



The Traditional Building Materials in the Ksours of Rissani

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Abstract. The preservation and restoration of historical monuments are essential for cultural heritage and identity. In Morocco, traditional construction materials have been used for centuries in the construction of historical monuments. This article explores the traditional construction materials used in the historic ksour of Rissani, located in the southeastern region of Morocco. Focusing on materials such as rammed earth, stone, and wood, the study examines their advantages, limitations, and relevance in the contemporary context. The study was conducted through a documentary analysis of scientific literature and field data collection in the Tafilalet ksours. Data was gathered through interviews with local experts, surveys among the local populations, and direct observations. The article delves into the significance of these materials in terms of durability, aesthetic appeal, energy efficiency, and cultural heritage preservation. By understanding their characteristics and considering their integration into modern architectural practices, the article underscores the importance of preserving these traditional construction techniques. Through this exploration, it aims to shed light on the unique essence of Rissani's ksour and their invaluable contribution to Morocco's cultural and heritage wealth.

Keywords: Ksour · Rammed earth · Mud brick · Stone · Palm wood · Durability

1 Introduction

The ksour of Tafilalet, nestled in the enchanting region of Sijilmasa in southwestern Morocco, are captivating historical treasures. These ancient fortified villages, characterized by their distinctive architectural style and traditional building techniques, offer a captivating glimpse into the rich cultural heritage of the area. In this article, we embark on a journey to explore the extraordinary world of earthen construction materials that have been utilized in the construction of the ksour of Tafilalet.

For centuries, the local inhabitants have harnessed the abundant resources of the surrounding landscape to create remarkable structures that harmoniously blend with their natural surroundings. Earthen construction materials, such as rammed earth, adobe, and clay, form the very foundation of these awe-inspiring ksour, embodying the essence of sustainable and environmentally-friendly building practices (Gil-Piqueras and Rodríguez-Navarro [8]).

The unique characteristics of these earthen materials have contributed to the enduring charm and resilience of the ksour of Tafilalet. The use of rammed earth, for instance, provides exceptional thermal insulation, keeping the interiors cool during scorching summers and warm during chilly winters. The inherent thermal mass of these materials regulates temperature fluctuations, reducing the reliance on artificial heating and cooling systems. Furthermore, the local availability and affordability of these materials have made them an integral part of the vernacular architecture of the region.

The construction techniques employed in the ksour of Tafilalet reflect a deep understanding of the local climate, culture, and available resources. The meticulous craftsmanship exhibited in the formation of earthen walls, intricately designed decorative elements, and sturdy structural components is a testament to the ingenuity and expertise of the local builders.

While these traditional construction practices have stood the test of time, the preservation and revival of earthen construction face contemporary challenges. Rapid urbanization, changing lifestyles, and modern building materials have influenced the way buildings are designed and constructed. However, by recognizing the intrinsic value and sustainable advantages of earthen construction, there is a growing appreciation for the revival and integration of these techniques in contemporary architecture.

In this article, we delve deep into the world of earthen construction in the ksour of Tafilalet, unraveling the secrets of their unique materials, exploring their environmental benefits, and highlighting their cultural significance. By understanding the historical context, properties, and potentials of these earthen materials, we hope to inspire a renewed appreciation for the architectural wonders of Tafilalet's ksour and foster a sustainable approach to construction that embraces both the past and the future.

2 Materials and Methods

2.1 Description of the Ksours and Their Cultural and Architectural Importance

Rissani's ksours are traditional fortified structures that were once used as fortified villages. They were designed to provide protection from tribal conflict and invasion, while serving as economic and social centers for local communities. The ksours are generally built using local materials such as raw earth and stone, thus reflecting the adaptation to the natural resources available in the region and their adaptation to the semi-arid climate of the south eastern region of Morocco (Fig. 1).

These ksours have a characteristic architecture with their thick walls, their defense towers, their narrow passages, their interior courtyards and their large giant arched door decorated with carved motifs of the culture and aesthetics of the region. They are often arranged in a compact way, thus forming fascinating architectural ensembles. Additionally, the ksours feature unique ornamental details, such as carved patterns and decorative wooden elements, which add an artistic touch to their construction (Fig. 2).

2.2 The Traditional Materials and Techniques Used in the Ksours of Rissani

In this research we proceeded to a field visit to some ksours of rissani (ksar abbar, ksar oulad abdelhalim), in order to make a survey with the local expert (Imaalem) to know the



Fig. 1. Aerial view ksar oulad abdelhalim in Rissani



Fig. 2. The main entrance to ksar abbar in rissani

adapted techniques and the materials in the construction of these ksours, with the taking of photos for the exterior architecture and the main elements of the structure (walls, post, roof, etc.).

The key element in the traditional construction method of ksours is the use of earth material, which is employed in various situations due to its ideal suitability in effectively adapting to the warm and dry climate of the region.

