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Comparison of costs, mechanical strength, and quality between traditional and reinforced adobe

CHRISTIAN J. CARRASCO-AHEN[1], JOSUALDO C. VILLAR QUIROZ[2]

ABSTRACT

In Peru, traditional constructions with adobe blocks have shown structural vulnerabilities during seismic events. This study comparatively analyzed the costs, mechanical strength, and quality of traditional versus reinforced adobe using a quantitative approach and a non-experimental design. The results indicate that reinforced adobe increases costs by 4.7% to 11.3% compared to traditional adobe. Adobe with 200 g of quicklime achieved the highest mechanical strength: 20.44 kg/cm² in compression, 2.56 kg/cm² in flexion, and 0.32 kg/cm² in mortar tensile strength. Additionally, adobe with 10% by weight of eucalyptus bark fiber obtained an excellent quality index (90%). It is concluded that, although traditional adobe is more economical, its low mechanical strength and insufficient quality index make it unsuitable for construction according to NTE.080. Therefore, reinforced adobe is positioned as a move viable alternative.

Key words: *Traditional technology, comparative analysis, earth block.*

[1]Master in Engineering with Project Management and Direction, Civil Engineer, Graduate School, Catholic University of Trujillo, Trujillo, Peru, 222103301c@uct.pe, ORCID https://orcid.org/0000-0002-6221-9150.
[2]Master in Business Administration, Civil Engineer, Graduate School, Catholic University of Trujillo, Trujillo, Peru, j.villar@uct.edu.pe, ORCID https://orcid.org/0000-0003-3392-9580.

Autor de Correspondencia: Christian J. Carrasco-Ahen, 222103301c@uct.pe

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Comparación de costos, resistencia mecánica y calidad entre adobe tradicional y reforzado

RESUMEN

En Perú, las construcciones tradicionales con bloques de adobe han mostrado vulnerabilidades estructurales ante eventos sísmicos. Este estudio analizó comparativamente los costos, la resistencia mecánica y la calidad del adobe tradicional frente al reforzado, mediante un enfoque cuantitativo y diseño no experimental. Los resultados indican que el adobe reforzado incrementa los costos entre 4.7 % y 11.3 % respecto al tradicional. El adobe con 200 g de cal viva alcanzó la mayor resistencia mecánica: 20.44 kg/cm² en compresión, 2.56 kg/cm² en flexión y 0.32 kg/cm² en tracción del mortero. Además, el adobe con 10 % en peso de fibra de corteza de eucalipto obtuvo un índice de calidad excelente (9 %). Se concluye que, aunque el adobe tradicional resulta más económico, su baja resistencia mecánica e insuficiente índice de calidad lo hacen inadecuado para la construcción según la NTE.080, lo que posiciona al adobe reforzado como una alternativa más viable.

Palabras clave: *Tecnología tradicional, análisis comparativo, bloques de tierra.*

INTRODUCTION

Adobe construction is a millennia-old practice still widely used in developing countries, particularly in rural regions where economic and material resources are scarce. In the Peruvian context, this construction technique holds significant historical and cultural relevance, representing a sustainable housing solution that utilizes local materials such as earth. However, despite its advantages, adobe construction faces notable challenges, including high raw material consumption, elevated logistical and transportation costs, and vulnerability to seismic events, which limit its feasibility in modern contexts.

Numerous studies have addressed these issues from various perspectives. For instance, research in the Colca Valley, Peru, has identified significant structural deficiencies in rural adobe buildings, highlighting the need for innovations to enhance their strength and sustainability [1]. Similarly, the importance of implementing experimental methodologies for a comprehensive geotechnical characterization of materials has been emphasized, aiming to optimize their use and reduce associated costs [2]. Despite these advances, a gap remains in integrating innovative construction techniques that combine adobe traditions with current demands for safety, efficiency, and sustainability.

In this context, the present study seeks to contribute to the understanding of adobe construction by exploring solutions that balance the preservation of cultural elements with the need for safer, more sustainable buildings. Specifically, it proposes to evaluate the performance of reinforced adobe variants, analyzing their mechanical properties, energy efficiency, and costs, with the goal of offering viable alternatives for construction in rural areas of Peru.

Antecedents

Various economic-comparative studies have yielded significant findings regarding the use of alternative materials in adobe wall construction. Sujatha and Selsia [3] assessed the cost of a traditional adobe wall, determining that its construction requires an investment of S/ 51.28 (equivalent to ₹ 1,217.50 at the March 2025 exchange rate). In contrast, reinforced variants with organic and inorganic materials exhibit costs ranging from S/ 50.63 (₹ 1,201.90) to S/ 41.36 (₹ 981.90), suggesting economic optimization. Similarly, Omongin et al. [4] identified incremental cost variations in reinforced adobe walls, depending on the material used, with increases of 38.78%, 43.79%, 116.10%, and 133.65% based on the type of applied reinforcement.

