ULTERIOR WALL DAMPPROOFING BY THE SILICOPHOB-ANHYDRO METHOD

By

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Much of the building stock in this country — according to earlier surveys, some 300 thousand buildings — are increasingly damaged by rising wall dampness. This process is rather harmful to building interiors, but still more, often irreversibly injurious — although not in a spectacular way — to human organisms.

Rising wall dampness is particularly destructive to ancient buildings constructed without dampproofing, uncluding the most valuable ones: the monumental buildings. Damages due to wall moisture often inhibit, or nearly, respect of the legal category "unconditional preservation". Nearly all the monumental buildings suffer from wall moisture damages, hence no lasting preservation is possible else than by ulterior wall dampproofing.

Damaging processes are the more severe since wall moisture initiates or sustains quite a number of destructive physical (frost), chemical (sulfate or nitrate efflorescences, crystallizations) and biological (fungi, algae etc.) processes (Figs *1a*, *b*). Besides, dampproofings are gradually destroyed, and the process goes increasing, difficult to keep pace with by whatsoever up-to-date, purposeful, careful, continuous maintenance, all these imposing application of ulterior wall dampproofing. Principle and technology of wall dampproofing have been discussed in several studies, reports and comparative analyses at the *Section of Monuments Preservation, Institute of History and Theory of Architecture, Technical University, Budapest*, and at research institutes concerned with similar problems.

The principles underlying ulterior wall dampproofing (obturating the path of rising soil dampness) belong to either of three groups:

— electrical
— chemical
— mechanical.

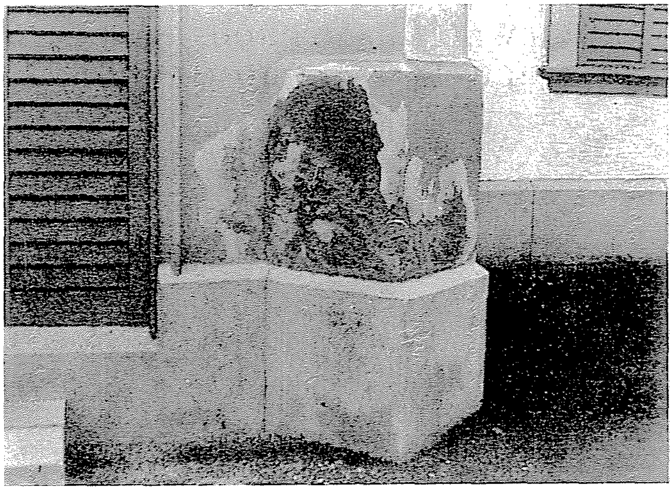
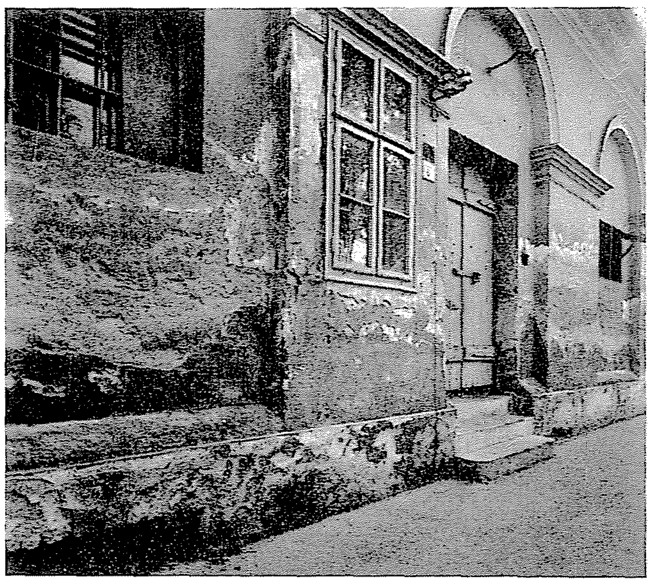


Fig. 1. Damp buildings: *a)* Brunswick Castle in Martonvásár, Hungary



b) Granary in Kiszombor, industrial monument

Wall drying by electro-osmosis

This method developed in 1957 and patented in 1960 *(I. Biczók, M. Lipcsey* and *Z. Horváth)* had several applications both in this country and abroad during these two decades. It relies on the phenomenon of electro-osmosis, suppressing the potential difference between subsoil and moist wall to stop capillary suction of dampness, creating thereby a dampproofing zone at a level over that the damp wall gets naturally dried. (Remind that in any ulterior wall dampproofing, natural exsiccation of walls has to be reckoned with. A wall one meter long and 60 cm thick releases some 0,6 litre of water by evaporation; decrease of the capillary rise reduces the wall dampness level, possibly to the level of dampproofing).

