# Moisture transfer monitoring into porous materials

Jan Skramlik, Ing., Ph.D.
*University of Technology, Faculty of Civil Engineering, Czech Republic*
Miloslav Novotny,Doc.Ing.CSc.
*University of Technology, Faculty of Civil Engineering, Czech Republic*

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ABSTRACT: Most of the building constructions consist from the porous materials – damages caused by the excessive moisture – it is required to know moisture characteristic of the particular material to specify the negative effect of the moisture. We use as a characteristic quantity the coefficient of capillary conductivity κ. This will help us to define moisture characteristics of the building materials.

## 1 INTRODUCTION

The main objective of the work is to deal with the transfer of the moisture monitoring. In the same time, we compare results of the reconcilable calculation methods as well as expression towards the source of the methodology used in the building practice. To determine the coefficient of capillary conductivity using non-destructive monitoring of distribution and the moisture transfer within building materials by expression of deliquescence curves using moisture and electromagnetic microwave radiation interaction [1].

## 2 TRANSFER OF THE MOISTURE

As a characteristic quantity 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 [2]

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

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 number 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 done by microwave way we can specify moisture in the particular material part as well as deliquescence curves. We need these curves to define coefficient of capillary conductivity calculation.

To obtain deliquescence curves' coefficient of capillary conductivity calculation, we use the following formulas:

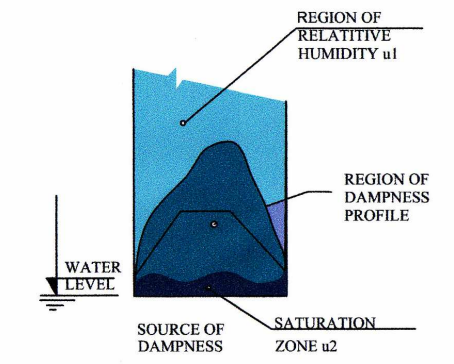
Lykov formula covering the consistency of moisture flow [2]:

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

Continuity formula [2]:

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

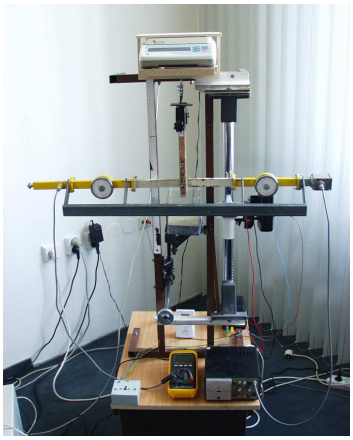
and supposed mock-up moistening tracked exhibits material [3] s.pic 2




Picture 1: Hypothetical progress of sample's deliquescence free of immurement [3]

## 3 EXPERIMENTALLY ASSEMBLED APPARATUS

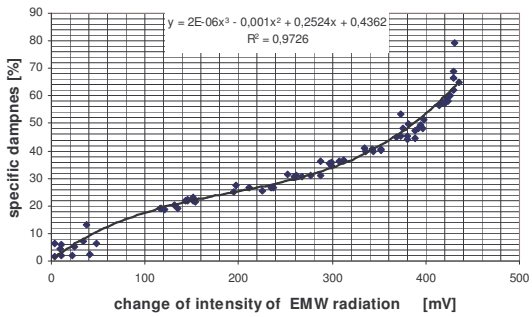
On the basis of the patens has been by the institute (US) measurement apparatus (experimentally assembled) [3] s. pic 2



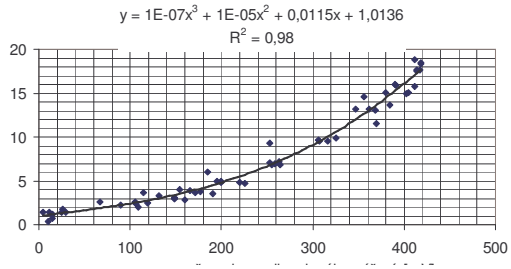
Picture 2 Measurement apparatus constructed experimentally [3]

## 4 CHANGE INTENSITY OF EMW RADIATION

By the help of measurement apparatus constructed experimentally – pict. 3, has been functional dependence formulation.




