World Academy of Science, Engineering and Technology
International Journal of Structural and Construction Engineering
Vol:14, No:03, 2020

Thermal Properties and Water Vapor Permeability for Cellulose-Based Materials

Authors : Stanislavs Gendelis, Maris Sinka, Andris Jakovics

Abstract : Insulation materials made from natural sources have become more popular for the ecologisation of buildings, meaning wide use of such renewable materials. Such natural materials replace synthetic products which consume a large quantity of energy. The most common and the cheapest natural materials in Latvia are cellulose-based (wood and agricultural plants). The ecological aspects of such materials are well known, but experimental data about physical properties remains lacking. In this study, six different samples of wood wool panels and a mixture of hemp shives and lime (hempcrete) are analysed. Thermal conductivity and heat capacity measurements were carried out for wood wool and cement panels using the calibrated hot plate device. Water vapor permeability was tested for hempcrete material by using the gravimetric dry cup method. Studied wood wool panels are eco-friendly and harmless material, which is widely used in the interior design of public and residential buildings, where noise absorption and sound insulation is of importance. They are also suitable for high humidity facilities (e.g., swimming pools). The difference in panels was the width of used wood wool, which is linked to their density. The results of measured thermal conductivity are in a wide range, showing the worsening of properties with the increasing of the wool width (for the least dense 0.066, for the densest 0.091 W/(m·K)). Comparison with mineral insulation materials shows that thermal conductivity for such materials are 2-3 times higher and are comparable to plywood and fibreboard. Measured heat capacity was in a narrower range; here, the dependence on the wool width was not so strong due to the fact that heat capacity value is related to mass, not volume. The resulting heat capacity is a combination of two main components. A comparison of results for different panels allows to select the most suitable sample for a specific application because the dependencies of the thermal insulation and heat capacity properties on the wool width are not the same. Hempcrete is a much denser material compared to conventional thermal insulating materials. Therefore, its use helps to reinforce the structural capacity of the constructional framework, at the same time, it is lightweight. By altering the proportions of the ingredients, hempcrete can be produced as a structural, thermal, or moisture absorbent component. The water absorption and water vapor permeability are the most important properties of these materials. Information about absorption can be found in the literature, but there are no data about water vapor transmission properties. Water vapor permeability was tested for a sample of locally made hempcrete using different air humidity values to evaluate the possible difference. The results show only the slight influence of the air humidity on the water vapor permeability value. The absolute ‘sd value’ measured is similar to mineral wool and wood fiberboard, meaning that due to very low resistance, water vapor passes easily through the material. At the same time, other properties – structural and thermal of the hempcrete is totally different. As a result, an experimentally-based knowledge of thermal and water vapor transmission properties for cellulose-based materials was significantly improved.

Keywords : heat capacity, hemp concrete, thermal conductivity, water vapor transmission, wood wool
Conference Title : ICBP 2020 : International Conference on Building Physics
Conference Location : Tokyo, Japan
Conference Dates : March 23-24, 2020