In terms of energy efficiency, Marçal et al. [5] found that, for an area of 44.80 m², earth blocks consume 12,450.81 kWh, representing a significant reduction compared to the 16,016.91-kWh required by concrete blocks. Meanwhile, Abbassi et al. [6] established that the optimal cost-benefit ratio in adobe constructions is achieved with a wall thickness of 0.32 meters, enhancing both thermal insulation and energy consumption.

Regarding mechanical properties, Cuitiño-Rosales et al. [7] determined that while traditional adobe exhibits tensile strengths ranging from 3 to 21 kg/cm² and a shear strength of 3.16 kgf/cm², reinforced variants achieve significantly higher values of 117 and 121.8 kgf/cm², respectively. Likewise, Bedoya-Montoya [8] documented compressive strengths of 40.89 and 39.16 kg/cm² in reinforced adobe variants, meeting or exceeding the requirements of Colombian Technical Standard (NTC 5324).

These findings highlight substantial progress in using alternative materials for adobe wall construction, emphasizing improvements in costs, energy efficiency, and mechanical properties. Nevertheless, further comparative evaluation of reinforced adobe variants is needed to assess their feasibility in specific contexts, such as rural areas of Peru, which motivates the present study.

Objective and signification of the study

The overall objective of the study was to comparatively analyze the costs, mechanical strength, and quality between traditional adobe and reinforced adobe, incorporating organic materials (natural fibers) and inorganic materials (mineral additives, powdered gypsum, cement, and quicklime) during its production.

The significance of the study lies in its multidimensional approach to assessing the suitability of adobe for safe and sustainable constructions. This approach integrates four fundamental dimensions: environmental impact, material availability, technical improvement, and cost. Through the quantitative evaluation of these parameters, a quality index expressed as a percentage was developed, classifying materials into categories ranging from “deficient” to “excellent.”

This index provides an objective tool for making informed decisions in construction projects, maximizing structural safety and the economic sustainability of buildings. Furthermore, the study aligns with Sustainable Development Goal 11 (SDG 11, “Sustainable Cities and Communities”), promoting sustainable construction and the development of resilient communities.

METHODOLOGY

The employed methodology aimed to evaluate the relationship between costs and mechanical strength of diverse types of adobe, to determine their technical and economic feasibility for safe constructions. Below, the main aspects of the study design, sample selection, analysis procedures, and conducted tests are described.

Study design

The study adopted a non-experimental design, as variables were not intentionally manipulated. Adobe blocks incorporating organic and inorganic additives available in the construction market, as sold in the study area, were analyzed. A comparative approach was used to assess costs per square meter (m^2) for reference areas of 50, 100, 150, and 200 m^2. These areas were chosen because suppliers typically offer tiered discounts: 10% for purchases over 100 m^2, 15% for those over 150 m^2, and 20% for purchases exceeding 200 m^2.

Sample selection

Sample selection was conducted through non-probabilistic sampling, based on the researchers’ judgment and adhering to the specifications of the Technical Building Standard (NTE.080) [9]. This standard stipulates that each sample must exhibit a strength equal to or greater than the required ultimate strength. To ensure representativeness, a defined census sampling approach was used to select adobe blocks marketed in the study area.

For an approximate area of 1 m², it was determined that eighteen adobe blocks each measuring 40 × 20 × 12 cm, with a mortar thickness of 2.5 cm, are required. Consequently, the quantities used for economic analysis were: 900 units for 50 m², 1,800 for 100 m², 2,700 for 150 m², and 3,600 for 200 m², totaling 9,000 units.

Analysis procedures and test

Mechanical strength was assessed through compression, flexion, and tensile tests performed on adobe blocks available in the market. For the mortar tensile test, a mixture was prepared with materials supplied by providers, following NTE.080 specifications [9]. Per this standard, each test requires a minimum of six units, with results derived from the average of the four highest-strength samples, provided these meet or exceed the specified ultimate strength. In total, 36 units were used for compression tests, 36 for flexion tests, and 72 for mortar tensile tests, totaling 144 units.

Quality analysis

To evaluate the adobe quality index, the methodology proposed by Guzmán and Iñiguez [10] was applied, integrating parameters such as environmental impact, material availability, technical improvement, and cost into a quantitative index. The study adhered to normative technical parameters ensuring result validity per national construction standards, without seeking probabilistic statistical representativeness.

