CIENCIAS HUMANAS:

POLÍTICA DE DIÁLOGO Y COLABORACIÓN

5

Edwaldo Costa
(Organizador)

Atena Editora
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Este tercer eBook tiene por vocación posibilitar el diálogo internacional sobre los principales desafíos de la ciências humanas, desafíos que no pueden ser enfrentados sin políticas de diálogo, sin estrategias bien diseñadas y sin una decidida voluntad de acción a nivel científico. Uno de esos desafíos consiste em asegurar una educación de calidad para todos: fomentar el diálogo acadêmico internacional y hacerlo más eficaz constituye una de las estrategias clave para alcanzar este objetivo.

El debate sobre educación, inclusión, informática, síndrome de Down, competence evaluation, mathematical skills, assessment strategies, aprendizaje, ambientes, innovación, modelo suplementario, Moodle, tutor virtual, aprendizaje autorregulado, educational management, educational leadership, learning, gestión educativa, liderazgo educativo, aprendizaje, cambio conceptual, práctica, enseñanza de ciências, discapacidad, inclusión, empresa, reclutamiento, selección, maritime transport, biofouling, marine pollution, protección de datos, vinculación, técnicas de organización, prácticas curriculares, sectores de la sociedade, compasión, sentimientos, emociones, vulnerabilidad, salud, políticas educativas, labor docente, relaciones, autorrealización, estabilidade, ambiente positivo, calidad educativa, estrategias de aprendizaje, población vulnerable, práctica docente, sistematización de experiencias, investigación en educación, enseñanza teórico-práctica, ingeniería química, operaciones unitárias, cultura escolar, adobe/Earth, structures/ renovation y otra, ofrece una oportunidad para reflexionar sobre la sociedad contemporanea.

Finalmente, se espera que con la diversa composición de autores, investigadores, interrogantes, problemas, puntos de vista y perspectivas, ofrezca un aporte plural y significativo a la comunidad científica y profesionales del área.

Edwaldo Costa

SUMÁRIO

CAPÍTULO 19

TRADITIONAL ADOBE BUILDINGS IN THE ALTO RIBATEJO REGION

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ABSTRACT: Earth was the first material moulded by man to build houses, its use dates back to many millennia. Half the world's population currently lives in earth buildings made with different technologies. The most widely used earth construction techniques are *rammed earth, adobe* and *tabique*. The *rammed earth* and *adobe* techniques produce resistant walls. Whereas *rammed earth* forms a monolithic structure made of tamped earth between sidewalls on site, the *adobe* technique consists in small-block masonry made of earth in timber moulds and dried in the sun. The *tabique* technique is used to build non-resistant partition walls of earth that is applied on wood strips, also used in front walls. *Adobe* is one of the oldest building materials, being considered one of the precursors of clay brick. It was used in various parts of the world, especially in hot, dry regions, traditional constructions and buildings of heritage value in many cities. In Portugal, this type of construction is disseminated across various regions of the country, having a significant presence in many historic centres. The 19th-century industrial revolution increased the supply of industrialised materials, which led to earth techniques being gradually abandoned. Recently, with the rise of environmental and sustainability concerns, the use of more sustainable construction processes is being considered. Earth construction, including adobe, meets current sustainability requirements. An understanding of these building techniques is also useful to rehabilitate existing earth structures. This paper describes the peculiarities of traditional adobe constructions in the Alto Ribatejo region. The choice of this theme is justified by the fact that there is a vast heritage in this region, both rural and urban, that is well-adapted to climatic and territorial conditions. In order to preserve this interesting heritage, it is therefore crucial to better understand these construction techniques.
KEYWORDS: Adobe/Earth Structures/ Renovation.

1 | INTRODUCTION

Earth as a building material has more than a thousand years, being adopted in various buildings, from mere dwellings to military and religious buildings. Currently more than half of the world's population lives in earth homes.

Descriptions of building techniques using clay and straw date back to Bible times. In ancient Egypt and Mesopotamia, most buildings were made of adobe - sun-dried clay bricks. Some of the oldest cities in the world are in Iran, many of them made of earth and still inhabited to this day. The Crusades, between the 11th and

13th centuries, contributed to disseminate this building technique across Europe and the European maritime expansion allowed its dissemination through the world (PACHECO, 2009).

In Portugal, there are some examples of earth constructions of which some are in adobe (FERNANDES, 2016). Many need conservation works and consequently an understanding of these age-old sustainable techniques.

