Characterization of an erudite construction in Adobe

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ABSTRACT
Adobe construction is a very old type of earth construction, due to the simplicity of its manufacture and the subsequent construction. The oldest examples of adobe blocks date back more than 10,000 BC, some of which were discovered in the Tigris River basin. They are thought to have been introduced to the Iberian Peninsula during the Arab occupation. Several examples of adobe constructions are well known in Portuguese popular architecture, particularly in the south of the country, in Ribatejo and in the lower Vouga River valley. However, not much is known about the adobe construction of classical buildings, such as palaces and others, as well the pathologies that exist in these buildings and the possible solutions for their rehabilitation. The erudite construction of adobe in Portugal is often associated with the Art Nouveau period. During this period, at the turning of the century, with the perfect use of steam traction and the good production of cast and rolled iron, new possibilities were created for the manufacture of manual adobe presses, as well for machines to manufacturing tiles, a covering material that was an effective protection of the adobe walls against the weather. This paper describes and illustrates a seigniorial house - Casal Francisco José - located in Valada, in the municipality of Cartaxo, which belongs to the Ribatejo region. The architectural characterization of the building is presented, highlighting aspects related to the Art Nouveau aesthetic and identifying the main construction features of this type of building.

Keywords: Adobe, construction, heritage, pathology, popular architecture.
RESUMO
A construção em adobe é uma forma muito antiga de construção em terra, dada a simplicidade do fabrico dos adobes e da subsequente edificação. Datam de há mais de 10.000 a.C. os exemplares mais antigos de blocos de adobe alguns dos quais foram descobertos na bacia do rio Tigres. Pensa-se que terão sido introduzidos na Península Ibérica durante a ocupação árabe. Na arquitetura popular portuguesa são bem conhecidos vários exemplos de construções em adobe, sobretudo no sul do país, no Ribatejo e no vale do baixo Vouga. No entanto, é escasso o conhecimento sobre a construção em adobe de edifícios clássicos, como palácios e outros, bem como as patologias existentes nesses edifícios e as possíveis soluções para a sua reabilitação. A construção erudita de adobe em Portugal aparece muito associada ao período da Arte Nova. Nesse período, de viragem do século, com o perfeito domínio da tração a vapor e da boa produção de ferro fundido e laminado, abriram-se novas possibilidades para o fabrico quer de prensas manuais de adobe, quer de máquinas para fabrico de azulejos, material de revestimento que constituía uma proteção eficaz das paredes de adobe contra as intempéries. Neste artigo é dado a conhecer, de forma ilustrada, uma casa senhorial em adobe – Casal Francisco José, localizada em Valada concelho do Cartaxo, na região do Ribatejo. Apresenta-se a caracterização arquitetónica do edifício, realçando os aspetos relacionados com a estética da Arte Nova e identificam-se as principais características construtivas deste tipo de edifícios.


RESUMEN
La construcción con adobe es una forma muy antigua de construcción con tierra, dada la sencillez de su fabricación y posterior edificación. Los ejemplos más antiguos de bloques de adobe datan de más de 10.000 a.C., algunos de los cuales han sido descubiertos en la cuenca del río Tigres. Se cree que fueron introducidos en la Península Ibérica durante la ocupación árabe. En la arquitectura popular portuguesa, son bien conocidos varios ejemplos de construcciones de adobe, sobre todo en el sur del país, en el Ribatejo y en el bajo valle del Vouga. Sin embargo, poco se sabe de la construcción en adobe de edificios clásicos, como palacios y otros, así como de las patologías existentes en estos edificios y de las posibles soluciones para su rehabilitación. La construcción erudita en adobe en Portugal está estrechamente asociada al período Art Nouveau. En el cambio de siglo, con el perfecto dominio de la tracción a vapor y la buena producción de hierro fundido y laminado, se abrieron nuevas posibilidades para la fabricación tanto de prensas manuales de adobe como de máquinas para fabricar tejas, material de revestimiento que protegía eficazmente los muros de adobe de las inclemencias del tiempo. Este artículo ilustra una casa solariega de adobe - Casal Francisco José, situada en Valada, municipio de Cartaxo, en la comarca del Ribatejo. Se presenta la caracterización arquitectónica del edificio, destacando aspectos relacionados con la estética modernista e identificando las principales características constructivas de este tipo de edificios.

Palabras clave: Adobe, construcción, patrimonio, patología, arquitectura popular.
1 INTRODUCTION

Raw earth is a notable building material that has been used by man for over 10,000 years, with the first known adobe constructions dating from 8,000 to 6,000 BC, or rammed earth from 5,000 BC (Torgal, et al, 2009). There are paintings that identify the method of manufacturing adobes and building adobe walls in ancient Egypt, which already served as a demonstration of the principles of earthen construction (Fig.1).

