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Water Repellents and Anti-graffiti : a Standard Safe Approach ?

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Abstract

The paper presents a case study of a monument in the centre of Lichtervelde in the Flanders region, constructed after World War II using Massangis Roche Claire limestone. Fifty years later, the local community decided to protect the monument by applying a water repellent and an anti-graffiti product. Shortly after, severe damage occurred in the form of superficial loss by detachment of a surface layer and spalling.
In the framework of a possible durable restoration plan, an investigation was carried out at KIK-IRPA and BBRI to understand the construction method and the material properties so as to understand the origin of the damage phenomenon.
This case study illustrates the need for standards and/or guidelines regarding the preliminary investigations required prior to the application of a treatment, in particular protective treatments, so as to ensure that the treatment will not result in an increased damage risk.
An introduction to a EU-project Graffitage on the development of anti-graffiti products is presented.

Keywords: water repellent, anti-graffiti, damage, standardisation

1 Introduction

Restoration of external masonry generally consists of many different phases, beginning from the repair of its materials and the cleaning of its surfaces, to the application of a water repellent and an anti-graffiti product. The applications of these last two products can not be considered standard operations: the real necessity for such products must be thoroughly verified before any treatment is carried out.

This paper deals with a case study in the Flanders region regarding a monument constructed shortly after the World War II. Fifty years later, the local community decided to protect the monument by applying a water repellent and an anti-graffiti product. Shortly after, severe damage occurred in the form of the detachment of a superficial layer of a depth of several centimetres. To be noted is that no damage had appeared during the first fifty years of its construction.

In the framework of a possible durable restoration plan, an investigation was carried out by the consortium KIK-IRPA and BBRI to understand the construction and material properties and hence the damage phenomenon.

This case study illustrates the need to investigate the possibility and risk of such treatments prior to their application. And it also serves to introduce the EU-Project Graffitage on the development of anti-graffiti products.

2 History

Built in the shadow of the church, the War monument at Lichtervelde (Figure 1) was constructed to remember the victims of the second World War in 1946. The type of material of this pyramidal construction is described in the archives as the French Massangis limestone “Roche Claire”. At the end of the 1990’s the local community decided to apply a water repellent and an anti-graffiti product. The water repellent product was applied to the entire monument, while the anti-graffiti product was applied only to the base of the monument, including the sculptured parts.

The choice of an anti-graffiti product was in this specific case not a logical one since no graffiti had been applied to this monument located in the centre of a rather small community.

Soon after the intervention, cracks developed and severe material loss occurred in some blocks of the lower part of the monument while others remained undamaged (Figure 2). Despite the almost complete removal of the anti-graffiti product one year later, the deterioration continued.

Figure 1: War monument at Lichtervelde

Information necessary to understand the damage phenomenon as well as to formulate a possible durable restoration plan was missing, among it:

- The construction plan with respect to the interior part or core of the monument. In case the interior part was reinforced concrete, corrosion and hence expansion of steel could result in cracking of the thrust and pushing out of the limestone panels.
- The type of water repellent product and the water repellent effect of the treatment carried out.
- The type and in-depth distribution of the anti-graffiti product.
- The state of conservation of actual undamaged panels of the lower part of the monument.

3 Preliminary research

First, the structural conception of the monument as well as the cohesive properties of the corresponding building materials were evaluated by means of core drillings (Ø : 10 cm) followed by endoscopic investigation through the resulting holes.

The microstructure of the limestone was investigated by petrographic analysis of thin sections from samples taken from both the deteriorating as well as undamaged panels, i.e., that appear undamaged by visual examination.

