EARTH CONSTRUCTION CONSERVATION: PATHOLOGIES DUE TO WATER

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Introduction
Earth has always been used as a construction material. Even where it is no longer used for new construction, the existent historic earthen architecture is a heritage that must be preserved for future generations.

There is a widespread recognition of the potential of earth construction in terms of ecological, economic, technical and human aspects. However, much research is still needed for the efficient and ethical conservation of this type of buildings.

Technologies and pathologies in earth construction
Earth walls present different construction technologies based on the type of earth of the site and the tradition of the region. The most frequently used technology in Europe was the adobe blocks masonry and the monolithic rammed earth (“taipa” or “pisé”) walls. In adobe masonry walls, there have been identified many differences in the dimensions of the blocks, its constitution and the masonry mortars used. Rammed earth walls, frequently have variations related to the formwork dimensions, the types and materials used in the joints, as well as the material itself (for instance the use of earth with straw, as the English cob walls).

From the analysis of the most frequent pathologies in earth constructions, several deterioration agents can be identified. The most important, concerns the horizontal forces originated by seismic actions but the most frequent, relates to effects caused by water. It is important to characterise the role played by each of the agents, in order to design adequate maintenance strategies.

Pathologies due to water
In addition to the direct effects of water, hygroscopic soluble salts are a significant source of damage. The most common types of these salts in earth buildings are chlorides (especially in coastal areas), sulphates (near to polluted environments) and nitrates (where human or animal contamination is present). These salts currently exist in building materials, migrating with the water and crystallising when it evaporates. Salts cyclic crystallisation/dissolution processes leads to successive alterations of volume, with expansions/retractions which in turn may induce separation between material layers, when open porosity does not allow enough space for those expansions.

In earth construction, salt crystallisation commonly occurs near the interface between the support and the render, resulting in detachment of the render and degradation of the outer layers of the support. The effects may be enhanced by water absorption, which causes a decrease of mechanical strengths and thermal insulation properties.

Considering the problems associated with the absorption of water in earth constructions, the existence of protective barriers assumes great importance. Hence, particular care should be given to renderings.
Earth construction conservation

Ancient earth walls were always rendered for protection and aesthetic aspects. The exception was when the economic standards of the owners would not make it possible. Often the rendering systems were made with decorative purposes, trying to give the surfaces the aspect of having a substrate that was "stronger" and "nobler" than the earth wall behind.

Nowadays, in general, most ancient wall finishes are in poor condition, resulting from either reaching the end of the life expectancy of the rendering materials (always shorter than the wall itself) or from technically incorrect repairs which have speeded up the deterioration of those renders and/or of the wall materials.

The main characteristics of renderings are defined in terms of functional requirements that should be met and the properties that determine their capacity to fulfill them. Some of these characteristics are adhesion to the support, wall waterproofing, permeability to moisture and aesthetics. Since the total satisfaction of all these requirements is not possible (for it would mean having mortars with contradictory properties), a compromise must be sought in order to achieve the best solution. In general, the render must have physical, chemical and mechanical properties similar and compatible to the wall to which it is applied.

It is important to determine the properties of the render to be applied, as well as the earth wall with "in situ" non-destructive tests and/or laboratory tests. These tests should focus on the characterisation of the soils, integrity determination, measurements of compressive, tensile and shears strength, as well as of the modulus of elasticity, capillarity absorption, porosity structure and water vapour permeability.

In many circumstances, cement based mortars are often used as wall renderings. The drawbacks of this procedure are obvious for newly built walls but are even more severe when applied to old earth
constructions. After a short time, the new rendering is lost and the support, instead of being protected, is in fact badly damaged. In fact, the incompatibility between the applied cement mortars and the earth wall often cause mechanical stresses, establishes a water vapour barrier and produces a concentration of salts, which creates internal erosion, detachment of superficial material and partial loss of the render and of the external part of the wall.

The need of a substitution mortar to be applied as render, compatible to the wall, is obvious and could not be met with this kind of binders. Mechanical, physical and chemical compatibility could only be achieved with lime based mortars or earth pastes. Consideration should also be given to the wall finishing. Most of the paints currently used, exhibit low permeability to moisture in comparison to the plasters that should be used on earth construction, which may cause blistering and detachment of these paints. On the other hand, paint solidification is merely the consequence of the evaporation of the solvating agent, in traditional lime "paint", solidification occurs in the crystallisation of the components, which assists with the consolidation of the plaster. Therefore, a traditional paint acts as a protective layer that contributes to the overall performance of the wall rendering. Furthermore, in traditional paints, organic or inorganic colouring products are frequently used, helping to improve durability and aesthetics aspects.

Discussion and conclusions
The protective effect of renders is fundamental for the earth walls conservation. But the compatibility between the earth walls and the applied materials are crucial in terms of assuring the good performance of the system and especially the efficient conservation of the walls.

From studies that have been developed, the analysis and characterisation of some ancient rammed earth walls show that optimized hydrated lime based mortars with pozzolanic components, can be applied as render. The compatibility is assured, the behaviour of the walls in contact with water is beneficiated and especially, the soluble salts resistance is incremented.

In countries where natural pozzolans are not available, artificial pozzolans, developed by thermal treatments of industrial by-products are an efficient technical and sustainable solution. The finishing layer should be achieved with a lime wash system.

Specifications related to the composition, proportions, application and curing of rendering systems are fundamental, in order to achieve a good and durable protection of the walls and assure a better conservation of earth constructions.

CURRICULUM
Paulina Fania Rodrigues received her degrees in Civil Engineering and MSc in Construction from the Universidade Técnica de Lisboa and her PhD in Rehabilitation and Conservation of the Building heritage from the Universidade Nova de Lisboa, where she currently teaches and researches at the Materials and Construction Technologies Division.
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