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Methodical conflict among the ways for drying out of historic masonry

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ORIGINAL SCIENTIFIC ARTICLE

ABSTRACT

The purpose of this paper is to give a focus on evaluation of effectiveness of technologies aimed on remedy of unwanted moisture in masonry constructions of historic architectural heritage buildings standing under architectural heritage protection. There are many ways how to achieve the wonted state of the constructions, but some of them are quite invasive, some are not that much invasive and some of them are doubtful. The usual resistance of a group of officers of Heritage authorities to invasive technologies makes the practise complicated, as the, so called invasive technologies are usually the most effective. Officers usually welcome not that much invasive technologies and a special place in their understanding of this problem is held by the Method of Sequential Steps. This method is based on step by step introduced ways of solving of the problem, which should start with minimal interventions and continue towards more intervening interventions. This approach might be relatively sensitive to the structures, but it takes a lot of time and a success is not ensured.

Keywords: *Moisture**;** Masonry; Architectural heritage; Ventilation; Undercutting; Injecting.*

1 INTRODUCTION

There are many technologies available for suppressing the unwanted moisture in masonry construction of historic buildings. Some of them are very effective, some of the less and some of them are absolutely not effective, or even doubtful. Highly effective technologies include certain level of invasive and destructive interventions into the historic material of protected buildings [12].

The sense of architectural heritage protection is to avoid wide technical interventions into historic construction materials. Such standpoint is also asked in some of the methodical documents dealing with architectural heritage protection. However, all international methodical documents do not give a clear standpoint to the question how to decide about anti moisture technologies.

A capillary moisture invading traditional masonry walls of the architectural monuments is a typical wide spread problem for most of the historical buildings. Wet masonry and its plasters pose not only a technical but also a hygienic problem. Wet masonry can partially lose its strength and the wet walls are losing on their thermal isolation. On top of that, water is a medium that can in a very long-time perspective dissolve all of the traditional materials of the architectural heritage building [11, 13]. Besides that, excess water in plasters creates a favourable environment for algae and moulds. These have

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consequently a negative impact on human health. Stating the above, it is crucial to fight such unwanted moisture in a historic masonry and its plasters.

To help to answer questions on the best way to fight moisture field research on sites of architectural heritage, where several different methods were introduced was organized. Following are the results of four selected typical approaches which can give a preliminary basis for answers. But any way next field research is inevitable.

2 USE OF THE METHOD OF SEQUENTIAL STEPS

For dealing with the problem of unwanted moisture in the masonry of the monastery of Franciscans in Bratislava the **Method of Sequential Steps** was recommended and welcomed by the monument´s protection authorities with technologies coming out of it. This method advanced the realising of repair interventions in a Step-by-Step order [14, 15]. Between the steps there is always the time for evaluation of the influence / results of the previous steps. In between the steps the masonry has some time to react on changed situation. There is always the possibility to adapt the following interventions, according to the changed situation.

2.1 Basic interventions

According to this approach, after the initial measuring, old plasters were removed from the walls, propped maintenance of the drainage system was organised, regular ventilation of the interiors was established etc. During the time of appr. one and three quarters of year systematic measurement of the levels of humidity on the surfaces of the room´s walls of the monastery were organised with following results

Tab. 1 Selected outcomes of the measuring of the moisture level on the surfaces of the walls on ground floor of the monastery. Measured by the instrument of Hygromete.

Date of measuring	2.2.2016	11.10.2016	31.03.2017	25.10.2017
Place/height of measuring [cm]	Moisture content [%]	Moisture content [%]	Moisture content [%]	Moisture content [%]
17/20	17,4	14,4	9,2	13,1
17/80	14,0	10,1	10,9	9,3
17/150	12,7	9,8	6,9	7,4
25/20	12,6	-	8,5	11,7
25/80	11,4	9,0	8,3	17,4
25/150	10,4	8,4	7,9	10,0
47/20	8,2	7,7	8,0	7,2
47/80	13,4	11,0	9,1	8,3
47/150	11,0	10,1	12,4	10,2
48/20	9,6	9,8	8,1	7,4
48/80	9,5	8,2	7,1	7,2
48/150	8,2	7,8	5,5	6,9
51/20	9,3	9,5	6,8	8,6
51/80	10,1	8,1	8,8	8,2
51/150	17,3	12,0	6,0	7,1
52/20	17,4	15,2	13,6	9,5
52/80	17,3	17,1	12,9	7,9

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52/150	17,3	14,6	6,5	4,9

Notice: For practical use in this article only selected representative points of measurements were used. In real much more points on the buildings were measured.

