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R. Šadzevičius
V. Gurskis

INVESTIGATION OF THERMAL CONDUCTIVITY OF CONCRETE COMPOSITES WITH HEN FEATHERS AND SHEEP WOOL

Vytautas Magnus university

Introdution

In order to reduce the energy consumption of buildings, it is necessary to increase the energy efficiency of the component elements of the building, both in their production and in operating conditions [7]. In order to build environmentally friendly, energy efficient and affordable buildings, it is expedient to connect agricultural and construction industries [1]. Environmentally friendly buildings can be built when renewable resources are used [8]. Renewable resources such as hemp, flax, jute straw, various types of wood, wool are increasingly used in the production of thermal insulation materials [2,3,4,9].

Testing methodology

The production of composites from hen feathers and sheep wool raw materials was carried out in the following stages: material preparation, determination of material density and thermal conductivity, fiber mixing, fiber mixture forming, sample preparation, treatment by heat and determination of thermal conductivity. Preparation of the materials is illustrated in Figure 1.

Figure 1. Preparation of sheep wool

The thermal conductivity of the materials was investigated by the constant heat flow method according to LST EN 12667: 2002 [5] and LST EN 12939: 2002 [6]. The computerized thermal conductivity measurement device LaserComp FOX 200 was used for testing (Figure 2).

Figure 2. The computerized thermal conductivity measurement device - heat flow meter LaserComp FOX 200

Device characteristics:

Size of the samples

♣ Base dimensions of samples: 200 × 200 mm;

♣ Thickness up to 51 mm.

Temperature range - -20 ° C ... 75 ° C.

The accuracy of the temperature is ± 0.01 ° C.

The accuracy of the coefficient of absolute thermal conductivity is ± 2%.

The reproducibility is ± 0.5%.

The thermal conductivity coefficient range is 0.005 ... 0.35 W / (m·K). .

The heat flow meter LaserComp FOX 200 is accurate, easy to use and designed to measure thermal conductivity in accordance with LST EN 12667: 2002, ASTM C518 and ISO 8301. The device incorporates two thin film heat transducers, digital gauges for thickness measurements and control device for the temperature. LaserComp FOX 200 is a versatile device and is particularly suitable for measuring the thermal conductivity of porous materials. The principle of device measurements are based on solid-body cooling / heating. The thickness is measured with an accuracy of 0,025 mm.

Hens' feathers and sheep's wool fibers were subjected to test for thermal conductivity. The wool was sprayed with water, mixed with lime in various proportions (Figure 3).

