly acquired from the steel belts incorporated within the waste tires during tire recycling. The fibers so produced serve as a reinforcement alternative in concrete, without using new virgin steel fibbers as these are extracted after shredding tires. Fig 2 represent the various types of waste steel fibers widely



used in concrere.

Fig. 2. Waste Tires Steel Fiber in Concrete [2]

Pavements: TDSF is known to help improve crack resistance of road pavements enhancing the durability of the wearing surfaces.

1.) Industrial Floors: Incorporated into the flooring parents to prevent cracking due to excessive loads.
2.) Precast Concrete Elements: Reinforced elements such as pipes

Fig. 3 represents methodology adopted during the current research work

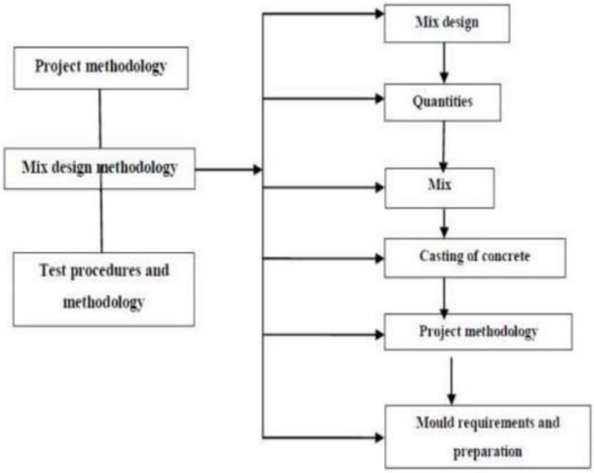


Fig. 3. Methodology of Recycled Steel Fibre

5 Experimental Result

The experimental results as represented in Table 1 and table 2 shows that adding recycled steel fibers (RSF) improved the compressive strength of concrete cubes. Among all the specimens, Cube 3 with 2 mm fibers and 1.5% RSF gave the best performance, achieving the highest peak load of 926.916 kN and a compressive strength of 41.19 MPa after 28 days. It was also observed that increasing the RSF content from 1.5% to 3% in 1 mm fibers increased the concrete strength. However, in the case of 2 mm fibers, a slight decrease in strength was noticed at higher fiber content, which may have happened because of uneven distribution or fiber clustering within the concrete mix. The hybrid combination of 1 mm and 2 mm fibers showed comparatively lower strength than the single-fiber mixes. Overall, the study indicates that recycled steel fibers can effectively enhance the strength and performance of concrete when used in suitable proportions.

Table 1. Compressive Strength Re for Concrete Cubes with Various Fiber Configurations

Fiber Configuration	Peak Load (kN)
1 mm fibers @ 1.5% RSF (Cube 1)	876.138
1 mm fibers @ 3% RSF (Cube 2)	911.844
2 mm fibers @ 1.5% RSF (Cube 3)	926.916
2 mm fibers @ 3% RSF (Cube 4)	919.596
1 mm + 2 mm (hybrid) @ 1.5% RSF (Cube 5)	851.614
1 mm + 2 mm (hybrid) @ 3% RSF (Cube 6)	886.796

TABLE2. Comparative Compressive Strength

Specimen	Diameter in mm	Rsf %	Compressive Strength after 28 days in KPA
Cube 1	1mm	1.5	38.9
Cube 2	1mm	3	40.52
Cube 3	2mm	1.5	41.19
Cube 4	2mm	3	40.87
Cube 5	Mixed 1mm & 2mm	1.5	37.85
Cube 6	Mixed 1mm & 2mm	3	39.41