2.2 Outcomes and evaluation

As it is visible from the data introduced in Table 1, there was no significant success achieved, even that on most of the measured places the level of moisture went down. But this decline was still not sufficient. Especially because of the use of the interiors of the monastery for offices with people working there for more less a whole day and with documents stored there. That is why for achieving a sufficient environment in the rooms some of the invasive technologies should be used. Such approach was clear even at the beginning of construction works in monastery, but because of the conservation demands time was lost and nowadays as the construction works are finished it is at this moment impossible to introduce an effective intervention.

The main advantage of the Method of sequential steps lies in the fact, that it can eventually save quite a significant amount of money and the destructive influence to building standing under heritage can be limited. More invasive and less reversible technologies are to be used only in the case that previous group of technologies has not enough influence. But the main disadvantage of this way to fight the moisture is, that it consumes a lot of time and the achieved results could be in most of the cases inappropriate

3 USE OF THE METHOD OF VENTILATION OF THE MASONRY

Slovak University of Technology was asked by the order of the Piarists in the town on Nitra to assist with the problem of fighting moisture in constructions of their buildings. So regular measurement of the moisture level in wet masonry of their church and sacristy were undertaken by the use of the GANN instrument. For solving the problems ventilation technology was chosen [14, 15].

3.1 Ventilation of the crypt

The first step, which was recommended was the opening of the original ventilation holes in the crypt, which were closed probably during the 40-ties of 20th century. Thanks to this action the quality of the interior air in the crypt raised dramatically to a level where comfortable breathing was possible. It has to be mentioned, that there were dozens of cadavers of dead people buried in the crypt before.

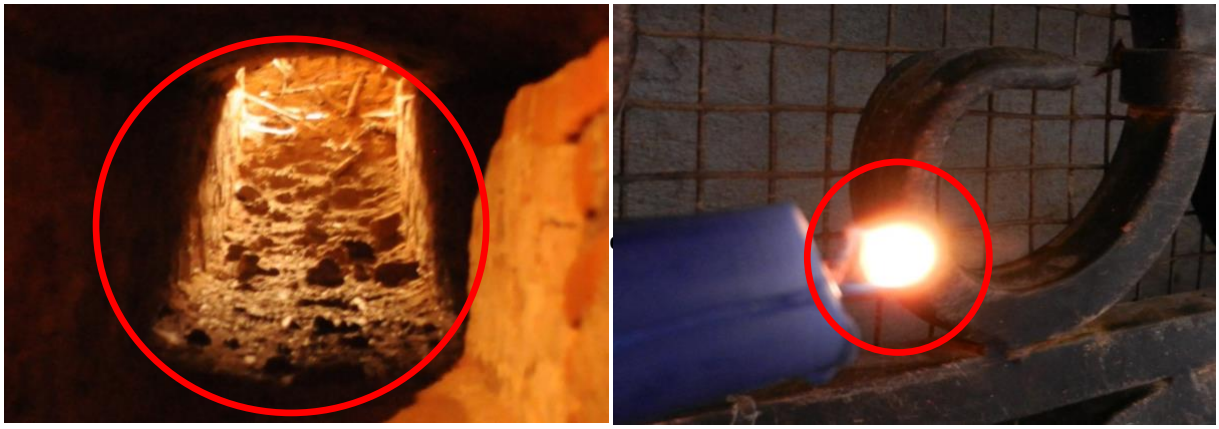

Fig. 2 The ventilation opening of the crypt (left) and a strong flow of the air inside of it (right)

After the original ventilation was set into action also the contents of relative moisture in the masonry lowered. But it was still not enough, as the masonry stands humid. But in any case, the situation was better and a chance for new use of the crypt, for example for prayers was made possible. The function of the ventilation was afterwards proofed by using the flame of a candle.

3.2 Ventilation channel

Unfortunately, the monks did not follow our recommendations and they gave in to a practical engineer, who submitted them his own way how to deal with the moisture. He constructed a "ventilation" channel around the baroque basement of the church and sacristy.

