ISSN: 2594 - 2905

EFFECTS OF ADDING NATURAL FIBRE FROM MAGUEY BAGASSE (CUISHE OR CUISH) ON THE SIMPLE COMPRESSIVE STRENGTH AND ABSORPTION PROPERTIES OF PORTLAND CEMENT MORTAR PARTITION WALLS

EFFECTS OF ADDING NATURAL FIBRE FROM MAGUEY BAGASSE (CUISHE OR CUISH) ON THE SIMPLE COMPRESSIVE STRENGTH AND ABSORPTION PROPERTIES OF PORTLAND CEMENT MORTAR PARTITION WALLS

Ramírez-Ortiz Arturo Emanuel[1] , Cortés-Jiménez Edgar Alberto[2] , Hernández-Moreno Francisco[3] , Quero-Ramírez Guillermo[4] , De Paz-Montes Uriel Felipe[5]

[1] National Technological Institute of Mexico, Technological Institute of Oaxaca,arturo.ramirez@itoaxaca.edu.mx , ORCID ID: 0009-0009-8282-9608.
[2] National Technological Institute of Mexico, Technological Institute of Oaxaca,edgar.jimenez@itoaxaca.edu.mx , ORCID ID: 0009-0009-0371-2314.
[3] National Technological Institute of Mexico, Technological Institute of Oaxaca,francisco.hm@itoaxaca.edu.mx , ORCID ID: 0009-0002-6303-1851.
[4] National Technological Institute of Mexico, Technological Institute of Oaxaca,guillermo.quero@itoaxaca.edu.mx , ORCID ID: 0009-0005-8695-7253.
[5] Student, National Technological Institute of Mexico, Technological Institute of Oaxaca,17160097@itoaxaca.edu.mx , ORCID ID: 0009-0007-2653-7833

https://doi.org/10.61117/ipsumtec.v8i2.372

Summary -- In this study, Cuishe or Cuish maguey bagasse was determined to be a suitable natural fiber to be added in the manufacture of cement-sand mortar partitions in percentages of 0.5, 1.0, and 1.5% of the weight of the constituent materials (sand, water, and cement). as it is one of the most widely used types of maguey in the artisanal production of mezcal in the state of Oaxaca, which offers a large amount of available and usable maguey bagasse. Twenty-five prismatic specimens with dimensions of 100 mm x 140 mm x 280 mm were produced using a manual three-cell compaction blocker or molds in which the compaction was carried out by the same operator to reduce the variation in the force applied during the manufacturing process of the partitions, which were tested for axial compression in a Matest brand hydraulic press with four pre-stressed frames with calibration certificate No.: CIMED-FZA-362/2022, which complies with the requirements of ASTM C39 |BS 1610 | NF P18-411| AASHTO T22 at 7, 14, 28, and 56 days, selecting 5 specimens for each specified age. The absorption tests were carried out at 56 days on 5 specimens following the procedure described in standard NMX-C-037-ONNCCE-2013. It was observed that at 56 days of age, compressive strength increases as the percentage of fiber replacement increases. It was also observed that at 28 days of age, the mixture with a fiber content of 1.5% had the highest load-bearing capacity, followed by the control mixture (without added fiber), then the mixture with 1.0% fiber, and finally the mixture with 0.5% fiber.

Keywords: Maguey bagasse; mixture; partitions; compressive strength.

