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MEASUREMENTS OF PHYSICAL PARAMETERS OF ENVELOPE STRUCTURES IN REAL CONDITIONS IN SITU

Наведено результати експериментального вимірювання фізичних параметрів у виробничих приміщеннях влітку та взимку. Багато вимірювань проводилось у численних приміщеннях. У роботі викладено характеристики та цілі дослідницького проекту "Центр підтримки досліджень високої якості для інтегрованих досліджень прогресивних будівельних конструкцій, матеріалів і технологій". Особливим завданням № 2 цього проекту є "Підтримка досліджень конструкцій систем "інтелектуальних – розумних будівель", зосереджуючись на якості життя стосовно енергетичної ефективності і прийнятності по відношенню до довкілля".

Ключові слова: обгорткові структури, тепловий мікроклімат і зволожування, оптичні параметри, коефіцієнт денного освітлення, поверхневі температури, експериментальні вимірювання, фізичні умови, проблеми, викликані сирістю.

The article shows the experimental measurements of physical parameter results in production halls in winter and summer periods. Many measurements were conducted in numerous halls on site until recently. The article expresses the characteristics and goals of the research project „Research support centre of excellence for integrated research of progressive building structures, materials and technologies". Specific goal No. 2 of this project is to "Support the research of structures of intelligent - smart buildings by focusing on the quality of life by orienting towards energy efficiency and environmental acceptability.

Key words: envelope structures, thermal and humidity microclimate, optical parameters, daylight lighting coefficient, surface temperatures, experimental measurements, physical conditions, moisture problems.

Introduction. The thermo graphic (thermo-visual) diagnosis of envelope structures reveals temperature anomalies caused by the thermal properties of claddings. Defects have been detected, especially in buildings built in the 1960s. Thermo-grams show the unsatisfactory condition of the buildings due to excess heat loss in winter and heat gain in summer. Following the work of a previous author who specialized in monitoring physical parameters of building envelope structures, an in situ envelope monitoring device reflecting quasi-stationary states of internal dynamic changes in the external environment was established.

Previous Research An employee subjective feeling review of envelope designs and production techniques was conducted to evaluate the internal environment of industrial factory building directly by those who populate it, who live in it. People feel most satisfied with their environment during the transitional period, which is expected. Dissatisfaction is at its highest during summer and winter caused by overheating and insufficient heating respectively. For this purpose several tests measuring thermal parameters were carried out in the summer and winter periods.

Heat and moisture transport Moisture control is a very serious problem in buildings. In some cases it is challenging to solve the conditions of thermal moisture in the microclimate. With increasing relative humidity due to partial pressures the balancing and diffusing of water vapour occurs in damp claddings, especially if the barrier is porous and absorbs moisture from the surrounding air. Porous concrete and its impact of liquid moisture transfer have been studied in addition to water vapour diffusion. For non-linear mathematical models of heat and moisture transfer in porous materials, numerical algorithm solutions have been constructed. Algorithm t is designed to show the unsteady heat transfer and moisture not only in the direction through the mass envelope (wall thickness) but also as a consequence of time t.


A


B

Rožňava – old object – reconstructed

Rožňava – new object


C


D

Prešov – new object

Prešov – interior of hall object

Figure 1. Some objects where experimental measurements in situ were made

The results of calculations show that the proposed method gives satisfactory numerical solutions to address boundary conditions and their corresponding solutions.

Measurements of temperatures and humidity were made on site on a particular object and verification was performed according to proposed computational models. Measured results are comparable with the solution proposed by mathematical and physical models of heat transfer and moisture.

Overhead and Day lighting Systems Measurements of light microclimate conditions of the internal environment where only side lighting in the plane of exterior walls was considered has been carried out in many buildings. Based on measurements, it is clear that in a side lighting system, i.e. light only from the sides and not from above, there is a significant deficit in illuminance, in areas which are far from transparent panels. Based on the statistical evaluation of measurements, a mathematical model of the approximate nature of a preliminary determination for resulting values of the daylight factor of production facilities was derived, taking into account sky, reflecting both external and internal components of the daylight factor. These daylight factors are so small that it is necessary to activate an artificial lighting system, i.e. combination of natural and artificial light daily.

The situation is different if the premise utilizes a natural overhead lighting system. In assessing the internal lighting, normative calculation procedures are used, which in principle, uses extremely simplified external conditions - (standard heavy sky, its brightness and gradation, etc.). Innovative computer technology now allows us to address the broader problem of time in order to achieve accurate results in a relatively short period of time.

