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Influence of coconut fiber on mortar properties in masonry walls

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Abstract

The scarcity of stone materials, such as sand, has led to the exploration of alternative, sustainable options for mortars, including coconut fiber. This material, with minimal intervention in various areas of Peru, has proven to be an excellent choice in mortar preparation due to its characteristics of strength and durability. The study aimed to assess the influence of coconut fiber in mortar applications on the mechanical properties of clay brick masonry. Mixes were created with ratios of 1:3, 1:4, and 1:5, incorporating coconut fiber pre-treated at percentages of 0.5%, 1%, 1.5%, and 2% relative to the weight of cement and a length of 3 cm, respectively. Tests, including fluidity, compressive strength, and flexural strength, were conducted on mortar specimens. The behavior of clay brick masonry was evaluated through flexural strength, axial compression in prisms, and diagonal compression in walls. The most favorable result was observed in the 1:3 mix with the addition of 0.5% fiber, demonstrating a remarkable 22.6% increase in flexural strength compared to standard mortar. Subsequently, in masonry tests, the addition of 0.5% coconut fiber in 1:3 ratio mortars showed increases of 3.9%, 65.9%, and 3.3% in compressive strength, flexural strength, and diagonal compression in walls, respectively, compared to the standard samples. In conclusion, the addition of coconut fiber contributes significantly to the enhancement of mortar properties.

Keywords

Coconut fiber, Masonry, Mechanical properties, Mortar, Strength

1. Introduction

Civil construction activities hold significant social and economic importance as they involve the utilization of natural components that can be repurposed in the construction sector. This practice, however, contributes to environmental challenges (Silva et al., 2015). The incorporation of vegetable fibers as reinforcements in weak matrices, such as mortars (Affan et al., 2023; Boubaaya et al., 2023; Benaniba et al., 2020; Dridi et al., 2023; Khelifi et al., 2023) or cement concretes, presents a noteworthy alternative in construction. Banana (Suárez et al., 2021), cotton (Tang et al., 2023), and coconut (Marvila et al., 2021; Hamada et al., 2023) fibers, due to their mechanical properties, enhance adaptability, flexibility, and crack resistance in resulting materials. Their low cost, coupled with renewable and biodegradable characteristics, qualifies them as 'green' materials (Claramunt et al., 2011). Coconut fiber, abundant in many countries and recognized for its strength and durability, is suitable for use in cement matrices for high-performance structural elements (Zhijian et al., 2006). Certain fibers, like coconut fiber, exhibit tensile strengths 4 to 6 times higher than other fibers (Hwang et al., 2016), making it one of the top fifteen vegetable fibers globally due to its high lignin concentration, reaching up to about 50%, imparting greater strength compared to other fibers (Bui et al., 2020).

There are two types of this type of fiber: one is extracted from mature coconuts turning brown and white fibers are extracted from immature coconuts. Brown fibers are robust, strong and have a high resistance to abrasion, while white fibers are softer, thinner and weaker; therefore, due to these differences, brown fibers have better characteristics for engineering studies (Ali, 2011).

In recent times, cementitious composites reinforced with natural fibers are being considered for their properties when blended with building materials (Bui et al., 2019), experimental tests are often carried out to investigate the mechanical properties of mortars incorporating coconut fibers (Bui et al., 2022).

A comparative study of various natural fibers, including banana leaves, sugar cane, palm leaves, and coconut shells, demonstrated improved mechanical properties at percentages of 0.25%, 0.5%, 0.75%, and 1%. The results indicated a linear growth in strength and bending characteristics of the specimens (Al-Zubaidi, 2018). In cement and lime mortars, coconut fibers were added at a 1.5% ratio relative to the volume of the mortar. Cement mortars showed a 3% decrease in compression, while flexure exhibited a 24% increase compared to the cement mortar design pattern (Kesikidou & Stefanidou, 2019). Another study focused on geopolymeric mortars based on fly ash and solutions of sodium hydroxide and sodium silicate, incorporating coconut fiber up to 1% of the mortar volume. This study revealed a decrease in fluidity, while flexural test results showed a significant improvement with the addition of coconut fibers (Wongsa et al., 2020).

In a mortar containing cement, lime, sand, and coconut fiber (Sathiparan et al., 2017), no significant improvements were found in flexural and compressive strength, but workability and durability properties were reduced, leading to a recommendation of 0.5% fiber. Conversely, Perez et al. (2020) suggested that the combined use of coconut husk (endocarp) and coconut fibers (endocarp) in Portland cement-based mortars decreased their mechanical properties, particularly with increased fiber content in the mix design. Coconut fiber has also been employed in pumice setting (Lam et al., 2020), where up to 10 mortar designs with a cement-sand ratio of 1:3 were developed. Flexural strength tests with the incorporation of 30% pumice stone and 3% coconut fiber resulted in a modulus of rupture value of 7.20 MPa, surpassing the control design. However, the compressive strength and workability of the mixture were adversely affected.

Based on the reviewed studies, a knowledge gap emerges concerning the limited understanding of the behavior resulting from the interaction of different dosages of mortar cement: sand ratios (1:3, 1:4, and 1:5) with varying doses of coconut fiber when applied in clay brick masonry using materials from Peru. Therefore, this study aims to assess the influence of coconut fiber on the mechanical properties of mortar for clay brick masonry walls. Furthermore, particular attention is given to how the origin of the fibers affects the mortar's behavior upon their addition, considering that the properties of coconut fiber are noteworthy when extracted from the external part of the shell. The positive impact of the interaction between treated coconut fiber and mortar, utilizing materials from the area, is demonstrated as a significant finding in the conducted tests.

2. Materials and methods

2.1 Fine aggregate

Aggregates retained on the 4.75 mm I.S. sieve are primarily coarse aggregates, while those passing through are classified as fine aggregates. In this study, fine aggregate, as used by Syed et al. (2020), is specified. The fine aggregate selected is natural coarse sand, devoid of organic matter and salts, meeting the criteria outlined in ASTM C144. According to ASTM C144 (2018), not more than 50% of the sand should be retained between two consecutive meshes, and the fineness modulus should fall within the range of 1.6 to 2.5. The detailed physical characterization of the sand is provided in Table 1.

