International Journal on Applications in Civil and Enviornmetal Engineering
Volume 1: Issue 4: April 2015, pp 23-27. www.aetsjournal.com ISSN (Online) : 2395-3837

REINFORCEMENT OF CONCRETE WITH RECYCLED-TIRE STEEL FIBERS USING HYBRID FIBER

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Abstract - In this work, a hybrid fiber technique is used to investigate the reinforcing of concrete using steel fibers made from recycled tires. By combining the advantages of conventional steel fibers with the sustainable utilization of recycled tire materials, the objective is to improve the mechanical qualities of building materials, among them tensile strength, flexural efficiency, and crack resistance. The mechanical behavior of the hybrid concrete reinforced with fibers was examined experimentally in comparison to ordinary concrete and concrete reinforced only with steel fibers. The outcomes illustrated the potential for employing recycled-tire steel fibers to improve the performance of concrete buildings sustainably by showing how the hybrid fiber reinforcement led to gains in both tensile and flexural capabilities. The results highlight the potential of hybrid fiber reinforcement as a possible path to obtaining improved mechanical qualities while encouraging recycling in building materials.

I.Introduction

The material's mechanical characteristics its general efficiency have been improved by using steel fibers as reinforcements. The use of steel fibers improves the durability, ductility, and resistance to cracking of the concrete, overcoming some of its shortcomings. Parallel to this, there has been an increased focus on sustainability in building, which has prompted research into other alternatives for reinforcement from concrete.

Materials made from recycled tyres provide a special possibility to ful fil cement reinforcement's performance improvement and sustainability needs. In this study, a hybrid fiber technique is used to examine the reinforcing of concrete, combining conventional steel fibers with steel fibers made from recycled tyres. This ground-breaking approach strives to maximise the advantages of both materials while promoting green building techniques.

This study's main goal is to thoroughly evaluate the mechanical performance of hybrid fiber-reinforced concrete. Through comparisons with standard concrete and concrete reinforced only with traditional steel fibers, the performance improvement brought on by the addition of recycled-tire steel fibers is assessed.

Experimental research is used in the inquiry to find out how hybrid fiber reinforcement affects important mechanical parameters including yield strength as well as flexural function. This study examines how the hybrid fiber mix affects the concrete's overall strength, cracking behaviour, and deformation properties.

This hybrid fiber technique has numerous potential benefits. It not only provides a way to improve concrete's mechanical characteristics, but it also encourages recycling and reusing components that would otherwise end up in waste streams. A balance among performance improvement and environmentally friendly building can be reached by combining conventional steel fibers and recycled-tire steel fibers.

This work adds to the continuing conversation about cutting-edge concrete reinforcing methods. It clarifies the viability and advantages of hybrid fiber reinforcing in a setting of environmentally friendly building techniques. The results are anticipated to offer important insights for engineers, academics, and practitioners looking to use recycled elements to improve practical efficiency while reducing environmental effect.

II. Materials and Techniques

1. Materials choice

Create a concrete mix design with precise workability and compressive strength specifications. Establish the proper ratios for the addition of water, admixtures, cement, and aggregates. Steel Fibers: Obtain conventional steel fibers and steel fibers made from recycled tyres that have the correct size and mechanical qualities.

2. Making Specimens:

Several concrete specimens, including plain concrete (concrete without fibers) and concrete containing hybrid fiber assemblages, were cast. Prepare test specimens with common sizes and forms, such as prisms for flexural strength testing and cylinders for compressive strength tests.

3. The Use of Fiber:

During the batching process, include the steel fibers into the concrete. Prepare samples with various fiber content ratios, including pure traditional steel fibers, pure steel fibers from recycled tyres, and various hybrid fiber ratios.

4. Moulding of Specimens:

Cast the specimens using the suitable moulds to ensure proper compaction and surface finishing.To get a consistent dispersion of fibers and to get rid of air voids, use vibration or tapping.

5. Testing Mechanically:

Compressive Strength: Use a hydraulic testing machine to perform uniaxial compression tests on cylindrical specimens. By using the maximum load and the cross-sectional area, get the compressive strength.Tests to measure the flexural strength of prismatic specimens should be performed at three or four points.

a. Tensile Strength: To determine the splitting tensile strength, use indirect tensile tests on disc-shaped specimens.

b. Crack Propagation: To evaluate the crack resistance of various specimens, watch for crack initiation and propagation during loading.

6. Analysis of Microstructure:

In order to study the microstructure of hybrid fiber-reinforced concrete, scanning electron microscopy (SEM) is used. To comprehend bonding mechanisms, analyse the interface between the fibers and the matrix.

7. Data gathering and evaluation:

When conducting mechanical tests, note load-displacement curves to document the behaviour of the specimens under various loading scenarios.Calculate the mechanical properties, such as crack propagation traits, compressive strength, flexural strength, and tensile strength.

