WATER REPELLENT RENDERINGS FOR THE DAMP-PROOFING OF MONUMENTS

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The most common technical difficulty of monument preservation all over the world but especially in Hungary consists in the protection against moisture of monumental buildings constructed without damp-proofing. Monument reconstructors are faced even by two aspects of the problem: sound interiors, convenient for the actual occupants, are to be provided for, as required by the new function of the building, and besides, an aesthetic aspect has to be safeguarded for the outer wall surfaces, by applying durable wall paints, safe against staining and moulding. This problem has to be approached by various means, different almost from building to building. This is perhaps the most important principle in this field, the respect of which saves from — often unjustified — failures the specialists who, advocates of a "unique salutary" method that nevertheless may have failed, begin to believe the other extreme, namely that to solve the problem is hopeless. Thereby — to our observation — stains appearing soon on the reconstructed building, followed by the loosening of paint and rendering are considered a kind of natural plight involving the resignation to repair and repaint the building every year (Fig. 1).

Evidently, no satisfactory solution is possible without the knowledge of various methods from the oldest to the newest ones, reconsidering the special circumstances and perhaps applying a combined method. Even here, the primordial technical principle of monument reconstruction must be kept in mind, namely, that to be rescued from destruction the most ancient buildings require the most recent, scientifically experimented methods. The same is true for the preservation, reconstruction of old buildings in general, technical problems being similar.

Of course, accurate diagnostic examinations are needed to select moisture-proofing methods. Though practical investigations may detect an infinity of case — and remedy — varieties depending on the origin and rate of moisture, the nature and intensity of chemical impurities in the building materials, the atmospheric agents, as well as the material resistance against all them, the following fundamental cases may be distinguished from the aspect of the remedial measure to be applied:

Fig. 1. Rákóczi Castle, Sárospatak. Façade, soon after reconstruction

1. Wall moisture due to wrong structural design or technology, faulty treatment or external injuries

This is a rather simple — though frequent — case of moisture damages on monuments. No special investigation or description is required and no problems peculiar to monuments arise. Notice only that these deficiencies — ranging from damaged eaves gutters through poorly designed new doors and windows to the neglected maintenance of reconstructed buildings — entrain much more important, sometimes irreplaceable damages to monuments that is to building stock under the "unconditioned upkeep" law. These may be avoided by using appropriate materials, a good technology and careful craftmanship, general and necessary requirements for any construction.

2. Corrosion effect of atmospheric agents

Climate in this country is known to be adverse to the durability of building façades. Congelation of rain-water, deterioration of soaked rendering, wall paints are everyday *tangible* problems. The danger is increased by chemical impurities, ever heavier in metropolitan atmosphere, easily diffused by wall moisture.

A special problem, peculiar to monuments, is to preserve the great variety of façade materials and structures in the original condition. This means that mostly, the original rendering cannot be replaced by a new one, only repaired and completed, so that the durability of both old and new materials has to be safeguarded. The same is true for stone or brick supplements.

Accordingly, protection consists in the elimination of outside moisture from old parts using some colourless, dull, *aerating* water repellent material; in case of a new paint, this can be achieved by using a paint material of similar effect; parts to be newly rendered — especially on footings, ground floors and near rain-water pipes — can be protected by *aerating* water repellent renderings. (Notice that very heterogeneous façades are advisably prepared part by part as specially required, and thereafter the entire surface treated by a water repellent coat.)

3. Risk of freeze or other harm due to the combined effect of wall dampness raising at times over the ground level, and of outside moisture

Observations on wall dampness of old buildings lacking damp-proofing have led — at least in this country — to the conclusion that ground-water oozing up to periodically varying level is insignificant in itself, causing only unaesthetical corrosion without the contribution to the damaging effect of external moisture sources: rain-water, service water, condensation and moisture penetrating from outside because of structural deficiencies. Accordingly, during some months of the year, damp stains appear on footings, damaging paint, facilitating efflorescence due to salt minerals in the masonry to cause marble staining, freezing out and crumbling of paint and rendering, even if in some seasons the hygrometer indicates insignificant wall dampness.

