# THE USE OF POLYURETHANE IN SURFACE TREATMENT

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## 1 INTRODUCTION

The most valuable components of our urban environment - an important part of our cultural heritage - have been made with stone or brick surfaces. However, for a number of reasons these components deteriorate more rapidly in Hungary than in most other countries; the use of non-frostproof, coarse limestone whose porosity is inadequate, our climatic conditions (on average 40-50 freeze-thaw cycles annually) and, in recent years, atmospheric conditions. Furthermore, we are having to cope with the results of the significant urban development which occurred at the turn of the century - the Age of Historicism and Art Nouveau. Then, building surfaces were also made from gypsum (most problematic) and exposed brick (clinker brick, as it is called), while typically Hungarian building ornaments were fashioned from building ceramics such as pyrogranite and glazed tile products from the Zsolnay factories. These surfaces are also deteriorating.

Hence, we have the added challenge of dealing with a wide range of building materials. It is not only a question of conserving coarse limestone facades. We also have to conserve the brick and composite facades constructed at the turn of the century (which were proclaimed as being "in no need of repair"). What is more, these facades were uniformly used for railway buildings, hospitals, schools, garrisons, industrial and agricultural buildings, etc., which only makes the problem more acute.

Since the 60s, the surface protection of building facades has been in the foreground of the research activities into the preservation of monuments. Some twenty years ago, the Laboratory for Monuments Preservation at the Technical University of Budapest was set up to coordinate research of this nature.We first reported our work in Bologna in 1971 and joined the ICOMOS Stone Committee in 1972. On the international field, we are pleased to see that important developments are taking place, that research is addressing the challenge of tangible problems and that recent achievements are actually being applied in practice.

The authors are indebted to Mrs E. Tonk, Head of the Laboratory for Monuments Preservation for her contribution to our research.

# 2 ACHIEVEMENTS AND PRACTICAL EXPERIENCE IN STONE CONSERVATION IN HUNGARY

## ACHIEVEMENTS

- the evolution of an approach to monuments preservation, involving diagnostic tests (before treatment, after cleaning, after conservation); the methods used and their importance;

- the identification of destructive factors whether physical, chemical or biological;

- the demand for non-destructive or semi-destructive tests;

- the importance of treating every problem as unique;

- in addition to laboratory tests, the importance of cleaning and preservation trials in situ in order to evaluate procedures based on peculiarities of the stone in question and local climatic conditions;

- a generally accepted "system of requirements" for facade cleaning and conservation, including special requirements for monuments;

- in the early years of the ICOMOS Stone Committee a universal attitude was already apparent (although unrecognised as such), with regard to considering a building facade a "complete structural unity" rather than individual pieces of stone (N.B. the process of destruction usually begins at the joints);

- this recognition gives emphasis to the interaction of agents used to repair stone surfaces and the ensuing problem of surface appearance.

Some achievements demand special consideration. The fields in which further research has been conducted are described below:

It is no longer a problem of deciding which agents are most suited to stone conservation or brick facade surfaces (that is, if we are in possession of the relevant facts); the problem nowadays focuses on which treatment yields the most lasting protection of the facade in question, given the system of requirements. That is why appropriate comparative testing methods - demonstrating practical efficiency and taking into account economic factors - are of primary importance.

In practice, three or four agents should be selected as well as various methods of treatment and tested on the stone material in question, taking local conditions into consideration. Exact answers will then be obtained, particularly relating to freeze-thaw cycles and frost resistance.

Based on practical experience, we have come to realise that our earlier standpoint needs to be modified; namely, that monuments should be classified into two groups: those with weathered facades needing to be strengthened, conserved and consolidated, and those in no need of strengthening, only needing to be made water-repellant. New buildings fall into this second group, i.e. those with concrete surfaces. But hardly any monuments have sound, homogeneous facade surfaces since the joints will always contain weathered parts. Joints cannot be repaired perfectly, neither can stones or bricks be replaced perfectly. On the other hand, we know of no case in this country where, as stated in the relevant manuals, the silicone treatment has been repeated every three to five years.

