EXPERIENCE OF WALL-DRYING BY MEANS OF ELECTROOSMOSE

Electroosmose belongs to the field of electrokinetics, which bdivided into the following groups :

1. An electrical voltage on the boundary between the phases - mostly fluid solid - moving against one and other.

2. In the reverse case, the movement of the two phases against one another produces an electrical voltage which can be measured.

Thereby the following special cases can be distinguished

1.1. A solution is passed through a porous diaphragm which is connected to an electrical field (Electroosmose).

1.2. Colloidal particles moving in a liquid are connected to a field (Electrophorese).

2.1. A liquid - passed through a capillary system - produces a flow potential.

2.2. Particles which are in suspension, moving in a liquid, produce an electrophoretic potential.

By means of the electrode in practical electroosmose, a form of electrolytic refining takes place whereby in the electrolytes (the water contained in the capillary system is an electrolyte) a transportation of ions takes place, and under certain circumstances corrosion oi the conductor system can take place.

Practical application - in our case by the building engineers - is based on a fundamental knowledge of these phenomena. A number of publications dealing with basic research on this subject have been published. A. BELLUIGI (1) has produced a formula to calculate the electro-geo-osmosic water flow in connection with soil stabilisation.

A publication by the Ministry of Building of the USSR(2) deals with theoretical observations on electroosmose, and in particular with flow potential, and gives a formula through which the specific conductivity of the capillary liquid, the viscosity of the liquid and - given the power-current and the quantity of liquid transmitted - the electrical potential, can be calculated.

Electrokinetic potentials are listed for the common building materials such as brick, slagstones, lime cement mortar etc. Mortar reacts most positively to the effects of electroosmose. Moisture rises twice as fast as in slagstone. A brick wall consists normally of brick and mortar, and in very damp old walls the mortar will have lost a lot of its lime-content and be honeycombed. It is our opinion that in this case the electroosmose effect primarily take place in the brick, whereby the moisture contained in the mortar is used to connect the layers.

E. FRANKE (3) has recently produced a comprehensive survey of experience acquised in the field of electroosmose, and with the help of models tries to show the effect of the electrical field on water-flow, moisture-pressure in the pores and the strength of the structure.

B. ROSSINSKI(4) and associates have attempted to calculate the speed of the withdrawal of moisture, and have made practical experiments to prove their theory. Attention is drawn to the fact that the conductivity of the moisture in the pores is important for the effectivness of the method.

In connection with point 1.2 of the introduction, dealing with electrophorese, I would like to describe our experiments with a square foot of wall. As a result of two years observation, we had reason to believe that the capillary system was stopped up as a result of electroosmose. To what extent a chemical reaction between the Ca^{++}-ions of the water and the soluable silicate particles took place should be further considered.

That such an effect exists is so far no more than and unconfirmed deduction. A wall was kept in a dry state in accordance with the electroosmose system, using a subsidary electrical voltage of 1.2 v, and after 12 months the poles were reversed. After a test period of six weeks no change in the situation was observed. We put this down to the stopping up of the capillary system as a result of the effect of the electroosmose.
As far as the problem of the electrolytic corrosion of the electrodes is concerned, as a result of our observations on a test building, we came to the following conclusions :

After as little as 4 months, using a subsidiary electrical voltage of 8 v, corrosion of the electrodes could be observed. After a further 5 months using an active connection, with a subsidiary voltage of 8 v, the probes showed advanced corrosion. The extreme right probe was by this time destroyed. The most important knowledge gaines as a result of these long-term experiments was that as a result of the corrosion, together with the subsequent electrical stoppages, a reduction or total cessation of the effectiveness of the system is to be expected.

As a result of our experience we know that this type of thing has already taken place in active operated plants; after 8 years using passive charged equipment with a much lower electrical voltage (max. 800 mV), this type of corrosion has not been observed.

To conclude this chapter it should be noted that the very complex phenomena of the potential theory, electroosmose, electrophorese, or electrolysis, in connection with the extremely distorted picture of a wall which is in a process of decay through salt damage, should be the subject of intensive basic research.

Tests on existing buildings.