Picture 3 Functional dependence formulation for gas concrete [3]



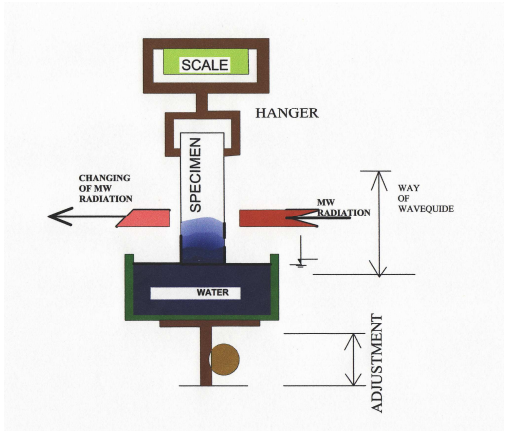

Picture 4 Functional dependence formulation for material of ceramics [3]

## 5 SAMPLE OF MATERIAL

Before measurement of the moisture transfer were specimens of material concerted in plastic film pict. 5.

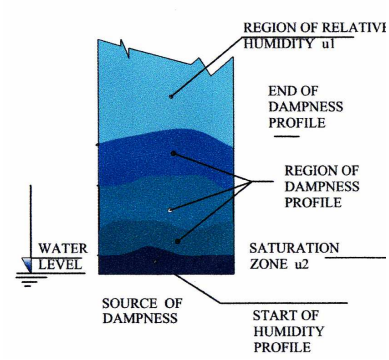
Picture 5 Specimens of ceramics ware and gas concrete conditioned to surveying [3]

Specimens were in measurement apparatus pendent s. pict. 6 and 7.

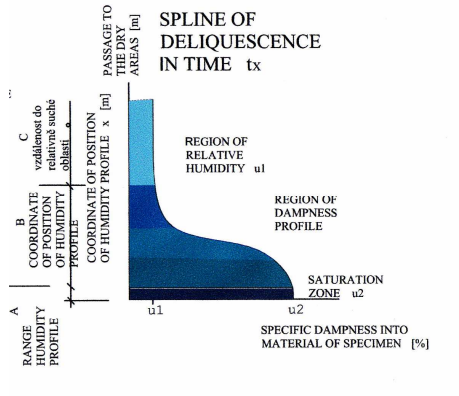



Picture 6 Scheme metering position [3]

Picture 7 Specimens in to metering process [3]



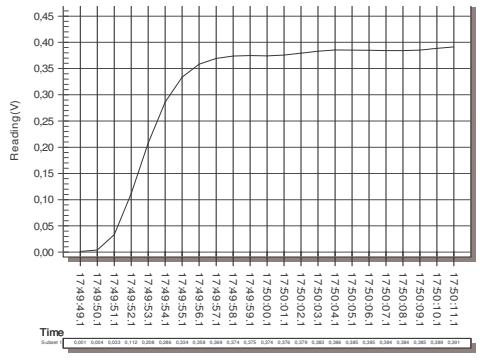

Picture 8 Hypothetical progress of sample's deliquescence with immurement [3]




Picture 9 Hypothetical progress of sample's deliquescence curves [3]

## 6 PRIMARY MEASURE

By the help of change of intensity of electro magnetic microwave radiation in depending on quantities of moisture into porous material by the dampness is pursuance of moisture transport.

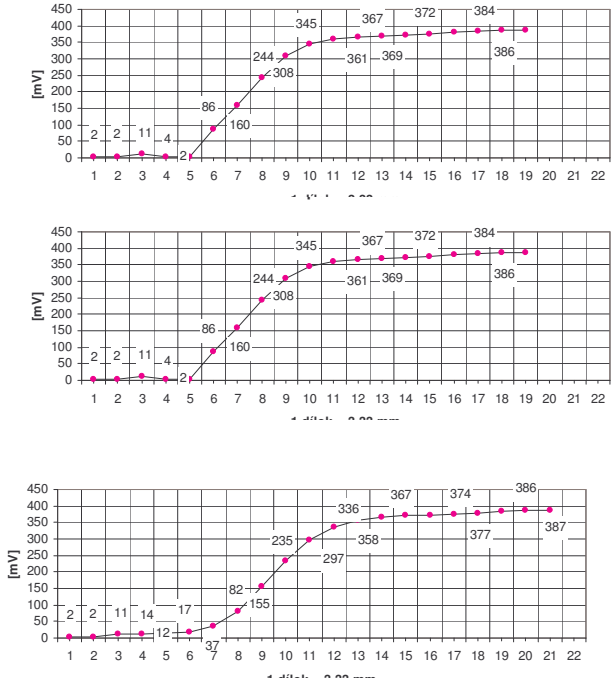



Picture 10 Primary measure results [3]

Such results can be used by Linregrease Excel software for additional mathematic processing – profile of the moisture's front in the particular time line [3] s. picture 4

In conformity with speed of feed per second has been in the Linregrease Excel software processing coordinate graphics of quantity of moisture position
into porous material – s. pic 3 and 4.

