

# Earth mortars and earth-lime renders

## *Argamassas em terra e rebocos em cal e terra*

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### Abstract

Earth surface coatings play a decorative architectural role, apart from their function as wall protection. In Portuguese vernacular architecture, earth mortars were usually applied on stone masonry, while earth renders and plasters were used on indoors surface coatings. Limestone exists only in certain areas of the country and consequently lime was not easily available everywhere, especially on granite and schist regions where stone masonry was a current building technique.

In the central west coast of Portugal, the lime slaking procedure entailed slaking the quicklime mixed with earth (sandy soil), in a pit; the resulting mixture would then be combined in a mortar or plaster. This was also the procedure for manufactured adobes stabilized with lime. Adobe buildings with earth-lime renderings and plasters were also traditional in the same region, using lime putty and lime wash for final coat and decoration. Classic decoration on earth architecture from the 18<sup>th</sup>-19<sup>th</sup> century was in many countries a consequence of the François Cointeraux (1740-1830) manuals – *Les Cahiers d'Architecture Rurale* (1793) – a French guide for earth architecture and building construction. This manual arrived to Portugal in the beginning of XIX century, but was never translated to Portuguese. References about decoration for earth houses were explained on this manual, as well as procedures about earth-lime renders and ornamentation of earth walls; in fact, these procedures are exactly the same as the ones used in adobe buildings in this Portuguese region.

The specific purpose of the present paper is to show some cases of earth mortars, renders and plasters on stone buildings in Portugal and to explain the methods of producing earth-lime renders, and also to show some examples of rendering and coating with earth-lime in Portuguese adobe vernacular architecture.

### Keywords

Earth architecture; earth-lime renders; plasters.

### Resumo

As superfícies arquitectónicas em terra desempenham um papel decorativo, para além da função meramente protectora dos paramentos. Na arquitectura vernácula portuguesa, as argamassas em terra eram tradicionalmente usadas na elevação de paredes em alvenaria de pedra, enquanto os rebocos em terra eram aplicados nas paredes interiores. A pedra calcária existe apenas em algumas zonas do país e consequentemente a cal não estava disponível, especialmente nas regiões de xisto e granito onde a alvenaria em pedra era uma técnica corrente.

Na região centro litoral de Portugal, o procedimento para extinguir a cal consistia na mistura de terra arenosa com cal aérea viva, posteriormente regada e usada como argamassa e reboco. Este era também o procedimento para estabilizar as terras usadas na produção de adobes. Os edifícios construídos em adobe eram posteriormente rebocados com argamassas em cal e terra e decorados com argamassas de cal em pasta e areia muitas vezes com acabamento colorido em barramento de cal.

A ornamentação do tipo clássico na arquitectura em terra dos séculos XVIII e XIX foi em muitos países influenciada pelo manual de François Cointeraux (1740-1830) – *Les Cahiers d'Architecture Rurale* (1793), um guião francês para a construção e arquitectura em terra.

Este manual chegou a Portugal no início do século XIX, mas nunca foi traduzido para a língua portuguesa. Referências à decoração para as casas construídas em terra são devidamente explicadas neste manual, assim como os procedimentos para a aplicação de argamassas em terra e cal na ornamentação das paredes em terra. De facto essas indicações são coincidentes com as que encontramos na arquitectura de adobe em Portugal na região do centro.

O objectivo deste artigo é mostrar alguns casos de argamassas e rebocos em terra existentes na arquitectura vernácula elevada em alvenaria de pedra e explicar os métodos usados na produção de argamassas em terra e cal, assim como exemplos de rebocos existentes na arquitectura vernácula de adobe em Portugal.

### Palavras-chave

Arquitectura em terra; rebocos em terra; cal.

## ■ Earth mortars and renders

Earth can be used for construction purposes, if it has inherently good cohesion, provided by the presence of clay which acts as a natural binder. Soil or earth is the result of the transformation of the underlying parent rock under the influence of a range of chemical, biological and physical processes related to climatic conditions and to animal and plant life. Essentially the origin of a soil or earth is determined by the nature of the parent rock, the climate, the vegetation and the topography.

Earth is available everywhere and has undoubtedly been one of the most widely-used construction materials in the world. In Portuguese vernacular architecture, earth mortars were usually applied on stone masonry, while earth renders and plasters were used on indoors surface coatings. Lime was not easily available in certain areas of the country, especially on granite and schist regions where stone masonry was a current building technique (figures 1 and 2). Traditionally, earth renders or plasters were used for coating indoors on vernacular stone architecture in Portugal and earth mortar was applied in the construction of stone walls. Different grain size distribution or textures were used for mortars, renders or plasters. The texture reflects the particle sizes contained in the soil and influences the properties of the earth for construction. Each particle fractions - gravel,



Fig. 1 Mozinhos – Penedono (Guarda). Example of vernacular stone architecture.



