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Content

Investigation of moisture influence on thermophysical parameters of PORFIX aerated concrete

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Thermophysical properties of porous materials like aerated concrete are strongly dependent on moisture content in pores. This fact influences the use of such material in a practice. The knowledge of this behaviour and its influence on overall performance of the masonry material is one of the criteria for competitive success of the industrial product.Thermophysical parameters, e.g. the thermal conductivity, thermal diffusivity and specific heat of two PORFIX materials were measured by pulse transient method.Two sets of PORFIX specimens of two different volume densities (400 and 520 $kg.m^{-3}$) were prepared. Specimen sets were conditioned under air protected conditions and were saturated with moisture content for a period of about one month. Final moisture content for each set was determined by weighting method. Thermophysical parameters were measured for six different moisture contents - 0, 3, 6, 10, 15 and 20 wt%.The results show strong dependency on moisture content for all thermophysical parameters within an investigated range of conditioned moistures. We found, that the value of thermal conductivity measured for dry specimens and the conditioned ones to the 20 wt% of moisture content increases two times.

Study of the curing process of an epoxy resin by monitoring of the thermal conductivity by the Hot Ball method

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Epoxy resins are materials capable of polymerizing under determined conditions, i.e. a temperature increase or the presence of a hardener, yielding a three-dimensional net formed by the cross-linking of the chains. This polymerization is also called curing process. During the curing process different physical changes are produced in the system. First, blocks of polymers are formed and then, the blocks are cross-linked obtaining the cured epoxy resin with high molecular weight and viscosity. As a consequence of the aforementioned changes, the heat capacity and the main free path of phonons are affected, altering the thermal conductivity of the system as well. This paper deals with the study of the curing process of an epoxy resin by monitoring of the thermal conductivity using the Hot Ball method.

Moisture transport through porous materials monitored by the Hot Ball Method

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Cultural and historical monuments are predominantly constructed of porous materials, where moisture plays a dominant role in their deterioration. Considering this fact, we performed experimental measurements of moisture diffusion through porous materials as sandstone. Our experimental studies are focused on a 17% porosity sandstone piece (dimensions $100 \times 50 \times 50$ mm) from Sander Schilfsandsteingbruch (Germany). A new hot ball method technique was used for monitoring moisture transport. Our sandstone block has been used for one-dimensional diffusion experiments in which water was diffused through a 50x50mm base surface, while side surfaces remained isolated for moisture transport. Three processes were studied, drying, saturation through a step-wise regime and water-pulse regime. With our work we were able to characterize and calibrate the sample, and to study the changes in moisture transport with temperature.

Diffusivity determination from measurement of the time development temperature inside a slab

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The conditions are discussed under which the non steady temperature field inside a slab of the thickness l can be considered as 1D problem. In this case we introduce two solution of the 1D heat conduction eq. under constant temperature at the border planes of the slab as well as at a constant initial temperature inside the slab. Knowledge of the time development temperature from experiment in a plane inside the slab parallel to the border planes permit us to determine thermal diffusivity a of the slab. To this aim the solutions of the 1D heat conduction eq. represented by infinite series it is possible to cut after first n terms and to omit the rest. Such finite series well approximate time development of the temperature in two cases: in the short period of the time and in the long period of the time.

Relationship between calcium silicate permitivity and thermal conductivity moisture content dependences

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The permittivity of a calcium silicate as a function of the moisture content was determined using standard TDR equipment. The obtained results were compared with available results of moisture dependent thermal conductivity of the same material. A similarity between both material properties determined by moisture content has been found.

Computational modelling of coupled heat and moisture transport with hysteretic hydric parameters

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A computational model of coupled heat and moisture transport in porous building materials taking into account hysteresis of hydric parameters is presented. A practical application of the model shows that the hysteretic moisture transport and storage parameters can be considered as quite important in service life analyses of multi-layered systems of porous building materials.

