Zukunft Bau

Short Report

ERBE

Survey and evaluation of safety-relevant delamination processes at plaster and façade elements using non-destructive measurement and testing methods

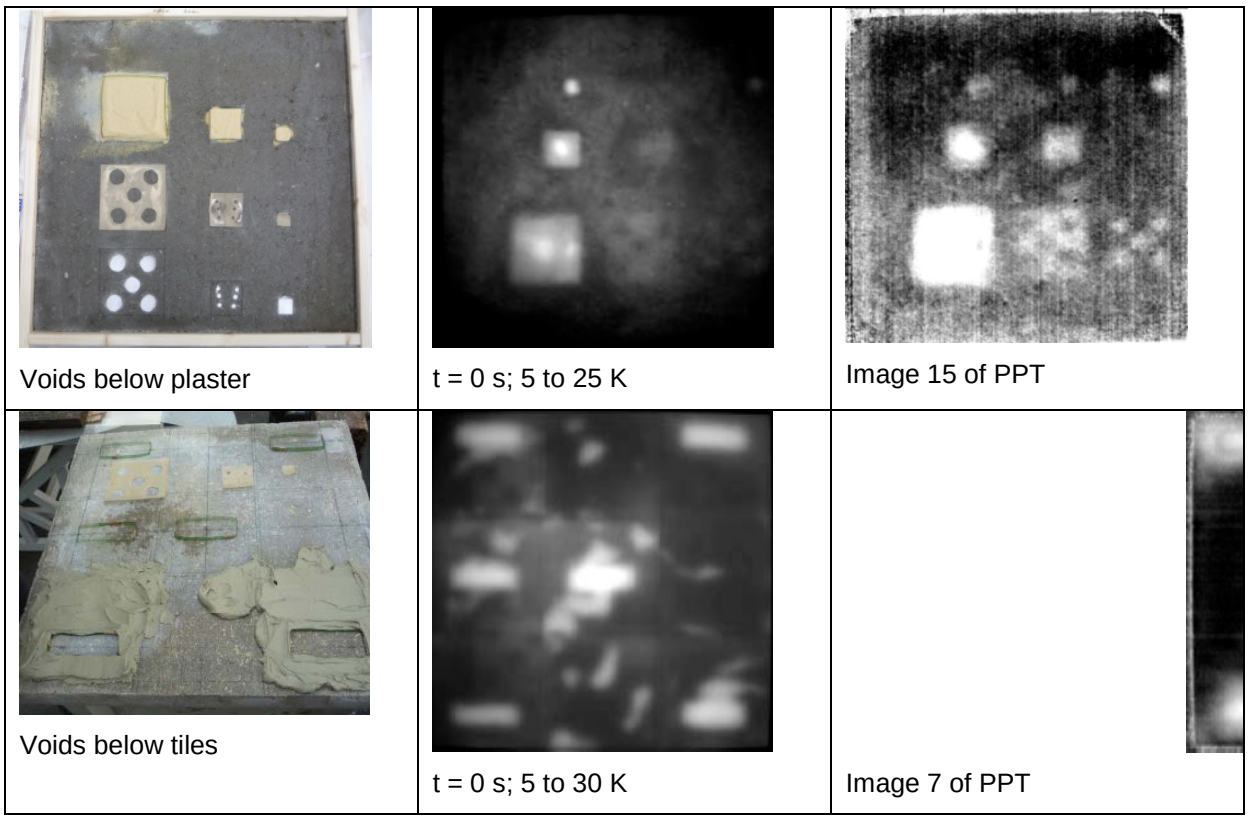

Figure 1: Visualisation of the results of active thermography of two different test specimens with plaster (top) and with tiles (bottom), where the heat was introduced with an IR radiator. The middle column shows the thermograms directly after heating, the right column displays phase images of the sequences calculated by pulse phase thermography (PPT). The phase images show more voids than the thermograms.

Cause/ Initial Situation

Cause and aim of the project was the development of methods and strategies for non-destructive detection of (possibly) safety-relevant damage and delamination of façade systems in the area of building conservation and preservation. For that purpose, measurement methods based on optical and thermographic methods were developed further, were evaluated and were proven at four different case studies. The 2D and 3D data sets were fused.