6 Result And Discussion

A.) RESULT

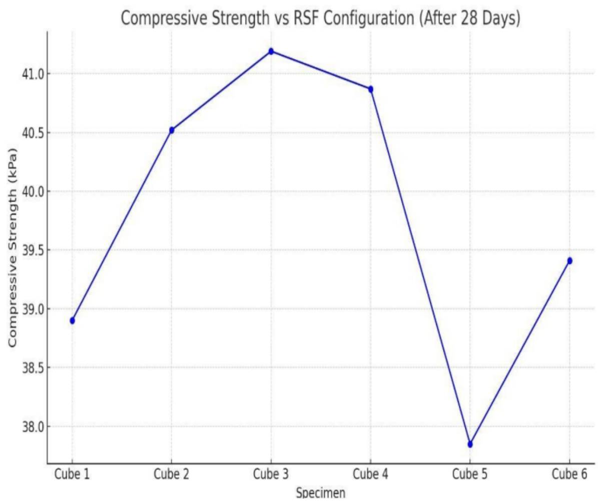


Fig. 4. Compressive Strength VS RSF Configuration

The following are the compressive strength results that we got using Universal Testing Machine.

1. CUBE 1:

- Diameter – 1mm
- RSF percentage – 1.5 percent

- Result – 876.138 KN peak load

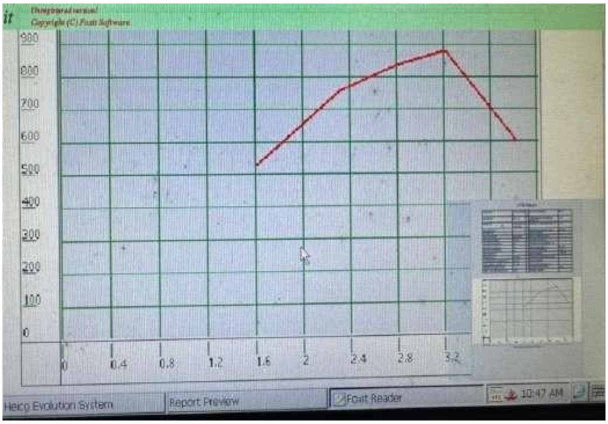


Fig.5. Experimental Result for Cube 1 (Lab Image)

2. CUBE 2:

- Diameter – 2mm;
- RSF percentage – 1.5 percent
- Result – 926.916 KN peak load

Fig. 6. Experimental Result for Cube 2 (Lab Image)

3. CUBE 3 :

- Diameter – 1mm
- RSF percentage – 3.0 percent
- Result – 911.844 KN peak

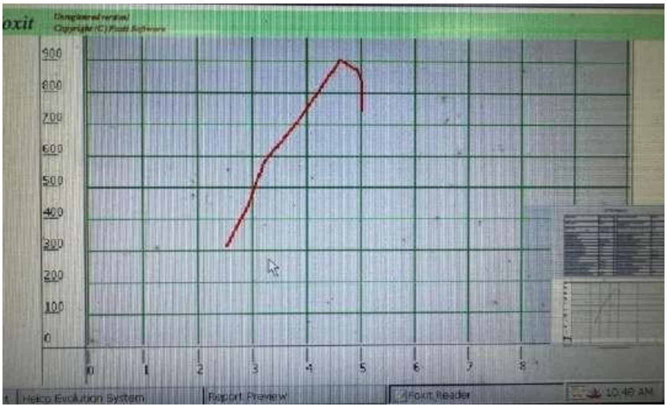


Fig. 7. Experimental Result for Cube 3 (Lab Image)

4. CUBE 4 :

- Diameter – 2mm
- RSF percentage – 3.0 percent
- Result – 919.596 KN peak load

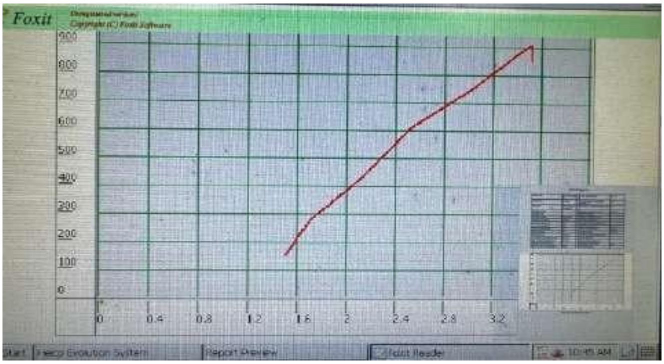


Fig 8. Experimental Result for Cube 4 (Lab Image)

