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ABSTRACT

PRESENTATION

PAPER

Bojan Milovanović graduated from the Faculty of Civil Engineering of the University of Zagreb in 2007 and received a doctorate in 2013. Since 2007, he has been working at the Department of Materials at the Faculty of Civil Engineering, where he began as a junior researcher and assistant professor, while today he is an associate professor and participates in the teaching of several undergraduate and graduate courses. He participates in numerous international and domestic projects and is the author or co-author of several professional and scientific papers.

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USING INFRARED THERMOGRAPHY FOR THERMAL DIFFUSIVITY TESTING OF CONCRETE

When performing non-destructive testing of existing concrete structures, infrared thermography became one of the best performing methods when doing defect localisation activities, but quantification of the detected damages in concrete structures still needs some research. One of the key aspects of quantifying defects (determining depth, thickness, and size of defects) is to know the thermal diffusivity of the material. When working with materials such as concrete where every component can alter its thermophysical properties but also when its mixing, placement and curing can have an influence on its thermophysical properties it is important to measure these properties (i.e. thermal diffusivity) to be able to quantify embedded defects. Quantification of defects is on the other hand essential for prioritizing maintenance and repair efforts to ensure structural safety and integrity.

The ratio of thermal conductivity to the volumetric heat capacity of a substance is represented by the thermophysical characteristic known as thermal diffusivity, which measures the rate of heat transfer through a material. The determination of thermal diffusivity is a long-standing problem in science, but it is still relevant today for the obvious reasons: understanding this property of materials is essential for the design, diagnosis, and control of numerous engineering products as well as various concrete structures.

Particularly, thermal diffusivity is essential if heterogeneous materials like concrete are tested because this characteristic, and the same, its proper change may give potentially many pieces of information about heat flux which may take place in an investigated object. For instance, change of a material's structure or composition (mix design) will effectively alter its thermal and physical properties (thermal conductivity, density and heat capacity) and, ultimately, also alter its thermal diffusivity.

Numerous studies on the various methods of determining thermal diffusivity, including their theoretical foundations and tests based on them, can be found in the literature. Currently, it is also evident that the application of infrared thermal imaging is becoming more widespread, if not indispensable, in this field. The shared element among the aforementioned techniques is the knowledge of an exact solution to the heat equation for the specific initial boundary conditions that are attempted to be realized in laboratory settings for material specimens in order to measure the temperature field in them and compute the thermal diffusivity from there.

In this research, testing of the thermal diffusivity of concrete was carried out using the technique of heating the sample on one side and monitoring the temperature development using infrared thermography on its opposite surface. The specimens were heated with a Par 64 reflector, which contains a 1000 W halogen lamp. The thermal diffusivity test was performed on concrete specimens in the form of a disc with a diameter of 10 cm and a thickness of 1 cm.

The step heating method was used to measure the thermal diffusivity of concrete, whereby a thermal pulse is applied to the front surface of the samples, and the temperature change is measured from the back side of the sample.

Three concrete types were used in order to replicate the three most used concrete types in real structures. Due to their different mix composition, these three concrete types vary in density, compressive strength and thermal conductivity, thermal diffusivity (due to different density and conductivity). Different thermal properties are mostly due to the different air content in concrete, since the same aggregate was used for all three mixtures, dolomite aggregate D_{max} = 16 mm.

In-depth thermal diffusivities were found to be about $3{,}3887 \cdot 10^{-7}$ and $4{,}2461 \cdot 10^{-7}$ m^2/s which is in line with the literature values of the same moisture content and aggregates type.