Objective of the Research Project

The survey and evaluation of damage and delamination of plaster and façade elements was achieved by the combination of active thermography and contacted and contactless recording of geometrical data.

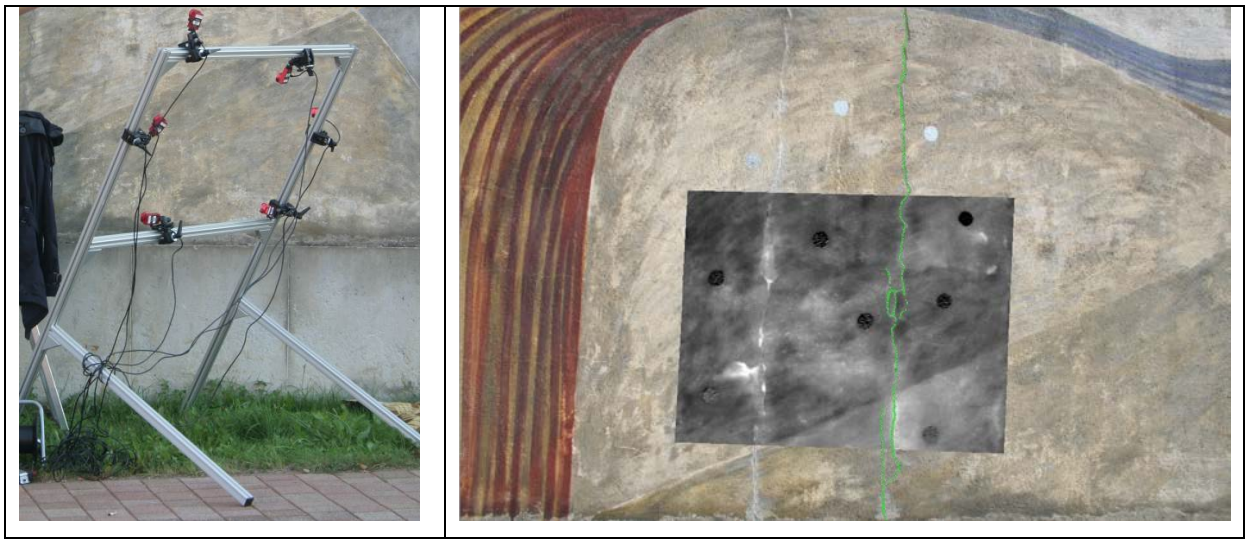

Figure 2: Left: Frame with flexible fastening possibilities for the tracking cameras and adjustable tilt. Right: Fusion of a thermogram (grey, middle of the image) with a photo and with a tracked crack (green) as an example of an area of a façade with reference markers at the rural painting in Cobbelsdorf.

First, systematic investigations with active thermography were performed at test specimens representing different façade systems (plaster, tiles, brick tiles) with various artificial defects. The test specimens were constructed together with the State Office for Heritage Management and Archaeology of Saxony-Anhalt. Comparative measurements were carried out with artificial heating using an infrared (IR) radiator and with natural heating by the sun. The energy input by the sun radiation was about a factor of four lower than for the artificial heating. Nevertheless, with both heating types voids with sizes down to 2 x 2 cm^2 could be detected. Studies with active thermography using solar heating on façades belonging to the case studies showed that solar heating with alternating breaks by clouds is particularly suited for the detection of voids and cracks. Here, surface reflexions should be avoided and different emissivities of the surfaces in visual and infrared spectral ranges have to be considered. For the processing of the experimental data, the calculation of the difference of thermograms, which were recorded at different times, and pulse phase thermography were proven to be suitable.
Second, for the crack tracking method (3D recording of crack topologies and further surface features), a frame consisting of aluminium profiles was designed for enabling a more flexible use. This frame is detached and has flexible mountings for the tracking cameras, which can be fixed with a maximum distance of 1.5 m to each other. Thus, for the tracking a greater detection range was achieved. In addition, the software for data recording and visualisation was improved with respect to its usability and reliability. Accuracy tests were performed.

