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Substitution ventilated render systems for historic masonry: Salt crystallization tests evaluation

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HIGHLIGHTS

- Water repellent in outer layer increases the salt accumulation in base layer.
- The grooves enable the use of a water-repellent on the outer layer.
- The grooves reduce the surface damage without risking the substrate salt accumulation.
- Salt accumulation in the support does not seem to be induced in the tested specimens.

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ABSTRACT

The treatment of rising damp in historic building walls is very complex due to the thickness and heterogeneity of the walls. Some techniques, such as watertight barriers and injection of hydrofuge products, that have been used until now to deal with rising damp, are sometimes ineffective, justifying the need for a new approach. When there is the presence of rising damp with soluble salts the solution to the problem may involve a higher level of complexity. Salt damage is one of the major causes of render decay, not only near the sea but also in continental areas. Salts can appear in the walls from different sources: from the ground due to rising damp, carried by the wind or fog as salt spray, by flooding, or they can originally be present in the building materials themselves as is the case of unwashed beach sand. Salts crystallization depends on several factors including salt transport behavior of the substrate/render and the surrounding ambient environmental severity (temperature and relative humidity). An experimental program was developed using six different small scale specimens with traditional bricks as substrate, rendered on both sides with several optimized render systems. These specimens were submitted to several cycles of dissolution/crystallization with a NaCl solution due to the common presence of this salt in historic buildings. Particular attention is given to the influence of different renders when contaminated with NaCl and to the location of sodium chloride crystallization in the test specimens. The final goal of this study is the development of a replacement render system called “ventilated render” (“emboço ventilado” in Portuguese) for historic constructions with renders damaged due to the presence of high moisture content and soluble salts. The ventilated renders have two layers (base and external layer) which are supposed to act as an accumulating system in which the salt is induced to crystallize in the base layer (executed with vertical grooves) of the render and not in the masonry nor in the external layer.

1. Introduction

In historic buildings rising damp can be considered one of the major causes for the buildings’ decay [2]. Rising damp occurs due to the capillary suction in porous masonry materials such as brick, mortar and stone. The strong affinity of water with the capillary pores in the masonry and the lack of capillarity barriers draw moisture up into the walls from the ground and make rising damp a very damaging mechanism [2,6].

When water rise is associated with the presence of soluble salts, the result may be particularly severe with an extensive decay of the masonry materials and/or of the renders on the walls (Fig. 1).

In this case rising damp may carry dissolved soluble salts up into the walls where cyclic wetting and drying may take place

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Fig. 1. Decay of renders on the walls due to the presence of soluble salts.

due to temperature and relative humidity variations. Consequently crystallization happens, in the form of efflorescence, and as cryptoflorescence within the pores of the masonry. When there is cryptoflorescence, the detachment of a render layer or of the render from the masonry may occur. When there is efflorescence, lacunae or loss of cohesion (sanding or crumbling) may occur in the evaporation zone [12].

To effectively deal with the problem there is the need to deal with rising damp and hygroscopic salts. On the one side, it is known that in many cases even when the rising damp is cut off, hygroscopic salts can still dissolve and recrystallize due to changes in the atmospheric humidity (the hygroscopic nature of salts attracts water from humid atmospheres leading to their dissolution and an apparently dry wall becomes suddenly damp). On the other side, the techniques that have been used to minimize the effects of rising damp, such as physical, chemical and electroosmotic barriers [9,11], have been demonstrated to be, in most cases, difficult to apply and considered ineffective due to the great thickness and heterogeneous composition of historic masonry walls. Ventilation at the wall base, due to the difficulty of access or to the existence of render is not sufficient in itself to eliminate the problems of capillary rise [12,11]. The development of transport and accumulation systems [5,10] have demonstrated partially good results, but it is still necessary to test their effectiveness considering the support, the render and in-situ conditions.

In this study, an innovative render solution was developed and its performance analyzed. It is to be used as replacement render for salt laden historic masonry in the presence of moisture due to capillary water rise. The system "ventilated render", is a two-layer render (base and outer layer) acting as an accumulating render system in which the salt may crystallize in the base layer of the render, avoiding contamination of the substrate and of the outer layer. It is intended to assess that the render system: (i) does not allow crystallization within the masonry; (ii) has higher durability compared with other renders existing in the market, because it allows crystallization inside vertical "grooves"; (iii) does not cause damage to the outer layer contributing to good external appearance.

Six different small scale specimens were executed using traditional solid bricks covered on both sides, with different renders. Four render solutions, intended to work as accumulation renders, were executed with vertical grooves in the base layer. The render/-plaster systems were tested in combined render-brick-render specimens in order to enable a reproduction of real situations and to verify degradation on the interfaces.

This research has been focused on the effects of salt crystallization tests on the salt distribution in the several layers of the render systems and in the location of NaCl crystallization after salt crystallization tests and damage patterns.

2. Salt crystallization tests

2.1. Aims

Salt crystallization tests were performed in order to compare the performance of different render systems, especially developed to resist the severe action of water, applied on the same type of substrate and submitted to the same environmental conditions. In this article the results obtained on specimens are presented with the objective of evaluating the influence of those render systems on the salt accumulation on the substrate and damage patterns on the outer surface.

A salt crystallization test has been carried out in the laboratory to check the salt resistance of different lime based render systems under the same conditions [4]. This article uses the results of this test carried out on rendered specimens with the objective of evaluating the influence of those render systems on the salt distribution and damage patterns.

2.2. Materials and methods

The experimental study described in the present paper was carried out at the Wall Covering Unit of the National Laboratory for Civil Engineering (LNEC) in Lisbon.

The "ventilated render" system is composed of two layers (a base layer with vertical grooves and an outer layer), with 2.5 cm total thickness (Fig. 2). The bottom and top of the grooves are exposed to outside air allowing circulation of air within the grooves. A grid was used between the base and outer layers to avoid filling of the grooves.

Besides these systems, two render systems without grooves (Fig. 3) were also evaluated under the same test conditions for comparison purposes.

The tested specimens are traditional solid bricks rendered with the render system in both larger sides, to simulate internal plaster and external render (composed by one or two layers with different mortars compositions – Table 1) on brick masonry, developed to resist salt laden substrates in high humidity conditions [2].

Lime mortars were specially designed in collaboration with Fradical company [3] using lime putty, pozzolanic addition, another mineral addition used to increase the pozzolanic reaction velocity, and calcareous sand. Based on previous work [8] the pozzolanic addition used which has a low reactivity, and was incorporated in three different proportions, 4%, 8% and 10% of the whole mix by volume.

The specimens were sealed on upper and lateral sides with a commercial waterproofing paint, to stop evaporation at those locations and thereby promoting the unidirectional migration of moisture through the render system. Using the different types of layers shown in Table 1, six different render systems were tested (Table 2