Fig. 2 Mozinhos – Penedono, indoors earth render.

sand, silt and clay - with a specific set of characteristics can define those of the soil if the fraction is present in adequate quantities<sup>1</sup>. For example: ten per cent clay is enough to give soil cohesive and plastic properties but for mortars a sandy soil is required (with sand predominance of size between 2 mm and 0.08 mm), and for renders and plasters a sandy-clay soil is preferable (with sand predominance of size between 1 mm and 0.06 mm). Coarse sand is required for earth mortars and fine sand for earth renders and plasters.

Local knowledge and traditional know-how was enough to select earth material, gathered from the natural environment, to be applied on building stone masonry. General procedure was to mix earth with water in order to obtain a semi-soft paste. With this homogeneous material it is easy to shape an earth ball which is neither sticky nor soiling and that flattens without disintegrating when dropped from a height of 1 m. Sometimes earth is previously passed through a sieve (10 mm for a mortar or render and 4 mm for a plaster) and mixed with 50 % of sand (coarse and fine sand for mortar and fine sand for render). The quantity of water depends on the clay properties but it is more or less between 16 and 20 % of the mixture.

On Portuguese vernacular architecture built on stone masonry, particularly in the Beiras region, earth renders and plasters were used on indoors surface coatings. The procedure was called “barrar” the house, and it

<sup>1</sup> The classification of grain sizes adopted is ASTM-AFNOR, standards are as follow: pebbles (200-20 mm), gravel (20-2 mm), coarse sand (2-0.2 mm), fine sand (0.2-0.06 mm), silts (0.06-0.02 mm), fine silts (0.02-0.002 mm) and clays (>0.002 mm).

means to apply a single thick or thin layer of sandy-clay plaster on a stone wall [1]. Its thickness varies between 2 to 4 mm.

Earth renders and plasters were applied to dry stable walls which were prepared. The preparatory phase in applying rendering was carried out with particular care. The support was rid of all loose and crumbling material, dust, and it was brushed with a metallic brush. In order not to reduce the adhesion of the rendering, the wall was moistened to avoid capillary suction, but not too much. Indoors surfaces used earth plaster in a single-coat applied with the hands, sometimes smoothed with the laying-on trowel and the float. In general, interior finishes are often smooth, to diminish the adhesion of dust produced by activities inside. A mixture of earth, cow dung and water was also used as a mortar to cover the floor.

Only a few examples of these renders and plasters still remain on some decayed Portuguese houses of the Beiras region. This technique of rendering and plaster with earth in Portugal has disappeared a long time ago, since these houses were abandoned by their inhabitants on the mid-20<sup>th</sup> century.

### ■ Earth-lime renders and plasters

Apart from their wall protection function, surface coatings play a decorative architectural role. The main functions of a protective coating are:

- Protection of the wall against bad weather and impact;
- Improvement of appearance by hiding the imperfections of the wall;
- improving thermal comfort, specially indoors;
- giving an attractive decoration, ornamentation and colour to the surface [2].

Adobe buildings in Portugal appear in valleys near the rivers, like Tejo, Sado, Mondego and Guadiana, and central coastal area, Beira Litoral and Estremadura Setentrional.

Most of the Portuguese adobe architecture is rendered, surfaces varying from a 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 the Beira Litoral region because rendering is limited to the public façade, the rest having no rendering at all [3].



Fig. 3 Oliveirinha (Aveiro), workshop V ATP Slake the quicklime, already mixed with earth.



Fig. 4 Oliveirinha, workshop V ATP, the adobe production. Earth stabilized with lime.

In the central west coast of Portugal the lime slaking procedure entailed slaking the quicklime mixed with earth (sandy soil), in a pit; the resulting mixture would then be combined in a mortar or plaster (figures 3 and 4). The lime needs to be in small lumps so it can be accurately batched by volume against the earth. The process requires time and space. The technique has, however, a distinct advantage over more familiar mixing procedures, consisting of an early marriage between binder material and aggregate, which encourages the covering of all the aggregate particles with a lime paste in a way and to a degree which can never be matched by conventional modern mixing [4]. Adobe buildings with earth-lime



Fig. 5 Oliveirinha, workshop V ATP. Earth-lime mortar.



Fig. 7 Vilamar 1, architectonic surface detail.



Fig. 6 Oliveirinha, workshop V ATP. Rendering adobe wall with earth-lime render.