Abstract -- The use of Cuishe or Cuish maguey bagasse was determined in this work as an added natural fiber in the manufacture of cement-sand mortar partitions in percentages of 0.5, 1.0, and 1.5% with respect to the weight of the materials (sand, water, and cement) constituting the same, as it is one of the types of maguey most used in the artisanal manufacture of mezcal in the state of Oaxaca, which offers a large amount of available and usable maguey bagasse.
Twenty-five prismatic specimens with dimensions of 100 mm x 140 mm x 280 mm were made using a manual compaction block with three cells or molds in which the compaction was carried out by the same operator to reduce the variation in the force applied during the manufacturing process.
The partitions were tested for axial compression in a Matest brand hydraulic press for four-column prestressed frames with calibration certificate number: CIMED-FZA-362/2022, which complies with the requirements of ASTM C39| , BS 1610| , NF P18-411| , and AASHTO T22 at 7, 14, 28, and 56 days, selecting 5 specimens for each specified age. The absorption tests were carried out at 56 days in 5 specimens following the procedure described in the NMX-C-037-ONNCCE-2013 standard.
It was observed that at 56 days of age, compressive strength increases as the percentage of fiber substitution increases. It was also observed that at 28 days of age, the mixture with a fiber content of 1.5% has greater load-bearing capacity, followed by the manufactured control mix (no fiber added), then the 1.0% fiber mix, and finally the 0.5% fiber mix.

Key words – Maguey bagasse; mix; partitions; compressive strength.

INTRODUCTION

Natural fibers have been used in the manufacture of building materials since ancient times. For example, the Greeks used wood and straw fibers to increase the volume stability of mortars [1]. Jute and straw were also used in Indo-Muslim culture to improve the bonding of mortar pieces and reduce cracking [2], [3], and [4].

In general, natural fibers are added to mortar or concrete mixtures to improve their flexural strength [5], [6]. However, some authors also report increases in compressive and tensile strength [7], [8]. The percentages of fiber added to concrete mixtures are usually less than 5%, and their lengths vary between 10 and 50 mm [9], [10]. The use of natural fibers, particularly maguey bagasse, in the manufacture of masonry units improves their post-cracking performance, exhibiting more ductile behavior than units that do not contain fiber [11], [12], and [13]. In addition, the aspect ratio of the fiber plays an important role in the compressive strength of masonry units; low aspect ratios lead to an increase in compressive strength [14] and [15]. The objective of this research is to evaluate the effect of adding maguey bagasse fiber (Cuishe or Cuish) to mortar blocks on their compressive strength and water absorption.

DEVELOPMENT

Materials and method

For the preparation of specimens, sulfate-resistant CPC Portland cement with a density of 3.10 g/cm3 was used. The fine aggregate used was characterized to determine its loose dry bulk density, compact dry bulk density, density, absorption, particle size distribution, and fineness modulus following the procedure described in ASTM C-128-1 and ASTM C-136-1. Figure 1 shows the particle size distribution curve of this aggregate, and Table 1 shows its main physical characteristics.

Table 1. *Physical properties of the fine aggregate Source: Own elaboration.*

Properties (kg/m^3)					
Type of aggregate	Loose dry bulk weight	Dry bulk density compact	Specific gravity	Absorption (%)	Fineness module
Sand	1483	1588	2532	1.53	3.35

The dosage of materials for a batch (3 specimens) remained constant and only the amount of fiber was added in percentages of 0.5%, 1.0%, and 1.50% of the weight of the mixture materials according to Table 2 (cement, sand, and water).

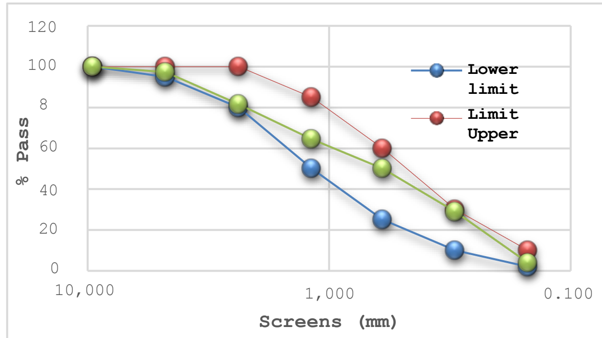


Figure 1. *Fine aggregate particle size distribution curve. Source: Own elaboration.*

The natural fiber from maguey bagasse (Cuishe or Cuish) began its processing with a washing stage, which involved placing the fiber in water for 24 hours to soften the maguey bagasse and remove impurities. The fiber was then dried in the sun for 12 hours.