Among the building techniques adapted using earth as the main material, we have rammed earth is called “allouh”, and we also have mud bricks called “toub”, these two techniques are used separately in the different parts of the construction.

– **Rammed earth**

The technique of rammed earth involves compacting layers of moist soil within a wooden formwork. This method enables the creation of robust continuous load-bearing walls with considerable thickness (40–100 cm). The construction process begins with horizontal masonry until the entire perimeter is completed. After allowing sufficient drying time (usually not less than one week, depending on the climate) to prevent wall deformation or collapse, the construction proceeds to higher levels (Fig. 3).



Fig. 3. Rammed earth wall

The building is lifted to add subsequent layers using shifting formwork, block by block. This approach maintains a relatively uniform wall thickness along the perimeter and throughout the height of the structure. When constructing masonry buildings, careful attention is required to ensure proper interlocking between blocks, walls, and partitions. The dimensions of the formwork can vary, and in the ksours of tafilalet, the average size is about 200 cm in length, 80 cm in height, and a width ranging from 60 to 100 cm, depending on the building's height. The height of the plans is determined by the number of rammed earth blocks used [5].

– Mud bricks

Mud bricks are one of the traditional building materials used in ksours, these bricks are made from raw clay, sometimes mixed with aggregates such as sand then shaped and dried in the sun [15].

the size of the bricks varies according to the needs and the tradition, generally the width of brick equal to a half-length and the height equal to a half width.

the brick earth must be carefully selected rich in clay (at least 40%), and water until you obtain a magnificent and plastic paste, you can add vegetable fibers such as straw to fight against cracking of the bricks during drying due to the high percentage of clay in the mix.

the bricks are formed by hand, molded and left to dry in the sun, once dried can be stored and used later [3] (Fig. 4).

the drying time varies according to the climate and the season (2 to 3 days in summer and 10 to 15 days in winter).



Fig. 4. Mud brick sun dried. Credit by Baglioni [5]

the bricks are then used in the construction of walls, arcades, vaults and other structural elements of buildings.

– Stone

Stone is another traditional building material used in ksours. Local craftsmen use locally quarried stones, usually limestone or sedimentary rock.

Stone construction involves cutting and shaping the stones as needed and then assembling them using traditional lime-based mortars. The craftsmen use specific bonding techniques, such as the “boutisse” or stone on stone”, to guarantee the stability and solidity of stone structures. Stone is often used either in foundations or as a base for walls, and also in the construction of posts in mixed masonry with earthen bricks [9].

Typically, the base of the ksar consists of a variety of stones arranged in layers of 0.50 to 0.80 m in height. These stones are positioned on a trench measuring 0.50 to 1.00-m-wide and are held together by a layer of mud. This construction method ensures the wall’s stability [10].

All the buildings are generally built on a stone base of various height. The presence of a good stone basement limits the water capillary rise and protect the wall from water splashes and human actions.

– Wood

The wood used in its ksours is palm wood and cedar wood to utilize the sturdy and elaborate timber frames. Often made of interlocking beams and joists to provide structural stability.

Wooden doors are an essential element of ksour architecture. They are often decorated with carved patterns and traditional ironwork. Wooden windows are commonly used in ksours. They usually have wooden frames and shutters which make it possible to regulate the ventilation and the luminosity inside the buildings. The wooden windows also add a touch of charm and authenticity to the architecture of the ksours [3].

In addition to structural elements, wood is also used to create decorative elements such as carved beams, relief patterns and wooden friezes. These elements contribute to the overall aesthetics of buildings and showcase local craftsmanship (Figs. 5 and 6).



Fig. 5. Wooden roof

3 Results and Discussion

3.1 The Advantages of Using Traditional Building Materials in the Ksours of Rissani

The use of these traditional earth-based building materials in this region brings many benefits. For example, rammed earth, wood and stone have natural insulating properties. They have a low thermal mass, which means that they can absorb, store and release heat more slowly than modern materials such as concrete. This helps maintain a more stable interior temperature and reduces heat fluctuations during hot periods, also creating thick rammed earth walls with low thermal conductivity helps to reduce the transmission of heat through the walls of buildings, thus contributing to better thermal insulation. These materials also have the ability to regulate humidity inside buildings. El Azhary [6].



Fig. 6. Wood frame

For example, rammed earth has a good water vapor permeability, which helps to limit the accumulation of moisture and prevent problems of excessive humidity, it helps to maintain a comfortable and healthy indoor environment, especially in dry climates in which the air dehydration can be a problem [11].

these materials are characterized by their durability, rammed earth and stone can withstand bad weather and extreme climatic conditions, intense heat, temperature variations and strong winds, while wood used properly can last for decades or even centuries.

local and economic availability is another advantage of these traditional building materials used in the ksours of tafilalet, they are often available locally, which reduces transport costs and makes them more economical compared to imported materials, for example earth Raw material is used in abundance due to the presence of clay and sand in the region. The availability of these materials has facilitated their use in construction and has helped to strengthen the local economy and preserve natural resources [13].

