Comparation of Two Different Methods for Fighting Moisture in Historic Masonry

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Abstract. Nearby all historic building built in Central Europe before the half of the 20th century have to face problems with unwanted moistening of their constructions. A significant part of them stands under legal protection as architectural monuments. There are several technologies which can be used to deal with this problem. Some of them are more invasive into historical masonry, some of them are less invasive. Some of them are much more effective in insulating effort, some of them are less. According to the Venice charter from 1964 methods which are less invasive should be preferred. Some of them are the ventilation methods. But are they really effective? On the other side of the spectrum are undercutting methods, which are drastically invasive. So, they are standing in a clear opposition the recommendations of the Venice charter. Why should they be used? Are they really so effective? And what should be done with their conflict with the Venice charter? The article tries to find answers on these questions on a base of introduced anti-moistening technologies from both sides of the mentioned spectrum. From a couple of renovation interventions undertaken in Slovakia, in the climate of Central Europe, two typical examples were taken out to support a – hopefully – right result. We used natural ventilation in a church in Western Slovakia and we achieved a success. Then we used the undercutting technology in some other church - again in Western Slovakia. We were also successful. So what is the matter? The matter is that one of this method was not successful in an adequate extent. The other one was.

1. Introduction

For a comparing case study of evaluation of effectivity of anti-moisture technologies two churches were chosen, which were built during the same period – the 18th century in a baroque architectural style and from the same kind of material – bricks. Both churches suffer by the same problem, which is the unwanted moistening of their masonry of their main load bearing constructions. This is a typical defect of all historical buildings in Central Europe, especially those standing under architectural heritage protection.

The negative results of the influence of water on brick masonry lies in their weakening, in their lowered frost resistance, as also in creation on an environment which is suitable for grow of moulds and algae. This can lead to disturbing of the stability of the walls, which can be theoretically very dangerous. But in the praxis such problems appear rarely. Another effect of moistening is the lowering of warm insulation characteristics of the walls, which can be more serious and which can be even easily documented. And probably the most important negative effect is the influence of the interior’s environment in rooms in a way which seriously affects the health of people living, or using it. Increased
air moisture acts also very negative on subjects stored in the rooms, like books, furniture, museum’s artefacts and others. So is the fight for lowering such unwanted humidity in historic masonry a very important part of the struggle for decontamination of architectural heritage buildings.

2. Technologies to deal with moistening

There is a couple of technologies, which can be used in the fight for dry historic masonry. Some of them are quite sensitive towards architectural heritage building material, some of them are more radical, some of them are doubtful. Today we do have a lot of experiences with the use of all such anti-moisture technologies, so we can already make a comparison [4,5].

From the technical point of view the situation is quite clear. We prefer technologies which can lead to a significant success in the effort for achieving a masonry which will be dry as much as possible. But as we have to deal with architectural heritage buildings there is also another point of view, which have to be taken into consideration. This point represents methodical recommendations, which have their background in a couple of internationally accepted methodical documents. Slovakia decided to accept such recommendations in its Declaration of Protection of Cultural Heritage, which was accepted by the National Council (Parliament) of the Slovak republic in the year of 2001.

These international methodical documents, especially the Charter of Venice from the year of 1964 asks for protection of historical masonry substance, which should be affected by some technological intervention as less as possible. But this lies in a direct conflict with introduction of technically effective anti-moisture measures. Especially if we take the mentioned recommendation literally. So, what to do with it?

For the purpose of trying to find an answer two examples of introduction of anti-moisture technologies were selected. The first example was the try to solve the drying out of baroque brick masonry in a church in Western Slovakia by introduction of ventilation methods. The second example, taken for evaluation was another baroque church built of bricks in a different location - but also in western Slovakia.

3. Results - Case study No.1

In the first mentioned church a hidden crypt, laying under the presbytery of the church was discovered. All original ventilation openings were closed by masonry several decades ago. The level of moisture in the surface parts of the masonry was extremely high – like it is illustrated in attached table No.1. So, we recommended to activate the historic ventilation system in the crypt.

From the attached graphic it is clearly visible, that the introduced ventilation technology was effective – the humidity in masonry went down. But it was still not sufficient, as the most of the figures show a level of moisture in masonry which is still above the degree of 10%. The moisture was evaluated on the base of Czech standard ČSN P 73 0610, which we are accustomed to use for a couple of decades.

