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METHODOLOGY FOR DETERMINATION OF MOISTURE DISTRIBUTION

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Abstract: *The aim of the research is to determine the capillary conductivity coefficient as a characteristic material moisture parameter of the building materials using a non-destructive method while using microwave radiation. A test specimen of ceramic is subjected to an isothermal moisture intake process. The transient moisture distribution in the specimen during the process is determined, at different stages of the process, using EMW-ray equipment. Boltzmann transformation of the experimental data results in a single moisture distribution curve, characteristic of the specimen.*

Keywords: ***Moisture, capillary conductivity, diffusion, water flow, EMWR microwave radiation***

1. Introduction

Into porous material of structures can penetrate moisture in liquid or gaseous form. To express the negative effects of moisture on building materials or building structures more accurately, it is needed to use the most accurate method of detecting moisture diffusion. The article deals with the issues related to moisture content in building materials and presents the results of experimental monitoring of one-dimensional water flow in inert porous materials and it's entrapping in non-stationary damping condition. The measuring device developed at the Institute of Civil Structures, University of Technology Brno, is used to verify the measurement method using samples of building materials.

2.Transfer of the moisture

As a quantity characteristic to define moisture transfer within materials consists from capillary porous matters is used the coefficient of capillary conductivity. It is characteristic parameter (by humidity gradient) for transfer of liquid moisture within porous substance. All methods explaining the coefficient of moisture conductivity used the one-dimensional diffusion equation (Kutilek 1992):

$$\frac{\partial u}{\partial t} = \frac{\partial}{\partial x}(\kappa \frac{\partial u}{\partial x}) \qquad (1)$$

The basis is set as definition of moisture distribution $u(x,t)$ for particular length of sample in the defined time scale (deliquescence curves). The higher is the moisture level of material the lower is amount of microwave radiation, which goes through the material. This is caused by the fact that hydrogen nuclei of water molecule absorb the microwave radiation. Based on the measurement applied by microwave way there can be specified moisture in the particular material part as well as deliquescence curves. These curves are necessary to define coefficient of capillary conductivity calculation.

To obtain deliquescence curves' coefficient of capillary conductivity calculation, is used the following Lykov formula covering the consistency of moisture flow (Kutilek 1992):

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$$\rho_S \frac{\partial u}{\partial t} = -\frac{\partial q}{\partial x} \qquad (2)$$

and continuity formula (Mrlík 1986):

$$q = -\rho_S \kappa \frac{du}{dx} \qquad (3)$$

and supposed mock-up moistening tracked exhibits material s. Fig. 1 and Fig. 2.

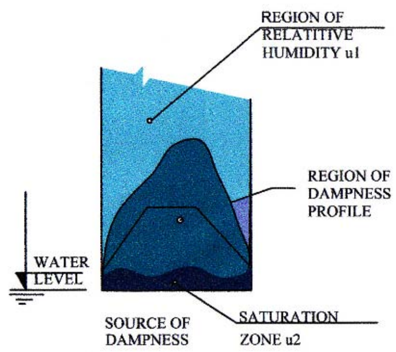


Fig. 1 Hypothetical progress of sample's deliquescence free of immurement

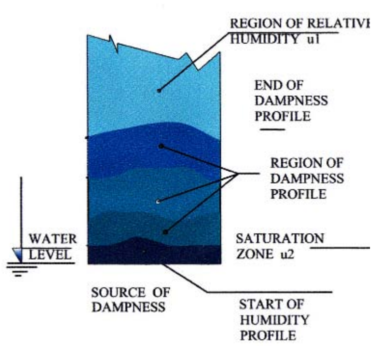
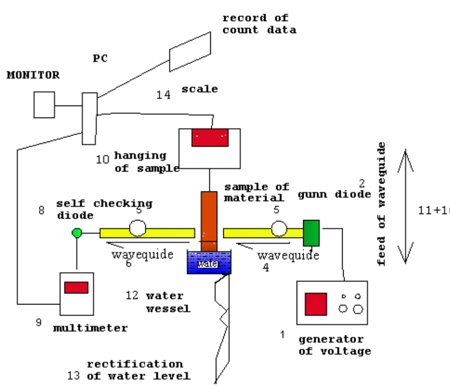


Fig. 2 Hypothetical progress of sample's deliquescence with immurement

3. Experimentally assembled apparatus

On the basis of the patens there has been experimentally assembled by the institute (US) the measurement apparatus s. Fig. 3 and detail Fig. 4.