Materials and technical specifications

Five types of adobe blocks (traditional and reinforced) were evaluated. These blocks were, sourced from local suppliers, and selected based on their availability and potential to enhance mechanical strength and durability. Table 1 presents the technical specifications of the evaluated blocks, including the proportions of stabilizing materials incorporated by suppliers, the physical characteristics of the stabilizers, and the applicable technical standards.

In accordance with the technical specifications outlined in Table 1, the proportions of the stabilizing materials (10% by weight for eucalyptus and cabuya fibers, and 200 g for each type of mineral additive: powdered gypsum, Portland cement Type I, and quicklime) were determined by the adobe block suppliers. The blocks were sourced from certified local producers and allowed to be cured for a maximum period of 28 days, adhering to the guidelines of NTE.080 [9], before being subjected to the mechanical tests described in the methodology.

Table 1. Technical specifications of materials

Traditional/Reinforced Adobe	Code	Proportion of stabilizer (per supplier)	Physical Characteristics	Applicable standard
Traditional adobe	M_0	—	—	NTE.080 [9]
Adobe with eucalyptus bark fiber	M_1	10%	Length: 3-5 cm	NTP 251.010 [11]
Adobe with cabuya fiber	M_2	10%	Length: 3-5 cm	NTP 231.301 [12]
Adobe with powdered gypsum	M_3	200 g	Granulometry ≤ 200 μm	NTP 334.125 [13]
Adobe with portland cement type I	M_4	200 g	Fineness: 95% passes 352 mesh	NTP 334.009 [14]
Adobe with quicklime	M_5	200 g	Granulometry ≤ 180 μm	NTP 334.125 [13]

Costs

The economic analysis of this study was grounded in the microeconomic theory of resource optimization, aiming to evaluate the costs associated with constructing using traditional and reinforced adobe blocks. A cost structure integrating direct and indirect components was adopted, following the incremental analysis methodology proposed by Rincón-Soto et al. [15]. This methodology, specifically adapted to assess innovations in traditional construction materials, enabled the comparison of costs for different adobe variants with organic and inorganic materials across reference areas of 50, 100, 150, and 200 m², considering the discount quantities specified by suppliers.

Table 2 details the cost structure by component, breaking down direct costs (materials, labor, equipment, tools, and general expenses) and indirect costs (profit and taxes). The calculation factors were defined based on construction industry standards and the experience of local suppliers, adjusted to the study's context.

Table 2. Cost structure by component

Component	Subcomponent	Calculation
Direct costs	Materials	Base unit price
	Labor	Civil construction regime (Peru)
	Equipment	3% of labor cost
	Tools	2% of direct cost
Indirect costs	General expenses	7% of direct cost
	Profit	10%
	Taxes	18% of direct cost, general expenses, and profit

Technical characteristics

Compressed blocks exhibit distinctive characteristics in terms of density, thermal conductivity, and mechanical strength [16]. The addition of natural additives, within prescribed limits, enhances thermal insulation capabilities and mechanical properties [17], as shown in Table 3.

Table 3. Cost structure by component

Strength tests	Ultimate strength
Simple compression	10.2 kg/cm^2
Bending or traction	0.81 kg/cm^2
Mortar traction	0.12 kg/cm^2

Note: Adapted from NTE. 080 [9]

1. Environmental conditions: 20 ± 2 °C, 65 ± 5% relative humidity
2. Maximum Age for Testing: 28 days
3. Equipment: Calibrated hydraulic press (accuracy ± 0.5%)
4. Loading Rate: As per NTE.080 standards

Stabilizer quality index

The quality of the stabilizer evaluates the energy consumption associated with the material's production through four fundamental criteria: environmental impact, availability, technical improvement, and price. As shown in Table 4, the evaluation criteria provide a structured framework for its assessment. Collectively, these parameters ensure a comprehensive evaluation of the material's quality, guiding the selection process for optimal performance and sustainability. The evaluation methodology employed is based on the model developed by Guzmán and Iñiguez [10], specifically adapted for the Peruvian construction context through validation by expert judgment. Each instrument was independently assessed by eight earth construction specialists using Aiken's V equation [18] (average content validity index = 0.902), thereby ensuring the robustness and applicability of the classification criteria.