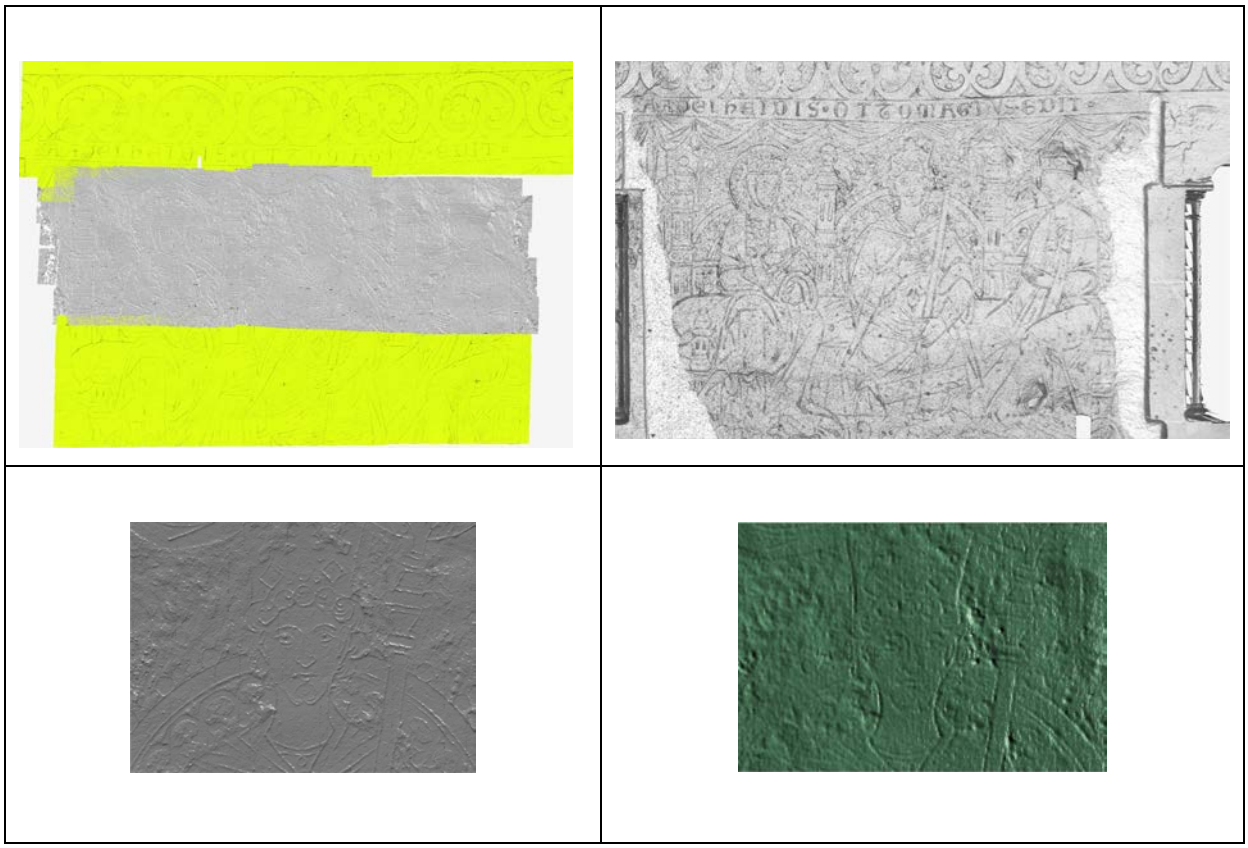

Figure 3: Comparison of the results of 3D recording of the plaster scratches at the Magdeburg Cathedral with the stereo sensor (left) and a commercial laser scanner (right). On the top, the complete central image is displayed, the bottom shows partial sections. These partial sections provide a distinct better resolution in the data of the stereo sensor (left).

Third, for the stereo photogrammetry system, a sensor bracket with a fixed carriage was developed. Now, the individual images can be recorded with a constant overlap and faster than before. Using this system, the existing data of the central image of plaster scratches were enhanced. In addition to the measurements with the stereo system, the entire plaster scratches were recorded with a laser scanner. These data allowed a correction of the orientation of individual images of the stereo system to each other in z-direction (depth). The reference data of the laser scanner have a lower spatial resolution and contribute to the improvement of the registration process of the stereo sensor.

