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A quantitative analysis of IRT data for the evaluation of plaster degradation at the Dome of Magdeburg (Germany)

Rosa Di Maio (1), Christiane Maierhofer (2), Cecilia Mancini (1), and Ester Piegari (1)

(1) Department of Earth Sciences, Environment and Resources, University of Naples "Federico II", Naples, Italy, (2) BAM Federal Institute for Materials Research and Testing, Berlin, Germany

Infrared Thermography (IRT) is a helpful method for the nondestructive evaluation of artworks and buildings of historical interest since it is able to provide indications about most of degradation sources, such as alteration of material consistency, formation of microcracks, debondings, etc. The most used procedures for physical and geometrical characterization of the thermal anomaly sources are based on numerical models that solve the forward thermal problem, i.e. they find the solution of the Fourier differential equation, which describes the heat transfer in a medium. In this framework, we present a Finite Difference method to evaluate the conservation state of the Dome of Magdeburg (Germany). In particular, the study is focused on the analysis of the thermal images acquired on the east wing of the cloister from the 13th century, and is aimed to characterize its plaster score. The structure was heated with an infrared radiator and thermal images were acquired on both heating and cooling phase for fifteen minutes.
The proposed conservative FD method allows taking into account for varying thermal conductivity, density and specific heat of defects and disrupted materials. The heat transfer problem is formulated in one and two dimensions and, therefore, it is able to characterize multi-layered structures.
The investigated structure is made of three plaster layers (one lime wash layer that overlaps two lime mortar layers) and a sandstone background. Numerical simulations have shown a very good match between the experimental and theoretical curves for all the considered anomalous areas, for both 1D and 2D formulations, providing an average percentage error of the order of 10-1%. In particular, the study allowed to define thickness, depth and nature (density, thermal conductivity and specific heat) of the thermal anomaly sources, attributable to the degradation of the lime mortar layer at different depths. The application of the codes provided helpful indications for restoration work planning.