Finally, in the second washing stage, a pressure washer was used to clean the fiber more thoroughly. It was then dried in the sun for the same amount of time as in the first washing stage. Once the washing process was complete, the natural fiber was stored in a plastic container and in completely clean jute sacks, in both cases, to begin cutting, with the aim of obtaining lengths with a maximum size of up to 10 mm. The cut fiber was then placed in jute sacks so that it could be mixed with the other materials (sand, gravel, water, and cement) after being moistened a few minutes beforehand to prevent the fiber from absorbing the water calculated for the manufacture of the partitions.

Table 2. *Mix proportions Source: Own elaboration.*

Weight of materials in kg			
Mixture	Cement	Sand	Water
Final	4.8	16	1.933

The materials were mixed in three stages: first, the sand and cement were dry mixed until they were evenly blended, then half of the water was added and mixed for 5 minutes; finally (after manually drying the fiber and removing excess water), all of the water and the percentage of fiber were added.

Consider mixing everything for approximately 7 minutes. The mixture was placed in a three-cell manual compaction blocker or molds for the production of the pieces. The compaction was carried out by the same operator to reduce the variation in force applied during the manufacturing process of the partitions. For each mixture, 25 prismatic specimens with dimensions of 100 mm x 140 mm x 280 mm were produced. The partitions were tested for axial compression at 7, 14, 28, and 56 days using five specimens for each specified age. Absorption tests were performed at 56 days using five specimens following the procedure described in standard NMX-C-037-ONNCCE-2013.

DISCUSSION AND ANALYSIS OF RESULTS

The results of the axial compression strength are shown in Figure 2. These results correspond to four test ages. No clear effect of increased compression strength or trend with respect to test age could be identified. However, at 56 days of age, it can be observed that the compression strength increases as the percentage of fiber replacement increases.

Variations in results with respect to age may be due to a lack of control in the compaction of the specimens or to variations in humidity during the curing process. Because partition walls have a high fine aggregate content, we can assume that the main variable in their strength is the degree of compaction of the specimens, since the influence of hydration is minimal due to the low volume of cement paste in the mixture. Furthermore, as not all fibers are of the same length, they can affect compressive strength values, as shown by Arunraj et al. [9] in their work, which found that as fiber length increases, the compressive strength of the specimens (bricks) decreases.

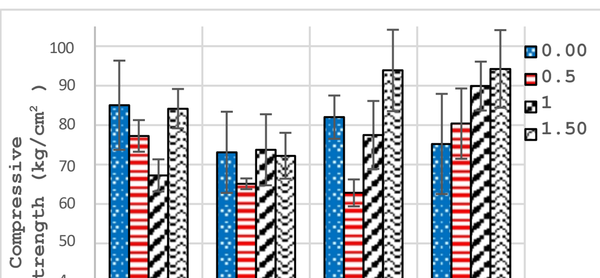


Figure 2. *Compressive strength relative to the test day for all mixtures.*
Source: Prepared by the authors.

Before performing the axial compression tests, measurements were taken of the three dimensions of all specimens of each mixture, and their weight was also determined. With this data, the volumetric weight of each mixture was estimated (Figure 3). The heterogeneity of the specimens can be seen in the variations in volumetric weights with respect to the test age. It should be noted that the specimens to be tested for compression were chosen at random. The specimens with fiber content remained almost unchanged in their volumetric weights over time, with the fiber-free mixture showing the greatest variations.

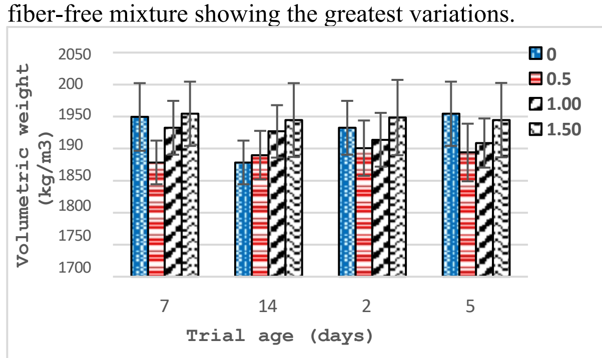


Figure 3. *Variations in the volumetric weight of each mixture over time.*
Source: Own elaboration.

