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Conservation and Sustainability of an Earth Architectural Heritage located in the Historic Center of Lima (Peru): House Museum, Challenges and Opportunities

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Abstract

Cities continue to face increasing challenges caused by climate change and urbanization, and the conservation of architectural heritage is no exception to this, having become a priority. In this context, an adobe building located in the Historic Center of Lima is analyzed in order to evaluate its conservation, the environmental impact of its rehabilitation and the possibilities of integrating sustainable energy solutions adapted to the building's current use as a museum. In this way, the building presents both challenges and opportunities for its conservation in the current environment. Firstly, the architectural and constructive characteristics of the building, which reflect a significant cultural heritage, are evaluated, followed by the identification of the structural and typological elements, such as the existing "teatinas", which require conservation to ensure their long-term integrity. From an environmental approach, alternatives to optimize the building's energy consumption without compromising its historical value are analyzed and sustainable rehabilitation solutions are explored. The benefits of a rehabilitation that not only preserves the cultural heritage, but also reduces the ecological footprint of the building are highlighted. This approach not only protects cultural heritage, but also plays a fundamental role in the revitalization of historic centers, contributing to the cultural identity and environmental sustainability of cities in the face of the challenges of the 21st century.

Keywords: *heritage conservation; sustainability; energy efficiency; historic center; earthen building*

1. Introduction

The conservation of architectural heritage is fundamental to preserve the cultural identity and history of communities. However, it is important that this process be compatible with environmental and energy sustainability requirements. Earthen buildings, which have played a fundamental role in the traditional architecture of various regions around the world, require a specific approach to their conservation so that their integrity is not compromised. These buildings face particular challenges related to climate, materiality and adaptation to contemporary uses, such as museums.

In this context, the analysis of the Casa de la Cultura Criolla Rosa Mercedes Ayarza building, located in the Historic Center of Lima, is essential to identify both the opportunities and

challenges associated with its rehabilitation. The building was constructed using the traditional adobe technique. This analysis is of great importance to integrate sustainable energy solutions, ensure the preservation of its heritage value and improve its operational efficiency.

Lima's viceregal houses, built between the 16th and 19th centuries, which are still preserved, have been the subject of multiple studies from different perspectives. However, the focus on environmental and energy aspects, as well as thermal comfort, has been limited. Some relevant works include the studies of Wieser, who investigated the improvements in thermal and lighting conditions provided by the Teatinas (Fig. 1) on the roofs of houses, and Agüero, who made a similar interpretation with respect to viceregal balconies. However, it should be indicated that both authors addressed the energy performance of traditional buildings in Lima. Therefore, it is pertinent to mention that, to date, very few studies have been carried out in this area.

In terms of thermal comfort, one of the main challenges faced by traditional museum buildings is the preservation of their functional characteristics. In the city of Lima, it is common for museums to keep their doors open during visiting hours, which affects thermal regulation. These aspects, together with the morphology, orientation and quality of the spaces, generate both challenges and opportunities for their use as museums. On the other hand, traditional adobe dwellings located in regions with climates similar to that of Lima must address issues that impact both the preservation of artworks and the safety and well-being of visitors, while also considering the inherent benefits of adobe as a building material.

The case study building, known as the “Casa de la Cultura Criolla Rosa Mercedes Ayarza” (Fig. 2), is located in the original layout of the foundation of Lima, in an expansion area known as the “damero” of Pizarro. Despite the absence of direct historical sources about the building, archaeological studies have revealed the existence of a viceroyalty canal nearby. The proximity to the Church of San Marcelo, established in the mid-16th century, suggests that this environment was still in an initial phase of population development, although it maintained the orthogonal layout characteristic of the founding of Lima, with dwellings occupied by the humble population. At the end of the 16th century, the area was described by Father Bernabé Cobo as impoverished, with the church under development and surrounded by modest dwellings.

Fig. 1 – *Aerial photography and Teatinas on the roof* (Diaz, 2024).

Fig. 2 – *Facade of the study building* (Diaz, 2024).

