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Are electrokinetic methods suitable for the treatment of rising damp?

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A R T I C L E I N F O

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A B S T R A C T

The treatment of rising damp is an important issue when dealing with the conservation and restoration of historic buildings. The most effective solutions for the problem of rising damp are usually very 'invasive': depending on the method, there might be a substantial loss of authentic materials, the intervention may have a significant impact on the stability of the construction, there could be a mild to very important visual impact, and the intervention might be irreversible. An efficient treatment for rising damp, without these disadvantages, would therefore be more then welcome. Several companies offer nowadays such a solution, in the form of so-called 'electrokinetic' methods. Within the research project EMERISDA (www.emerisda.eu) (Effectiveness of Methods against Rising Damp), on-site measurements have been carried out on more sites, in order to evaluate their effectiveness. On one of the sites, the effectiveness of such an electrokinetic method has been compared to more conventional injections of water repellent agents.

1. Research aim

1.1. Subject of the research

The point of attention are the so-called electrokinetic dehumidification techniques, which we may 'define' generally as the method where rising damp in masonry is being 'pushed back' by using electromagnetic waves. These waves are emitted by a central 'device'. The device needs to be operational as long as one wants to protect the masonry against rising damp.

Other names for this technique, such as 'electromagnetic' or 'electrokybernetic' methods have been observed as well in the commercial literature. In this article, we will continue to use the word 'electrokinetic'.

We were not able to extract a 'uniform' explanation of the principle of these devices from the commercial literature. Sometimes one refers to the technique as a wireless form of (active) electro-osmosis [1]. A somewhat odd comparison, since an electromagnetic wave is a fluctuating electromagnetic field, while electro-osmosis uses a steady (static) electric field.

In one particular case, the supplier states that the waves influence the (tetrahedral) molecular structure of water, which in its turn would change the density, surface tension and evaporation rate of the humidity in the masonry.

1.2. Aim of the research

The aim of the research is to evaluate the effectiveness of the electrokinetic method on the scale of a building (so not in laboratory), as this technique is specifically designed to act on the larger scale of a building (typically these devices have an action radius of about 10 metres), instead of small laboratory scale models or samples.

It was specifically not the aim to research the theoretical background of the method, nor was it intended to perform a research on the devices themselves, for instance to study the properties of the electromagnetic waves themselves (frequency, amplitude. . .).

2. Some initial thoughts about electrokinetic dehumidification

Even though it was not the aim of this research to investigate the theory behind this dehumidification method, there are some fundamental issues and questions that we would like to mention here.

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2.1. Action of an electric field on a water molecule

Water molecules are electric dipoles. They therefore can interact with electric fields, be it constant, steady fields or fluctuating fields (electromagnetic waves).

For dehumidification, it is required that water molecules migrate under the influence of an electric field. This is not evident under the influence of a constant and homogeneous electric field, because in that case the net force on an electric dipole would be zero.

When the electric field is constant, but shows a gradient on the scale of the dipole, the water molecule could experience a net force, and could therefore start to move. It is however definitely hard (or even impossible) to obtain field gradients on molecular scale, when employing macroscopic means (large electrodes, as in the case of electro-osmosis).

In the case of electromagnetic waves, the resulting force on a water molecule is always zero, because of the fluctuating nature of such an electric field: the average field is zero, and therefore also the average force on a charged particle, or on a dipole.

This explanations does not take into account possible polarisation effects between water and pores in a solid material, as is for instance described in [2]. Even if such polarisation effects exist, it is still not evident to employ them (by inversing the tension, for instance) for dehumidification of masonry.

2.2. The Structure of the water molecule

The dipole character of a water molecule is caused by the tetrahedral structure of such a molecule. This dipole character is definitely influencing many specific physical properties of water, such as its rather high surface tension, and therefore relatively low evaporation rate.

It is therefore logical to assume that, if one succeeds to change the structure of a water molecule, that one therefore also influences the surface tension, evaporation rate and density of water, and therefore also the capillary uptake of water by a porous material.