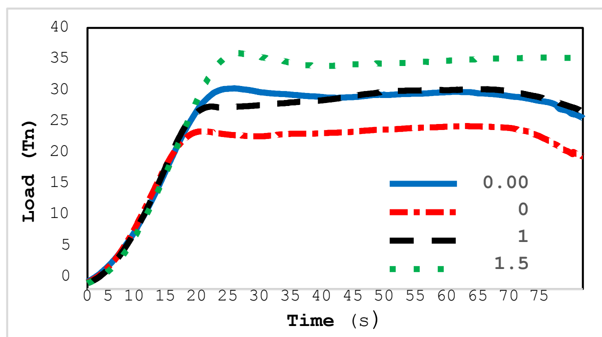
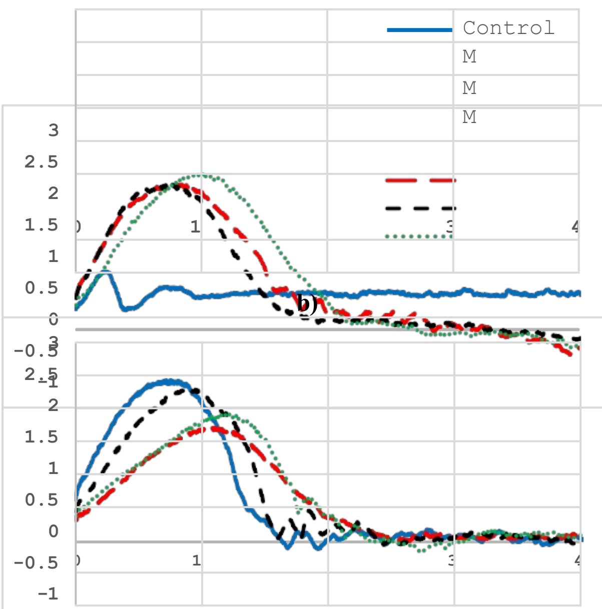


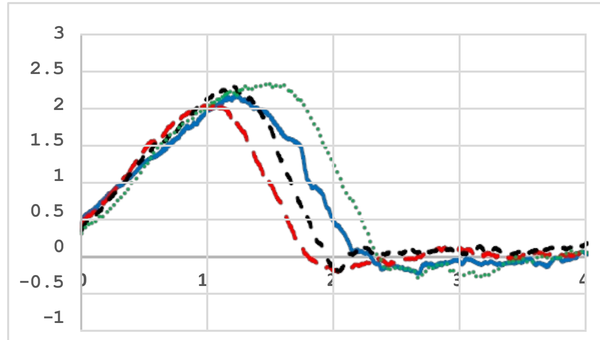
Figure 4. *Variations in axial load with respect to test time at 28 days of age.*
Source: Prepared by the authors.

From the data obtained from the compression testing equipment (Matest hydraulic press for prestressed frames with four columns, calibration certificate no.: CIMED-FZA-362/2022, which complies with the requirements of standards ASTM C39| BS 1610| NF P18-411 | AASHTO T22), the load applied over the test time was recorded, obtaining curves such as those shown in Figure 4.