## 3 COMPARATIVE LABORATORY TESTS INVOLVING ZKF, AN ALIPHATIC-TYPE POLYURETHANE UNDER HUNGARIAN PATENT

About a decade ago, it was decided a common solution to two problems had to be found, viz. surface protection and water-repellency. The answer was ZKF, a stone consolidant and aliphatic product under Hungarian patent. As ZKF has already been presented at international forums, only the most recent experimental and practical achievements will be outlined here.

As has been demonstrated in laboratory tests ZKF, which is at the same time a hardener and water-repellant, possesses features missing from earlier water-repellant agents - those of adherence and abrasion resistance - the lack of which made the use of these agents rather risky, especially on old buildings since frequent treatment was necessary.
In the next issue of the periodical "Müemlékvédelem" (Monuments Preservation), data will be given representing material losses based on the "Taber-Abraser abrasion resistance test". Data is given in grams for silicone, silica ester, methyl methacrylate and the Hungarian aliphatic polyurethane product. The first two did not produce any gaugeable results while the second two, stone consolidant and a stone replacement agent - proprietary names Paraloid B72 and ZFK - resulted in material losses of 0.026 g and 0.020 g respectively.

A special study has examined the problem of non-adherence of a number of agents used in Hungary. However, where silicons are concerned the explanation is quite simple: in the outer parts of the pores, which make up about 30% of the surface, the agent takes hold but not in the remaining 70%.

Other agents raise other problems; inflexibility (stiffness, rigidity) and no resistance to acid rain or UV radiation.

In the comparative tests involving aliphatic polyurethane and other agents, much emphasis was laid on frost-resistance tests:in Hungary stone is classified as frost-resistant after 25 freeze-thaw cycles. Frost-resistant tests are performed optically and also mechanically on "Sóskut" coarse limestone samples as well as on limestone grind prism, which is found to best simulate weathered stone.

Results of optical tests on coarse limestone samples:

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|---|---|---|---|
| - | untreated | 7-8 | freeze-thaw cycles |
| - | silica ester treated | 20-21 | freeze-thaw cycles |
| - | methyl-methacrylate treated | 18-20 | freeze-thaw cycles |
| - | polyurethane treated | 31-34 | freeze-thaw cycles |

The mechanical tests showed that untreated samples exhibited a bending-tensile strength of 1.5 N/sq.mm, while polyurethane- treated samples (classified as frost-resistant after 26 freeze-thaw cycles) exhibited a bending-tensile strength of 5.4 N/sq.mm. Compressive strengths increased from 6.9 to 12.8 N/sq.mm. Mechanical tests could not be performed on the stone grind samples treated with the other two agents used in the comparative tests as the samples failed soon after reaching 26 freeze-thaw cycles.

# 4 PRACTICAL EXAMPLES OF TREATMENT USING AN ALIPHATIC-TYPE POLYURETHANE (ZKF STONE CONSOLIDANT)

Some of the following examples were reported at the Lisbon symposium in 1992.

- the base of the TUB Central Building; treatment has endured for nine winters while the untreated quarrystone crumbles if handled manually.

- Central Post Office, Sopron, built in 1918. This was the first major application of ZKF six years ago. Although initially we did not think conditions entirely satisfactory (cleaning method, control opportunities, the quality of some of the operations involved in the conservation process), the enormous stone facade which then showed signs of complete destruction in some places, now shows no visible damage;

- the Zeughaus Gate in the Buda Castle district is the most spectacular achievement to date. This Baroque gate used to be part of the castle's arsenal (Zeughaus). The castle was demolished at the turn of the century, the gate incorporated into a wall of medieval origin and the opening walled in, making the gate merely decorative. Five years ago its conservation was a rather difficult problem. The stone could be manually crumbled while most of the carvings had disappeared. The wall into which it had been incorporated was very thick and subjected to damp. Careful decision had to be reached as regards the agent's depth of penetration in order to avoid crustification, a problem in any in situ stone conservation. The carvings were first cleaned manually and restored by a skilled craftsman. Treatment with ZKF followed and the gate underwent a rebirth. There are however signs of salt efflorescence due to dampness in the wall which could probably be reduced by injections behind the stones;

