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Experimental studies of coir and jute-fiber reinforced concrete with M-sand

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ABSTRACT

Recent years have seen a rise in both concrete costs and environmental impact. M-sand containing coconut and jute fibers was used in traditional concrete. This study explores the potential of eco-friendly coir and jute fibers as a sustainable alternative to conventional fiber reinforcement in concrete production. The coconut and jute-fiber concretes are made using a set percentage (0.5%) of the volume's total weight of concrete. 18 cube and 18 prism specimens in total are cast and evaluated. Each type of fibre reinforced concrete specimens such as Jute fibre reinforced concrete mix (CMJF) and coconut fibre concrete mix (CMCF) contains 0.5% of the volume's total weight of the concrete mixture. This consistency was maintained to guarantee a fair comparison among the different mix designs. The two crucial strengths of compressive and flexural force are investigated and their ratios are also evaluated. In the design mix constantly M sand was taken. The three mix designs were traditional M-sand concrete, M-sand concrete with jute fiber and M-sand concrete with coconut fiber. In this study, native river sand is fully substituted with M sand and no chemical admixture is added. The mechanical properties of compressive and flexural strength tests were checked with mean and standard deviation. The coconut-fiber M-sand concrete has reached its utmost compressive and flexural strengths of 19.3% and 24.8% respectively. With coconut fiber M-sand concrete, the ratio of compressive to flexural strengths is at its highest, 0.31.

Keywords: M sand; fibers; coir; jute; compressive; flexural strength.

1. INTRODUCTION

The challenging issue, recently faced by construction is acute shortage and non-availability of natural-river sand. Mining on river beds to meet growing demand for sand in construction-related activities. This will lead to severe environmental inequality and imbalance for as long as the nation exists. So, the ministry has taken some initiatives to inhibit the depletion of natural resources. The most affordable substitute for natural sand is manufactured sand, which is made by shredding rocks and stones into different sizes and wells. Finally, after two decades, fiber-reinforced concrete has been applied to a variety of structures. Research focuses on concrete that has been strengthened with steel, glass, or synthetic fibers. The aforementioned fibers are highly expensive, and a lot of energy is used to produce them. The natural-fibers used by concrete are palm, coir, kenaf, jute, sugarcane, bamboo, sisal, banana, and pine. The shrinkage crack issue in concrete is lessened with natural fiber reinforcement. Due to the composition of the crushed-stone sand-combination of fine-grained concrete, it is possible to create a material in a modified structure that has the physical-mechanical properties and performance indicators needed for the construction and reconstruction of roads and airport constructions. The selection of any concrete grade requires consideration of a variety of parameters, including the strength properties of the concrete, in addition to the water content in the mix proportion. Flexural stability of the specimens under uniform circumstances with different fiber compositions. Concrete mixes made with jute fibers showed a greater slump decrease than those made with coir fiber. The stiffness and flexural strength of the concrete were greatly improved by the addition of coconut fibers [1–5]. It has been discovered that additional fiber parameters, including aspect ratio, length and geometry, have an effect on the creep behaviour of fiber reinforced-concrete [6]. The tests were

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carried out at a certain age of 15 days. The compressive and tensile strengths of concrete samples were assessed using optical microscopy. It was discovered that sisal fiber made for the best fiber reinforcement material, and that 1% was the appropriate concentration [7]. Because of a lack of flowability, a heavier proportion of jute fiber reduces concrete's mechanical and durability performance. As a result, the study suggests using more plasticizer to account for the higher amount of fibers [8]. The designer may add a new dimension to solve emission and energy issues in order to develop sustainable and eco-friendly design by taking environmental consequences into account from the earliest phases of planning and designing in concrete [9]. Due to a number of benefits, natural fibers are increasingly being used in composite materials. For natural fibers to replace synthetic fibers and prevent global warming, surface treatment is essential [10]. Alkali can be used as the first step in the treatment of all types of fibers. After treatments with 5%, 6%, and 10% strength NaOH solutions, flexural properties have been observed to improve [11].

Natural plant fibers provide a variety of advantages, including low cost, simple availability, reusable break down and light weight. Its inclusion in composites reflects the increased worldwide need for environmentally friendly building supplies [12]. Regardless of the length and number of fibres added to the concrete, thick fibres increase the fraction of air content compared to thin threads [13]. The density of coconut fiber is low. Because of this, it makes concrete lighter and may be utilised everywhere that lightweight concrete is needed [14]. Coir prevents and regulates tensile cracking in composite materials. Recent research has proven that cement increases concrete's strength and durability by 1.5% weight, and this quantity has been considered to be the perfect level. Sisal and coir fibres have various advantages in concrete constructions, while coir slows down and regulates tensile cracking in composite materials [15]. Concrete is strengthened in both the tensile and compressive directions when banana fibers are added [16]. Composite jute fiber with fabrication offers stronger tensile strength because of the greater weight (%) of the jute fiber [17]. Jute and polypropylene fiber ropes coiled on steel bars can lower the price of concrete steel-reinforced beams [18]. Moreover, as fibre length grew, a decrease in compressive strength was noted. The durability of concrete is reduced as recycled coarse aggregate and jute fibre are used in greater quantities in all types of the mix [19]. By reducing the quantity of vacancies in M-sand reinforced concrete with coconut fibre, adding more fine aggregate boosts the material's compressive, flexural, and break tensile strengths. The rate of change in compressive strength with density is larger in concrete with a low water-cement ratio [20]. River sand and illicit sand mining would become less necessary as M-sand gained popularity in the building sector. The Indian concrete industry urgently needs a well-processed manufactured sand as a partial or complete replacement for river sand until other acceptable alternative fine aggregates are produced [21]. By using polypropylene fibers, recycled aggregate-concrete specimens' permeability is decreased [22]. Figure 1 shows the natural fiber classification [23]. A major issue is the bamboo fibers tendency to swell and the concrete's deterioration in an alkaline atmosphere [24]. The load-carrying capacity of beams is enhanced by incorporating steel fibres into both fly-ash cement concrete and ordinary concrete [25]. When the amount of polypropylene fibre increases, the split tensile strength of M20 grade concrete rises [26]. A useful material resource for environmentally and energy-friendly infrastructure applications is concrete made of fly ash, steel, and synthetic fibers [27]. The experimental findings show that the compressive strength decreases with increasing length and coir fibre content [28]. As the percentage of coconut and jute fiber is increased in concrete, the density of concrete is decreased, making it lighter and reducing the dead weight of structures as well [29]. The primary quality of coir pith is its ability to retain moisture even after drying. Improving internal curing helps to keep a constant temperature and retention throughout the concrete process, which helps to minimise or completely solve crack issues. This process of preserving moisture content inside the concrete for a