In the 17th century, the urbanization intensified, reflecting the urban consolidation and the progressive occupation of the territory. The name of the street on which the building is located as “Calle Mariquitas” is a testimony of the period, while today it corresponds to block 3 of the jirón Moquegua. The city experienced two earthquakes of considerable magnitude, in 1687 and 1746, which caused the devastation of a large part of the area, leaving structures in ruins and walled lots. The rehabilitation and recovery of historic buildings, such as the Casa de la Cultura Criolla Rosa Mercedes Ayarza, presents an opportunity to integrate heritage conservation with the development of sustainable energy solutions. This study not only contributes to the preservation of architectural heritage but also provides insight into how to adapt traditional buildings to contemporary requirements without compromising their cultural and architectural values.

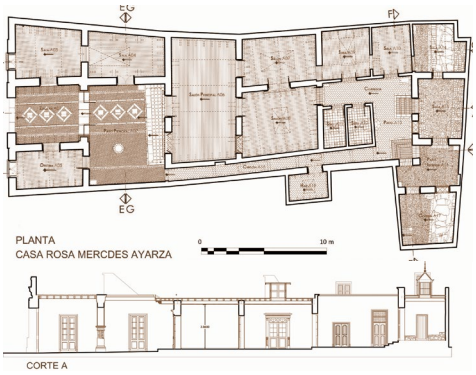

Fig. 3 – *Floor plan of the Casa de la Cultura Criolla.* (PROLIMA Documentary Archive 2022).

2. Objective

This study focuses on evaluating the state of conservation of an earthen heritage building, built using the traditional adobe technique. For this purpose, the environmental impact of its rehabilitation will be analyzed and the possibilities of integrating sustainable energy solutions will be explored, taking into account the temperate climate of the region and the current use of the building as a house museum.

3. Methodology

The research began with the compilation of bibliographic documentation and historical background of the environment and the building, as well as the compilation of documents on the history of the building. It was organized in several phases, including a visit to the building and an evaluation of its current state of conservation and functionality.

Based on this exhaustive analysis, a graphic and historical database of the building was generated. Subsequently, the construction system and the representative architectural elements were analyzed, identifying the construction elements, including dimensions, shape, materiality, state of conservation and pathologies associated with the material.

Once the constructive recognition of the building was completed, a record of shots and measurements was taken in certain areas of the museum, with the purpose of identifying climatic and lighting data in interior areas during the hours of operation of the museum. For this purpose, Testo measuring instruments were used and a photographic record was taken.

With the information gathered and the online information from the city's weather stations, an analysis of the climate and lighting was carried out, taking into account the characteristics of the building and its location.

Finally, sustainable energy solutions were explored, integrating them with the functionality, materiality and conditioning factors of the environment.

4. Results

4.1. Chapter: Historical Background of the building

The House Museum, located in the Historic Center, reflects an architectural evolution from the viceregal era to the remodeling of the 19th and 20th centuries. According to the PROLIMA

report and on-site observations, its construction combines load-bearing adobe walls and quincha systems that are wooden frameworks, filled with a weave of reed and a layer of mud on which the plaster coating is found with wooden ceilings. Despite subsequent interventions, original features such as pebble floors and wall paintings are still preserved.

However, with the growth of Lima and the need to optimize traffic, many of these structures were buried under stone slabs throughout the nineteenth and twentieth centuries, gradually transforming the urban space and giving way to a more modern subway water distribution system (PROLIMA, 2019).

The property, object of the present analysis, has also been home of outstanding personalities in the social context, being this the case of the Marquise of Torre Tagle, owner in the second half of the XIX century. However, the building achieved great cultural relevance as the residence of Rosa Mercedes Ayarza de Morales, who lived there until her death in 1969. Ayarza, composer, singing teacher and researcher, was a key figure in the development of Lima's music. Her legacy lives on through institutions such as the Escuela Nacional de Arte Lírico, now part of the National Conservatory of Music, as well as her pioneering role as the first woman to conduct an orchestra in Lima. Her impact has spread throughout the country's musical arts, marking a milestone in their development.

The integral restoration of the building was completed in 2022, as part of the Master Plan for the Historic Center of Lima (2029-2035), which was approved in December 2019. The architectural restoration intervention executed in the building has allowed its reconversion as a cultural space dedicated to the traditional music of the Peruvian coast.

This cultural transformation has been a key factor in the consolidation of Lima's cultural identity, while highlighting the intrinsic heritage value of the city of Lima. In this sense, the property not only preserves the legacy of Rosa Mercedes Ayarza de Morales, but also reflects the evolution of Lima's hydraulic and urban heritage, from its vice-royal hydraulic infrastructure to its modernization today (Prolima, 2019).