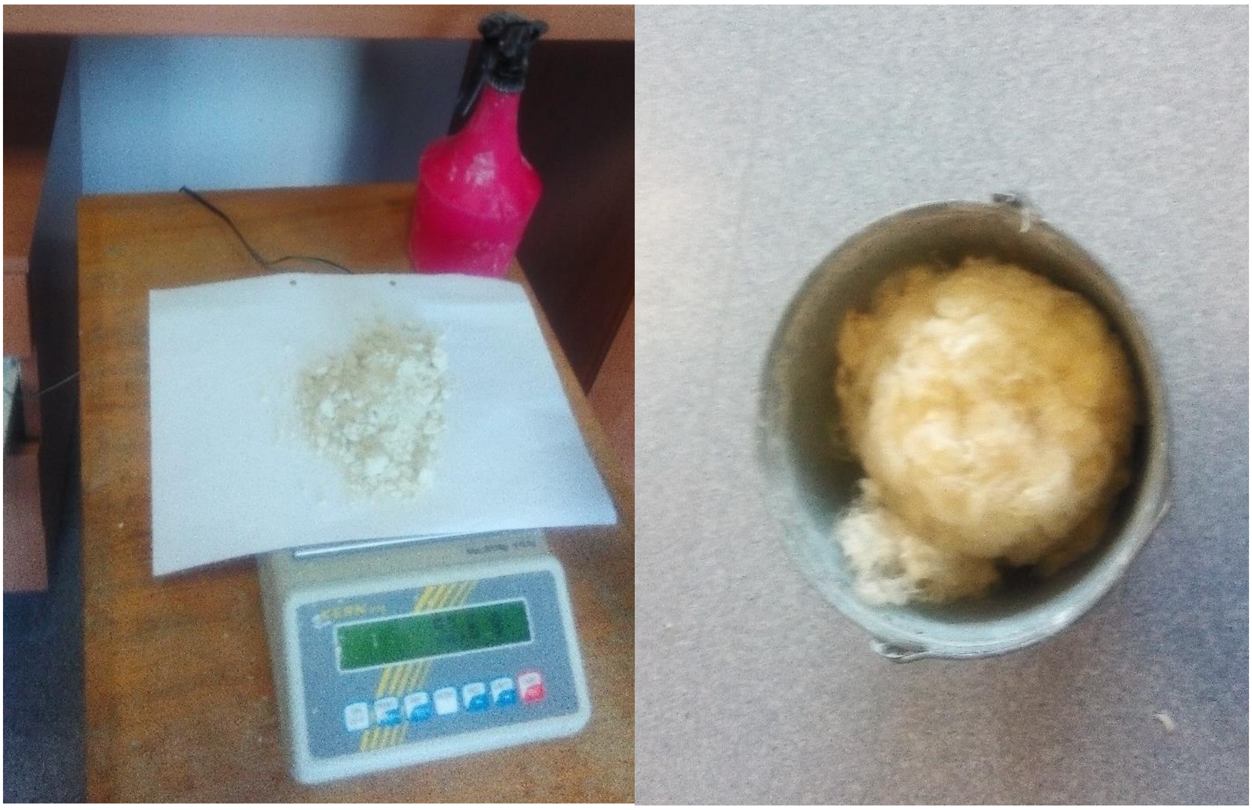


Figure 3. The wool was sprayed with water and the lime was weighed

Prepared specimens were dried in the oven (Figure 4).

Figure 4. Drying of the prepared samples

Test results

The thermal conductivity coefficient of the raw materials was determined using the heat flow meter LaserComp FOX 200 (Table 1).

Table 1. Density and thermal conductivity of loose feathers and sheep wool

Material	Density in kg/m^3	Thermal conductivity W/(m·K)
Feathers	89.85	0.0330
Wool	54.12	0.0361

The composition of composites made from hen feathers and hydraulic lime is presented in Table 2.

Table 2. Compositions of heat-insulating materials composite made of hen feathers and hydraulic lime

Notation of composition	Components	Volume in kg per m^3
P/K=1:1	Feathers P	69.5
Feathers **P**/ Lime **K**	Lime K	69.5
	Water	139.0
	Sum (density of forming mass)	278.0
Notation of composition	Components	Volume in kg per m^3
P/K=1:0.75	Feathers P	70.5
	Lime K	52.9
	Water	123.3
	Sum (density of forming mass)	246.7
Notation of composition	Components	Volume in kg per m^3
P/K=1:0.5	Feathers P	69.6
	Lime K	34.8
	Water	104.4
	Sum (density of forming mass)	208.9
Notation of composition	Components	Volume in kg per m^3
P/K=1:0.25	Feathers P	76.4
	Lime K	19.1
	Water	95.5
	Sum (density of forming mass)	191.0

The composition of sheep wool and hydraulic lime composites is shown in Table 3.

