[EE] Evening Poster | H (Human Geosciences) | H-TT Technology & Techniques

[H-TT14]Non-destructive techniques applied to stone cultural heritage

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Non-destructive and non-invasive techniques applying to cultural heritage made of stones, soils and earthen materials have been significantly developed over past years, and thus, the interest in such techniques has greatly increased. Here, we focus the session on new devices, new protocols and new data treatments that allow better understanding of weathering mechanisms, decay states and response to treatments.

A few topics would be listed as follows: 1) The development of new techniques and devices in cultural heritage and new protocols using non destructive techniques; 2) The application of these techniques and protocols on indoor and outdoor case studies and laboratory studies; 3) The assessment of weathering mechanisms, weathering kinetics, decay state, and response to treatments; and 4) The modeling and simulation of decay processes.

[HTT14-P02]In situ monitoring of the weathering agents of Saint-Remi Basilica (Rheims, France)

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Historical buildings are subjected to weathering through different factors such as the variations of temperature and humidity that have a direct impact on stone behaviour. Insolation produces thermal expansion differences within the stone, creating stresses at grain boundaries that can lead to disaggregation. If water is involved, it can freeze in case of low temperature, inducing ice expansion and cryosuction. These phenomena cause a weak stress compared to the resistance of the materials, however it can lead to a breakdown after repeated exposure through fatigue failure.

Temperature and humidity on a monument will depend on daily and seasonal variations and on the orientation and height of the considered stone. The intensity of these factors variations will influence the weathering. The knowledge of the physical properties of the stone and the micro-environmental parameters are essential in order to anticipate the weathering and to identify the risk areas.

The monitoring of the Saint-Remi Basilica was achieved through a sensor network, to identify the micro-climatic conditions on a monument. This monument, listed as a UNESCO World Heritage site, was built from the 10^{th} to 13^{th} centuries, and since then, various elements were added, changed, restored or rebuilt, especially after WWI damages. As a result, several types of stones and mortars with very different properties can be found. Fourteen i-Buttons were placed on the two towers of the building facing different directions and heights. The sensors were installed in December 2017 and since then, they continuously monitor the monument, with measurements performed every hour. In order to observe

shorter cycles due to wind-speed or cloud cover, a sampling of 1 minute was used for one day.

The data obtained by the sensor network highlighted the various microclimates on the building. As expected, the orientation of the façade had a clear influence on the surface temperature. The maximal temperatures were reached on the façades facing South and West, due to the longer solar exposure of the stone throughout the day. The minimal temperatures were recorded on the North and East façades, with differences of temperature up to 17°C between South and East directions. The orientation of the stone with respect to the building itself has also been taken into account, as the shadow of the building influenced the exposition of the façades: one sensor facing south does not go through the same variations as the others because it stays most of the day in the shadow of the nave. The measured relative humidity was linked to the temperature, a decrease of humidity was observed with a temperature increase. The humidity variations between the different façades reached up to 35%. The height of the measured points did not significantly impact the results.

Climatic cycles were identified on the stone surface with the long-term (hour scale) and short-term (minute scale) monitoring. The cycle of night/day induced a temperature cycle: on average in January, an increase up to 11.4°C followed by a decrease down to 5.6°C. Whereas the short-term monitoring results showed abrupt variations of temperature (1 or 2°C) on façades exposed to the sun. Within 24h, 13 short cycles (5-15 minutes) and 2 longer cycles (about 40 minutes) could be observed. These cycles were due to cloud cover and/or wind-speed. The temperature variation rate was rarely superior to 1°C/min. The temperature decrease induced by shorter cycles had no significant effect on humidity, while humidity increased from 60 to 75% during the 35-40 minutes cycles.

This first in-situ climatic monitoring on the Basilica showed significant micro-variations, mostly depending on the sun exposition. It will continue for the next 3 years, to study the variations during other seasons and obtain representative measurements. This study will be coupled with a monitoring by infrared thermography (IRT) and results will be used to reproduce ageing tests in the laboratory.