## ABSTRACT

This dissertation has involved interdisciplinary studies in conservation, environmental and material sciences.

The overall aim of the research was to study the effectiveness and durability of methods and materials used for conservation of Gotland sandstone. For this purpose a number of objects on which conservation projects were carried out recently and up to 15 years ago were selected for study. The selected objects were studied over a five-year period. The project has benefited from studies of ongoing conservation projects and from the possibility to conduct research in conjunction with such projects.

Three main topics were identified as relevant for further studies on the objects, at field-stations and in laboratory:

1) Studies of consolidation treatments; efficacy and durability as well as effects of re-treatment.
2) Studies of hydro-protective treatments; durability of treatments, including various hydrophobic products.
3) Studies of stone-repair mortars; weathering, durability and adhesive capacity.

The effects and the durability of treatments were for all objects evaluated by means of ocular inspection. Water repellence and absorption were determined by testing the wet-ability of the stone and measured by use of Karsten's testing tube. Salt analyses were made by means of paper pulp extraction. Porosity measurements were taken on two of the objects before and after consolidation treatment using ultrasound pulse velocity. Freshly quarried as well as weathered sandstone samples were used for studies in the laboratory and at field-stations. Laboratory methods included capillary absorption, humidity sorption and nitrogen adsorption tests as well as ultrasound pulse velocity measurements and analysis of thin sections by means of optical microscopy. Colour changes were measured by spectrophotometer.

Field and laboratory studies showed that consolidation treatment in most cases had reduced the deterioration of the sandstone without negative effects. The durability of treatments differed considerably. Some cases of sanding, only a few years after the consolidation treatment, were observed, but there were also examples of very long lasting treatment effects on several objects. Further the studies showed that stone sculptures exposed to outdoor conditions benefit from hydro-protective treatment, i.e. showed an evident reduction in water uptake, when the treatment was made correctly at the completion of an adequate conservation programme, including consolidation treatment. The observed negative effects, likely due to hydro-protective treatment, were discolouring, water traces and slight colour changes. Problems with colour changes and bad adhesion of filling materials were observed in the study. Due to this the amount of fillings made for technical reasons should be kept to a minimum necessary for filling and sealing fissures and cracks to secure the stone from penetration of water and damp.

The most important observation and reflection made in the study was the lack of adequate, systematic maintenance on many of the objects. Conservation interventions had usually occurred too late, when the stone objects already showed severe damage. Extensive conservation interventions were then necessary. After conservation the objects had again been left without maintenance. Monitoring by means of continuous survey, including evaluation at regular intervals, and timely maintenance interventions would significantly improve the service life of stone objects. The lack of common policies, methods and programmes for conservation impedes systematic maintenance planning.



*Keywords:* Gotland sandstone, conservation, weathering, deterioration, consolidation, hydro-protective treatments, stone-repair mortars, ultrasound pulse velocity, Karsten's testing tube.

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