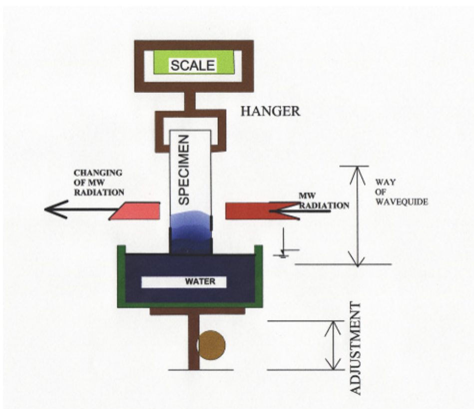


Fig. 3 Scheme of measurement apparatus *Fig. 4 Position of specimen - detail*

4. Change in intensity of EMW radiation

By the aim of measurement apparatus constructed experimentally, has been defined functional dependence for each material – Fig. 5 and 6.

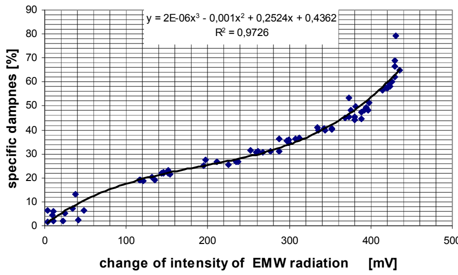


Fig. 5 Functional dependence formulation for gas concrete

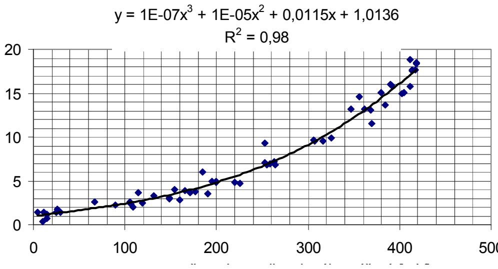


Fig. 6 Functional dependence formulation for material of ceramics

5. Primary measure

By the help of change of electromagnetic microwave radiation intensity depending on quantities of moisture in porous material is description of moisture transport, Fig. 7.

Such results can be used in Excel software for additional mathematic processing – profile of the moisture's front in the particular time line s. Fig. 8. In accordance with the speed waveguides was determined dependence of EMWR on moisture in specimen (in graphics software Excel) Fig. 8.

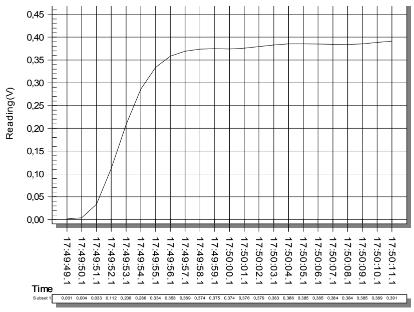


Fig. 7 Primary measure results within time interval 10 min

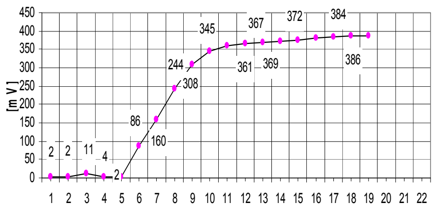


Fig. 8 Primary results measured into time interval 10 min in Excel processing

The Fig. 8 shows the spread of moisture in porous material, which is capture of liquid water within time interval after 10 min from beginning of deliquescence. One section on the axis x = 3 mm on the sample.

The Functional dependence formulation, s. Fig 5 (or 6), is defined by the Maple software s. Fig. 9

In the Fig. 10 is dependence formulation of EMW radiation change within time interval 10, 20 and 30 min. for length of specimen.