Table 4. Evaluation criteria

Environmental impact		
Level	**Characteristic**	**Score**
Excellent	Materials with reduced energy costs, locally available, minimal costs of transportation, and low environmental impact throughout their life cycle.	5
Good	Slightly higher energy costs than natural, traditional materials, harmful to the ecosystem during subsequent stages.	3
Deficient	Materials with significant energy costs, not locally sourced, requiring considerable transportation, and causing significant negative environmental impacts.	1
Materials availability		
Excellent	Widely available stabilizer in the market with no limitations, requiring minimal characterization difficulties.	5
Good	Available stabilizer with certain restrictions, requiring permits or facing supply challenges.	3
Deficient	Scarce stabilizer, requiring permits, facing supply constraints, or presenting adaptation difficulties.	1
Technical Improvement		
Excellent	Stabilizers that enhance the physical and mechanical strength of the soil and optimize external properties.	5
Good	Stabilizers that prioritize technical improvement in mechanical strength, meeting current standards.	3
Deficient	Available stabilizers to improve durability but inadequate for reinforcing adobe during production.	1

Note: Adapted from Guzmán and Iñiguez [10]

Range evaluation

The evaluation methodology is based on the indicators presented in Table 5. These indicators are assessed using specific criteria, each assigned a score. The score ranges from 5, indicating excellent performance and the most cost-effective option, to 1, indicating deficient performance and the least cost-effective choice.

Table 5. Overall stabilizer evaluation

Score	Level
5	Excellent
3	Good
1	Deficient

Note: Adapted from Guzmán and Iñiguez [10]

Additionally, the quality of the stabilizing material is evaluated based on the parameters specified in Table 6, using a scoring system ranging from 1 to 5. In this system, one represents the lowest possible score, and 5 the highest.

Table 6. Overall Stabilizer evaluation

Indicators →	Environmental Impact	Availability	Technical Improvement	Price	Total, quality
Maximum score →	5	5	5	5	20

Note: Adapted from Guzmán and Iñiguez [10]

To determine the quality of the stabilizing material, the final evaluation integrates the four criteria, where:

1. Total quality = Sum of score
2. Quality index = (Total quality / 20) x 100%
3. Categorization: (Excellent: ≥ 90%; Good: 70-89%; Fair: 50-69%; Deficient: < 50%)

RESULTS AND DISCUSSION

Cost comparison: Traditional and reinforced adobe

Figure 1 illustrates the costs of diverse types of adobe (M_0 to M_5) based on the reference area for supply and demand applicability (50, 100, 150, and 200 m²). The data reveals, a clear trend: the larger the area, the lower the cost per m². This behavior is primarily attributed to progressive discounts applied by suppliers for large-volume orders, achieving reductions of up to 20% for areas of 200 m². This relationship indicates that larger-scale constructions are more cost-efficient per m².

Traditional adobe (M_0) has an initial cost of S/ 91.54 for an area of 50 m², decreasing to S/ 73.23 for 200 m², reflecting the impact of economies of scale on unit cost reduction. The absence of stabilizers suggests that the cost decrease is linked to these discounts. Adobe reinforced with eucalyptus bark fiber (M_1) exhibits a similar trend, with an initial cost of S/ 95.85 for 50 m², reducing to S/ 76.88 for 200 m². Although this type of adobe incurs higher costs in smaller areas due to the incorporation of fiber, it also benefits from volume discounts, justifying the additional cost of stabilizers in larger constructions. Adobe reinforced with cabuya fiber (M_2) has a cost of S/ 97.99 for 50 m², decreasing to S/ 78.40 for 200 m². Like M_1, its higher initial costs are due to the inclusion of fibers, but discounts applied to larger areas enable significant reductions.

Adobe stabilized with powdered gypsum (M_3) starts at S/ 95.89 for 50 m² and decreases to S/ 76.71 for 200 m². Despite being a more economical material compared to other stabilizers, it maintains the trend of cost reductions as the construction area increases. Adobe stabilized with Portland cement (M_4) has the highest initial cost of S/ 100.37 for 50 m², decreasing to S/ 80.30 for 200 m². The high-energy requirements for cement production justify its considerable initial cost; however, volume discounts make it more accessible for larger projects. Adobe stabilized with quicklime (M_5) exhibits the highest cost in smaller areas, at S/ 101.89 for 50 m², with a significant reduction to S/ 81.51 for 200 m². As indicated in Figure 1, the high environmental and energy impact of quicklime justifies its elevated initial cost, though volume discounts significantly improve its competitiveness in larger projects.

