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PARAMETERS OF MICROCLIMATE MONITORING RESULTS ON SHEEPFOLD MADE WITH STRAW FILLER

Keywords: *microclimate parameters, renewable local resources, sheepfold, straw filler*

Abstract

Animals are adversely affected by high relative humidity and low temperatures. The optimum temperature range depends on the species, age and weight of the animals. The aim is to analyze parameters of microclimate (humidity and temperature regime) in sheepfold environment and sheepfold walls made from wooden panels with straw filler and to promote science innovations, the use of effective and renewable local resources (straw) in buildings construction. Humidity, temperature regime parameters of the sheepfold microclimate were monitored by sensors and stored in the data loggers. The article presents analysis of parameters microclimate in sheepfold made from wooden panels with straw filler monitoring results (monitoring period 21/02/2015 – 20/04/2015) of the measurement of the external (outdoor), internal (indoor), inside walls (at the depth 10 and 30 cm) temperatures and relative air humidity. The monitoring results in the sheepfold have shown that the relative humidity of the air is too high. It has been observed that the straw filler performs thermal insulation function – after the outside temperature drops to –6° C, the indoor temperature and temperature inside walls in all the measuring points in the sheepfold did not fall below 0°C.

Introduction

Building materials (bricks, concrete, reinforced concrete and other materials) used for construction of agricultural buildings require a lot of energy. Prices of energy grew up several times in recent years, so the prices of construction materials significantly (almost 10 times) increased [1]. It is suggested to use more local building materials (straw, wood, sawdust, clay, etc.) produced with low energy consumption, which would reduce the economic costs of buildings and at the same time increase the competitiveness of the agricultural sector [2]. New and rehabilitated agricultural buildings could be used for several decades. This would be not only the economic benefit, but it also would help create a more modern and attractive image of the agriculture.

The usage of local, renewable raw building materials (straw, hemp fibers, etc.) rather than imported materials can reduce CO_2 emissions, ambient air pollution; improve the competitiveness of local producers, recruit residents for production of these materials and building construction [3].

Agricultural buildings are not often studied in terms of comfort and energy efficiency as their purpose is only to shelter animals or goods. But some of the activities which take place in those buildings (e.g. cheese making, mushroom growing, poultry or animal breeding, etc.) need steady hygro–thermal levels and often require the usage of active or passive heating/cooling systems when the external conditions are not appropriate. The implementation of nearly–zero energy buildings in such cases, combined with the usage of local renewable materials will highly improve the conditions for such activities and enhance the efficiency of the buildings while decreasing the cost for the farmers.

As a constructional renewable material, straw has recently been thoroughly researched [4]; [5]; [6]; [7]. In Austria, Denmark, the USA, Germany and other countries, standard methods were used to determine the main characteristics of straw: heat conductivity, fire and humidity resistance, durability, strength of compressed straw, etc. [8].

Indoor microclimate is a climate of limited space, its physical, chemical and biological parameters. Microclimate consists of many factors (temperature, humidity, air velocity, noise, lighting, CO_2, CO, NH_3, H_2S and other amounts of gas, dust and micro–organisms) that depend on the climate of the area, the properties of building materials, and the ventilation system, manure removal method, sewage condition, lighting devices, heating, stocking density, storage technologies [9]. Indoor microclimate depends on animal health and productivity, age of production premises, working conditions of employees, quality and duration of operation of equipment [10]. Without a proper indoor microclimate, the yield of cows is reduced by 15–20%. For young animals, the optimum temperature range is narrower than that of adult animals – 12–22 degrees for lambs, 18–20 for ewes, 0–15 degrees for adult sheep [11].

The aim is to analyze parameters of microclimate (humidity and temperature regime) in sheepfold environment and sheepfold walls made from wooden panels with straw filler and to promote science innovations, the use of effective and renewable local resources (straw) in buildings construction.

Work Methodology

The company *Ecococon, Ltd* is successfully showing that houses can be built from straw panels. The panels are made from straw tightly packed into wooden frames, which are produced in standard sizes of 300cm by 120cm, with a thickness of 40cm but which in principle can be sized to fit any requirement. Ecococon straw panel houses are built on wooden bases mounted on a waterproof layer. These panels consist to 99% from rapidly renewable materials. Very little energy is necessary for production and no water is used for production, except for growing wheat or rye for food. Straw paneling technology is unique, unmatched in the world. The Straw panels have been presented to Cradle to Cradle Product Innovation Challenge, where Ecococon has been between finalists and took the 4th place in the worldwide competition [12].

