

NON DESTRUCTIVE INVESTIGATIONS OF HISTORICAL PLASTER AND STONEMWORK IN SAN GIOVANNI DEI NAPOLETANI CHURCH IN PALERMO (ITALY): EVALUATION OF THE EXCHANGE BETWEEN ARCHITECTURE AND ENVIRONMENT BY THERMOGRAPHY AND RADAR SURVEY

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ABSTRACT

Historic plasters will be increasingly at risk, due to natural alteration as well as renovation projects when internal and external plaster is refused and refaced. To sensibly conserve as much as possible of the historic substance, the preliminary inquiry is very important to get a profound knowledge of the integrity of materials and their decay, and to decide how to restore them. The application of NDI like infrared thermography (IRT) and radar investigation can be a reasonable support to evaluate the relationship between interior and exterior plaster, the microclimatic exchange in the architecture surfaces and the related alteration of materials. In fact they're used for the detection of problems with isolation, to detect evaporating humidity flows on the surface of buildings and to locate adherence loss and cavity of plasterlayers.

Thermography and radar survey had been applied to study the facade of San Giovanni dei Napoletani church in Palermo (Italy) during a collaboration between the Department Denkmalpflege of the Technische Universität Berlin and the L.I.R.B.A. Laboratorio di Indagini e Restauro dei Beni Architettonici of the University of Palermo. The main line for the thermographic measurement was to get a profound knowledge about the current status and damage of the plaster and stonework; in addition the radar investigation was of interest to underline the achieved results. It was possible to locate various damage like adherence loss and cavity between the layers of the plaster and humidity at the surface, which was not visible. Another important focus of the contribution was to study the influence of different climatic conditions at different times of day during thermographic measurements. The three studies which were carried out from September to November 2007 generated an interesting variety of results.

INTRODUCTION

The essay presents the interdisciplinary research between the Heritage Institutions Denkmalpflege der Technischen Universität Berlin and the Laboratorio di Indagini e Restauro dei Beni Architettonici (L.I.R.B.A.) Palermo, which intended to analyze the historic plaster of the façade of San Giovanni dei Napoletani church in Palermo/ Italy. Using the application of NDI to analyze the current condition and degradation state of the plaster surface in an exemplary way.

Plastered surfaces of buildings used to be repaired, replastered and whitewashed using traditional materials. Nowadays, in contrast, it is common practice to renew and to replaster with incompatible material. In the past the material was used economically and plaster was cared for and repaired with lime whitewash every 30 to 50 years. This is the main reason that historic plaster is still found today. Such a protective method should be at the forefront with the sustainable savings and conservation of the traditional structure with its alteration and changes. To sensibly conserve the historic substance as much as possible, the preliminary inquiry is very important. For a long time NDI have been very well established in material testing and diagnostics and are always being developed further. They are used to support the visual mapping of condition and the extend of erosion. The advantage of the non-destructive methods like Infrared Thermography (IRT), Ultrasonic Testing, Radar Survey and the new

method of Optical Lasers is the preservation of the indagated structure. They have been in use since the 1990s in an increasing manner and appear a reasonable alternative solution to the subjective method of the percussion.

These methods are successful because they are essentially non-destructive and their results are reproductible. They work very sensitively, because they can give explicit objective information about the status and the ratings of degradation without a direct contact with the object.

BASIC CONCEPTS

The principles of the IRT method are based on temperature. Thermal radiation, the infrared radiation, which is invisible to the naked eye is emitted from the surface, which was heated before. The infrared camera records and changes the infrared radiation into thermograms. On the basis of the distribution of different temperatures at the surface of the tested object it is possible to get information about erosion, damage, humidity on and under the facing, which are invisible. The structural-diagnostics uses the sector of short wavelength (2-5 μm) and long wavelength (8-14 μm), because of the best intensity in these areas.

The non-destructive Radar method on monument plaster is carried out on the basic fact, that animated and extended electromagnetic waves can give information about constitution and inhomogeneity inside the structures. Also it is possible to investigate the consistence and construction of walls, masonry, floors and ceilings up to a deepness of 1,00m.

INVESTIGATION

The aim of the application of both methods during this project was the analysis of historical plaster and stonework. The thermographic measurement was used to get a profound knowledge of the present status and the extend of the degradation of the plaster and masonry. In addition the radar investigation was of interest as well as to underline the achieved results.

The object for the measurement was the facade of the 16th century San Giovanni dei Napoletani church, in the old town centre of Palermo. The appearance of the facade is composed of two essentially different types of facade, whose structure has often been modified, renewed and transformed in their structure. That also applies to the plaster surface because of the diversity, the age and its present state. The alignment to the south-east of the facade was helpful for the infrared thermal measurement. The warming up of the facade by the sun throughout the day was necessary for the investigation of the emission of heat during the cooling down phase.



