MICROSTRUCTURAL AND PHYSICAL-MECHANICAL ANALYSIS OF THE PERFORMANCE OF NANOSTRUCTURED AND OTHER COMPATIBLE CONSOLIDATION PRODUCTS FOR HISTORICAL RENDERS

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Abstract

This work is inserted in a wider project aiming at the conservation and durability of historical renders, through compatible techniques and materials; in particular the restitution of cohesion of historical renders is studied.

Surface consolidation, directed to restore cohesion and stability, is based on the use of materials with aggregating properties. This operation is reached usually through the use of inorganic or mineral consolidants, which are preferred to organic ones, due to better compatibility and durability.

Based on the results of previous studies, two mineral compatible products were selected: a commercial dispersion of nanoparticles of calcium hydroxide in propanol and a calcium-silicate product, consisting on a limewater dispersion of ethyl silicate.

Consolidation products were applied on mortar specimens (mortar prisms and mortars applied on bricks) in order to assess their efficacy by determining their microstructural and physical-mechanical properties, before and after consolidation treatment. A low binder ratio mortar was studied with both consolidants.

Microstructural (optical and SEM microscopy) and chemical analysis of the consolidation products and of the consolidated samples were performed; physical-mechanical analysis, namely superficial hardness is reported.

Keywords: Consolidation products, Compatibility, Nanoproducts, SEM/EDS

Introduction

Materials for architectural restoration must be compatible with the pre-existing ones, not only in terms of physical-chemical properties, but also concerning the aesthetic point of view, since the architectural surface materials actually transmit the building image (Brandi, 2006); the conservation of the structural materials helps to preserve the city's image and place identity (Norberg-Schulz, 1976; Tavares [a], 2009).

Great part of the historical and artistic materials haven't an homogeneous structure, and porous materials such as mortars, obtained by a mixture of lime and aggregates, are inherently heterogeneous for the internal micro-porosities between the micro-elements which constitute the mortar.

A common degradation phenomenon is the loss of cohesion of the binder-aggregate system, which is usually followed by the alteration of the visual aspect and colour, deposition and formation of new products, loss of material from surface and loss of mechanical strength.

The loss of cohesion can happen by the cumulative effects of mechanical deformation processes, due to the hygrothermal variations along the years, related to the environment (rain, humidity variations, temperature, wind, pollutants agents); or as a consequence of a group of chemical and biological phenomena that can modify the nature of the binder. Weathering processes can generate a loss of intergranular strength in the superficial layers (powdering and efflorescence) or in depth (crypto-efflorescences, erosion, flaking, scaling, detachment and cracking). Among all, historical plasters at work are subjected to flexural stresses due to the action of salts and horizontal drift that can cause scaling, detachments and finally loss of cohesion, materials and lacunas (Gullotta, 2008; Toniolo, 2010).

The restitution of cohesion between particles of a mortar, turned friable by the loss of binder, is reached through the application of organic or mineral consolidants. The concept of consolidation in a modern way was born only in the middle of the 19^{th} century, through the experimentation of silicates, fluorides, barite and limewater (Hansen, 2003), and subsequently in the 20^{th} century with the introduction of polymers such as silicon resins, acrylics and epoxy resins (Horie, 1990). This synthetic compounds are easier to apply, more flexible and present better adhesiveness, but do not obey to the fundamental rules of physical-chemical compatibility with the substrate, and cannot be considered as suitable for consolidating purposes.

Inorganic consolidants are becoming preferred due to better compatibility and durability. The best known inorganic consolidants are calcium hydroxide (limewater), barium hydroxide, ethyl silicate, calcium oxalate and calcium tartrate.

Consolidants based on limewater (suspension of calcium hydroxide) present a high compatibility and low cost; however, due to low solubility in water, this consolidant requires a large number of applications to get an acceptable efficacy. The use of some additions could help to increase the solubility of calcium hydroxide and its fixation and penetration degree, increasing its efficiency; moreover the resource to calcium hydroxide nanoparticles should improve the depth penetration, as shown in various studies (Dei, 2006; Giorgi, 2000).

For a well-succeeded consolidation, it is fundamental the knowledge of the correct properties, such as penetration capacity, viscosity, capillarity, particles size, setting and hardening time, consolidation power and compatibility.

A consolidant product should initially present a fluid form with low viscosity allowing a homogeneous diffusion by capillarity in the material with loss of cohesion; the penetration of the consolidant product must be followed by setting which improves the cohesion of the render. It is fundamental to maintain an adequate permeability between the consolidated layer and the more internal material, in order to avoid mechanical stresses with consequent cracks and detaches.

The aim of this work is the experimental characterization of two different consolidant products, namely a traditional compatible product such as a limewater, mixed with ethyl silicate, and a commercial alcoholic dispersion of nanoparticles of calcium hydroxide, which presents an innovative consolidant product.

The characterization of these products was carried out and their effect on damaged mortars was evaluated through tests on specimens before and after treatment. Test methods have been developed, using weak mortars to simulate degradation. The two consolidant products were then applied on weak mortar specimens and the evolution of their effect was accompanied and periodically evaluated.