PROBLEMS AND ACTUAL STADE OF STONE CONSERVATION

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Summary

The major part of monuments all over the world are of stone, particularly sensitive to atmospheric pollution, stressing the importance of preventive measures. The work of national institutions concerned with monuments preservation is coordinated by international organizations such as ICOMOS, ICOM, RILEM, ICCROM, etc. Recently, a wide range of conservation agents and treatments have been developed, the application of which has to be preceded by diagnostic tests. Hungarian monuments preservation encounters difficulties due to the limestone quality but recent attempts with specific agents and treatments look promising, in particular as concerns conservation with consolidation.

Most of the wealth of monuments all over the world have been built of stone, understandably making the fight to stone destruction the primary task of organizations for monuments preservation and of architects engaged in reconstruction. This activity has become prevalent since the '30s, with the worsening of atmospheric pollution concomitant to industrial and traffic development. Actually, the rate of destruction is about 5 to 10 times that of 50 years ago.

The increasing risk of stone material destruction was by far not paralleled by that of the means of preservation (previously paraffine, wax, grease, oil paint, etc.; recently, agents relying on latest achievements of chemistry but improperly reckoning with monumental, petrological aspects or environmental effects) doing more harm to the stone that to leave it untreated. The same is true of the first invisible plastic coats (e.g. magnesium fluor silicate, so-called "fluorinating", etc.).

As a consequence of the development of chemistry, of the cooperation between specialists of marginal sciences, and above all, on the definite intention, initiatives and organizatory functions of organizations for monuments preservation and of UNESCO, actually a significant progress, an essential quality change can be spoken of. This is true mainly for some part problems — certain stone materials and the so-called cases needing no consolidation — where no difficulties arise from the principle of solving the problem, as demonstrated by great many buildings kept in good state of preservation for a long time after treatment. Other fields of stone conservation still require further research work. The overall picture of practical utilization of up-to-date scientific research, conservation of stone monuments, or in general, of stone surfaces, is rather heterogeneous: in some countries (e.g. Italy, France, Federal Republic of Germany, Poland, etc.) it became general practice, while in other countries, only beginnings, diminishing of the unjustified mistrust to new methods, can be spoken of.

The evolution of this situation will be outlined; ramifying, then convergent paths of international and domestic activities, as well as practical possibilities, respectively available and expected from subsequent research for preventing further destruction of stone monuments in this country.

Main features of international development (Research centers, organizations, essential methods)

In recent decades, several important research centers and a number of eminent specialists have been concerned with this problem in different countries — as a function of the respective wealth of stone monuments and of financial possibilities. So are international organizations, of them the first was ICOMOS to organize a relevant conference by the mid-'60s, followed by ICOM, federation of museums, in New York, 1970, while RILEM invited to international cooperation and formed working committees to solve this problem. ICOMOS (International Council of Monuments and Sites), international organization for monuments preservation, has been deeply concerned with saving perishing stone monuments immediately following its foundation in the mid-sixties. It was the first to attempt uniting specialists with different qualifications, aspects and working spheres in the same working committee (ICOMOS Stone Committee) [1] and forwarding the exchange of experience, interdisciplinary cooperation, by organizing international conferences. The first international center of this activity was in Brussels, conferences were held in the Belgian restoration institute directed by Prof. Sneyers, the first chairman of ICOMOS. (It was here that Hungarian specialists joined international activity.) Both Belgian and Dutch restoration institutes — initially, especially under the direction of e.g. Munnikendam, van Asperen, Stambolov, much more active than now, — were common institutions for museal and monumental restoration-coservation, resulting in differences of approach still prevailing between monuments preservation specialists, mostly devoted to in-situ conservation, and museum conservators working under laboratory conditions (and laboratory-minded). Obviously, no complete building façade can be cleaned and conserved in vats of the restoration workshop. At the same time, advantages, possibilities and practical facilities of restoring stone sculptures or removable building parts in museum laboratories or workshops must not be left out of consideration.

A quite different approach was that of RILEM (Réunion Internationale des Laboratoires d'Essais et Recherche sur les Matériaux et les Constructions), an international organization uniting institutions concerned with research and quality testing of building materials. Specialists mainly concerned with petrophysical-type tests investigate quarried building stones for suitability, a fact imprinting both methods and approach.