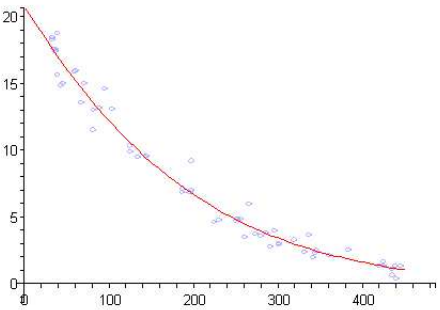
In the Picture 11 is demonstration of headway, let us say aloft of moisture into porous material, which is capture of liquid water into time interval 10, 20 and 30 min from beginning of deliquescence. Axis x is length of sample and coming out on the basis uniform speed of advance of microwave detector.




Picture 11 Primary results measured in the Linregrease Excel software processing [3]

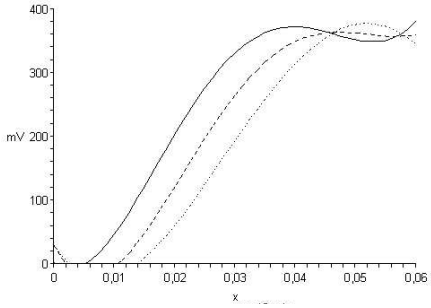
## 7 ELABORATION MEASURE RESULTS

On the Basis of the Functional dependence formulation s. pic 4, defined by the Maple software s. pic 12



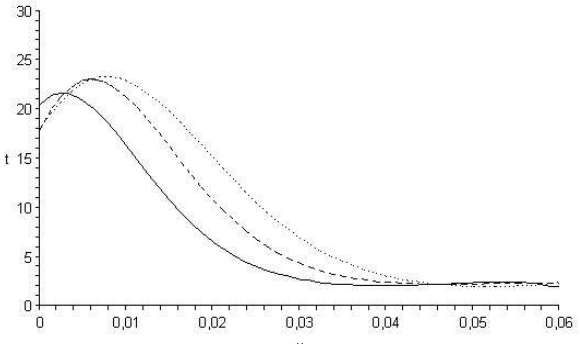
Picture 12 Functional dependence formulation of measured variable defined by the Maple software [4]

In the Picture 12 is dependence formulation of change EMW radiation into time interval 10, 20 and 30 min. for length of Specimen




Picture 13 Deliquescence curves defined by the Maple software [4]

As well as in the Maple software – split of the moisture through the whole sample in the particular time lines [3]




Picture 14 Deliquescence curves defined by the Maple software [4]

## 8 PROCEDURE DELIQUESCENCE CURVES ASSESMENT [4]

a) Dependence between EMWR radiation and content of moisture in material from regression formula, pic 3,4 and 12

$u_m$ = -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, pic 13

c) Deliquescence curves defined by the Maple software, pic 14

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

$u_m$ is specific dampness
z EMWR intensity which come through Specimen
x position data of moisture
t time interval of measurement

## 9 COEFFICIENT OF CAPILLARY CONDUCTIVITY

Pursuant to deliquescence curves by using Matan method is coefficient of capillary conductivity $\kappa(u(x))$
advantage: just one deliquescence curves, time from beginning of deliquescence and coordinate, when not assert edge condition into the dry end of sample; with conjunction
continuity formula (3) a Lykov formula (2) [2]

$$\frac{\partial u}{\partial t} = \nabla.(\kappa(u)\nabla u) \qquad (4)$$

by help Boltzman transformation from lay of humidity u(x) in time t = constant and u(x) is function of one variable x can we convert with introduction $\xi$ - substitution in behalf from point into length of deliquescence curves - in formula (5) to $\infty$ [2]

$$\kappa(u(x)) = \frac{1}{2.t.u'(x)} \int_x^{\infty} \varsigma u'(\varsigma).d\varsigma \qquad [m^2.s^{-1}] \qquad (5)$$

## 8 CONCLUSION

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.

DISCLAMER
Opinions expressed in this publication are the authors own.

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