As well as in the Maple software – spread of the moisture through the whole sample in the particular time lines.

6. Procedure deliquescence curves assessment

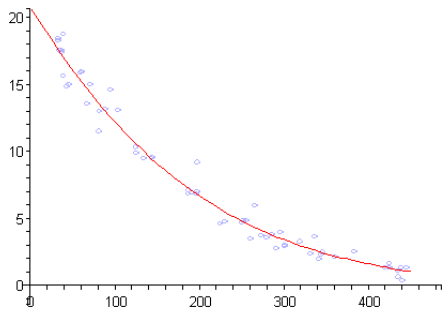


Fig. 9 Functional dependence of measured variable defined by the Maple software (y-axis = moisture by weight /%/; x-axis = dependence of EMWR on moisture /mV/

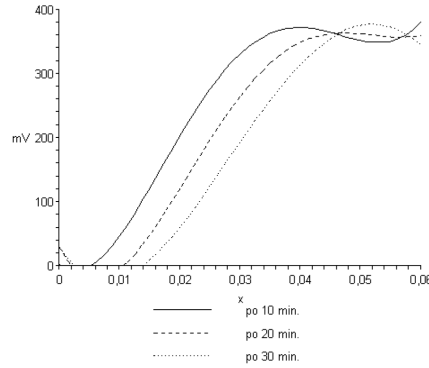


Fig.10 Curves of dependence of EMWR on moisture in the Maple software

a) Dependence between EMW radiation and content of moisture in material from regression formula, Fig. 3, 4 and 10

u_m = -1,342033167.10-7 .z^3 + 0,0001936510773 .z^2 - 0,1038753765 .z + 20,78641097

b) Dependence between change of EMWR and moisture into distance from source of dampness,

c) Moisture distribution defined by the Maple software, Fig. 11

$u_{m,t} = f(z_t(x))$

u_m is specific moisture

z EMWR intensity which come through Specimen

x position data of moisture

t time interval of measurement

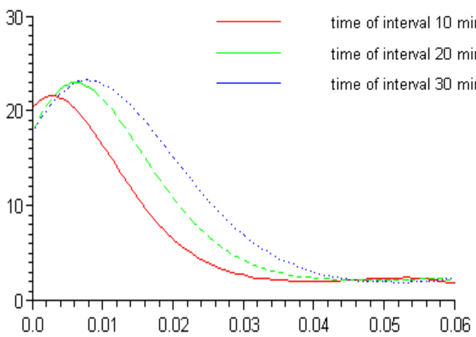


Fig. 11 The moisture distribution defined by the Maple software (y-axis = moisture by weight /%/; x-axis = length of sample /m/

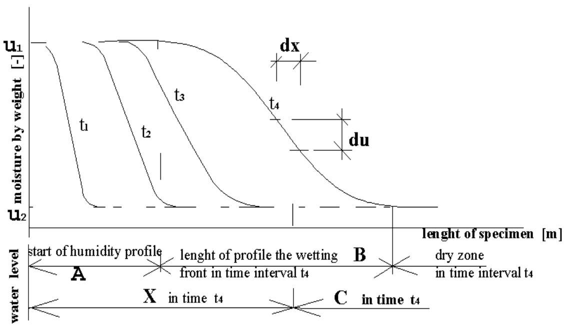


Fig.12 Assumption of the moisture distribution in porous material u (x) at the time intervals t_x (Mrlik 1986):

Figures measured by experimentally assembled measurement apparatus allow us to calculate coefficient of capillary conductivity. Moreover, there are several other possibilities how we can use these figures – for example mass moisture dependency in the particular time intervals.

7. Conclusions

Diffusion of moisture in porous material is currently adequately addressed. The problem remains the condensations of water vapor inside of the porous structures, for which there is no practical basis. In comparison with the destructive method, this methodology of calculating the capillary conductivity coefficient provides more data and more accurate information of the moisture content in detailed sections. The advantage is the relatively fast obtaining of the measurement results and the possibility of continuous measurement of more moisture curves on one sample of the material in any time interval without interrupting the measurement and handling the sample.

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