Fig. 3 The New made "ventilation" channel around the basements which stands, because of the use of concrete (left), beyond repair and the minimal air flow in this channel was proofed by a candle (right)

4 RESULTS

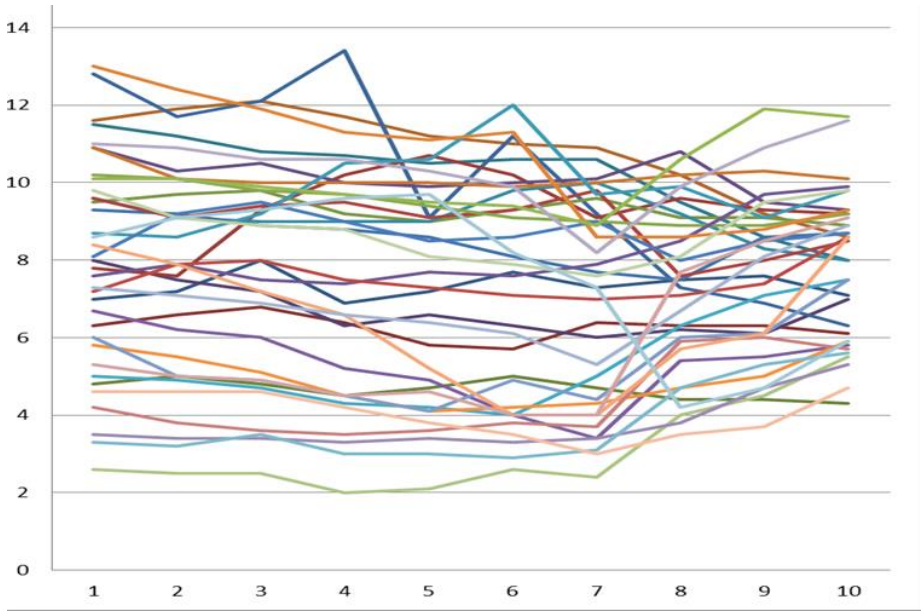

Fig. 4 Development of the level of moisture on the facade. Interrupted line shows when the ventilation channel was introduced. Figures were measured by the use of GANN instrument.

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The use of ventilation technology showed its limits. After setting the original ventilation system in the crypt into function, the level of moisture in the church went down, but still not sufficient. Generally, this was around 3 to 7 % in the interior of the church, or 1 to 3 % in the crypt. Construction of the ventilation channel [3 – 6] around the basement of the masonry was not enough sufficient, but helped to raise the level of moisture in the masonry up.

5 USE OF THE METHOD OF INJECTING OF THE MASONRY

The technology of injecting of the masonry is one of the more effective and less invasive. It is based on drilling of opening in the masonry which are afterwards used for injecting a liquid, or creamy sealing agents into them. The agents can be transported by using of atmospheric pressure, or by using of higher pressure produced by an injecting machine. The second mentioned way is more effective as it transports the agent more deeply and widely into the masonry [1, 14, 15].

Fig. 5 Drilling boreholes (left) and injecting them with a creamy sealing barrier (right).

5.1 Use of injecting of baroque masonry

As an example of effectiveness of such technology the injecting of the basis of the baroque altar in the town Nitra can be listed.

Fig. 6 Visible damages on the baroque altar.

Tab. 2 Data from measuring of the masonry of the altar. Used measuring device: GANN UNI 1.

Date of measuring	3/2010	10/2010	6/2011	10/2011	6/2012	12/2012	4/2013	10/2013	12/2013	7/2014
Place of measuring	%	%	%	%	%	%	%	%	%	%
34a	14,0	13,6	13,2	13,0	10,9	6,7	6,1	4,7	3,8	4,6
34b	13,8	13,5	13,2	11,7	9,7	7,4	5,1	4,9	4,8	4,9
35a	10,1	9,9	9,6	9,7	9,6	5,9	4,6	4,0	4,1	3,7
35b	13,8	13,5	13,2	12,5	7,7	4,5	4,3	4,1	4,0	3,8
36a	8,0	7,6	7,9	7,0	6,1	4,9	4,7	4,6	4,1	4,2
36b	12,0	10,9	10,3	9,8	8,3	4,1	3,9	3,8	3,6	3,6
37	9,8	8,1	8,0	7,2	4,7	4,0	4,0	4,0	4,1	3,8

Like it is visible, after the injecting of the basis of the altar with a liquid sealing barrier in the mid of the year of 2011 the situation went immediately better only on half of its construction. The rest went better after about two years. As there was no possibility to examine the construction material inside of the altar we can only expect, that there was different material used in both sides of its construction, which caused a different reaction on the introduced sealing material. This could explain the much slower insulation reaction. Finally, after three years the situation was already satisfactory. There were no more measurements undertaken, so we can only expect that the level of moisture went in the following time even more down.