4.2. Architectural and constructive characteristics of the House Museum: historical and technical analysis

The House Museum, located in the Historic Center, shows a series of architectural and constructive characteristics, whose observation allows tracing its evolution from the viceregal period to the remodeling carried out in the 19th and 20th centuries. According to the archaeological report Casa Rosa Mercedes made by PROLIMA, and based on what was observed during the visits to the site, the building is mainly constructed with adobe load-bearing walls and quincha systems, which are wooden frames, filled with a cane or reed fabric and a layer of mud on which the plaster coating or plaster is found; while wood is used in the ceilings. In spite of the successive interventions, it has been possible to verify that vestiges of its viceregal origin are conserved, such as cobblestone flooring and the mural paintings that adorn the interior of the building.

The House Museum has a spatial organization typical of vice regal houses, with a hallway (zaguan), two courtyards (patios) connected by a side corridor and rooms distributed around these courtyards (Fig. 4), which favors circulation and ventilation. Currently, several rooms house thematic exhibitions aimed at explaining the history of the building and its link to musical culture.

Fig. 4 – Photograph of Zaguan and patio (Diaz, 2023).

In the analysis of the existing walls, different wall thicknesses were observed, which gives an answer to the different characteristics of the walls. The architect Daniel Flores, current director of the museum and who carried out the restoration project, explained in an interview that there are five types of walls in the building (Fig. 5). The ceramic brick walls correspond to more recent interventions, located on the façade, which shows modifications dating from the 20th century. However, the viceregal stone façade, which is one of the most emblematic elements of the original façade, has been preserved.

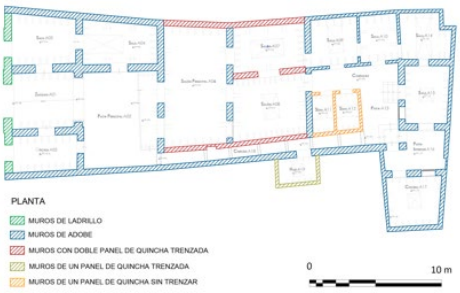

Fig. 5 – *Floor plan of the Casa de la Cultura Criolla. Own elaboration* (Flores, 2024).

The rest of the walls of the building are made of various systems based on adobe and quincha. The use of walls built with a double panel system of quincha (interlaced reeds) with an interior air chamber, as well as walls made of a single panel of simple quincha, stand out. This construction system, characteristic of traditional architecture, is also observed in the walls that delimit the restrooms, which are composed of contemporary quincha panels, made of non-woven reeds and therefore a lighter material.

It is well known that adobe, as a building material, has thermal properties. In the particular case of the quincha wall construction system, Scaletti (2024) examines the performance of the double quincha panel in his article “Double Quincha in Lima, Peru: Innovation, Adaptation and Comfort in the XVII–XIX Centuries”. According to Scaletti's (2024) studies, the thermal properties of double quincha walls show a significant improvement compared to simple quincha and adobe in terms of insulation capacity, buffering and thermal lag (Table 1).

Table 1 – *Thermal properties of components, wall and roof* (Scaletti, 2024).

Wall	Thermal Transmittance (U Value) W/m2·K	Decrement factor	Time lag (h)
Adobe	1.070	0.07	7.11
Viceroyal Quincha	1.563	0.74	4.59
Viceroyal double Quincha	0.778	0.40	9.50
Brick	2.183	0.79	3.98
Concrete	4.245	0.77	3.39
Mud cake (roof)	1.494	0.62	5.20

Although double quincha exhibits similarities to adobe in terms of thermal inertia and lag time, its insulating capacity is superior, resulting in greater efficiency in terms of thermal comfort. This finding is particularly relevant, as double quincha has significant advantages over contemporary construction alternatives.

Regarding the floor systems, PROLIMA's report highlighted the presence of a pebble floor under the modern coatings in the kitchen area, suggesting the preservation of original construction elements. In addition, the presence of a smaller secondary channel projected to the south has been identified, as well as ceramic fragments used to cover the interstices between surfaces. These findings contribute significantly to the enrichment of knowledge about the construction techniques used in the past.

