Research project purposes

The main purpose of the project is to gain profound understanding and thorough description of phase change kinetics of liquids contained in a pore system. It is also expected to determine the relation between the phase transition progress and strain in the material skeleton. These findings enable to improve precision of the porous materials durability prediction. The vast majority of man-made materials as well as natural ones, which are applied in industry possess complex microstructures. The pore system is usually filled with water and various substances dissolved in the liquid, i.e. contamination, salts, antifreeze, etc. Due to the variation of the environmental conditions, e.g. temperature or relative humidity, pore liquid changes its state of matter.

Based on the procedure recommended by International Confederation for Thermal Analysis and Calorimetry the kinetic equation describing phase change of liquids filling the pore system is going to be determined. The relation between extent of conversion, its rate and the strain occurring in the skeleton will be investigated by means of a specifically designed and constructed equipment. Degradation of material subjected to fast temperature variation will be analyzed through experimental measurements of properties such as elastic modulus, compressive strength, pore size distribution, permeability, etc.

Research project methodology

First-order phase transitions are always related to some heat effect. It is planned to apply heat flux differential scanning calorimetry (DSC) to measure the progress of phase change in porous materials. At the beginning the calorimetric analysis of water freezing, salt crystallization, etc. in mesoporous silica with one dominant pore diameter (MCM-41, SBA-15) will be carried out. This research will enable to propose the relation between the parameters of kinetic equation, i.e. activation energy, reaction model, etc. and pore diameter. Subsequently the analogous research will be conducted for the natural and man-made materials such as: stones, concrete, brick, etc. The influence of phase transition kinetics on strain arising in the materials will be also investigated. Based on well-known Archimedes' principle the measuring device will be constructed. It is going to monitor the volume change of material immersed into the liquid with controlled, changing temperature. These results will enable to assess quantitatively the phase change inducing strain in the skeleton. It is planned to analyze the material microstructure by means of optic method, mercury intrusion porosimetry and gas adsorption using the equipment available in the Department of Building Physic and Building Materials Lodz University of Technology (DBPBM LUT) and other faculties of LUT. Interaction between chemicals dissolved in a porous liquid and a skeleton will be analyzed using Fourier Transform Infrared Spectroscopy.

Expected impact of the research project on the development of science

The results achieved in the framework of the proposed project will enable to better understanding of the processes associated with the phase change of pore liquids. Due to fast growth of economy the environment becomes more and more aggressive and its parameters fluctuate very rapidly. Therefore the new techniques and tools both experimental and numerical are necessary for prediction of durability of materials exploited in such conditions. The research device constructed during the project might be applied in other fields of science and engineering, i.e. to assess the proper dosing of air-entraining admixture, the cooling strategy of passive houses based on phase change materials, etc. Concluding, the outcome of the project will contribute to protection of the cultural heritage and will help to ensure the sustainable development of the main branches of economy. The results of the conducted research will be presented during conferences, described in articles published in the journals from the JCR list and will also contribute to the PhD thesis.