5.2 Conclusions

The use of injection technology can be effective, but its positive effect comes only after some time. Its use depends also on the character of injecting material. Especially porous materials are sensitive on it and good results can be achieved in such material. Another issue is how long will such an injected barrier last. For the answer on this question further research should be undertaken.

6 USE OF THE METHOD OF UNDERCUTTING OF THE MASONRY

This technology is based on cutting the masonry mostly, but not only in horizontal level. The cutting is in nowadays times achieved by the use of a special machine with an endless rope enforced by diamonds, which circulates through it and through the masonry. As a result of the cutting process a cutting gap appears, in which an insulation foil can be afterwards placed [14, 15].

Fig. 7 Process of undercutting the masonry (left) and placing a solid insulation foil in the sawed gap (right).

6.1 Use of undercutting in a baroque manor house

Asks formulated for renewing of a baroque masonry in Bratislava stated that there should be a dry and pleasant environment in the buildings as it is widely used by people working there in the office and meeting there for longer time. That is why this radical technology was chosen.

Before and after the realising of this technology measurement of the level of moisture in the baroque masonry were measured. Results are presented in Table 3. As it is visible, the level of moisture in the constructions went during the years radically down. We can state, that a major success was achieved.

Tab. 3 Some data from measuring of the baroque masonry by the device Hygromete.

Place of measurement	Height of measurement [cm]	Moisture content [%]			Height of measurement [cm]	Moisture content [%]		
		5/ 2017	6/ 2018	9/ 2018		5/ 2017	6/ 2018	9/ 2018
M5	50	12,0	2,0	1,8	100	4,3	6,8	2,4
M10	10	9,1	3,7	1,5	180	4,4	1,4	1,9
M13	10	16,7	5,3	2,6	180	11,9	1,6	2,0
M14	10	11,0	1,2	2,0	180	16,4	1,6	1,5
M15	10	17,0	2,0	1,8	180	10,4	1,4	1,8
M24	30	7,4	6,6	4,0	100	1,9	1,1	4,8
M25	30	9,4	1,6	1,8	100	5,4	3,1	3,6
M26	30	8,3	7,4	1,1	100	17,3	6,9	2,3
M27	30	17,4	8,8	2,0	100	2,9	2,5	5,0
M28	50	18,5	2,8	2,3	100	17,5	3,3	3,2
M29	30	17,5	2,6	2,3	100	5,1	5,1	2,6
M30	30	15,5	0,7	0,8	100	17,4	8,8	6,8
M32	30	8,4	8,0	**1,7**	100	5,0	5,4	5,3
M33	30	12,1	**5,5**	2,0	100	4,7	**3,0**	2,5
M35	30	10,4	**12,5**	6,7	100	14,4	**6,5**	7,1
M36	30	17,4	**17,5**	6,7	100	6,5	**3,0**	4,1
M38	30	17,1	**16,4**	11,1	100	9,5	**9,4**	4,0
M43	30	11,0	**5,6**	5,0	100	17,5	**17,5**	11,5
M49	30	10,6	**2,9**	3,2	100	9,1	**3,1**	2,4

6.2 Discussion

There is also a couple of risks and complications connected with the introduction of this technology, which have to be solved. The avoidance of such complications depends mostly on experiences of the realizing company. The major complication, which can be even crucial is in the possibility, that the cutting gap could not be secured enough. Thanks to it the enormous weight of the above standing masonry will settle in it. As a result of such process cracks will appear in the constructions. That is why special chocks needs to be placed into the gap immediately after cutting the masonry.

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The process of placing the insulation foil into the gap has a limit in the thickness of the masonry which can be effectively insulated. It can usually stand around 1,20 m, maybe 1,30 m. If the wall is thicker, the insulation needs to be placed in it from both sides. That is why the final limit of the effectively insulated wall stand around 2,50 m. But in most of the cases this can be enough.