In such cases ulterior incorporation of a d.p.c. may often be avoided after investigating the peculiar character of the given building, by applying, after minor completions, an aerating rendering, water repellent and impermeable to a certain degree.

4. Infiltration of heavy soil dampness (requiring ulterior damp-proofing)

This case which requires no further explanation involves the most problems of expenditure, technique and aesthetics from among the wall damp-proofing methods. Besides of the earlier ulterior damp-proofing methods consisting in cutting through the walls by sections and applying conventional materials, recently some success with electro-osmotic damp-proofing methods has been reported of. Some other methods have been encountered, such as the *Massari* system, based equally on wall cutting but using modern tools, as well as chemical procedures or experiments of damp-proofing.*

Practical work may profit from procedures under 1 to 3 as complementary means of protection against outside damp sources.

Because of the infinity of varieties, it is rather difficult to reduce the problem to a few basic cases. Nevertheless, for the sake of both research and practice, it was attempted to establish theme groups as few as possible though including all possible problems. This was kept in mind in establishing the four basic cases above, defining at the same time the peculiarities of the protection method, in the increasing order of expensiveness.

After this indication of the entire problematics, a single protection means, i.e., water repellent renderings, will be considered, likely to be helpful and feasible especially for basic cases 2 and 3.

In Hungary the monument preservation activity is often faced by this problem and some experiments have been made on the use of water repellent renderings. Also in this respect it appears that *cement renderings* used in civil engineering are useless for façades, since the wall dampness, inhibited to evaporate, migrates higher by capillary effect, and freezing out of the wall behind the rendering causes the newly rendered surface to lift off the masonry.

On the other hand, *Tricosal renderings* are quite extended, and also *Sikurite renderings* are being made use of. Renderings prepared with these two agents available in Hungary exclusively to damp-proofing purposes provide some aeration and some waterproofing to the masonry, these two agents, however, are unlikely to meet our purpose. Their characteristics and special technology can be described as follows.

All these water repellent renderings are multilayered, at least 3—4 layers of 6 to 8 mm are required. Their application depends on a careful workmanship and respect of the specifications. Carelessness either in mixing or in applying the mortar would involve failure. The two primordial technological rules governing the application are:

1. Layers are to be prepared continuously, without leaving time to the previous layer to dry out;

2. joints between layers have to be shifted (no continuous joints) and bevelled to 45°.

In Hungary, monument preservation is often done by means of Tricosal plastering. One example of the Sikurite plastering can be mentioned, namely that applied in 3—4 layers of the indicated composition and technology for the reconstruction of the Mathias church interior. Here a special problem arose due to the decorative mural painting: old rendering, destroyed or heavily

* N. B. Relevant tests made in Hungary in collaboration with chemists follow paths other than those abroad.

damaged on many spots, had to be replaced by a new one (especially on vaults), after having recorded the pattern and carefully conserving the original painted, plastered spots. This Sikurite plastering of 3—4 layers obtained the usual cement-lime mortar finish, textured as convenient for decorative painting.

Fig. 2. Mathias Church, Budapest. In spite of heavy soaking of the vault above the sanctuary after reconstruction, the Sikurite plastering prevented any but slight damage. A perfectly aerating plastering could prevent even this damage. (Interior reconstruction 1966 to 1970 by the author)

The new plastering was required to protect against minor casual soaking due especially to structural deficiencies (failure of roofing tile, tinsmithery, generally speaking to the actual drainage shortcomings), the decorative painting, rather expensive, and — especially at great heights, — irreparable without scaffolding at least to the elimination of moisture source. The plastering was found to essentially fulfil its task: minor temporary soaking (e.g. in the sanctuary) left a hardly visible stain (Fig. 2). It is, however, of no use against heavier soakings because of its insufficient water repellency and especially of the complete absence of aeration, though it is undoubtedly superior to the Tricosal plastering, and relatively it is the most convenient to the indicated purpose among agents available in this country.

