

ADOBE CONSTRUCTION IN PORTUGAL, THERE IS A FUTURE FOR VERNACULAR ARCHITECTURE?

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Abstract. Adobe is a low cost construction material, locally available with good thermal and acoustic properties and it is also associated to simple building techniques. The majority of the adobe vernacular houses are normally associated with a high quality of space and ambiance. Unfortunately, adobe material and architecture are practically abandoned and underestimated in Portugal. The lack of knowledge concerning the material properties and the social rejection about this architecture are between the main causes of the decay and substitution of vernacular adobe architecture in Portugal.

Since 2005, a research group at the University of Aveiro has been developing work focused on the characterization of the mechanical properties of adobe units and on the structural behaviour of adobe walls. These studies aim to establish a basis of knowledge, essential for the safety analysis of adobe constructions. At the same time, architectural studies conducted by several Portuguese faculties are being developed, in which the research work is focused on the design, and typology and quality characterization of vernacular architecture. These studies are an excellent contribution for the eventual conservation of the adobe architecture and also, for the recognition of the advantages of adobe as a building material, encouraging its use in new architecture. Essentially, for the reduction of the resources consumptions associated with new edifications, that frequently replace the adobe existing ones.

In balance, this paper aims to contribute for the discussion and awareness of the need for preservation of adobe vernacular architecture, as well as to the opportunity of using adobe as a building material for new constructions.

1. Adobe vernacular architecture

The adobe vernacular architecture in Portugal is still not appropriately recognized. The most complete research on this building technology and living is due to Portuguese ethnographers, anthropologists and architects of the mid-20th century [1]. Adobe material and architecture in Portugal appears in valleys, near rivers (as for example: Vouga, Mondego, Tejo, Sorraia, Sado, Guadiana), where the estuaries meet the plains and in areas of the central coastal where the land meets the sea (Atlantic Ocean). Water and alluvial soils rich of minerals, sand and silt, the ideal soil for the adobe production, predominate in these regions [1].

Adobe is a low cost construction material, locally available with good thermal and acoustic properties and it is also associated to simple construction techniques. In Portugal the adobe has only been used in masonry walls, exterior and interior walls, mostly building on parallelepiped rectangular adobes. The skill in building a house lay in the clever way that half

adobes and third adobes were used to close a corner, support eaves and make windows or doors in the walls. Adobe is also used in the building annexes, enclosure walls, and hydraulic systems for agriculture; the most original use has been in the lining of wells. The adobe was produced in slightly curved moulds so as to fit on to the sides of the well.

The majority of the adobe vernacular houses are normally associated with a high quality of space and ambiance. In Portugal were identified almost ten architectural types of urban and rural houses [2].

There is also a great variety of subtypes, and the Mediterranean way of life it's present on the majority of them. From the shelter or basic house, to the complex or compact house we can recognise architectural types with patio and courtyard, urban houses with two levels and rural evolutionary houses [2]. In all of them kitchen has a primordial role in the living space and mostly is rendered, surfaces varying from simple smooth finishing to exuberant and colourful

decorations. This architecture is difficult to identify, as layers of renderings cover the construction. But it can be recognised in central coastal, namely in Aveiro region, because rendering is limited to the public façade, the rest having no rendering at all. Unfortunately, adobe material and architecture is practically abandoned and underestimated in Portugal. The lack of knowledge concerning the material properties, structural behaviour and the social rejection of this architecture are between the main causes of the decay and substitution of adobe vernacular architecture in Portugal.

2. Scientific research

Since 2005, a research group at Civil Engineering Department of the University of Aveiro has been developing work focused on the characterization of the mechanical properties of adobe units and on the cyclic response of adobe walls. These studies aim to establish a basis of knowledge, essential for the safety assessment of adobe constructions and to contribute for the conservation of the adobe architecture. Generally, adobe walls perform well in compression, but have low tensile, bending and shear strength. Attention must be given to the size and stability of the main structural and partition walls, to the support of arches and vaults, pillars and buttresses, as well on the bond conditions between masonry and other structural systems and closures [3]. The research group from the Civil Engineering Department has been involved in an experimental program to characterize the structural behaviour of adobe buildings [4]. Adobe and mortar samples were taken and analyzed, and then the performance of reduced-scale wallets built in the laboratory was studied. The structural non-linear response of adobe walls was also investigated in a series of full-scale tests conducted both in the laboratory and in situ.

