ETH zürich

Annual project July 2017 – June 2018

Conservation of Swiss Molasses

Executive summary

Molasses are the most important material in stone built heritage in the whole Swiss plateau. These stones contain swelling clays, which makes them particularly susceptible to weathering. More specifically, dimensional changes of clays resulting from humidity changes can lead to cracking and scaling. In the context of altered monuments, swelling clays also deteriorate the products used for stone restoration very quickly.

Swelling inhibitors are specific chemicals that have been shown to potentially extend the durability of consolidation treatments applied on molasses by inhibiting the swelling of clays. However, such products are viewed with scepticism because of past experiences with other materials successfully tested under laboratory conditions turned out to show poor performance on site. Furthermore, the mechanisms and initiation causes of the typical degradation pattern of Swiss molasses have not yet been unanimously cleared.

For this reason, during this project, we used a combination of on-site measurements and laboratory analysis to provide an objective basis for the interpretation of the degradation phenomenon and the recognition of the most detrimental factors, which ought to be minimized or controlled.

Characterization of typical degradation

On-site measurements were performed at the cathedral of Lausanne to investigate the typical features of the degradation of Swiss molasses.

Drilling resistance measurements (DRMS) and core drills showed that molasses subjected to contour scaling are affected by a deep degradation beneath the detaching scales. DRMS showed degradation depths exceeding 5 cm; core drills showed that the degradation can reach as deep as 7 cm. This poses a question about whether consolidation treatments can be applied successfully, that is reaching depths higher than the degradation itself to anchor degraded areas to the healthy core of the stone. As a consequence, preliminary testing for the verification of the effective treatment penetration and optimization of protocols of application are recommended.

Measurements of water content and distribution by means of impedance highlighted the presence of liquid water in the core of façade stone blocks during the whole year. This result is particularly relevant for questions concerning both the transport of soluble salts, which could potentially cause crystallization damage and the risk of freezing damage in winter.

Impedance measurements also showed a characteristic accumulation of liquid water between 2cm and 4cm beneath the façade during the colder months of the year. This depth is compatible with the zone of formation of the scales and suggests that freezing damage could have a relevant role in the initiation of contour scaling damage, which would then be propagated by the swelling due to the clay presence.

Laboratory testing

Laboratory tests were performed to develop a protocol for the production of artificially aged samples to be used in preliminary test of consolidation.

A controlled impregnation of stone specimens via capillary absorption with solutions of sulfuric acid at a concentration 0.7M showed the most suitable to produce samples with degradation depths and stone contaminations similar to the ones encountered on-site.

Development of conservation strategies

The information gathered during our on-site measurement campaign and laboratory testing was useful to give suggestions for the development of conservation strategies for the Cathedral of Lausanne and – potentially – for other monuments in the Swiss plateau:

1. Consolidation treatments must be applied only after assessment of the characteristic depth of degradation at each specific façade orientation;

2. Pre-tests must be performed to ensure that the penetration depth of the treatment is higher than the gradient of degradation in the stone blocks. In the case of the zones observed at the cathedral of Lausanne, a quantity of 6L/m^2 of Wacker OH 100 was estimated;

3. The use of hydraulic mortars for repair is recommended, as conditions optimal for carbonation of lime-based binders (porosity not saturated with liquid water and relative humidity between 70% and 40%) only occur over a 3 months period from August through October;

4. Measures for the protection of the façade over the coldest weeks in winter might be useful to prevent the initiation of contour scaling.

Benefits realized

An international collaboration with experts in the field of stone conservation was developed during this project. Such collaboration lead to a co-authored paper on the theme of stone consolidation to be publish in RILEM Technical letters, an invitation only journal from RILEM which is published in diamond open access with a resulting very high visibility and accessibility.

Another result of this project is the developement of a digital tool to assist practitioners in finding the best suited conservation treatment for their case study. This « digital advisor » is developed in the form of a quiz formulated to characterize the critical aspect of each case study. On the basis of the answers given by the user, a list of possible promising consolidation treatments is generated for the user. A demo of this tool is available at https://consolidantfinder.ucraft.net.