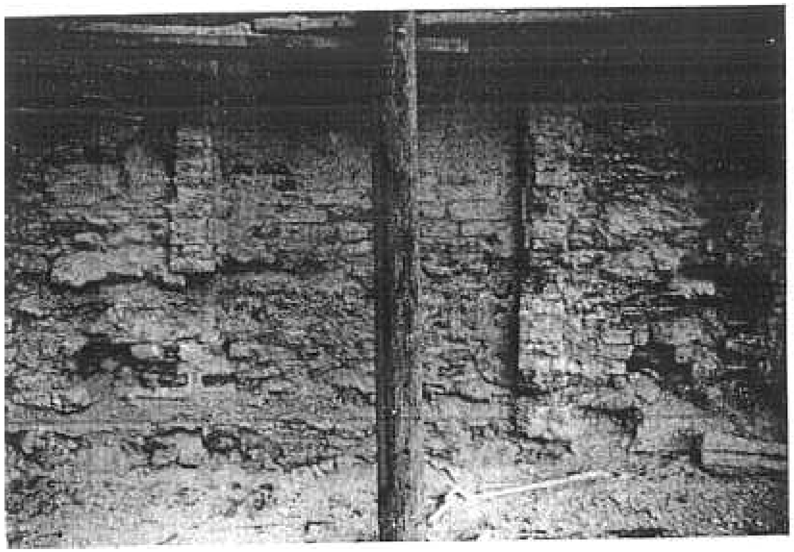
Measurements taken from bricks and a test wall in the Institute have only a restricted implication, as the hetrogeneous conditions in a heavily salted, and extremely weathered wall, partly devoid of lime-content cannot be reproduced in a laboratory.
In collaboration with the Bundesdenkmalamt, Vienna, various moisture-entraining systems were tested, the Hohenbrunn Castle being used as test building.

The object of the test was to determine which system was to be used in the future. In the summing up of the results, after a test period during which the material was compiled it was found that electroosmose produced the best results. In this case the moisture-content was as low as 3% (by weight).

The control measurements took place every 10 sq. inches. It could therefore be confirmed that the resistance field to rising moisture had no gaps. Chemical treatment, using waterglass, showed a slightly higher value: on the other hand gaps in the resistance field were found, which of course considerably reduce its value.

As a second test object, I would like to describe the work on the Laxenburg Castle near Vienna. As a result of the total restoration of the Blue Courtyard of the Laxenburg Castle it was necessary to dry out the entire building. As is usual with constructions of this type, no horizontal insulation against moisture was built in during the building.

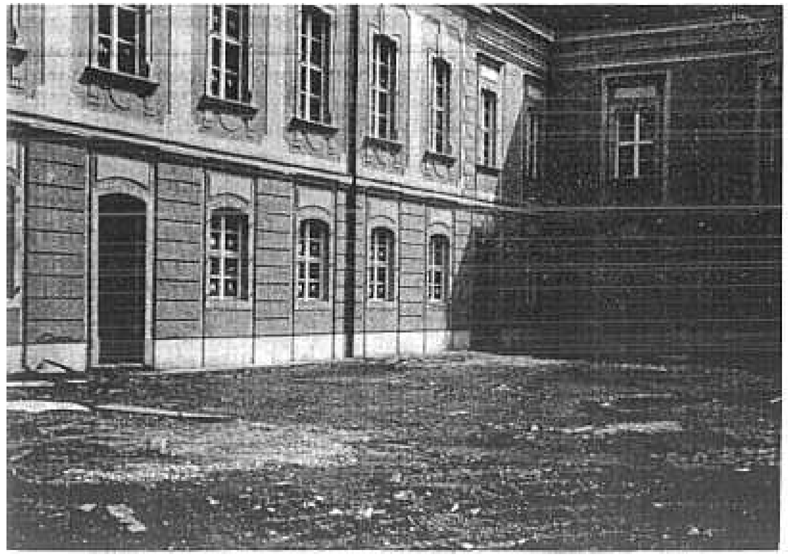
Several drying systems, such as sawing through the walls and laying a foil sheeting, chemical methods; and electroosmose, were available. After careful consideration, and on the basis scientific and technical results already available in the Institute, it was decided to use the electroosmose system. Under the contract for this very extensive work (originally 1,5 km and later extended to 2 km) the contractor was bound to a clause under which the work and equipment were to be subject to the control of our Institute.



Laxenburg Castle. Badly demaged plaster. Efflorescences of Epsomite ($MgSO_4 . 7H_2O$)

Laxenburg Castle. Installation of electroosmotic system May 1963) K = control box

Laxenburg Castle. Front. View 4 years after installation of passive electro-osmotic system.



Laxenburg Castle. "Blauer Hof", detail, 1966.

For more details about this test, see the publication by P. WIEDEN [5,6].

The control measurements were taken over a period of a year, so that the seasonal differences could be taken into account. In the meantime a further 3 1/2 years have passed, so that an experience of at last 4 1/2 years is available. As the electroosmose equipment was built in to form a resistance field, it is essential that the origin of the dampness be known. By taking measurements it was ascertained whether or not the dampness really came from the foundations.