Table 1. Fine aggregate characteristics

Description of tests	Results
Maximum size (mm)	4.75
Density (g/cm³)	2.497
Loose unit weight (kg/m³)	1571
Compacted unit weight (kg/m³)	1664
Absorption percentage (%)	0.604
Moisture content (%)	1.21
Fineness module	2.46

2.2 Cement Portland

Portland cement Type I, a commonly used type that does not require specific properties of any other type, is utilized (ASTM C150, 2007). The characteristics of the cement used are detailed in Table 2.

Table 2. Cement Portland properties

Properties	Results	Limits as per ASTM
Density (g/cm³)	3.12	3.15
Initial setting time (minute)	71	>45
Final setting time (minute)	300	>375
Specific Surface (cm²/g)	3810	2600 minimum

2.3 Potable water

The water used in the preparation must adhere to all the conditions outlined in ASTM C1602 (2006) and preferably be drinkable. The pH value of the water should not be less than 6.0, as recommended by Syed et al. (2020).

2.4 Coconut fiber

Locally available untreated coconut fiber (CF) (Cocus nucifera L.), illustrated in Fig. 1, with an average length of approximately 30 mm, was employed in several stages. Various properties of the coconut fiber are outlined in Table 3.

Fig 1. Coconut fiber

Table 3. Some physical properties of coconut fiber

Description of tests	Results
Length size (mm)	30
Diameter (mm)	0.17 – 0.24
Loose unit weight (kg/m³)	571
Density (g/cm³)	1.202
Natural humidity (%)	13.40
Tensile strength (kg/cm²)	198.95

2.5 Mix Design

The mortars were produced in volumetric proportions of 1:3, 1:4, and 1:5 (cement: aggregates). The water/aggregate ratio varied based on the required mixing water for each mortar, maintaining a consistency set at 110 ± 5 mm according to the flowability table in ASTM C1437 (2020). This standard ensures adequate workability for the plasters. The composition of the mortars produced in this study is detailed in Table 2. The incorporation of fiber residues was analyzed in four proportions: 0.5%, 1.0%, 1.5%, and 2.0% by weight of cement. Due to the low bulk density of coconut fiber, the expressed volumes represent a substantial weight of incorporation, with a length of 3.0 cm utilized. Additionally, the average diameter of the mortar and the fluidity of the mixture are provided in Table 4.

Table 4. Proportioning of treated samples

Mortar	R w/c	Cement	Fine aggregate	Coconut fiber	Mortar diameter (mm)	Fluidity (%)
Pattern 1:3	0.74	1	3	0.00	206.5	107.33
0.5CF	0.74	1	3	0.005	169.00	70.18
1.0CF	0.74	1	3	0.010	160.75	61.40
1.5CF	0.74	1	3	0.015	132.75	33.28
2.0CF	0.74	1	3	0.020	124.25	24.75
Pattern 1:4	0.86	1	4	0.00	207.5	108.33
0.5CF	0.86	1	4	0.005	170.25	70.93
1.0CF	0.86	1	4	0.010	156.25	56.88
1.5CF	0.86	1	4	0.015	143	43.57
2.0CF	0.86	1	4	0.020	123.5	24.00
Pattern 1:5	0.97	1	5	0.00	209.75	110.59
0.5CF	0.97	1	5	0.005	159.75	66.39
1.0CF	0.97	1	5	0.010	144.00	44.58
1.5CF	0.97	1	5	0.015	121.50	21.99
2.0CF	0.97	1	5	0.020	104.75	5.17

2.6 Sample preparation

Cubes of 50 x 50 x 50 mm and beams of 130 x 40 x 40 mm were designed for both the standard mortar and the experimental mortar with the addition of coconut fiber to see if there is an improvement over the standard mortar. The samples were cured for 7, 14 and 28 days before testing. The samples were prepared at the following dosages 1:3, 1:4 and 1:5 for both the standard mortar and the mortar with added CF, with percentages of: 0.5%, 1.0%, 1.5% and 2.0%.

The mortars were manufactured following the following process: all the materials were homogeneously mixed for 30 s using a mixer at slow speed (140 ± 5) rpm, then the design water was added, mixing for 3 min at (140 ± 5) rpm and for 60 s at medium speed (285±10) rpm; subsequently, the manufactured mortar is checked to ensure that it complies with a flowability of 110±5 %, for which the flowability table was used.

Immediately after the mixture is prepared, the fresh mortar is placed in molds, and depending on the test for which it is required, these will have the shape of cubes or beams. The following day, once the specimens had been demolished, they were left to cure in a container filled with water, considering the ambient temperature under air-drying conditions (23°C and more than 50% relative humidity) (ASTM C511, 2013). Figure 2 shows the processes of the study.