- our most complex task to date was the restoration of the facade of Brunswick Castle in Martonvásár. Here, our stone conservation method could be tested on a facade made up of a multiplicity of materials (stone, brick and painted plastering, which was applied on facades particularly at the turn of the century). In addition to conserving the stone and pyrogranite, the original plastering had to be preserved. Firstly, the plastering, comprising two layers 3 to 5 cm thick, was fastened to the wall with ZKF, then painted. This initiated another study - to find a paint which could be applied to ZKF-treated plastering;

- an example of partial construction is the corner balcony on the quarrystone facade of the house at No.3 Alkotmány Street in Budapest; a difficult problem of stone replacement as well as conservation;

- the set of balustrades of the Hungarian Academy of Science building created an unusual problem but one that recurs frequently. Should the strengthening/water-repellant treatment be applied on hard limestone and if so, to what extent ? Without going into the problem in any detail, we would just like to remark that hard limestone surfaces frequently exposed to acid rain undergo a delayed corrosive effect and their treatment should be considered.

We should also like to emphasize that the conservation agent and method of treatment used on old buildings, also provide lasting protection to new and sound brick and stone facades; their enhanced adherence and abrasion-resistance permits them to maintain facade-soundness for the normal renewal cycle of 20-25 years.

PHOTO 1 Deterioration of sculptures from the House of Parliament in Budapest.