It was observed that at 28 days, the mixture with a fiber content of 1.5% had the highest load-bearing capacity, followed by the control mixture (without added fiber), followed by a mixture of 1.0% fiber, and finally a mixture of 0.5% fiber. Although this trend is not consistent across all ages, nor is there a general trend over time, the graphs load load versus time attempted attempted to indirectly correlate with the ductility of the mixtures (Figure 5), Donkor et al. [5] found that fiber-reinforced flexural test specimens suggest an improvement in ductility as a result of reinforcement, as did Zac et al. [16], who found that flax fibers do not produce a significant change in flexural strength. to compression compression, but reduce the brittle fracture behavior of the material. The analysis process consisted of calculating the differentials of the load curves versus test time for each test age (7, 14, 28, and 56 days). The test time it took to reach its maximum slope value was used as an indicator of the effect of the fiber on the ductility of the partitions; longer times may suggest greater ductility of the mixture. Table 3 presents the maximum slope values of the curves, as well as the test time at which they were reached. **a)**



c)



d)

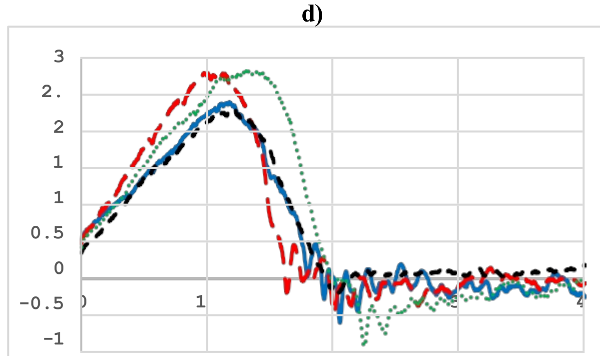


Figure 5. Differentials in the load vs. test time graph a) 7 days, b) 14 days, c) 28 days, and d) 56 days. Source: Own elaboration.

The analysis process consisted of calculating the differentials of the load curves versus test time for each test age (7, 14, 28, and 56 days). The test time it took to reach its maximum slope value was used as an indicator of the effect that the fiber had on the ductility of the partitions; longer times may suggest greater ductility of the mixture. Table 3 shows the maximum slope values of the curves, as well as the test time at which they were reached.

Table 3. *Test times at which the maximum value of the load vs. time curve differential is obtained. Source: Own elaboration.*

Mixture (% fiber)				
Age of (days)	**0.00**		**0.5**	
	Time (s)	Differential (tn/s)	Time (s)	Differential (tn/s)
7	2.25	0.878	7.6	2.21741513
14	7.55	2.45072707	10.15	1.73012493
28	11.45	2.01809386	10.45	2.05262838
56	11.8	2.39607007	10.9	2.79158547
Blend (% fiber)				

ISSN: 2594 - 2905

Age at (days)	1.00		1.50	
	Time (s)	Differential (tn/s)	Time (s)	Differential (tn/s)
7	7.5	2.19688477	10.05	2.35460146
14	9.45	2.30687857	11.9	1.94956868
28	12.05	2.3066	14.7	2.34984277
56	13.4	2.46867414	13.6	2.58120457

As can be seen in Figure 6, specimens with a fiber content of 1.0 and 1.5% show longer times in which they reach their highest slope on the load versus time graph; these times increase as the test age progresses. The proposed analysis procedure and the results obtained are consistent with those found by Juárez et al. [11], where fiber content is related to the post-cracking performance of the piece.
The mixture with a fiber content of 0.5% shows very little variation with respect to the test age and only reaches values greater than the maximum value of the differential at 7 and 14 days of age with respect to the control mixture.

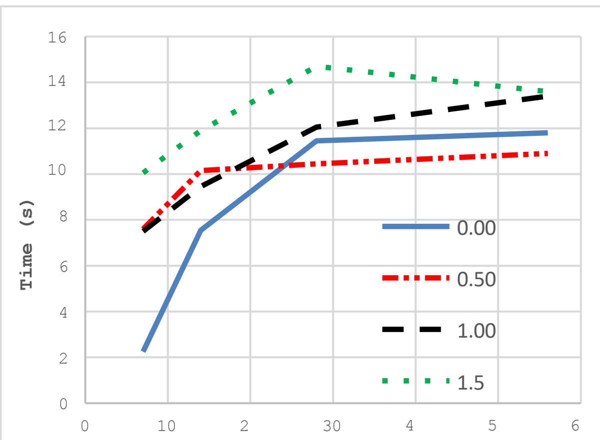


Figure 6. *Variations in maximum differential times with respect to test age for all mixtures.*
Source: Own elaboration.