Table 3. Compositions of heat-insulating materials composite made of sheep's wool and hydraulic lime

Notation of composition	Components	Volume in kg per m^3
V/K=1:1	Wool V	56.1
Wool **V**/ Lime **K**	Lime K	56.1
	Water	112.2
	Sum (density of forming mass)	224.4
Notation of composition	Components	Volume in kg per m^3
V/K=1:0.75	Wool V	64.3
	Lime K	48.2
	Water	112.6
	Sum (density of forming mass)	225.1
Notation of composition	Components	Volume in kg per m^3
V/K=1:0.5	Wool V	58.8
	Lime K	29.4
	Water	88.2
	Sum (density of forming mass)	176.4
Notation of composition	Components	Volume in kg per m^3
V/K=1:0.25	Wool V	58.1
	Lime K	14.5
	Water	72.6
	Sum (density of forming mass)	145.2

The density and thermal conductivity test results for composites made of hens' feathers and hydraulic lime (Figure 5) and sheep's wool and hydraulic lime (Figure 6) according to LST EN 12667: 2002 are given in Tables 4 and 5.

Figure 5. Composites made of hens' feathers and hydraulic lime

Table 4. Natural density (volumetric mass) and coefficient of thermal conductivity of air dry heat-insulating materials composite made of feathers and hydraulic lime

Notation of composition	Natural density (volumetric mass) kg/m^3	Coefficient of thermal conductivity W/(m·K)
P/K=1:1	134.0	0.0431
P/K=1:0.75	124.7	0.0431
P/K=1:0.5	100.8	0.0385
P/K=1:0.25	93.5	0.0382

Figure 6. Composites of sheep 's wool and hydraulic lime

Table 5. Natural density (volumetric mass) and coefficient of thermal conductivity of air dry heat-insulating materials composite made of sheep's wool and hydraulic lime

Notation of composition	Natural density (volumetric mass) kg/m^3	Coefficient of thermal conductivity W/(m·K)
V/K=1:1	112.0	0.0408
V/K=1:0.75	108.7	0.0390
V/K=1:0.5	83.0	0.0379
V/K=1:0.25	72.0	0.0364

The dependencies between the composition and coefficients of thermal conductivity for composites made of hens' feathers with hydraulic lime and sheep wool with hydraulic lime are shown in Fig. 7.