The electro-osmotic method has two alternatives: active, involving a power supply, and passive, stopping capillary rise without power supply, by simple voltage shortcircuiting. In Hungary, this latter has been preferred to the active method, mainly because building owners or users are reluctant to manage the former.

The passive method has been applied in hundreds of cases where preliminary investigations demonstrated the required potential difference to exist.

This has to do with observed difficulties of practical application: in this country the passive method cannot be applied in about 50 percent of cases, preventing application of the method as a whole.

Practical effectiveness of this otherwise sound method is hampered by the following factors:

1. Even in the design stage this procedure is technically prohibitively complicated for mass applications in this country where, however, soil dampness is a widespread disease. For instance, required design data include — besides of building documentation in drawing — soil profile, groundwater depth, specific electrical resistance of soil, earthing resistance, capillary properties, and chemical composition of groundwater.

2. There exists no special enterprise. Most failures may be reduced to execution errors such as:

- other than specified electrode spacings;
- missing or defective mortar grouting of boreholes;
- faulty welding between electrodes and wiring; burning of this latter during welding;
- actual earthing resistance different from the specified one.

3. Beside corrosion due to deficiencies in execution, in virtue of the underlying principle, electrolysis in the wall rapidly corrodes the electrodes.

4. The electrodes being series connected, failure of one electrode stops the entire process.

These difficulties argue against the application of electro-osmotic wall dampproofing in this country, increasingly replaced by chemical wall dampproofing.

Chemical wall dampproofing

Since the mid-sixties, our research works have been concerned with the problems of this "widespread disease" of old buildings. First, requirements for up-to-date ulterior wall dampproofing have been established, such as:

a) Up-to-date preliminary diagnostic tests are needed to detect the source and rate of wall dampness (conditioned by a point-wise rapid, inexpensive site moisture measurement method) underlying the selection of the actual wall dampproofing method.

b) The wall dampproofing method has to be universally applicable.

c) It must not disfigure the building.

d) Failures of ulterior wall dampproofing being mostly due to structural deficiencies, nonstructural solutions are to be preferred.

e) Technical-technological requirements of the selected method have to fit the actual level and possibilities of building industry, taking building utilization aspects into consideration (e.g. execution in occupied dwellings).

f) Expenses must not exceed those of the conventional method of section-wise wall cutting, have to match economical possibilities, and the use of materials to be purchased for hard currencies has to be avoided.

g) Wall dampproofing — like any other ulterior dampproofing — has to precede façade restoration by one or two years.

All these highlighted research and application aspects of chemical wall dampproofing methods both in this country and abroad. The first application in 1970 of the *Silicophob-Anhydro* method, under Hungarian patent, was followed by trial applications of several foreign methods in Hungary (e.g. the *Bauiso* method), actual and prospective applications being restricted to those of *Vandex* (Denmark), *Penetrat* (Switzerland) and the Hungarian *Silicophob-Anhydro* method, all of them subject of a comparative report by this Institute on commission of the Program Committee No. 11 of the Hungarian Ministry of Building and Urban Development. These three methods have been regularly applied in building reconstructions.

In the following, only the Hungarian Silicophob-Anhydro method will be considered, since the dampproofing methods Bauiso, Vandex and Penetrat have been described in the respective booklets, whereas they have little been applied in this country. All three methods are those of the cement-slurry type, differing from Silicophob-Anhydro by:

- their manner of action, namely material crystallizing in the pores obturates the path of capillary suction, killing thereby the wall aeration in the dampproofing zone;
- the aqueous solution of the commercial whitish-grey powder has to be injected into the wall boreholes, economically advantageous, but less so from the aspect of danger of frost;
- the uniform application of these methods relying on the manufacturer's instructions (rather than on preliminary diagnostic tests such as the Silicophob-Anhydro);
- the inaccessibility to macroscopy of the agent diffusing from the boreholes to the masonry. An advantage is the whitish-grey cement mortar grouted in the boreholes to obturate them at the same time, however, the material quantity diffused from the borehole to the masonry cannot be checked.