Such problems arose mainly at the beginning, in the ICOMOS-RILEM common working committee [2] formed in La Rochelle in 1972 (of them the Author has been member, together with Dr. Pál Kertész, since the very beginnings). It was hard to explain fifteen or twenty members of the working committee, eminent specialists accustomed to wide-range tests on great many samples, that e.g. the quantity of samples from a Romanesque doorway would use it up almost entirely.

At last, the working committee has elaborated methods for testing causes and rate of stone destruction, and suitability of preservatives, accepted for international recommendations at the 1978 Conference in Paris [3].

The activity in the frames of international organizations had been boosted by the 1970 UNESCO Conference in Venice, meant to direct the attention of governments of member countries and of the world-wide public opinion on the disintegration of outstanding stone monuments of the universal culture history, and urging countries to forward a solution. This had been the scope of a series of comprehensive symposia organized every four years, attended by eminent specialists (La Rochelle, 1972 [4]; Athens, 1976 [5]; Bologna, 1980 [6]).

In this respect, special mention is due to Bologna, the center maybe No. 1 of stone monuments conservation, where the Centro per la Conservazione delle Sculture all'Aperto organized independent international meetings (1971, 1975) mainly promoted by R. Rossi-Manaresi, and published proceedings thereof. A practical implementation of the work made in Bologna has been conservation of the San Petronio doorway.

The other important Italian basis is ICCROM, the international center of monuments conservation in Rome. The restoration project of the large-scale complex in Via di San Michele has grown of this institution of international importance both for training specialists and for practical activity as concomitant. Its work is helped by the Institute for Monuments Restoration in Rome, responsible, in addition to forming Italian specialists, for a number of important monuments conservations (such as that of the well-known stone column in Piazza della Colonna in Rome, now under way. (High-grade, effective work in Rome is based on the efficient cooperation between ICCROM (G. Torraca), Institute of Restoration (M. Tabasso), and research institutes of the Academy (P. Rossi-Doria). Of course, these are joined by work at other Italian centers (Firenze, Venice, Torino, etc.).

While stone conservation in Italy is mainly the responsibility of institutions for monuments conservation (integrated by research at universities and Academy institutes), in France, a team has formed in the Institute for Building Research (CEREB), concerned, in addition to quality testing of building stones and conserving new stone surfaces, with the examination and conservation of monumental stone surfaces. (The concerned section of this Institute is headed by M. Mamillan, chairman of the ICOMOS-RILEM working committee.) Their experimental plant comprises an exemplary testing station.

In the USA, stone conservation bases have formed mainly at universities, such as at the New York University, under the guidance of Prof. S. Lewin. Beside education and research, Prof. Lewin has been active as expert on conservation methods abroad. His method named LSP-I consists in exchanging calcium ions to barium ions of a higher resistance. This method does not provide water repellency but a second component can do it. It better suits hot-climate countries (e.g. Ethiopia), namely in countries with freezing-thawing cycles in winter, stone surfaces need primarily to be made water repellent. An important basis of research in the USA is the National Bureau of Standards, counterpart of the Hungarian Institute for Quality Control of Building (ÉMI). Two comprehensive reports survey the stade of stone conservation, types of materials, and the relevant bibliography.

Next, the centre at the Louisville (USA) University should be mentioned, site of the last symposium on stone conservation in 1972. This work is directed by Prof. Lal Gauri. The method they developed relies — at a difference from that by Prof. Lewin — on epoxy resin treatment of a marked consolidating effect but risky for stone carvings in humid environment — like that prevailing in this country (without mentioning other inconveniences such as stiff, "dead" surface, discoloration, etc.).

The same is true for the method developed by Prof. Domaslowski (University of Toruń, Poland), although it has been applied for quite a number of outstanding monuments in Poland. (By the way, vapour transmission can be much increased also for the epoxy resin method, this is, however, still below the recommended 95%, or even the acceptable 85%. There are opponents to the epoxy resin method even in Poland. For instance, Prof. Barbara Penkala (Technical University of Warsaw), cooperating with the team of the National Museum in Poland, is looking after the solution in a quite different way, better fitting the natural texture of stone material.

In England, similarly to France, this discipline has Building Research Establishment as basis, concerned mainly with the development of testing methods and testing of various conservation agents. Good results have been achieved with "Brethane", a conservation agent they developed. Mention has to be made of British Museum, traditional center of museum-borne restoration (K. Hempel) concerned, in addition to restoring stone sculptures, also with monuments preservation by developing methods suiting monumental stone conservation.