These facts leave no doubt that alongside with the development of modern building technique and chemistry, the demand to apply new, up-to-date materials, of importance both for the living conditions of man and for the townscape, gets ever more stressed. Also the replacement of the existing water repellent or impermeable renderings by recent, more convenient materials (especially synthetic ones) comes to the foreground. Evidently, surfacing materials have to provide aeration, at the same time, to keep out outside moisture and its harmful consequences. Throughout the world, several such materials have been tested and applied, hence the problem is not an unsolvable one. Nevertheless, the relative recentness of the most up-to-date materials (maybe in the test stage) require the new mortar to be selected after a careful test from any possible aspects, and then to safeguard the application of the material most appropriate for monument preservation, and in general, to the reconstruction of old buildings.

Without enumerating all the relevant materials and technologies, tested or referred to in the literature, let us outline the final conclusions.

Our aims are best met by mortars with silicone admixture. Several such products are made by foreign factories such as *Rhodorsil Blanc* 50 *K* (France), the *Wacher* mortars based on BS and BRS sodium-methyl-siliconate, silicone powder BS 200 as mortar admixture (West Germany), as well as an aerating water repellent rendering mortar admixed with *Bayer F* powder of the Bayer Co. (West Germany).

In what follows, the Bayer F powder will be investigated, namely Rhodorsil Blanc 50 K based on potassium-methyl-siliconate, is not formulated especially to this purpose. Wacher BSR cannot be ulteriorly coloured, pigment has to be mixed to the mortar, while BS plasterings can be painted but become water repellent only after one or two months. There are several companies abroad who are discouraged by technology or strength loss problems from producing such compounds. Besides, marketing of such products is hampered by the uncertain requirements. These, however, cannot be clearly formulated since specialists in the reconstruction of ancient buildings are insufficiently aware of the recent achievements of modern chemistry.

In 1963 to 65, the Survey and Soil Exploration Enterprise (FTV), Hungary, carried out experiments on mortars with silicone admixture (guided by Dr. Iván Meggyesi), including the use of silicone powder, water soluble silicone products and quartz flour made water repellent in vapour phase. Since no silicone powder has been produced in this country to now, the only Hungarian products under test were *Silonite 1100* made by Nitrochemical Plants, Fűzfő, and the test product *No. 1115*.

According to tests made in common with the Institute of Building Research (ÉTI), Silonite 1115 applied to specimens 4 by 4 by 16 cm made with cement No. 554 at dosages of 350 and 450 kg/cu.m, admixed in 1 and 3 per cent to the mixing water, produced water repellency only at a dosage of 3 per cent. Experiments also extended to the comparison of the properties of mortars made with the Bayer F powder (dosed at 1 and 3 per cent by weight of cement) with those made with Silonite 1115. 28-day crushing tests showed a strength loss for mortars made with Bayer F powder, and a slight strength gain for Silonite 1115. (It is difficult to truly compare strength values, since water repellency of mortars made with 2 per cent of Bayer F powder is much superior to those made with 3 per cent of Silonite 1115. Bending-tensile and compressive strength values of a specimen are, however, of less interest for us than the effective adherence values of the mortar to the masonry. This latter is, however, unaffected by silicone admixture.) Water and vapour absorption tests showed marked superiority of Bayer F. According to tests made by FTV, at a water pressure of 50 mm the specific water absorption of an ordinary mortar specimen made with a cement dosage of 350 kg/cu.m (100 cycles of 3 hours' soaking and 21 hours' drying) was as high as 100 mg/sq.cm, the same admixed with 3 per cent of Silonite 1115 and with 2 per cent of Bayer F adsorbed max. 70 and 10 mg/sq.cm of water, respectively.

Similar were the results of tests made by the producing factories. From the diagrams in Figs 3—4 it appears that at a water pressure of 50 mm (practically corresponding to driving rain conveyed by stormy wind at 100 km/h) the mortar specimens 5 cm dia., 1 cm thick, without admixture, and admixed with Bayer F powder in 0.8 per cent by weight of solids, absorbed 11 per cent and about 2 per cent of water after an exposure of 2 and 20 hours, respectively. (Thus, this latter resists driving rain of this duration, meaning practically perfect weatherproofness under our climate.)