So, it means there was still a very high level of moisture in the crypt.
Table 1. The measuring of humidity in the masonry of the crypt.

| Place / Date of measuring | 9.3.2010 | 6.10.2010 | 21.6.2011 | 5.10.2011 | 19.6.2012 | 4.12.2012 | 12.4.2013 | 30.10.2013 | 10.12.2013 | 2.7.2014 |
|---------------------------|---------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|---------|
| 1 | 2 | % mass | % mass | % mass | % mass | % mass | % mass | % mass | % mass | % mass |
| 44 | 120 | 17.6 | 17.3 | 16.9 | 16.5 | 16.1 | 13.8 | 11.3 | 7.2 | 7.2 | 7.1 |
| 45 | 150 | 17.4 | 13.2 | 13.0 | 11.5 | 10.1 | 9.4 | 8.4 | 8.3 | 8.8 | 9.1 |
| 46 | 100 | 13.5 | 13.8 | 13.9 | 14.0 | 13.6 | 12.0 | 11.8 | 12.1 | 12.1 | 10.9 |
| 47 | 120 | 12.1 | 12.3 | 12.5 | 12.0 | 11.8 | 11.8 | 11.8 | 12.0 | 11.4 | 11.3 |
| 48 | 180 | 13.7 | 13.2 | 13.1 | 12.5 | 12.7 | 12.4 | 12.2 | 9.5 | 9.1 | 9.1 |
| 49 | 160 | 14.1 | 12.1 | 12.1 | 12.1 | 12.3 | 14.6 | 14.2 | 13.3 | 13.1 | 12.9 |
| 50 | 160 | 14.2 | 13.8 | 13.4 | 13.1 | 12.9 | 12.6 | 12.4 | 12.0 | 10.2 | 10.0 |
| 51 | 160 | 14.0 | 13.9 | 14.0 | 13.5 | 13.2 | 11.8 | 11.0 | 11.4 | 11.2 | 11.6 |
| 52 | 200 | 14.2 | 13.8 | 12.4 | 11.5 | 11.1 | 9.7 | 12.5 | 13.4 | 14.2 | 11.5 |
| 53 | 140 | 14.3 | 14.3 | 14.8 | 14.2 | 14.3 | 14.8 | 13.9 | 14.4 | 13.3 | 13.0 |
| 54 | 160 | 14.3 | 13.4 | 14.1 | 13.7 | 13.6 | 13.4 | 13.4 | 12.5 | 12.6 | 12.0 |
| 55 | 120 | 14.4 | 14.0 | 13.9 | 13.7 | 13.3 | 12.9 | 12.4 | 12.0 | 12.0 | 12.1 |
| 56 | 140 | 8.3 | 8.3 | 9.1 | 9.9 | 9.5 | 9.4 | 9.3 | 9.1 | 9.3 | 9.1 |
| 57 | 160 | 13.1 | 13.5 | 13.9 | 14.1 | 13.0 | 12.7 | 12.0 | 12.9 | 12.4 | 12.4 |
| 58 | 140 | 13.2 | 13.4 | 13.5 | 13.5 | 13.0 | 12.9 | 13.5 | 13.7 | 13.5 | 12.9 |
| 59 | 140 | 14.8 | 14.9 | 15.2 | 15.6 | 13.5 | 13.5 | 13.5 | 13.2 | 13.0 | 13.7 |
| 60 | 140 | 14.5 | 13.9 | 13.5 | 13.1 | 13.3 | 13.0 | 13.6 | 12.9 | 11.2 | 11.0 |
| 61 | 120 | 14.5 | 14.3 | 13.9 | 13.7 | 13.0 | 12.9 | 12.6 | 12.6 | 12.1 | 11.6 |

1° - No. of the measuring point  
2° - Distance of the measuring point from the floor [cm]

Table 2. Evaluation of moisture in masonry according to the standard ČSN P 73 0610 [2,4]

| Degree of Moisture | Moisture (u_M) [%] |
|--------------------|--------------------|
| 1 Very low moisture | < 3,0 |
| 2 Low moisture | 3,0 - 5,0 |
| 3 Increased moisture | 5,0 – 7,5 |
| 4 High moisture | 7,5 – 10 |
| 5 Very high moisture (waterlogging) | > 10 |
Figure 1. Decline of moisture based on measuring of humidity in the masonry of the crypt in a graphic form.