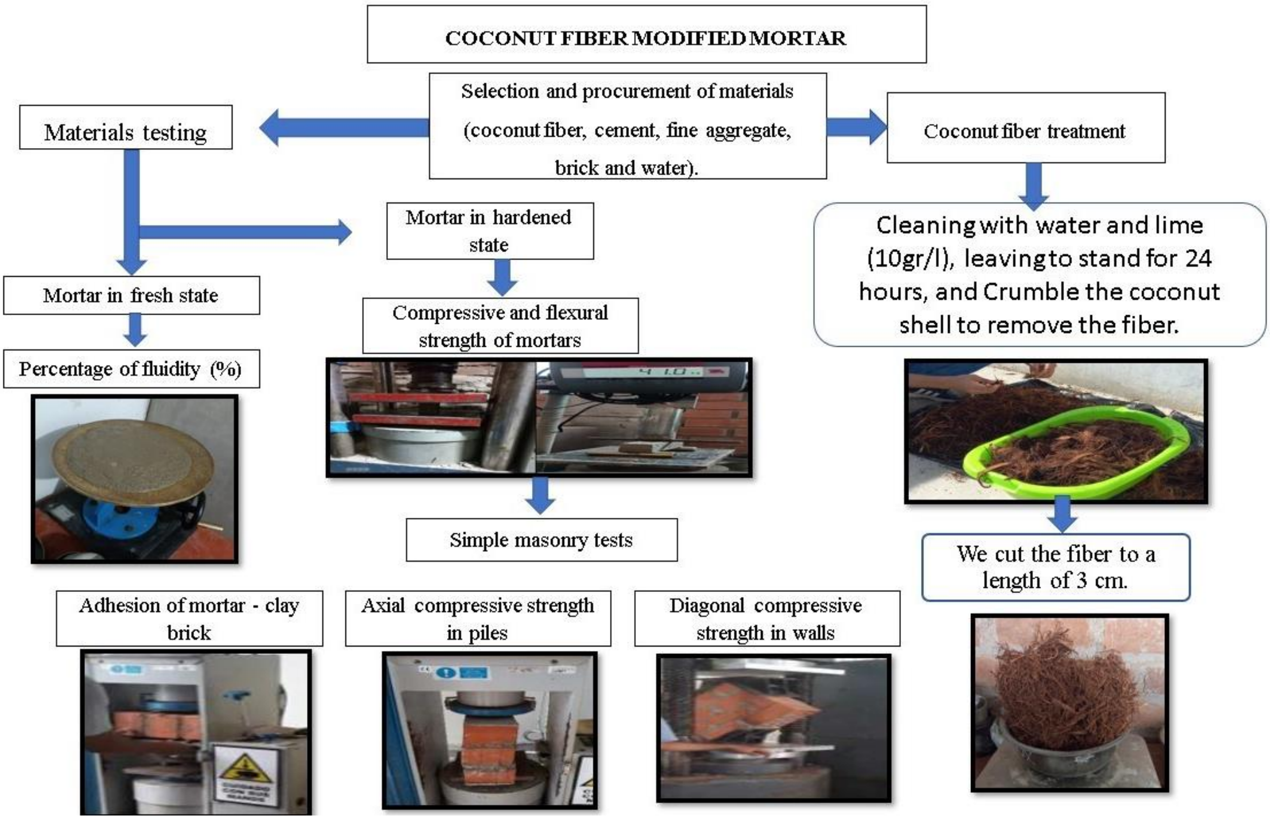

Fig 2. Flowchart of study procedures

2.7 Test methods

Fluidy diameter

Immediately after mixing the components, at the corresponding dosage, the workability was evaluated using one part of the mortar for a standard sample and another with CF in the flow table according to ASTM C230. The fresh mortar was placed in a conical mold with two layers of 25 mm thickness each, compacted with a tamper, the flow dispersion diameter was measured after removing the mold and the result was recorded from the average of 4 measurements (ASTM C230, 2020), detailed in Fig. 3.

Tests on mechanical properties

Compressive strength tests on cubes (50 x 50 x 50 mm) were performed in accordance with (ASTM C109, 2020). At 7, 14 and 28 days, the specimens were compressed using a hydraulic testing machine at a considerable speed; the maximum capacity recorded was fractionated by the area of the compressed space (50 x 50 mm) to reach the strength of the specimens; the strength of the specimens was determined by averaging the three repetitions. The flexural strength tests of the beams (160 x 40 x 40 mm) were carried out according to (ASTM C348, 2021). The testing machine will have an accuracy greater than or equal to 1, in addition to this it has 2 rollers of 10 mm located at 100 mm or 106.7 mm, and a roller equivalent to the 2 support rollers and of equal diameter to them, these will be mobile around their center to allow a uniform distribution of the loads. In any case, it was considered that, by gradually introducing the fiber (in the percentages required for each sample), it would be randomly sprinkled into the mixture, ensuring a homogeneous dispersion (Thanushan et al., 2021), detailed in Fig. 4.

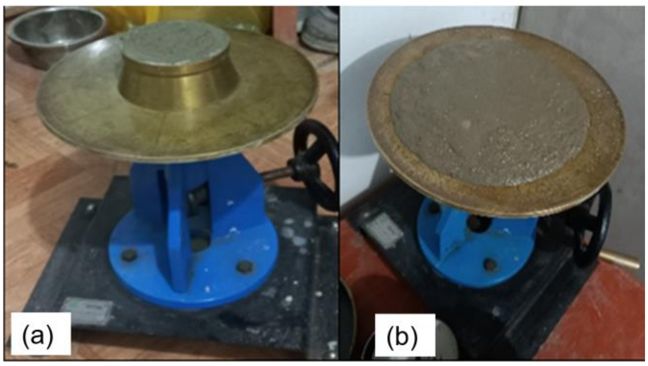

Fig 3. Test: a) Flow table preparation, b) demoulding of the mortar.

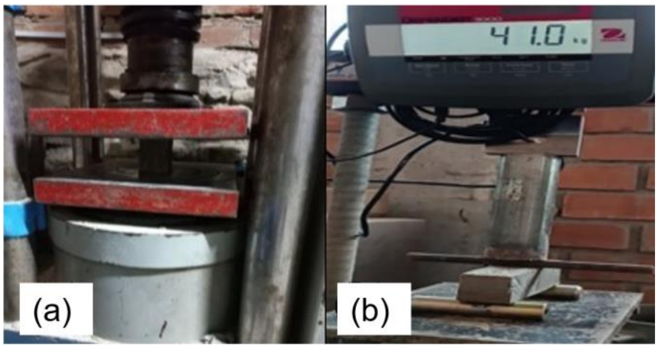

Fig 4. Test: a) Compression strength, b) flexural strength

Pretreatment of coconut fiber

The pre-treatment procedure is based on coconut tow, which proceeds to the extraction of the coconut fiber, previously cut, and soaked in water. This allows easier shredding of the fiber. Then they were soaked in a pool of water that was previously treated with 10 g/l with lime for 24 hours, then rinsed several times with plenty of water. The treatment with lime solution is to eliminate impurities and to have a better adhesion texture of the fiber with the mortar. In addition, it protects the fiber from deterioration due to the high alkalinity of the cement paste and improves adherence, since it confers a certain roughness to the fiber. Pre-treatment of fibers led to a change in composition and ultimate changes occur due to their properties and their properties of composite materials (Syed et al., 2020).