Water absorption tests without water pressure showed still better results: while untreated specimens became water saturated during 2 to 5 hours (9 per cent), the specimen treated with Bayer F powder absorbed 0.4 to 0.5 per cent of water during 20 hours, a mere 10 per cent of that of the untreated specimen. Salt absorption of specimens immersed in 5 per cent sodium thiosulphate solution caused no efflorescence for Bayer F but specimens both without admixture and admixed with Silonite 1115 showed efflorescences.

On this basis, FTV concluded that mortars with silicone admixture lend themselves as water repellent, waterproof and even impermeable renderings.

In view of our actual needs and possibilities, water repellent mortars made with Bayer F admixture (considered as impermeable to a certain degree) had to be studied. Publications of the Bayer factory as well as research made in the Leverkusen factory in 1969 have led to conclusive observations. After preliminary tests of scientific and experimental character, the first practical use was the application on the footing of the *Gothic church of Köröshegy.* Façade of the church was made with stone dust rendering coloured in its material. South and east footings were surfaced with the same rendering at

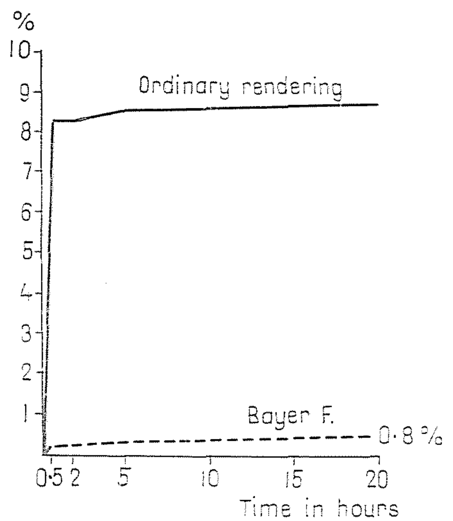

Fig. 3. Water absorption (in percentage by weight of solids) vs. time of lime + cement mortar 8:2:1 admixed with Bayer F powder

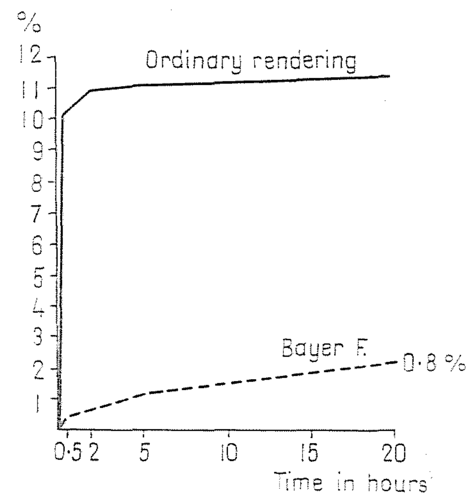

Fig. 4. Water absorption (in percentage by weight of solids) vs. time of lime + cement mortar 8:2:1 admixed with Bayer F powder exposed to a water pressure of 5 mm water column

a higher cement dosage, exhibiting shortly after finishing the picture usual for monument preservations: marked humid stains and salt efflorescences. Thereafter, the eastern and northern footings have been rendered using 10 kg of Bayer F admixture obtained for experimental purposes, at a dosage of 1 kg of Bayer F admixture to 100 kg of mortar solids. Results are evident from Fig. 5, making any further comment unnecessary. Some important features of material and technology will be considered instead.

Bayer F admixture is a fine white powder, with a specific weight of 1.2 at 20°C, bulk density of 0.60 kg/l, about 40 sq.m/g specific surface. It is insoluble both in water and in common organic solvents.

Its technology is a rather simple one: the powder has to be carefully admixed to the solid constituents of mortar, taking care to the uniform distribution of silicone particles. Therefore not manual but mechanical mixing has to be applied if possible.