A major focus of the project was the merge of the recorded measurement data from different domains for having a basis for a better evaluation of the damage features close to the surface. Various methods were developed and existing tools were used to enable the fusion of these data. So 3D point clouds could be fused with 2D thermograms, 3D crack data with 2D images and several 2D images were fused with each other.

In four case studies, these methods were applied in different combinations:

- Plaster scratches at the Magdeburg Cathedral: Detection of voids and cracks and visualisation of the plaster scratches (active thermography, stereo photogrammetry, laser scanner, photos)

- Rural painting at Cobbelsdorf: Assessment of the plaster connection to the metal bars and detection and determination of the course of cracks (active thermography, crack tracking, photos)
- Tile pictures in Halle-Neustadt: Detection of voids and delaminations of the tiles (active thermography, former manual damage mapping, photos)
- EffizienzhausPlus in Berlin: Delaminations of the photovoltaic thin layer solar modules, which were mounted at the vertical façade, could not be detected (active thermography)

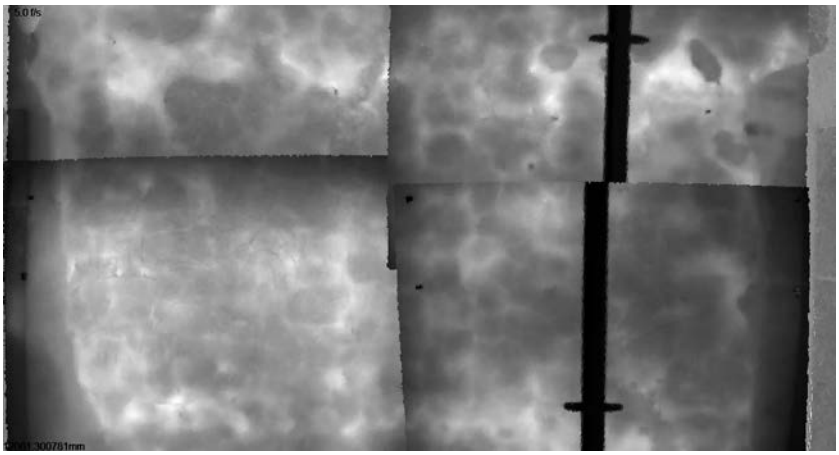

Figure 4: Fusion of four single thermograms of the central image of the plaster scratches at the Magdeburg Cathedral with a 3D data set. The thermograms were recorded directly after a heating period of 5 min using an IR radiator. The overlapping areas were not corrected concerning the temperature values. Warmer (lighter) areas are denoting to voids.

For the use of the measurement methods as well as for the operation of the tool for data fusion, in total five guidelines were developed, which are included in the annex of the final research report.

Conclusion

The aim of the project was the development of methods and strategies for non-destructive detection of damage and delamination in façade systems.
For that purpose, active thermography (among others, exploitation of solar heating), a crack tracking method (adaption of the system to various on-site situations, improvement of accuracy and operability) and stereo photogrammetry (among others, a rail system for faster data recording) were further developed with success. Tools for fusing different 2D and 3D experimental data are enabling an objective comparison and interpretation of measurement results (cracks, delaminations, voids) obtained at the four case studies.