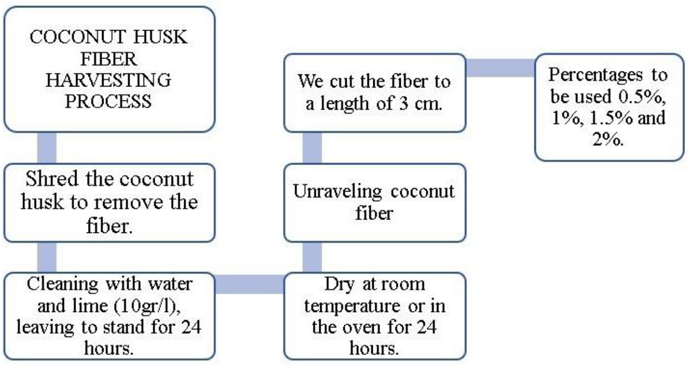

Fig 5. Process flow of treated coconut fiber

3. Results and discussions

3.1 Fluidy diameter

As shown in Table 5, one of the most important factors in the design of the mortar mix, in addition to the cement-sand ratio, was to select the appropriate water-cement ratio, considering the changes in the properties that CF can produce when incorporated into the mix. Consequently, for the different dosages of 1:3, 1:4 and 1:5 used, the percentage of flowability of the mortar was calculated by adding CF in four percentages 0.5%, 1.0%, 1.5%, 2.0%; it was observed that, with respect to the standard mortar, in each dosage the mortar added obtained more unfavorable flowability percentages as more CF was added, verifying with what is indicated in ASTM C1437.

Table 5. Results of the mortar fluidity test

Mortar	R w/c	Mortar diameter (mm)	Fluidity (%)
Pattern 1:3	0.74	206.5	107.33
Pattern 1:3 + 0.5CF	0.74	169.00	70.18
Pattern 1:3 + 1.0CF	0.74	160.75	61.40
Pattern 1:3 + 1.5CF	0.74	132.75	33.28
Pattern 1:3 + 2.0CF	0.74	124.25	24.75
Pattern 1:4	0.86	207.5	108.33
Pattern 1:4 + 0.5CF	0.86	170.25	70.93
Pattern 1:4 + 1.0CF	0.86	156.25	56.88
Pattern 1:4 + 1.5CF	0.86	143	43.57
Pattern 1:4 + 2.0CF	0.86	123.5	24.00
Pattern 1:5	0.97	209.75	110.59
Pattern 1:5 + 0.5CF	0.97	159.75	66.39
Pattern 1:5 + 1.0CF	0.97	144.00	44.58
Pattern 1:5 + 1.5CF	0.97	121.50	21.99
Pattern 1:5 + 2.0CF	0.97	104.75	5.17

Table 5 shows the results of the diameter measurement for the mortar flowability test, for the standard mortar, complies at all dosages, compared to the experimental mortar with the addition of coconut fiber, which reduces the percentage of flowability as the percentage of fiber incorporation increases. Similarly, in the research of (Hwang et al., 2016) where, through flow tests, the workability of the mortar mixtures with coconut fibers was evaluated, resulting in a decrease as the coconut content increased, for which they opted to use a superplasticizer additive. Likewise, (Wongsa et al., 2020) tested geopolymeric mortars based on fly ash and sodium hydroxide and silicate, by means of flowability tests, obtaining flowability percentages ranging from 22 to 54% for percentages of natural coconut fiber for additions of 0.5 to 1% in the cement fraction.

3.2 Prism adhesion

As for the following test, the adhesion capacity between the mortar and the masonry units was determined by applying a perpendicular force in the center of the prisms, according to the procedure of ASTM C1072. (ASTM C1072, 2019). Fig. 6 summarizes the test results, the addition of 0.5% CF in the masonry prisms represents increases of 65.9, 1.4 and 5.5% for the 1:3, 1:4 and 1:5 dosages respectively, showing that the greatest influence is achieved in the 1:3 dosage mortars. However, the highest value of bond strength was for the 1:4 mortar with the addition of 0.5% CF, being 11.13 kg/cm2, however it does not exceed that obtained by (Qaisar et al., 2012) with a 1:4 cement: sand mortar. It is demonstrated that, the analysis of variance to determine the response to flexural adhesion resistance in prisms of dosage 1:3 and 1:5 in 28 days, according to the optimum percentage of coconut fiber addition, concluding that the percentages of the treatments under study, that is to say that the optimum % of coconut fiber addition did influence its response to flexural adhesion resistance in prisms 1:3 and 1:5, it was shown that the percentages of the treatments under study, i.e. the optimum % addition of coconut fiber did not influence their response to prism flexural bond strength (1:4) at 28 days.

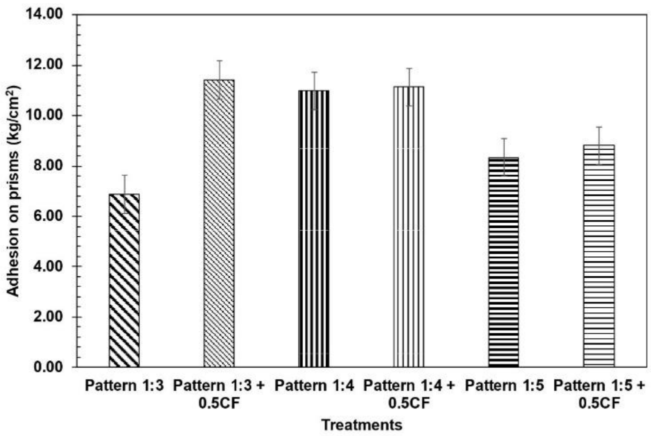

Fig 6. Prism adhesion results

3.3 Compressive strength applied in mortars

The samples of the mortar with the incorporation of 0.5% coconut fiber, in all the dosages of the mortar, registered an increase in the compressive strength in the first 7 days of curing, while at 14 and 28 days they presented a reduction with respect to the strength of the mortar, which showed higher compressive strength at 14 and 28 days of curing, the explanation is due to the degradation of the fiber with age in the alkaline environment of the cementitious matrix. The explanation for this is due to the degradation of the fiber with age in the alkaline environment of the cementitious matrix.