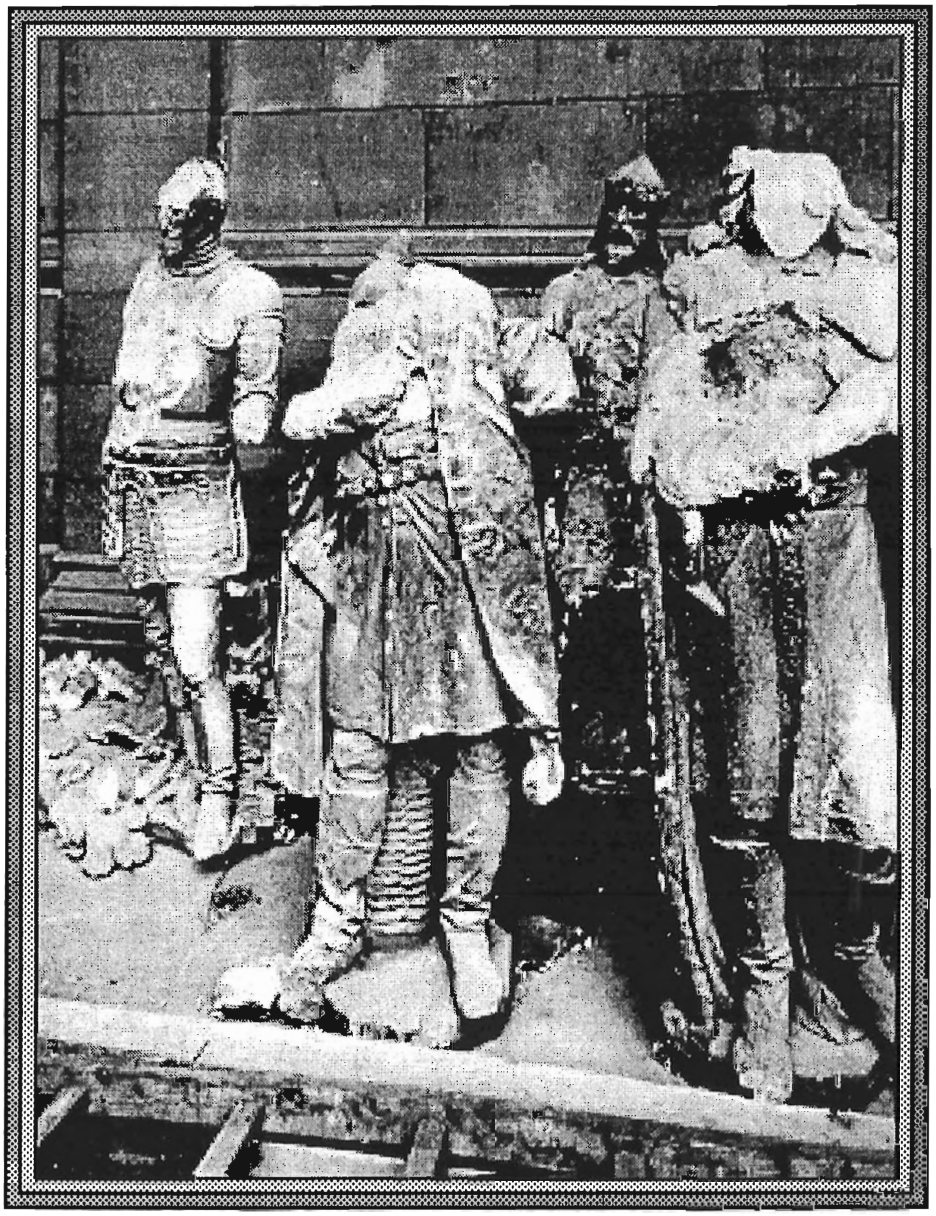

PHOTO 2 Brick deterioration of a new building (15 years old) in Sopron.

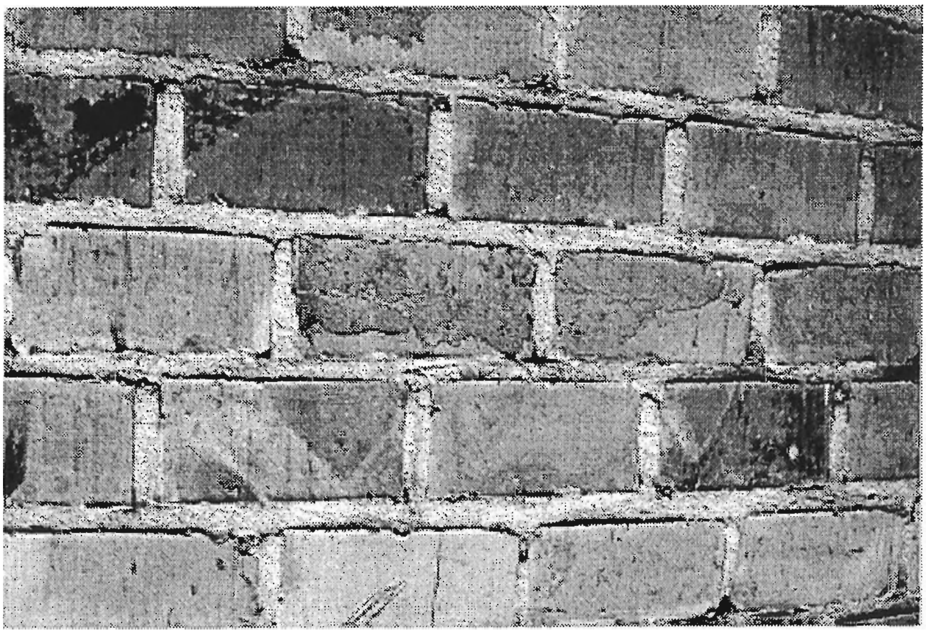

PHOTO 3 A typical Hungarian soft limestone, deterioration and partly cleaned.