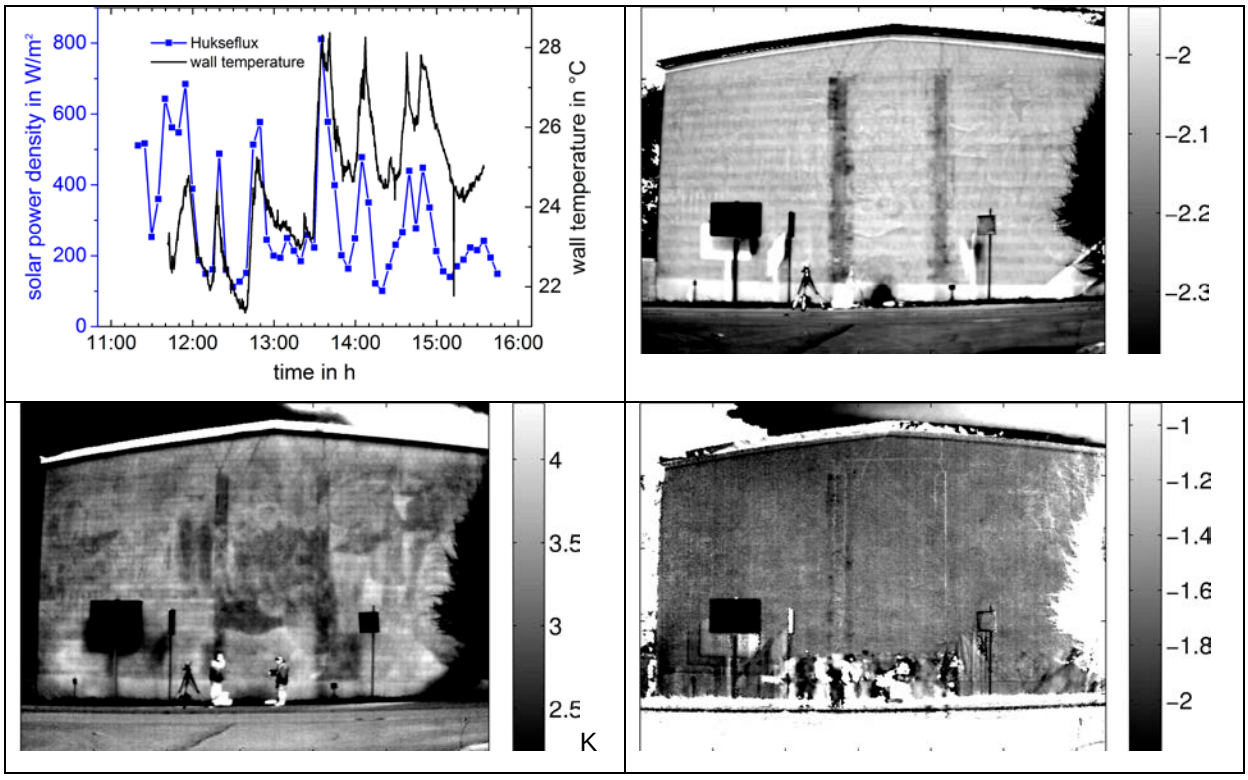

Figure 5: Results of investigations at the rural painting in Cobbelsdorf using active thermography with solar heating during a day with alterations of sun and clouds. Top left: Radiant flux density of the sun and mean wall temperature as a function of measurement time. Bottom left: Difference thermogram at 1:56 p. m. related to a thermogram at 11:40 a. m.; both metal bars in the middle of the thermogram can be recognised as cooler (darker) areas. Top right: 2nd phase image of the sequence, the metal bars can be recognized even better as in the thermogram. Bottom right: 10th phase image of the sequence, the cracks below the roof and near the metal bars can be detected.

Basic data

Short title: ERBE

Reseachers / project leader:
Bundesanstalt für Materialforschung und –prüfung (BAM), Berlin
Dr. Christiane Maierhofer, project leader
M.Eng. Mathias Röllig
Dipl.-Ing. Henrik Steinfurth
Dipl.-Phys. Sven Augustin,

Fraunhofer Institut für Fabrikbetrieb und -automatisierung (IFF), Magdeburg
Dr. Rüdiger Mecke
Dipl.-Ing. Michael Schiller
Dipl.-Ing. Alexa Kernchen

Institut für Diagnostik und Konservierung an Denkmalen in Sachsen und Sachsen-Anhalt e.V. (IDK), Halle
Dipl.-Ing. Uwe Kalisch
Dr. Jeannine Meinhardt

Dr. Christiane Hennen, Bauforschung – Denkmalpflege, Wittenberg
Dipl.-Rest. Ernst Thomas Groll, Restaurator, Magdeburg
Dipl.-Rest. Torsten Arnold, Landesamt für Denkmalpflege und Archäologie Sachsen-Anhalt, Halle

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Contribution of the government: 175.711,07 €

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