The explanation for this is due to the degradation of the fiber with age in the alkaline environment of the cementitious matrix. It was found that the higher the proportion of coconut fibers in the mortar, the lower the compressive strength at all dosages of 1:3, 1:4 and 1:5; where the greatest loss of strength occurs at the 1:4 ratio at 28 days. According to other studies, the increase in fiber content proves to be detrimental in compromising the compressive strength values of the experimental mortar at 28 days, being reduced up to 49% with respect to the 65MPa of its standard mortar, with the addition of 4% CF (Hwang et al., 2016).

The one-factor ANOVA test showed a value less than 0.05 ($p=0.0139<0.05$), rejecting the null hypothesis, therefore, there is a significant difference in the mean compressive strength of at least two treatments. Likewise, the Tukey post hoc test showed that the treatments did not present a significant difference, as shown in Fig. 7. Although the increase of coconut fiber in the mortar produces lower and lower compressive strengths, another study revealed that there is a better post-cracking behavior of the samples, since the incorporated fiber distributes the stress better, even reaching an increase of 5.7% for 0.5% CF (Sathiparan et al., 2017). Fig. 7 shows the results and the variability of the cube compressive strength results.

3.4 Flexural strength applied in mortars

The flexural strength results with coconut fiber addition 0.5%, 1.0%, 1.5% and 2.0% at the 1:3 and 1:5 dosages recorded an increase in flexural strength at 7, 14 and 28 days of treatment, with respect to the standard specimens that did not contain coconut fiber. The results at 28 days indicate that the addition of 0.5% CF was the one that presented the highest values of modulus of rupture of 33.22, 25.59 and 20 kg/cm2 for the dosages 1:3, 1:4 and 1:5, respectively; representing an improvement of up to 58.6% with respect to its standard design, as is the case of the 1:5 mortar. A similar study by (Sathiparan et al., 2017) found similar results for the modulus of rupture of mortar beams, achieving a 6% increase using an incorporation of 0.5% CF in relation to the cement value, as in the present study.

As for the 1:4 mortar designs, the flexural strength decreased with the inclusion of coconut fibers, as the amount of fiber increased, the flexural values of the mortar decreased, similarly occurs in the study of (Lam et al., 2020), with the incorporation of pumice stone 30% and coconut fiber 3% at the same time, a reduction of up to 27.1% of the flexural strength, with respect to its standard design, is achieved. Secondly, in all mortar dosages, at early fracture ages of 7 days, a linear increase in flexural values is shown, as shown in Fig. 8. The one-factor ANOVA test showed a value less than 0.05 ($p=0.0347<0.05$), rejecting the null hypothesis, therefore, there is a significant difference in the mean flexural strength of at least two treatments, likewise, the Post Hoc Tukey test, allowed us to know that the treatments did not present a significant difference. The results of the increase in flexural strength coincide with previous studies of hydraulic cement mortars, where the inclusion of coconut fibers achieves an increase in a range of 16 to 22% compared to their designs without fiber (Kesikidou & Stefanidou, 2019; Bui et al., 2019).

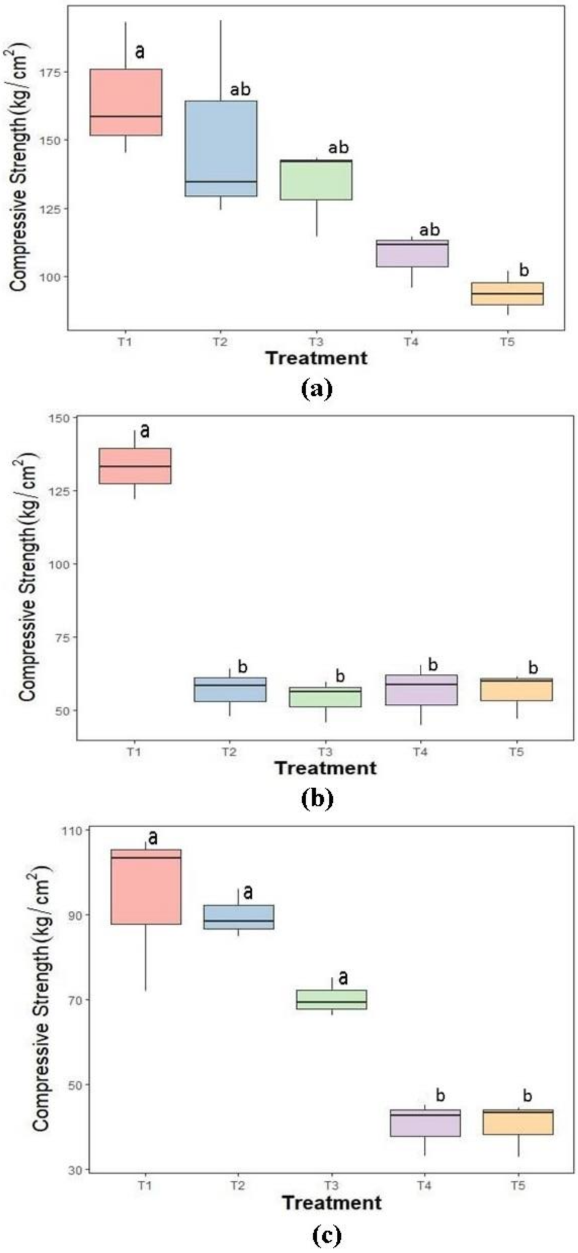

Fig 7. Boxplot of the study on compressive strength at ratios: a) 1:3, b) 1:4 and c) 1:5 with each ratio of CF