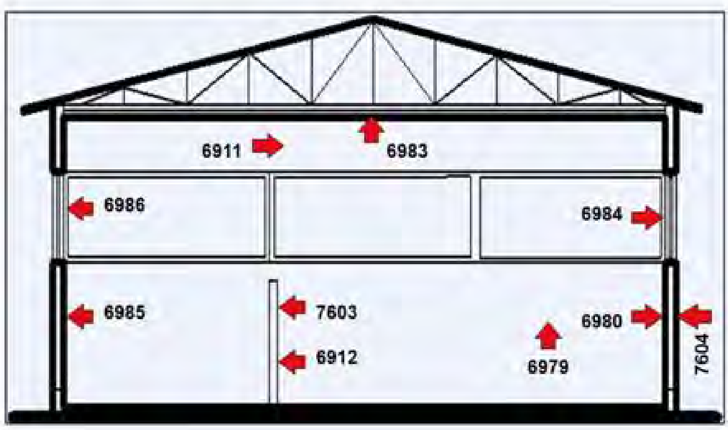

Figure 2. Cross Section – measurements points (internal, surface temperatures and humidity)

Even though it is nowadays common to use simulation programs in design practice, for efficiency in the process of architectural design and construction of buildings, especially for large hall-type buildings - industrial as well as multi-purpose sports, cultural, civic buildings, it is necessary to determine the prediction plane for boundary terms of physical components of the internal environment in order to determine what conditions the internal environment will compute of the real interior. (Lopušniak 2010)

In practice, real indoor test measurements were made daylight in order to compare the results obtained by computer simulation with those measured in site.

Test measurements for summer and winter periods On site measurements in summer and winter were made in several production facilities. Some of them are shown. Weekly measurements during the summer of two different halls, oriented towards the cardinal points revealed the following results while outside temperatures in summer varied between 13.2 to 30.4 °C

- The south-facing lobby's indoor air temperature varied from 24.1 to 35.5 ° C
- The north-facing lobby's indoor air temperature varied from 24.4 to 32.8 ° C

It follows that the minimum temperature during the week of measurement are comparable, but the maximum interior temperature varies only about 1 ½ ° C, which is negligible.

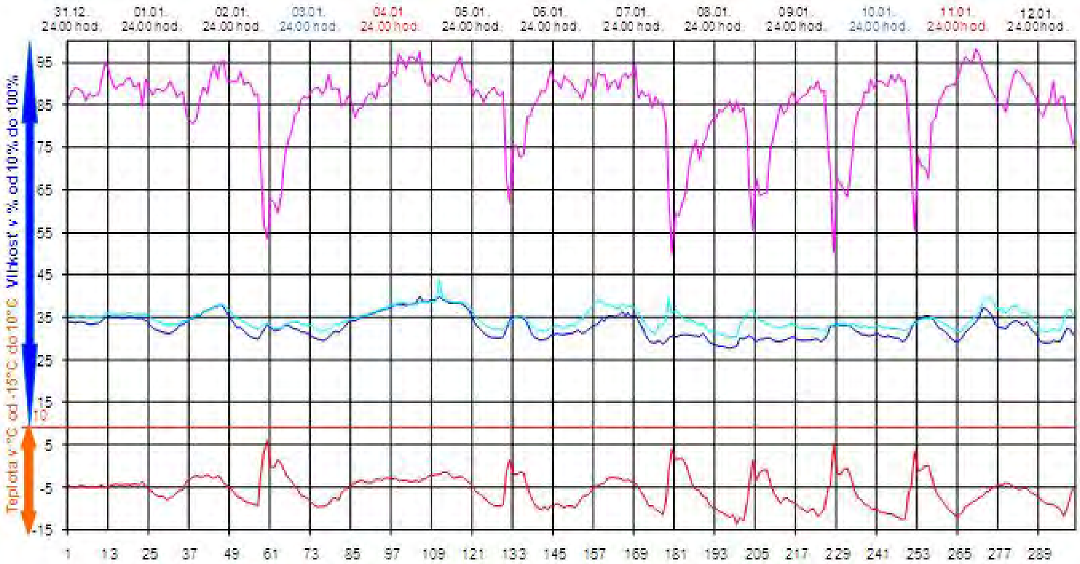

Figure 3. Relative humidity of internal air, internal air temperatures in three different highs and external temperatures as results of measurements from 31. of December to 12. of January

On this basis it can be concluded that the impact made by the orientation of the production hall is not as pronounced as in residential and public buildings due to the fact that a large air cushion is created in the interior of a lightweight construction design with a low accumulation of light within the partitions, which does not provide sufficient heat accumulation in the nucleus and as a result promote the inability to cool down (to reduce indoor air during the night) by ventilation. Measurements were only made at one point, but applied a wide range of differentiated labor networks, where work was an ongoing process. Temperature distributions in the internal network environment were determined.

In winter, the internal surface temperatures of envelope structures were measured. The greatest variance of the surface temperature occurred at the skylight. Other structures did not express such significant differences as the ridge skylight had. A minimum surface temperature of - 5.4 ° C was recorded and a maximum of 19.9 ° C +, which is more than a 20 ° C temperature gradient for the same day. Taking into account the large thermal expansion and subsequent volume changes of the structural elements, making it the most difficult design detail, it is necessary to see the incidence of these effects on the structural elements which can cause the occurrence of cracks, leaks and water below.