8.Statistical Evaluation:

To compare the mechanical qualities of various concrete mixtures, use statistical techniques like variance analysis.

III. Testing and Preparation of Test Specimens

To ascertain the range of test findings for various attributes, three different batches of each of the unique mixes were created. Results showing properties in their fresh and hardened states are average values for each blend. All of the attributes were examined on a mini-mum of six samples, and the results are shown below along with the statistical mean and variance of the data.

The density, slump test, and air content of fresh concrete were tested in accordance with tests on compressive strength and elastic modulus were conducted.

Fig1. Unsorted RTSF

For bending tests on notch samples, nine specimens were tested in order to get an average value that was statistically significant. The curves shown are a mean of nine specimens, in which the corre- sponding stress values of every specimen were determined from the collected data and then averaged in order to determine the average load values for various deflection values. Prisma- tic notched specimens with cross sections of 15 by 15 cm and lengths of 60 cm were examined using the same support distance.

Fig 2. RTSF with Rubber Residue

A four-point bending load solution was adopted due to a three-point bending. The movement transducers, that gauge the magnitude of the deflection in the vertical direction at two places, are supported by a unique stiff frame (Fig. 4). The crack mouth opening displacement transducer was positioned along the specimen's longitudinal axis at the midpoint of its breadth. The test was performed on supports that could be freely rotated during testing and were spaced 450 cm apart. Remaining strengths, fracture energy, and force-deflection curves were used to assess the reinforced concrete's tensile behaviour.Using ImageJ software, which allowed counting of fibers in a specific area of interest and offered an overview of the distribution of fibers in the cross section, digital image analysis of the fractured cross sections was performed. After four-point bending, the prisms were saw-cut to create the specimens for the study. Exposed surfaces were polished and moistened to provide improved reflection of steel fibers, which allowed for additional image processing. To produce high-quality photos with an image resolution of 300 dots per inch (dpi), photographs were captured with a high-resolution camera. Following that, more preparation was carried out,

Fig 3. Scratched RTSF

which included the steps that followed: (1) converting the picture to grayscale; (2) developing a binary image; (3) applying adjustments to remove influence (small noise, etc.) and to different fibers grabbing each other; and (4) choosing an ellipse for each fiber to determine the total number of fibers in a cracked cross section**.**

IV. The Findings and Discussion

A. Specifications of New Concrete

It is common knowledge that fibers have a propensity to ball up after being introduced to the mixture, which negatively affects the workability of concrete . According to Angelakopoulos et al. (2011), earlier studies on the effects of RTSF have revealed that increasing the amount of fibers results in a reduction in slump value of 20 to 70%. This study's analysis of the test results for the qualities of new concrete revealed that the decrease in goal workability,

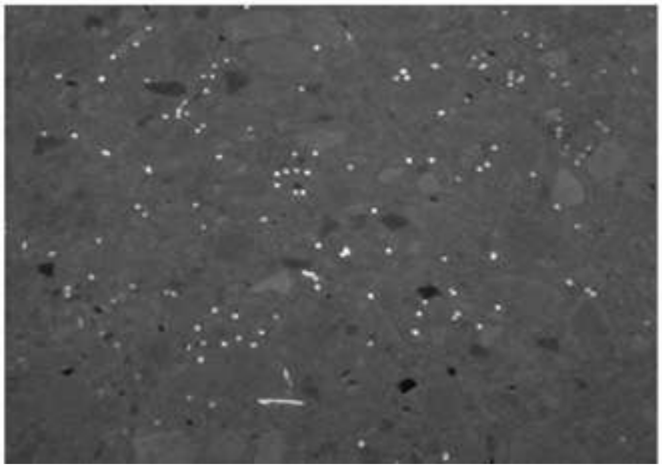

Fig 4.Grayscale Image Analysis

overall concrete volume, as assessed by a slump test, was the desired result produced In other instances, it was unable to draw a direct connection between the quantity of unsorted RTSF and/or M fibers added and the degree of fresh mix workability.Variations in fresh SHFRC's air content may be related to fiber dosage, as well as the dosage ratio between produced and unsorted RTSF. Up to a certain degree, adding more fiber has a positive effect; after that, too much air is trapped (Tlemat 2004). In this case, 0.65% of the total volume of the concrete was the crucial amount of unsorted RTSF in terms of increased air content.

B.Strength in Compression and Elastic Modulus

According to the study's findings (Fig 3), compressive strength dropped as unsorted RTSF concentration increased. The increased air content, which was a result of the increased amount of fibers leading to greater levels of entrapped air, was associated with the decrease in compressive strength. The results revealed that the compressive Strength.

