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Assessment of the thermo-physical properties of leaves

Anna Vaivare[a], Indra Muizniece[a]*, Dagnija Blumberga[a], Mantas Pranskevicius[b], Olga Glazkova[c]

[a]*Institute of Energy Systems and Environment, Riga Technical University, Azenes iela 12/1, Riga, LV−1048, Latvia*
[b]*Department of Environmental Protection, Vilnius Gediminas Technical University, Saulėtekio al. 11, LT−10223, Vilnius, Lithuania*
[c]*ITMO University, 49 Kronverksky Pr., St. Petersburg, 197101 Russia*

Abstract

The aim of this research is to determine the thermal conductivity of apple tree leaves and the factors influencing the thermal conductivity. In this paper the natural material remain (leaves) usage as a thermal insulation material is discussed. In this study samples for a 2 factor experimental plan are created. The moisture content, density and the heat flow measurements for the calculation of the thermal conductivity coefficient are carried out for the samples. The main factors that influence the thermal conductivity are density and particle size. This paper will evaluate the possibility of a natural material rational usage in making thermal insulation.

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Keywords: leaves; thermal insulation; thermal conductivity coefficient; natural heat insulation

1. Introduction

The European Parliament and Council prepared Directive 2010/31/EU envisages that the acceding countries (including Latvia) need to increase the energy performance of buildings so that the existing buildings would satisfy the minimum requirements, and all the new buildings would be nearly zero-energy consumption buildings (an increased energy efficiency class, where the energy consumption for heating purposes is no more than 30 kWh/m^2 per year) by 31 December 2020 [1].

* Corresponding author.
E-mail address: indra.muizniece@rtu.lv

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To achieve the European Union set “20-20-20” targets, the main difficulty is to decrease the energy consumption by 20 % till 2020. The building sector is one of the sectors that has a great potential for increasing energy efficiency so there is a big focus on that [2].

As the energy efficiency of buildings will increase the use of thermal insulation materials also will increase. Natural material usage in heat insulation production will help to provide the necessary amount of insolation as an alternative for mineral and synthetic material insolation.

One of the main positive aspects of using natural materials in construction and as insulation materials is that they are biodegradable. Using a proper amount of binding agent and with a proper maintenance the house can last for years. But after the house demolition the building materials are not as big of a problem as they are now when construction and demolition takes place [3–5].

Another current environmental issue is how to reduce the amount of residue of various sectors of the economy. For example, the wood processing residues from forestry, which is still one of the largest groups of waste [6].

Finding natural material remains that can be used as thermal insulation materials will help to reduce the amount of remains and thereby they will be rationally used. There already has been research on the use of coniferous tree needles from forestry residues for thermal insulation material development [7–10].

To increase the energy efficiency in the building sector and to comply with the basic principles of bioeconomy strategy, to approach ecological, effective resource management and bio-based products manufacturing is important, thereby ensuring environmental protection [11]. In this research a thermal insulation material that already exists in the nature is examined – the plant aerial part in autumn serves as the insulation layer for roots in the winter.

A similar research has been made a long time ago – in the seventies and eighties – but the research was evaluating the thermal conductivities of fresh leaves [12, 13]. Also some tropical plant species were evaluated, for example palm leaf insulation [14]. There has been research on the usage of leaves in the building sector – they can be added into cement therefore decreasing the material density, and improving the thermal properties. For example there has been research on 4 kinds of leaves – poplar, gingko, sophora japonica and magnolia denudate – adding to cement. Adding 10 % of crushed and granulated leaves to cement decreases the thermal conductivity coefficient to 0.144 till 0.190 W/(m*K). Better results for the leaf concrete are found for the use of magnolia leaves, but a higher thermal conductivity is found using sophora leaves. This can be explained with the density of the whole leaf – sophora has the biggest bulk density (22.9 kg/m^3) but magnolia has the smallest (15.1 kg/m^3). Also increasing the amount of the added leaves to 15 % can decrease the thermal conductivity coefficient by about 0.03 W/(m*K) [15]. Other research on dried leaf thermophysical properties is not found.

2. Materials and methods

The evaluated insulation material is based on the idea of the natural insulation layer that is formed by the aerial part of the plant and fallen leaves in the autumn that serves as a natural heat insulation layer for roots. The thermal properties of leaves are evaluated in this study. In particular the apple tree leaves. The leaves were harvested in the autumn of the year 2014 and dried in room temperature (around 20 °C). The leave samples can be seen in Fig. 1.

Fig. 1. Samples of apple tree leaves used in the experiments.