THE MICROCLIMATE OF THE HISTORICAL CHURCH IN FRYDMAN

Miczyński J. – Zawora T.

Janusz Miczyński, Tadeusz Zawora, Chair of Meteorology and Climatology, Department of Environmental Engineering and Geodesy, Agricultural Academy, al. Mickiewicza 24-28, 30-059 Cracow, Poland, e-mail: rmmiczyn@cyf-kr.edu.pl.

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1. INTRODUCTION AND METHODOLOGY

The origin of the reservoir complexes in Czorsztyn-Niedzica and Sromowce Wyżne have brought with them the irreversible flooding and destruction of certain areas and certain objects in the cultural landscape. Regarding the remains, there is a possibility of the influence of a variety of unfavorable factors in the vicinity or sphere of influence of the containers. Test results, changes in the mezoclimate closest to the existing containers as well as the forecasting of future changes of the mezoclimate in newly built containers are not in agreement, they are rather divergent. (Lewińska 1974, March 1971, Starklowa and Grzybowska 1997).

This is why the most important monuments situated in the vicinity of the Czorsztyn Dam are closely monitored. This study presents the test results of one of these monuments i.e. a historic church in Frydman, built in XIII century in Podhale, (a first class monument in southern Poland)

By applying combined electronic sensors with anti-radiation protection from the English ELE International firm, placed inside and outside the historic church, relative temperature and humidity measurements were taken. The sensor readings are automatically registered on the hour and stored in the internal Data Logger. The data is collected every quarter of a year, then processed, and stored in the Chair.

2. TEST RESULTS AND DISCUSSION

Based on the hitherto two year tests (10.1996 - 09.1997) we can affirm that the mean yearly temperature in the interior of the church is about 1°C higher than the outside temperature (table 1). The highest difference in temperature was 5°C noted in December.

In the individual months, however, the adequate temperature values can be lower in the interior as were noted in March, April, May, June, and August of 1997. In the mentioned months, the temperature inside the church was 0,3°C lower in March and August 1997, and up to 1,5°C lower in April 1996.

The mean yearly twenty-four hour air temperature fluctuations inside the building, as determined by a standard deviation of 1,7-1,8°C, are two times smaller than the adequate outside temperature fluctuations, which are between 3.6-4,0°C. The late autumn and late spring months are the most unfavorable periods due to the large temperature fluctuations inside the church (table 2). For example in November 1995, the standard deviation of the inside temperature was 3°C, and in December 1996, it was 2,9°C.

Besides the mean air temperature values in the mentioned months characterized above, a good and supplementary characteristic is the frequency difference of the mean twenty-four hour air temperature inside and outside the church (table 3).

On the December 1995 example, where the mean difference between the inside and outside temperature was 4,7°C, it was visible that the value of the difference was comprised of, in sporadic incidents, a difference of up to 16°C. One can also note that in this month, in nine twenty-four hour periods, the inside temperature of the building was lower, with the largest differences between 4-6°C.

The temperature inside the church is influenced by the outside temperature fluctuations. This is shown by the high and statistically significant adequate correlation coefficient (table 4) in all the months. One can also note that there is a larger dependence of the outside temperature to the inside temperature in the spring and in the fall, and it is smaller in the summer and in the winter.

The relative humidity inside the church on a yearly scale is slightly lower (0 – 3%) than the humidity outside. Relatively favorable conditions, because of the large differences between the inside and outside humidity reaching on average up to 15% can be observed in the winter months (table 5).

The spring months of 1996 as well as the spring and summer months of the following year were characterized by an unfavorable relative humidity situation – the humidity inside the building was a few – even up to 9% higher - than outside the building. In the above-mentioned spring – summer season, the highest relative humidity value was observed inside the church.

If we were to accept the most probable scenario of the future climate changes around the area of the reservoir – a slight decrease in temperature in the summer months, then we can most probably predict that this will bring about an increase in the relative humidity. An additional increase in humidity will be due to rise of the level of ground water in the depressional region around which the building is located.

The relative humidity fluctuations inside the church as measured by the standard deviation value, which can be estimated at about 8% (table 6) where the fluctuation inside the church are measured at 5%. The difference is rather small. In three out of the 24 tested months (November 1995, December, 1995 and January 1996), we observe a larger humidity fluctuation inside the building.

Table 7 best illustrates the scale of humidity fluctuations by presenting the frequency of the differences in humidity inside and outside the church. The table shows that in the least favorable months – April and May, these differences reach up to a 25% value of the mean twenty-four hour value, and in sporadic instances it even exceeds 35%.

January is the most favorable month where there was no observation of any instance of a larger degree of humidity outside of the church in any of the tested years.

In contrast to the air temperature, we can observe a lesser dependence of the relative humidity inside the church than that outside the church. The value of the adequate correlation coefficients is a lot smaller, and in nine out of the 24 tested months, they were statistically insignificant (table 8).
The tested building therefore has its own humidity regimen, with a weak dependence on the outside factors.

