Comparison of classic aging and realistic tests: study of the compatibility between limestones and restoration mortar

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Laboratory aging tests allow the study of stones' behaviors on the monument indirectly. **Classic aging tests** are designed to compare materials' resistance to different weathering mechanisms: they are **more intense than the on-site conditions** and do not reflect the real weathering intensity and kinetics. To study the **real weathering on a monument** and the **materials' behavior**, a **non-destructive experimental setup** using **realistic experimental conditions** was designed.

Materials of the Saint-Remi basilica of Rheims (France)were studied. In particular, the **compatibility of the restoration mortar Lithomex**, used in recent years, with the **Courville limestone** (original stone) and the **Savonnières limestone** (restoration stone) were compared.

The realistic experimental setup was designed to **reproduce the thermal and hydric strains experienced by a stone on a vertical façade** in a stone sample (10x5x4.5cm). The hybrid samples were constituted of a 1cm thick mortar layer applied on the limestones.

The temperature and humidity variations were based on **typical variations identified with an** *in-situ* **monitoring** of the basilica: **sunny days** with temperature cycles (20/35°C), **rainy days** with a 1h imbibition followed by temperature variations (20/35°C), and **frost days** with a 1h imbibition preceding low-temperature cycles (5/-10°C). The mild conditions, similar to the on-site conditions, did not damage the samples.

Temperature and humidty variations were applied unidirectionally through one surface, defined as the exposed surface, placed against a heating/cooling plate or immersed in 5mm water for a 1h imbibition. The sample's behavior was monitored with thermocouples and strain gauges measuring **heat transfer** and **differential micro-dilatation**.

The stress **at the interface between the mortar and the limestones** was calculated from the deformation data. It appeared that higher stress was generated at the Lithomex-Savonnières interface. Unlike the Courville, the Savonnières limestone dilated very little compared to the mortar; the differential deformation generated higher stress. This indicated **a better compatibility between the Lithomex mortar and the Courville limestone**.

Accelerated aging tests were also applied on hybrid samples (\emptyset = 4.5cm and h=5cm) constituted of the limestones presenting a 1 or 3cm thick layer of mortar. **29 thermal shock cycles** (10h at 70°C followed by 2h immersion in 20°C water) and **17 freeze/thaw cycles** (10h at -10°C followed by 2h immersion in 10°C water) were carried out and monitored with weight and ultrasound velocity measurements.

The harsh conditions and number of cycles **caused visible damage**. Some hybrids {Lithomex+Courville} were broken during the cycles, while the hybrids {Lithomex+Savonnières} did not present any measurable or visual damage. These results let us suppose, contrary to the realistic experiments, a **better compatibility between the restoration mortar Lithomex and the Savonnières limestone than between the Lithomex and the Courville limestone**.

The realistic setup allowed a simulation of the temperature and water repartitions in the samples closer to reality. The materials' properties, such as thermal conductivity and water transport properties, were taken into account. The water rarely attained the limestones underneath the mortar due to the low capillarity of the Lithomex. On the contrary, the accelerated aging tests with total sample' s immersion led to both wet limestone and mortar, generating stress that does not normally occur on the monument.

These experiments highlighted the **need for realistic experimental conditions** to assess the durability of restoration mortars and stones on which it is applied. This experimental setup provides more **relevant information in this specific environment** and **more accurate description of the real behavior of materials** without damaging the samples.

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