The Silicophob-Anhydro wall dampproofing method

This method, *service invention of the Hungarian Academy of Sciences*, suits walls of whatever high moisture content and chemical composition. At a difference from other methods, efficiency of the dampproofing can be predetermined. Grouting tables have been compiled for walls with different characteristics, permitting unambiguous specification of the mode and rate of grouting.

The method consists essentially in grouting alcoholic solutions of silicon and silica derivatives into the wall to be dampproofed. Alcohol mixing with the wall moisture dehydrates the wall, precipitating its components that are deposited on pore walls and make them water repellent, stopping capillary rise. This process dampproofing a wall strip 20 to 40 cm thick in its material provides for an adequate safety not only for a given period but throughout the life of the given masonry material.

The dampproofing procedure

Preliminary diagnostic test

The dampproofing has to be designed individually in each case, based on diagnostic test results (Fig. 2), stating moisture contents of different masonry materials to be dampproofed. Chemical composition and impurities of the rising soil dampness are determined in laboratory analyses upon special hints

Fig. 2. Diagnostic test

(e.g. marked efflorescences). Moisture sources are exactly determined by measurements made in predetermined spots.

The fundamental prerequisite of wall dampness determination could not be satisfied until no field instrument rapidly delivering spot-wise data was available.. Such an instrument was the tensiometer probe for moisture determination developed by *Dr. Kazó—Princz—Dr. Zádor (service invention of the Hungarian Academy of Sciences*, Fig. 3).

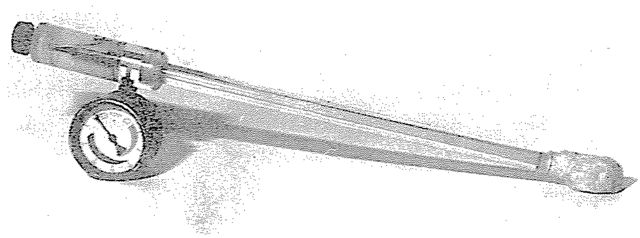


Fig. 3. Tensiometer for determining the dampness

The instrument essentially consists of a closed system of a vessel (glass tube) filled with a liquid, with a special ceramic head pushed through a borehole to the desired point of the masonry, applying suction on the ceramic head as a function of moisture content, indicated by the manometer of the instrument. Special tables have been compiled to read off the moisture percentage by weight (in stone, brick or mortar) and the moisture percentage of the maximum capacity.

Several measurement points on horizontal and vertical faces unambiguously decide between damaging moisture sources. For instance, moisture due to driving rain exhibits much higher values near the surface, eventually permitting to apply much cheaper surface protection methods. Again, moisture data decide whether the whole of the building or only parts have to be dampproofed. (Remind that in certain marginal cases, the necessity of wall dampproofing can only be decided from exact data. There is no Hungarian standard value for permitted wall moisture. Brick walls are deemed to need dampproofing over a moisture content of 4 percent by weight but damages generally appear only beyond 10%.)

Multipoint measurements are not invariably required. In general, single moisture determinations on side walls, internal structural walls, at typical moisture damage spots, bilaterally on wall corners exhibiting different surface destructions, stainings, on façades and wall interiors are sufficient. The measurement points are 20 to 40 cm above the floor level (dampproofing level), at depths of 20 to 30 cm depending on the wall thickness (for single point measurements). Rate and importance of surface moisture may be determined from

