

Coupled capillary water uptake and Infrared Thermography to assess crack evolution

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Stones are submitted to thermal cyclic variations due to diurnal, monthly and seasonal changes. In addition, summer storms may drop the temperature of the insulated stone very fast, producing a contraction of the minerals. These processes, if repeated during years, may produce a crack development and irreversible damage to the stone. When a stone is used in buildings, its resistance to external phenomena must be tested in order to avoid great structural damages at long term. For this reason, two parameters are important: i) the crack threshold or the temperature from which the stone starts to crack and ii) the thermal fatigue, that is the following cycles that make the crack to grow irreversibly. The thermal properties of a stone and its heat equilibrium kinetics with the environment vary in relation to its fracturation state. When fractured, a stone has faster cooling and water absorption kinetics as well.

Infrared thermography is a non-destructive technique that measures temperature and emissivity changes. To probe the effectiveness of IRT to evaluate the evolution of fracturation, three stones (chalk, sandstone and granite) were submitted to two tests consisting in different heating cycles. The first test consisted in five progressive heating cycles from 90°C to 130°C with 10°C of increasing interval. The aim was to determinate the crack threshold by an increase in cooling velocity or capillary coefficient. The second test consisted in five cycles of repeated heating at 200°C in order to assess the evolution of a cracked stone in time.

For both cycles, the heating rate was of 6°C/min to assure the fracturation at least of the two quartz-rich stones and the temperature was maintained for 4 hours in order to reach the stone core. Once the heating finished, the stones cooled down freely up to 40°C. This temperature was selected to avoid wrong measurements from the balance but to keep enough contrast to be observed with the IRT camera. The samples were placed on a water film and suspended from a balance that recorded automatically the weight every 10 seconds. At the same time, a IRT FLIR A-655 camera measured the thermosignal of the process every second.

The analysis of the samples allowed to follow the capillary fringe of the sandstone and the granite, and the time to fill the chalk by water uptake. Capillary coefficient evolved during the cycles indicating a fracture distribution and development for the sandstone and the granite while the chalk did not show a great variation with heating.

The cooling rate index (CRI), that is the temperature difference for the 10 first minutes of cooling, was calculated from the IRT data in two areas: the bottom part of the sample that cooled down by the water that rise by capillarity, and the upper part, not reached by the capillary water and cooled down by the room temperature (the latter only for the granite and the sandstone). The chalk experimented few variations during the first test of progressive heating, while a faster cooling (higher CRI) during the fatigue test, that implies an increase in porosity. Sandstone developed cracking during the first cycles for both heating tests probed by a higher CRI, followed by a stabilization. The fracturing was slightly higher for the progressive tests, due possibly to a higher quartz irreversible expansion at 200°C. Granite showed a

redistribution of cracks, with higher and lower values through the cycles.

This test showed that IRT data treatment give reliable results to evaluate evident fracturation, although the IRT images were blurred by evaporation process.

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