THIS ARTICLE IS UNDER FORMATTING, AS THE PDF IS READY FILE WILL BE REPLACED

Experimental Study on Waste Fibers in Concrete

Kalapala Vijay Babu[1]*, CH. Mallika Chowdary [2]

[1]PG Student, Department of Civil Engineering, KLEF University, India

[2]Assistant Professor, Department of Civil Engineering, KLEF University, India

Formatted: Font: (Default) Times New Roman

Abstract

The rising expense of building, along with the progressive impact on the environment, has driven experts to adopt natural fibers such as coir and bamboo fibers and synthetic fibers such as plastic fibers for boosting concrete strength. Fibers are readily available at the test location, making them comparatively suitable as a reinforcing material in concrete. Concrete with fibers was compared to conventional concrete, and different strength parameters such as bending, compression, and tensile strength of coir, bamboo and plastic fibers were varied as a proportion (0.5%, 1%) of total weight of the volume of concrete. The influence of fiber form on strength property was investigated by testing using fiber of predefined dimensions. The ideal amount of both natural fiber and synthetic fiber was identified via a trial-and-error procedure, as was the zero percentage of super plasticizer are used for both regular cement concrete and coir, bamboo and plastic fibers in the concrete to function properly.

Keywords: *Bamboo Fiber, Bitumen, Coir Fiber, Compressive Strength, Flexural Strength, Plastic Fiber, Tensile Strength.*

****Author for Correspondence*** E-mail: kalapalavijay122@gmail.com, Tel: 9618288696

Formatted: Font: (Default) Times New Roman

INTRODUCTION

Cement concrete is the predominant building material for creating secure and sound structures, ranking second only to water in terms of use. Hence, it is imperative to implement measures on a worldwide scale to mitigate the environmental damage [1]. Although the building sector creates a serious risk to the environment, efforts are being undertaken to lessen its effects. A number of researchers have experimented with fiber made from waste materials such as coir, plastic, and bamboo in concrete, which is seeing growing worldwide usage [2]. City development on a global scale is encountering challenges as a result of fast expansion and economic progress. This is leading to the use of sustainable materials and the depletion of substantial natural resources [3].

Bamboo is widely used as a natural fiber for reinforcement in the building sector due to its notable tensile strength, affordability, and ease of harvesting. In ancient times, this material was easily accessible and widely used as a scaffolding material for small- scale city construction projects [4]. In concrete, a combination of synthetic and natural fibers is utilized as admix, with observable results [5]. The use of steel fibers in a standard concrete mix results in a significant difference in strength [6]

The use of natural fibers has several advantages, such as their lightweight and cost- effectiveness, high specific strength, renewable origin, favourable fiber-matrix interaction, and eco-friendliness. As a consequence, these materials exhibit enhanced mechanical, thermal, and physical characteristics. Several different natural fibers, such as coir and bamboo, use this substance as a replacement for fibers in the manufacturing of composite materials, which is significant [7]. Fiber-reinforced concrete demonstrates ductile failure when subjected to compression and tensile stress. This is because of the presence of equally dispersed dis- continuous fibers, which establish links inside the cementitious matrix. These connections persist even after the concrete fails, so improving its resistance to cracking [8].

These fibers were found to enhance the strength of cement composites and might be used as a substitute for traditional fibers in concrete. This would contribute to sustainable development and help decrease carbon emissions. Nevertheless, the use of coir-reinforced concrete is restricted owing to inadequate data about its long-term endurance. Researchers concentrate on characteristics such as fiber length, kind, and proportion in concrete to comprehend and optimize their use. The use of coconut fibers in the construction sector lacks clarity owing to a dearth of adequate information. [9].

A lot of problems are occurring with the use of ordinary concrete. It mitigates the low resistance to cracking and low ductility caused by concrete failures by adding Fibers to the concrete. Fiber concrete may crack due to thermal expansion and water loss, causing increased thermal stress and fracture. This can lead to thermal expansion and water loss, causing increased thermal stress and fracture. This can lead to microcracks and significant fire damage, weakening the plate under impact loads [10][11].

This experimental study examines the impact of bitumen- coated fibers, such as plastic, bamboo, and coir fibers, whether added separately or in different combinations, to improve the long-lasting properties of concrete mixes. In the present condition of the building sector, the incorporation of novel materials and techniques is crucial for addressing the dual challenges of environmental impact and structural stability. Fiber modification is a distinctive method that involves the direct incorporation of fibers into pre-existing materials. With little knowledge on any new changes to manufacturing, engineering, or handling protocols. The efficacy and widespread appeal of fiber modification may be attributed mostly to its distinctive characteristics. Research indicates that the addition of bitumen to both natural and artificial fibers may improve the performance of fiber-modified concrete, leading to higher tensile strength and better durability. This natural resource also improves the longevity of fibers such as coir and bamboo. Bitumen coatings improve the water resistance of concrete, hence enhancing its durability and strength. [12][13].