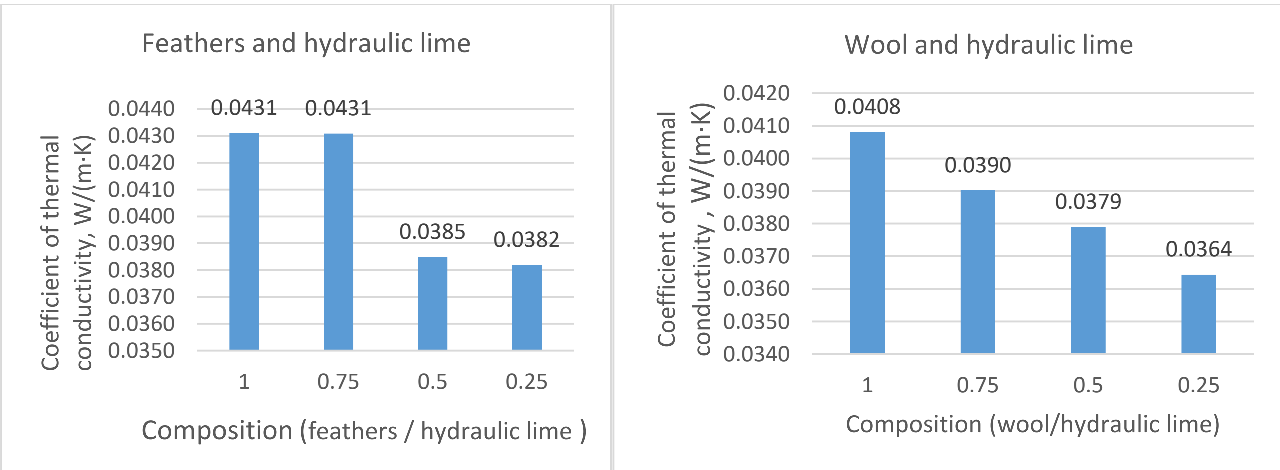


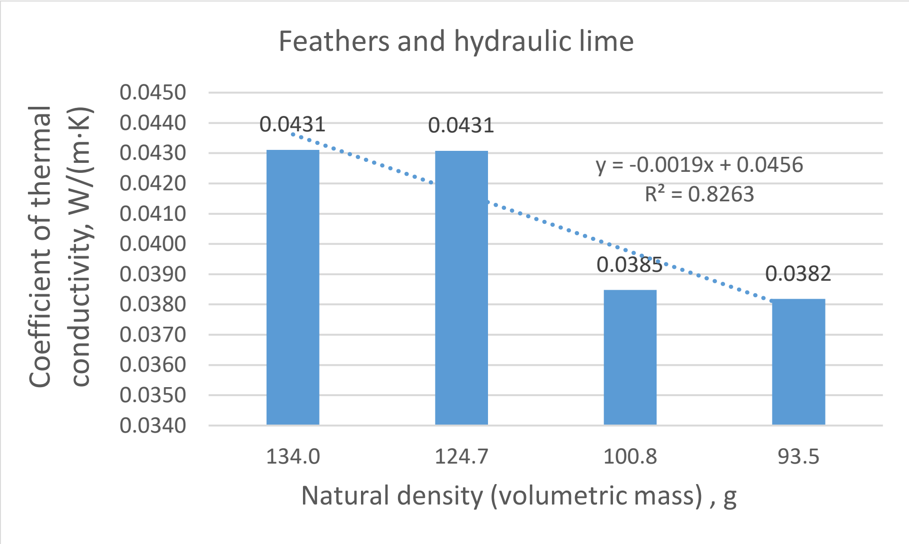
Figure 7. The dependencies between the composition and coefficients of thermal conductivity for composites made of hens' feathers with hydraulic lime and sheep wool with hydraulic lime

According to the results presented in Fig. 7. higher content of hydraulic lime has a greater influence on the coefficients of thermal conductivity for composite made from hens' feathers and hydraulic lime. The coefficient of thermal conductivity increased significantly from 0.0385 W / (m · K) to 0.0431 W / (m · K), then the composition was changed from P / K = 1: 0.5 to P / K = 1: 0.75 and P / K = 1: 1). The coefficient of thermal conductivity increases from 0.0364 W / (m · K) to 0.0408 W / (m · K) as the composition changes from V / K = 1: 0.25 to V / K = 1: 1. The lowest coefficient of thermal conductivity is then composite was made from sheep wool and hydraulic lime ratio of 1: 0.25.

The dependencies of density and coefficients of thermal conductivity for composites made from hens' feathers with hydraulic lime and sheep wool with hydraulic lime are shown in Fig. 8.

According to the results presented in Figure 8. higher densities were found for composites made from hen feathers and hydraulic lime (natural density 134.0 g at P / K = 1: 1 and 124.7 g at P / K = 1: 0.75). The coefficient of thermal conductivity of composites made from hen feathers and hydraulic lime were higher than those composites made from of sheep wool and hydraulic lime.

The coefficient of thermal conductivity increases from 0.0364 W / (m · K) to 0.0408 W / (m · K) for sheep wool and hydraulic lime as the density increases from 72.0 g at V / K = 1: 0.25 to 112.0 g at V / K = 1: 1). The dependence is reliable - $R^2 = 0.9924$, which indicates that the coefficient of thermal conductivity is directly dependent on the density.