The term *adobe* originates from the Arabic word "thobe", meaning sun-dried brick, which suggests that this technique has expanded more across the Iberian Peninsula during the Muslim occupation. Adobe bricks require little energy for production as they are not fired like conventional bricks. They are often obtained *in situ* and are moulded by hand or using manual presses.

Adobe bricks are also thermal and acoustic insulators and therefore contribute to the reduction of energy consumption. Due to its high capillarity, clay is an excellent humidity regulator what causes adobe constructions to create healthy environments (MINKE, 2006).

However, until recently, earth constructions were associated with construction technology of the past, using local and natural resources.

At present there is a paradigm shift, with earth constructions re-emerging all over the globe. In Portugal, especially in the South, we are witnessing the construction of single-family earth dwellings and tourist complexes.

This paper describes examples of adobe constructions in the Alto Ribatejo region providing construction details.

2 | TRADICIONAL ADOBE BUILDINGS

Today there is an interest in raw earth techniques due to the existence of a huge earth building heritage. In mainland Portugal, earth buildings can be found almost all over with an important presence in historic centres. The techniques vary from region to region. The *tabique* technique is essentially used in interior partitions, but also often in upper-floor external walls of buildings in the Douro region, Trás-os-Montes and Beiras, in particular Vila Real, Bragança, Viseu, Guarda, Castelo Branco and Santarém (PINTO, 2010). *Rammed earth*, much used in exterior walls, can be found all over the country, especially in the South, in the Alentejo and the Algarve, particularly in Évora, Beja and Faro. The areas of the country that have the greater number of traditional adobe buildings is Aveiro, Leiria, Santarém and the Coimbra coastline (RODRIGUES, 2006). Ribatejo also has traditional adobe constructions.

Geographically the Ribatejo comprises three natural regions: l*ezíria, bairro* and *charneca*. The *lezíria* comprises the floodplain area of river Tagus and adjacent lands, and includes alluvial soils of excellent quality, where vineyards predominate. In these fertile lands, cereal, melon and tomato plantations can also be found, as well as excellent pastures

grazed by cattle and horses. The *bairro* lies on the right bank of the Tagus (Northern Ribatejo), with low steep-sided hills of sandstone, limestone and clay formations, with shades varying from whitish to brownish, red and orange. In these clay soils are shrub and tree crops, particularly olive trees that coexist with vine, wheat and maize crops. The *charneca* extends from the left bank of the river Tagus to the Alentejo (South of Ribatejo). The area has sandy soils, including vast areas of cork oak forest, as well as eucalyptus and pine trees. However, cereals and vines can also be found, as well as rice in more irrigated areas.

The buildings studied are located in the *bairro* of the Alto Ribatejo, which is rich in traditional architecture, including earth constructions. Similar to the traditional brick masonry construction, adobe can be used both in interior and exterior walls as well as in the extension of existing constructions.

Adobe was not only used in small buildings such as country houses, storages, dividing walls or wells. There are several examples of adobe masonry structures with historical and heritage value, namely religious, military and industrial.

Many of these buildings have been doomed to abandonment due to population migration to the coast, are brought to ruin or destruction because of the increase of the tax burden, in particular the property tax, and also because of the loss of territorial integrity due to abundant and indiscriminate use of eucalyptus plantation.

On the other hand, living in earth buildings is considered non-prestigious, which leads many of these inhabitants to leave them and erect new concrete buildings beside the old ones. These houses are not usually repaired, and an important heritage has already been lost.

However, there are reasons to build and renovate the region's adobe buildings as they are a unique heritage that may provide important know-how that will help build new, more sustainable adobe constructions or to renovate existing ones.

2.1 The system used to buid adobe structures

In order to provide a detailed description of adobe structures of the Alto Ribatejo region, on-site visits have been carried out to collect specific data. We opted for the buildings that were accessible from the interior and that were falling into ruin in order to be able to examine the construction details.

The figure below shows a sectional view of the structural frame of these dwellings.

