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DETERMINATION OF SALINITY CHANGES IN BUILDING MATERIALS USING ELECTRIC METHODS

POMIARY ZMIAN ZASOLENIA W MATERIAŁACH BUDOWLANYCH ZA POMOCĄ METOD ELEKTRYCZNYCH

Abstract: Building materials salinity is an important exploitation problem of many objects, especially those which are built without obeying the essential rules connected with performing of waterproof insulation. Porous structure of building materials which form the building barriers is the cause of water capillary rise and thus the movement of salt ions which are the reason extensive barriers destruction. In high concentrations the salt ions crystallize inside the pores of building materials and are the reason of their destruction. It is especially visible in the form of dropping external layers from the walls - plasters, which are mainly vulnerable on the salinity phenomenon. Simulations and measurements of salinity change processes in building materials give the possibility to evaluate the threat and may help to choose the suitable renovation method. The paper presents measurements of water desorption in aerated concrete sample and also the simultaneous process of salinity change in particular layers of the material. The measurements of the above mentioned processes are done using TDR probes (*Time Domain Reflectometry*) which enable constant monitoring of water flow and thus salinity changes.

Keywords: salinity, monitoring, resistance, capillary rise

Many building objects both historical and currently built suffer the problem of excessive moisture which is mainly caused by their porous structure [1, 2] and the strong capillary parameters. In 2010 year the problem of water presence in building barriers became even more important because of the strong inundations which were noticed in the very extensive range of Poland and Central Europe. The problem which is directly connected with water presence inside the building materials structure is salinity. This is caused by the fact, that water is a great salts solvent which are often capillary risen from the soil or from the rain waters (acid rains). Salinity is the problem which leads to the building material structure and particularly to the external plasters demolition. This is mainly caused by the gradual ions concentration which leads to the internal crystallization and then material destruction. As it was mentioned before the problem is the most important in external layers, where the rate of water evaporation is the highest and the crystallization phenomenon the biggest. These salt crystals increase their volume and may destroy the air gaps and then decrease material's strength and insulation parameters.

In case of many old buildings it is even visible several years after the renovation processes, where the destruction and plasters demolition occurs. Salinity presence can be also noticed in the form of splashes in the external parts of red brick masonries.

The problem of extensive salinity presence in building barriers and materials is presented in the following papers [3-5].

All above mentioned problems are the reason to run investigations which may help to detect and predict the water and salinity presence in building barriers and materials. Methods which may be used for the above-mentioned tasks are the modeling and monitoring.

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This paper it is an attempt to model and quantitatively determine the process of moisture changes in a sample of aerated concrete. Aerated concrete was applied for our investigations because it is one of the most popular building material in Polish market [6]. Its structure is representative for any porous building material. Other interesting parameters of this materials have been presented in the following literature items: [2, 7].

In this paper we present the possibility of monitoring of water desorption and salinity changes in the sample of aerated concrete using the standard TDR (*Time Domain Reflactometry*) equipment.

Materials and methods

The experimental setup used for experiment consisted of the following elements:

- TDR Soil Multimeter (Easy Test),
- LP/mts TDR probes (Easy Test)
- PC computer controlling the TDR device,
- aerated concrete sample (SOLBET Lubartow), bulk density 700 kg/m^3.

As a sample we used the block of aerated concrete produced by the local manufacturer SOLBET Lubartow. The sample dimensions were the following: 60×240×240 mm. The sample was initially poured into the 0.5% mass solution of KCl (*Potassium Chloride*). After 5 days of moisturizing the obtained volumetric water content was about 27% vol. (maximum water content is estimated for 30% vol.) what was the initial value for the desorption experiment. Then the sample was covered with the bitumen layer to isolate it from the external environment parameters. Only the upper surface remained not isolated. In such a prepared sample a set of TDR probes was installed. For the experiment we used LP/mts probes by EasyTest, Lublin. LP/mts (*Laboratory Probes for moisture, temperature and salinity*) enable constant monitoring of moisture and salinity. Moisture determination was done using the TDR method (the determined parameter was time of signal propagation along the sensors [ps] and thus dielectric permittivity and moisture). To determine water content of aerated concrete the following calibration formula was used, previously developed by the authors of this article [8]:

$$\theta_{700} = -7.0 \cdot 10^{-4}\varepsilon^2 + 3.29 \cdot 10^{-2}\varepsilon - 1.05 \cdot 10^{-2}$$

where: θ_{700} - volumetric water of aerated concrete with bulk density 700 kg/m^3, ε - dielectric permittivity read by the TDR device.

Salinity was determined with electrical conductivity sensors which are built in the applied TDR probes and after the suitable calibration can determine saline ions concentration.

Calibration was conducted for each of four applied probes with the following KCl solutions: 0.5, 0.3, 0.1% and distilled water.