3. SUMMARY

To sum up– it is essential to note that the following belong to the unfavorable microclimate traits of the church in Frydman:

1. A small thermal autonomy displaying a large dependence of the outside factors on the inside temperature.
2. A high relative inside humidity especially during the summer months higher than the critical values for museum and historical monument interiors, which with in connection with the high temperatures of this period can create favorable conditions for the development of moulds and fungi.
3. The own humidity regimen of the building with a small dependence on the outer influences.
4. The possibility of a rise in relative humidity in the summer as a result of its high value due to the fall in temperature after the filling of the reservoir.
5. Because of the location of the reservoir in a depression and the rise of the ground water level, there is a danger of the humidity rise in the near-ground air layers.

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TABLE NR 1

THE MEAN MONTHLY AIR TEMPERATURE VALUES INSIDE AND OUTSIDI THE CHURCH IN FRYDMAN [o C]

MONTHS	INSIDE TEMP.		OUTSIDE TEMP.		DIFERENCE IN TEMP.	
	95\96	96\97	95\96	96\97	95\96	96\97
X	8,2	8,1	7,5	7,1	0,7	1
XI	0,3	5,8	-4,1	4,6	4,4	1,2
XII	-0,2	-2,5	-4,9	-7,3	4,7	4,8
I	-4,2	-5,3	-7,8	-7,4	3,6	2,1
II	-4,5	-1,9	-7,3	-1,5	2,8	-0,4
III	-1,7	1,3	-2,9	1,6	1,2	-0,3
IV	3,8	2,4	5,3	2,8	-1,5	-0,4
V	12,6	11,9	13,7	12,7	-1,1	-0,8
VI	15,5	14,5	15,3	15,8	0,2	-1,3
VII	14,7	16,4	14,2	16	0,5	0,4
VIII	15,9	16,4	15,8	16,7	0,1	-0,3
IX	11,1	13,1	8,4	12	2,7	1,1
MEAN	5,8	6,7	4,4	6,1	1,4	0,6

TABLE NR 2.

THE STANDARD DEVIATION OF THE MEAN MONTHLY AIR TEMPERATUR AND OUTSIDE THE CHURCH IN FRYDMAN

	INSIDE		OUTSIDE	
MONTHS	95\96	96\97	95/96	96\97
X	2,1	1,2	4,1	3,2
XI	3	2,4	5,1	5
XII	1,5	2,9	5,2	5,5
I	1,6	1,3	5	3,8
II	1,9	1,7	4,7	4,8
III	1,6	1	3,7	3,1
IV	2,7	1,6	4,9	4
V	1,9	2,5	3,5	4,2
VI	1,5	2,3	3,5	3,5
VII	1	0,9	3,3	1,6
VIII	0,6	0,4	1,9	1,6
IX	2,6	2,6	2,6	3,4
MEAN	1,8	1,7	4	3,6

TABLE NR 3 **THE INCIDENCE NUMBER OF THE DIFFERENCE OF THE MEAN TWENTY-FOUR TEMPERATURE INSIDE AND OUTSIDE THE CHURCH IN FRYDMAN**

		INSIDE TEMP. HIGHER THAN THE OUTSIDE TEMP.								INSIDE T. LOWER THAN THE OUTSIDE		
YEAR	MONTH	16,0-14,1	14,0-12,1	12,0-10,1	10,0-8,1	8,0-6,1	6,0-4,1	4,0-2,1	2,0-0,1	0,0-2,0	2,1-4,0	4,1-6,0
1995	X					2	3	5	5	14	2	
1996	X						4	8	10	3	5	1
1995	XI	1	1		1	4	9	6	4	4		
1996	XI					4	2	9	3	7	5	
1995	XII	1	1		1	3	4	7	5	7	1	1
1996	XII				5	9	6	2	6	3		
1996	I			2	3	3	4	10	4		3	2
1997	I				2	1	5	8	8	1	6	
1996	II				2	4	4	7	3	7	2	
1997	II				1		3	3	4	8	4	5
1996	III					1	4	7	7	8	4	
1997	III						1	6	7	8	10	
1996	IV						2	1	4	10	9	4
1997	IV							7	6	4	10	3
1996	V						2	2	3	10	12	2
1997	V							9	4	6	6	6
1996	VI					1	2	4	8	8	4	3
1997	VI							3	5	12	7	3
1996	VII						5	3	8	9	6	
1997	VII							4	15	10	2	
1996	VIII						2	1	10	16	2	
1997	VIII							3	5	23		
1996	IX						5	14	10	1		
1997	IX						1	6	15	7	1	
95\96		2	2	2	7	18	46	67	71	94	45	12
96\97					8	14	22	67	88	92	56	18
95\96					215				151			
96\97					199				166			
95\96					59%				41%			
96\97					55%				45%			

TABLE NR 4.

