Protection of marble surfaces by using nano-particles

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Stone has been used as one of the main building material in a significant part of our cultural heritage. The beauty, the abundance and the durability of stones were the reasons of their long lasting application to construction. In the case of stones, special skills were needed during all stages of stone elaboration. From the extraction from the quarry, the transportation, the curving and application, each stage had to be carefully designed and detailed executed. In classical Greece, marble and limestone were used for the construction of temples, theatres, Odeon's and forums. Blocks of stones with or without binding layers in between were used for erecting masterpieces some of which were rendered and some were left with their original surface exposed to the atmosphere.

During time these materials were exposed to different natural or anthropogenic deteriorating agents. Usually decay is occurring on the material's surface as this layer is directly exposed to the environment. Gradually, the decay could proceed to the internal structure through cracks and pores, resulting in a diminutive building material in terms of mechanical and physical properties. The type and extent of decay significantly depends on the material's nature.

Ancient masons were trying to protect the materials since very early against the sun and the rain. Traces of wax, oil or natural resins proves this effort. Since then, there was a continuous effort by using the available in each period technological means to protect stone surfaces. During the last decades it has been understood that each monument is unique and a multi disciplinary scientific approach is needed for stone treatment. The study of the reasons of decay, laboratory analysis, documented application of the method and monitoring of the results are necessary steps for a durable and compatible intervention.

Based on the principles of the minimum intervention, of reversibility of each application and the compatibility of the new material with the original one, the present paper negotiates the application of known materials such as silanes and silicones in admixtures with siliceous pyrogenic silicon nanoparticles on the surface of stones.

The addition of these nanoparticles increases the BET specific surface area because of the small diameters of the particles. This large surface area-to-mass ratio causes intense inter-particular interactions, which are the result of attractive dispersion and dipolar forces. And that is precisely the reason for the outstanding water repellency effect of these nano-particles admixtures to silane and siloxanes.

The aim is to increase water repellency of the stone surface, protecting the material against all deteriorating effects dealing with water absorption.

The tests were applied to white marbles from Dionisos, Thasos and Naxos and they concern the application of three different solutions containing nanoparticles. The application was performed by immerging the samples into the solutions for 5 minutes and after drying the properties measured were: water absorption and open porosity according to RILEM CPC11.3 before and after the application, capillary absorption according to EN1015-18:2002 and water drop tests. Also their exposition to open air was tested for a period of three months. Additionally the samples were examined under SEM.

The tests proved the adequate protection achieved the application of the solutions enriched with nano-particles to marble surfaces. The durability of the layers to environment is left to be studied.