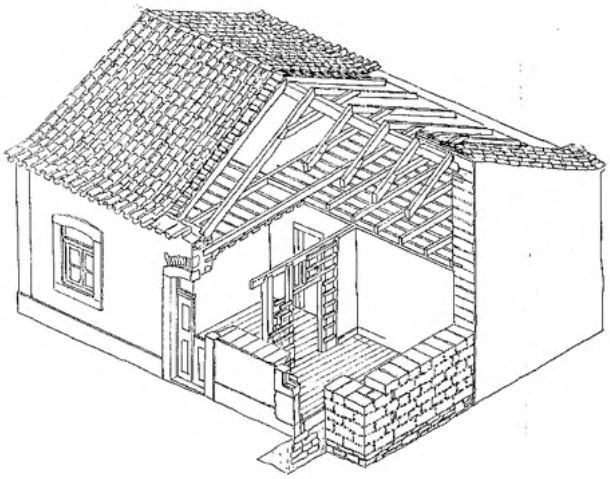


Figure 1 - Traditional dwelling of the Alto Ribatejo region

Simple but intelligent solutions making use of the scarce resources available are often found in adobe constructions.

2.1.1 Building Typology

The design of earth buildings is strongly influenced by their exposure to earthquakes and bad weather (CORREIA, 2006). The main purpose was to prevent the walls from collapsing opting for a regular structure with a dynamic behaviour for better seismic performance Construction plans were regular and symmetrical avoiding long unbraced sections or continuous, asymmetrical items (Minke, 2006).

In this region traditional typologies are very simple, most of them are of rectangular plan of about 10x7.5 meters, differing in room layout and arrangement. The kitchen is usually located in the back of the house and is the largest room as this is where the majority of domestic activities took place. This location has to do with fire safety and the fact that the back of the house was reserved for activities relating to cattle breeding and agricultural work.

In rural settings dwellings have larger areas and are similar in what regards the number of rooms and plan dimensions. The main entrance of the house leads to the living room and the interior spaces are arranged therefrom. In urban areas building arrangement is more limited because construction areas are smaller. Later, for sanitary and public health reasons, sanitary equipment was installed, more often than not, outside existing buildings. Most houses have only one floor.

Figure 2 - Traditional building typology: a) located in urban areas, b) located in rural areas

The figure below shows the arrangement of rooms in rural houses.

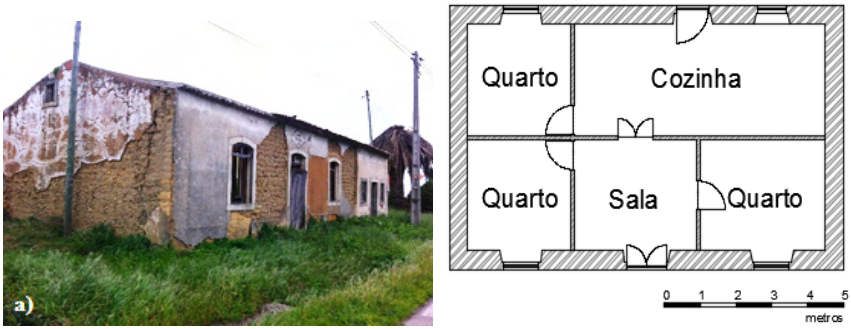


Figure 3 - Traditional building typologies

Rural houses are typically isolated which gives the landscape a unique character. In urban areas they were usually aligned along the roads.

2.1.2 Foudations

In the region under study building foundations are usually made of ordinary stone masonry of variable depth depending on soil type (DELGADO, 2007). Their width may exceed that of the walls and extend up to 60 cm above the ground. Then walls were erected so as to prevent adobe bricks from coming into contact with soil moisture.

2.1.3 Exterior walls

The masonry has different widths depending on the size of adobe bricks and specially the way they are arranged: half-brick, one-brick, one-and-a-half-brick or two-brick (MASCARENHAS,2015).

Here adobe bricks of different sizes can be found but the most widely used are the ones measuring 15x20x46 cm^3 and 13x23x46 cm^3. Half-brick is also used to brace the walls

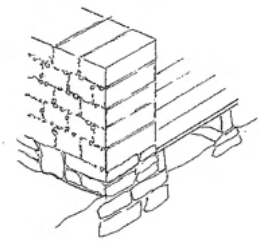
in the corner areas. Many of the bricks found have the peculiarity of having cut off edges, in order to facilitate the introduction of small stones (Fig. 4a) or tile fragments (Fig. 4b) into the joints with the purpose of improving plaster adhesion. Adobe bricks can be made of varying soil types, some of them include natural fibres or a binder such as lime used mainly in sandy, fragile soils.

a)

b)

Figure 4 - Examples of adobe walls of the Alto Ribatejo region

Adobe walls do not follow a particular pattern. The first row is laid directly on the foundation (Fig. 5a) and the walls are built like brick walls. Adobe bricks were laid so as to brace the walls (Fig. 5b) and applied with a mortar mixture made of sand and earth. There was a concern to align the bricks on the corners to ensure that the wall panels were braced. This adjustment was made by using a narrower brick, smaller stones (Fig. 5c) or a stone block.