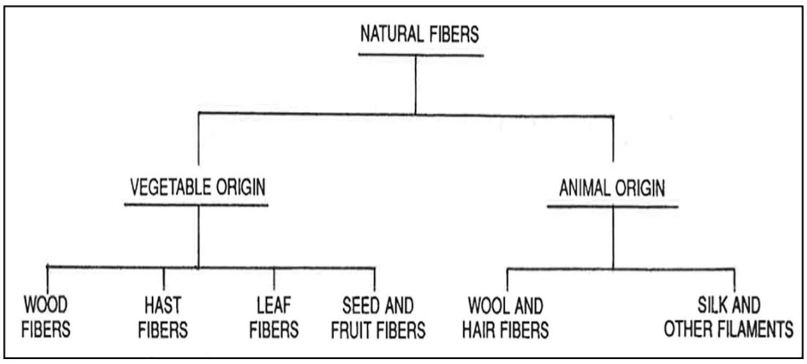

Figure 1: Natural fibers - classification.

certain amount of time results in or enhances mechanical strength, and is known as the concrete curing process [30]. It is generally agreed that crack arresting qualities of concrete would be greatly enhanced by the addition of tiny, closely spaced, evenly dispersed fibres [31]. A range of techniques, such as chemical treatments, coatings composed of different materials, and hybridization, can be used to enhance the physical and mechanical characteristics of natural fiber-reinforced polymer composites [32]. In a one-year-old mortar with water and air curing, the coconut fiber fared well in the presence of sea water, sulfuric acid, and sodium sulfate solution [33]. With a mix ratio of 1:1.41:2.83 and a water-to-cement ratio of 0.45, jute fiber is added to concrete. For concrete to achieve its maximum compressive strength, the ideal fiber dose is 0.4 percent [34]. The concrete is strengthened to a greater extent when jute fiber with a cementitious material concentration is included. Increased jute fiber-length and content can affect mechanical characteristics adversely [35]. Comparing jute fiber beams to traditional concrete beams, flexural strength can be increased by up to 43% [36]. As a long-term sustainable building material, natural-fiber reinforced concrete can be utilised commercially for flooring slabs and interior or exterior pavements [37]. The workability of natural-fiber reinforced concrete can be improved by adding an appropriate super-plasticizer and mineral [38]. The ductility of coconut fiber columns was lower than that of other natural fibres including wheat husk, rice husk, and wood fiber. When the column was fully loaded, there was debonding between the fibers and the concrete [39]. Concrete's flexural toughness and damping ratio are improved with coir fibers [40]. As a partial replacement for fine aggregate, coir-fiber is added at levels of 0%, 1%, 1.5%, and 2%. The strength increased to 1.5% from 0% before dropping to 2% [41]. The study emphasizes the importance of maintaining workability and removing toxic substances in E-waste aggregate for improved strength and toughness properties [42]. The optimal number of CFRP layers for increasing axial stress with strain is found, making CFRP wrapping a beneficial option for retrofitting applications [43]. As a result, the tensile, bending, compressive, and impact performance decrease as the percentage of natural fibers increases. Concrete plates' flexural strength is increased by adding coconut fibers. This is especially advantageous for small-scale construction projects like making concrete tiles. Due to the pore-filling effect of natural fibers, which results in denser concrete, the durability properties of the optimum mix, such as water absorption, sorptivity, and rapid chloride penetration test values, perform better than those of the control mix. The addition of coconut fiber significantly improved both the tensile and flexural strengths. Concrete contains natural fibers with a M-sand content that ranges from 0.1% to 0.3%. Therefore, an effort has been made in the present study to examine the impact of jute and coconut fiber reinforced with M sand concrete in two different designs. The mechanical characteristics of natural fiber-reinforced concrete are influenced by the length of the fibers, which were soaked, dried, and distributed in the concrete with a constant water-cement ratio. The choice of coir and jute fibres indeed reflects to investigating sustainable alternatives that can decrease the environmental impact of the construction industry. In this study, the native river sand is replaced with M-sand; no superplasticizer is added; and a concrete made of fibers was tested in addition to traditional M-sand concrete. Though, many studies have been performed with utilization of jute fiber, coconut fiber along the utilization of M-sand as replacement for fine aggregate. Hence, more systematic studies are required to establish guidelines. Hence, this study aims to analyse the workability and mechanical properties of the Jute fiber reinforced concrete and coconut fiber reinforced concrete along with utilization of M-sand as fine aggregate.