The technology requires using renewable materials with specific characteristics, for example only up to 15% humidity straws are used in the production of straw panels. The compression degree of 100–120 kg/m^3 is maintained while pressing the straw panels, preserving multidirectional straw structure, resulting in better thermal resistance of the straw panel. The surplus of straw is cut off very accurately using special mechanisms. This is done very smoothly that it is used about twice less plaster for this type of panels compared with other paneling or thatched surfaces. Ecococon panels are plastered with special natural Ecococon clay plasters. The straw panels have undergone various tests, have assessments and certifications. The certification document is available on [13].

The investigated sheepfold (Figure 1) is designed to meet the requirements of barn air humidity, lighting, ventilation, etc. microclimate indicators. Sheepfold has 35 square meters of floor area. Foundation made from reinforced concrete piles with grillage. Outside walls from straw panels. From outside breathable membrane for wind protection and Steico wood fiber board of 6 cm for protection of straws and extra insulation used. Outside facade plastered with mineral plaster. Inside sprayed 3 layers brown clay plaster for microclimate and thermo mass. Part of wall from the foundation to the window sill – covered with plywood plates. Sheepfold mounted with four windows and two doors. The windows are high up the wall, with a tilting opening section, and occupy the equivalent of 15% of the shed floor area (according to requirements of animal welfare). Sheepfold equipped with at 8 pens (enclosures ewes), each area not less than 2.2 m^2 (according to requirements of animal welfare). Sheepfold equipped with a ventilation system: naturally ventilated (roof vent pipe with adjustable air extraction, the door – equipped with adjustable air vents for air supply). Ceiling made from wooden construction. Insulating material could be straw, recycled paper or similar cheap insulating material. Everything sealed with breathable membrane. On outside of the roof covered with wood chips.

Fig. 1. Sheepfold made from wooden panel with straw filler and detectors, transmitters, controllers for temperature regime monitoring

Source: own research

Results and discussion

During the construction of the sheepfold, the humidity of the straw of the sheep's walls was measured by humidity meter. As the device only shows humidity values of more than 10%, the straw humidity was not recorded at more than 10% during the construction of the sheep, with the exception of the area of the walls near the outside door, with 12% recorded during one observation. During the period of keeping the sheep (during monitoring), the straw moisture was not recorded above 10%. On completion of the period from 19/05/2015 13% humidity was recorded in the straw filling. Monitoring of sheepfold temperature regime started on 21 February 2015, closed on April 20, 2015 During the monitoring, 8 sheep were kept in the sheep. Fig. 2 shows the total results of this period for monitoring the temperature regime.