The results of the compressive and splitting tests on adobe cylindrical specimens revealed that the adobe compressive strength can vary significantly, with values varying from 0.32 to 2.46 MPa. Tensile strength was found to be approximately 20% of the corresponding compressive strength. Results also indicate that samples with larger fractions of small dimension particles (grain size) have consistently higher strength. Ten mortar samples (two plaster and eight bedding mortar) taken from three different houses were tested in compression. Results obtained for the unconfined average strength of the mortar samples varies from 0.45 to 1.68 MPa.

To estimate the compressive and shear strength of traditional adobe walls, small wallets, $17 \times 17 \times 10$ cm, were built and tested under compression, in the

perpendicular and diagonal directions relatively to the bed joints [5]. To build the wallets, blocks extracted from adobes units were adhered together with mortar that had a similar composition than the local material. The compressive and shear strength values obtained from testing the samples are between 0.77 and 1.57 MPa, and between 0.05 and 0.19 MPa, respectively. The wallets made from adobe blocks with lower compressive strength showed lower shear strength. Transversal modulus of elasticity and shear strength for each series of masonry samples tested were about 1/10th of the corresponding modulus of elasticity and compressive strength values obtained in compression tests perpendicular to the bed joints. Full-scale walls were tested until their collapse, in laboratory and in situ. For each studied wall/construction, two types of tests were performed, namely the dynamic characterization tests, and cyclic tests with increasing horizontal forces (in-plane and/or out-of-plane loading tests).

The most important results obtained from the experimental work address: i) the strength and stiffness of adobe units and mortars, and ii) the strength, stiffness, energy dissipation capacity, and common collapse mechanisms of adobe walls. These experimental results provide a basis for interpreting the typical structural pathologies, for calibrating refined numerical models, for assessing structural safety of adobe constructions, and to design adequate repair and/or strengthening solutions. The results also supply reference values for the design and construction of new adobe buildings.

3. The conservation of vernacular adobe architecture

The studies briefly presented contribute for the discussion and awareness of the need for preservation of adobe vernacular architecture, as well as to the opportunity of using adobe as a building material for new constructions. Essentially, the rehabilitation of this built heritage may contribute for the reduction of the resources consumptions associated with new edifications that frequently replace the adobe existing ones.

There is a future for adobe vernacular architecture in Portugal, because the majority of the architecture typology meet very well the actual requirements for these building typology. Only occasionally examples of spaces/constructions do not meet these requirements, in terms of quality of the spaces and/or structural safety. It's possible and viable the rehabilitation of these constructions, but also, adobe (mechanical and industrial produced material) can be adopted in future new constructions.

References

- [1] FERNANDES, Maria (2005) – Moulded adobe. Earth Architecture in Portugal. Lisbon: Argumentum, 45-49, ISBN 972-8479-36-0.
- [2] LOPES, Maria Conceição; FERNANDES, Maria (2011) - L'adobe au Portugal. Échanges transdisciplinaires sur les constructions en terre crue, vol.3. Les cultures constructives de la Brique Crue. Montpellier: Editions l'Espérou, ISBN 978-2-912261-58-8.
- [3] HOUBEN, Hugo; GUILLAUD Hubert (1994) – Earth construction, a comprehensive guide. London: Intermediate Technology Publications, ISBN 1-85339-193-X.
- [4] VARUM, Humberto [et al] (2011) - Study of the structural behaviour of traditional adobe constructions. Terra 2008, proceedings. Los Angeles: Getty Publications, ISBN 978-1-60606-043-8.
- [5] MARTINS, Tiago; VARUM, Humberto (2006) - Adobe's Mechanical Characterization in Ancient Constructions: The Case of Aveiro's Region - Materials Science Forum, Trans Tech, Switzerland, Vols. 514-516, 1571-1575, ISSN 0255-5476.
- [6] VARUM, Humberto [et al] (2011) - Outputs from the research developed at the University of Aveiro regarding the mechanical characterization of existing adobe constructions in Portugal. Revista Informes de la Construcción, Vol. 63, N. 523, 127-142.