2. MATERIALS AND METHODOLOGY

2.1. Cement

In this investigation, conventional Portland cement, 53-grade, is employed and analysed for specific gravity of cement using Lechatlier's flask method.The specific gravity test was conducted using a Lechatlier flask (W2) that contained 50 g of cement. To determine the lechatlier flask's empty weight, it must be dried and weighed (W1). Kerosene has a specific gravity of 0.79 after being added to a Lechatlier flask with cement (W3) and sealed with a stopper. Kerosene is poured into the unfilled Lechatlier flask (W4). The aforementioned weights are used to calculate the specific gravity of cement, which is 3.12. Cement has a specific gravity that varies from 3.1 to 3.9 (IS 2720, Part 3, 1963).

2.2. M sand and coarse aggregate

For use in cement or concrete construction, M Sand is a manufactured sand produced by crushing rock or granite. M sand's physical and mineralogical characteristics set it apart from regular river sand. M sand was chosen as a full substitute for river sand because of its prevalent consistency in quality, availability, and reduced environmental impact. M sand, being a manufactured sand, avoids the ecological damage caused by river sand mining. Besides, it offers better control over the granule thickness, which is pivotal for accomplishing the desired strength in concrete. Stone that has been broken into small, atypically shaped pieces is known as coarse

Table 1: Physical properties.

NAME OF THE TEST	M-SAND	COARSE AGGREGATE	SPECIFICATION
Specific gravity	2.43	2.8	IS 2386 – Part 3 (1963)
Water absorption	1.72%	0.82%	IS 2386 – Part 3 (1963)

Table 2: Fiber properties.

INGREDIENTS	JUTE	COCONUT
Appearance	Brown fiber	Golden fiber
Length	50 mm	50 mm
Diameter	0.2 mm	0.3 mm
Density	1.5 g/cm^3	1.15 g/cm^3
Tensile strength	773 MPa	500 MPa
Aspect ratio	250	166

Figure 2: a) Coconut-fiber; b) Jute fiber.

aggregate. In construction projects, aggregates like limestone, granite, and river aggregate are frequently used. Coarse aggregate is defined as aggregate with a size greater than 4.75 mm or that has been retrained on a 4.75 mm IS sieve. The physical characteristics of M sand and coarse aggregate are tabulated in Table 1, which was tested using the IS 2386, Part 3 procedure (1963).

2.3. Natural fibers

Figure 1 shows the classification of fibres. Jute and coconut fibers in market forms were produced by Fiber Region company. Jute and coconut fibers are used in these practical investigations. The various properties of fibers are presented in Table 2. Jute fiber is biodegradable, environmentally friendly, and effective as insulation. Coconuts' tough, water-repellent fiber is a natural. These organic materials cost less to produce. 10.36 kg/m^3 of fibers have been steadily added to the concrete during mixing. Natural fibers sold in the market are cut into 50-mm lengths. Jute and coir fibers are easily available on the market. Jute and coconut fibers are employed in concrete, as seen in Figures 2a and 2b.

2.4. Mixed design

Three mix designs of natural fiber reinforced concrete are shown in Table 3. The mixing-design technique is as follows: M-sand and cement are first added to the mixer. Then coarse aggregate is added. The mixing-design technique is continued, and then the water is added to the mixture, and the process is continued. All the constituents are mixed for 60 seconds. Totally 36 specimens were cast included with cubes and prisms. The control concrete mix (CM) samples were cast 6 nos. for cubes and 6 nos. for prisms. Jute fiber reinforced concrete mix (CMJF) samples were cast each 6 nos. for cubes and prisms. In coconut fiber concrete mix (CMCF) were cast cubes (6 nos.) and prisms (6 nos.) samples. In the above respective jute and coconut fiber reinforced concrete, before mixing in concrete mixture these fibers were soaked in water and removed the water in fibers. Then it

Table 3: Mix design.

SPECIMENS	W/C	M SAND	CEMENT	COARSE AGGREGATE	FIBER	SLUMP
	(ratio)	(kg/m^3)	(kg/m^3)	(kg/m^3)	(%)	(mm)
CM	0.4	552	479	1172	0	144
CMJF (jute)	0.4	552	479	1172	0.5	132
CMCF (coconut)	0.4	552	479	1172	0.5	128

added to the mixture and rotate the drum for 180 section order to cure all the concrete samples after casting, they were kept in molds for 24 hours to keep them moisturized and then placed in a curing tank of water at a temperature of 19–230 C. The concrete samples were removed from the water curing tank after curing for 28 days; 36 samples were dried in laboratory for 24 hours and then placed and tested in respective testing machines. The choice of 0.5% fibre content was depended on preliminary tests and literature review, which recommended this percentage as optimal for balancing improvements in mechanical properties with manageable changes in workability. Both jute and coir fibers were cut into uniform (required) length. The fibers were included with the mix during the dry mixing stage for even distribution throughout the concrete. Initially, all dry components (cement, sand, and aggregate) were mixed thoroughly. Then, the fibers were sprinkled gradually into the mixer, while it was running to avoid clumping and to facilitate even distribution of fiber within the mix.