The TDR probes were invasively installed inside the structure of the material with the distance of 5 cm between each probe. The position of the first probe was 5 cm below the upper surface of the probe. The scheme of the experiment presents Figure 1. The experiment was conducted in isothermal conditions - 23°C (±0.5°C) during the period of 30 days (650 hours).

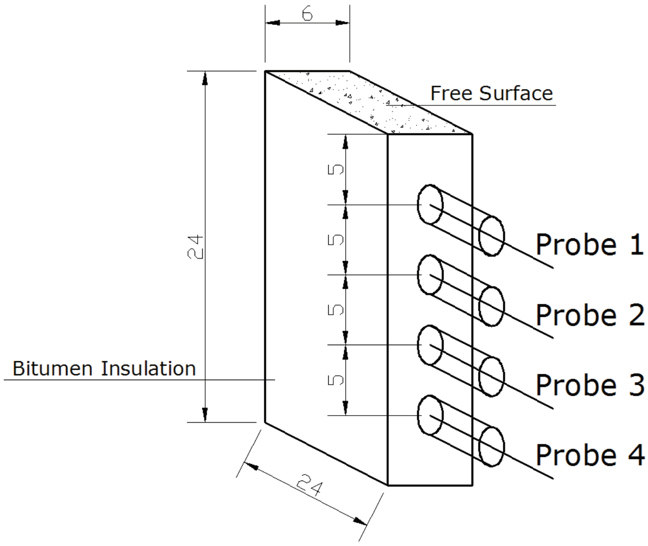

Fig. 1. Experiment setup

Results

With the calibration of the LP/mts for salinity determination the following formulas were obtained:

Table 1

Calibration formulas for salinity determination

Probe No.	Formula
1	$S = 5E^{-09}U^2 - 3E^{-06}U + 0.0018$
2	$S = 6E^{-09}U^2 - 2E^{-05}U + 0.0195$
3	$S = 5E^{-09}U^2 - 6E^{-06}U + 0.0063$
4	$S = 1E^{-09}U^2 + 3E^{-05}U - 0.0479$

where: S - salinity [% mass], U - voltage [mV].

The process of water desorption is presented in Figure 2.

From the diagram it is visible that during the period of 30 days water did not completely evaporated. The amount of water decreased for about 14% vol. - from the initial 26÷27% vol. to about 12% vol. The process progress indicates comparable desorption rate at each altitude. The differences can be recognized by some displacement of all 4 curves. Assuming that the method accuracy is about 0.5% vol. it is hard to predict if those displacements are caused by measurement errors or differences in process progress. The reason of such a situation may be the salinity ions presence which may reduce the TDR signal voltage and flatten the signal peaks from which the dielectric permittivity is determined. It will not influence the moisture readouts but may decrease the measurement accuracy.