5. CUBE 5 :

- Diameter – 1mm,2mm MIX
- RSF percentage – 1.5 percent
- Result – 851.614 KN peak load

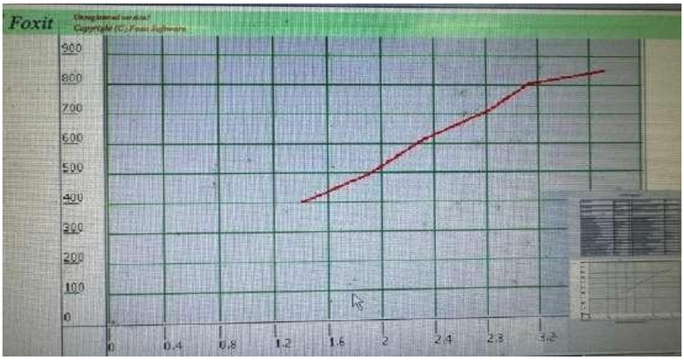


Fig 9. Experimental Result for Cube 5 (Lab Image)

6. Cube 6 :

- Diameter – 1mm,2mm MIX
- RSF percentage – 3.0 percent
- Result – 919.596 KN peak load

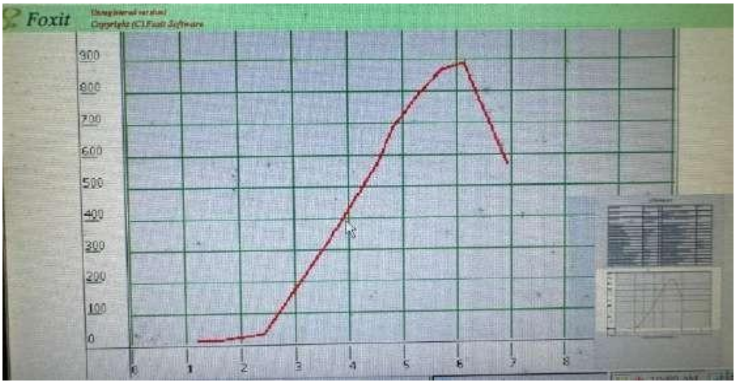


Fig 10. Experimental Result for Cube 7 (Lab Image)

Fig. 4 -10 show the compressive strength behavior and laboratory testing results of concrete cubes prepared with different percentages and combinations of recycled steel fibers (RSF) using the Universal Testing Machine (UTM).Concrete cubes reinforced with RSF of varying diameters (1 mm and 2 mm) and volume fractions (1.5% and 3%) were tested under uniaxial compression to determine compressive strength after 28 days.

The highest peak load (926.9 kN) was recorded for Cube 3 using 2 mm fibers at 1.5% RSF, showing the greatest compressive strength among all specimens. This mix proved optimal for larger-diameter fibers.

Increasing the volume fraction of 1 mm fibers from 1.5% to 3% improved strength from ~876 kN to ~912 kN, indicating finer fibers perform better at higher dosages due to improved dispersion and crack-bridging.

In contrast, raising the content of 2 mm fibers from 1.5% to 3% slightly decreased peak load from ~926.9 kN to ~919.6 kN, suggesting that higher volumes of thick fibers lead to clustering or "fiber balling," which reduces uniformity and strength.

Hybrid mixes (1 mm + 2 mm fibers at 1.5% and 3%) recorded lower compressive strengths than the best- performing single-fiber specimens. Cube 5 (1.5% hybrid) had the lowest strength (851.6 kN), while Cube 6 (3% hybrid) reached 886.8 kN, underperforming both single- fiber mixes at equivalent volumes.

Technical analysis indicates that fiber diameter and dosage significantly affect compressive performance. While 1 mm fibers require higher volume for maximum effect, 2 mm fibers are more effective at lower volumes. The benefits plateau or decline beyond optimal volume due to dispersion issues.