Bayer F is dosed at 3 to 10 per cent by weight of binder (lime + cement), or at 0.6 to 1.2 per cent by weight of mortar solids. It can also be admixed to scratch coat without causing discoloration. It does not affect rendering process neither reduce bond strength.

Fig. 5. Gothic church at Köröshegy (Hungary) reconstructed by the author 1968 to 1970, using rendering admixed with Bayer F powder on W and N footings. Buttress on the SW corner exhibits a marked difference between conventional and experimental rendering

A peculiarity is, however, to protract setting time. In the practice of monument reconstruction, — and in general for the resurfacing of old buildings — this is more an advantage than a disadvantage. Namely, except for humid parts, old masonry extracts more water from the rendering than new buildings do, and if, besides, also weather conditions accelerate drying out, hair cracks may appear on the rendering, as a function of other factors related with composition and material structure. In such cases protraction of setting time is an explicit advantage.

Immediately after setting, the plastering exhibits water repellency, too well known to be more than outlined here. Silicone powder counteracts capillary absorption of moisture, while rendering pores remain open and aerating.

Tests show an excellent vapour permeability, fundamental for the outer moisture protection of unsealed masonry (since at the same time evaporation of the internal humidity has to be maintained). Accordingly, permeability coefficient D in g/sq.m.h.Torr, where g is the weight of humidity diffused during 1 hour through 1 sq.m of specimen surface at 1 mm of mercury column pressure (Torr) decreases by about 0.5 per cent for scratch coat admixed with 0.6 per cent of Bayer F, while for lime + cement mortars the permeability grows instead of decreasing, and its reciprocal 1/D, i.e. the resistance to moisture penetration, decreases. This is evident from laboratory test results published by the manufacturer, and compiled in the following table:

Rendering	Bayer F admixture	D g/m².h. Torr	$\frac{1}{D}$ m².h,(Torr) g.
Scratch coat	without	0,47	2,1
Scratch coat	0,6	0,45	2,2
Lime+cement mortar	without	0,49	2,0
Lime+cement mortar	0,6	0,64	1,6
Lime+cement mortar	0,8	0,58	1,7

The presented factors evidence the possibility, — as for the presented example of the Köröshegy church, — for the soil dampness to continuously evaporate through the rendering, which in turn prevents the outer moisture from entering and thereby increasing the wall moisture. The low water absorption reduces or fully counteracts the risk of freezing out and of damages by harmful impurities, efflorescences, settling of algae and moss etc. What is more, as any water-repellent surface, this one also becomes self-cleaning under the effect of rain.

An adverse property of this compound is, however, that if rendering is applied in misty, rainy, cool weather, the surface may be affected by lime efflorescence, this weather being inappropriate to these operations. This, however, must not be confused with the white line staining likely to get after rain onto the footing made with Bayer F originating from the untreated rendering above, and easy to brush off.

These considerations make it obvious that there exists a solution for several cases seemingly unsolvable or nearly in the hitherto practice of monument reconstruction. Of course, some cost excess will result (of the order of a few hundred Fts for a cu.m.), what is higher for this imported material than it would be if there existed a home-made compound. Compared, however, with the costs for continuous repairs or the moral and aesthetic damage because of the unpleasant aspect of monumental buildings, the expense sum looks like dwindling.

Summary

The problem affected by perhaps the greatest difficulties in monument preservation is the moisture protection of monument buildings. One possibility is to apply water repellent renderings.

Four basic categories of moisture troubles have been established. One category includes a wide range of possibilities for damp-proofing buildings by means of water repellent renderings, without having recourse to the much costlier ulterior incorporation of damp-proof courses. From the special aspect of monument preservation, laboratory and field tests made in Hungary on water repellent mortars are of interest. The author is of the view that for these specific cases, but also to render the façade or footing of an old building with rather dry masonry, the mortar admixed with Bayer F powder is likely to be convenient. This statement is supported by a practical application in Hungary.

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