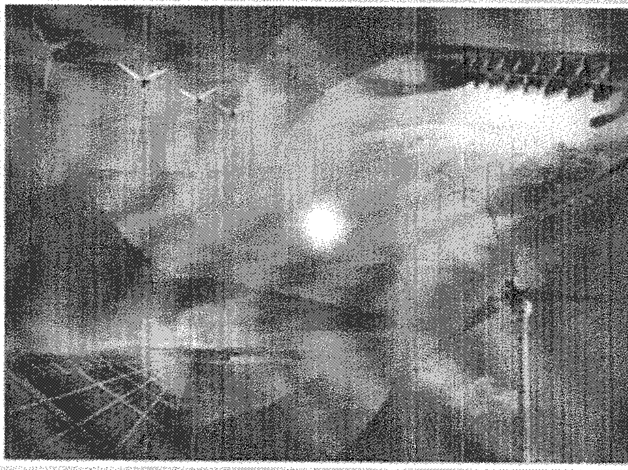

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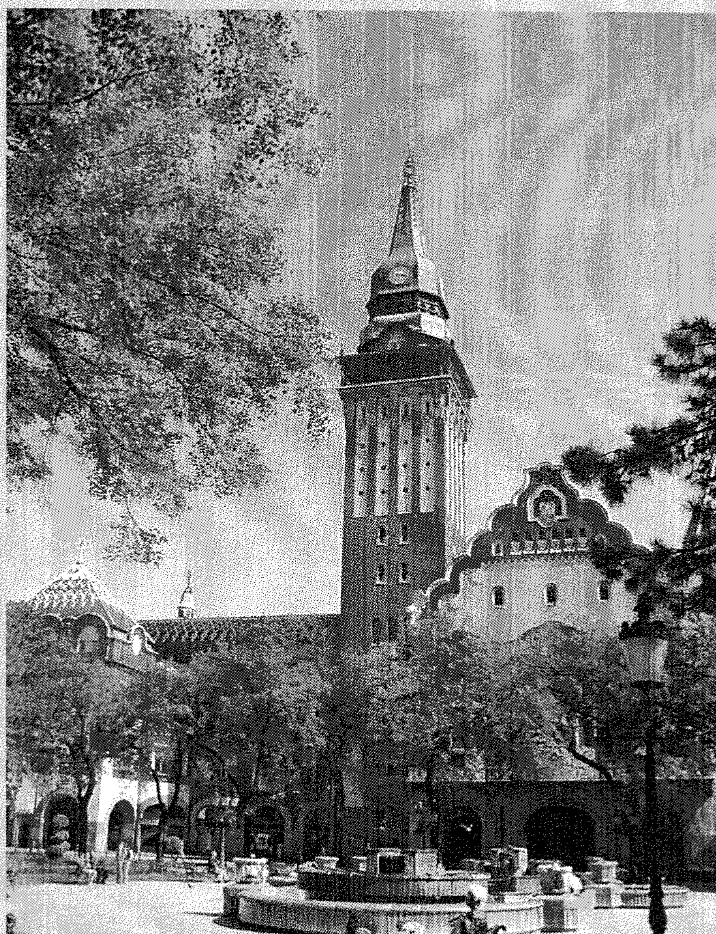

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OVERHEATING HOURS IN SUMMER PERIOD IN PASSOL LABORATORY

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Abstract - At the University of Debrecen, Department of Building Services and Building Engineering a PASSOL laboratory was developed. Over the years, different heat storage, mechanical ventilation for different air change rate experiment results were presented. During these investigations the window of the laboratory was oriented north, south, west and east. It was also resented the internal air and operative temperature in many publications.

Keywords: *Passol laboratory, Simulation, Air and Operative Temperature*

1. Introduction

At the University of Debrecen, Department of the Building Services and Building Engineering an PASSOL laboratory was developed in 2009.

The PASSOL Laboratory which is situated in Hajdu-Bihar county, Debrecen, Hungary. This special rotating laboratory is next to the downtown. Geographically Debrecen is located in 47 31.8' N. and 21 37.8' E.

In the last eleven years Csáky et. al in many article presented the different experiment results in the PASSOL laborartory. [1], [6], [7], [8], [9], [10]

In 2009, when the envelope was built up, first investigations focuses on internal and operative temperatures especially in summer period using different heat storage capacity, night ventilation and different window orientation.

Since then in many publications were discussed the thermal comfort, heat load calculation for different building types and methods, indoor temperature monitoring, effect of the replacement for the heat load, internal air and operative temperature. [2], [3], [4], [5], [11] Even in the year when the envelope was established, air tightness of the laboratory was measured with a Retrotec 3300 Blower Door equipment.

In this way we were able to analyze the air thickness of the room. Measurements demonstrated that there is relatively no air change rate between the test
laboratory and external environment, even at a ±200 PA pressure difference.

In 2009 in the laboratory we placed 81 temperature sensors, from these 27 are air temperature sensors and 54 are surface temperature sensors.