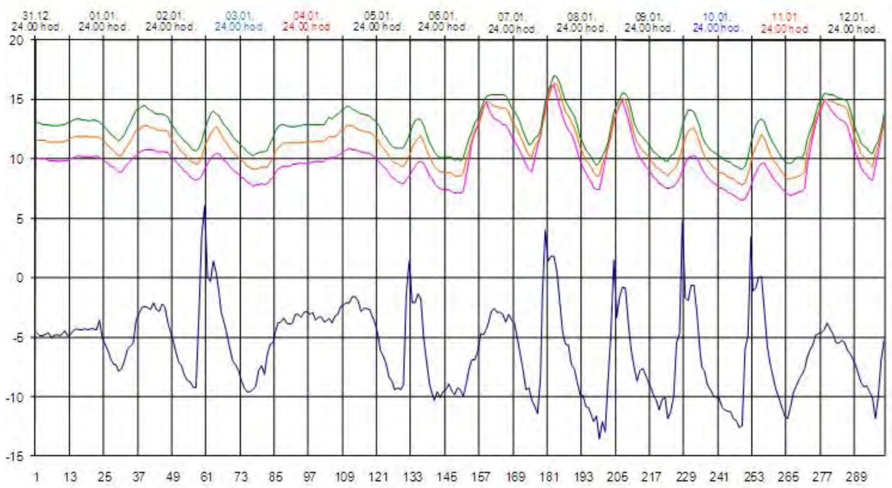

Figure 4 Results of measurements - comparison of internal and external temperatures measured from 31 of December to 12 of January 2010 in Hall objects in Rožňava (fig. 1A,B)

Annual on site measurements have been logged in recent years in several production facilities. This was done to not only monitor physical parameters of the claddings and the roof of the ground but also to create growth in this field of study. One factory building in the Prešov region has had its soil temperatures taken to a depth of up to 3.0 m during several probes under the production floor (Fig. 1, C,D). (Rudišin, 2009) , (Rudišin, Scherfel, 2010)

Quasi-Stationary State Assessment. The ongoing project ITMS has a specific objective to: "Promote excellent research designs for intelligent buildings with emphasis placed on the quality of life while ensuring energy efficiency and environmental acceptability". This depends on Creating a test facility for researching envelope designs of intelligent buildings. This enables researchers to accurately monitor the changes in physical characteristics of envelope structures, their elements and details in quasi-steady thermal-moisture state conditions for the interior climate, based on environmental factors on site. This experiment studies the properties of intelligent building structures and the effects of climate variables caused by external influences.

Test equipment and an experimental model of an intelligent building system using progressive technologies environment are to be prepared. This test device monitors the state of the internal environment, using advanced systems of heating/cooling, ventilation and air conditioning in buildings and implements the dynamics of stored energy in the building structure without adverse hygiene effects placed on the internal environment.

The aim is to improve the quality of integrated research of advanced building constructions in civil engineering by focusing on progressive design and building technology, with a goal of devising and evaluating design elements intended for creating advanced envelope designs.

Figure 5. Test boxes- monitoring chambers - view outside

The idea is to create a research facility for progressive design and intelligent building envelopes, designed for interiors. The second objective is capable of simulating the thermal humidity of processes occurring in rooms equipped with a progressive engineering environment (heating/cooling, ventilation and air conditioning in combination with renewable energy), by continuously monitoring the microclimate conditions and environmental loads placed on the internal environment.

Proposed monitoring chambers are intended for research and the evaluation of structural and physical requirements as well as other characteristics of building structures under realistic conditions caused by external climatic factors, while maintaining the so-called quasi-stationary state of the internal environment in an experimental model.

Lessons learned so far from long-term measurements of physical characteristics of building structures and in real conditions carried out by faculty staff in recent years has resulted in the processing of several research tasks, dissertations and other findings from experimental research in this scientific field (Figures 5,6).

Figure 6. Test equipment – view inside

The objective of the test equipment - monitoring chamber – is to monitor the physical characteristics of advanced envelope building constructions, their elements and details in quasi-steady thermal-moisture state conditions against changes in the external climate which are based on environmental factors.

Test boxes, where elements of structural components are tested, have their interiors separated into two parts. The first part simulates the heat and moisture microclimate and the second houses the instrumentation devices. Boxes for monitoring physical properties of vertical, horizontal, or location can have the angle of the embedded sample altered depending on experimental conditions and requirements. This allows the test boxes to be more flexible in their capabilities. Required physical data is tracked using an automatic logger that contains necessary sensors and computer technology. To monitor year-round progress and changes, the climate is determined by exchanging meteorological data.

Conclusion. The end result is a device designed for experimental research and testing on site measurements, which provides an idea of the physical quality of construction arrangements intended for the creation of intelligent buildings, or how to edit outputs and create these structures and their details. The device should also apply to the development and production of roofs, siding, flooring and transparent structures.

The ability to research new constructions with advanced actuators and computing control systems, which enable long-term control, by monitoring changes in their physical properties as a result of current effects of exposure:

- Changing external physical factors and climatic conditions
- A stationary indoor environment, based on the integration of results and lessons learned from testing the theoretical solution and experimental measurements on site.

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