

Consolidation of weak historic lime-plaster with Calcium hydroxide and *Bacillus cereus*

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The consolidation of weak historic lime-plaster is an important part in the field of conservation and restoration of historic monuments and buildings. Nowadays, several strengthening agents based on silica ester or calcium hydroxide are commonly used for conservation, with variable success. Due to the partly extreme climatic conditions in the valley of the Mauerbach (Lower Austria near Vienna), mainly during the winter, construction materials are heavily stressed. Frost-thaw-cycles, ascending humidity in combination with different types of salt, especially magnesium sulfate and several nitrates and microbiological activity are the main processes, responsible for the deterioration of lime-plaster. Different stages of damage from nearly perfect state of preservation to complete damage are visible. Since many years, empiric observations on the historic facades in the former Carthusian monastery in Mauerbach, covered with partially very weak lime-plaster, showed successful consolidation of the plaster fabric penetrated with calcium hydroxide (“lime-water”). On the other hand laboratory investigations with fresh lime-plaster samples treated with calcium hydroxide displayed contradicting results, no change in physical properties could be observed. Two years ago the conservation of lime-mortar from the baroque so-called Kreuzbrunnen in Mauerbach was done with Calcium hydroxide with resulting remarkable increased strength properties. Due to this observation the investigation on the facades in the monastery started.

A microbiological survey indicated a microbiological community with a predominance of *Bacillus cereus*, a common soil bacterium able to induce the precipitation of calcium carbonate in its immediate environment. Therefore it was evident, that this bacterium could play an important role in the reaction with lime-water. The following exploration on several test sites in Mauerbach was done with destructive and non-destructive investigation-methods (e.g. ultrasonic velocity, peeling test, microscopy, SEM, etc.) and different fluids,

such as lime-water, freshwater from the pipe, demineralised water, limewater + *Bacillus cereus*, limewater + *Myxococcus xanthus*.

The results of this examination showed that the application of calcium hydroxide in combination with *Bacillus cereus* could be a reasonable, sensible and primarily ecological technique for the consolidation of weak historic lime-plaster, if the contamination with salt is very low and no other destructive organisms are living in this ecological niche. It is important to use calcium hydroxide and *Bacillus cereus* together because a calcium source from outside of the rendering system is necessary for the process. Mineralogical, chemical and microbiological investigations are essential before using this consolidation technique and last but not least there are some open questions, e.g. the quantity of feeding suspension, which call for further investigations.