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VERIFICATION OF CALCULATED SELECTED MICROCLIMATETIC AIR QUALITY AT TIMBER HOUSES IN REALITY

OVĚŘOVÁNÍ PŘEDPOKLÁDANÝCH VYBRANÝCH MIKROKLIMATICKÝCH VLASTNOSTÍ DŘEVOSTAVEB V PRAXI

Abstract

In the article are described research results of the elected microclimatic values (internal air temperature, internal air humidity) at representative timber houses. The research was done as base for dissertation work of authoress article.

Keywords

Microclimate of building, internal air temperature, internal air humidity.

Abstrakt

V článku jsou popisovány výsledky výzkumu zvolených mikroklimatických hodnot (vnitřní teplota, vlhkost vnitřního vzduchu) u vybraných dřevostaveb. Výzkum byl prováděn jako podklad disertační práce autorky článku.

Klíčová slova

Mikroklima budov, vnitřní teplota vzduchu, vlhkost vnitřního vzduchu.

1 INTRODUCTION

The standard [1] stipulates the requirements for the designed indoor temperature during the winter period Θ_i in (^{0}C), see [4] (see also [2], where the value $\Theta_{int,i}$ is called the calculated indoor temperature) and for the relative indoor air humidity ϕ_i (%). The objective of the research was to establish whether or not these standard values were met in practice in residential houses. The practical research was carried out in the period November 2008 - March 2009.

- Region of research:

Moravian and Silesian region.

- Selected houses.

The decisive criteria for selection of the houses were as follows:

Diversity of wooden structures - 6 houses in total were measured; they represent 3 technological system types – OSB panels, stud sandwich, log cabin design and trim stud system.

Location of the houses by altitude - for the purpose of the research, houses located 210, 260, 322 and 446 meters above sea level were chosen.

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Kind of development - the localities were chosen with respect to the layout of the house in question: 2 isolated houses, 2 houses inside a developed area, 2 houses on the outskirts of a developed area.

- Selection of the method of measuring the microclimatic data.

1) To establish and compare the basic microclimatic conditions, indoor air temperatures and relative indoor air humidity were measured in the houses in question. Measurements were performed using 2 measuring devices The first device measured the values continuously at selected 10-minute intervals and was installed in the highest-traffic room, in the majority of cases that being the combined living room and kitchen. The measured values were recorded for a time period of 24 hours as a minimum.
2) To achieve the maximum possible objectivity of the measurements of the indoor air temperature and relative indoor air humidity in the whole house, other rooms in individual measured timber houses were chosen - in our case the bedroom, nursery and bathroom.
3) The indoor air temperature and the relative indoor air humidity were measured in the latter rooms by the second device at preset time intervals: 6:00pm, before going to bed, in the morning immediately after getting up and at noon.

2 METHOD OF DATA COLLECTION

Collection of individual data was distributed so that the indoor air temperature θ_{ai} (°C) and the relative indoor air humidity φ_i (%) could be measured in the timber houses during the whole week in the heating period. Thanks to these all-week measurements we were able to obtain screening of traffic in individual houses both during working days and during weekends, when the traffic differs materially, depending on the lifestyle of the family. Measuring in the winter period, during the heating season, was chosen because this period affects power consumption for heating; during the summer period the rooms are not heated.

The values of the outdoor air temperature, relative humidity, wind direction and wind speed were taken from the data of the Czech Hydro-meteorological Institute, Lysá hora, Frenštát pod Radhoštěm, Mošnov and Ostrava – Poruba stations.

2.1 Devices used for measurements

1) Continuous measurements were performed using the Datalogger universal ALMEMO 2690 – 8 with 1 combined sensor for measurements of indoor air temperature and humidity, the FHA 646 – E1 probe .The temperature range is -20 to + 80 (°C), resolution 0.1 (°C), humidity range is 5 to 98 (%), resolution 0.1 (%), accuracy of measurements: temperature ± 0.2 (°C) ± 2 digits, humidity <± 2 (%) ± 1 digit.