Figure 2. Strong air blow inside the crypt achieved after activation of the original baroque ventilation system.

4. Results - Case study No.2

In the second example another baroque church was de-humidified by the use of undercutting technology. The masonry was cut with the use of so-called diamond rope, which a steel rope strengthened with the use of industrial diamonds. The masonry was cut in high, which was approximately equal to the level
of the interior floor. Not absolutely equal, as the mechanism needs some space to operate, so it was cut in a level of approximately 10 cm above the interior floor.

Afterword insulation foils were placed into the slotted gap and the masonry was ensured by the use of plastic chocks. At the end the gap was filled by the use of expansion mortar to ensure the stability of the masonry. The cutting technology was introduced approximately 1 months before the last measuring was undertaken. And it was evaluated on the base of the above-mentioned Czech standard ČSN P 73 0610.

Table 3. Figures from the measuring of humidity in the masonry of the church.

| Place/Height of measuring | % mass | Place/Height of measuring | % mass |
|--------------------------|--------|--------------------------|--------|
|                          | 07/2017 | 11/2019 | 3/2020 | 07/2017 | 11/2019 | 3/2020 |
| V2/30cm                  | 11,3    | 10,5    | 9,8    | V2/150cm | 10,3    | 8,8    | 7,4    |
| V3/30cm                  | 17,3    | 17,4    | 5,9    | V3/150cm | 12,4    | 12,4   | 3,8    |
| V4/30cm                  | 17,0    | 14,2    | 8,7    | V4/150cm | 10,8    | 10,2   | 8,3    |
| V5/30cm                  | 15,7    | 15,7    | 5,6    | V5/150cm | 12,4    | 12,6   | 2,5    |
| V6/30cm                  | 16,1    | 9,3     | 10,6   | V6/150cm | 11,3    | 5,7    | 6,6    |
| V7/30cm                  | 11,5    | 6,1     | 7,5    | V7/150cm | 14,8    | 11,6   | 8,5    |
| V8/30cm                  | 14,4    | 13,3    | 8,2    | V8/150cm | 17,4    | 13,3   | 5,8    |
| V9/30cm                  | 17,4    | 17,4    | 9,6    | V9/150cm | 16,2    | 15,4   | 4,2    |
| V10/30cm                 | -       | 17,4    | 9,8    | V10/150cm | 11,4    | 10,4   | 2,4    |
| V11/30cm                 | -       | 12,5    | 7,3    | V11/150cm | 17,4    | 15,4   | 4,3    |
| V12/30cm                 | 3,5     | 4,5     | 5,2    | V12/150cm | 3,0     | 4,4    | 0,5    |
| V13/30cm                 | 4,0     | 4,6     | 2,8    | V13/150cm | 3,7     | 4,0    | 0,4    |
| V14/30cm                 | 4,2     | 5,6     | 1,7    | V14/150cm | 3,0     | 3,8    | 0,5    |
| V15/30cm                 | 11,5    | 8,7     | 9,2    | V15/150cm | 16,3    | 12,4   | 2,6    |

The figures show a clear success in a rapid decreasing of the level of moisture in masonry, even only in a few weeks after the introduction of the undercutting technology.

Figure 3. A machine for undercutting of the masonry.
Figure 4. Placing of insulation foils into the slotted gap.

5. Conclusions
From the two listed examples a clear result comes out – the hard and a bit drastic undercutting technology looks much more efficient as the soft ventilation technology. So it looks like the way for solving moisture problems of architectural heritage buildings lies by introducing of drastic invasive technologies is a right way.

In the case of solving a possible conflict with methodical point of view, given by the Venice charter is can be stated, that such invasive technologies can achieve a very good results in drying out of historic masonry. A dry masonry creates a much more sufficient environment inside the buildings and it preserves the original historic constructions, especially plasters against further damage caused by humidity. And not only by humidity, by also by water soluble salts.

Besides the undercutting technologies there is also another group of technologies which can be so effective - the injection technologies. The decision which one of them to use depends on concrete situation. We usually prefer to use undercutting technologies mostly for baroque and younger masonry, and also for hard stone masonry. The injection technologies can be successfully used in a brick masonry, or in the masonry of weaker stones – like sandstones. It is not so effective in stone masonry made of hard stone.

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