At this point it is advisable to say a few words about moisture measurement. The usual resistance measurement systems must be disregarded, as if we have aside the very complicated four point method with the normal equipment (for example, GANN Hydromette), depending on the choice of electrodes etc., adhesive pressure of the plug-in type of electrode etc. the values can hardly be regarded as reliable. Apart from this, this type of equipment measures merely the surface dampness, which of course cannot be regarded as a measurement of the wall dampness itself. DK measurements are very difficult to take on walls. The standardising of this equipment is rather complicated and it is usually used only by scientists in research institutes. In the same way, micro wave measuring instruments (e.g. WATSON instrument[7]) are restricted to use in the laboratory. They cannot be used on the building site. The micro-wave equipment developed by Philips was also considered. The CM-instrument, which was developed in connection with soil measurement, has proved to be most useful. The method of use consists in placing a quantity of bore materials or finely-ground mortar in a steel container together with calcium carbide, whereby azethylen is developed from the moisture content. The gas-pressure produced by the azethylen can be then used to measure the moisture-content. A suitable sample to be tested is obtained by drilling to the desired depth in the wall. Alloy-tipped drills allow a drilling of up to 25 inches.

The CM-instrument gives very accurate and reliable readings. A measurement, inclusive of drilling, lasts about 10 minutes. It is therefore possible to make a difference between foundation dampness, moisture, due to condensation and secondary damage due to defective gutters, drain pipes etc.

It should however be remembered that electrical resistance zones are effective only against dampness and have no influence on the dampness caused by the presence of salts which lie above the resistance zone. It can merely prevent further salts being transported with the rising dampness into the mortar or plaster. Experience has shown that it is desirable to remove plaster to an extent of about 2 ft 6 inches above the salt-damaged area. By this means about 90% of the concentrated salts, which are mainly to be found in the plaster, can be removed. With moisture-entraining by the electroosmose system, which shows results after about 3 to 4 months (tons of water take time to evaporate), it is not advisable to replace the plaster until several months have passed. It is also advisable to remove any damaged walling, otherwise a revival of the local damage to the plaster must be reckoned with. In order to form an opinion as to what is meant by dampness, it is necessary to consider what a dry wall is. F. BRUCKMAYER [8] allows brickwork to have a moisture content of 1,7% to 2,5 % by weight for outer walls of heated rooms. I. ZIEN[9] allows 3% by weight as the top limit for inhabited rooms.

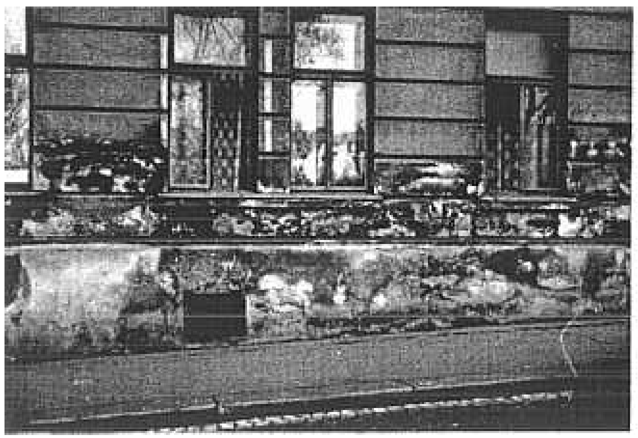
According to our observations and measurements, walls containing brick and natural stone can practically be regarded as dry when having a moisture-content of 5% by weight. This value is an average for a whole year, taking into consideration spring and autumn dampness and summer dryness.

On the basis of this value it has been be observed that with equipment which has been installed for several years, no damage has been caused by dampness, either on inside or outside walls.

