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Change of thermal dilatation coefficient of sandstones under cyclic thermal load, a laboratory simulation of sandstone weathering

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Sandstone weathering is one of the most studied phenomena. Besides the natural occurrences sandstones are often used in historic monuments. The weathering is often associated with the different thermal behavior of sand particles and cement and also to the variation of fabric and fabric related thermal expansion. The present study is focused on the detection of changes in thermal dilatation coefficient under laboratory conditions. Three different sandstones, a clay cemented quartz sandstone and two varieties of carbonate-cemented and clayey quartz sandstone from the Czech Republic were analyzed. These stones are also considered as potential replacement stones at The Charles Bridge in Prague. Twenty one prismatic test specimens of 25*5*5 cm were used for the tests. Bulk densities were between 2014 kg/m^3 to 2212 kg/m^3.

The specimens were tested in climate chamber and three cycles were applied. For modeling winter cycles -15 ˚C to +5 ˚C degrees, for testing summer conditions +5 ˚C to +50 ˚C and for a annual changes a -15 ˚C to +40˚C temperature range were applied. The thermal dilatation was measured by a Demec-type thermal-shrinkage detecting equipment which applies the Huggenberger-method. Each cycle had a gradual heating and cooling and thus one cycle lasted 8 hours. For each rock type more than 80 cycles

were applied and the thermal dilatation coefficient were detected after each ten cycle. Both air-dry and water saturated samples were tested. Besides the detection of thermal dilatation coefficient, non-destructive tests such as ultrasonic sound velocity were also measured on each specimen.

The test results show that the summer cycles have a regular pattern in the change of thermal dilatation coefficient, namely after the first 10 cycles the coefficient decreases and than it shows a rapid increase up to 30 cycles, which is followed by a drastic drop up to 50 cycles. The annual cycles also show significant changes namely after a drop in dilatation coefficient after the first 10 cycles, a significant increase in thermal dilatation coefficients were recorded up to the first 30 cycles. It was followed by a decrease in thermal dilatation coefficient up to 50 cycles. The thermal dilatation coefficient has a range α =12-15 [1/°C] * 10^{-6}. The ultrasonic sound velocities show a decrease in the order of 5-11%, having the maximum decrease of 11% in winter cycles. The lowest values were measured on the water saturated samples of clayey sandstones after 80 winter cycles with an average decrease of 30% in ultrasonic sound velocities.

Visual signs of deterioration were also recorded and the most obvious forms of deterioration were the formation of micro-cracks and flaking especially on clayey water saturated sandstones experienced 40 cycles. These weathering simulation tests provide further information on the cyclic weathering pattern of sandstones.