The hybrid strategy, though conceptually beneficial, did not yield strength improvement due to reduced individual fiber content and potential non-uniform dispersion. These results align with previous studies noting that combining similar fiber types often shows limited mechanical synergy.

Despite slightly lower peak loads, hybrid mixes may still offer benefits like enhanced ductility or post-peak toughness, although this was not quantified in the current compressive strength tests.

B.) DISCUSSION

Concrete cubes reinforced with recycled steel fibers (RSF) of varying diameters (1 mm and 2 mm) and volume fractions (1.5% and 3%) were tested under uniaxial compression to determine compressive strength after 28 days.

The highest peak load (926.9 kN) was recorded for Cube 3 using 2 mm fibers at 1.5% RSF, showing the greatest compressive strength among all specimens. This mix proved optimal for larger-diameter fibers.

Increasing the volume fraction of 1 mm fibers from 1.5% to 3% improved strength from ~876 kN to ~912 kN, indicating finer fibers perform better at higher dosages due to improved dispersion and crack-bridging.

In contrast, raising the content of 2 mm fibers from 1.5% to 3% slightly decreased peak load from ~926.9 kN to

~919.6 kN, suggesting that higher volumes of thick fibers lead to clustering or "fiber balling," which reduces uniformity and strength.

Hybrid mixes (1 mm + 2 mm fibers at 1.5% and 3%) recorded lower compressive strengths than the best- performing single-fiber specimens. Cube 5 (1.5% hybrid) had the lowest strength (851.6 kN), while Cube 6 (3% hybrid) reached 886.8 kN, underperforming both single- fiber mixes at equivalent volumes

Technical analysis indicates that fiber diameter and dosage significantly affect compressive performance. While 1 mm fibers require higher volume for maximum

effect, 2 mm fibers are more effective at lower volumes. The benefits plateau or decline beyond optimal volume due to dispersion issues.
The hybrid strategy, though conceptually beneficial, did not yield strength improvement due to reduced individual fiber content and potential non-uniform dispersion. These results align with previous studies noting that combining similar fiber types often shows limited mechanical synergy.

7 CONCLUSION

The research has analyzed the impacts of Recycled Steel Fibers (RSF) as a sustainable concrete additive by assessing its mechanical properties like compressive strength, split tensile strength, and flexural strength at three volumetric concentrations of 1.5%, 2.25%, and 3%. The findings showed that increasing RSF content resulted in enhanced mechanical performance of concrete. Enhanced RSF-mixed concrete displayed significantly improved ductility, crack resistance, and load bearing capacity when compared to plain concrete. The results highlight the promise of RSF as an environmentally friendly, cost-effective substitution for methods of reinforcement. This method strengthens concrete using industrial steel waste, thus aiding in the reduction of waste, conservation of resources, and sustainable construction.
Also, this study shows how optimizing the fiber dosage and distribution can improve mechanical advantages without sacrificing workability. Due to the enhanced performance from RSF, it can now be used for most structural and non-structural elements, particularly where greater resistance to cracking, dynamic loading, or other severe stresses is expected. Further research is needed in assessing other influencing factors like the long-term durability of fiber, its orientation, curing conditions, and the use of supplementary cementitious materials. Evaluating the findings from lab-scale experiments using field-scale trials and actual real-world applications will support the construction industry’s readiness to incorporate RSF.
This study proves that concrete reinforced with RSF components have huge potential in promoting sustainability and resilience within modern civilization. This is due to the claimed benefits of decreased costs of construction and the integration of recycled materials into structural beefed-up concrete.
In general, this research accounts for RSF reinforced concrete as a backbone for enhanced sustainability and durability of a structure. Incorporation of secondary raw materials into performance structural concrete poses an increase in its effectiveness and proves that circular economy concept can be applied in civil engineering. This method contributes to the development of construction practices that address the problem of environmental protection exacerbated by the construction industry.