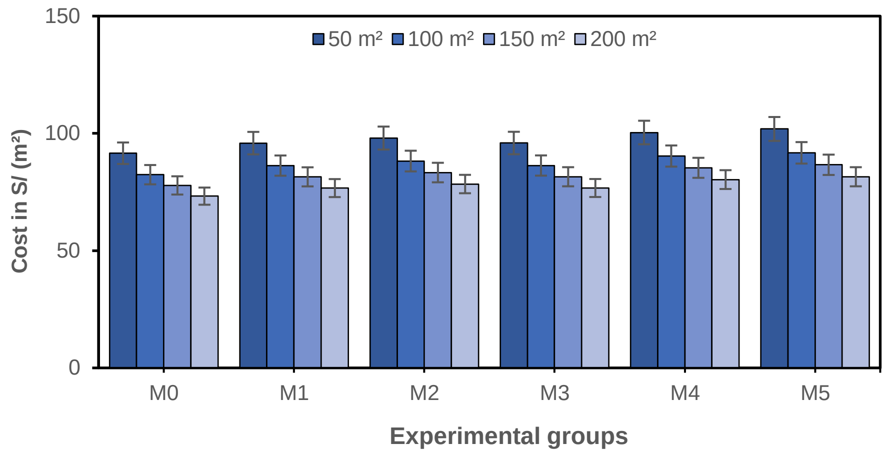

Figure 1. Costs of adobe area/m².

In this regard, the research by Sujatha and Selsia [3] demonstrated that traditional adobe has a lower cost compared to reinforced adobe. The findings of the present study confirm that reinforced adobe is more expensive than traditional adobe. This highlights the importance of the materials used in determining total costs, as the construction of each wall is influenced by the type of material and its mechanical properties. Consequently, construction costs increase when additives are used to reinforce adobe. The most expensive materials are M_5 and M_4, while M_0 remains the most economical option. However, the higher costs are justified by substantial improvements in the mechanical strength of the adobe. As a result, stabilizers with greater energy demands in their production process exhibit higher initial costs. Nevertheless, economies of scale significantly reduce these costs, making adobe with higher initial costs economically viable for large-scale projects. The cost optimization achieved through production scaling enhances the economic feasibility of incorporating high-performance stabilizers in larger constructions.

This trend underscores the importance of strategic planning in material selection, particularly for projects involving large areas. By leveraging bulk purchasing and efficient resource allocation, developers can offset the higher initial costs associated with energy-intensive stabilizers. The resulting balance between cost and performance provides a compelling argument for their use in improving structural durability and meeting technical standards, ensuring that high-performance materials remain accessible for broader applications.

Compressive strength

Figure 2 illustrates that traditional adobe (M_0) exhibits the lowest compressive strength at 7.41 kg/cm², which is 27.35% below the ultimate strength required by NTE.080 of 10.2 kg/cm². The incorporation of stabilizers demonstrated significant improvements: adobe with eucalyptus bark fiber (M_1) increased compressive strength by 25.29%, reaching 12.78 kg/cm². Cabuya fiber (M_2) further enhanced the strength to 13.32 kg/cm², representing a 30.59% improvement. Powdered gypsum (M_3) and Portland cement (M_4) showed notable increases of 63.24% and 97.84%, achieving values of 16.65 kg/cm² and 20.18 kg/cm², respectively. Quicklime (M_5) exhibited the highest compressive strength, with a 100.39% increase, reaching 20.44 kg/cm².

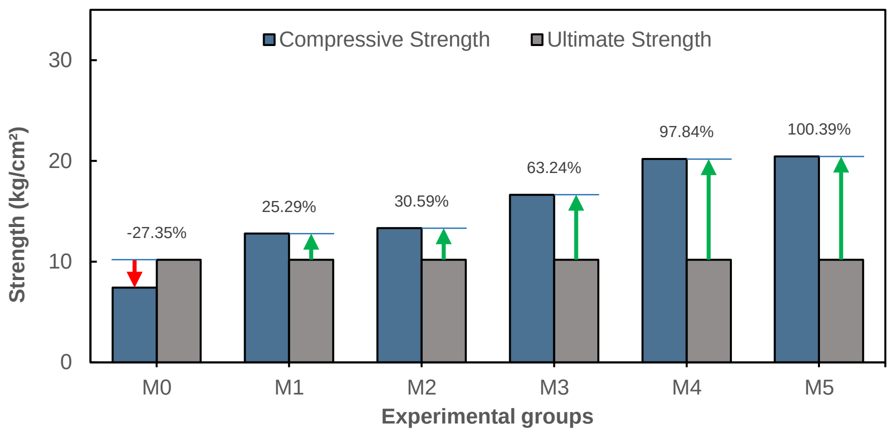

Figure 2. Technical characteristic: compressive strength.