The literature research indicates that including Coated fiber waste into concrete mix improves mechanical integrity and promotes adhesion, leading to superior outcomes.[2]. Natural fibers provide exceptional mechanical characteristics and serve as ecologically sustainable and renewable resources. To optimize the use of plant-based fiber-reinforced concrete, the existing techniques for modifying plant fibers may be tailored depending on specific application [14].

The fiber is used with aspect ratios such as AR 10, i.e., 50 mm * 5 mm, with a bitumen coat in the concrete mix. The Fibers used the same aspect ratio as the concrete mixes of grade M-40. included in the individual mix of bitumen-coated Fibers of both natural and synthetic Fibers in concrete mixtures containing 0.5 and 1.0% by weight of total volume of concrete and control mix with zero Fibers and for each mix, 0% of chemical admixtures.

MATERIALS

Cement

The Sri Chakra Cement undergoes a thorough testing process to validate its properties and assure adherence to industry standards. It is specifically used in the manufacturing of 53 Grade Ordinary Portland Cement (OPC) render. The tests include a broad spectrum of criteria, such as chemical composition, setting time, fineness, and specific gravity, Table 1 displays the characteristics of cement.

Tabe 1: Properties of cement following laboratory testing.

Test Performed	Value
Fineness (sieving by 90 m sieve)	225m^2/kg
Specific gravity	3.15
Initial setting time	50 min
Final setting time	520MIN

Standard consistency	33%

Fine Aggregates

Fine aggregates are essential in the construction industry, playing a crucial role in mortar and concrete composition. They are sourced locally and undergo severe testing to meet quality requirements, including specific gravity, fineness modulus and partial size distribution as per codes. The characteristics of the coarse aggregate are given in Table 2.

Coarse Aggregates

Coarse aggregate are crucial concrete components in construction. They undergo various tests to ensure quality standards and proper distribution. These tests ensure their suitability for various construction applications and meet specifications. The characteristics of the coarse aggregates in Table 2 are as follows:

Table 2: Physical properties of aggregates

PROPERTY	FINE AGGREGATES	COARSE AGGREGATE
density kg/m^3	1.69	1.61
water %	2%	0.47%
fineness modules	3.26	3.2
max Dia (mm)	-	20
Zone	II	-
Specific gravity	2.65	2.92

Bitumen

Bitumen, a sticky, viscous petroleum product, is a crucial material in the building and road construction industries, often referred to as tar or asphalt and is produced from refined crude oil, essentials for global infrastructure expansion.

Bitumen Coated Fibers

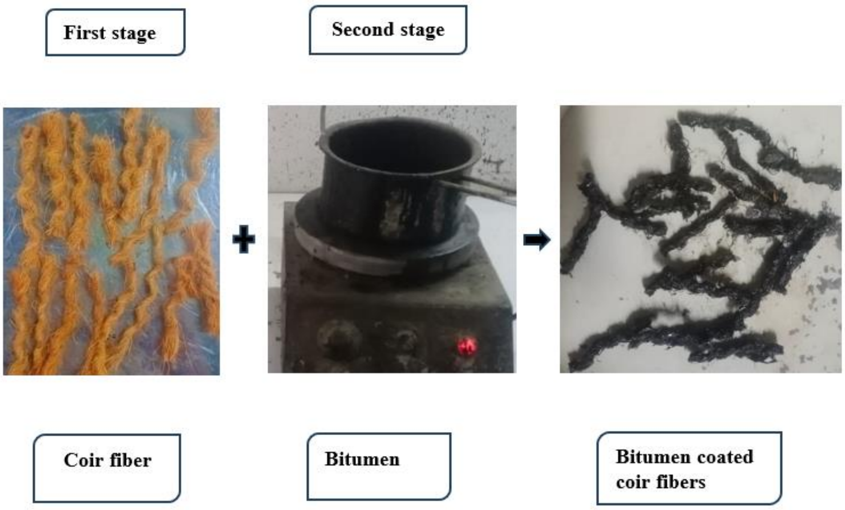
Natural and synthetic Fibers are extracted through cutting, with a 50mmx5mm aspect ratio. Natural Fiber as "coir and bamboo" while preparing the coir Fiber will prepare like a yarn with matching aspect ratio after dipping into the hot bitumen it will be cooled by room temperature. Bamboo Fibers will cut into pieces with required aspect ratio and dipped into bitumen and then cooled. Same process will repeat for plastic fibers too it will buy from hard ware shop plastic Fiber yarn it will cut according to base on aspect ratio. Fig. 1 shows the progressive mixing procedure that was used for the purposes of the research.