Fig. 1: DatalogGer ALMENO 2690-8

2) A contactless multifunctional device measuring temperature, humidity and pressure in parallel (thermo-hygro-barometer), C4130 type. Operating temperature range -10 (°C) to + 60 (°C), accuracy of temperature measurements ±0.25 (°C) within the range -50 to +100 (°C), ±0.5 (%) of the measured value from 100 to 250 (°C), accuracy of humidity measurements ±2.5% of the relative humidity within the range 5 to 95 (%) at 23 (°C), resolution 0.1 (%).

Fig. 2: Termo-hygro-barometr C4130

2.2 Conditions for measurements of selected microclimatic data

1) Select characteristic rooms for the houses in question. This requirement was met.
2) Measure the indoor air temperature θ_{ai} and the relative indoor air humidity φ_i (see diagrams - documentary section, see [5] pages 25 – 62) in the selected rooms so that max. 30 (m2) of the floor space of the room falls on one sensor [2,3,6]. Met.
3) Place the sensor in the living rooms in the centre of the floor area of the room at a height of 1.0 (m) above the wear floor layer [2,3,6]. The requirement was met. The air temperature sensors must be protected from radiation. Met.
4) The requested accuracy of determination of the indoor air temperature is 0.25 (K). Met.
5) The sensor for measuring the relative indoor air humidity φ_i is placed in the same way as the sensor for measuring the indoor air temperature. Met.
6) The requested accuracy of determination of the relative indoor air humidity is 5%. Met All sensors for measuring indoor environmental features must be shielded from direct sun radiation. Met.
7) The outdoor air temperature θ_{ae} is measured by a sensor placed in a meteorological box and/or - in an area of free air flow - at a height of ca 2 (m) above the ground, and the sensor must be shielded from direct sun radiation. The requested accuracy of determination of the outdoor air temperature is 0.25 (K). Met.

8) Relative outdoor air humidity φ_e is recorded. A sensor is placed either in a meteorological box or in the area for measuring the outdoor air temperature. The requested accuracy of determination of the relative outdoor air humidity is 5%. Met (HMÚ/Hydro meteorological Institute).

3 INPUT UNDERLYING DOCUMENTS FOR MEASUREMENTS OF SELECTED MICROCLIMATIC DATA OF THE TIMBER HOUSES I-VI

1) Analysis of the project documentation.
2) Thermal and technical survey of the house.

Analysis of the project documentation and thermal survey of the house in question with the objective to define the reference section of the house and to obtain own underlying documents for determination of the measurement conditions - i.e. characteristic area, selected rooms for sensor layout, installation of measuring devices and the measurements themselves.

The thermal and technical survey is understood as an inspection and check of the existence of possible anomalies of technical features of the house cladding, an inspection and comparison of the as-built state with the project documentation and the establishment of restricting conditions for realization of the measurements. If anomalies and defects are established, their possible impact on the measurements must be assessed and their removal or a method for their incorporation into the evaluation must be decided afterwards. The thermal and technical survey of the timber houses did not reveal any defects, the nature of which would not satisfy the set conditions for the measurements.

3.1 Procedure for measurements of selected microclimatic features of the timber houses I-VI

1) Installation of the measuring device.
2) Connection of the heating source. Double-tube low-temperature floor heating with forced circulation was used in all the houses.
3) Measuring.

The measuring itself is carried out under special and/or operating conditions. Intervals of measured and recorded values are regular and are governed by the requirement for determination of their average daily values. The measuring interval of the indoor air temperature and the resultant temperature is max 1 (hr). The procedure for measuring was performed in conformity with the section “Selection of the measuring method of the microclimatic data”; for more detailed data, see [5].