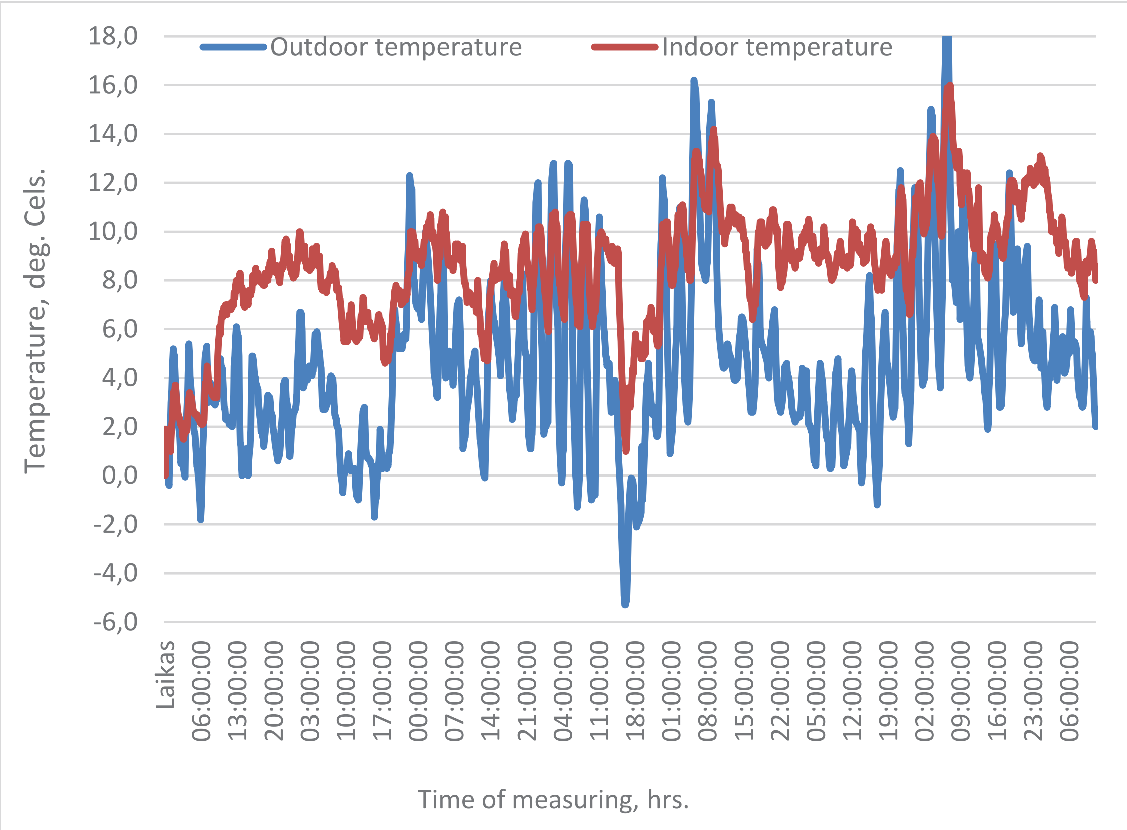

Fig. 2. Results of the measurement (21/02/2015–20/04/2015) of outdoor and indoor temperatures in the sheepfold

Source: own research

The lowest outdoor temperature was observed at 22/03/2015. During night time was recorded –5.3 ^{o}C. At the same time indoor temperature in the sheepfold lovered 1.4 °C. The highest outdoor temperature (18.1 °C) was observed at 10/04/2015. At the same time indoor temperature in the sheepfold was 16.1 °C.

Monitoring of sheepfold temperature regime, shows, that inside sheepfold walls made from wooden panels with straw filler at measuring point 10 cm depth from indoor side temperature curve (marked in red color) fits to measures of sheepfold indoor temperature (marked in green color) (Fig.3).

Analysis of results presented in Fig.4 shows, that that inside sheepfold walls made from wooden panels with straw filler at measuring point 30 cm depth from indoor side temperature curve (marked in red color) more close to measures of sheepfold outdoor temperature (marked in blue color).

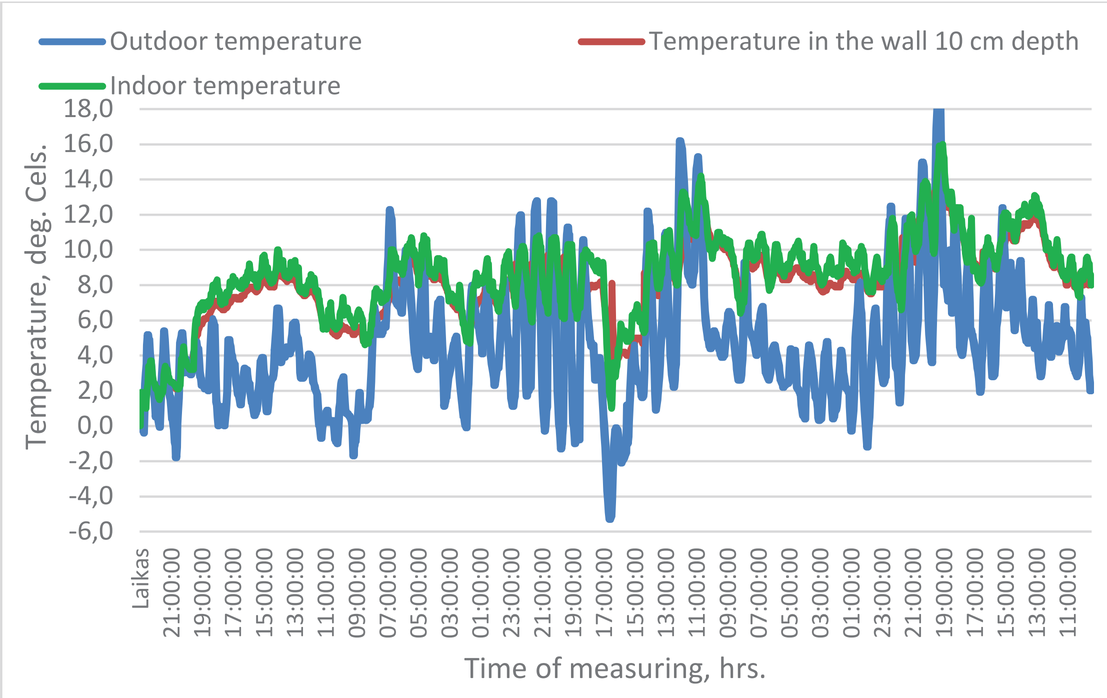

Fig. 3. Results of the measurement (21/02/2015–20/04/2015) of outdoor, indoor and in the wall at 10cm depth temperatures in the sheepfold