Water

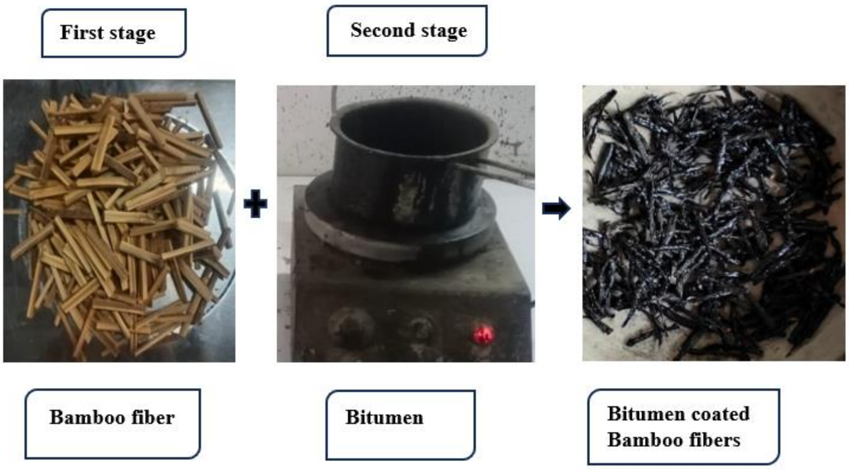
The laboratory uses tap water for concrete mixes, following IS 456, the Indian Standard Code for Plain and Reinforced Concrete, to ensure the quality of materials used in construction.

Design Mix

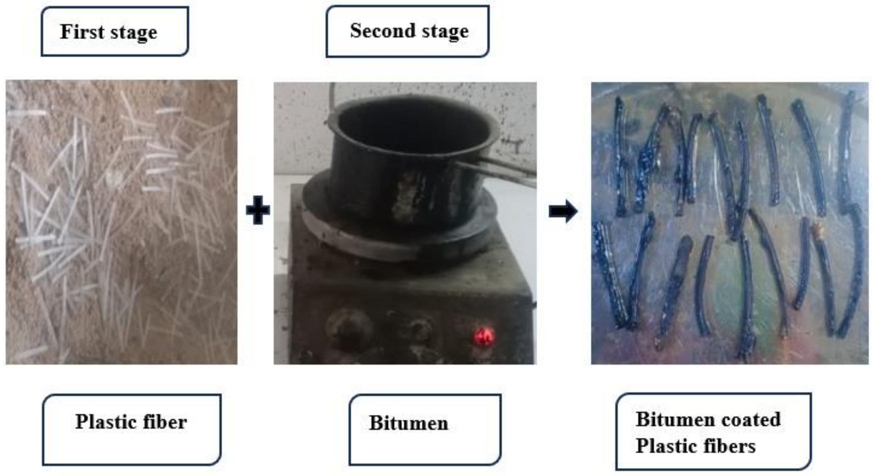
The IS Code IS-10262:2016 guidelines were followed in the creation of the M40 grade design mix. The ratios of the concrete mix are plotted on Table 3. The finalized mix proportions are the result of several trials carried out to guarantee the best possible results. The seven mixes are cast out of concrete in order to examine its performance and the impact of fiber. Fig. 2 shows the schematic model for concrete mixing. Concrete performance by volume using three different types of fibers, and one is a nominal mix with zero percentage of fiber content in the V0. As part of preparation, bitumen-coated plastic fiber 0.5% (V3 – 0.5 mix) and 1.0% (V3 – 1.0 mix), bitumen-coated bamboo fiber 0.5% (V2 – 0.5 mix) and 1.0% (V2 – 1.0 mix), and bitumen-coated coir fiber 0.5% (V1 – 0.5 mix) and 1.0% (V1 – 1.0 mix) by the weight of concrete volume. After 24 hours of casting, the specimens were removed from the mould and subjected to proper curing conditions, as specified in the necessary standards for each test program shown in Table 5. This was done to prepare the specimens for the experimental testing.



(a)



(b)



(c)

Fig. 1. coated fibers (a) coir fibers, (b) Bamboo fibers and (c) Plastic fiber
(Fibers samples are modified that were evaluated and maintained for each bitumen-coated fiber during the bitumen-dipping process.)

Table 3: Mix proportions of concrete

CONSTITUENTS	PROPORTIONS
Cement	448.04 (kg/m^3)
Water	202.6 (kg/m^3)
Fine aggregate	741.2 (kg/m^3)
Coarse aggregate	1069.5 (kg/m^3)
20mm	855.6 (kg/m^3)
10mm	213.9 (kg/m^3)
Water /cement ratio	0.45

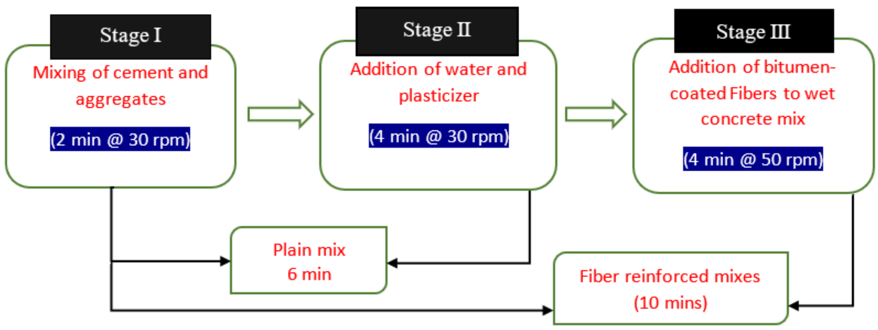


Fig. 2. Phases of mixing was carried out to generate batches of concrete.