*Pict.1: The investigated facade of San Giovanni dei Napoletani church, Palermo.
The red line shows the interior space of the church*

Proceeding

In three studies from September to November 2007 it was possible to observe the influence of different climatic conditions and of different times of day during the thermography measurements. The September testing represents the basis for the analysis and the interpretation of the achieved results, because of the almost ideal conditions during the measurement. For the investigation it was necessary to warm up the facade by the sunlight, which made it possible to start the thermography-measurement with to detect the emission of radiation, using the cooling down phase when sun warming was finished. For the registration the camera FLIR THERMACAM B2 with an objective of 9,2mm wide angle was used. The thermographic measurement took place scanning the whole facade successively in several single shots, that had been saved as Infra red images. As a basis for the complete proceeding it was necessary to develop an exact deformed overmeasure by using the photogrammetric survey. The montage of these images together with the Infrared images created the thermograms, which are variable in their transparency. Three adequate scales of the great spectrum of scales were used for the analysis, thus the pseudocolours Iron and Rainbow, as well as the grey representation Grey.

RESULTS

Infrared-Thermography

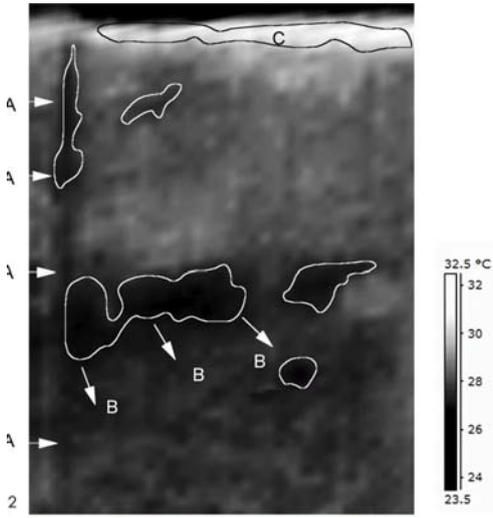
In the visual study it is possible to detect erosion, like the total loss of plaster and adherence loss. However the extend under and between the layers, as well as the cavity of plasterlayers is cannot be observed. The humidity cannot be observed either, due to its position. Improvements which have been made with another type of plaster, like cement, can be seen in small areas and in a larger area which has already been sanded.



Pict.2 Detail of the current status of the facade. IRT was made on 2007/09/17 at 20.30 p.m. after sunset in the direct cooling down phase temperature +31°C, relative humidity 34%

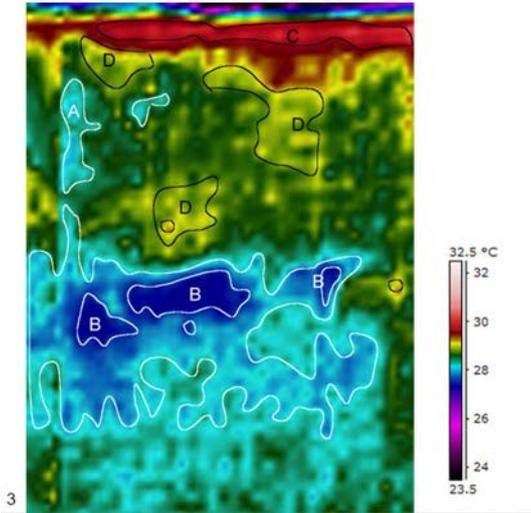
The thermogram Grey shows in the central position dark-gray tones, which are to be expressed in the cold temperatures of the scala. They indicate humidity on the surface, which may have been caused by the eaves gutter (A). Another reason could be the interfusion of the humidity from the inside to the outside, where it evaporates (B). In the infrared picture the humid parts on the surface have the lowest temperatures and are shown in the darkest colors.

The reason is, that the cooling down of H₂O is faster than that of the surrounding plaster and of the continuous process of evaporation from liquid into gaseous status.



*Pict.3 Scale Grey 100% opaque shows phenonema:
(A), (B) humidity
(C) adherence loss, cavities*