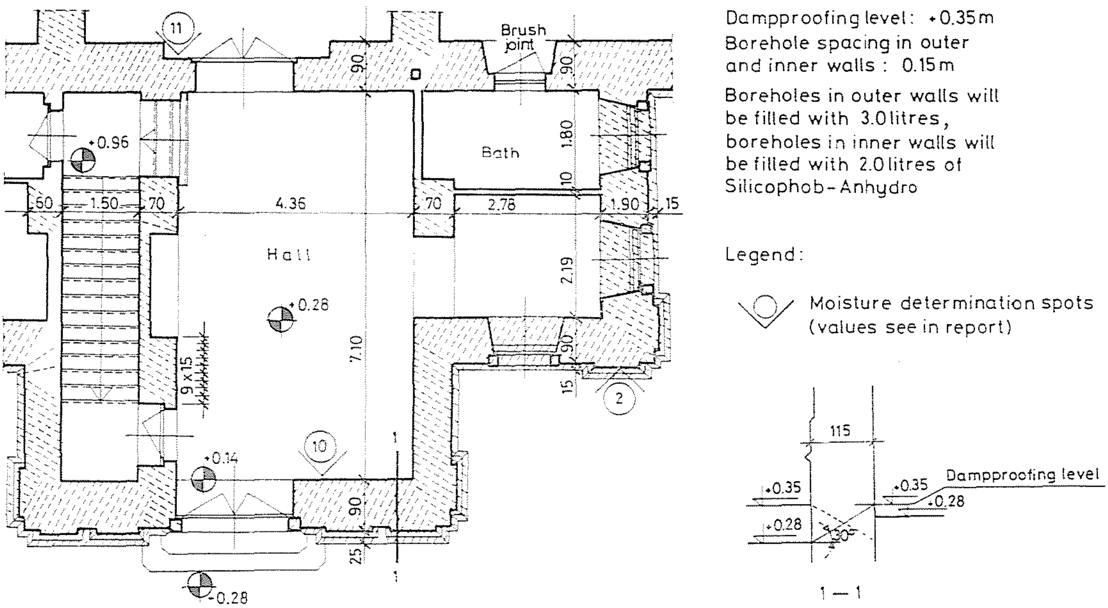


Fig. 4. Detail of a wall dampproofing plan

measurements starting at 10 cm below the surface, followed by measurements at 30, 40 cm in the same borehole.

Measurement results are indicated by numbered spots in the building ground plan (Fig. 4). The same numbers are entered in the record of the measurements, indicating wall moisture values both as percentages by weight and as percentages of the water absorption capacity.

Diagnostic test results underlie the design of chemical dampproofing, the system of boreholes and the quantity of compound to be grouted in.

Design

As mentioned above, the Silicophob-Anhydro chemical wall dampproofing method is the only one that can hence must be designed. The arising excess work and time consumption are amply justified by the elimination of hitherto uncertainties of ulterior dampproofings, concomitant to the "technical unpretentiousness". Diagnostic tests forward individual examination and solution of each part problem. Results are recorded, and conclusions drawn in the first part of plan documentation "Technical Description and Technological Instructions". The second part refers to the drilling of boreholes, the technology of grouting and borehole obturation, the determination of the grout quantity, all these, in knowledge of the number of boreholes and of the material costs, permit cost forecasting.