RESULTS AND DISCUSSIONS

Recent advances in concrete

The workability and unit weight (UW) of the new concrete mixes are shown in Table 4 Each item also includes information on its fiber content. The design slumps values of 12-13 cm for all concrete combinations were achieved with SP dosages of 0% under the circumstance of pumping concrete. It is important to mention this. The fresh concrete mixes had a range of fiber types, including natural fibers such as coir and bamboo, as well as artificial fibers like plastic. The fiber content levels varied, with 0.5 percent and 1.0 percent used to achieve the same workability as the reference mixture. Prior studies have also shown the efficacy of incorporating fibers into concrete mixtures [15].

The specimens' density was measured in accordance with code C-11249. The empty mould was first thoroughly oiled, then weighed, filled with concrete, and then weighed once more. To calculate the wet density, the weight of the filled concrete was subtracted from the weight of the empty weighed mould and divided by the specimen's volume.

The tests used to study to evaluate the effort of bitumen coated Fiber's inclusion on the performance of waste Fiber reinforced concrete are summarized in Table 5. Density of concrete specimens Controlled mix density –2496 kg/m3.

Table 4: Density of concrete specimens

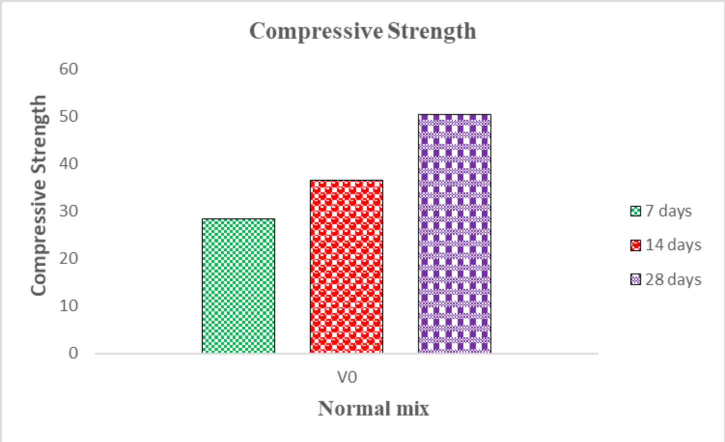
Aspect Ratio	Bitumen coated coir Fiber		Bitumen coated bamboo Fiber		Bitumen coated plastic Fiber	
	0.5%	1.0%	0.5%	1.0%	0.5%	1.0%
AR 10	2495.95	2495.91	2495.95	2495.91	2495.95	2495.91
Slump (cm)	11.5	11.1	11.3	11	11.5	11.1

Compressive Strength

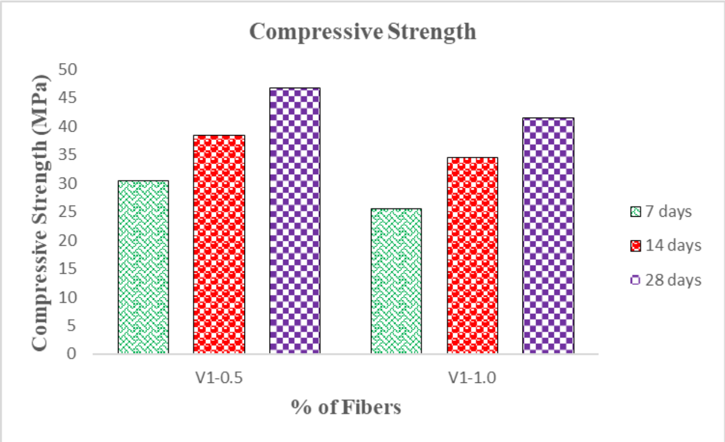
The M 40 concrete underwent compressive strength testing for varying durations, following the IS Code guidelines. Concrete mixes without superplasticizer (0%) are presented for achieving the M-40 target mean strength at 28 days in Fig.3 illustrates the values of compressive strength. The graphs (Fig 3a) show the conventional concrete and Fig.3b, Fig.3c and Fig.3d representing bitumen-coated coir, bamboo, and plastic Fibers. The amount of fibers covered with bitumen is added according to the volume of concrete. The compressive strength of the concrete specimens was observed with the use of three different types of Fibers (coir, bamboo, and plastic) mixed differently. Almost all of those Fibers carried compression strength very close to each other, which will lead to not reaching the target strength at 28 days, which was 46.5 MPa in the V2-0.5 mix and 38.5 MPa in the V2-1.0 mix (Fig.3b, Fig.3c, and Fig.3d). It was found to be lower than the target mean strength of 50.5 MPa in the V_0 mix (Fig.3a). When fibers (coir, bamboo, and plastic) are implemented in concrete, we observe that there is an increase in early-age strength. This is due to the load imposed on the hardened concrete, causing bulging of the specimen at its peak point. The fibers play a significant part in this process. The fibers serve to enhance the structural integrity of hardened concrete by mitigating its inherent brittleness.

Table 5: The tests were conducted in various settings.