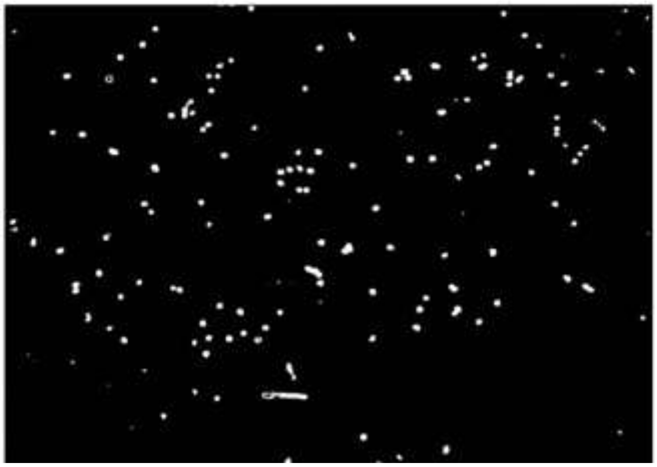

Fig 5. Binary Image

If it is required by the specific application, compressive strength of mixes with significant amounts of fibers may be further optimised by utilising mineral additions like silica fume in the concrete mix.Similar results on the decline in modulus of elasticity were seen. This is consistent who demonstrated that despite the high modulus of the fibers, fibers in a concrete mix do not effect or have a little influence on the modulus of elasticity of concrete. The modulus of elasticity for average by 7.5%, meaning that for every 10 kg of RTSF per cubic metre, an increase of 7.5% occurred.

V. Behaviour after Cracking During Bending

By dispersing energy on fiber pull-out from matrix in such a way as to increase the toughness of brittle concrete, the presence of fibers in the framework bridges cracks and inhibits their further propagation.The effectiveness of the stress transfer from the matrix to the fiber depends on the quality of the interface between the fiber and matrix, but it also depends on the mechanical component of the bond, such as hooked-end, crimped, and other deformed fibers. According to the market analysis, steel fibers with hook ends make up up to 67% of all sold fiber.Compared to flat fibers, their form influences the growth of high flexibility and large absorbent capacity. However, the typical limit for these fibers per cubic metre of concrete is 20–40 kg. As a result, the mixes.Figure 6 shows the force-deflection curves and scattered for each of the tested specimens. Scatter is shown as the variations between the mean force-deflection contour and readings for each mix. Given that three distinct batches were generated for each mix, the obtained scatter values are minimal.

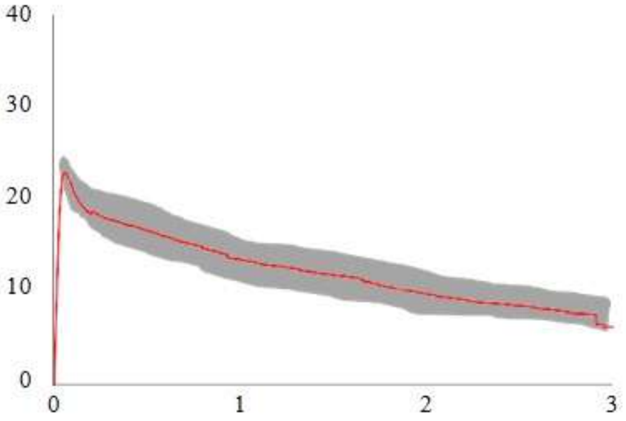

Fig 6. Force Vs Deflection in RTSF

Flexural strength was positively impacted by the high concentration and close proximity of short, thin fibers like RTSF. For instance, while Mix 10M200RTSF reached a strength of 5.9 0.3 MPa, Mix 10M40RTSF has a maximum flexural strength of 4.9 0.3MPa. This indicates that a higher proportion of fine fibers in the ideal orientation contributed to a 20% increase in flexural strength (Figs. 6 and 7). Unsorted RTSF is presently roughly tenfold less expensive than M fibers. This makes it possible to incorporate large amounts of RTSF into concrete for comparatively little money.

V. Conclusion

This study shows for the first time how to create sustainably hybrid fiber-reinforced concrete (SHFRC), which has qualities comparable to or superior to those of regular fiber-reinforced concrete made with only M fibers, by calculating the ideal quantity and ratio of fibers (M and RTSF). Additionally, it is demonstrated that the synergy between RTSF and M fibers may be exploited to make SHFRC when used in the ideal quantity and ratio.• A single SHFRC with deflection-hardening activity in the ideal quantity and appropriate ratio. • Based on a visual examination of cracked portions as well as values of the division coefficient, the consistent vertical distribution of unsorted RTSF and M fibers is confirmed for all fiber contents and within all examined specimens, resulting in savings of up to 33% per m3 of concrete when using Mix as the substitute for referent • The developed deflection-crack width model can be successfully applied. Overall, it can be said that a suitable mix of RTSF and M fibers can be used to create sustainable hybrid fiber-reinforced concrete with characteristics that are equal to or similar to those of FRC with M fibers. When considering both ecological and financial advantages, this material is the best option.

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