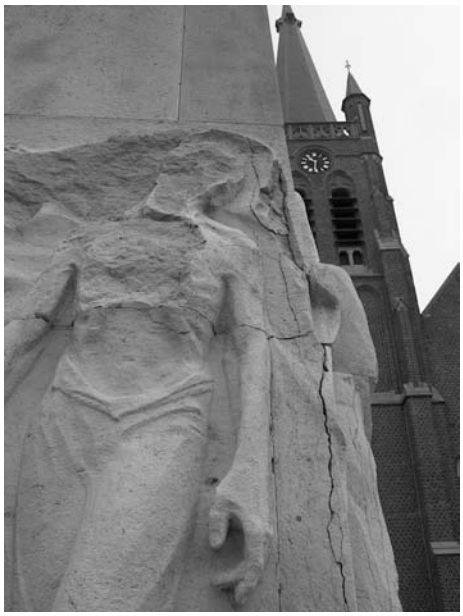

Figure 2 : Crack formation and material loss

The anti-graffiti product was analyzed by means of Fourier Transformation Infrared Spectroscopy (FT-IR) and visualized by optical microscopy of a cross section.

The water repellent properties were evaluated by means of water absorption measurements with the Karsten (Rilem) pipe. Results are expressed as the amount of water absorbed (ml) between five and fifteen minutes ($\Delta_{15\text{-}5}$) [1]. The impregnation depth was determined by sprinkling water drops on a cross section. Water absorbing materials get darker through the absorption of moisture thus enabling a visual evaluation of the penetration depth of a hydrophobic product.

4 Results

During the core drilling, it was noticed that the interior part of the monument was brick masonry and not reinforced concrete. Hence, the corrosion of steel of concrete as responsible for the pushing out of a surface layer of the panels could be excluded. Endoscopic examination of the resulting hole in a damaged panel revealed the presence of a crack parallel to and at a distance of 2 cm from the surface (Figure 3).

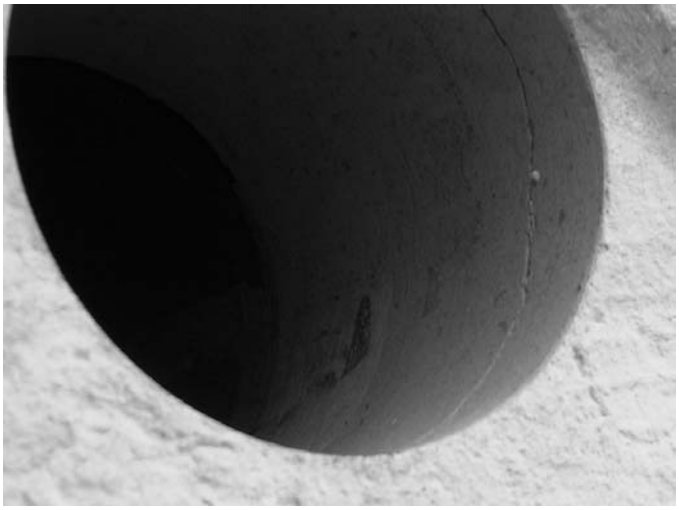

Figure 3: Hole resulting from the core drilling. The limestone panel presents a crack parallel to and at a distance of 2 cm from the surface.

Petrographic research confirmed the type of limestone. As mentioned in the archives, it was the French Massangis limestone Roche Claire. This limestone is known to have a high frost sensitivity.

Microscopic analysis of the cross section of a sample taken from an area showing traces of the anti-graffiti product revealed the presence of an organic film of some 100 µm thickness (Figure 4).

Based on FT-IR analysis of this rather easy removable organic film, it was determined to consist in a combination of a polyacrylate and a polyurethane.

Water absorption measurements with the Karsten pipe resulted in a $\Delta_{15\text{-}5}$ of 0,01 ml indicating that the limestone hardly absorbs water. The impregnation depth of the water repellent treatment ranged from 1 to 3 mm.

The microstructure of the sample taken from the damaged panel (Figure 2) was characterized by several microcracks at a distance of at least 14 mm from the surface. Unfortunately, microcracks were also detected on the sample taken from a visually undamaged panel (Figure 5).