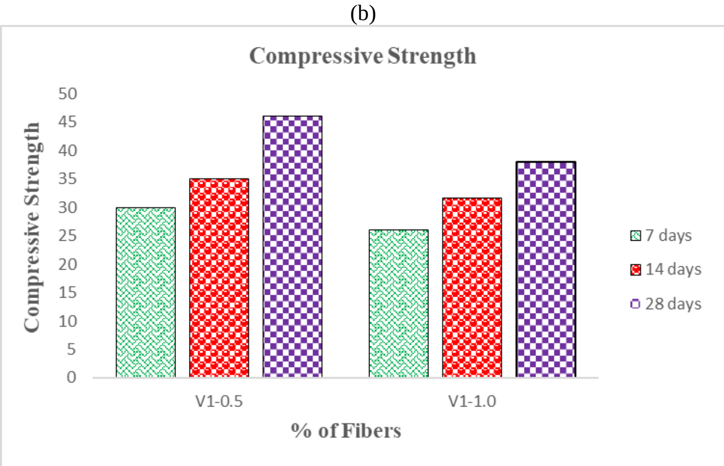
No.	Test	Sample age (day)	Sample size (mm)
1	Workability	After mixing	-
2	Unit weight	After mixing	-
3	Compressive strength	7,14,28	150X150X150
4	Flexural strength	7,14,28	500X100X100
5	Split tensile	7,14,28	150X300
6	Water absorption	90	150X150X150



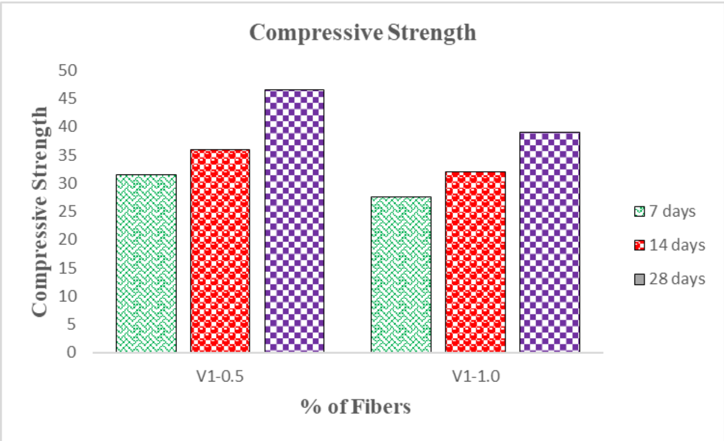
(a)



(b)



(c)

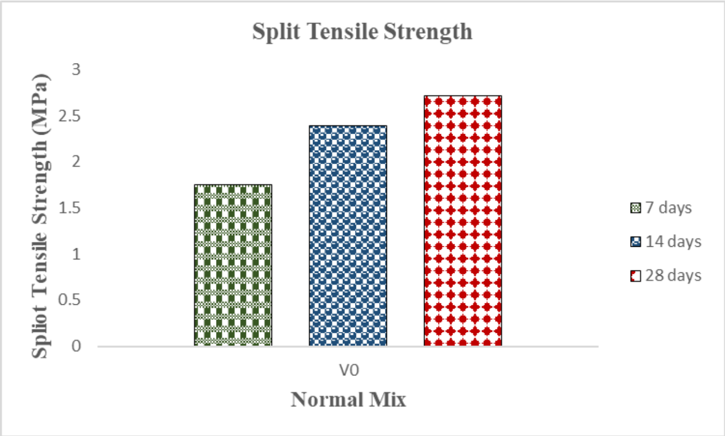


(d)

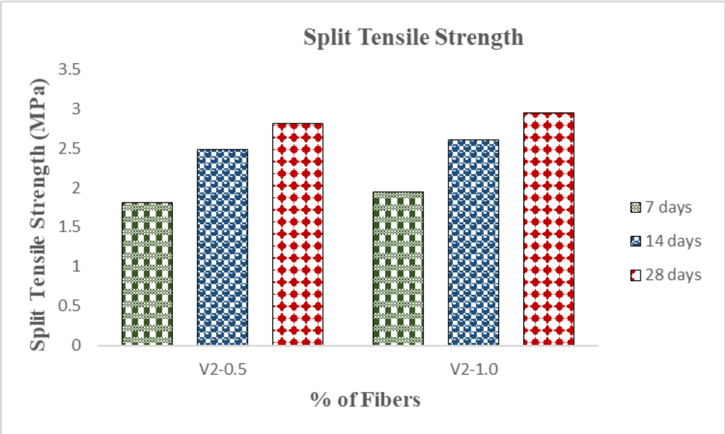
Fig.3. compression strength graphs
(a-Nominal mix, b-coir Fiber, c-bamboo Fiber and d- plastic Fiber)