Another architectural element of relevance in the Museo Casa de la Cultura Criolla are the teatinas, zenithal components that were used as vertical windows placed on the roof of the rooms, which were mostly made of wood (Fig. 2). This element has been extensively studied by Wieser, who affirms that the teatinas were systematically used in the buildings of the city of Lima from the middle of the 18th century until the end of the 19th century. These architectural devices served mainly for ventilation and natural lighting. In the

restoration process of the building, the theatinas were subject to rehabilitation due to the damage caused by xylophages to the wood, including the glass component to protect the restored spaces, allowing their preservation and functionality. With regard to the roofs of the House Museum, a common feature of Lima's buildings can be observed, where the low incidence of rainfall favors the use of flat roofs without a pronounced slope.

With regard to the architectural characteristics of the House Museum, there is a tendency representative of the architectural typology of the Historic Center of Lima, characterized by the presence of flat roofs without a pronounced slope. This configuration, which is manifested in the roof structure, composed of wood, with a framework of beams and joists of rectangular section, which transmit the loads to the load-bearing walls, and an external layer of clay approximately 10 cm thick, used as a protective layer, reflects an adaptation to the climatic environment of the region, where rainfall is scarce.

In addition to its representative value, this element reinforces its spatial functionality due to the presence of the Teatinas integrated into the roof (Fig. 6), which provides improvements in terms of ventilation and natural lighting to the interior spaces.

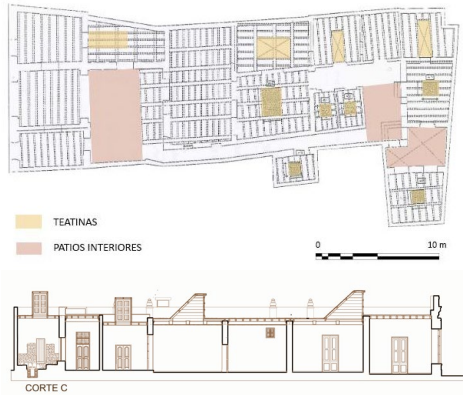

Fig. 6 – *Floor plan and Teatinas Casa de la Cultura Criolla* (PROLIMA Documentary Archive 2022).

The house follows the architectural patterns of viceregal residences described by Hart-Terre and reflects, according to Crespo, a dynamic architecture designed to be inhabited and adapted to the needs of its users. In this case, its transformation into a museum implies a significant change in its original function, maintaining its residential essence while assuming a new cultural role.

In 2022, the building was restored and rehabilitated as the Rosa María Ayarza Museum and House of Creole Culture. It is an outstanding example of viceregal architecture, adapted over time through interventions that respect its original structure. The use of traditional materials such as double wattle and adobe, together with passive ventilation and lighting systems such as the teatinas, highlights the sustainability and effectiveness of ancient construction techniques compared to modern ones.

4.3. Environmental analysis - climate data for the city of Lima

The climate of the city of Lima has features of a temperate climate, characterized by an absence of sudden variations in temperature. This condition is attributed to its geographical location close to the equator and the influence of the Pacific Ocean. For the elaboration of this study, specialized computer tools have been used, such as the CBE Clima Tool software, which has allowed meteorological data to be obtained from reliable sources. Specifically, the data has been extracted from the databases provided by the Meteonorm program, covering the period between the years 2000 and 2019. In addition, the analysis has been integrated with data from the Photovoltaic Geographical Information System (PVGIS-SARAH2), which covers the period from 2005 to 2020.

The results obtained show that the hottest months are between January and March, with a maximum of up to 27.39 °C. On the other hand, the months with the lowest temperatures are observed between June and October, with minimum values of up to 14.17 °C. Finally, the transition months are identified, comprising April, May, November

and December, where the minimum temperature recorded in the mornings is 14.9 °C, and the maximum, 25 °C. In the Historic Center of Lima, temperatures usually range between 14 °C and 29 °C, although the heat island phenomenon raises temperatures in central urban areas. However, since 2023, the National Meteorology and Hydrology Service (SENAMHI) has reported more extreme variations, reaching 33°C in summer and 10°C in winter.