3.2 Assessment of measurements of the selected microclimatic data of the indoor air temperature θ_{ai} and relative indoor air humidity φ_i

Each timber house is represented by 2 types of graphic assessment, A and B. The first, “A” type always reflects the continuous measuring performed by the Datalogger universal ALMEMO 2690 – 8 device with 1 combined sensor for measurements of indoor air temperature and humidity, FHA 646 – E1 probe. The graphic assessment “B” is applied for measurements at predetermined time intervals by the contactless multifunctional device measuring temperature, humidity and pressure in parallel (thermo-hygro-barometer), C4130 type. The results of the measuring are processed as diagrams and well-arranged tables contained in the documentary section [5].

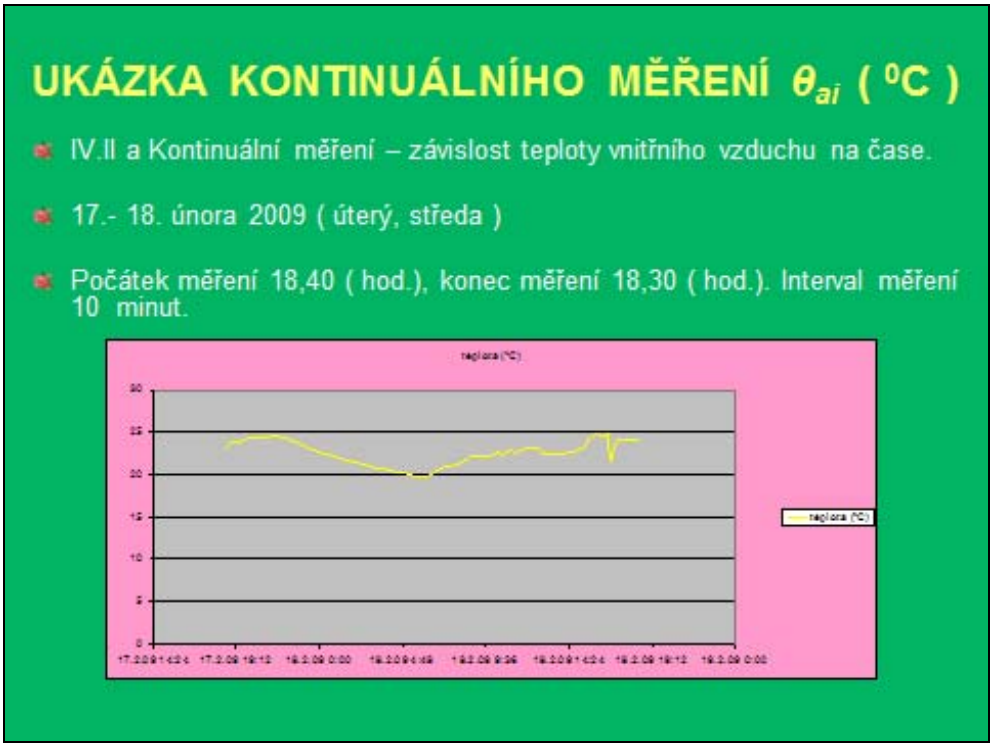

Fig. 3: Continuous measuring of indol air temperature θ_{ai}

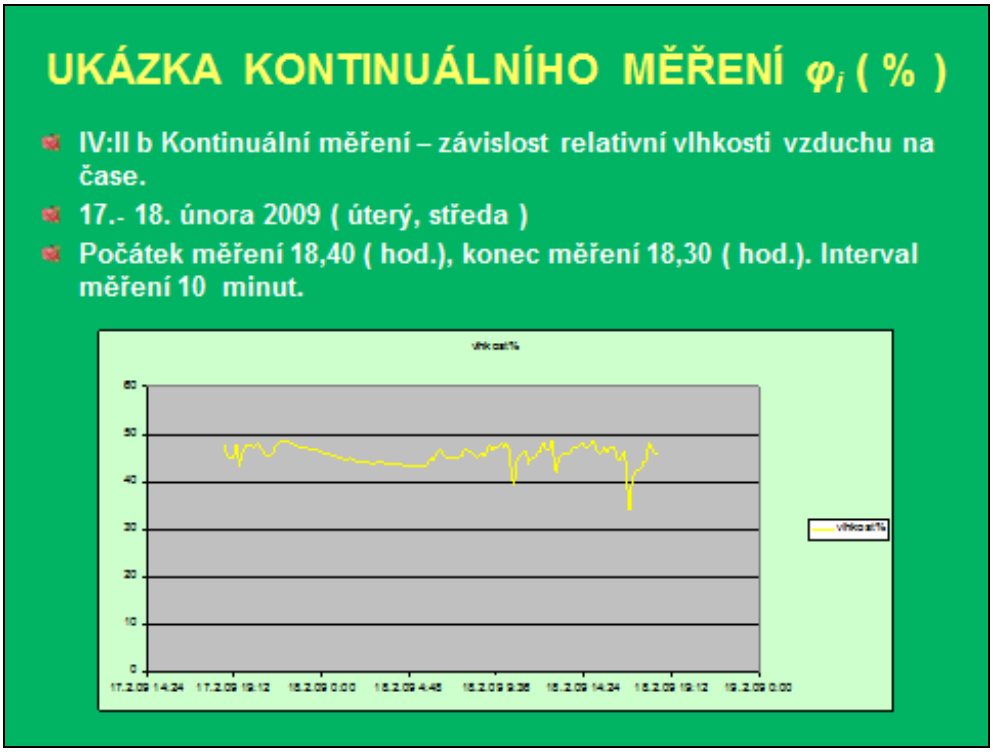

Fig. 4: Continuous measuring of relative indol air humidity φ_i

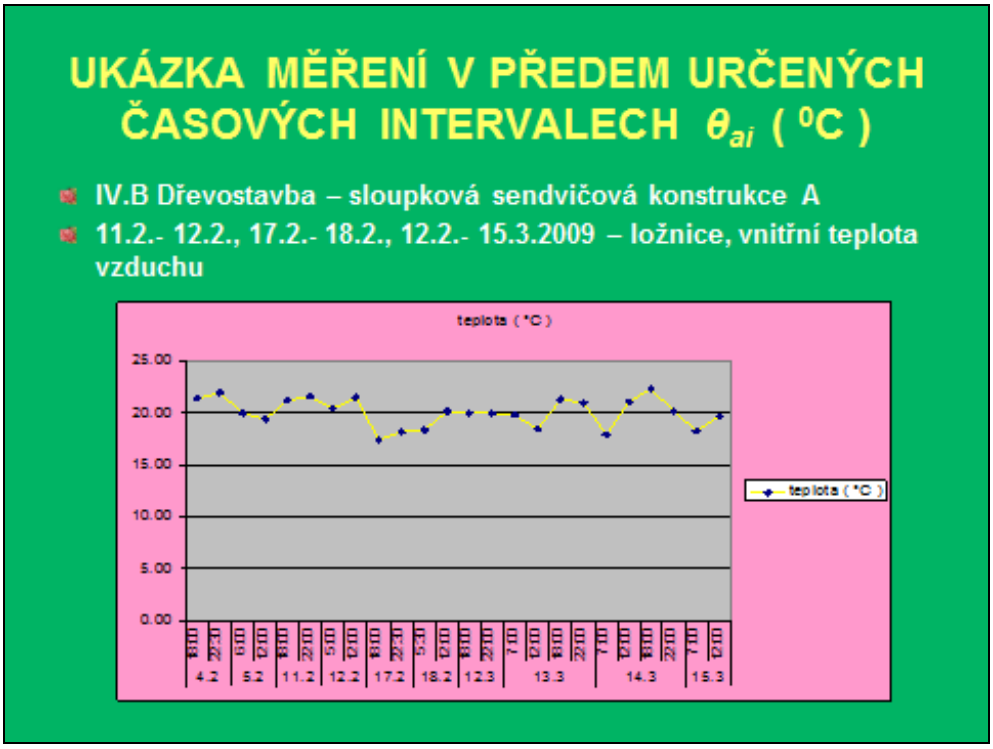

Fig. 5: Measurements of the indol air temperature θ_{ai} at predetermined time intervals