Flexural strength

Figure 3 shows that traditional adobe (M_0) exhibits a flexural strength of 0.79 kg/cm², which is 2.47% below the NTE.080 standard requirement of 0.81 kg/cm². The incorporation of eucalyptus bark fiber (M_1) increased this strength to 1.29 kg/cm², representing a 59.26% improvement. Cabuya fiber (M_2) further enhanced the flexural strength by 107.41%, reaching 1.68 kg/cm². The most significant increases were observed with the addition of powdered gypsum (M_3), which improved the strength by 151.85%, achieving 2.04 kg/cm². This was followed by Portland cement (M_4) and quicklime (M_5), which exhibited increases of 207.41% and 216.05%, reaching values of 2.49 kg/cm² and 2.56 kg/cm², respectively.

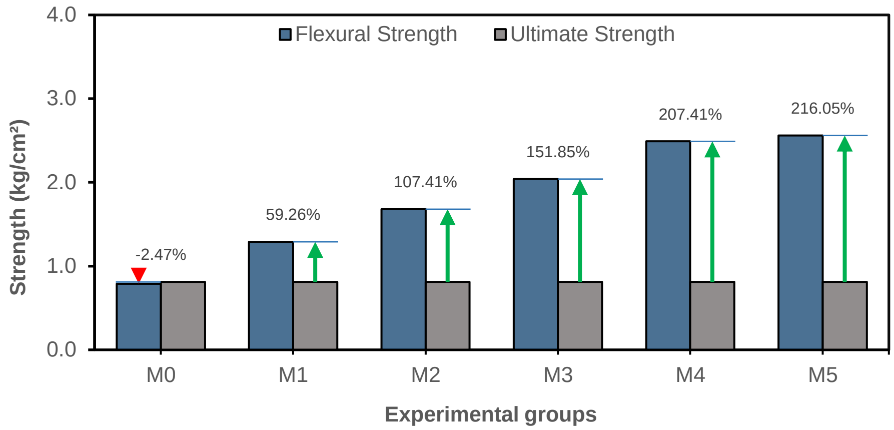

Figure 3. Technical characteristic: flexural strength.

Mortar tensile strength

Figure 4 demonstrates that traditional adobe (M_0) exhibits the lowest mortar tensile strength at 0.06 kg/cm², a value 50% below the ultimate strength required by the NTE.080 standard, set at 0.12 kg/cm². The addition of eucalyptus bark fiber (M_1) increased the tensile strength to 0.17 kg/cm², representing a 41.67% improvement. Cabuya fiber (M_2) further enhanced the tensile strength by 66.67%, reaching 0.20 kg/cm². Powdered gypsum (M_3) showed a 116.67% increase, achieving 0.26 kg/cm². Portland cement (M_4) and quicklime (M_5) exhibited the highest tensile strengths, with values of 0.30 kg/cm² and 0.32 kg/cm², representing improvements of 150% and 166.67%, respectively.

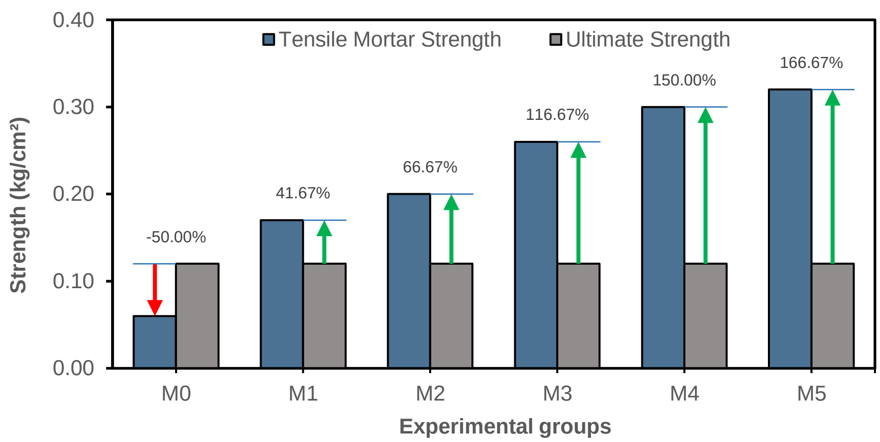

Figure 4. Technical characteristic: tensile mortar strength.

The study conducted by Cuitiño-Rosales et al. [7] found that the compressive and flexural strengths of traditional adobe were significantly lower than those of reinforced adobe. In the present investigation, traditional adobe did not meet the requirements established by the NTE.080 standard for compressive, flexural, and tensile mortar strengths. On the contrary, the reinforced adobe materials demonstrated higher levels of ultimate strength, complying with the standard. The results reveal that traditional adobe does not meet the minimum requirements of the NTE.080 standard for compressive strength (10.2 kg/cm²), flexural strength (0.81 kg/cm²), and mortar tensile strength (0.12 kg/cm²). Consequently, seismic safety cannot be ensured when using low-quality materials.