Split tensile strength

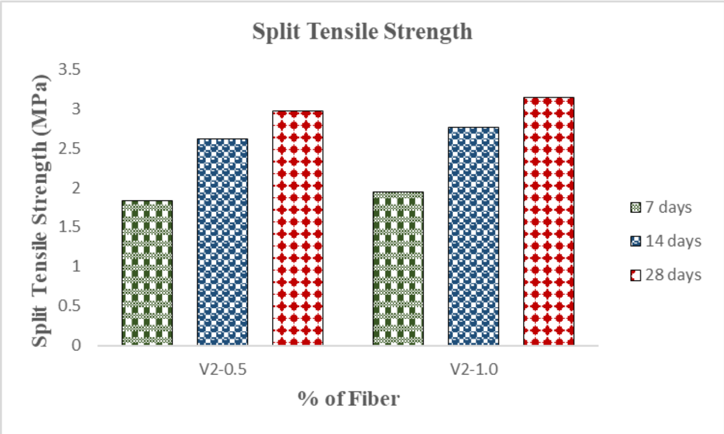
A split tensile strength test was conducted under code IS 5816 for 7, 14, 28, and 56 days, with the results displayed in Fig.4. This test is important for understanding concrete's tensile strength, which is crucial for applications involving bending stresses. It shows how the concrete can withstand tensile stresses applied across the splitting plane. In applications where tensile stresses indicates greater durability. The concrete specimen's split tensile strength of V2-1.0 of bitumen coated bamboo Fiber used specimen is increased strength 3.15 MPa for 28 days (Fig.4c) when compared to the bitumen coated coir and plastic Fibers (i.e.V2-1.0 is 2.95 MPa for 28 days Fig.2b and V2-1.0 is 3.05 MPa for 28 days Fig.4d). The tensile strength increased for bamboo because of bamboo is a used as reinforced material for houses in olden days it has good mechanical strength. It shows how the concrete can withstand tensile stresses applied across the splitting plane. In applications where tensile stresses indicates greater durability.



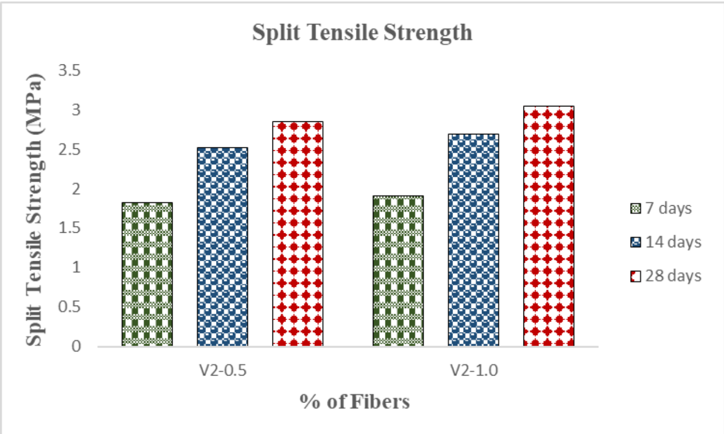
(a)



(b)



(c)

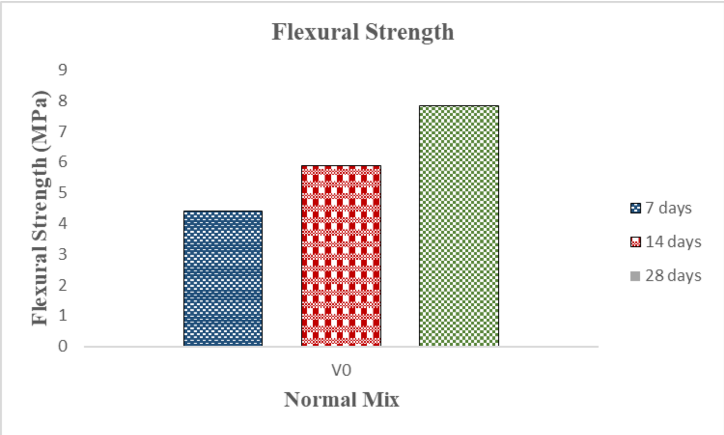


(d)

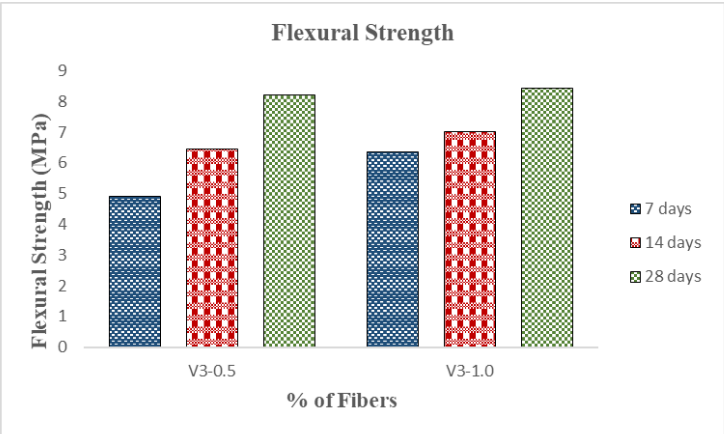
Fig. 4. split tensile strength graphs
(a-Nominal mix, b-coir Fiber, c-bamboo Fiber and d- plastic Fiber)