3.5 Axial compressive strength in prisms applied in mortar

Axial compressive strength in prisms tested at 28 days in clay brick prisms for the different standard mortar ratios and with the dosage of CF, observing that at 0.5% fiber, it obtained the best mechanical characteristics. Following the parameters of the (ASTM C1314, 2021), the results of the tests can be seen in Fig. 9. For the 1:3 mortar, the axial compression in prisms (f'b) with mortar with the addition of CF was 65.76 kg/cm2, which represents a slight increase of 3.9%. Likewise, in the prisms with 1:4 mortar, the addition of coconut fiber represents a 2.0% increase in f'b; however, for the 1:5 design, the addition of 0.5% CF decreases the standard value of f'b by 6.4%. Compared to other studies that analyzed the compression of clay brick prisms with gypsum and cement mortars, these obtained f'b values of 5.5 MPa and 12 MPa, respectively (Moayedian & Hejazi, 2021), the prisms with mortar with coconut fiber addition represent f'b values similar to the prisms with cement mortar, and higher than the prisms with gypsum mortar.

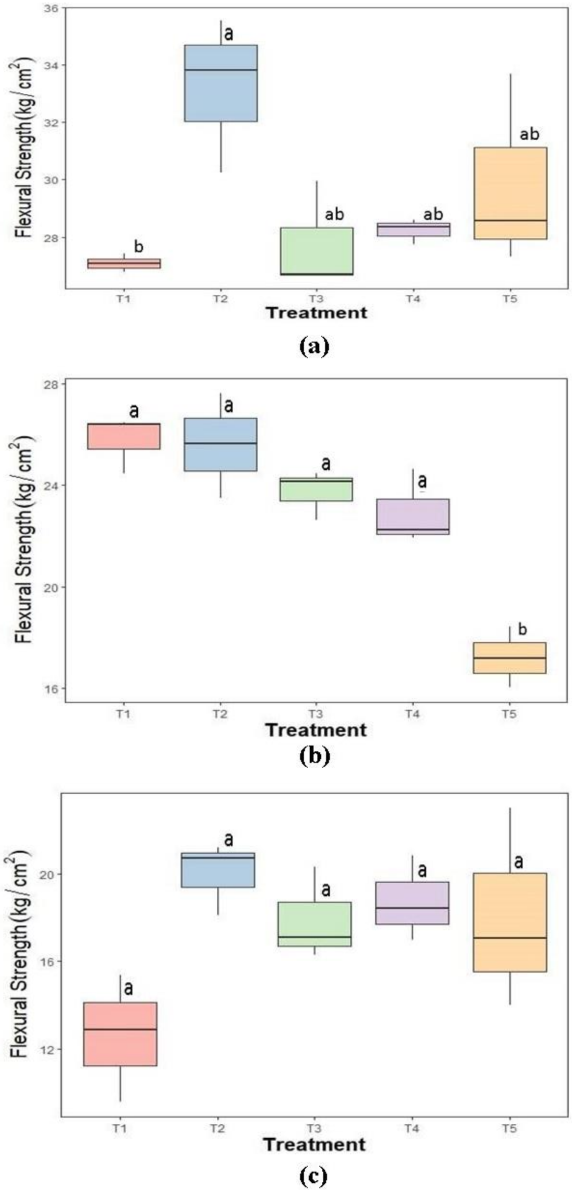

Fig 8. Boxplot of the study on flexural strength at ratios: a) 1:3, b) 1:4 and c) 1:5 with each ratio of CF

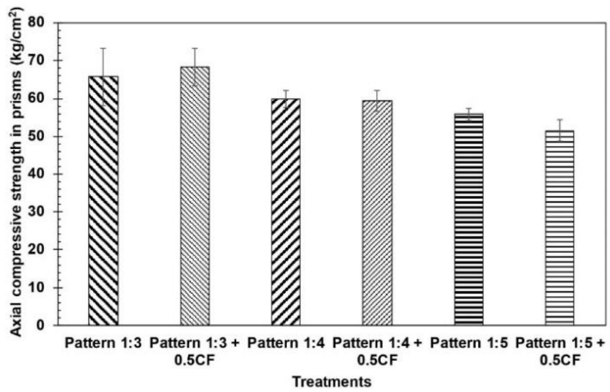

Fig 9. Effect of optimum CF mortar on axial compressive strength in prisms

3.6 Diagonal compressive strength applied in mortar

For the preparation of the diagonal compression test, the provisions of ASTM E519 were followed (ASTM E519, 2007). Using mortar with 0.5% CF, low walls were fabricated and placed in a press that applied force along one of its diagonals, thus generating a diagonal tensile failure. Fig. 10 summarizes the test results, the addition of 0.5% CF in the masonry walls represents increments of 3.3, 1.1 and 25.1% for the 1:3, 1:4 and 1:5 dosages respectively. In this case, the greatest influence of coir fiber was obtained for the 1:5 mortar. In the research of (Qaisar et al., 2012), the diagonal compression values vary from 0.75 to 1.7 MPa for clay brick masonry with 1:4 cement: sand mortar, being like those obtained in the present study.