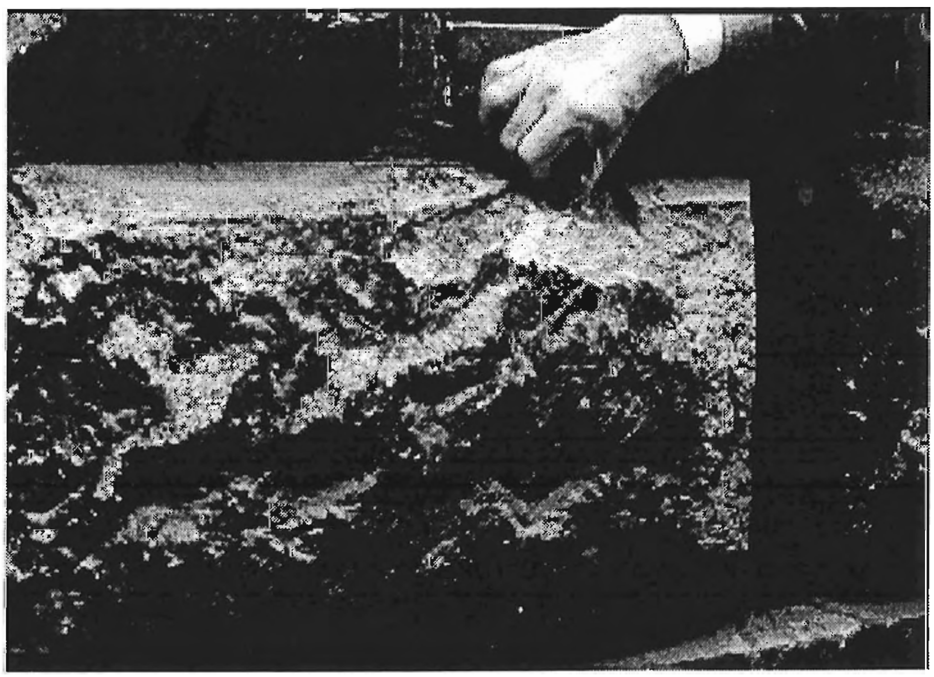

PHOTO 4.a, b The most popular less destructive cleaning method in Hungary (J.O.S. method).