In the Federal Republic of Germany — besides of research done at Doerner Institut, by J. Riederer and at universities — primarily industrial research has offered new achievements. Research laboratories, among others, of Bayer and of the actually leading Wacker factories achieved outstanding results by integrating the technological process of production and immediate feedback of experience from applications, earning thereby international acknowledgement (Wacker Sandsteinverfestiger OH and H, Wacker surface coatings).

Alongside with referring to principal international centers, workshops engaged with the research of efficient conservation methods for stone monuments, and in general, stone surfaces, some methods have to be outlined. In the following, the actually world-wide prevailing main principles and methods will be systematized and sketched, starting from the fundamental distinction made by me earlier at international meetings [7]: first, fundamental step of stone conservation is to make a diagnostic test [8] for being included into one of the following two fundamental cases:

I. Conservation without consolidation, possible by surface treatment;

II. Conservation requiring consolidation.

Distinction between these two cases, careful consideration of the tasks and stating the issuing requirements are imperative from several causes. First, since some researchers (and publications) state stone conservation to involve only problems relevant to case II: conservation by consolidating weathered surfaces. This approach is typically that of museum conservators and related researchers devoted mainly to the conservation of sculptures of stone, a material prone to weathering yet unthinkable to be peeled (at most a few microns of polluted surface) but conserved mostly in restoration workshops — rather than in-situ — under the best conditions possible.

The other extreme (represented by building research institutes also concerned with the protection of new stone surfaces) is to prefer conservation by an invisible, aerating, water repellent coating meeting up-to-date requirements, actually an easy, proven method simple to execute, looking back to some decades of practical applications — provided it is applied in the proper case. This latter is an essential problem justifying ranking into two groups as the first step determinant over the entire process, "condition sine qua non" of stone conservation. Namely, this problem is actually solved with no difficulty, primarily by using silicones of the needed quality (in aqueous solution or with an organic solvent) meeting essential requirements (invisible, water repellent, aerating), available throughout the world, applicable without special skill [9]. On the other hand, specialized knowledge is needed to decide when silicone treatment would achieve the wanted result. Namely, it cannot be efficient in cases where

- — the surface is other than clear, strong and perfectly smooth;
- — there is an important rising soil dampness (empirically found to produce over 10% by weight of brick masonry dampness);
- — though at a lower wall dampness, the masonry material or the groundwater contains sulfate or nitrate pollution, likely to produce salt concentration behind the treated surface, entraining thereby destruction of the surface layer;
- — no treatment repeated each 8 to 10 years can be safeguarded.

In the cases above, surface protection by an invisible coating (silicone) is unadvisable even if the surface is in a good condition of repair, in no need of consolidation, only start of the weathering process is to be prevented. Well, here resides the motivation of international debates, contradictions resulting from generalizations, summary statements, either accepting and propagating silicone treatment without reservations, glad to be able to successfully solve the basic problem: to keep away dampness — the main destructive agent — from the masonry still maintaining at least 95% of aeration ability. Again, failure to take the quoted preconditions into consideration leads to the other extreme: refusal of silicone treatment on hand of negative experience (either due to ignorance of the quoted excluding preconditions or to the need of a consolidating conservation in the given problem belonging to the second basic group).

From the aspect of practical needs, in fact, most of monumental stone surfaces in Hungary belong to the group of the first basic case where it suffices to prevent starting of the weathering process. This group includes the majority of ruin conservation problems, new stone material of reconstructions with stone replacement and of course, existing and newly constructed non-monumental stone façades, engineering structures, objects built of stone. This group includes — as of a special interest — part of our stonework finds still on this side of destruction. There would be much more of them if the past decade were spent on applying one of the simple, inexpensive surface protection methods, e.g. that by silicon treatment available in this country. Its omission — in spite of our earlier suggestions — has reduced most of the highly valuable Roman and Mediaeval stone carvings to case II, the group in need of consolidating conservation, much more difficult, questionable and costly than that without consolidation. Surface protection, water repellency raise increasing interest internationally, and give rise to an increasing number of studies — reports on research items and comprehensive evaluations, such as those by the three greatest research centers of the world: those in England (BRE), in Belgium (CSTC) and in France (CEREB) published in recent years. Among them, special interest is due to those by CSTC issued in 1981 and in 1982, systematizing the different surface protective, water repellent materials into groups of siliconates, silicones, metal organic compounds or siliconates, silicate esters, silanes, siloxanes and silicone resins) CSTC-Revue, February 1982, and CSTC — Note d'Information Technique, No. 138, Sept. 1981).