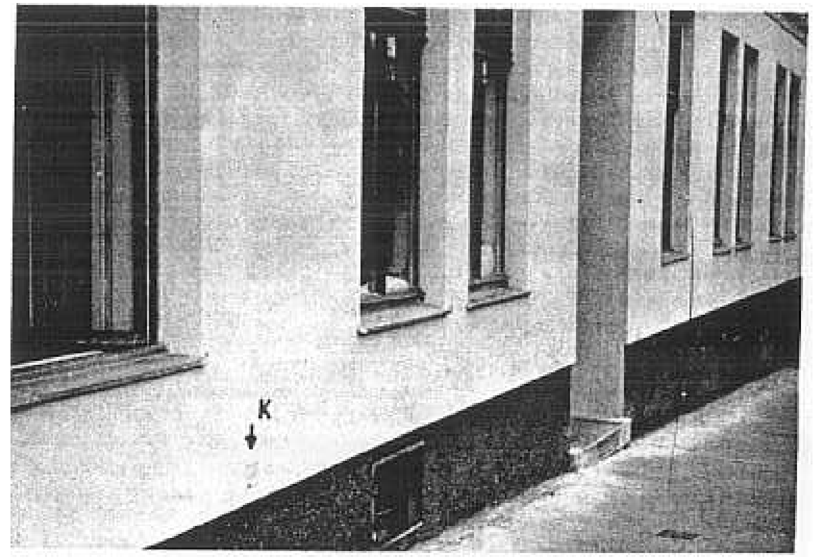
In Laxenburg Castle, with a distribution network of over 2 km in length, - it is a passive equipment and the conductor was made of copper looping instead of working with probes - 102 test-points were measured by the CM-method during the first year, and during the next 3 years were controlled only during high water. It was found that the required level of moisture of 5% by weight did not exceed the yearly average, in fact the values were often under the required level.

As a last example I would like to draw your attention to a typical Viennese house. At the time of the work on Laxenburg Castle, the question was brought up as to whether or not the use of chemicals such as fluat, sika, silicate solutions, hardstone etc. would produce our improvement in the resistance of the plaster to the influence of salts. To this end tests were carried out. The house was dried out according to the electroosmose system and kept under constant control. Before the plaster was applied, the areas to be restored were treated in accordance with the instructions of the manufacturers of the various materials. The area to the right of the doorway was treated with hardstone, a French product, whereby the Na-, K-, Ca- and Mg-ions are turned into chemicals of low solubility. The next area was treated with a silicate solution (Kaliwaterglass). The remaining area was treated with a standard German product consisting mainly of salts of silicat-fluoridacid. The original efflorescence was analysed, both chemically and by X-ray, and it was found that it consisted mainly of magnesium sulphate (epsomit), calcium chloride and small quantities of alcali nitrate.

House in Vienna 19.
Situation 1963



Detail of front



Situation after installation of a passive electroosmose system 1967.

To date there have been no signs of damage to the plaster since the wall was treated for salts. Attention is drawn to the fact that of there is also effective horizontal wall-insulation, generally speaking no damage or signs of efflorescence should appear. Following careful study of the available literature and after divising on a large number of cases of damage it is felt advisable to abstain from using chemicals to cure damaged walls. Systematic research is necessary in order to find a combination of chemicals which is effective in every case. As, however, due to the different types of soil, various salts are contained in the efflorescence, it is necessary first to cary out an analysis in order to find the right combination of chemicals which will give the desired low solubility to the ions of the efflorescence. In view of these difficulties it must be considered that stoichiometrical use of precipitable chemicals is not workable. On the other hand, every overdose must lead to increased efflorescence.

Some problems in connection with electroosmose.

Even where the use of electroosmose has been most successful, its value as such is reduced should the smallest efflorescence appear. Although this efflorescence has nothing to do with the original damage (the restriction field cannot prevent efflorescence), this is of no interest to the giver of the contract. It is therefore necessary that in the future more attention be paid to the problem of efflorescence and that research be made. Further it must be regarded as a de feet that the passive equipment cannot be immediately controlled as to performance. In spite of written and verbal warnings to the householder, damage to the equipment during house repairs is a common occurence. Further, one would like to suggest that new buildings should be fitted with electroosmose equipment. In view of the relatively short life of the mechanical insulation (the first repairs are necessary after 10 years or so) the extra cost is bearable.

The future.

Purely theoretical knowledge on the subject of electrokinetic procedure in the capillary system must be enlarged increased specially with regard to the heterogeneous conditions in the wall itself, together with the physiochemical process of the efflorescence. The practical experience obtaind from - probably - thousands of plants (in Austria some 300 have been installed) show that passive electroosmose is an effective method of drying out damp walls. Causes of failure of the plant are :

1. False polarity,
2. Interruption of the conductor system, or
3. False application (no rising dampness).

Controls by means of CM measurements (resistance tests with probes are not advisable) should be carried out over a period of at least two years. It is further necessary to develop a control apparatus to show whether the plant is working or not. In the case of the active plants, which we do not use owing to their high rate of corrosion, a control system is easier to produce.

The problem of wall curing, in particular in respect to efflorescence, must be dealt within the near future. The conservators of ancient monuments will be particularly grateful for an effort in this direction.