Fig. 8 Vilamar 2, decoration detail.

renderings and plasters were also traditional in the same region. Lime was used for stabilizing earth material because of its action on the clay particles of the soil (figures 5 and 6). The effect of lime on earth material is to reduce the voids of the earth material and to modify the links between the particles. The clay acquires a flocculated structure, which the calcium ions provided by the lime forming contacts between grains. The clay-lime reaction results in the appearance of new crystalline structures which glue the earth particles together. This phenomenon occurs after a fairly long time [2].



Fig. 9 Martingança (Leiria), adobe wall detail.

## ■ Case studies: Vilamar and Martingança

The three samples of earth-lime renders from adobe buildings in Portugal (the case studies from Vilamar and Martingança) are good examples of the above described phenomenon (figures 7, 8 and 9). On both case studies, mortar procedure was to slake the quicklime mixed with the earth which was combined with plaster for rendering. The difference between those houses was the adobe material and the joints mortar of the masonry. On Vilamar houses adobe was stabilized with lime and masonry joints were built with earth-lime mortar; on the contrary, the Martingança house was built with adobe without stabilization and the masonry joints were built with earth mortar. The houses from Vilamar (Cantanhede-Coimbra), built on 1931 and 1932, are from the architectural type Gandaresa house, a courtyard house with a decorated public façade and no rendering on the other façades. The house of Martingança (Leiria), built perhaps on 1920 or 1930, is from the architectural type house with an integrated porch, completely rendered, without decoration and without differences among façades.

The decorated façades from Vilamar houses, Vilamar 1 and Vilamar 2, present a rendering in two coats. The anchor coat, the first one, is an earth-lime render which thickness ranges from 2 to 4 mm and its surface has a rough appearance; the second coat is a lime-putty layer with a 1 mm thickness. Some coloured lime-wash layers are also visible as wall finishing over the second coat. The ornamentation or decoration in relief applied over the first coat, exclusively on the top, base and angles of the façade, is a plaster rendering built with lime-putty and fine sand which thickness ranges from 3 (column) to 4 mm (cornice). Some iron pleats act as anchor points between the wall and the reliefs.

The Martingança house walls have renderings in two coats with a wall finishing on multiple layers of white lime-wash. The first and second coats of renders are very similar in what concerns grain size distribution, their thickness ranging from 1 to 2 mm. It is visible, on the Martingança case, the poor adhesion of the render to the support. The main reason for this defect is the structural tension between the earth wall and the earth-lime render (figure 9).

Maybe if the masonry joints were built with the same material as the render this deficiency would not have taken place. That is what has happened in the Vilamar houses, where there is a complete adhesion between the support and render.

In what concerns rendering decay there are some differences between Vilamar houses. Vilamar 1 has numerous symptoms of render decay and their causes are multiple. For example: it is visible the render crumbling on the wall base caused by rising damp, the small craters pitted on the surface of the rendering, the presence of cracks and the surface maintenance with unsuitable materials like cement (figure 7). In Vilamar 2 there are also symptoms of rising damp and render crumbling on the wall base; cracks are caused by structural defects in foundations and by the presence of efflorescences on the wall (figure 8).

The difference on grain size distribution on the first coat of render can explain some of these differences between Vilamar 1 and Vilamar 2. The crumbling on the Vilamar 1 render and the presence of small craters on the surface are directly caused by the unbalanced grain size distribution of the render with a high percentage of coarse sand and silts. On the Vilamar 2 render the grain size distribution is much more balanced.

These three houses were abandoned a long time ago. Unfortunately this is the most common situation for adobe architecture in both regions. The emigration, the new uncharacteristic architecture, and the prejudice against adobe architecture are the main reasons for the abandonment and in consequence for the destruction of this vernacular architecture.

## ■ François Cointeraux (1740-1830) and the earth-lime renders on earth architecture

François Cointeraux was a French builder from Lyon, France. He was the author of 72 fascicles or edition pamphlets about earth architecture and the responsible for the renovation of these traditional building techniques in France and, later, in many other countries<sup>2</sup>. The purpose of this movement in the 18<sup>th</sup>-19<sup>th</sup> centuries was to provide cheap, healthy, incombustible and durable

<sup>2</sup> The original documents are available on the French National Library. Photocopies and micro-films of all this documentation are also available in CRAterre (International Centre for Earth Architecture) in Villefontaine, France.

housing. François Cointeraux's writings were translated into various languages and published in United Kingdom, Germany, Denmark, Italy, even Australia, and played a important role in spreading the earth techniques in these countries [5].