Flexural strength

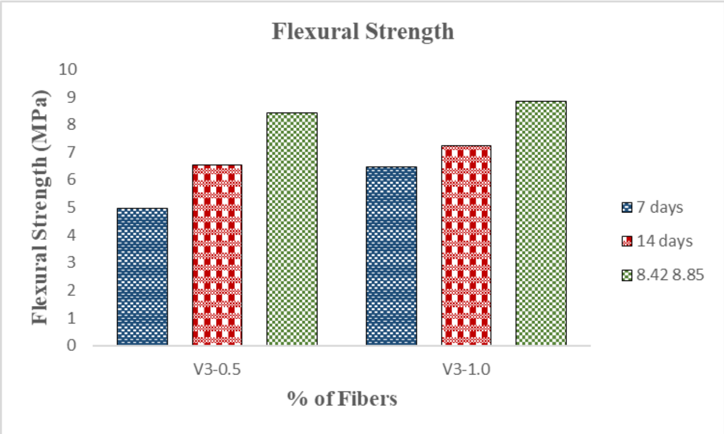
The Fig.5 presents the results of the flexural strength tests conducted on the concrete specimens. while comparing of flexural strength results to the nominal mix it give good result for all types of Fibers while evaluating the results in between Fiber to Fiber the V3-1.0 of both bitumen coated bamboo Fiber Flexural strength is 8.8 MPa and plastic Fibers is 8.85MPa (Fig.5c, Fig.5d) will give better result than coir Fiber Flexural strength is 8.42 MPa (Fig.5b).


Flexural Strength
Flexural Strength (MPa)
9
8
7
6
5
4
3
2
1
0
V0
Normal Mix
7 days
14 days
28 days

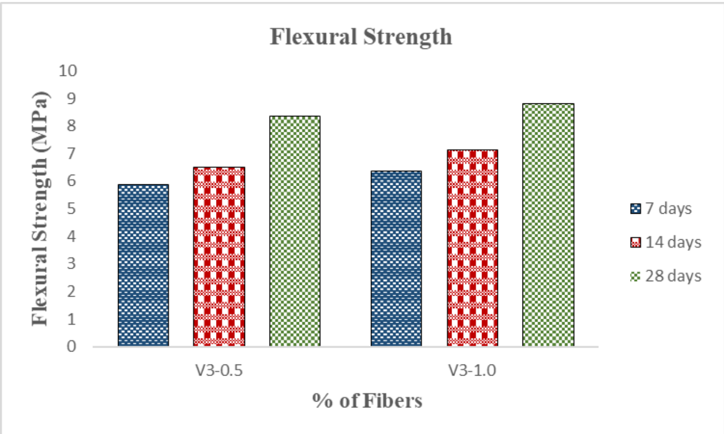
(a)


Flexural Strength
Flexural Strength (MPa)
9
8
7
6
5
4
3
2
1
0
V3-0.5
V3-1.0
% of Fibers
7 days
14 days
28 days

(b)



(c)



(d)

Fig. 5. Flexural strength graphs
(a-Nominal mix, b-coir Fiber, c-bamboo Fiber and d- plastic Fiber)

CONCLUSIONS

Following to the research investigation the impacts of bitumen coated Fibers, the following conclusions are verified by the experimental results:

1. After the expire of twenty-eight days the results shows that Compressive strength decreased in fiber mixes by 9.3% for V1 -0.5 and 23.76% for V1 -1.0 almost same of decreasing of strength to the Fibers (i.e. coir, bamboo and plastic) content as compared to the nominal mix of V0.
2. The split tensile strength got increased for adding of Fibers to the concrete when compared to the nominal mix. Split tensile strength of bamboo Fibers got increased when compared to coir and plastic Fibers by 8.41% for V1 -0.5 and 13.65 % for V1 -1.0 mixes. Split tensile strength of plastic Fibers increased when compared to nominal and coir Fiber by 4.56 % for V1 -0.5

and 10.81 % for V1 -1.0 mixtures. The coir Fiber split tensile strength also increased than nominal mix by 3.54% for V1 -0.5 and 7.79% for V1 -1.0 mixes of V0.

3. The Flexural strength was increased 11.4% for V1 -1.0 and 6.88% for V1 -0.5 for bamboo fiber, 10.9% for V1 -1.0 and 6.1% for V1 -0.5 for plastic fiber, and 6.88% for V1 -1.0 and 4.62% for V1 -0.5 for coir Fiber. Bamboo Fiber outperformed than coir and plastic Fibers, plastic Fiber outperformed than coir Fibers in terms of flexural strength. The Fibers (i.e. coir, bamboo and plastic Fibers) are increased strength than nominal mix V0.
4. The impact of the fibers on the density of the concrete particles can be the reason for the decreased compressive strength of the fiber mixes in comparison to the standard mix. However, the statistics on tensile and flexural strength indicate that bamboo and plastic fibers may outperform coir in some circumstances.
5. Overall, the split tensile and flexural strength results suggest that bamboo and plastic fibers, particularly at a concentration of 1%, surpass coir fibers in performance, despite the observed decline in compressive strength in fiber blends. These findings indicate that bam- boo and plastic fibers might be viable alternatives in bitumen-coated waste fiber reinforced concrete when high tensile and flexural strengths are required.
6. This research emphasizes the potential of using waste fibers into concrete mixes to pro- mote sustainability goals, while also considering specific application requirements.