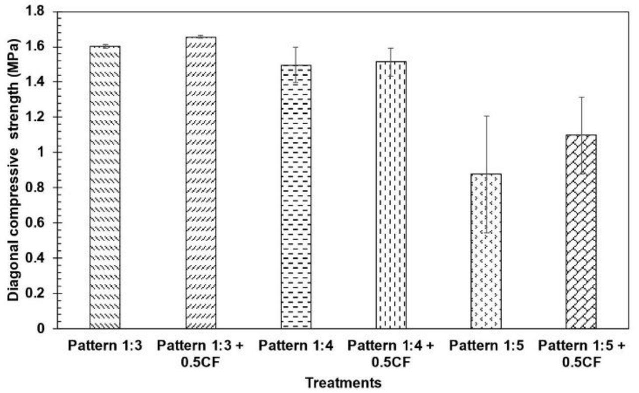

Fig 10. Effect of optimum CF mortar on diagonal compressive strength in masonry walls

4. Conclusions

The study compiles assertive findings in terms of the properties on the use of CF as mortar reinforcement in the application of clay brick masonry, using materials originating from Peru, being a sustainable and viable alternative for the use of eco-friendly constructions, in addition to these findings the following conclusions are drawn:

- Regarding flowability, water demand was directly proportional to the increase in coconut fiber; due to this, the mortar mix with CF presented reduced flowability with respect to conventional mortar dosages.
- The compressive strength was negatively affected by the addition of CF; however, at the early age of 7 days of curing, all the dosages with CF showed increases with respect to the standard designs. At ages 14 and 28 days, strengths decreased progressively with increasing percentages of coir fibers.
- The results at 28 days indicate that the addition of 0.5% CF was the one that presented the highest values of modulus of rupture of 33.22, 25.59 and 20 kg/cm2 for the 1:3, 1:4 and 1:5 dosages, respectively; representing an improvement of up to 58.6% compared to its standard design, as is the case of the 1:5 mortar.
- The behavior of the experimental mortar with the masonry units was more than remarkable, in its optimum conditions at 28 days, the mortar with the addition of 0.5% CF showed superior values in all the tests with the masonry, obtaining axial compression values of 68.32, 59.34 and 51.50 kg/cm2 for the dosages of 1:3, 1:4 and 1:5 respectively.
- The axial compressive strength of the prism obtained an improvement of up to 65.9% with the addition of CF for the 1:3 dosage.
- The diagonal compressive strength test on low walls had an increase of up to 25.1% with the addition of CF.
- Therefore, it can be stated that the properties of manufactured clay brick masonry are significantly improved with mortars that include coconut fiber in their design.
- With the results of the tests, it is finally concluded that natural coconut shell fibers could be used as reinforcement material in the proportions indicated to produce mortars, complying with the minimum standards according to Peruvian regulations.

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References

Affan, H., Arairo, W., & Arayro, J. (2023). Mechanical and thermal characterization of bio-sourced mortars made from agricultural and industrial by-products. Case Studies in Construction Materials, 18(e01939). https://doi.org/10.1016/j.cscm.2023.e01939

Ali, M. (2011). Coconut Fibre – A Versatile Material and its Applications in Engineering. Journal of Civil Engineering and Construction Technology, 9(2), 189-197. Retrieved from https://academicjournals.org/journal/JCECT/article-full-text-pdf/D540A213064.

Al-Zubaidi, A. B. (2018). Effect of natural fibers on mechanical properties of green cement mortar. AIP Conference Proceedings, 1968(1), 1-7. https://doi.org/10.1063/1.5039162

ASTM C1072. (2019). Standard Test Methods for Measurement of Masonry Flexural Bond Strength. West Conshohocken, PA: ASTM International. https://doi.org/10.1520/C1072-19

ASTM C109. (2020). Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens) (Vol. 11). West Conshohocken: ASTM International, PA. https://doi.org/10.1520/C0109_C0109M-20

ASTM C1314. (2021). Standard Test Method for Compressive Strength of Masonry Prisms. West Conshohocken, PA: ASTM International. https://doi.org/10.1520/C1314-21

ASTM C1437. (2020). Standard Test Method for Flow of Hydraulic Cement Mortar. West Conshohocken, PA: ASTM International. https://doi.org/10.1520/C1437-20

ASTM C144. (2018). Standard Specification for Aggregate for Masonry Mortar (Vol. 254). West Conshohocken, PA: ASTM International. https://doi.org/10.1520/C0144-99

ASTM C150. (2007). Standard Specification for Portland Cement (Vol. 273). West Conshohocken, PA: ASTM International. https://doi.org/10.1520/C0150-07

ASTM C1602. (2006). Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete. West Conshohocken, PA: ASTM International.

ASTM C230. (2020). Standard Specification for Flow Table for Use in Tests of Hydraulic Cement. West Conshohocken, PA: ASTM International. https://doi.org/10.1520/C0230_C0230M-20

ASTM C348. (2021). Standard Test Method for Flexural Strength of Hydraulic-Cement Mortars (Vol. 305). West Conshohocken, PA: ASTM International. https://doi.org/10.1520/C0348-21

ASTM C511. (2013). Standard Specification for Mixing Rooms, Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes. West Conshohocken, PA: ASTM International. https://doi.org/10.1520/C0511-13

ASTM E519. (2007). Standard Test Method for Diagonal Tension (Shear) in Masonry Assemblages. West Conshohocken, PA: ASTM International. https://doi.org/10.1520/E0519-07

Benaniba, S., Driss, Z., Djendel, M., Raouache, E., & Boubaaya, R. (2020). Thermo-mechanical characterization of a bio-composite mortar reinforced with date palm fiber. Journal of Engineered Fibers and Fabrics, 15, 1-9. https://doi.org/10.1177/1558925020948234

Boubaaya, R., Djendel, M., Benaniba, S., Kessal, O., & Driss, Z. (2023). Impact of the loading of date palm fibers on the performances of mortars. REM - International Engineering Journal, 76(2), 159 - 168. https://doi.org/10.1590/0370-44672022760052

Bui, H., Levancher, D., Boutouil, M., & Sebaibi, N. (2022). Effects of Wetting and Drying Cycles on Microstructure Change and Mechanical Properties of Coconut Fibre-Reinforced Mortar. Journal of Composites Science, 6(102), 1 - 13. https://doi.org/10.3390/jcs6040102

Bui, H., Sebaibi, N., Boutouil, M., & Levacher, D. (2020). Determination and Review of Physical and Mechanical Properties of Raw and Treated Coconut Fibers for Their Recycling in Construction Materials. Fibers, 8, 1 - 18. https://doi.org/10.3390/fib8060037