THE CORRELATION COEFFICIENT BETWEEN THE AIR TEMPERATURE VALUE INSIDE AND OUTSIDE THE CHURCH IN FRYDMAN

MONTHS	95\96	96\97
X	0,8	0,63
XI	0,72	0,85
XII	0,7	0,85
I	0,61	0,49
II	0,72	0,78
III	0,75	0,66
IV	0,86	0,78
V	0,66	0,65
VI	0,59	0,83
VII	0,64	0,6
VIII	0,52	0,61
IX	0,83	0,9

R critical for alfa=0,01and n=30 amounts to 0,45

MEAN MONTHLY RELATIVE HUMIDITY VALUE INSIDE AND OUTSIDE THE CHURCH IN FRYDMAN [%]

MONTHS	INSIDE HUMIDITY		OUTSIDE HUMIDITY		HUMIDITY DIFF.	
	95\96	96\97	95\96	96\97	95\96	96\97
X	78	81	83	83	-5	-2
XI	67	80	80	82	-13	-2
XII	71	68	79	78	-8	-10
I	67	65	76	80	-9	-15
II	64	71	68	75	-4	-4
III	70	75	71	73	-1	2
IV	77	76	70	74	7	2
V	80	78	75	74	5	4
VI	77	79	76	73	1	6
VII	78	81	79	72	-1	9
VIII	80	78	81	72	-1	6
IX	81	77	89	77	-8	0
MEAN	74	76	77	76	-3	0

TABLE NR 6.

THE STANDARD DEVIATION OF THE MEAN MONTHLY RELATIVE HUMIDI INSIDDE AND OUTSIDE THE CHURCH IN FRYDMAN [%]

	ISIDE		OUTSIDE	
MONTHS	95\96	96\97	95\96	96\97
X	7	2,5	7,2	6,9
XI	6,4	4,9	6,3	5,9
XII	8,2	9,6	7,1	10,9
I	6,1	4,5	6,4	6,7
II	7,2	6,4	5,5	8,2
III	5,7	4,4	6,5	8,6
IV	4,6	4,2	10,5	8,5
V	5,2	4	9,9	11,5
VI	4,8	2,8	7,7	9,8
VII	4,4	3,8	7,7	8,5
VIII	2,9	3,7	8	8,3
IX	2,1	4,8	4,2	6,9
MEAN	5,4	4,6	7,3	8,4

TABLE NR 7. **THE INCIDENCE NUMBER OF THE DIFFERENCE OF THE MEAN TWENTY-FOUR RELATIVE HUMIDITY INSIDE AND OUTSIDE THE CHURCH IN FRYDMAN**

		INSIDE HUMIDITY HIGHER THAN OUTSIDE								INSIDE HUMIDITY LOWER THAN OUTSIDE					
		40,0-35,1	35,0-30,1	30,0-25,1	25,0-20,1	20,0-15,1	15,0-10,1	10,0-5,1	5,0-0,0	0,1-5,0	5,1-10,0	10,1-15,0	15,1-20,0	20,1-25,0	25,1-30,0
YEAR	MONTH														
1995	X						1	2	3	9	7	7	2		
1996	X					1	1	2	8	9	6	3	1		
1995	XI									2	9	7	10	2	
1996	XI						1	4	6	9	4	5	1		
1995	XII									4	14	12	1		
1996	XII							1		2	9	14	5		
1996	I									2	17	12			
1997	I									1	6	5	14	4	1
1996	II								7	11	8	3			
1997	II						1	1	6	8	7	3	2		
1996	III						1	2	6	13	9				
1997	III					1	4	6	8	8	2	2			
1996	IV				3	3	6	3	5	8	2				
1997	IV					1	4	3	8	9	5				
1996	V				1	2	7	6	7	4	1	3			
1997	V	1			3		4	6	5	5	3	3	1		
1996	VI					1	6	1	10	7	5				
1997	VI					3	9	8	5		2	2	1		
1996	VII						1	5	9	6	4	2	4		
1997	VII						7	7	10	3	4				
1996	VIII					1		4	7	12	3	4			
1997	VIII						4	11	8	4	2	2			
1996	IX								1	7	14	8			
1997	IX						2	4	8	7	6	2	1		
95\96					4	7	22	23	55	85	93	58	17	2	
96\97		1			3	6	37	53	72	65	56	41	26	4	1
95\96							111					255			
96\97							172					193			
95\96							30%					70%			
96\97							47%					53%			

TABLE NR 8.

THE CORRELATION COEFFICIENT BETWEEN THE RELATIVE HUMIDITY VALUE INSIDE AND OUTSIDE THE CHURCH IN FRYDMAN

MONTHS	95\96	96\97
X	0,48	-0,15
XI	0,6	-0,04
XII	0,86	0,88
I	0,94	0,53
II	0,75	0,6
III	0,67	0,52
IV	0,32	0,58
V	0,47	-0,02
VI	0,28	0,43
VII	0,29	0,65
VIII	0,64	0,6
IX	0,3	0,32

R critical for alfa=0,01and n=30 amounts to 0,45