In addition to practical recommendations, the mentioned publications express the view of the research institutes to consider application of water repellent surface protective agents indispensable, and the suitability of either silicones or silanes or even siloxanes, to be decided via appropriate preliminary diagnostic test.

Agents exclusively suiting stone conservation with consolidation are grouped by James R. Clifton in "Stone Consolidating Materials — a Status Report" [10] as follows:

1. Inorganic materials
   1.1. Siliceous consolidants (alkali silicates, silicofluorides)
   1.2. Alkaline earth hydroxides (calcium hydroxide, strontium and barium hydroxides)
   1.3. Other inorganic consolidants
2. Alkoxysilanes
3. Synthetic organic polymer systems
   3.1. Acrylic polymers
   3.2. Acrylic copolymers
   3.3. Vinyl polymers
   3.4. Epoxies
   3.5. Other synthetic organic polymers
4. Waxes

ad 1) Stone consolidation using inorganic materials looks back to a long past with little success. Most of these materials produce an insoluble white deposit in stone pores, a hard surface crust prone to scale off, often without the needed consolidating effect.

1.1 Among siliceous conserving agents, alkali silicates are typically prone to salt efflorescence, with its harmful consequences, producing a vapour-tight surface layer, and harmful metamorphoses in the crystalline texture of the stone. They fit limestone even less than sandstone.

The same is true for fluosilicates expressively prohibited to be applied on limestones because of harmful chemical reactions. Relevant fluosilicates of magnesium, zinc and aluminium form a thin hard layer on the limestone surface soon cracking and scaling off.

1.2 Alkaline earth hydroxides such as e.g. calcium hydroxide have long been stone conserving agents combining with atmospheric carbon dioxide to calcium carbonate "nourishing", consolidating the limestone surface. Lime water or limewash have ever been recommended for stone conservation both in this country and abroad. Their greatest advantage is to be harmless but at the same time they afford little surface protection against chemical and physical aggressive agents (acting in the presence of moisture). Their application imposes frequent repetitions and special care on the correct proportion of lime and water.

On the other hand, strontium and mainly barium hydroxides proved for Prof. S. Z. Lewin assisted by E. V. Sayre to be efficient (method LSP-I) [11]. According to the mentioned ion exchange method, barium carbonate or barium sulfate rather deeply penetrate stone to form a solid, undissoluble layer. Our common research work done at the New York University in 1974/75 where consolidation was made under laboratory conditions showed this method to be promising, provided a water repellent agent is added as second component. Most of the specialists consider it to a mere research result and await further evidence mainly in the field of in-situ conservation.

1.3 From time to time, other inorganic conserving agents emerge in publications or in the practice (e.g. stearates, phosphoric acid, hydrofluoric acid). The latter proved to be effective in the FRG (J. Riederer), mainly in cleaning with consolidation where the weathered part is removed to obtain a sound surface. (By the way, this is possible by mechanical cleaning, too !)

2. Alkoxysilanes are the most promising (also according to Clifton) because of the affinity to stone and of deep penetration. Similar materials are widely used in the FRG (e.g. Sandsteinverfestiger OH produced by Wacker Co.) and in England (Brethane, a novelty) [12]. Among alkoxysilanes, the favourable effect of tetraethoxy silane could be confirmed by our research. For a decade, American specialists spend increasing interest on this group of materials and consider it as one way of lasting preservation of stone monuments. The possible slight discoloration is a drawback.

3. Two typical groups of synthetic organic polymers are thermoplastic acrylates and thermosetting epoxy resins. Recently, interest has been focussed on methyl metacrylate, a conserving agent considered by several specialists to be the most efficient of all. For acryl polymers in organic solvents, as well as for acryl copolymers, the greatest problem is how to achieve the needed depth of penetration.

The subsequent two groups of synthetic organic polymers are less convenient as stone conserving agents than are the former ones. Vinylic polymers (e.g. PVC, PVA) in an organic solvent are either of low efficiency or, in a thicker solution, they are of poor vapour transmission. Besides, they are likely to produce other — not to be discussed — harmful transformations. (Author's experience made with PVA in the Aquincum [Hungary] ruin field in 1962 fell short of expectations.)