Source: own research

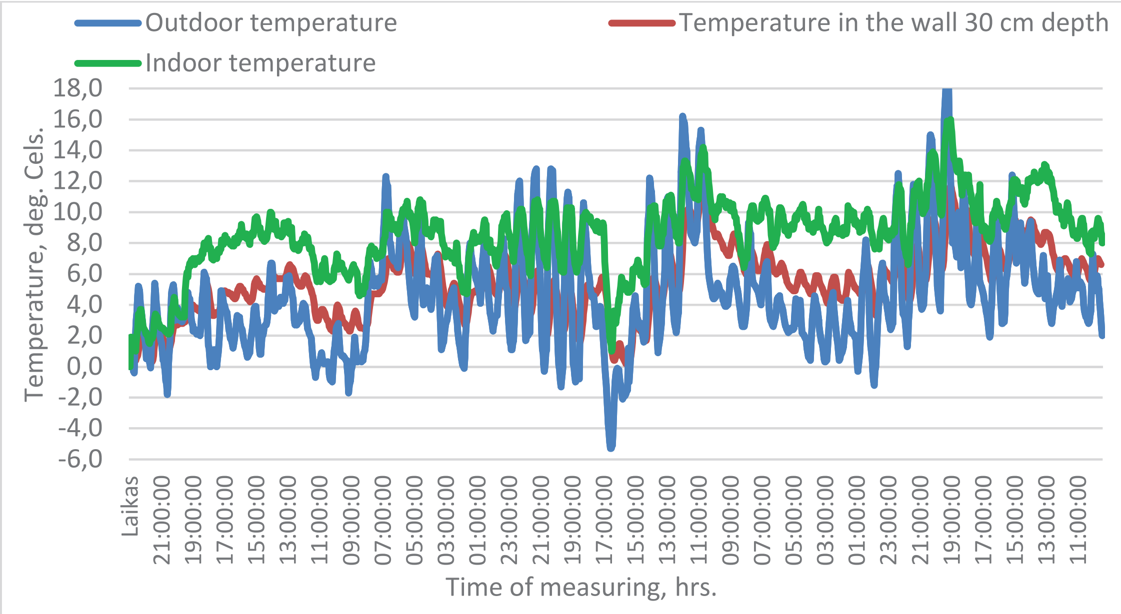

Fig. 4. Results of the measurement (21/02/2015–20/04/2015) of outdoor, indoor and in the wall at 30cm depth temperatures in the sheepfold

Source: own research

Analyzing the results of the measurement performed in 21/02/2015–20/04/2015 of the external (outdoor) and internal temperatures and relative air humidity of the sheepfold were found to be too high for relative air humidity at temperatures between 5 and 20 ^{o}C, and the maximum values for relative air humidity should be between 88 and 65%. One week (21 March 2015 – 21/03/2015) during the sheepfold monitoring of temperature regime, the lowest external (outdoor) temperature was measured (–6°C), but at all measuring points in the sheepfold the indoor temperature and in the wall straw filler did not decreased below 0° C.

Analyzing monitoring of the greenhouse and the traditional greenhouse temperature regime in spring 2006 [14], it was found that the internal temperature of a traditional building is rising at an external temperature, but the temperature inside the straw greenhouse is not significantly elevated by sudden changes in outside temperature. This is also confirms the results of our studies, which show that the internal temperature of the sheepfold has changed less compared to the sudden fluctuations of outside temperatures.

Conclusions

1. During the period of keeping the sheep the straw humidity in walls of sheepfold was not recorded above 10%, but after completion of the barn period – 13% humidity was recorded in the straw filling.
2. Analyzing the results of monitoring the sheepfold microclimate parameters: the outdoor and indoor temperatures and relative air humidity measurements, it was found that the relative humidity of the air is too high at indoor temperature from 5 to 20 ^{o}C - the maximum values of relative air humidity should be from 88 to 65 %.
3. During the research it was observed that the straw filler performs its assigned thermal insulation function – after the outdoor temperature of the sheepfold has fallen to – 6° C, the indoor temperature of the unheated sheepfold and in the walls with straw filler has not fallen below 0 ° C. Also, the indoor temperature of the sheepfold changed less compared to the outdoor temperature fluctuations.

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