Year by year present rotating laboratory was developed. In 2013 a new mechanical ventilation system using the air duct, fan and one ventilation plenum box was developed. Different air terminal devices can be connected to the plenum box giving the ventilation possibility. Finally, it is also possible to analyse the effect of different air ventilation mode of the internal air temperature.

In 2015 in my PhD dissertation Energy Analysisis of Building's Summer Heat Loads I presented the different calculation methods and the calculation method validation using the PASSOL laboratory.

The article published in 2019 by Csáky, I., and M., Lakatos, Heat storage effect of the operative temperature in Passol laboratory presents the laboratory's operative temperature in summer period with different heat storage. [10]

2. Simulation of the overheating hours using the CASAnova software

The Passol laboratory simulation model data.

The internal Geometry size:

Length of north and south facade: 2,6 m

Length of west and east facade: 2,6 m

Height: 2,6 m

Ground area: 6,8 m^2

Volume total: 17,6 m^3

Building:

Limit of overheating: 26,0 °C

Internal gains: 0,0 kWh/(m^2 a)

Kind of outdoor walls: light, medium, heavy construction

Windows:

Window area: 2,3 m2

Fraction of windows area at the facade: 34,0 %

U value glazing: 1,40 W/(m^2 K)

U value frame: 1,50 W/(m^2 K)

g value glazing: 0,70

Fraction of frame: 20,0 %

Output Climate data of the model:

Table 1: Output external air temperature in the simulation software

Month	*Mean temperature in °C*	*Maximum temperature in °C*	*Minimum temperature in °C*
January	-0.6	13.4	-16.2
February	1.1	15.6	-8.7
March	6.1	19.3	-4.5
April	10.6	23.7	-2.7
May	15.6	30.8	0.7
June	18.9	32.6	6.6
July	20.6	31.9	9.9
August	20.6	34.3	7.6
September	16.7	25.3	7.2
October	10.6	27.2	-2.5
November	3.9	19.4	-9.1
December	1.1	11.4	-11.5

Table 2: Overheating hours in the simulation building without window

	light construction				*medium construction*				*heavy construction*			
n [h^{-1}]	0	1	2	3	0	1	2	3	0	1	2	3
	without window											
January	0	0	0	0	0	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0	0	0	0	0	0
April	0	0	0	0	0	0	0	0	0	0	0	0
May	0.1	0.3	0.4	0.4	0	0	0	0	0	0	0	0
June	1.9	2.5	2.8	3	0.5	0.9	1.4	1.8	0	0.1	0.6	0.9
July	1	1.5	2.1	2.6	0	0.1	0.3	0.7	0	0	0	0.1
August	5.1	5.3	5.3	5.2	5.4	5.3	5.1	5.3	4.9	5.5	5.5	5.3
September	0	0	0	0	0	0	0	0	0	0	0	0
October	0	0	0	0	0	0	0	0	0	0	0	0
November	0	0	0	0	0	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0	0	0	0	0	0

As you can see above table 2 shows the overheating hours without window in the laboratory. Regardless of heat storage capacity generally in the presented 5 hours the overheating hours are in August.

Table 3: Overheating hours in the simulation building with window orientation North

	light construction				*medium construction*				*heavy construction*			
n [h^{-1}]	0	1	2	3	0	1	2	3	0	1	2	3
	North											
January	0	0	0	0	0	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0	0	0	0	0	0
April	2.2	1	0.7	0.5	0.3	0.1	0	0	0	0	0	0
May	7.7	5.1	3.8	3.5	6.3	3.9	2.7	2.2	6.3	3.2	1.7	1.4
June	12.2	9.5	8	6.9	12	9.1	7.3	6.1	11.1	9.1	7.7	6.3
July	14.3	11.3	10	9	17.4	11.6	9.3	7.9	19.5	12.2	8.8	6.9
August	12.4	9.8	8.8	8	12.3	10.3	9	8.1	12.6	10.4	9.4	8.6
September	5.3	3.6	2.8	2	1.1	0.1	0	0	0	0	0	0
October	1.3	1	0.8	0.7	0.6	0.3	0.3	0.3	0	0	0	0
November	0	0	0	0	0	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0	0	0	0	0	0

Table 4: Overheating hours in the simulation building with window orientation South

	light construction				*medium construction*				*heavy construction*			
n [h^{-1}]	0	1	2	3	0	1	2	3	0	1	2	3
	South											
January	1.2	0.8	0.6	0.5	0.6	0.3	0.3	0.1	0.3	0.2	0	0
February	1.9	1	0.6	0.3	0.1	0	0	0	0	0	0	0
March	3.1	2	1.5	1.1	2	0.9	0.7	0.5	1.1	0.5	0	0
April	5.2	3.8	2.7	2	3.9	1.5	1	0.8	2.2	0.7	0.3	0.2
May	9.2	6.6	5.6	4.7	8.9	5.5	4.3	3.7	8.7	5.7	4	3
June	12.6	9.9	8.6	7.7	13.8	10.4	7.5	6.5	13	9.8	8	6.5
July	14.3	11.7	10.4	9.4	19.2	13.3	10.4	9	20.5	14.7	10.9	9
August	15	12.4	10.9	10	16.8	13.5	11.4	10.1	17.5	13.4	11.2	10
September	10.1	7.8	6.6	5.7	12.1	7.5	5.3	4.4	13.6	6.9	4.2	3
October	5.9	4.3	3.5	3	5.9	3.2	2.3	1.9	5.7	2.7	1.8	1.5
November	2.3	1.5	1	0.7	0.9	0.6	0.4	0.2	0.3	0.1	0	0
December	0.7	0.4	0.2	0.1	0.1	0	0	0	0	0	0	0