Figure 1 - Egyptian illustration showing the method of making and executing adobe walls in 1,500 B.C.

Earth architecture is universal, having arisen apparently independently in various regions of the world. It may be associated with the sedentary peoples' lifestyles and the consequent growth of settlements. There are examples of earthen constructions, some of which, due to their importance and longevity, are on the UNESCO World Heritage List (Fig.2).

There are earthen constructions in inhabited regions of all continents and in the most varied climatic conditions. Studies carried out in recent decades suggest that more than a third of the world’s population lives in earthen dwellings (Blondet, 2011).

Earth, as a building material, continues to be one of the most widespread forms of building dwellings worldwide, as it is on a par with the noblest building materials and is aligned with the theme of sustainable development.
There is a diverse range of earth construction techniques. The CRATerre Association, in its Treatise on Earthen Construction published in 1989, presented a diagram showing twelve traditional and contemporary earthen construction techniques. The construction systems were classified into three main groups: monolithic earth structures; earth masonry and earth filling systems for load-bearing structures.

In Portugal it is possible to find different traditional construction techniques that use raw earth as a material. Rammed earth is mainly used in buildings in the south; adobe was used near the Tagus and Sado estuaries and on the central coast and tabique in the centre and north of the country. The distribution of the regions in Portugal where these techniques were used can be seen on the map in Figure 3.
2 BUILDING WITH ADOBE

2.1 GENERAL CONSIDERATIONS

Earthen constructions have been identified in Portuguese territory since the Chalcolithic period (3rd millennium BC), although building systems, particularly rammed earth, were more widespread in the Islamic period. The term adobe derives from the Arabic "attob" meaning sun-dried brick, hence it is thought that this technique was introduced to the Iberian Peninsula during the Arab occupation.

Adobe construction has a number of constructive advantages over other earthen construction systems, such as rammed earth or tabique: the adobe construction process is similar to brick masonry and therefore does not require specialized techniques and equipment’s; given the size of the adobes, it can be built quickly and versatility; the adobes can be prepared in advance on site or elsewhere, where the raw material available is appropriate; the variety of devices makes it possible to build not only exterior and interior walls, but also arches, vaults and domes, which would be difficult to build using other earthen construction systems. In Portugal today, there are many examples of old buildings using this type of masonry, both in urban and rural areas, especially in the coastal center region, although there are also adobe buildings, albeit on a smaller scale, in other regions of the country, particularly in the Alentejo and Algarve. There are examples of various types of adobe constructions that mark the rural landscapes, which in the past served as housing and a place of shelter for people who worked in agriculture and local commerce, and in urban areas, larger buildings, and mansions, which today have great cultural and heritage value.

2.2 THE ADOBE

Adobe construction is used in places where clay can be found. Its traditional manufacture consists of manually molding earth in its plastic state, using wooden forms, to form small blocks (adobes). The adobes are removed when they are still fresh and left to dry at room temperature, turning them over every day to ensure that they dry uniformly. When the soils are very plastic, it is usual to add straw or vegetable waste to the soil to minimize the appearance of shrinkage cracks when the clay dries.
The oldest known representation of the adobe production and construction process is the mural painting in the Rekmire tomb in Thebes, Egypt (Fig-4): it shows all the stages of the process, including the type of workers, many of them Nubians and Jews, given the expressivity of the representation.

Adobes were produced by hand and varied greatly in shape, size, composition, color and texture depending on the region in which they were produced. The usual dimensions of traditional adobe in the Aveiro region are 0.45x0.30/0.20x0.15m3, but in the Tagus valley the dimensions vary from 0.35x0.25x0.10m3 to 0.30x0.15x0.12m3. In the Alentejo Interior, the most common dimensions are 0.32/0.33x0.16x0.10m3. The interior adobe walls are built with a thickness of between 0.11m and 0.21m (without plaster) and between 0.15 and 0.25 (with plaster) and the exterior walls are generally between 0.20m and 0.35m (Correia, 2010).

Figure 4 – Mural painting of the cycle of manufacturing/production and building in adobe in the tomb of Rekmire (1450 BC) in Thebes, Luxor, Egypt.

Source: Campell and Pryce, 2009

Adobe masonry is built in a similar way to conventional ceramic brick masonry. The adobes can be arranged in various configurations and are laid with compatible earth-based mortars, which are also used to wall coverings (Fig.5).
At the end of the 18th century, with a better scientific understanding of ceramics and the impetus of the Industrial Revolution, the production and processing of ceramic products has undergone a major development in the manufacture of bricks and tiles.