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Effect of water vapour permeability moisture dependence on simulation of dynamic moisture response

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In simulations of an isothermal moisture flow the surface flow effects can be involved in the moisture dependent water vapour permeability. Generally, the water vapour permeability is function of moisture content but it is often modeled as vapour permeability / relative humidity relation using the standard cup method measurements results. In this work the effect of the used water vapour permeability function on the reliability of simulation results was evaluated for the case of drying of capillary porous material in the hygroscopic range . The simply experiment, consisting in monitoring of isothermal 1-D drying of the chosen building materials (burnt clay bricks, autoclaved aerated concrete) was done. In the following simulations of the drying process different expressions of vapour permeability moisture dependence were used. On the base of the comparison of the measured and simulated results the suitability of the used water vapour permeability functions was determined and the consequences for simulation of dynamic moisture response were discussed.

Thermophysical Analysis of Porous System

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Contribution discusses application of the instrument RTLab (Thermophysical tester) for thermophysical analysis of the porous materials. Here, thermophysical analysis means the measuring specific heat, thermal diffusivity and thermal conductivity at the specific thermodynamic condition. Thermodynamic conditions are given by temperature and the specific degree of moisture. In addition investigation of the advance of freezing/melting front will be demonstrated due monitoring system RTM in connection with Thermophysical Tester RTLab. We discuss a possibility of experimental study of the moisture transport in porous materials. We show effects of the air bubles in porous materials that are responsible for moisture transport due to temperature variations. The mentioned effects will be demonstrated on sandstones and marble.

A detailed characterization of the Thermophysical tester RTLab and the monitoring system RTM will be presented. Measuring regimes of these instruments will be discussed considering above mentioned effects.

Analysis of water vapour sorption process in static desiccators method

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The samples of characteristic interior finish materials were placed in static desiccators to obtain the sorption isotherms. The time courses of water vapour adsorption/desorption of particular samples were measured by gravimetric method in weekly intervals. A solution of the diffusion equation describing the sorption process was applied in an analysis of the obtained results. A possibility to determine water vapour transport parameters from the sorption courses was given by the actual boundary conditions and water vapour permeabilities for particular materials, defined by the Biot number.

A statistical mechanical description of phases and first-order phase transitions

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We briefly review the Pirogov-Sinai theory that allows one to rigorously study phases and first-order phase transitions from a statistical mechanical point of view. We wish to demonstrate that it is a powerful tool that may be used in various applications from materials physics to physical chemistry and biology.

Analysis of moisture hysteresis of building materials in hygroscopic range

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The moisture hysteretic behaviour of building materials in a hygroscopic range was investigated. Based on available main adsorption, desorption curves and primary scanning curves, the functions of the hysteretic factor (Chatterjee 2001) for investigated materials were treated. Following the hysteretic factor similarity, parameters of the hysteresis model proposed by Pedersen (1990) were determined.

Thermodilatometry of ceramics using by the simple push-rod dilatometer

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This paper describes a dilatometer of the own construction, its calibration, evaluation of the systematic errors and calculation of the uncertainty of the measurement. The example of dilatometry of the quartz crystal is shown.

The influence of heating rate on thermal processes in cylindric samples of different radius

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Heating of traditional clay electroceramic causes the elimination of physically and chemically bonded water. This process depends on the size and heating rate of the sample. We discuss the influence of the surface temperature and the difference between the surface and the bulk temperature.

Numerical validation of the scanning mode procedure of thermal diffusivity investigation applying temperature oscillation

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Problem of the thermal diffusivity investigation applying a modified Ångstrom thermal wave technique has been analysed. The analysis has been focussed on effect of the linear changes of the oscillation offset temperature on the results in view of the temperature dependent thermal properties of the investigated material. In the course of the numerical analysis effects of violation of model boundary conditions has also been investigated. Convective heat loses and the temperature sensor positioning have been considered at the most. A numerical model for calculations has been developed applying Comsol software that is a finite element method modelling package. Effectiveness of the proposed procedure for the thermal property investigation even in case of strongly temperature dependent properties has been finally proved. The outcomes of the numerical experiments contributed to optimisation of real experiments.

