Design of the ventilated air channel to resolve moisture problems in the historical church

Ladislav Tazky***, Anna Sedlakova a

aTechnical University of Kosice – Civil Engineering Faculty, Vysokoskolska 4, Kosice 042 00

Abstract

The purpose of the research is to find adequate solution against rising damp in historical buildings. The improvement of this case is with ventilated air channel. Special part of historical buildings are churches because not use routinely as for example museums, galleries. We are designed 10 differently construction of ventilated air channel. These are: open or closed, with overpressure and underpressure. We use for verification relevance these construction we simulated in software Ansys CFX the air flow of channels. We modeling the equal segment of the channels. This research should be offer for architects the solution against problems of rising damp for historical buildings. For find the right solution is necessary to research everyone case. The aim of the research is to prepare the design process of the ventilated air channels for the architects without simulation every building, cross section or geometry of these construction.

Keywords: ventilated air channel, moisture, historical building

1. Introduction

Nowadays architects use ventilated air channels only for remediation of damp masonry in historical buildings. But in the past they routinely used for new buildings as a protection against moisture. The principle of the systems is 4500 year old but it is still functional only the material is different. Ventilated air channel systems are important every time. This is because in historical buildings the use of radical methods are prohibited. At present many ventilated air systems

* Corresponding author. Tel.: +421 915 342 777.
E-mail address: ladislav.tazky@tuke.sk
are designed incorrectly and are not functional. The channels are divided according to various aspects such as: location (exterior, interior), method of ventilation (from the exterior, from the interior) and method of airflow (naturally or forced). Ventilated air channels in the exterior are divided into open and hidden. For the church in Gemersky Jablonec we proposed only the external channel.

### Nomenclature

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(w_m)</td>
<td>moisture content mass by mass</td>
</tr>
<tr>
<td>(g_k)</td>
<td>the all-year amount of condensed water vapour</td>
</tr>
<tr>
<td>(g_v)</td>
<td>the all-year amount of evaporated water vapour</td>
</tr>
</tbody>
</table>

2. **History of the church**

During the visual survey it was found that the moisture content of the internal masonry pillars reaches up to the height at around 1700 – 1900mm. The situation was the worst at the apse of the east side of the church. On the inner surface of the plaster there was visible efflorescence and mildew occurrences especially in the higher parts of the plinth. On the outside of the walls there are still visible lichens, mosses and algae. During the reconstruction of the 80es a gutter walkway was built around the church which only worsened the situation. The biggest problem is the concrete sidewalk on the west side of the church, which compresses the water towards the walls and concentrate at the foundations.

Samples were taken from the perimeter walls for moisture laboratory evaluation. Each sample is taken from the plaster or mortar from the peripheral wall. These samples were collected from the bottom of the wall. The highest value of moisture at around 9% have been measured on the east side of the outer walls of the apse.

In the summer of 2013, work began on the dehumidification of masonry which started by removing of the original plaster to the height at around 1500mm and replaced by the appropriate remediation plaster.

3. **Geometry of air channel**

The church is a protected cultural monument and a historic value should be particularly sensitive to any remediation done. To improve the technical condition of the church minor structural modification is required [7]. The drain pipes will be replaced with outdoor air channels. The channel must be masoned of ceramic burned bricks with lime-cement mortar to ensure the natural evaporation of moisture from the soil through the brick masonry. The bottom of the air channel will be filled with gravel; the drain pipe will be placed in this layer to ensure the drainage of water. The next step will be the coverage of the channel with precast concrete panels. These panels are perforated to ensure the natural evaporation from the channel (Figure 2) [4, 5, 6].
Fig. 2. Detail of the foundation with air channel.

3.1. Simulated variants

We designed the cross-sections dimensions of ventilated air channel in 10 variants. The size and values of air pressures and air velocities are shown in the Table 1. The air pressure and air velocity values are from the second simulation. In the second simulation we used the values of air pressure what we obtained from the first simulation. We designed the church and terrain in the first simulation to get the properties of the wind on the surface church.

Table 1. Air velocity and air pressure in the air channel for each variants.

<table>
<thead>
<tr>
<th>Versions</th>
<th>Dimensions (mm)</th>
<th>Velocity (m/s)</th>
<th>Pressure (Pa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Version 1</td>
<td>450 x 400</td>
<td>0.163681</td>
<td>0.0133150</td>
</tr>
<tr>
<td>Version 2</td>
<td>450 x 450</td>
<td>0.153650</td>
<td>0.0134039</td>
</tr>
<tr>
<td>Version 3</td>
<td>450 x 500</td>
<td>0.142533</td>
<td>0.0121934</td>
</tr>
<tr>
<td>Version 4</td>
<td>450 x 550</td>
<td>0.132798</td>
<td>0.0111474</td>
</tr>
<tr>
<td>Version 5</td>
<td>450 x 600</td>
<td>0.125289</td>
<td>0.0104080</td>
</tr>
<tr>
<td><strong>Version 6</strong></td>
<td><strong>500 x 400</strong></td>
<td><strong>0.165185</strong></td>
<td><strong>0.0155124</strong></td>
</tr>
<tr>
<td>Version 7</td>
<td>500 x 450</td>
<td>0.149221</td>
<td>0.0121549</td>
</tr>
<tr>
<td>Version 8</td>
<td>500 x 500</td>
<td>0.137618</td>
<td>0.0110277</td>
</tr>
<tr>
<td>Version 9</td>
<td>500 x 550</td>
<td>0.128301</td>
<td>0.0101979</td>
</tr>
<tr>
<td>Version 10</td>
<td>500 x 600</td>
<td>0.121408</td>
<td>0.0094466</td>
</tr>
</tbody>
</table>
3.2. Numerical model

The first model was realized with an air flow of 3 m/s, during the summer with air temperatures approximating 25°C. In the second model we used obtained values of pressure in monitored points, what represented the location of the inlets on the wall in the first model (Figure 4, 5).
3.3. Results of numerical simulation

In the Figure 3 is displayed dependence of the air velocity on the depth of the air channel. If the depth of the air channel is higher air velocities are lower. Therefore in the final numerical simulation we used lower depth of the air channel with the enlarged width. Final cross-section dimensions of the air channel are 500 x 400 mm (Variant 6).

Fig. 5. Simulation model of the church and air pressure on surface.

The Figure 6 displayed streamlines of air in the air channel around the apse of church. The streamlines air is coloured according to air velocity. In this part of the church is the worst situation, because water content in the masonry is around 9%. The tested samples have been collected from the bottom part of the masonry wall. Results obtained from the numerical simulation in the software ANSYS SFX are satisfactory in the complicated parts of the church as well as at the apse [1, 2, 3].

Fig. 6. Streamlines coloured by air velocities in the Variant 6 around the apse of the church.
The graph in Figure 7 displayed air velocity in the monitored points 1 – 118 in the second model. Location of the monitored points is in the center of the channels in the distance 300 mm.

4. Conclusion

The air channel around the church Gemersky Jablonec is simulated in many different variants, see Table 1. Results obtained from the numerical simulation in the software ANSYS CFX showed cross-section 500 x 400 mm (Variant 6) as the best for this church. In this case is air velocity in the air channel highest as well as maximal drying effect of the masonry. Final results showed average air velocity in the air channel on the value 0.032 m/s, more.

Fig. 7. Air velocities in the air channel with the dimensions 500 x 400 mm (Variant 6).

Acknowledgements

This contribution has been supported by the project “The use of the virtual laboratory for designing energy-efficient buildings” with the project code: 052TUKE-4/2013.

References