Stabilizer quality

Figure 5 presents the quality indices obtained for the different compositions: traditional adobe (M_0) achieved 75% (15 points), adobe reinforced with 10% eucalyptus bark fiber (M_1) achieved 90% (18 points), and adobe with 10% cabuya fiber (M_2) achieved 80% (16 points). The additions of 200 g of powdered gypsum (M_3), 200 g of Portland cement (M_4), and 200 g of quicklime (M_5) each obtained 65% (13 points). The results indicate that adobe reinforced with 10% M_1 represents the alternative categorized as excellent (≥ 90%) for incorporation into the mud mixture. This superiority is attributed to greater efficiency in the extraction, transformation, and transportation processes associated with this material, offering manufacturers advantageous options for decision-making.

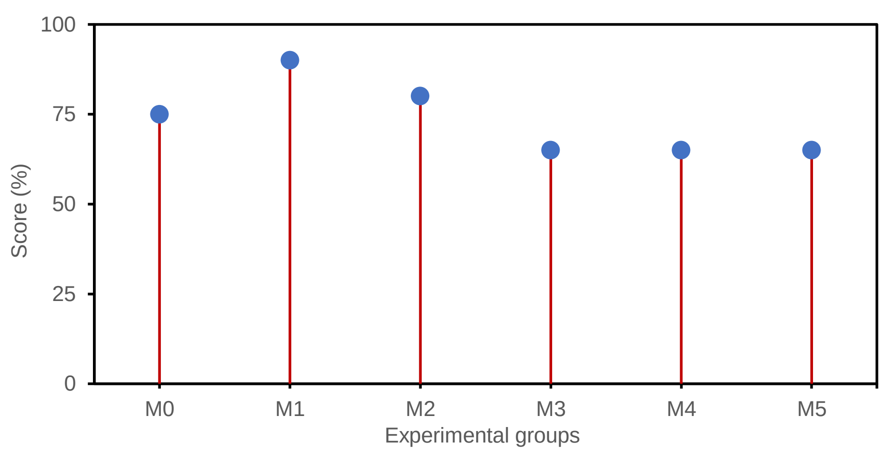

Figure 5. Quality score of adobe stabilizer.

Marçal et al. [5], in their study on energy consumption associated with building construction using earth blocks compared to concrete blocks, found lower energy consumption in earth blocks. The present study analyzed the energy modifications contributing to the environmental consequences of the energy requirements associated with producing reinforced earth adobe. The findings suggest that the use of renewable materials (natural fibers) positively impacts energy efficiency in earth constructions.

Comparative analysis of mechanical strength

Table 7 presents the results of the comparative analysis of mechanical strength. The comparative analysis of compressive strength revealed that traditional adobe (M_0) exhibited insufficient strength at -2.79 kg/cm², demonstrating inadequate capacity to withstand compressive stresses. Adobe with the incorporation of organic and inorganic stabilizers showed significant improvements: adobe with eucalyptus bark fiber (M_1) reached 2.58 kg/cm², while cabuya fiber (M_2) increased the strength to 3.12 kg/cm². Powdered gypsum (M_3) elevated the strength to 6.45 kg/cm². The best results were obtained with Portland cement (M_4) and quicklime (M_5), achieving 9.98 kg/cm² and 10.24 kg/cm², respectively, representing a substantial improvement compared to traditional adobe.

Table 7. Comparative analysis of mechanical strength (kg/cm²)

Samples	Compressive	Flexural	Tensile mortar
M_0	-2.79	-0.02	-0.06
M_1	2.58	0.48	0.05
M_2	3.12	0.87	0.08
M_3	6.45	1.23	0.14
M_4	9.98	1.68	0.18
M_5	10.24	1.75	0.20

Regarding flexural strength, traditional adobe (M_0) exhibited a value of -0.02 kg/cm², indicating low capacity to resist bending forces. The addition of eucalyptus bark fiber (M_1) increased the strength to 0.48 kg/cm², while cabuya fiber (M_2) raised it to 0.87 kg/cm². Optimal results were achieved with powdered gypsum (M_3), reaching 1.23 kg/cm², followed by Portland cement (M_4) and quicklime (M_5), with values of 1.68 kg/cm² and 1.75 kg/cm², respectively

In terms of mortar tensile strength, traditional adobe (M_0) demonstrated deficient performance again, with a strength of -0.06 kg/cm², highlighting its significantly low resistance capacity. The addition of eucalyptus bark fiber (M_1) increased the strength to 0.05 kg/cm², while cabuya fiber (M_2) raised it to 0.08 kg/cm². Powdered gypsum (M_3) further improved the strength to 0.14 kg/cm², with the highest values recorded for Portland cement (M_4) and quicklime (M_5), reaching 0.18 kg/cm² and 0.20 kg/cm², respectively.

