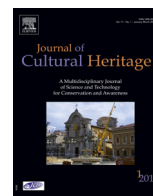




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Review

Lime render layers: An overview of their properties



María del Mar Barbero-Barrera^{a,*}, Luis Maldonado-Ramos^{a,1}, Koenraad Van Balen^{b,2},
 Alfonso García-Santos^{a,3}, Francisco Javier Neila-González^{a,4}

^a Department of Construction and Technology in Architecture, Universidad Politécnica de Madrid, Avenida Juan de Herrera, 4, 28040 Madrid, Spain

^b Department of Civil Engineering, Katholieke Universiteit of Leuven, Kasteelpark Arenberg, 40, box 2448, 3001 Heverlee, Belgium

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ABSTRACT

Lime renders are of great importance not only to enhance the appearance of the buildings, but also to protect and preserve old masonries. They constitute a specialized system, composed of several layers, in which each of them depends on the others and carries out some specific functions in order to assure a suitable performance of the whole. Knowledge of the traditional materials and techniques, as well as the *know-how*, is one of the key points in the maintenance and conservation of lime renders and, by extension, of our Heritage. However, the promotion of the use of cement and the industrialization process, which in the case of Spain took place about the 1960's, caused lime mortars to fall into disuse. In this article, classical treatises as well as the state-of-the-art researches were analysed to compile the properties of lime render layers, on the whole. The knowledge of these characteristics is essential to maintain and repair the existing renders as well as to formulate new compatible ones, while assuring their durability and appropriate performance. Lime is the selected binder for these recommendations because it was widely used as drawn from the literature.

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1. Research aims

The knowledge of lime renders layers is basic to repair and renovate the existing renders as well as to design new compatible ones. Hence, the aim of the research was to compile properties of the lime renders layers, based on recommendations of classical treatises, last decades' manuscripts as well as empirical experience. It can be considered an add-on to RILEM Technical Committee 203-RHM's paper [1], as it completes the render layers requirements, on the whole, in a referenced and analysed way.

2. Introduction

In order to allow the future generations to enjoy the cultural diversity of our society, we should focus on the conservation and preservation of our built heritage. Hence, the knowledge of traditional materials and techniques is a matter of vital importance, in order to achieve a criterion to select the most appropriate one in any circumstances. This aspect is captured as earlier as 1975

with the Declaration of Amsterdam in which the fact that “steps should be taken to ensure that traditional building materials remain available and that traditional crafts and techniques continue to be used” [2] is emphasized, and are enclosed in the following ICOMOS's documents [3–5].

On the other hand, renders play an essential role in the conservation and maintenance of buildings. Their application has not only an aesthetical reason but also the preservation and reduction of the wall's deterioration, acting as a “sacrifice” element [6,7]. The population's impoverishment and the architect's disdain for hiding the construction were the main reasons for the loss of renders that, in the case of Spain, took place in the postwar period [6,8].

Concerning binders, lime is mentioned in texts as diverse as the Old Testament [9]. Lime renders had been found in archeological sites of Sirian civilizations dated from 4250 B.C. [10], Chinese dynasties from 2000–1700 BC [11,12] as well as in Mayan, Inca and Aztec constructions [13,14]. The finding of a limekiln in old Mesopotamia revealed that limestone calcination appeared in 2450 B.C. [15]. And, the use of lime was extensive up to, in the case of Spain, the middle of 20th century as the literature reveals from the use of limekilns [16–18]. In comparison to other European countries, this delay in the loss of traditional materials and techniques as well as their recovery was due to the isolation of the country.

Hence, a gradual substitution of lime by cement was observed since the end of the 19th century and the beginning of the 20th century, in such a way that applications, originally performed by lime, began to be overspread by cement. Regarding this, the

* Corresponding author. Tel.: +34 91 336 44 10; fax: +34 91 336 65 60.

E-mail address: mar.barbero@upm.es (M.d.M. Barbero-Barrera).

¹ Tel.: +34 91 336 65 50; fax: +34 91 336 65 60.

² Tel.: +32 16 3 21172; fax: +32 16 3 21976.

³ Tel.: +34 91 336 42 46; fax: +34 91 336 65 60.

⁴ Tel.: +34 91 336 42 40; fax: +34 91 336 65 60.