In this study, concrete mixtures are designed without mineral and chemical admixtures. The samples contain CMJF and CMCF; the jute and coconut fibers have percentages of 0.5% and 0.5%, respectively. Totally 18 cube samples (150 × 150 × 150 mm) for the test of compressive strength according to the IS 516-1959 standard and 18 prism samples (100 × 100 × 500 mm) for the test of flexural strength as per the IS 516-1959 standard were cast for compressive and flexural experiments from three mix designs. The mean of six samples was considered the final result and checked with the standard deviation. The concrete mixture's compressive and flexural strength ratios were determined.

3. RESULTS AND DISCUSSIONS

The outcome of testing slump samples, cubes, and prism specimens made of concrete that also contained M sand and coconut and jute fibers. It is discussed the impact of using natural fibers in concrete with M-sand.

3.1. Slump

A slump cone test was used to evaluate the workability of the concrete. The CM mix achieved the slump value of 144 mm, CMJF achieved the slump value of 132 mm and CMCF achieved the slump value of 128 mm. As per IS: 456-2000 standards, the slump value of the developed mixes was falls under the category of high degree of workability. A slight decrease in slump value was observed with jute and coconut fiber. The addition of jute fiber decreases the slump value by 8.3% and addition of coconut fiber decreases the slump value by 11%. This is mainly due to those natural fibers when mixed with concrete produce a three-dimensional network. This network hinders the free movement of water and cement particles, which reduces the workability of the concrete. The slump value consequently declines [44–46]. The coir and jute fibres affect the concrete's workability in practical scenarios. The slump values of various concrete mixes are graphically shown in Figure 3.

3.2. Compressive strength

The concrete cubes were examined and determined by taking the mean of six cubes from each series and comparing it to the standard deviation. The compression strengths of concrete with 0.5% jute and coconut fibers were determined after 28 days of curing in the study. Figure 4 depicts the compression strength failure. Table 4 show the average concrete compression strength after 28 days of curing. Figure 5 shows the compressive strengths of various concrete mixes.

The addition of coconut fiber and jute fiber increases the compressive strength by 16.36% and 19.30% as shown in Figure 5. Comparing to the study of coconut coir with the polypropylene fibre reinforced concrete, CMCF compressive strength has increased by 10.74%. When the compressive strength of a length of 3 cm coconut coir used in M25 grade concrete at 0.5% weight of concrete was tested, the result was 28.19 MPa [47, 48]. In comparison to the CM, the CMCF compressive strength has increased by 9.75%. The concrete's compressive property was determined to be 32.02 MPa when jute fiber at a concentration of 0.5% was added to M25-grade concrete while maintaining a w/c ratio of 0.47 [31]. Comparing to the study above, the CMJF compressive strength has increased by 15%. The mean compressive strengths of all the cube specimens exceed the

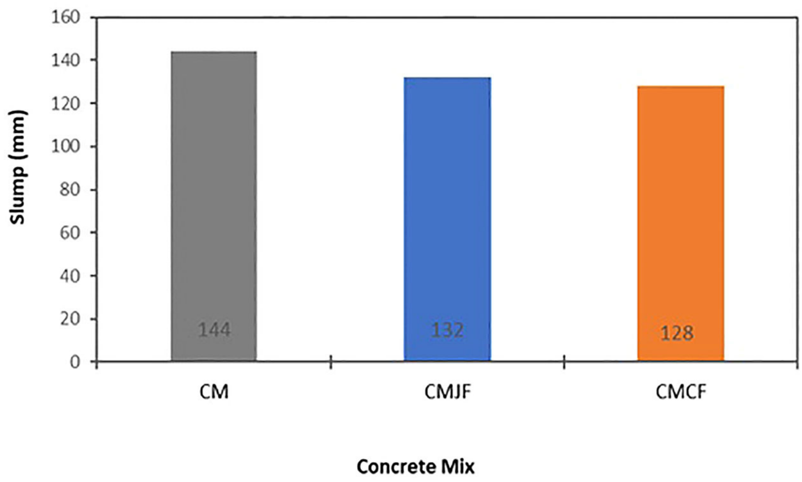

Figure 3: Slump values of concrete mix.

Figure 4: Failure of cube specimen under compression.

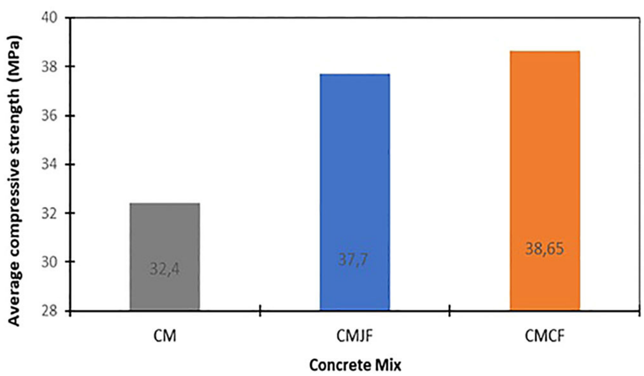

Figure 5: Average compressive strength.

Table 4: Average compressive strength.

SPECIMEN DESIGNATION	AVERAGE COMPRESSIVE STRENGTH (MPa)	STANDARD DEVIATION	PERCENTAGE INCREASE WITH RESPECT TO CM (%)
CM	32.4	1.74	–
CMJF	37.7	4.6	16.36
CMCF	38.65	5.19	19.30

target mean strength and the characteristic strength, respectively. The range of average compressive strengths' standard deviations is 1.74–5.19. The standard deviation with the lowest value is nearer to the mean value. The standard deviation of each experimental value is less than 5.5 (IS 10262:2019). Therefore, all of the experimental results are valid.