With industrial progress there was greater availability of construction products, which have helped reduce the fragility of earth constructions (Campbell and Pryce, 2009).

Especially, the production of tiles to protect facades and longer eaves tiles, which prevented rainwater from flowing on the facades of earth buildings. The use of manual steel machines to compress the adobes and the addition of small quantities of ground lime allowed the production rate of adobes with better mechanical characteristics (Mink, 2001).

3 CASAL FRANCISCO JOSÉ

The building Casal Francisco José (Fig.6) is located in Valada, in the municipality of Cartaxo, Portugal, and was built in 1901 by Francisco Ribeiro de Oliveira Freire, a member of the Republican Party who served on the Cartaxo Town Council between 1908 and 1912.

Júlio Augusto Marques, self-taught master builder who was inspired by French magazines and contemporary architectural books, was the man responsible for the design and construction of these building (Nobre et al., 2020).
3.1 ARCHITECTURAL CHARACTERISTICS

The singularity of the Casal Francisco José stands out if we consider the absence of public commissioning and the predominant lack of interest by the upper classes in Art Noveau, with eclectic architectural styles prevailing. Located in a farm, the building was coherently designed, articulating its sophisticated, erudite, predominantly Art Nouveau design with the regional constructive tradition (Mascarenhas et al. 2021).

Erected parallel to the road, the building is on two floors, has regular plan and gabled roof, and develops in a compact volume and the entrance is preceded by a staircase. To avoid the inconvenience of floods, the building was raised, and a crawl space was added as evidenced by the existing plinth (Fig.7).
Emphasizing the axis of symmetry is the central body composed, on the ground floor, by the access staircase and, on the upper floor, by a narrow body flanked by fluted pilasters surrounding the bay window with stonework frame and balcony supported by two corbels. The lateral single-skin elevations are composed of four windows with stonework frames. Three in the lower floor and the other bayed and centrally located in the attic.

The symmetry in these facades is enhanced by curved and jagged pediments of French and English influence, as in other buildings of the same period in Portugal. The mansard roof is covered with simple Marseille tiles and appears on the upper floor above the cornice that runs throughout the building, except for the back side.

It is above all on the outside that the Art Nouveau style is evident, where the exuberance of elements identifiable with this style proliferates, which demonstrates the quality of the building and the economic status of its owners: the symmetrical main facade and the fan staircase attached to it; the balustrade on the upper part resting on entablature; the frame of two rows of flower-patterned tiles; the central body with the protruding railing balcony; the twin windows; the protruding cornerstone forming corrugated pilasters and the curved pediments cut in the upper section of the side facades (Fig.8) (Madsen, 1967).
At the decorative level, a refined exuberance flourished through the stonework, porcelain, tiles, metalwork, carpentry and plastering works, evoking naturalist, and country motifs — characteristic of the Art Nouveau style — in which wine allusions prevailed (a crop typical of this region) (Fevereiro, 2017) (Fig. 9). The building also shows a strong Republican influence in its decoration, reflected in the use of acanthus leaves, red and green glass and a sculpture with an image of a woman, placed in top of the central body, that personifies the republican symbol, inspired in the painting of Eugène Delacroix's - The Liberty Leading the People.
3.2 CONSTRUCTIVE SYSTEM

The in-building in alluvial soils susceptible to floods led to the building being raised on a one-metre-high plinth base composed by pillars and stone masonry walls. The use of the plinth to support the resistant walls in adobe block masonry made it possible to create a ventilation space under the wooden ground floor and helped minimize the effects of the rising dampness by capillarity in the adobe masonry walls (Fig.10).

![Figure 10 – Figure 8 - View of the plinth and ventilated air box.](image)

1. Stone masonry of the socle; 2. Base wall is slightly wider than the upper wall; 3. Drilled ceramic bricks (0.23x0.11x0.07m³); 4. Adobe blocks (0.40x0.27x0.12m³) placed once; 5. Plinth with base; 6. Stone masonry foundation; 7. Pinewood beam, embedded in the wall; 8. Palmette to put on the floorboards; 9. Sanitary space for the air box; 10. Portuguese-style flooring; 11. Floor pillar.

Source: by the authors.