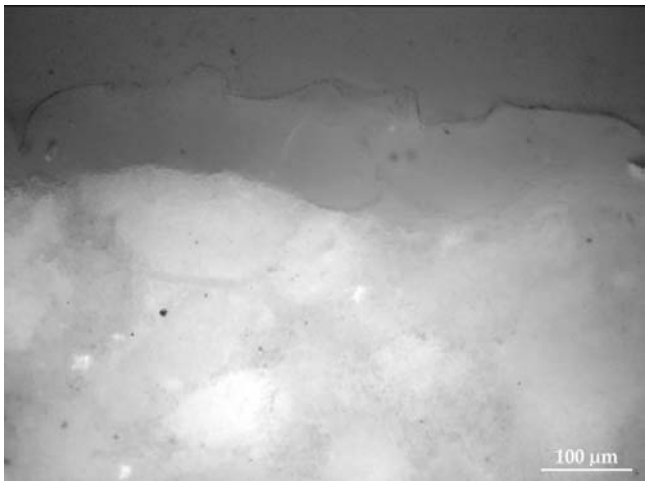

Figure 4: Cross section of a sample taken from a damaged panel showing traces of anti-graffiti product (Figure 2) (reflection, UV light). Under UV light, the organic layer appears as a bluish film on top of the white stone.

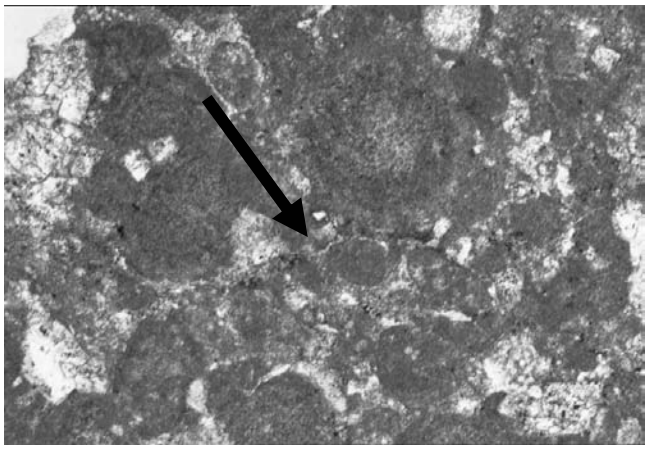

Figure 5: Microscopic analysis of a thin section of a sample taken from a visually undamaged panel.

Based on this investigation, it could be concluded that a durable conservation and restoration plan is hardly possible. Damage is irreversible and cannot be undone. To begin with, there was the poor selection of a frost sensitive limestone for the panels of the monument at

the time it was erected. Then came the application of a water repellent and an anti-graffiti product. If, as is likely, deterioration had already begun, the application of the anti-graffiti product accelerated the deterioration. Especially the anti-graffiti product, being a combined formulation of a polyacrylic and polyurethane, is characterized by a low water vapour permeability. Hence, any water penetrating into the monument is trapped inside. Because water can still penetrate through the flat, unprotected top of the monument, or as rising damp, and certainly through damaged stones or joints. The trapped humidity results in crack formation and material loss during the freeze-thaw cycling in winter months.

Even a careful removal of the anti-graffiti product will not help. Because all the cracks and fissures that have formed have weakened the stone so that damage will proceed at a much faster rate than before.

This case study illustrates the importance and the necessity of a risk assessment prior to an intervention on a monument. A proper risk assessment might have revealed that there were important water infiltrations, besides the ones via the sides of the monument. Thus, based on this information, the following interventions should have been carried out before even considering the application of a water repellent and an anti-graffiti product:

- Covering, eg by means of lead sheeting, of the horizontal part on the top of the monument. Because the application of a water repellent product on such surfaces to prevent water infiltration, is insufficient. An appropriate water run-off system (such as a narrow metal profile that takes the role of a dripstone) should have been included.
- Reduction or complete elimination of rising damp at the lower part of the monument. Due to its massive construction, and the extremely narrow joints, the injection of chemicals against rising damp is hardly possible. Therefore, other interventions are needed to reduce as much as possible the rising damp, such as an appropriate draining system around the monument or polyurethane injections in the soil under the monument.
- The complete restoration, and particularly joint repointing, of the monument.