3.3. Flexural strength

Flexural strength tests were performed on the concrete mixtures. Six prism specimens were cast in each mix category to get the results. Figures 6 and 7 depict the failure pattern of prism under flexural load.

The values for the six prism concrete specimens' flexural strengths (M sand concrete) are shown in Table 5 and Figure 8. Flexural strength was found to have an average of 9.48 MPa. These results reinforce the potential of natural fibres as viable reinforcements in concrete, contributing to stronger and more sustainable building materials.

It was found that the addition of 0.5% of coconut and jut fiber increases the flexural strength i.e., the compressive strength of the CMJF and CMCF concrete specimen was higher than the CM. The addition of coconut

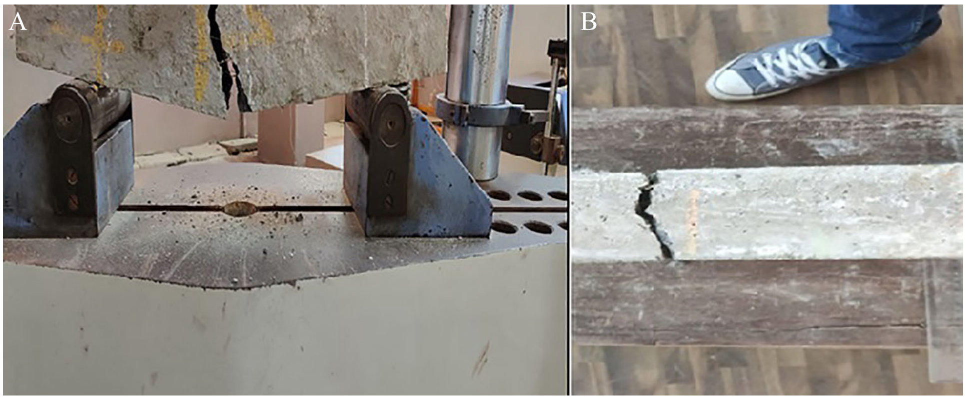

Figure 6: a) Specimen at failure in CM; b) Breaking pattern.

Figure 7: Jute-fiber mixed in concrete specimen.

Table 5: Average flexural strength.

SPECIMEN DESIGNATION	AVERAGE FLEXURAL STRENGTH (MPa)	STANDARD DEVIATION (σ)	COMPARING PERCENTAGES WITH RESPECT TO CM (%)
CM	9.48	0.75	–
CMJF	11.05	0.7	16.56
CMCF	11.83	0.58	24.79

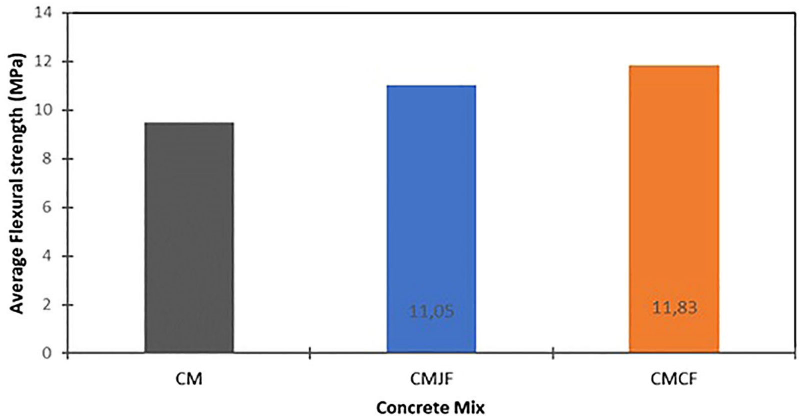

Figure 8: Average flexural strength.

Table 6: Ratio of compressive strength to flexural strength.

SPECIMEN DESIGNATION	AVERAGE COMPRESSIVE STRENGTH (MPa)	AVERAGE FLEXURAL STRENGTH (MPa)	RATIO OF COMPRESSIVE STRENGTH TO FLEXURAL STRENGTH
CM	32.4	9.48	0.293
CMJF	37.7	11.05	0.2931
CMCF	38.65	11.83	0.31

fiber and jute fiber increases the compressive strength by 16.56% and 24.79%. It was found that CMCF has an average flexural strength of 11.83 MPa. The CMCF specimens' standard deviation was 0.58. The average flexural strength with the standard deviation and the percentage compared to concrete with M sand. The outcome of this flexural strength is also inconsistent with the earlier studies [49–52]. Coconut fibre is used in concrete with a w/c ratio of 0.44 and a length of 40 mm. In concrete, 2% coir fiber is added to the cement weight 4.62 MPa is the flexural strength [51]. Compared to the previous fiber category, the CMCF's flexural strength has increased by 61%. The ideal strength for compressive and flexural forces, as well as for the durability characteristics of high-strength concrete in terms of water absorption, sorptivity, and speedy chloride penetration is obtained at 0.5% coir [52]. The enhanced strength offered by CMCF and CMJF concrete mix make it especially appropriate for infrastructure projects exposed to harsh environmental conditions like bridges, roads and coastal structures. Its increased crack resistance could also benefit earthquake-prone areas by giving more resilient building materials.

3.4. Ratio of compressive strength to flexural strength

At 0.31 in CMCF, the ratio of compressive strength to flexural strength is at its highest. The ratio between flexural strength and compressive strength is shown in detail in Table 6. In CMCF specimens, the maximum ratio between flexural strength and compressive strength is found.