Table 5: Overheating hours in the simulation building with window orientation West

	light construction				*medium construction*				*heavy construction*			
n [h^{-1}]	0	1	2	3	0	1	2	3	0	1	2	3
	West											
January	0	0	0	0	0	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0	0	0	0	0	0
March	0.8	0.5	0.4	0.2	0.1	0	0	0	0	0	0	0
April	4.4	2.8	2	1.5	2.2	0.8	0.5	0.4	0.7	0.2	0.1	0.1
May	9.8	7	5.8	4.8	9.8	6	4.5	3.7	9.8	5.8	4	3.1
June	13.8	10.6	9.2	8.2	15	11.5	9.3	7.8	15	10.8	8.9	7.5
July	15.7	12.2	10.7	9.7	20.3	14.6	11.2	9.5	21.3	17	12.1	9.6
August	14.7	12	10.5	9.5	15.8	12.5	10.6	9.6	16	12.1	10.7	9.6
September	7.6	5.5	4.4	3.5	6.8	3.6	2.7	2.1	5.6	1.9	0.9	0.6
October	2.3	1.6	1.4	1.1	1.5	0.8	0.7	0.6	0.9	0.5	0.4	0.3
November	0	0	0	0	0	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0	0	0	0	0	0

Table 6: Overheating hours in the simulation building with window orientation East

	light construction				*medium construction*				*heavy construction*			
n [h^{-1}]	0	1	2	3	0	1	2	3	0	1	2	3
	East											
January	0.2	0.1	0	0	0	0	0	0	0	0	0	0
February	0.6	0	0	0	0	0	0	0	0	0	0	0
March	2.3	1.5	1	0.7	1.2	0.4	0	0	0.4	0	0	0
April	8	5.2	3.6	2.6	6.6	3	1.8	1.3	5.7	1.8	1	0.5
May	12.6	9.7	8	6.8	14.1	9.4	7.1	5.7	14.3	9.2	7.1	5.8
June	14.8	12.3	10.9	9.7	17.7	13.7	11.4	9.9	18.9	14.2	11.5	9.4
July	17.3	14.4	13	12	21.5	17.7	14.5	12.7	22.2	19.6	16.4	13.5
August	16.5	14.1	12.3	11.1	19.1	15.5	13	11.5	19.8	15.7	13.3	11.7
September	10.2	8.1	6.9	5.5	11.5	7.5	5.5	4.5	12.4	7	4.5	2.9
October	3.4	2.4	1.7	1.5	2.5	1.5	1.3	0.9	2	1	0.4	0.3
November	0.7	0.4	0.1	0.1	0	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0	0	0	0	0	0

3. Results and discussion

In case of heavy construction of internal and external walls the maximum mean overheating hours are in July as table 3,4,5,6 shows. In the case of windows orientation maximum overheating hours are shown in the east, west, south and finally north orientation of the window.

In table 6 we can see the yearly average overheating hours for east orientation window, without mechanical ventilation:

light construction 86.6
medium construction 94.2
heavy construction 95.7

Also in table 6 we can see the yearly average overheating hours for east orientation window, mechanical ventilation with 3 air change rate:

light construction 50
medium construction 46.5
heavy construction 44.1

As can be seen in table 3,4,5,6 overheating hours are helped by mechanical ventilation.

Simulation related to East orientation's overheating hours were made in July, August, June, May months regardless of heat storage capacity. In the case of air change number increase, when the external air temperature is under then the internal air temperature, the external airflow helps to decrease the overheating hours.

4. Conclusions

In present paper I presented the overheating hours in PASSOL laboratory.

According to the Hungarian Meteorological Service, days that have a maximum air temperature over 25 °C are called summer days. [12]

Measuring the internal air temperature in PASSOL laboratory in summer days for light construction the overheating hours are 7.2 and for medium and heavy construction the overheating hours are 0.

By many standards and compfort papers the acceptable maximal internal air temperature in summer period is 26 oC. Therefore, in the simulation software I fixed the overheating limit to 26 oC.

Along this article I presented the 720 simulation results with different heat storage capacity, mechanical ventilation for different air change number.

It is also a result of the simulation, that the mechanical ventilation helps to temper the laboratory structure and in finally reduces the overheating hours. We can concluded that with reducing the overheating hours decreases the yearly cooling hours.

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