References about earth-lime renders and plasters on earth architecture can be read on the 1<sup>st</sup>, 2<sup>nd</sup> and 4<sup>th</sup> "Cahiers d'architecture rurale" and on the specific fascicle "L'Art de peindre a fresque sur le pisé", whose author is François Cointeraux. Renders based on mineral binders like lime should be applied in several coats, at least two, but preferably three: a first anchor coat, an uncracked second coat and a finishing thin coat, with the thickness of each coat diminishing towards the surface. François Cointeraux knew exactly the problems between an earth support and an earth-lime protect coat. On the "L'art de peindre sur le pisé" he researched the theme and concluded that anchor points are always necessary between earth support and mineral coat. On adobe walls, the fragments: flakes of stone or broken pottery could be inserted in the fresh joints mortar. This solution is very common on adobe walls in Portugal, when the adobe is not stabilized with lime. For rammed earth, anchoring points of the same composition as the rendering can be also provided. Layers of lime mortar or lime included in outer thickness of rammed earth could act like anchor points [6]. François Cointeraux discovered this solution for rammed earth when he compared the behaviour between an earth-lime render over an adobe wall and over a rammed earth wall. On the second case the rendering could be easily scratched; on the contrary, the render over an adobe wall had a good adhesion to the support. The other discovery made by François Cointeraux concerns the composition of the earth-lime render. If the composition of the joint mortar is the same as the rendering's, the adhesion between wall and render is better.

Another function of the wall protection surface coatings is the decoration and the ornamentation. This aspect of rendering in finishing and decorating adobe buildings is apparent in many countries and has been exploited for one or two hundred years in Portugal. The variations on geometric decoration, painted, sculpted or moulded in the thickness of the render, are numerous. On the other hand, some decorations are simple, like the coloured layers in lime-wash over the adobe walls or over earth-lime

render coats. François Cointeraux refers this aspect on the "4<sup>th</sup> Cahier d'école d'architecture rurale", with drawings of two situations: "maison de terre ou pisé décorée" and "la même maison de terre sortant de la main de l'ouvrier" [5] and also with a funny dialogue between the wall and the decoration coat, where the social differences among habitants were mentioned on the decoration motifs of their rammed earth houses [6].

The motifs of the decoration on a bourgeois house described by François Cointeraux are exactly the same as the farmer adobe houses in the Beira Litoral region in Portugal. Cornice on the top, pilasters, columns, and reliefs on the surface and a base course in a different texture and thickness are the motifs of the earth-lime renders and plasters. Different iron nails act as anchor points between the render coat and the decoration. Vilamar adobe houses are examples of this decoration and we can also find geometric and Art Deco ornamentation on the Gandaresa houses.

There is no clear explanation for this coincidence, only some hypotheses. The François Cointeraux "Cahiers" arrived to Portugal in the beginning of the 19<sup>th</sup> century, but were never translated to Portuguese. The know-how of these techniques from the builders on the region, the influences from France and from the emigration, especially from Brazil and North America, could explain this decoration and the solutions for rendering adobe buildings in Portugal.

## ■ Conclusion

The Gandaresa house is an adobe architectural house type, with a great quality of space, construction and architectural characteristics. Unfortunately the majority of these houses are abandoned and only a few examples were restored and still habitable. On the other hand, the house with an integrated porch is a poor adobe house, without architectural quality and unsuitable to nowadays use. The majority of these houses are also abandoned. It is essential to stimulate the discussion of the importance of value-based criteria. Perhaps the house with an integrated porch has no place in the present landscape of Portugal.

The use of earth mortars and renders in Portugal never surpassed a vernacular and regional craft, abandoned many years ago and replaced for lime mortars and

renders recently. The technology of this technique was not developed, and it is disappearing, like the vernacular dwellings built on stone masonry and earth. Measures to be implemented should considerer practical intervention to conserve the vernacular buildings, and a combination of traditional and modernity in the restoration of this architecture. Earth mortars and renders can be of use in the future, but not in a traditional way like it was in the past.

In what concerns earth-lime renders, the procedures for rendering adobe walls in Portugal have not been enough researched. The study and research associated to this subject of conservation investigation have been sporadic and characterized by the use of inadequate criteria and measures to guide their effort. Recent research on the Aveiro University is a successful example in Portugal. They designed and implemented a complete programme which analyses different aspects such as: existing pathologies of adobe buildings before conservation, laboratory analysis of the composition of earth and its stabilisation with lime, study and documentation of the adobe buildings on the Aveiro region, the compatibility of conservation materials for the application on adobe buildings, and finally a social involvement of the community with the Aveiro city council on the conservation and preservation of the adobe cultural heritage [7-8].

Still, it would be an illusion to treat such matter as indicative of success. In conclusion, a coherent and methodological programme of action to prevent decay and improve living conditions in the adobe Portuguese architecture should be undertaken.

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