The higher ratio of compressive to flexural strengths in coconut fibre M-sand concrete demonstrates a material that can withstand higher loads before failing, making it especially suitable for structural applications where both types of strengths are critical. This finding suggests that incorporating coconut fibres in M-sand concrete could improve the load-bearing capacity and durability of concrete structures.

Preliminary observations suggest enhanced durability characteristics in fibre-reinforced concretes because of better crack resistance. However, comprehensive durability studies, including resistance to various environmental factors, are planned for future work.

4. CONCLUSIONS

In conclusion, the determination of workability and mechanical properties of the jute and coconut fiber reinforced concrete with utilization of M-sand as fine aggregate is studied:

- Addition of natural fibers to M-sand concrete, slump is reduced. Jute fibers produce more slump when combined with concrete than does coconut coir.

- After the 28th day of curing, the concrete made with coconut coir reaches its maximum average compressive strength. In jute-fiber-mixed concrete specimens, the standard deviation is at its lowest.
- Concrete specimens made of coconut coir mix reach maximum levels of average flexural strength. For concrete specimens made of coconut coir, the standard deviation is the lowest possible value.
- In concrete specimens made from coconut coir, the average ratio of the compressive and flexural strengths is at its highest.
- The extended research is to analyses the structural behavior of large-scale beam both numerically and experimentally.

5. BIBLIOGRAPHY

[1] BIELIATYNSKYI, A., YANG, S., PERSHAKOV, V., *et al*. "Study of concrete properties based on crushed stone sand mixture and fiber of fly ash of thermal power plants", *Science and Engineering of Composite Materials*, v. 29, n. 1, pp. 412–426, 2022. doi: http://doi.org/10.1515/secm-2022-0167.

[2] AZIZ, A., "Analysis on mix design of M25 grade of concrete- a case study on modification of terminal building at silchar airport", *International Journal for Research in Applied Science & Engineering*, v. 7, n. 6, pp. 2463–2472, 2019.

[3] BARABANSHCHIKOV, Y., GUTSKALOV, I., "Strength and deformability of fiber reinforced cement paste on the basis of basalt fiber", *Advances in Civil Engineering*, v. 2016, pp. 1–5, 2016. doi: http://doi.org/10.1155/2016/6562526.

[4] SAVALIYA, M.M., VEKARIYA, K., BHUVA, P., "To develop high performance concrete using jute and coir fibers", *IJARIIE*, v. 7, n. 3, pp. 511–517, 2021.

[5] HARDJASAPUTRA, H., NG, G., URGESSA, G., *et al*. "Performance of lightweight natural-fiber reinforced concrete", In: *MATEC Web of Conferences*, p. 01009, 2017. doi: http://doi.org/10.1051/matecconf/201713801009.

[6] ANAS, M., KHAN, M., BILAL, H., *et al*., "Fiber reinforced concrete: a review", *Engineering Proceedings*, v. 22, n. 1, pp. 3, 2022.

[7] BESKOPYLNY, A.N., STEL'MAKH, S.A., SHCHERBAN, E.M., *et al*., "Enhanced performance of concrete dispersedly reinforced with sisal fibers", *Applied Sciences (Basel, Switzerland)*, v. 12, n. 18, pp. 9102, 2022. doi: http://doi.org/10.3390/app12189102.

[8] AHMAD, J., ARBILI, M.M., MAJDI, A., *et al*., "Performance of concrete reinforced with jute fibers (natural fibers): A review", *Journal of Engineered Fibers and Fabrics*, v. 17, pp. 15589250221121871, 2022. doi: http://doi.org/10.1177/15589250221121871.

[9] PRABHU, V., ROOBY, J. "Energy based design with eco-friendly materials in infrastructural systems", In: *6th Annual International Conference on Architecture and Civil Engineering*, 2018.

[10] GEREMEW, A., DEWINNE, P., DEMISSIE, T.A., *et al*., "Treatment of natural fiber for application in concrete pavement", *Advances in Civil Engineering*, v. 2021, pp. 1–13, 2021. doi: http://doi.org/10.1155/2021/6667965.

[11] SOOD, M., DWIVEDI, G., "Effect of fiber treatment on flexural properties of natural fiber reinforced composites: a review", *Egyptian Journal of Petroleum*, v. 27, n. 4, pp. 775–783, 2018. doi: http://doi.org/10.1016/j.ejpe.2017.11.005.

[12] KURPINSKA, M., PAWELSKA-MAZUR, M., GU, Y., *et al*., "The impact of natural fibers' characteristics on mechanical properties of the cement composites", *Scientific Reports*, v. 12, n. 1, pp. 20565, 2022. doi: http://doi.org/10.1038/s41598-022-25085-6. PubMed PMID: 36447015.

[13] NAGESWARI, N., DIVAHAR, R., "Experimental investigation on hybrid fibre reinforced concrete by partial replacement of m-sand with fine aggregate", *International Journal of Latest Engineering Research and Applications*, v. 7, n. 2, pp. 37–43, 2022.

[14] NEERAJA, D., WANI, A.I., KAMILI, Z., *et al*., "Study on strength characteristics of concrete using M-Sand and coconut fibers.", *IOP Conference Series. Materials Science and Engineering*, v. 263, n. 3, pp. 032014, 2017. doi: http://doi.org/10.1088/1757-899X/263/3/032014.