One of the most debated conserving agents is epoxy resin. It has numerous partisans and opponents though these latter are diminishing. Recently, epoxy resin has been transformed to such a polymer mixed with organic solvent in a proportion to provide for penetrating the stone at an invariable consolidating effect [13], requiring careful, rather tedious work, taking individual cases (stone material) into consideration. Problems arise from the destruction on the interface between conserving-agent-soaken and untreated parts. Still, as stated earlier, drop of vapour diffusion and stiff appearance of the surface argue against epoxy resin.

At times, the idea of applying other synthetic organic polymers (such as polyester) emerges but these are too vapourtight to be generalized.

The same is true for waxes, the oldest, once the most frequent stone conserving agents. But because of their vapour tightness and mainly, of proneness to pollution, they are not in use any more.

Recapitulating international observations and publications on stone conserving agents, problems in this country may lead to the following statements:

— There is no universal stone conserving agent and it is unlikely to exist in the future; agent and method to be applied have to be decided as a function of the stone material to be treated, the climatic conditions, the building type, on the basis of diagnostic testing of the stone surface to be treated.

— Little attention is paid on peculiarities in given countries by international research and literature in reports of achievements with given conserving agents. No doubt, problems are difficult enough to let researchers highly appreciate achievements in the considered case, but experience is seldom to be utilized under peculiar conditions of another country. For instance, conservation in nonfreezing regions is little instructive under conditions in this country.

— In the actual stade, conservation by means of an invisible, aerating, water repellent coating may be considered as solved. Its omission cannot be justified by professional uncertainties, hence the damage resulting from its omission is on the charge of the customer, the caretakers and users of monuments.

— No unquestionable solution exists — even internationally — for cases in need of consolidation, in particular, for in-situ conservation. Problems are due in particular to penetration to the needed depth, and to the connection between the treated stone crust and the sound, untreated inner parts.

— Among conserving agents, mainly alkoxysilane and acryl polymers are recommended by specialists of several countries. Some of them recommend a special (polymerizing) mixture of epoxy resin, felt, however, to command caution, and to be at most experimented with in this country.

Main features of development in Hungary (research centers, organizations, principal methods)

In Hungary, earliest stone conservations followed either of two, distinct approaches. On one hand, "conservation" was understood as to replace damaged stones of the concerned monument, with complements formally in style, recarving, replacing damaged stone parts. The new stone parts were made of soft limestone, not a bit more weathering resistant than the original. Early in the 20th century, reconstructed stone complements have been applied. No treatment had been applied to increase stone durability. (Survival of this century-old approach and the underlying principle is rather curious and arouses reflexion.)

The other approach has been to combine the outlined method with the application of treatments expected to increase resistance against natural harms — soon joined by environmental harms concomitant to technical development. By that time, no demand for conservation to consolidate weathered stones emerged, the concept of "fairly reconstructed monument" hardly involved such a preservation of historical values. Preventive treatment of sound stones (e.g. marble) was made by paraffin, wax and fat, harmless for perfectly dry stones safe from internal dampness, maybe for museum exhibits. By chance, this method was not applied outside in places of difficult access.

On the contrary, fluating caused visible damages both on the Matthias church and the Parliament building.

In this country, these two approaches were parallelled by the development of petrographical examination of building stones, underlying up-to-date testing of, and acquaintance with, stones utilized in historical periods.

Important monument reconstructions after the liberation, especially after the 1957 foundation of the National Monuments Inspectorate, contributed to the upswing of monumental stone conservation. A stone carving restoration school of European fame, directed by Ernő Szakál, has been established, with headquarters in Sopron. Works — relying partly on the construction methods by József Csemegi — are high-grade creations involving sediles, Gothic tracery windows in the Castle district, fountains in Visegrád, closed balcony in Siklós, etc. These integrated, reconstructed objects were, however, initially hardly conserved in the actual meaning of the word, and also later only here and there. (It began to take shape and to generalize only recently.)