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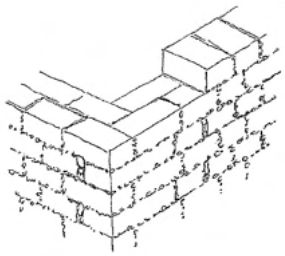

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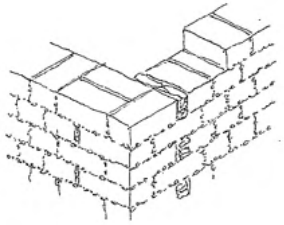


c)

Figure 5 – Construction of adobe walls

In the area below the windows the walls were thinner than in the other areas. There

were several alternative solutions to build this panel: small-size masonry (Fig. 6a); a stone of appropriate size (Fig. 6b) or a massive brick masonry structure (Fig. 6c).

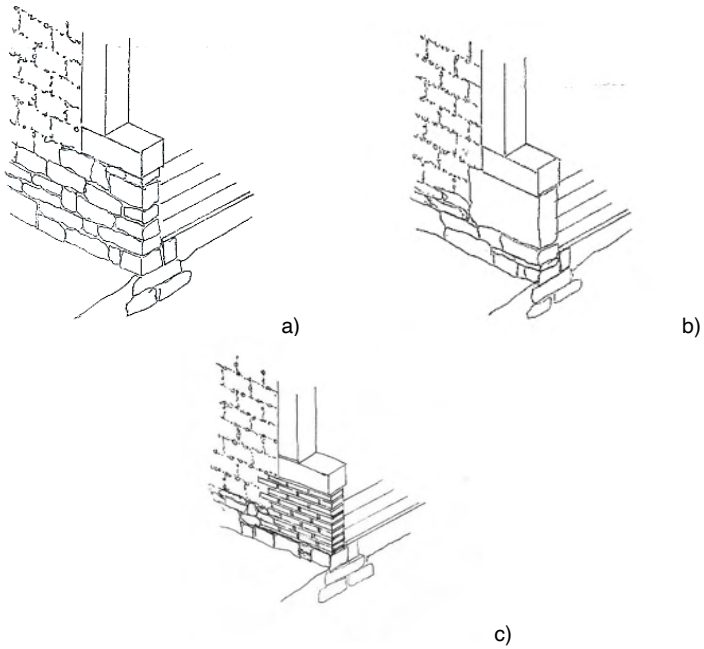
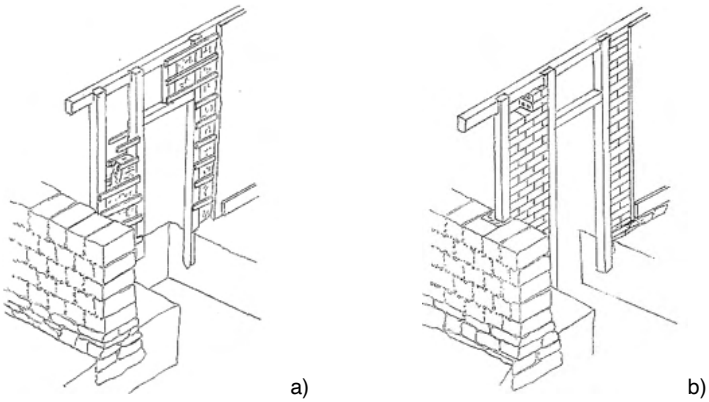


Figure 6 – Construction of the wall panel underneath the doorway

2.1.4 Interior walls

The interior walls are thinner than the exterior walls. They usually are half-timbered, consisting of a gridded wooden structure filled with earth, straw, stone or ceramic tiles. The ends of the horizontal wood beams are embedded in the adobe walls (Fig. 7a). They can also be made of *taipa de fasquio*, massive brick (Fig. 7b) or even adobe. They were then plastered with a mixture of earth, lime and sand. These walls are not designed to confer resistance but to divide rooms, brace exterior walls and sometimes support the roof structure; hence their simple building foundation.



a) b)