[15] SHADHEERAHAMED, M., RAVICHANDRAN, P., KRISHNARAJA, A.R. "Natural fibers in concrete-a review", In: *Materials Science and Engineering Conference Series*, p. 012038, 2021. doi: http://doi.org/10.1088/1757-899X/1055/1/012038.

[16] NURWIDAYATI, R., FARDHENY, A.F., ASYIFHA., "Investigation on mechanical properties of fiber reinforced concrete", *IOP Conference Series. Earth and Environmental Science*, v. 758, n. 1, pp. 012016, 2021. doi: http://doi.org/10.1088/1755-1315/758/1/012016.

[17] SINGH, C.P., PATEL, R.V., HASAN, M.F., *et al*., "Fabrication and evaluation of physical and mechanical properties of jute and coconut coir reinforced polymer matrix composite", *Materials Today: Proceedings*, v. 38, pp. 2572–2577, 2021. doi: http://doi.org/10.1016/j.matpr.2020.07.684.

[18] TARIQ, K.A., AHMAD, J., HUSNAIN, S.A., *et al*., "Influence on compressive and tensile strength properties of fiber-reinforced concrete using polypropylene, jute, and coir fiber.", *Journal of the Mechanical Behavior of Materials*, v. 32, n. 1, pp. 20220263, 2023. doi: http://doi.org/10.1515/jmbm-2022-0263.

[19] JAMIL, K., SHABBIR, F., RAZA, A., "Performance evaluation of jute fiber-reinforced recycled aggregate concrete: atrength and durability aspects", *Structural Concrete*, v. 24, n. 5, pp. 6520–6538, 2023. doi: http://doi.org/10.1002/suco.202200948.

[20] ZHAO, K., ZHAO, L., HOU, J., *et al*., "Effect of vibratory mixing on the slump, compressive strength, and density of concrete with the different mix proportions", *Journal of Materials Research and Technology*, v. 15, pp. 4208–4219, 2021. doi: http://doi.org/10.1016/j.jmrt.2021.10.033.

[21] KUMARS, A., KOTIAN, R., "M-Sand, an alternative to the river sand in construction technology", *International Journal of Scientific and Engineering Research*, v. 9, n. 4, pp. 96–102, 2018.

[22] PRABHU, V., XAVIER, A.C., JEFFIN, K., *et al*. "Polypropylene fibre reinforced pervious concrete with recycled aggregate", In: *AIP Conference Proceedings*, v. 2452, 2022. doi: http://doi.org/10.1063/5.0114528.

[23] SETHUNARAYANAN, R., CHOCKALINGAM, S., RAMANATHAN, R., "Natural fiber reinforced concrete", *Transportation Research Record: Journal of the Transportation Research Board*, n. 1227, pp. 57–60, 1990.

[24] BITTNER, C.M., OETTEL, V., "Fiber reinforced concrete with natural plant fibers—investigations on the application of bamboo fibers in ultra-high-performance concrete", *Sustainability (Basel)*, v. 14, n. 19, pp. 12011, 2022. doi: http://doi.org/10.3390/su141912011.

[25] PRABHU, V., ROOBY, J., "Behavior of steel fiber reinforced concrete beam using fly ash", *International Journal of Civil Engineering and Technology*, v. 9, n. 1, pp. 79–89, 2018.

[26] RASHEED, A., AKINLEYE, T.M., TAIYE, H.S., "Effects of polypropylene fibre on the compressive and splitting tensile strength of concrete", *Journal of Materials and Engineering Structures*, v. 5, n. 1, pp. 15–22, 2018.

[27] PRABHU, V., ROOBY, J., RAJARAMAN, A., "Investigational study on eco and energy friendly infrastructural material'", *Journal of Green Engineering*, v. 9, n. 1, pp. 112–135, 2019.

[28] YASHWANTH, M., "Evaluation of compressive strength of coir fibre reinforced concrete", *Turkish Journal of Computer and Mathematics Education*, v. 12, n. 10, pp. 68–73, 2021.

[29] SHARMA, B., SHUKLA, V.K., GUPTA, A., "Fiber reinforced concrete-use of coconut jute as a fiber", *Int. J. Eng. Sci. Comput*, v. 6, pp. 8734–8736, 2016.

[30] PRIYADARSHINI, V., FELIXKALA, T., DEPAA, R.A.B., *et al*., "Experimental investigation on properties of coir pith and its influence as partial replacement of fine aggregate in concrete", *Materials Today: Proceedings*, v. 45, pp. 6903–6906, 2021. doi: http://doi.org/10.1016/j.matpr.2020.12.1122.

[31] RAMLAL, S., JHA, P., "Strength behaviour of M25 grade concrete mixed with two natural fibers in both curing and without curing condition", *International Journal of Innovative Technology and Exploring Engineering*, v. 8, n. 9, pp. 101–104, 2019.

[32] KHALID, M.Y., ALRASHID, A., ARIF, Z.U., *et al*., "Natural fiber reinforced composites: sustainable materials for emerging applications", *Results in Engineering*, v. 11, pp. 100263, 2021. doi: http://doi.org/10.1016/j.rineng.2021.100263.

[33] RAMAKRISHNA, G., SUNDARARAJAN, T., KOTHANDARAMAN, S., "Evaluation of durability of natural fibre reinforced cement mortar composite-a new approach", *Journal of Engineering and Applied Sciences (Asian Research Publishing Network)*, v. 5, n. 6, pp. 44–51, 2010.