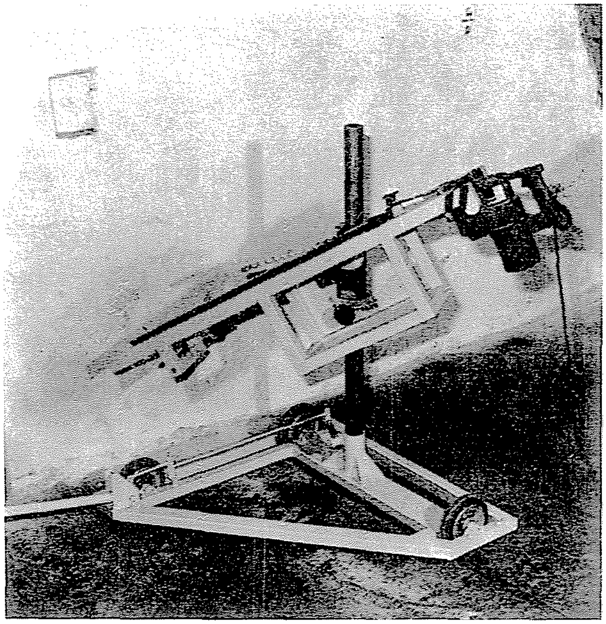


Fig. 5. Borehole drilling

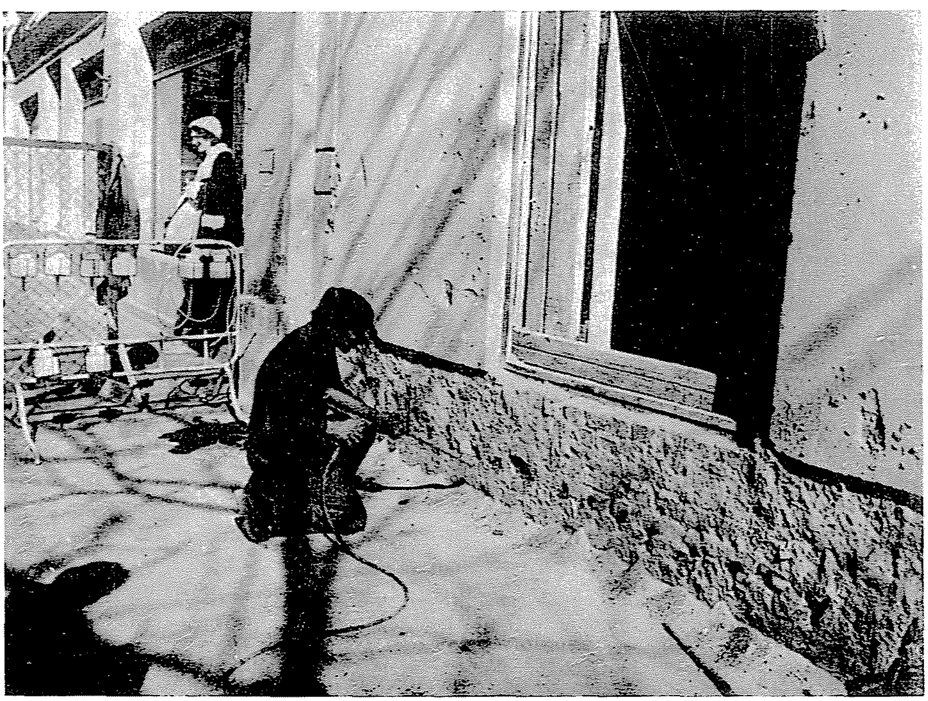


Fig. 6. Grouting and borehole sealing

The grout material quantity is determined from tables supplied by the manufacturer to users.

Work safety prescriptions are contained in the third part, and the patent specifications in the fourth part of the plan documentation. A separate part may be concerned with accessory works.

Application of this method comprises three stages:

1. Drilling skew boreholes at about 30°, by means of 25 to 30 mm bore rods, possibly bilaterally of the masonry (Fig. 5).
2. Grouting the Silicophob-Anhydro compound by simple gravity, without pressure, possibly simultaneously from ten plastic bins through tubes (Fig. 6).
3. Borehole obturation by cement mortar admixed with 10% of perlite.

Advantages of the Silicophob-Anhydro dampproofing method

- The procedure is universally applicable in any case.
- No structural parts are incorporated, excluding usual structural break-downs.
- Its alcoholic matrix permits work in wintertime.
- The use of the building is inaffected by dampproofing works (no removal to temporary accommodation is required).
- It does not interfere with the original wall plane, colour or surfacing.
- Freeze of dampproofed masonry is excluded, the compound itself being frost-resistant (as against Vandex and Penetrat). This is the only wall dampproofing method keeping pores open.
- Results of the prescribed preliminary building diagnostic tests are of use for the complex reconstruction and permit supervision afterwards.

This procedure has been actually applied by 60 Hungarian enterprises relying on contracts concluded with the Hungarian Academy of Sciences, patentee, and on training afforded by the *Section of Monuments Preservation, Institute of History and Theory of Architecture, Technical University, Budapest.*

Experience made during the over ten years of applications are favourable, the achieved dampproofings hold. There are two items requiring much care in application: parallellity of boreholes, possible by drilling from stands, and to be checked by putting straight rods into the boreholes; and economic use of material safeguarded by immediately turning the filling tube cock as soon as the borehole is full, lest the expensive material overflows, and gets spilled.

Again, care is needed to fill out with mortar the hidden gaps in the wall detected upon making the boreholes or grouting, and then to repeat the operations of drilling and grouting.

Last but not least, this procedure of chemical wall dampproofing is subject to the generally valid technical truth: even the most efficient new procedures cannot do wonder, the success depends on thorough preparations, on an integer approach to individual problems, and on work done with immense care and technological discipline.

Summary

Restoration of monuments — and in general, of ancient buildings — is preconditioned by protection against rising soil dampness, rather frequent in this country. This is why a new Hungarian method has been developed, subject to mass applications since 1970. The essential of this method is to convey a special chemical agent to the moist masonry through boreholes, where it diffuses, part of the agent combines with water and evaporates, with a drying effect, the other part is deposited inside the wall pores and impermeabilizes them. Thereby pores remain open, the masonry keeps aerating but its capillary water absorption stops, all these with no apparent changes.

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