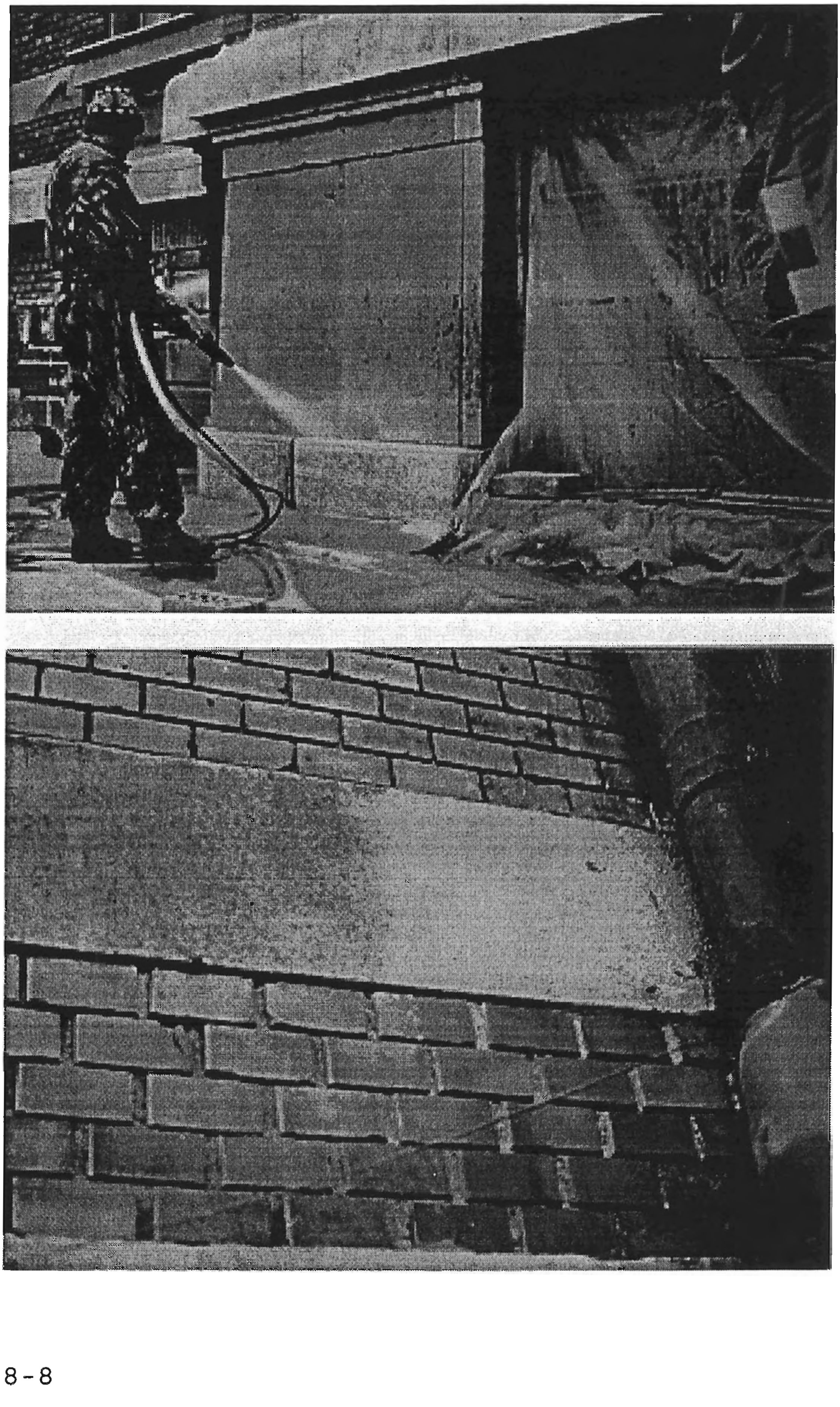

PHOTO 5 Soft limestone blocks on the building facade of the technical University of Budapest, treated by polyurethane (ZKF consilidating method). Nine years old difference between the treated and untreated part of the stone.