[34] DAYANANDA, N., KEERTHIGOWDA, B.S., EASWARAPRASAD, G.L., "A study on compressive strength attributes of jute fiber reinforced cement concrete composites", *IOP Conference Series. Materials Science and Engineering*, v. 376, pp. 012069, 2018. doi: http://doi.org/10.1088/1757-899X/376/1/012069.

[35] ZAKARIA, M., AHMED, M., MOZAMMEL, M.H., *et al*., "Scope of using jute fiber for the reinforcement of concrete material", *Textiles and Clothing Sustainability*, v. 2, n. 11, pp. 129–139, 2016.

[36] GOKULNATH, V., VIJAYAN, D.S., KATHIRVEL, P., *et al*. "Behaviour of retro fitted beams using natural fibers", *Materials Today: Proceedings*, v. 33, pp. 949–953, 2020. doi: http://doi.org/10.1016/j.matpr.2020.06.505.

[37] JAMSHAID, H., MISHRA, R.K., RAZA, A., *et al*., "Natural cellulosic fiber reinforced concrete: influence of fiber type and loading percentage on mechanical and water absorption performance", *Materials (Basel)*, v. 15, n. 3, pp. 874, 2022. doi: http://doi.org/10.3390/ma15030874. PubMed PMID: 35160829.

[38] GEETA, B., SALEEM, A., "The use of natural organic fibres in cement concrete: a review", *International Research Journal of Engineering and Technology*, v. 8, n. 6, pp. 950–952, 2021.

[39] SUTHAR, A.R., PATEL, Y.S., "Experimental studies on RC columns with natural fibers", *Journal of Physics: Conference Series*, v. 1714, n. 1, pp. 012047, 2021. doi: http://doi.org/10.1088/1742-6596/1714/1/012047.

[40] YA, L., "Infrastructure corrosion and durability: a sustainability study", Foster City, OMICS Group eBooks, 2014.

[41] AMIRTHARAJ, J. "Strength enhancement of concrete using coir fiber", *International Journal for Research in Applied Science and Engineering Technology*, v. 7, n. 4, pp. 1176–1183, 2019. doi: http://doi.org/10.22214/ijraset.2019.4210.

[42] SARAVANAKUMAR, R., ELANGOKRISHNANAN, S., RAJESHKUMAR, V., *et al*., "An analysis of the durability features and strength of the E-waste concrete", *Matéria (Rio de Janeiro)*, v. 29, n. 2, pp. e20240108, 2024. doi: http://doi.org/10.1590/1517-7076-rmat-2024-0108.

[43] VIJAYAKUMAR, A., SENGUTTUVAN, K., MOHAMMEDNABI, A.G.T., *et al*., "Numerical simulation of confinement effect of CFRP and GFRP strengthened concrete specimens", *Matéria (Rio de Janeiro)*, v. 29, n. 2, pp. e20240010, 2024. doi: http://doi.org/10.1590/1517-7076-rmat-2024-0010.

[44] YADAV, S.K., SINGH, A., "An experimental study on coconut fiber reinforced concrete.", *Int. Res. J. Eng. Technol*, v. 6, pp. 2250–2254, 2019.

[45] ANDIC-CAKIR, O., SARIKANAT, M., TUFEKCI, H.B., *et al*., "Physical and mechanical properties of randomly oriented coir fiber-cementitious composites", *Composites. Part B, Engineering*, v. 61, pp. 49–54, 2014. doi: http://doi.org/10.1016/j.compositesb.2014.01.029.

[46] VIJAYAN, R., KRISHNAMOORTHY, A., "Review on natural fiber reinforced composites", *Materials Today: Proceedings*, v. 16, pp. 897–906, 2019. doi: http://doi.org/10.1016/j.matpr.2019.05.175.

[47] NASIR, S., AYOUB, M., ZAFAR, S., *et al*., "Experimental study on comparison of strength properties of natural waste fiber (coir and jute) reinforced concrete", *Journal of Applied and Emerging Sciences*, v. 7, n. 2, pp. 105–110, 2018.

[48] VERMA, S.K., AHIRWAR, A.K., "Coconut Coir & Polypropylene Reinforced Concrete", *International Journal of Engineering Research & Technology (Ahmedabad)*, v. 6, n. 5, pp. 2278–0181, 2017.

[49] NEERAJA, D., WANI, A.I., KAMILI, Z., *et al*., "Study on strength characteristics of concrete using M-Sand and coconut fibers", *IOP Conference Series. Materials Science and Engineering*, v. 263, n. 3, pp. 032014, 2017. doi: http://doi.org/10.1088/1757-899X/263/3/032014.

[50] DAYANANDA, N., KEERTHIGOWDA, B.S., EASWARAPRASAD, G.L., "A study on compressive strength attributes of jute fiber reinforced cement concrete composites", *IOP Conference Series. Materials Science and Engineering*, v. 376, pp. 012069, 2018. doi: http://doi.org/10.1088/1757-899X/376/1/012069.

[51] SENEVIRATNE, R.A.C.J., THARMARAJAH, G., ARCHBOLD, P., "Use of natural fibres to enhance tensile strength of concrete", *Academic Journal of Civil Engineering*, v. 35, n. 2, pp. 48–53, 2017.

[52] PRIYA, S.T., THIRUMALINI, S., "Evaluation of strength and durability of natural fibre reinforced high strength concrete with M-sand", *RevistaRomâna de Materiale*, v. 48, n. 4, pp. 483, 2018.