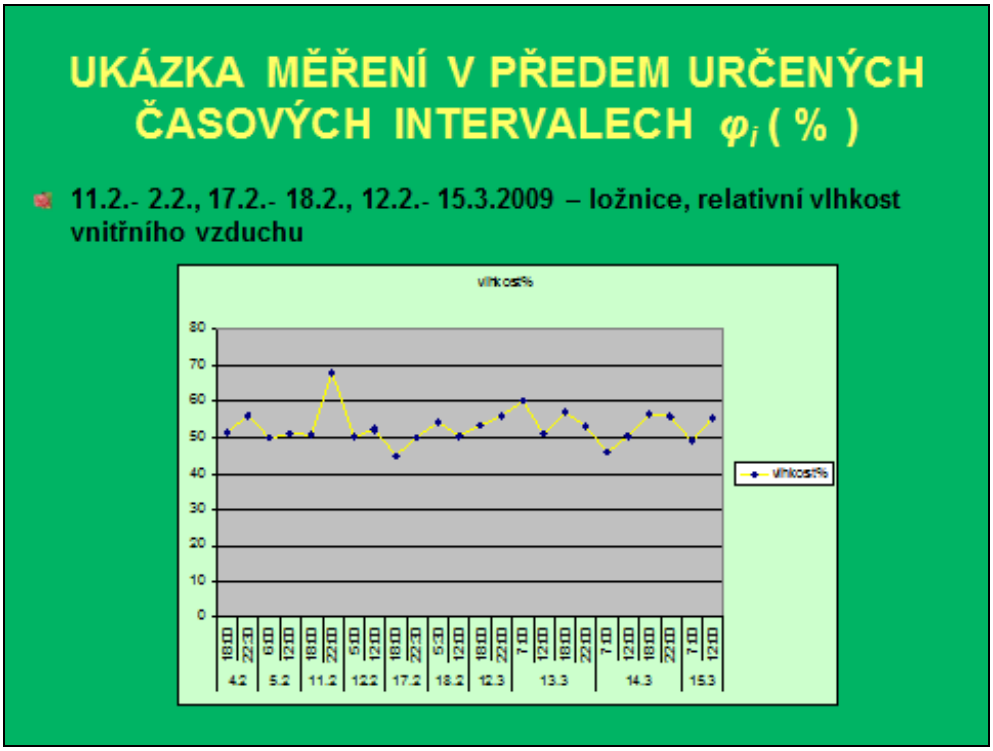

Fig. 6: Measurements of relative indol air humidity φ_i at predetermined time intervals

VYHODNOCENÍ KONTINUÁLNÍHO MĚŘENÍ

dřevostavba	kontinuální měření					
	teplota (°C)			vlhkost (%)		
	minimální	maximální	průměr	minimální	maximální	průměr
I	15,55	25,68	20,37	32,8	45,2	40,39
I	19,84	23,66	21,53	39	50	41,17
I	19,73	23,24	21,49	43	56,1	46,78
I	18,95	23,61	20,63	40,1	56,9	46,06
I	19,53	24,54	22,54	35,2	53,1	46,08
II	18,71	26,67	22,54	27	43,1	46,08
II	19,65	23,52	21,82	24,6	41,5	27,47
II	22,31	27,01	23,59	28,9	75,7	32,68
III	20,17	23,26	21,9	26,5	41,5	31,07
III	18,4	23,43	21,69	35	44,2	37,96
IV	19,3	24,4	22,95	34,5	54,6	47,98
IV	19,81	24,79	22,53	34,2	48,2	45,62
IV	19,09	24,84	22,85	36,6	55,9	51,02
V	21,71	23,4	22,49	42,2	46,3	44,44
V	19,86	23,13	21,19	24,6	36,7	27,94
V	18,65	24,58	21,46	35,5	65	52,32
VI	21,31	23,8	22,59	42,3	49,7	44,57
VI	19,74	25,56	23,11	35,2	53,1	35,1
VI	14,11	24,52	22,17	33,2	76,3	40,32