Figure 7 - Types of interior walls

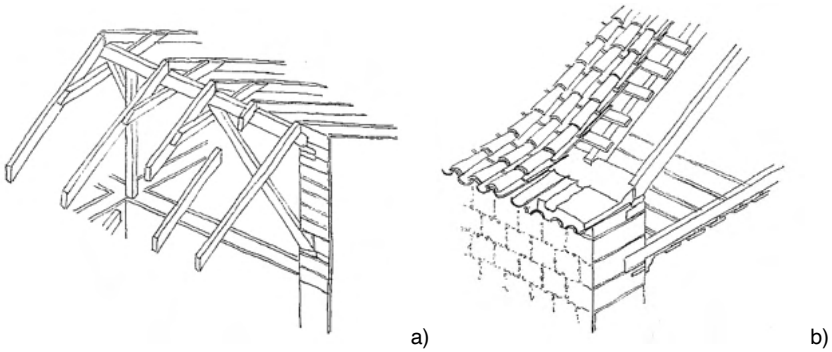
2.1.5 Doorways

In earth constructions, doorways are of small size to minimize heat transfers. Sun protection consisted in installing wood shutters inside the windows that were shut in summer to keep the house cool. Window frames, doorways, lintels, doorframes and doorsteps are made of stone slabs. The stone blocks that make up the lintels rest directly on the doorstep. These stone trims are essential, since metallic bolts were used to secure the wooden frame in place that could not be placed on the adobes, which otherwise would crumble.

Lintels rested directly on doorways and were aligned to the inner face. In areas where there was no stone or for economic reasons the lintels were made of solid brick laid with lime mortar. Typically, in the inner side of lintels was a timber rafter which projected beyond the doorway by 30 cm on both sides. To minimise the effect of the load of adobe bricks on the lintel stone, a spare brick arch was built or the eave was placed immediately above the lintel. On the inside of the buildings, the underside of the lintels was finished with a wooden lath plastered with a mixture of lime and sand to even the surface and then lime was applied as external finish coat. The frames of guillotine or two-leaf windows were made of wood and were fixed to the masonry of doorways. The windows and doors were placed later to allow ventilation for a faster drying.

2.1.6 Roof covering

The majority of the roofs are gable roofs with a simple and light wooden structure composed by a ridge board connecting two gable walls, the rest of the roof structure being laid directly onto the walls (Fig. 8a). The trusses are braced to prevent any outward movement. The rafters are supported by stone elements not to crush the adobe bricks. The roof is of ceramic tiles laid onto the timber lining boards. There is an eave that projects beyond the walls by 40 cm to protect them from rainwater dripping (Fig. 8b).



a) b)

Figure 8 – Example of the type of covering found

Adobe walls can be visible or else be coated with two layers of sand-lime-and- earth mortar. The walls may also be whitewashed directly over the coating with the purpose of protecting it from weather damage, particularly water damage.

2.1.7 Ceillings and floors

The floors of the houses studied are earthen floors coated with a frame of timber girders and beams laid onto brickwork dowels creating a ventilated crawl space over which the timber floor was laid. This type of flooring is mostly found in bedrooms and living rooms. Kitchen floors are unpaved (hard-pack floors) or covered with stone slabs. The structure of the ceilings is also made of timber, with elements of smaller section and therefore lighter. The timber boards placed under this structure, i.e. the lining, had reduced thickness (10 mm). They had mortise-and-tenon joints or the boards were arranged so as to form grooves and tongues. The recessed board is called tongue, and the protruding board is called groove, thus creating two levels. Only the main rooms had ceilings. In the kitchen there was no lining, the cover tiles were visible - unlined tile roof. Here was a fireplace for cooking, smoking food and heating the building. The fireplace consisted of a diagonal timber frame structure that supported the smoke canopy and that rested on one or two wooden columns, depending on whether the fireplace was in the corner of the room or not. The smoke canopy is of considerable size.

Figure 8 – Traditional kitchen and types of smoke canopy

3 | CONCLUSIONS

Earth construction was used at all times and all over the world. Earth is a natural, ecological, recyclable, cheap material and therefore a building material with enormous potential. The earth structures that reached our times are an evidence of the durability of this type of construction.

Earth construction in the Alto Ribatejo region form an important part of the existing adobe structures in Portugal.

We believe that the study in this paper will provide a better understanding of these structures and will give a further contribution to their preservation and renovation.

The study of age-old building techniques contributes to improve traditional building techniques insofar it provides a better awareness of the methods and techniques to be used in the conservation and restoration of earth buildings, a vulnerable heritage that is unprotected and at risk.

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