REFERENCES

1. Li, Yeou-Fong, Hung-Sheng Lin, Jin-Yuan Syu, Wei-Hao Lee, Chih-Hong Huang, Ying-Kuan Tsai, and Asia Shvarzman : Investigating the Static and Dynamic Mechanical Properties of Fiber-Reinforced Concrete Incorporating Recycled Carbon Fiber and Modified Basic Oxygen Furnace Slag Aggregate. Recycling 10 (6), 206 (2025) https://doi.org/10.3390/recycling10060206.
2. Raeesi, Ramin, Amin Soltani, Russell King, and Mahdi M. Disfani: Field Performance Monitoring of Waste Tire-Based Permeable Pavements. Transportation Geotechnics 24 (September), 100384 (2020) https://doi.org/10.1016/j.trgeo.2020.100384.
3. Othman, Paywand M., and Bengin M. Awdel: Influence of Locally Sourced Recycled Tire Steel Fibers and Waste Aluminum on the Strength and Absorption Properties of Fiber-Reinforced Concrete. Cihan University-Erbil Scientific Journal 9 (2), 33–41 (2025). https://doi.org/10.24086/cuesj.v9n2y2025.pp33-41.
4. Ahmad, Izhar, and Mehdi Shokouhian: Promoting Sustainable Green Infrastructure: Experimental and Numerical Investigation of Concrete Reinforced with Recycled Steel Fibers. Archives of Advanced Engineering Science, June (2025). https://doi.org/10.47852/bonviewaaes42022837.
5. Caggiano, Antonio, Paula Folino, Carmine Lima, Enzo Martinelli, and Marco Pepe: On the Mechanical Response of Hybrid Fiber Reinforced Concrete with Recycled and Industrial Steel Fibers. Construction and Building Materials 147 (August), 286–95 (2025). https://doi.org/10.1016/j.conbuildmat.2017.04.160.
6. Bendjillali, Khadra, Mourad Hadjoudja, and Mohamed Chemrouk: Utilizing Recycled Polypropylene Fibres as Reinforcement for Concrete Beams. Proceedings of the International Conference on Civil Infrastructure and Construction (CIC 2020), February (2025). https://doi.org/10.29117/cic.2020.0108.
7. Karaduman, Yekta. Experimental Investigation on the Flexural and Dynamic Mechanical Properties of Jute Fiber/Cork-Reinforced Polyester Sandwich Composites. BioResources 13 (2) (2018). https://doi.org/10.15376/biores.13.2.3958-3970.
8. Meza, Alejandro, Pablo Pujadas, Laura Montserrat Meza, Francesc Pardo-Bosch, and Rubén D. López-Carreño. 2021: Mechanical Optimization of Concrete with Recycled PET Fibres Based on a Statistical-Experimental Study. Materials 14 (2), 240 (2021). https://doi.org/10.3390/ma14020240.
9. Ji, Yongcheng, and Zhiyang Pei: Investigation of Mechanical Properties of Ultra-High-Performance Polyethylene-Fiber-Reinforced Recycled-Brick-Aggregate Concrete. Polymers 15 (23), 4573 (2023). https://doi.org/10.3390/polym15234573.
10. Vishnupriyan Marimuthu, and Annadurai Ramasamy: Investigation of the Mechanical Properties of M40-Grade Concrete with PCB Fiber from Recycled Electronic Waste. Journal of Hazardous Toxic and Radioactive Waste 27 (1) (2023).
11. Mahmoud Abo El-Wafa: Integrating Fiber with New Cement Trends to Create a Greener Future for Sustainable Concrete. Global Journal of Engineering and Technology Advances 21 (2), 1–6 (2024). https://doi.org/10.30574/gjeta.2024.21.2.0203.
12. He, Jingjing, Chuanwu Sun, and Xuezhi Wang: Mechanical Properties and Microanalytical Study of Concrete Reinforced with Blended Corn Straw and Scrap Steel Fibers. Materials 17 (15), 3844–54 (2024). https://doi.org/10.3390/ma17153844.