

The efficiency of nanolime and dibasic ammonium phosphate in the consolidation of beige limestone from the Pasargadae World Heritage Site

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The limestone used at the Pasargadae World Heritage Site in Iran, an outstanding open-air architectural heritage site dating from the Achaemenid period (sixth century BC), has suffered weathering due to interaction with the environment. It was built out of beige limestone that today shows scaling and pitting decay patterns. Two inorganic consolidating products that are very promising: nanolime and dibasic ammonium phosphate (DAP) were considered for the consolidation of the limestone. Consolidation treatments were conducted on samples from a quarry and applied using a paintbrush with 50% nanolime dispersion in isopropyl alcohol and 1.0 M DAP water solution. Superficial consolidation was evaluated by means of a micro-drilling resistance test, and color changes were assessed by spectrophotometry. The microstructure of the treated samples was observed using FE-SEM. The efficacy of the two consolidation treatments was also assessed by testing their hydric properties and durability (hydric tests, freeze-thaw, and salt crystallization cycles). The compactness in the altered samples was monitored by measuring the ultrasound propagation velocity. We found that the superficial resistance increased in a similar way with both treatments. However, spectrophotometry revealed a yellowish color in the samples treated with DAP. During FE-SEM observations, some diffused microcracks were detected on the surface of DAP treatment. When subjected to accelerated aging tests, both treatments managed to postpone the formation of the first microcrack during the freeze-thaw test and both showed outstanding stability during salt crystallization cycles. In conclusion, the nanolime product seems to be more compatible with beige limestone because it does not affect its aesthetic qualities (color, lightness,

and a homogeneous layer formed on the surface of the stone). Moreover, previous research found that lime has a low propensity for biological growth. This supports its use as a consolidating product for the stone used in open-air archeological sites that are prone to microbial growth, such as the beige stone used in the Pasargadae WHS.