The behaviour of relative humidity in the city center has been analyzed, observing that it presents a moderate behaviour during the summer months, with a minimum average value close to 52%, and an increase in winter, reaching 78%. The results of the measurements taken in the building bear out the above. The seasonal variability of atmospheric humidity is influenced by local climatic phenomena, such as the presence of low clouds and occasional light drizzle. With regard to temperature and relative humidity parameters, it can be seen that Lima's climate is moderate throughout the year. Rainfall is practically non-existent and solar radiation levels are generally high. Consequently, these conditions allow for thermal comfort during the summer months. However, the House Museum is affected by the existing neighboring buildings, which affects the hours of sunlight on the building.

The analysis carried out using Revit software (Fig. 7) reveals that at 7:00 a.m., the building is completely covered by the shadow of the adjacent building to the east; at 6:00 p.m., the building is completely shaded by the adjacent building to the west; and at 1:00 p.m., part of the analyzed building is shaded by the adjacent building to the west.

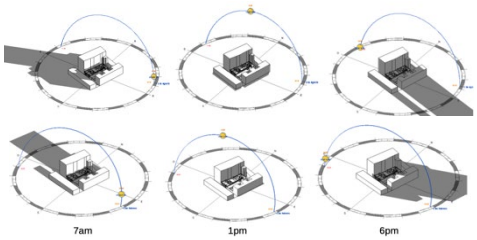

Fig. 7 – *Solar Path, Revit Software* (Author, 2025).

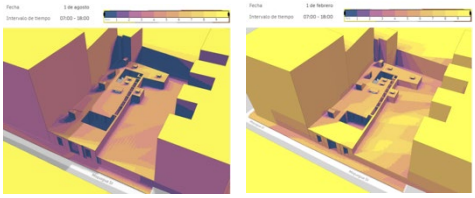

Fig. 8 – *Hours of sunshine, Autodesk Forma Software* (Author, 2025).

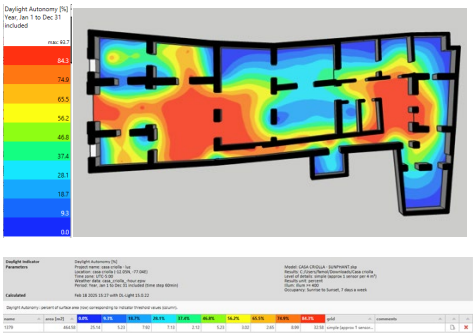

Fig. 9 – *Optimization of the use of natural light (400 lux), De Luminae Software* (Author, 2025).

Finally, the optimization of natural light in interior spaces was analyzed, considering the function of the building and establishing illumination levels of 400 luxes necessary for museum use (Fig. 9).

The results obtained are presented by year, the red tones determined that 84. 3% of the hours in a year, the spaces exceed 400 lux of natural light and the blue-toned spaces never exceed 400 lux of natural light, as this level of light is never reached.

5. Discussion

One of the main challenges facing the restoration of the Casa Museo building and in temperate climates such as Lima's, lies in the need to achieve a balance between the conservation of the original structure and the incorporation of modern solutions, both in terms of energy and accessibility.

Adapting the building to contemporary standards of safety, accessibility and energy efficiency without compromising its historical value is a complex task.

On the other hand, Lima's temperate climate offers a unique opportunity for the development of sustainable solutions based on passive design and efficient energy use. Taking advantage of the building's natural features, such as thermal inertia and natural lighting, is advantageous for reducing the museum's energy footprint.

Furthermore, the growing interest in architectural heritage and sustainable practices has the potential to transform this type of building into reference models for the rehabilitation of historic buildings globally.

6. Conclusions

The conservation of earthen architectural heritage in historic centers located in temperate climates requires a methodology that integrates technical aspects and sustainable solutions adapted to the climatic and social particularities of the environment.

The exhaustive evaluation of the state of conservation, the use of ecological materials and the implementation of renewable energies and passive design principles are essential to preserve these buildings without compromising their sustainability. In this sense, the rehabilitation of buildings such as the so-called house museums not only contributes to the conservation of architectural heritage, but also stands as a model of best practices for the restoration of traditional architecture in contemporary urban contexts.

Museums built with adobe in temperate climates face challenges derived from humidity, thermal variations, constant maintenance and compliance with modern regulations. However, they also offer valuable opportunities, such as energy efficiency, strengthening of cultural identity, environmental sustainability and boosting tourism. To maximize these benefits and reduce risks, a design that combines traditional techniques with contemporary innovations is essential, ensuring functionality, safety and heritage authenticity.

Acknowledgements

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