Bui, T. T., Boutouil, M., Sebaibi, N., & Levacher, D. (2019). Effect of coconut fiber content on the mechanical properties of mortars. Academic Journal of Civil Engineering, 37(2), 300-307. https://doi.org/10.26168/icbbm2019.43

Claramunt, J., Ardanuy, M., García-Hortal, J., & Filho, R. T. (2011). The hornification of vegetable fibers to improve the durability of cement mortar composites. Cement and Concrete Composites, 33(5), 586-595. https://doi.org/10.1016/j.cemconcomp.2011.03.003

Dridi, M., Hachemi, S., & Belkadi, A. A. (2023). Influence of styrene-butadiene rubber and pretreated hemp fibers on the properties of cement-based repair mortars. European Journal of Environmental and Civil Engineering. https://doi.org/10.1080/19648189.2022.2052968

Hamada, H. M., Shi, J., Al Jawahery, M. S., Majdi, A., Yousif, S. T., & Kaplan, G. (2023). Application of natural fibres in cement concrete: A critical review. Materials Today Communications, 35(105833). https://doi.org/10.1016/j.mtcomm.2023.105833

Hwang, C.-L., Tran, V.-A., Hong, J.-W., & Hsieh, Y.-C. (2016). Effects of short coconut fiber on the mechanical properties, plastic cracking behavior, and impact resistance of cementitious composites. Construction and Building Materials, 127, 984-992. https://doi.org/10.1016/j.conbuildmat.2016.09.118

Kesikidou, F., & Stefanidou, M. (2019). Natural fiber-reinforced mortars. Journal of Building Engineering, 25, 1-6. https://doi.org/10.1016/j.jobe.2019.100786

Khelifi, A., Boumaaza, M., Belaadi, A., Tarek, D., De Azevedo, A. R., Bourchak, M., & Jawaid, M. (2023). Effects of alkaline treatment of Washingtonia mesh waste on the mechanical and physical properties of bio-mortar: experimental and prediction models. Biomass Conversion and Biorefinery. https://doi.org/10.1007/s13399-023-04221-w

Lam, T. V., Dien, V. K., Phi, D. V., Luong, N. T., & Trin, N. D. (2020). Mechanical properties of construction mortar with pumice stone and coconut fiber. Energy Management of Municipal Transportation Facilities and Transport, 982, 648 - 659. https://doi.org/10.1007/978-3-030-19756-8_61

Marvila, M. T., Rocha, H. A., De Azevedo, A. R., Colorado, H. A., Zapata, J. F., & Vieira, C. M. (2021). Uso de fibras vegetales naturales en composites cementosos: conceptos y aplicaciones. Innovative Infrastructure Solutions, 6(3). https://doi.org/10.1007/s41062-021-00551-8

Moayedian, S. M., & Hejazi, M. (2021). Stress-strain relationships for scaled gypsum mortar and cement mortar brick masonry. Journal of Building Engineering, 33(101861), 1-16. https://doi.org/10.1016/j.jobe.2020.101861

Perez, V. A., Ramirez, R. M., Correa, F., Moreno, P., & Dyaz, A. (2020). Analysis on the mechanical resistance and water absorption capacity of prototype mortar with residual coconut mesocarp and fiber aggregates. Journal of Physics: Serie de conferencias, 1672(012011), 1-7. https://doi.org/10.1088/1742-6596/1672/1/012011

Qaisar, A., Badrashi, Y. I., Ahmad, N., Alam, B., Rehman, S., & Banori, F. A. (2012). Experimental Investigation on The Characterization of Solid Clay Brick Masonry for Lateral Shear Strength Evaluation. International Journal of Earth Sciences and Engineering, 5(4), 782-791.

Sathiparan , N., Nishanthana, M., & Pavithra, B. (2017). Performance of coconut coir reinforced hydraulic cement mortar for surface plastering application. Construction and Building Materials, 142, 23 - 30. https://doi.org/10.1016/j.conbuildmat.2017.03.058

Silva, E., Marques, M., Junior, C., & Velasco, F. (2015). Análise técnica para o reaproveitamento da fibra de coco na construção civil. Ambiência - Revista do Setor de Ciências Agrárias e Ambientais, 11(3), 669 - 683. https://doi.org/10.5935/ambiencia.2015.03.11

Suárez, C. M., E., V.-L., Torres, A. C., & Gaitán, C. A. (2021). Mechanical analysis of vegetable fiber versus a polymeric fiber added in cement mixtures. 5+1 International Meeting for Researchers in Materials and Plasma Technology, 5+1 IMRMPT 2021. Medellin. https://doi.org/10.1088/1742-6596/2046/1/012062

Syed, H., Nerella, R., & Madduru, S. R. (2020). Role of coconut coir fiber in concrete. 1st International Conference on Advanced Light-Weight Materials and Structures, ICALMS 2020. Hyderabad: Materials Today: Proceedings. https://doi.org/10.1016/j.matpr.2020.01.477

Tang, W., Monaghan, R., & Sajjad, U. (2023). Investigation of Physical and Mechanical Properties of Cement Mortar Incorporating Waste Cotton Fibres. Sustainability (Switzerland), 15(11). https://doi.org/10.3390/su15118779

Thanushan, K., Yogananth, Y., Sangeeth, P., Coonghe, J. G., & Sathiparan, N. (2021). Strength and Durability Characteristics of Coconut Fibre Reinforced Earth Cement Blocks. Journal of Natural Fibers, 18(6), 773-788. https://doi.org/10.1080/15440478.2019.1652220

Wongsa, A., Kunthawatwong, R., Naenudon, S., Sata, V., & Chinaprasirt, P. (2020). Natural fiber reinforced high calcium fly ash geopolymer mortar. Construction and Building Materials, 241(118143), 1 - 9. https://doi.org/10.1016/j.conbuildmat.2020.118143

Zhijian, L., Lijing, W., & Xuangai, W. (2006). Flexural Characteristics of Coir Fiber Reinforced Cementitious Composites. Fibers and Polymers, 7(3), 286 - 294. https://doi.org/10.1007/BF02875686