Experimental analysis of water and nitrate transport in porous building materials

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Water and nitrate transport is analyzed experimentally in several characteristic types of porous building materials. The main practical outcome is the determination of two principal transport parameters, namely the moisture diffusivity and nitrate diffusion coefficient. It is shown that the possible neglect of nitrate diffusion in the liquid phase is apparently wrong because the moisture diffusivity calculated from nitrate concentration profiles under this assumption is one to two orders of magnitude higher than moisture diffusivity calculated from moisture profiles.

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Thermomechanical modelling of a maturing concrete mixture

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Concrete is a natural composite whose properties are determined by hydro-thermo-chemo-mechanical processes at early age of its existence. It is namely in case of massive structures such processes should be controlled carefully to guarantee the optimal behaviour of a structure according to its proposed use. The complete mathematical model of heated concrete, treated as a multi-phase porous material, consists i) of 20 balance equations, coming from the mass, momentum and energy balance laws for continua with microstructure, corresponding to solid concrete, liquid mixture, water vapour and dry air, coming from the mass, momentum and energy balance laws for continua with microstructure and ii) of a set of constitutive relationships, identified by laboratory experiments. Some preliminary simulation results are available.

Dielectric Properties of Building Materials

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Building materials consist of at least three phases: solid, gaseous and liquid. Electrical parameters of building materials strongly depend on water content which has the great influence on them in the electromagnetic field. One of them is the dielectric permittivity ε which is the measure of the material particles interaction with the external, alternate electric field induction.

It is generally known that water molecule differs from the other phases of building materials by its polar character which is expressed in the value of dielectric permittivity (80) comparing to air – 1, or solid phase particles (4-8). This difference is often used for estimation of water content in building materials using several measurement techniques and is the most useful using TDR (Time Domain Reflectometry) method.

There article is a review of models and formulas describing dielectric permittivity of building materials used for moisture estimation.

Investigation of the thermal diffusivity of the $Fe_{52}Ni_{48}$ and $Fe_{40}Ni_{60}$ alloys by means of modified flash method

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The paper presents the results of the thermal diffusivity investigation of the two two-component $Fe_{52}Ni_{48}$ and $Fe_{40}Ni_{60}$ alloys. Investigations have been performed using the modified flash method [1, 2], which consists in measuring the temperature difference between opposite surfaces of a disc-like sample, just after the laser shot on the front sample surface. The investigated samples were 12 mm in diameter and had thicknesses - 1.60 mm ($Fe_{52}Ni_{48}$) and 1.51 mm ($Fe_{40}Ni_{60}$). Temperature range of the investigations was from 300 K to 1000 K.

It has been found that the thermal diffusivity values for both investigated alloys and for the above temperature range were within the range (4.5 ¸ 8.5)$\times 10^{-6}$ m^2/s. In the both cases the hysteresis loops of the Curie points T_C were observed [T_C (T ↑) = 774.4 K and T_C(T ↓) = 773.9 K for $Fe_{52}Ni_{48}$ as well as T_C(T ↑) = 861.1 K and T_C(T ↓) = 855.1 K for $Fe_{40}Ni_{60}$ alloy].

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Thermal conductivity in dependence on temperature

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A gradient method for the measurement of thermal conductivity at steady-state heat flow is presented in the paper. At the steady-state heat conduction across a multi-layer wall the heat flux is directly proportional to the temperature difference and thermal conductivity of every material. If the thermal conductivity depends on temperature, for a specified temperature interval a material can be characterized by a constant thermal conductivity value. Knowing the temperature field in a material in steady-state conditions and a single value of thermal conductivity at certain temperature, other thermal conductivity values can be calculated for other temperatures.