RECOMMENDATIONS

Subsequent research might explore the enhancement of fiber composition and quantity to mitigate the impact on compressive strength. An enhanced understanding of the mate- rial's performance would be obtained by assessing supplementary mechanical and durability characteristics, such as water permeability and resistance to abrasion. In the future, many types of fibers may be used for testing analysis, considering their relevant elements.

REFERENCES

[1] M. A. Farooq, M. Fahad, B. Ali, S. ullah, M. H. El Ouni, and A. B. Elhag, "Influence of nylon fibers recycled from the scrap brushes on the properties of concrete: Valorization of plastic waste in concrete," Case Stud. Constr. Mater., vol. 16, no. April, p. e01089, 2022, doi: 10.1016/j.cscm. 2022.e01089.

[2] S. Salhotra, R. K. Khitoliya, and S. Kumar, "Comparative study of uncoated and coated waste PET fiber for sustainable concrete," Mater. Today, Proc., vol. 80, no. xxxx, pp. 2022–2026, 2023, doi: 10.1016/j.matpr.2021.06.060.

[3] E. O. Fanijo, J. T. Kolawole, A. J. Babafemi, and J. Liu, "A comprehensive review on the use of recycled concrete aggregate for pavement construction: Properties, performance, and sustainability," Clean. Mater., vol. 9, no. December 2022, p. 100199, 2023, doi: 10.1016/j.clema.2023.100199.

[4] J. Ahmad, Z. Zhou, and A. F. Deifalla, "Structural properties of concrete reinforced with bamboo fibers: a review," J. Mater. Res. Technol., vol. 24, pp. 844–865, 2023, doi: 10.1016/j.jmrt.2023.03.038.

[5] C. M. Chowdary* and I. S. Kishore, "Comparative Study of the Natural Fiber and Artificial Fibre as an Admixture in M30 Grade Concrete," Int. J. Inven. Eng. Sci., vol. 5, no. 12, pp. 9–14, 2020, doi: 10.35940/ijies. k0998.1051220.

[6] I. S. Kishore and C. M. Chowdary, "Influence of steel fibers as admix in normal concrete mix," Int. J. Civ. Eng. Technol., vol. 7, no. 1, pp. 93–103, 2016.

[7] S. Muntongkaw, S. Pianklang, and N. Tangboriboon, "Modifications to improve properties of gypsum ceiling composites as multifunctional construction by embedding Typha angustifolia fiber and natural rubber latex compound," Case Stud.

Constr. Mater., vol. 15, no. August, p. e00658, 2021, doi: 10.1016/j.cscm. 2021.e00658.
[8] A. Jalal, L. Hakim, and N. Shafiq, "Mechanical and post-cracking characteristics of fiber reinforced concrete containing copper-coated steel and PVA fibers in 100% cement and fly ash concrete," Appl. Sci., vol. 11, no. 3, pp. 1–14, 2021, doi: 10.3390/app11031048.
[9] Y. O. Özkılıç' et al., "Lightweight expanded-clay fiber concrete with improved characteristics reinforced with short natural fibers," Case Stud. Constr. Mater., vol. 19, no. August, 2023, doi: 10.1016/j.cscm. 2023.e02367.
[10] I. Wijatmiko, A. Wibowo, and C. R. Nainggolan, "Characteristics of PVC Coated Welded Wire Mesh Fiber Reinforced Concrete," Civ. Eng. Dimens., vol. 21, no. 1, pp. 52–58, 2019, doi: 10.9744/ced.21.1.50-56.
[11] Y. Jiang, Y. Yan, T. Li, X. Cao, L. Yu, and H. Qi, "Comparison of the Mechanical Properties and Crack Expansion Mechanism of Different Content and Shapes of Brass-Coated Steel Fiber-Reinforced Ultra-High-Performance Concrete," Materials (Basel)., vol. 16, no. 6, 2023, doi: 10.3390/ma16062257.
[12] H. Jia et al., "Effect of synthetic fibers on the mechanical performance of asphalt mixture: A review," J. Traffic Transp. Eng. (English Ed., vol. 10, no. 3, pp. 331–348, 2023, doi: 10.1016/j.jtte.2023.02.002.
[13] N. S. A. Yaro, M. Bin Napiah, M. H. Sutanto, A. Usman, and S. M. Saeed, "Performance evaluation of waste palm oil fiber reinforced stone matrix asphalt mixtures using traditional and sequential mixing processes," Case Stud. Constr. Mater., vol. 15, no. July, p. e00783, 2021, doi: 10.1016/j.cscm. 2021.e00783.
[14] J. Li et al., "Research progresses of fibers in asphalt and cement materials: A review," J. Road Eng., vol. 3, no. 1, pp. 35–70, 2023, doi: 10.1016/j.jreng.2022.09.002.
[15] T. P. Huynh, T. Ho Minh Le, and N. Vo Chau Ngan, "An experimental evaluation of the performance of concrete reinforced with recycled fibers made from waste plastic bottles," Results Eng., vol. 18, no. June, p. 101205, 2023, doi: 10.1016/j.rineng.2023.101205.