turning point in the use of lime as a binder can be found in the middle of the 18th century when the scientific researches advanced to ascertain the setting process in hydraulic binders. In 1756, Smeaton found out that the main factor for a mortar to set in water was the clay content in the limestones [19–21]. In 1796, Parker patented a hydraulic lime called “Roman cement” or “English cement” and, in 1800, Lesage did so with a mixture of cement and gypsum, meanwhile Sanssurre pointed out the amount of silica and alumina to set under water [19]. However, it was not until 1812 that Vicat stated the reasons for the hydraulic behaviour from a scientific point of view. In 1824, Aspdin patented the Portland cement which was similar to Parker’s cement [20]. However, according to T. Alberti, “the origins of the real industry of moderns cement are from this period and this patent, since the first factory and the first book on cement manufacture date from 1828” [19]. In 1835, Johnson increased the calcination temperature and sieved the calcined material to get the Portland cement [20]. In 1948 Millington mentioned Vicat’s findings about the fabrication of artificial hydraulic lime [22]. Then, a whole section of Fontenay’s one provided information about the artificial hydraulic lime in which Vicat was quoted: “It’s no longer [...] about a laboratory experiment but rather a new art taken almost to perfection” [23]. In 1859, Espinosa dealt with cement at great length and gathered the tests conducted by European researchers. And, in 1870, Valdés described cement as a common material used in renders and plasters [24] and as a leak-proof coating with cement or hydraulic concrete in vaults “in order to prevent leaks from rainwater” [24]. This waterproof property of the cement was highlighted in different parts of the treatise and observed as well in Rebolledo’s 1875 treatise. Although, lime was also mentioned in the description about the execution of renders and plasters [25]. In 1923, T. Alberti still showed the importance of aged-slaked lime, although he encouraged the use of hydraulic lime and cement [19]. This exaltation of the cement is also pointed out by Barberot in 1927 who wrote that “cement is commonly used in all the important constructions, mainly when they should be carried out in a short time” [26]. And, in the same year, M. Martínez-Ángel reported the abandonment of the practice of the traditional render [6]. Finally, the technical regulations were the last token of the lime replacement. In 1948, the Spanish standard “Pliego de Condiciones de la Edificación”, cement appeared explicitly “to prepare the support, a creamy consistency of pure cement of 3–4 mm of thickness should be applied over the old masonry; and, after three hours, the render could be executed” [27]. Furthermore, in the description of some specific types of render, for instance the petrous ones, white cement is the only binder mentioned, excluding by omission the use of lime [27]. Hence, the exaltation of the properties of cement mortars, their acceptance by the technical regulations as well as the lack of systematic and scientific researches about the traditional lime mixtures, promoted the latter’s fall into disuse. It was followed by the loss of traditional techniques and materials which, in renders, was favoured by the secrecy regarding its execution.

In the 1990’s, the large amount of damages come about in historical constructions facilitated a return to lime mortars in restoration and renovation works. The properties of cement that were initially praised were not compatible with the old masonries. Especially, their higher mechanical strength, that makes them brittle and stiff, their lower water vapour permeability and the transfer of soluble salts to the support [11,28–49]. In spite of that, in the case of Spain, the conservative trend in construction, the late industrialisation process and the increase of the labour cost explain that most of the renders, that are executed nowadays, are industrial. Hence, traditional renders are allocated to the buildings placed within protected areas, where the town-planning regulations require the conservation and maintenance of the existing renders. This implies the loss of the renderer and plasterer trades

as well as the *know-how* [37,50–52]. However, the outstanding problem is the rejection towards traditional materials and techniques because of their handcrafted nature.

In order to prevent the loss of the popular knowledge, scientific researches are brought closer to the society by publications of different Institutions [11,31,32,53] as well as technical committees such as RILEM TC 203-RHM. The present article can be considered an add-on to the paper published by the latter, specifically about renders and plasters [1], as it completes the render layers requirements, on the whole, in a referenced and analysed way. These recommendations are distilled from last decades’ researches as well as the empirical experience of the crafts gathered in classical treatises. The knowledge of such characteristics is “de rigueur” to repair and renovate the existing renders and to design new compatible ones.

3. Discussion

Traditional renders are commonly carried out in three “layers”, broadly defined [6,11,12,29,31,51,53–79]. For instance, Vitruvius specified three “groups of layers” with a total of seven layers: *truslatio* (with rubble), three of *arenato* (the higher the total thickness, the higher the durability) and three of *stucco* (sand and marble powder). However, they received different names depending on the author: rough cast, *arenato* and render or *stucco* [6]; rough cast, render and finishing [63], rough cast, *truslatio* and *arenato* [11] or, in French, *accrochage*, *fond* and *finition* [66]. In contrast, Perrault obviated the base layer and, according to him, the renders are composed of the three layers of sand and lime and three of *stucco* [57], statement that is generally accepted nowadays [80]. In any case, it is clear that renders are composed of different layers which provide more strength and durability [56,57] as well as water protection capacity [81].

Each one of the render “layers” performed a specific function [65]. The base layer is in charge of contributing to join the support and the render as well as to homogenize the surface of the support [29,31,53,56,61,69], which implies the rectification of the irregularities [53,60,62,64]. The intermediate layer corrects the defects of the base and finishing ones [31,56,60,61]. The last one contributes to the colour and finishing of the surface and restricts the weathering and erosion phenomena [29,31,56,60,61,69].

From a mechanical point of view, strength of the mortar should be similar or lower than that of the support over which it is applied. This means not only the masonry wall but also than the previous render layers [11,28,29,66,69,75,82,83]. The placement of a layer with higher strength over one with less strength will cause additional stress over the base layer, provoking its rupture and detachment. At the same time, the deformability capacity and hardness should increase outwards [11,29,71,82] to counteract any variation of temperature and humidity movement as well as in the support [84].

From a hygrothermal point of view, water vapour permeability should be as high as possible. It should increase outwards and will be similar or higher than that of the support [34,52,65,84–86] to promote the water vapour flow through the overall constructive system. Its retention in any of the render layers will imply their detachment and degradation. Moreover, the finishing layer should be able to easily evaporate the rainwater [1,28,76,81,87]. Therefore, the capacity of water absorption, by capillarity, of each layer and the amount of pores should increase outwards [1,31,85,88–90], meanwhile, the pores’ size should diminish. The latter guarantees that the water, leaked from the finishing layer, does not seep inwards [1,31,66,87,91]. These criteria have a significant effect on the renders’ durability and, from the point of view of the salt crystallization, the render acts as a “sacrifice” element [87].

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