The thermodilatometric analysis of kaolin-quartz samples

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The thermodilatometric analysis (TDA) of kaolin-quartz samples from 20 °C to 1100 °C is presented. Samples were prepared from Sedlec kaolin and 0 wt.%, 9 wt.%, 20 wt.%, 30 wt.%, 40 wt.%, 50 wt.%, 60 wt.%, 70 wt.%, 80 wt.%, 90 wt.% and 100 wt.% of quartz. The processes occurring in the samples during heating up to 1200 °C (dehydroxylation of kaolin at 450 - 650 °C, the collapse of the metakaolinite structure at 950 °C, the alfa-beta transformation of quartz at 573 °C as well as a solid-state sintering at the temperatures higher than 1000 °C) are reflected in thermodilatometric curves in a different measure dependent on the quartz content.

Thermal, hygric and salt-related properties of high performance concrete

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Thermal, hygric and salt-related properties of four types of high performance concrete are analyzed. Experimental results show that all four studied materials have very good prerequisites for application in building industry. Their water transport characteristics are very suitable for high performance concrete. The low liquid water transport parameters can guarantee slow water penetration into the material, thus high durability.

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Thermal conductivity measurement of dynamo sheets

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Measurements of the thermal conductivity of non-oriented silicon steel (dynamo) sheets in the temperature range from 25 °C to 170 °C are presented. Samples in the form of thin metallic sheets were measured by steady-state method based on Guarded Hot Plate standard. Two different shields, guarded and thermal (radiation) shield were successfully introduced in order to eliminate heat losses along the thin samples even for higher temperatures. Experimental arrangement together with measuring procedure and uncertainty assessment are provided in details. Reliability of the method was verified by stainless steel A310S measurement as a standard.

The use of step wise and pulse transient methods for the study of photovoltaic cells laminating films properties

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The paper reports a study on thermal properties of laminating films used for the production of photovoltaic cells modules. Step wise and pulse transient method were used for the study. The results of measurements (diffusivity, specific heat and thermal conductivity) were compared with results of thermal vision analysis. New fractal model of heat transport through the material and heat losses for thermal parameters determination was used. This model was compared with classical models which have been used so far.

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Identification of some thermophysical and boundary parameters of black foamglas by an inverse method

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In this paper the temperature-dependent thermal conductivity k and the volumetric heat capacity (rho*c_p) as well as the heat transfer coefficients h_i of the cylindrical sample made of black foamglas with a medium density rho = 131 kg/m^3 were estimated simultaneously using an inverse method. The experimental setup consisted of a thin-layer Kapton heater put symmetrically into the sample which was divided into four parts. Temperature histories were recorded in the sample using the K-type thermocouples. The temperature histories located in the sample on both sides of the thin-layer heater were used to determine the heat partion just after the heater generation and the temperature responses at some locations of the outer faces of the sample were input data for an inverse procedure of the parameter estimation. The results of parameter estimation obtained by an inverse method and the measured ones by using a commercial apparatus ISOMET 2104 revealed that the values of the thermal conductivity of the sample were consistent with one another but there were some discrepancies with respect to values of the volumetric heat capacity.

Measurement of the thermophysical parameters of materials using the generalized non-stationare regime

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In this paper, the specific measurement method for the determination of thermo-physical parameters of materials is described. All the kind of non-stationary thermal processes in a specimen can be used in this method. In practice, the advantageous thermal processes (concerning to the dimension, etc.) are chosen. The repeated measurement does not require the application of the self-same non-stationary thermal process. In the measurement of the thermal conductivity coefficient, it is very advantageous to use the accumulated core. The time-dependence of the temperature in chosen points of the specimen is recorded continuously. An analysis of these records yields thermal parameters. In some cases, the variable thermal power of the laboratory oven is recorded continuously, too. The method can be applied to the measurement of the temperature-dependences of the thermo-physical parameters in the wide temperature interval.

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