Fig. 7: Assessment of continuous measuring of indoor air temperature θ_{ai} and relative indoor air humidity φ_i

VYHODNOCENÍ MĚŘENÍ V PŘEDEM URČENÝCH ČASOVÝCH INTERVALECH

dřevostavba	teplota (°C)								
	ložnice			dětský pokoj			koupelna		
	min	max	průměr	min	max	průměr	min	max	průměr
I	17	21,5	19,97	16,3	21,3	20,34	16,8	22,8	20,94
II	19,8	24	21,97	18,1	25,7	22,1	18,1	23,6	21,96
III	19,7	24,2	22,55	18,1	23,9	20,85	20,5	23,7	21,83
IV	17,5	22,4	20,09	19,5	23,1	21,29	19,2	22,8	21,18
V	18,1	21,2	19,96	19,1	22,4	20,77	19,4	21,9	20,49
VI	21,2	24	21,78	21,6	23,7	22,7	21,5	23,8	22,35
	vlhkost (%)								
	ložnice			dětský pokoj			koupelna		
	min	max	průměr	min	max	průměr	min	max	průměr
I	24,5	42,5	38,56	35,7	44,6	40,22	35,7	44,6	40,22
II	22,6	34,8	27,59	20,7	34,6	25,94	20,7	44,5	26,47
III	22	33,3	28,49	24,2	40,4	33,94	29	50	37,15
IV	45	60	53,03	48	56,9	52,81	42	68,9	55,06
V	38,2	59,7	48,31	40,4	57,1	48,76	47,2	59,2	51,8
VI	34,1	44	38,7	32,5	41,4	35,35	31,4	48,8	36,34

Fig. 8: Assessment of measurements of the indoor air temperature θ_{ai} and the relative indoor air humidity φ_i at predetermined time intervals

4 CONCLUSION

It was established by measurements of the indoor air temperature that the requirements of [2] and [1] are exceeded moderately in the living room, bedroom and nursery of the monitored timber houses, except in 2 cases, see Fig. 8 “Assessment of measurements at predetermined time intervals”. The establishment that stable design indoor air temperatures were not reached in any of the six timber house bathrooms during the winter period is a more serious fact. From the summary tables it also clearly follows that the average indoor air temperature θ_{ai} (°C) increased moderately in all the measured rooms of all the monitored houses compared to the designed indoor temperature during the winter season θ_i (°C) defined in [1]. It is affected by the human factor described in [5]. The fact that the average monitored relative indoor air humidity failed to meet the requirements of [7], [8] and [9] is a surprising finding. Nevertheless, for the winter period nearly all the measured values conform to [10]. The worst measured values of the relative indoor air humidity were established in timber houses II and III, see the documentary section [5]. If such state is permanent, health problems for the inhabitants of timber houses II and III can be assumed in the future. Timber houses IV and V, which also met classification B, i.e. economical houses, conform best to the requirements of [1] for relative indoor air humidity φ_i (%). The performed measurements indicated a failure to meet the values defined in [8]. To maintain stability of the indoor environment it is necessary to responsibly design the structure of the cladding of the houses, suitable control equipment (thermostatic valves, heating system control), together with an optimum design for air exchange and maintaining the recommended values of indoor air temperature and relative indoor air humidity, as early as in the preparatory stage of designing a timber house.

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