The absorption test was performed at 56 days of age, following the procedure described in NMX-C-037-ONNCCE 2013, as can be seen in Figure 7. the absorption of the specimens is higher in the mixture without fiber and much lower for the mixture with a fiber content of 0.5%, while the specimens with 1.0 and 1.5% fiber have similar absorption values.

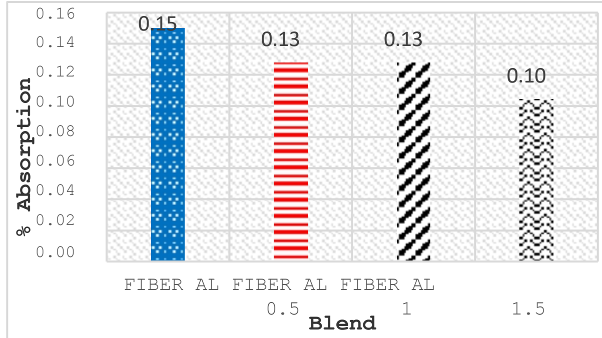


Figure 6. *Absorption percentages by type of mixture.*
Source: Prepared by the authors.

CONCLUSIONS

- The difference in the load-time curve of the axial compression test allows us to indirectly estimate the ductility of the partition in relation to its fiber content. The peaks of these curves occur at longer times in specimens containing 1% and 1.5% fiber than in specimens containing 0% and 0.5% fiber.
- This may be an indirect measure of the ductility of the material, with longer times implying greater deformation of the partitions before failure.
- The absorption of the specimens is reduced with the addition of fiber; the 0.5% content is the mixture with the lowest absorption; however, at 28 days, it has lower compressive strength.
- Based on the data obtained in this study, we can conclude that further investigation of this type of relationship between cement partitions and natural fibers such as those used in this study, such as maguey cuishe or cuish bagasse, offers great potential and a wide field for further research and the determination of more data and information on the subject, in order to further support its use in the future.

ACKNOWLEDGMENTS

The authors would like to thank the National Technological Institute of Mexico for funding the project to determine the compressive, flexural, and diagonal compressive strengths of concrete block with natural fiber, code 14219.22-P.
We would also like to thank everyone involved in carrying out this work, including the collaborating teachers Arturo Emanuel Ramírez Ortiz, Francisco Hernández Moreno, and Edgar Alberto Cortés Jiménez, as well as resident student Uriel Felipe De Paz Montes, whose efforts made this project possible.

ISSN: 2594 - 2905

BIBLIOGRAPHY

[1] Siouta, L., Apostolopoulou, M., & Bakolas, A. (2024). Natural Fibers in Composite Materials for Sustainable Building: A State-of-the-Art Review on Treated Hemp Fibers and Hurds in Mortars. Sustainability, 16(23), 10368.

[2] Kesikidou, F., & Stefanidou, M. (2019). Natural fiber-reinforced mortars. Journal of Building Engineering, 25.

[3] Sharma, V., Vinayak, H. K., & Marwaha, B. M. (2015). Enhancing compressive strength of soil using natural fibers. Construction and Building Materials, 93, 943-949.

[4] Toha, S. S., Mostofa, M. G., Islam, M. M., & Islam, M. S. (2025). Suitability of jute fiber in the production of eco-friendly building blocks. Discover Civil Engineering, 2(1), 2.

[5] Donkor, P., Obonyo, E., & Ferraro, C. (2021). Fiber Reinforced Compressed Earth Blocks: Evaluating Flexural Strength Characteristics Using Short Flexural Beams. Materials, 14(22), 6906.