The obtained values show that the different strengths of the materials used (organic and inorganic) explain the economic difference in reinforced adobe blocks. Furthermore, the study determined that adobe reinforced with organic material exhibits superior mechanical strength and achieves optimal quality when using eucalyptus bark fibers (M_1) and cabuya fibers (M_2).

Comparative analysis of costs and quality index

Figure 6 presents the comparative analysis of costs and quality between traditional adobe (M_0) and variants reinforced with different additives, revealing that M_0 achieved a quality index of 75%. Samples reinforced with eucalyptus bark fiber (M_1) and cabuya fiber (M_2) showed cost increases of 4.70% and 7.05%, with quality indices of 90% and 80%, respectively, standing out for their high quantitative indices. Reinforcement with powdered gypsum (M_3) resulted in a cost increase of 4.75%, presenting a quality index of 65%. The additions of Portland cement (M_4) and quicklime (M_5) significantly increased costs by 9.65% and 11.30%, respectively, both with a quality index of 65%. These findings indicate that, despite the cost increases, M_1 demonstrates the best cost-quality ratio, exhibiting a moderate cost increase and the highest quality index (90%).

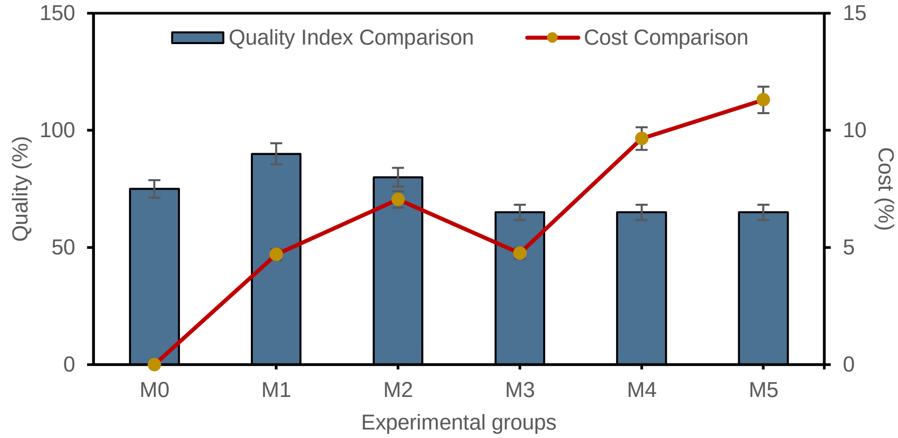

Figure 6. **Comparatives analysis of adobe cost and quality index.**

The results reported by Omongin et al. [4] demonstrated variability in cost percentages associated with each material analyzed. Similarly, the study by Bedoya-Montoya [8] achieved the production of soil-cement blocks with compressive strength equal to or exceeding the requirements established by NTC 5324. The findings of the present study consistently suggest that adobes reinforced with natural and chemical materials incurred higher costs compared to traditional adobe (M_0). However, these materials significantly exhibited superior mechanical strength concerning adobe stability and stabilizer quality. The compressive, flexural, and mortar tensile strengths exceeded the established standards by Building Technical Standard NTE.080.

CONCLUSIONS

The conducted analysis allows the following conclusions to be established:

1. The comparative cost evaluation between reinforced adobe and traditional adobe demonstrates that incorporating reinforcements with organic and inorganic materials requires a greater investment in resources for production, resulting in a significant cost increase compared to traditional adobe.
2. Reinforced adobe exhibits superior mechanical strength compared to traditional adobe, not only meeting the parameters established by NTE.080 but exceeding them in all conducted

tests. Consequently, the low mechanical strength and inferior quality of traditional adobe make it unsuitable for housing construction, thus justifying the higher cost of reinforced adobe.

3. The analysis of stabilizing materials indicated that traditional adobe fails to achieve an optimal quality index compared to adobe reinforced with natural materials. These materials, which are accessible and have low environmental impact, demonstrate greater sustainability than chemical additives like cement, gypsum, and lime, which generate negative environmental impacts. The biodegradability of adobe with natural components positions it as a favorable option for environmental sustainability.

4. The implementation of reinforced adobe with organic materials (fibers) provides significant advantages for the construction industry, particularly in developing safe housing and reducing environmental impacts. Additionally, it represents an optimal alternative for construction by ensuring the production of more durable and higher-quality materials.

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