The adobe facade walls are made up of blocks of 0.27x0.12x0.40 m³ placed at one time. In the half-brick walls (around openings and cornices) perforated brick masonry has been used. These walls are susceptible to fracture in the plinth area both by internal structural stresses (e.g., the roof beams) and by the differential laying of the foundations of two adjacent walls. In order to avoid this, the plinths were sealed with limestone masonry arranged in an imbricate manner making sure to keep the openings away from the plinths. Iron bracings were installed between orthogonal walls on the perimeter of the outer walls at each floor level and at the connection between the entrance block and the main body. Curiously, the central bracings do not cross the building to create monolithism with the interior walls. This indicates that these bracings may have been installed at a later stage.
All the information suggests that the building was erected in the early years of the 20th century (1900-1905) and on 23 April 1909 there was a major earthquake in the vicinity of Benavente and Salvaterra de Magos (Fonseca and Vilanova, 2010) which possibly interfered with the building. Although brick was an expensive material at the time, its use in the brickwork around the openings is very common as it allowed wooden fittings to be installed, which would be impossible to do directly on the adobe due to its fragility (Varum et al. 2010).

Figure 11a) shows that the thin area of the windowsill panel, impossible to make with adobe blocks, was made with clay bricks at half time. It also shows that the bricks, because they are smaller, fit well with a cut-out element for bracing the jamb around the stones. The versatility of the brick for building three-row arches is also evident (Fig.11b and c).

It can be said that in this construction the adobe blocks would be used to carry out the extensive facework at low cost, using brick masonry in the areas requiring more care. Perforated bricks, because of their smaller dimensions, adapted well to the cut edges of the adobe facework around the openings.

Everything indicates that, only after the openings were inserted in the adobe with brick masonry, was the carefully carved stonework pieces put into place.

The roof is gable, a roof beam and trusses that are supported on the load-bearing walls by means of a bracket (Fig.12). The elevated beam of the trusses provided the desired spaciousness of the attic's interior space. The elements that constituted the trusses...
were joine by complemented by brackets. The roof verge on the eastern elevation was externally protected by the covering with floral motifs typical of the Art Nouveau style (Silva and Simões, 2013)

Inside, the house has an interesting decor composed of various Art Nouveau elements such as the Dutch-style well-crafted rhombus shaped wood pieces used on the floor (Fig.13, 14). The planks are Portuguese style with tongue and groove planks nailed directly to the wooden beams.

Figure 12 – Perspective view of the interior of the attic:

The interior walls are made of a 0.15 m thick “flitch partition wall” (Fig.15), made of a wooden plank frame placed vertically and nailed to the beams on the floor. On both sides of the partition wall, a wooden frame was placed to apply the plaster. These walls, in addition to acting as a partition, served as a bracing to the facades due to their perpendicular arrangement. The wooden interior staircase has the steps arranged in a fan and its structure is supported on the walls (Fig.16)
Figure 13 - View of the corridor.

View of the corridor that makes up the central distribution, with Art Nouveau designs adapted for the wooden floor; a) construction scheme
Source: by the authors.

Figure 14 - Interior views of the ceilings.

Interior views of the ceilings: a) Coffered ceiling; b) Detail of the coffered ceiling: ① Moulding; ② Coffered ceiling (Hungarian-style herringbone molding); ③ Coffered ceiling; ④ Frieze; ⑤ Cornice
Source: by the authors.
Figure 15 - Construction detail of the partition wall.


Source: by the authors.

Figure 16 - Construction detail of the interior Staircase.


Source: by the authors.

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4 CONCLUSION

The Casal Francisco José building is a building from the beginning of the 20th century with great architectural interest. It belonged to an illustrious citizen of Cartaxo who, together with an enlightened and self-taught builder, would have sought to follow the trends coming from Central Europe. It is a building with great architectural interest. It belonged to an illustrious citizen of Cartaxo who, together with an enlightened and self-taught builder, would have sought to follow the trends coming from Central Europe. Today it is an example of Art Nouveau in this part of the country. The building was affected by a flood in 1979, when the Valada dam, built in 1881, collapsed. We believe that this event has encouraged the abandonment of the building, which led to its current state of degradation, but on the other hand, allowed it to remain unchanged from the original construction techniques.

Therefore, we are facing a rare opportunity to meet an example of erudite construction in adobe, Art Nouveau style, in Portugal. For their decorative exuberance, these buildings usually create a lot of interest, being therefore well preserved. From the description of the architectural features described in this paper, it is clear that the building represents the architecture of the Art Nouveau style. Also, the building construction system seems coherent with this architectural style.

This paper presents a brief architectural and constructive characterization and illustrates some details of this interesting building. The building survey contains a large number and variety of construction details that cannot be presented in their totality in a single article.

The knowledge of the construction system of a classical adobe building could lead to a better understanding of how to build with this material, thus contributing to new ways of building that are more ecological and sustainable.
REFERENCES