The question remains if one is effectively able to change the structure of a water molecule through electromagnetic waves. What happens, when using electromagnetic waves, is that one causes a vibration of the dipole structure around its equilibrium (tetrahedral) structure. Especially when using frequencies near the eigenfrequencies of one of the three main vibration modes (eigenmodes) of the molecule, one would cause a strong resonance in one (or more) vibration modes. The wavelengths, corresponding to these waves, are around 2.7 and 6.3 μm [3].

The mean dipole moment, and therefore interaction between water molecules, would however remain the same during such vibrations. One can therefore not expect any change at all in the density nor surface tension of the water. These vibrations would cause, on the other hand, the heating of the water (transfer of the molecular vibration energy to kinetic energy of the molecules in their entirety), therefore possibly causing indirectly an acceleration of the drying of the wall.

It is needless to say that such a heating effect would be totally undesirable, because of the danger for humans, animals and plants in the vicinity of the wave-emitting device.

2.3. Capillaries in stones, mortars, humans, animals and plants

The size of blood vessels varies from a few μm to several millimetres. The finest (capillary) vessels are therefore comparable in size to pores that we observe in many natural stones, mortars and bricks.

Even though the flow of blood in blood vessels is not caused by the capillary forces in these vessels, one might at least expect a perturbation of the blood flow in the human body, in the vicinity of an electrokinetic dehumidification device (if they would influence the flow of water in pores).

The water transport in plants is also not (entirely) driven by capillary rise, but the sap-vessels in plants have also dimensions comparable to the capillary veins in humans and animals and pores in stone-like materials. Therefore, one would again expect an influence of an electrokinetic dehumidification device on the water transport in nearby plants.

If the electrokinetic dehumidification works, it could therefore have a (hazardous?) influence on the blood- or humidity transport in living organisms, making the method unsuitable to long-term application in buildings.

2.4. Conclusion

We would like to emphasize that these phenomena have not been studied in the project. Even though the above questions could create doubt around the reliability of electrokinetic dehumidification methods, 'the proof of the pudding is in the eating': an evaluation of the effect of these devices on a building suffering from rising damp will demonstrate directly the effectiveness of the method.

3. Method

In order to study an in-situ effect of (any) technique against rising damp, one has to apply the technique to a building, where all side conditions remain unchanged during the testing period. So no change in climatic conditions (ventilation rate, room air temperature, etc.) and no material changes (i.e. restoration of mortars, stones, or application or renders, paints...) should occur.

Within the EMERISDA project [4], several buildings have been selected, according to the above-mentioned criteria, to be used as case studies. The moisture and salt content and distribution in the wall before the application of the devices was measured before according to the method described in [5].

The moisture content was measured gravimetrically, after drying the sample at 60 °C. The salt content was indicatively assessed, by measuring the hygroscopic moisture uptake (HMC) of the samples after 4 weeks storage at 20 °C 95% RH. Both the MC and HMC content were calculated as % of the dry weight of the samples. These measurements were carried out on regular intervals (typically each 6 months or each year). In two cases, only an electrokinetic device was installed. In the third case such a device was installed, while on another part of the building, far away from the electrokinetic dehumidification device, conventional injections with different injection products were carried out.

4. Results

4.1. Paardenmarkt, Delft, Netherlands

The former Artillery warehouse 'Paardenmarkt' is a listed monument in the centre of Delft. It was constructed in the 17th century. The buildings are constructed in brick masonry, and are subject to rising damp and salts. The salts cause the typical decay of disintegration of renders and flaking of paint. It is worth mentioning that the groundwater level is high. Samples have been taken at 3 locations within the action radius of two electrokinetic dehumidification devices (installed by the supplier). A reference location, within the same building, has been selected outside the action radius of the devices. The moisture and hygroscopic moisture distribution at the different locations before the application of the electrokinetic method, show the presence of rising damp;

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