[6] Dawood, A. O., Mussa, F. I., Al Khazraji, H., Abd Ulsada, H. A., & Yasser, M. M. (2021). Investigation of compressive strength of straw reinforced unfired clay bricks for sustainable building construction. Civil and Environmental Engineering, 17(1), 150-163.

[7] Khaloo, A. R., & Kim, N. (1996). Mechanical Properties of Normal to High-Strength Steel Fiber-Reinforced Concrete. Cement, Concrete and Aggregates, 18(2).

[8] Kasie, Y. M., & Mogne, A. Y. (2025). Improvement of mechanical properties of adobe brick reinforced with sisal fiber. Discover Materials, 5(1), 1-15.

[9] Arunraj, E., Jebadurai, S. V. S., Daniel, C., Shelton, J. J., & Hemalatha, G. (2019). Experimental study on compressive strength of brick using natural fibers. Int J Eng, 32(6), 799-804.

[10] Kadir, A. A., Mohd Zulkifly, S. N., Al Bakri, A. M., & Sarani, N. A. (2016). The utilization of coconut fiber into fired clay brick. Key Engineering Materials, 673, 213-222.

[11] Juárez, C., Guevara, B., Valdez, P., & Durán-Herrera, A. (2010). Mechanical properties of natural fibers reinforced sustainable masonry. Construction and Building Materials, 24(8), 1536–1541.

[12] Kamwa, R. A. T., Mousi, J. B., Tome, S., Nemaleu, J. G. D., Gérard, M., Etoh, M. A., & Etame, J. (2025). Effect of treated palm fibers on the mechanical properties of compressed earth bricks stabilized by alkali-activated binder-based natural pozzolan. International Journal of Ceramic Engineering & Science, 7(1), e10246.

[13] Gowda, R. P., & Zapata, C. E. (2016). Effect of Bagasse Fiber on the Properties of Compressed Cement Stabilized Earth Blocks. In Geotechnical and Structural Engineering Congress 2016 (pp. 1435-1449).

[14] Daniel, J. I., Gopalaratnam, V. S., Galinat, M. A., Ahmad, S. H., Hoff, G. C., Schupack, M., ... & Balaguru, P. N. (2002). Report on fiber reinforced concrete. Reported by ACI Committee, 544.

[15] Damanik, N. H. C., Susanto, D., & Suganda, E. (2020). The compressive strength of unfired clay brick with sugarcane bagasse fiber (SBF) and bio-enzyme reinforcements. International Journal of Technology, 11(7), 1422-1429.

[16] Zak, P., Ashour, T., Korjenic, A., Korjenic, S., & Wu, W. (2016). The influence of natural reinforcement fibers, gypsum and cement on compressive strength of earth bricks materials. Construction and Building Materials, 106, 179-188.

Contribution Role Table

Role	Author(s)
Concept	Arturo Emanuel Ramírez Ortiz "principal" Francisco Hernández Moreno "equal"
Data curation	Arturo Emanuel Ramírez Ortiz "principal"
Method	Arturo Emanuel Ramírez Ortiz "principal" Francisco Hernández Moreno "equal" Uriel Felipe De Paz Montes "equal"
Resources	Edgar Alberto Cortés Jiménez "principal" Arturo Emanuel Ramírez Ortiz "equal" Francisco Hernández Moreno "equal" Guillermo Quero Ramírez "supporting"
Supervision	Arturo Emanuel Ramírez Ortiz "principal" Francisco Hernández Moreno "equal"
Validation	Arturo Emanuel Ramírez Ortiz "principal" Edgar Alberto Cortés Jiménez "equal"
Visual	Arturo Emanuel Ramírez Ortiz "principal" Uriel Felipe De Paz Montes "equal"
Original draft	Arturo Emanuel Ramírez Ortiz "principal" Edgar Alberto Cortés Jiménez "equal"
Drafting-Revision and editing	Arturo Emanuel Ramírez Ortiz "main" Edgar Alberto Cortés Jiménez "equal" Francisco Hernández Moreno "equal" Guillermo Quero Ramírez "supporting"