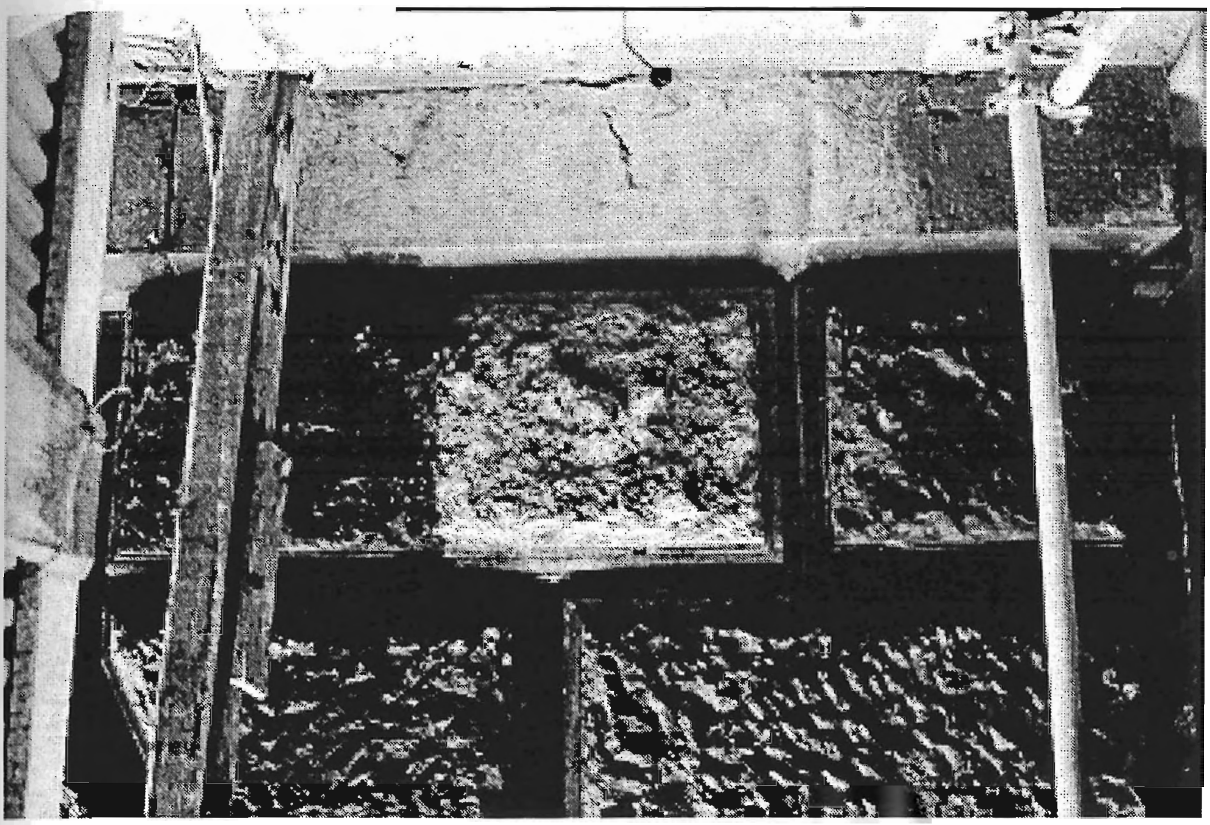

PHOTO 6 a,b,c, The gate of the formar Arsenal building (before and after polyurethane treatment, consolidated and water repellent).