7 CONCLUSIONS

All the measurements were evaluated by the use of previous Czechoslovak standard [9], which is actually not in service in Slovakia. But as there is no other standard in force there, also this old, but good standard can be used

Tab. 4 Degree of moisture in the constructions according to ČSN P 73 0610 standard.

	Degree of moisture	Proportion of moisture (U_m) [%]
1	Very low moisture	< 3,0
2	Low moisture	3,0 - 5,0
3	Raised moisture	5,0 – 7,5
4	High moisture	7,5 – 10
5	Very high moisture (even waterlogging)	> 10

A significant bettering of the moisture situation in the masonry of renovated buildings where more, or less invasive methods were introduced. Soft methods welcomed by a lot of officers working in the structures of architectural heritage protection are not that effective [2].

The unwanted moisture endangers the existence of our built cultural heritage [7]. Besides that, wet plasters and masonry creates a favourable environment for the grow of algae and fungi, which have a negative impact on human health [10, 11, 16, 17]. Wet walls are also losing their thermal insulation ability. Creating a healthy environment in the such buildings could be seen as a very positive help not only to heritage buildings themselves, but especially to a steady use of their interiors.

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References

[1] ASHURST, J. & ASHURST, N. (1989). *Practical Building Conservation. - Vol. 2. Brick, Terracotta and Earth, Hants: English Heritage Technical Handbook*, Gower Technical Press.

[2] BALÍK, M. & MAKÝŠ, O. (2023). *Vlhnutie objektov, soli a sanácia vlhkosti a biodegradácia (riasy, machy, huby)*, sanácia. 1. vyd. Bratislava: Pamiatkový úrad SR, B. Metodika princípov rozhodovania Pamiatkového úradu SR vo veciach stavebnotechnického /alebo reštaurátorského/ zásahu, časť 10. Údržba a preventívna ochrana. Dostupné z: https://www.pamiatky.sk/plan-obnovy-a-odolnosti

[3] BALÍK, M. & STARÝ, J. (2003). *Sklepy - opravy a rekonstrukce*. Praha: Grada Publishing, s. 110. ISBN 80-247-0221-5.

[4] BALÍK, M. (1997). *Vysušování zdiva 2*. Praha: Grada Publishing.

[5] BALÍK, M. (1999). *Vysušování zdiva 1*. Praha: Grada Publishing, 80 s. ISBN 80-247-0438-2.

[6] BALÍK, M. (1999). *Vysušování zdiva 3*. Praha: Grada Publishing.

[7] BRANSON, G. (2003). *Home Water and Moisture Problems: Prevention and Solutions*. Richmond Hill: Firefly Books. 144 s. ISBN 1552978354.

[8] KLOTZ-WARISLOHNER, G. & SAAR, M. (1999). *Reparatur in der Baudenkmalpflege, München Bayerisches Landesamt für Denkmalpflege*. 164 s. ISBN: 978-3874906982.

[9] LEBEDA, J. a kol. (1998). *Sanace zavlhlého zdiva.* Praha: SNTL.

[10] LEITNER, H. (1996). Stabilization of architectural surfaces. In: *Poznámky k prednáške na kurze ICCROM ASC-96: The Examination and Conservation of Architectural Surfaces, Viedeň – Mauerbach.*

[11] MAKÝŠ, O. & NÉMETH, A. (2017). *Renovácia omietok*. 1. vyd. Pezinok: Renesans. ISBN 978-80-89402-96-0.

[12] MAKÝŠ, O. (2000). *Rekonštrukcie stavieb – technológie*. Bratislava: Jaga group. 175 s. ISBN 80-88905-31-1.

[13] MAKÝŠ, O. (2004). *Technologie renovace budov*. Bratislava: Jaga group. 262 s. ISBN801-8076-006-3.

[14] MAKÝŠ, O. (2018). *Technológie obnovy budov - ochrana a oprava spodných a obalových konštrukcií*. Bratislava: ES STUBA, ISBN 978-80-227-4848-3.

[15] MAKÝŠ, O. (2004). *Technologie renovace budov*. Bratislava: Jaga group. 262 s. ISBN 801-8076-006-3.

[16] MĚŠŤAN, R. (1988). *Omítkářské a štukatérske práce*. Praha: SNTL, 304 s.

[17] VENZMER, H. & KOLLMAN, H. (1997). *Anwendung von Sanierputzen in der baulichen Denkmalpflege*. Freiburg: Aedificato Verlag, 176 s.