A new era of Hungarian stone conservation started by the late '60s. The Institute for Geodesy and Geotechnique (FTV) and Department of Inorganic Chemistry, ELTE, started cooperation in building surface protection against corrosion, giving rise to the first silicone-type agent patented in Hungary, Silicophob 7607 (Chemical), developed by this Institute at the Technical

University, Budapest for monuments preservation, together with the relevant system of requirements for surface preparation and technology [14].

Previously, however — in frames of target program research on façade surface protection (Target program No. 11: Development of Maintenance Construction) — it was attempted to be acquainted with, and to test the best foreign-made surfacing silicones in compliance with a specially developed system of requirements. Bayer LN, a silicone product in organic solvent of Bayer Co., FRG, had been chosen, subject to pilot application in the first stone conservation: a Roman Mithras relief, in 1971. Problems and first stone conservations works in this country have been reported on at the stone conservation symposium in Bologna, 1971 [6].

This was followed in 1975 by conserving the stone pylons of the Chain Bridge over the Danube, and entrance of the Tunnel using Silicophob 7607, under quite difficult conditions. Namely commission to this work arrived three weeks before the scheduled time of dismantling the scaffolding, an interval to perform all the diagnostic tests, surface preparation (far from being satisfactory), purchase of materials, training labour and directing the work. Even so, ten years after conservation, Chain Bridge pylon surfaces sharply differ from the dark greyish stone façades in Roosevelt square (where in 1973, some replaced stone parts were strikingly white).

Next step was to set out stone surface cleaning combined with conservation. In this course a target program study has been made at the Department of Building Management and Organization and later, in cooperation with the Communal Management Enterprise, on cleaning and conserving stone surfaces [15]. Cleaning and conserving the stone surface of the Király-bath in Budapest in 1974 can be considered as a practical pilot test. Cleaning was made by the British CIMEX method, using Dabolin paste, while conservation of façades applied three different agents: Bayer LN (FRG), Dri-Sil 48 (British) and Silicophob 7607 (Hungarian). The three compounds were found to be equivalent and equally efficient.

A similar conclusion was drawn from another interesting practical pilot test application on a new building surface. Namely, both for mediaeval monuments and recent constructions the Hungarian soft limestone causes problems. "Sóskút" limestone building surfaces are a priori not frost-resistant, and in the quoted cases, even rain driven through the joints appeared inside. The 1972 conservation applied either Bayer LN or Silicophob 7607. Yearly two to four control tests showed the surfaces to get only this year in need of retreatment (although measurement of water absorption in one façade is still reassuring).

The quoted examples refer to conservation without consolidation, using an invisible, aerating, water repellent coating. They have been parallelled by research in cooperation with Dr. Pálossy at the Department of Inorganic Chemistry (headed by Dr. József Nagy), Dr. Pál Kertész and Dr. István

Marek at the Department of Mineralogy and Geology, and Dr. Éva Orcsik (Laboratory of Monuments Preservation), all of this University.

Among practical works, conservations of the EFEDOSZ seat (Szilorlakk 1000, Finomvegyszer KTSZ producers' cooperative) and of the Parliament building should be mentioned. Here — after trial cleanings by several Western firms — the cleaning method has not yet been decided, also there are several alternatives for Hungarian-made surface coating agents to be selected from, in dependence of the stone kind and its soundness condition.

Actually, production of water repellent surfacings recently developed at TUB has encountered difficulties (for instance, manufacture of Szilorlakk 1000 and 1400 has been prohibited for environmental reasons). The latest developed agent named Aquaphob — now under patent application — is expected to be luckier. Also Silicophob W 190 and 290, now commercially available, have been efficient in applications recommended by careful diagnostic tests.

Research has been centered for years on the conservation with consolidation of poor-quality Hungarian soft limestone surfaces under climatic conditions peculiar to this country. No foreign method has been successful to now, because of the difficulty of meeting requirements for surface protection (no colour, no lustre, water repellency, adequate vapour diffusion, deep penetration, etc.) simultaneous to consolidation, conservation of weathered parts, resistance to weathering.

After seeking for solutions in different ways, a new method and material have been found (temporarily called ZKF) now under pilot test and patent application, expected to be soon available for practical treatments. Lack of realistic test methods truly simulating actual conditions is a problem both internationally and in this country, even for coatings, while the evaluation of consolidating effect faces fundamental problems. The term itself may be misleading, requirements for durability rather than solidity are to be met in attempting to render a weathered stone surface as (or more) durable as (than) the original one. All these are the scope of research to be reported later.

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