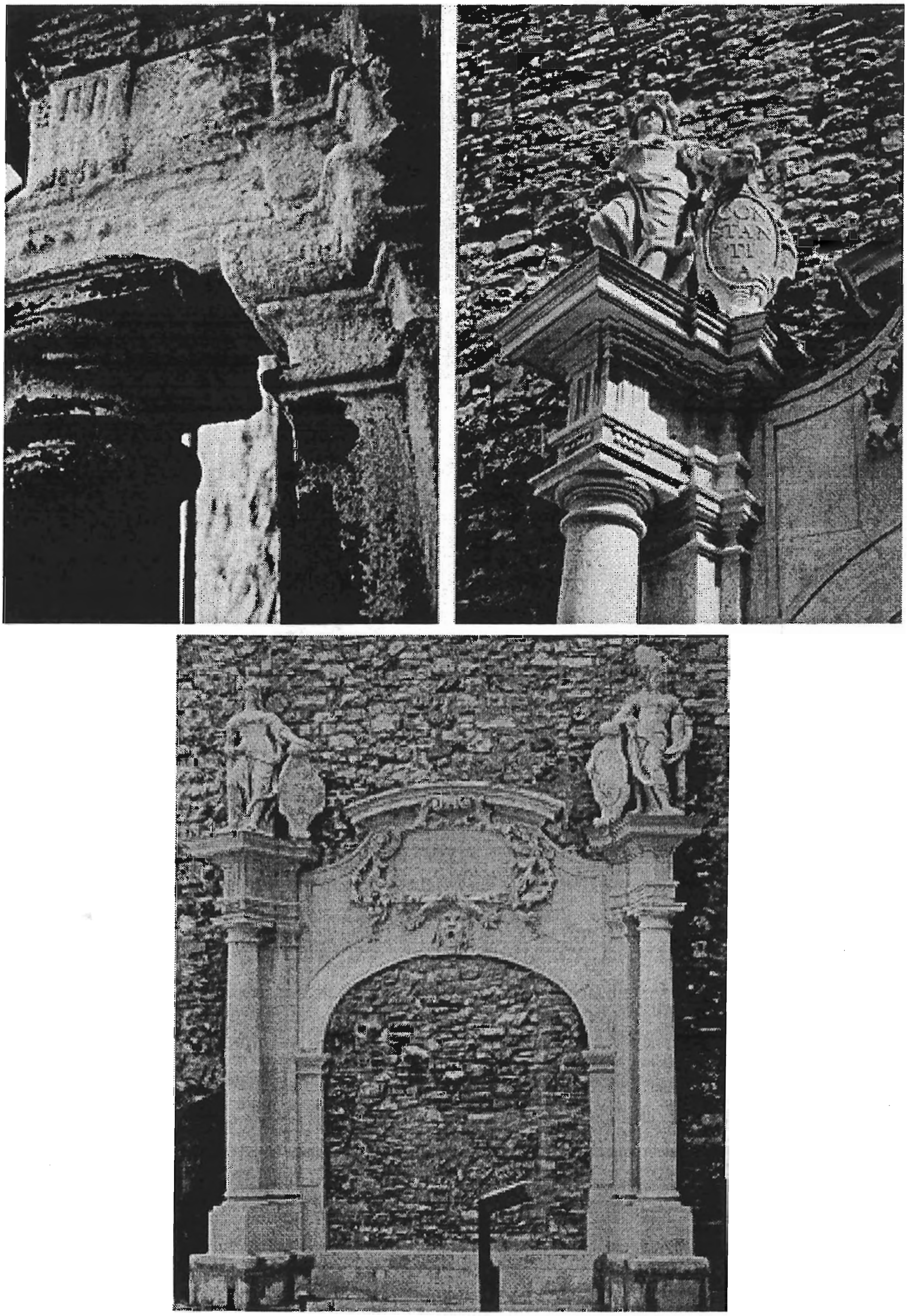

PHOTO 7 a,b Budapest, Hungarian Acadamy of Science building Substitutial material (new part was made by the powder of the stone mixing with polyurethane).

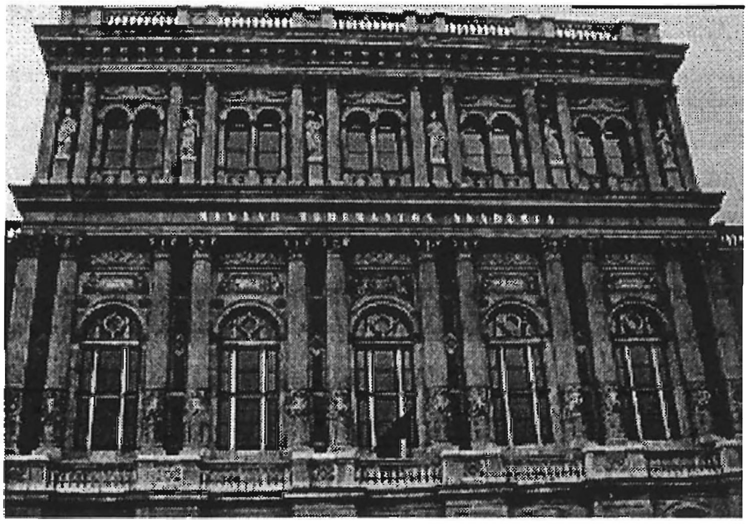

PHOTO 8 Budapest, Alkotmany utca 3. Consolidated, repaired and water repellency by polyurethane.

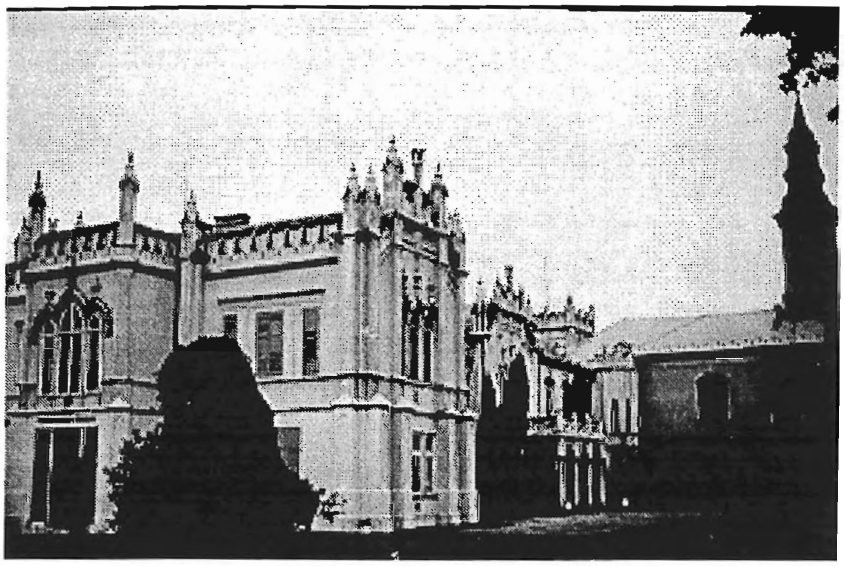

PHOTO 9 A special way of using our Hungarian polyurethane treatment for different kind of materials on the same facade (e.g. fixing the deteriorated plaster, stone and brick construction etc.,) by capillair transport from the polyurethane through the seperated layer and fixing to the brick wall behind.