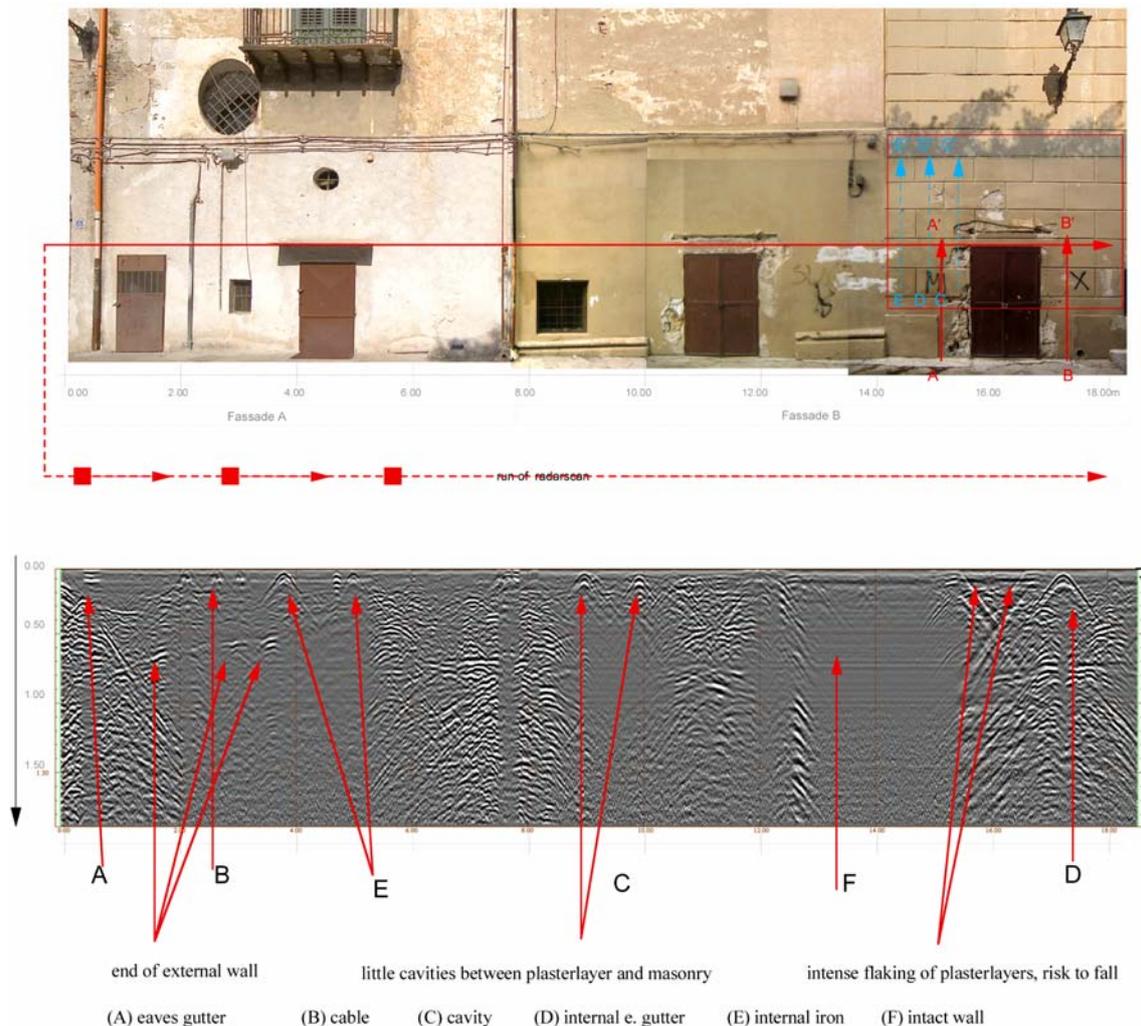
The thermogram Rainbow shows the extent of humidity in the whole lower area of the detail more clearly (B), which appears to be in good condition in the visual observation. There is also humidity near the gutter. The balanced temperatures in the scala are a symbol for parts which are still intact (D). In contrast flaking plaster, cavities and non adherent plaster are most probably in the hot parts (C), which can be seen in the warm colors and the high temperatures. Non-adherent plaster and cavities act as thermal barriers. These non-intact areas are like failings, which have a lower thermal conductivity under the surface area. This is the reason why the surface above this areas keeps warmer longer, which can be seen in the thermogram in the warmest colors and hottest temperatures.



*Pict 4 Scale Rainbow 100% opaque shows phenonema:
(A), (B) humidity
(C) adherence loss, cavities
(D) intact*

Radar

To get more information about the status and to test the potential combination of both methods the Radar survey was applied to the facade, which had already been investigated before by IRT. The high-quality Radar instrument RADAR IDS GRED with a 1600 MHz antenna was used for the measurement. The Radargram demonstrates different signal-reflexes in the form of Parabolcurves, which change to black and white colored curves and indicate variable phenonema. It was possible to measure a double-shell construction of the masonry, that is composed of one integrative compact masonry at the basement, exactly at the point of intersection of both facade-types. Other central signals in a profoundness of 90 to 100cm are refer to cavity or open splices.



Pict.5 Horizontal scan of Radar survey. The Radargram shows signal-reflexes, indicating variable phenonema

CONCLUSIONS

Thermography and Radar measurement can be used non-destructively to determine the extend of weathering of a plastered facade. The application of preliminary studies by non destructive investigation in combination with the visual study generated some very interesting and utilizable results in the determination of the status and damage of plaster and masonry. The achieved results offer the opportunity to check specific areas, fin later examinations for example by putting precise mini-bore holes into the plasterlayers or into the masonry, also as the humidity measurement of the surface. To get a basis for the future procedures for later maintenance NDI can be helpful.

The non-destructiveness would be a great advantage in the preservation of monuments by getting useful results of the preliminary testing of the object. However, this is not common and difficult to put into practice in the practical application of structural-diagnostics. We also have to critically consider the considerable amount of effort like the technical tools, cost and time as well as the efficiency of the diagnostic findings. The thermographic measurement in exterior areas is limited to surface areas, which are sunlit. Just as the readability and evaluation of the results needs a lot of experience as well as the prompt propagation of the various findings.

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