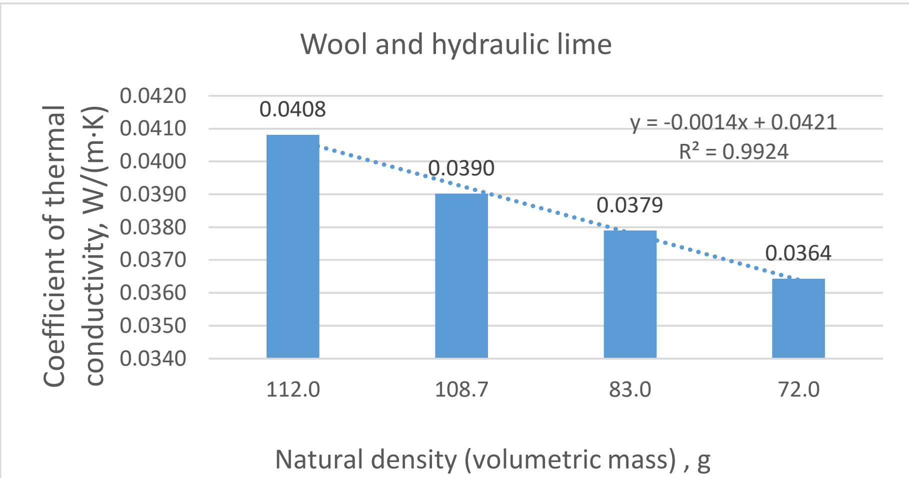


Figure 8. The dependencies of density and coefficients of thermal conductivity for composites made from hens' feathers with hydraulic lime and sheep wool with hydraulic lime

Conclusions and recommendations

The coefficient of thermal conductivity of composites made from hen feathers and hydraulic lime or composites made from sheep wool and hydraulic lime is directly dependent on the density, i.e. with increasing density (lime content) the coefficient of thermal conductivity increases.

Higher densities are found in composites made from hen feathers and hydraulic lime at a composition of 1: 0.25 - a difference between different composite densities is 23.02%.

The results of the thermal conductivity study show that composites made from hen feathers and hydraulic lime have the highest conductivity - the coefficients of thermal conductivity at the composition Feathers **P**/ Lime **K** = 1: 0.75 or Feathers **P**/ Lime **K** = 1: 1 are 0.0431 W/(m·K).

The composites made from sheep wool and hydraulic lime at the composition Wool **V**/ Lime **K** = 1: 0.25 have the lowest conductivity, the coefficients of thermal conductivity are 0.0364 W/(m·K).

The largest differences in the coefficients of thermal conductivity were found at the composite composition of 1: 0.75 - the difference between coefficients of thermal conductivity of the different composites was 9.42%.

Composites made from hen feathers with hydraulic lime or composites of sheep wool with hydraulic lime should be used in the construction of agricultural buildings where thermal insulation properties of the materials are required, e.g. installation of partitions. These composites are characterized by low cost, easy manufacturing, low density and so on. Also important and exceptional properties are that these materials are renewable and biodegradable. Hens' feathers and sheep's wool are environmentally friendly and usage them in the composites provide an alternative way to manage agricultural waste.

Literature

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R. Šadzevičius
V. Gurskis

Investigation of thermal conductivity of concrete composites with hen feathers and sheep wool

Vytautas Magnus University

The thermal conductivity of composites made from hen feathers with hydraulic lime and composites made from sheep wool with hydraulic lime was investigated in this study. The coefficient of thermal conductivity of composites is directly dependent on the density (lime content). Higher densities are found in composites made from hen feathers and hydraulic lime at a composition of 1: 0.25 - a difference between densities is 23.02%. The results of the thermal conductivity study show that composites made from hen feathers and hydraulic lime have the highest conductivity. The composites made from sheep wool and hydraulic lime at the composition Wool V/ Lime K = 1: 0.25 have the lowest conductivity, the coefficients of thermal conductivity are 0.0364 W/(m·K). Composites made from hen feathers with hydraulic lime or composites of sheep wool with hydraulic lime should be used in the construction of agricultural buildings where thermal insulation properties of the materials are required.

Keywords: composites, thermal conductivity, hen feathers, sheep wool.

Raimondas Šadzevičius Cheslovivych — assoc. prof., Vytautas Magnus university, e-mail: raimondas.sadzevicius@vdu.lt;

Vincas Gurskis — assoc. prof., Vytautas Magnus university, e-mail: vincas.gurskis@vdu.lt;