When it comes to environmental impact, these traditional materials are often considered more environmentally friendly than modern materials [12]. They are natural, renewable and require less energy to produce and maintain. They also reduce the carbon footprint associated with modern building materials [7].

Traditional materials give the ksours a unique aesthetic character and a strong cultural identity. Rammed earth, stone and wood are appreciated for their natural appearance, their texture, their carved patterns and their harmonious integration into the local environment. They contribute to preserve the cultural identity of the region and to maintain the link with the architectural heritage.

3.2 The Limitations of Using Traditional Building Materials in the Ksour of Rissani (Arial 10)

While earthen construction seems to be in perfect harmony with Tafilalet environment, it does exhibit some problems and limitations. Generally speaking, earthen construction deficiencies are mainly caused by three factors: atmospheric (wind and water), building design and the construction system [4].

Evidently, wind and water can affect any building. Whether in earthen or modern construction, cracks and other pathologies are caused by the infiltration of water. Earthen construction is very sensitive to water infiltration because rammed earth is not water-proof. Water can easily infiltrate the mansion and lead in the short-term to serious pathologies. In addition, rain attacks the surface plaster, which serves as the guarding shield of the house. The removal of the surface plaster accelerates the deterioration of earthen construction. Hence, a proper and frequent maintenance of plaster is essential to preserve earthen construction [4].

The design of earthen construction in Tafilalet is another cause of pathologies. Rammed walls are highly sensitive to water. A good way to enforce their water' resistance is the presence of a solid stone basement [14]. However, due to the scarcity of stones in the region, stone basement is either unavailable or insufficiently high [3]. Obviously, stone basement can protect walls against water-infiltration and enforce their durability.

Pathologies are also related to building techniques [14]. Walls are built separately without joints or connections in the corner. For economic factors, people tend to minimize the use of rammed earth. In the long term, walls start to separate from each other causing vertical cracks.

Some traditional materials such as wood may be more susceptible to attacks from pests and pests such as termites or fungi. This can lead to structural damage and require appropriate prevention and treatment measures.

Another disadvantage is that these materials may sometimes not meet modern building standards for seismic resistance or other specific criteria. Adjustments and additions may be necessary to comply with current regulations, which may result in additional costs or loss of authenticity of the structures.

Earthen constructions in this region require regular maintenance and periodic repairs to preserve their original condition. This may involve restoration, consolidation or replacement of damaged elements. The availability of qualified professionals to carry out this work can sometimes be a challenge.

4 Conclusions

In conclusion, the exploration of traditional construction materials in the ksour of Rissani reveals their significant advantages and limitations. These materials, including rammed earth, stone, and wood, have played a crucial role in shaping the unique architectural heritage of the region.

One of the key advantages of these traditional materials is their inherent durability. The use of rammed earth walls, for example, has demonstrated remarkable resilience against the harsh climate conditions of Rissani, including extreme heat and aridity. The

thermal mass properties of these materials allow for a more stable indoor temperature, providing natural insulation and reducing the need for excessive energy consumption.

Moreover, the authentic aesthetics of the traditional materials contribute to the cultural identity and sense of place in the ksour. The earthen tones, intricate stonework, and wooden elements blend harmoniously with the natural surroundings, showcasing the craftsmanship and artistry of the local communities. The preservation of these architectural traditions not only conserves the tangible heritage but also honors the intangible cultural values and knowledge embedded in their construction techniques.

However, it is important to acknowledge the limitations and challenges associated with traditional construction materials. Their susceptibility to weathering and erosion requires regular maintenance and periodic repairs. The availability of skilled craftsmen well-versed in these traditional techniques may also be limited, posing obstacles to the preservation and restoration efforts. Additionally, the compliance of these materials with modern building codes and regulations may necessitate adaptations and compromises to ensure structural integrity and safety.

The integration of traditional materials in contemporary architectural practices offers an opportunity to strike a balance between heritage conservation and sustainable development. By harnessing the advantages of traditional materials while addressing their limitations, innovative approaches can be employed to enhance their performance, such as reinforcing techniques, protective coatings, and complementary use of modern materials where necessary.

In summary, the use of traditional construction materials in the ksour of Rissani represents an invaluable cultural heritage that needs to be safeguarded. The sustainable and aesthetic qualities of rammed earth, stone, and wood contribute to the preservation of the region's architectural identity and environmental harmony. Recognizing the importance of these materials, further research, documentation, and collaboration between heritage conservation experts, local communities, and policymakers are essential to ensure their continued preservation and transmission to future generations. Embracing a holistic approach that combines tradition and innovation will enable the ksour of Rissani to thrive as living cultural landmarks while embracing the challenges of a rapidly changing world.

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