Only after these interventions, could the application of a water repellent treatment, and possibly a protection against graffiti, be considered. And then, the selection of the latter should have considered a product, preferably of the sacrificial type, that would not reduce water vapour permeability, especially considering the frost sensitivity of the limestone used in the monument.

For this monument, although damage visually appeared soon after the treatments, the question arises if these are the only ones to blame. This question cannot be answered unambiguously. What can be said is that the

treatments have dramatically accelerated the damage mechanism. But when considering the architecture of the monument, and the type of materials used, it is evident that damage might be expected to occur. Possibly gradually in the course of the years and accelerating as years went by, even without the application of these products.

Since no durable conservation plan can be formulated, this monument is lost together with its social and document value. The only possibility of restoring the monument is, apart from the interventions to prevent the uptake of moisture, to replace the damaged parts by copies in a more durable stone (such as the Massangis Roche Jaune).

5 Problems with anti-graffiti – the GRAFFITAGE research

Anti-graffiti coatings are designed to protect building materials from the impact of graffiti and to improve the ease of maintenance of buildings. They know a world wide use from which their positive outcome as protective treatment against graffiti can be conducted.

However, as shown by the case study of the monument of Lichtervelde, the main problem with the most common protection products against graffiti is often their very low water vapour permeability. Hence in case of water infiltrations behind the protective anti-graffiti coating, which can not be completely excluded even after a proper treatment, damage of the underlying materials can occur. This drawback limits the applicability of many existing anti-graffiti coatings for a lot of structures. Furthermore, the irreversibility properties of some of the anti-graffiti coatings might be considered as counter-indicative for their use.

The main objective of the GRAFFITAGE project (with EU-support) is to develop novel conservation coatings suited for protecting materials of historical monuments, based on a similar structure of ancient protein products, while avoiding the disadvantages of currently used anti-graffiti coatings. This development is based on the complexation of polymeric amines that are modified by fluorocarbon residues. These polyampholytes are “protein-mimics” having a structural similarity with traditional coatings, like casein, gelatine and egg-white. These products could be a new generation of anti-graffiti coatings. They should have the following characteristics:

1) A low surface energy;
2) Appropriate for outdoor applications, with a durability against environmental agents similar to traditional polyurethane or fluorinated systems;
3) Reversible through the use of a specially designed mild cleaning system and/or special environment friendly agents;
4) Similar water vapour permeability properties to sacrificial systems;

5) Similar hydrophobic action to that of commercial water repellent products;
6) Not change the visual appearance of the surfaces to which they are applied, i.e., transparency and no gloss, so as to minimize the aesthetic impact of the treatment .

The product could be, after further development, commercialised and applied by SME's involved in this market.

This research is being carried out by:

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10) Bilbao City Council (Spain): B. Brea

6 Conclusion

The application of water repellent treatments and anti graffiti products should be done with great caution.

In all cases such treatments should be considered as a final step of the protection of the building. It should only be made after the necessary 'classic' interventions to prevent the infiltration of moisture in the building materials.

If no proper risk assessment is carried out, then the possibility that water repellent and anti-graffiti treatments, particularly for the case of frost sensitive materials, may accelerate damage phenomena.

The worst situation to be considered is that of an applied treatment being the cause of the resulting damage. And that had a preliminary investigation been carried out, damage could have been avoided.

In the case of the Lichtervelde Monument, the damage that would possibly have occurred at a slower rate over many years, was drastically accelerated because a wrong decision was made. And this has resulted in the loss of a historical and social monument.

The field of anti-graffiti products offers many possibilities for improving existing products while developing new ones more suitable protection for sensitive building materials. This is the aim of the GRAFFITAGE-project, of which results will be shortly available.

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[2] website of the Graffitage project: www.graffitage.com