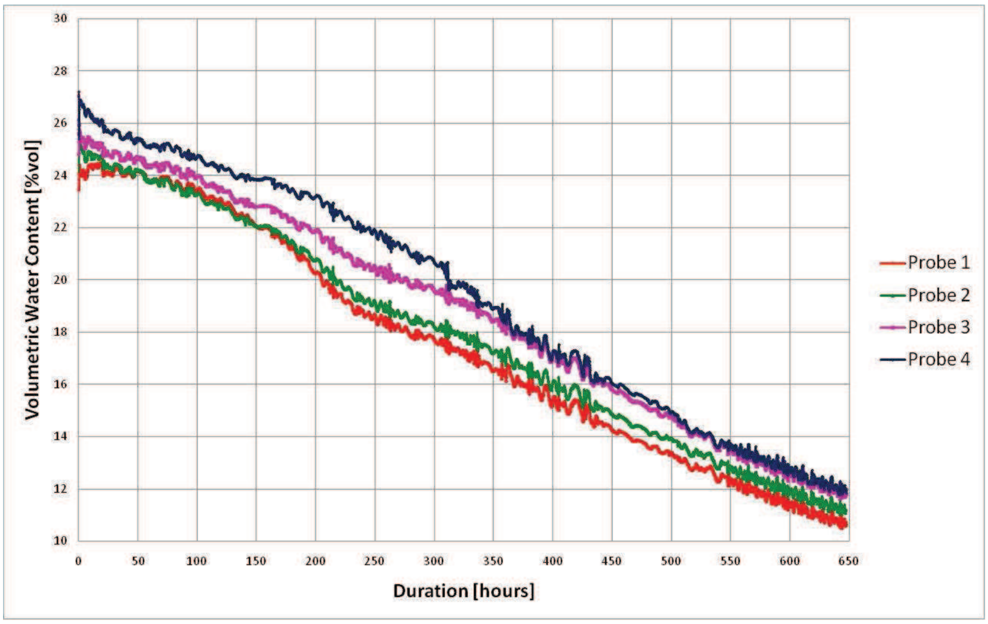

Fig. 2. Desorption process determined using TDR probes

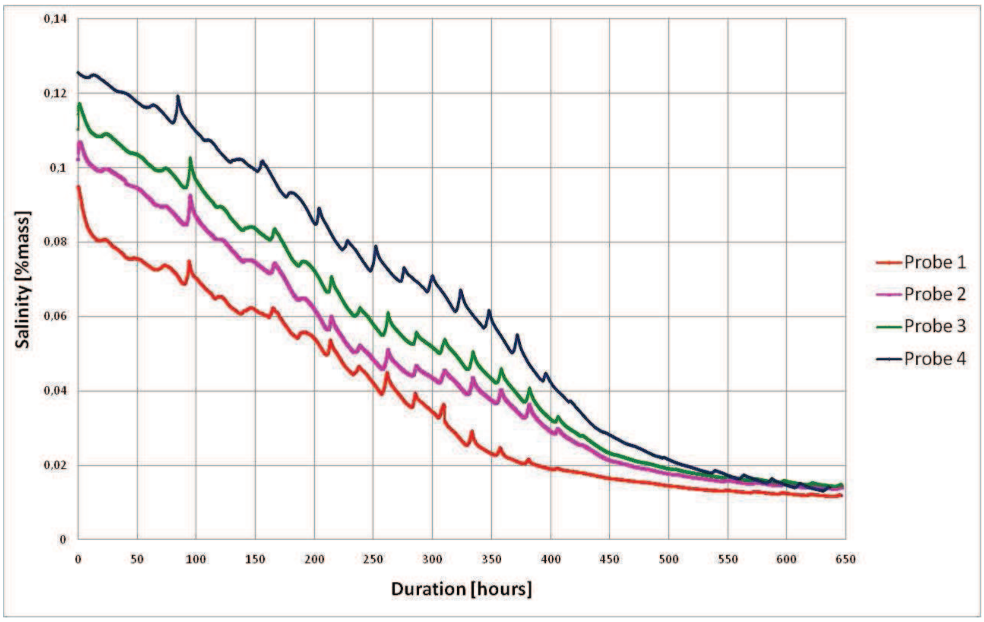

Fig. 3. Salinity changes in sample determined in described experiment

The results of salinity measurement are presented on Figure 3. The diagram below presents salinity change at each altitude of the sample. The curves symbolizing readouts on probes 1-4 start at the ordinate axis between 0.09 and 0.13% mass which can be interpreted as unequal location of salt ions inside the sample. The experiment indicates continuous decrease of salinity value on each probe to a final value 0.1% mass at the end of experiment at each probes.

Laboratory experiment confirmed that ions concentration within the material is combined with moisture. At low states of water content the salinity value is also very low (0.01%) and does not change with moisture changes anymore.

Conclusions

- Salinity presence may influence the measurement accuracy but does not influence moisture value read by the device. Application of moisture measurement method using capacitance or resistance probes would run to big measurement errors or even make it impossible to continue with the measurements.
- If volumetric water content of aerated concrete is below 10% vol. material salinity read by the described devices is close to zero.
- Time Domain Reflectometry (TDR) method enables constant quantitative monitoring of simultaneous processes of water and salinity flows.

Acknowledgement

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POMIARY ZMIAN ZASOLENIA W MATERIAŁACH BUDOWLANYCH ZA POMOCĄ METOD ELEKTRYCZNYCH

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Abstrakt: Zasolenie przegród budowlanych jest znaczącym problemem eksploatacyjnym wielu obiektów, w szczególności tych wzniesionych bez zachowania podstawowych zasad obowiązujących przy wykonywaniu zabezpieczeń przeciwwilgociowych i przeciwwodnych. Porowata struktura materiałów budowlanych, z których wzniesiono przegrody, sprzyja zjawisku podciągania kapilarnego wody, wraz z którą przenoszone są jony soli będące przyczyną przyspieszonego niszczenia przegród. W dużych stężeniach jony soli krystalizują wewnątrz porów materiałów budowlanych i są przyczyną ich niszczenia. Szczególnie jest to widoczne w postaci odpadających zewnętrznych powłok przegród budowlanych - tynków, które są najbardziej narażone na zjawisko zasolenia. Symulacje i pomiary przebiegu procesów zmian zasolenia przegród budowlanych dają możliwość oceny zagrożenia tym zjawiskiem i mogą być podstawą doboru właściwych zabiegów renowacyjnych. Artykuł przedstawia pomiary zjawiska desorpcji w modelowej próbce betonu komórkowego i następującą równolegle zmianę zasolenia w poszczególnych warstwach próbki wskutek powyższego zjawiska. Badania powyżej wymienionego procesu wykonano z wykorzystaniem sond TDR (*Time Domain Reflectometry*), które umożliwią jednoczesny monitoring zjawiska przepływu wody oraz zmian zasolenia.

Słowa kluczowe: zasolenie, monitoring, pomiary rezystancyjne, podciąganie kapilarne