RECONSTRUCTIONS OF HISTORICAL BUILDINGS FROM ENERGY POINT OF VIEW - VENTILATED AIR CAVITIES BELOW GROUND

Recently, more and more often total reconstructions of historical buildings that have not been administered for years by anyone, have taken place. Their stage neither meets the current user standards, nor the technical ones. On the other hand, this period is also a period of great interest in using the largely deprived buildings for commercial purposes.

INTRODUCTION

This work describes some basic methods of remedial treatment. Its priority is the selection of those remedial treatments, which, if not stop the spread of moisture, at least eliminate it. In all of that there is the emphasis on the methodology of preservation of historical monuments, constructional possibilities of historic buildings and their energy consumption. The evaluation must take into account the fact that buildings with traditional structures usually not attain the limit criteria of the energy needed for heating and limit criteria of the sanitary assessment. Appropriate, theoretically justified remedial treatments must then be looked for, to ensure adequate energy efficiency renewed historical building.

1. MOISTURE OF HISTORICAL BUILDINGS

Structural damages due to moisture can be caused by splash water, driving rain and other weather conditions, by hygroscopic moisture, by condensate resulting from wrong ventilation and heating habits or by rising damp.

A basic requirement with rising damp is the installation of a retrofitted horizontal damp proofing course with the essential accompanying treatments. Only once the cause of the moisture penetration into the masonry wall has been eliminated, the masonry will dry out. This reduction results from the evaporation of the moisture in the masonry, whereas the speed of evaporation depends on the thickness of the masonry, the degree of salinization and moisture penetration, on the climatic conditions around the facility and the airflow around the wall, as well as the make-up of the wall surface.
Historic buildings usually have no protection against the substructure moisture penetration in contact with the soil and if, thus only passively. Materials incorporated in the construction of these buildings are often saturated with moisture. Remedial treatments often require a comprehensive approach to design solutions and are financially very expensive. Appropriate, theoretically justified remedial treatments must then be looked for, in order to ensure satisfactory results, while respecting the requirement to preserve the historical values and also the values of our cultural heritage. They include measures of renewal of waterproofing layers, or the realization of measures which shall prevent the entry of water into the building [1].

1.1. Selection of remedial treatments

Historic buildings are often technically incorrectly rebuilt and moreover, rebuilt without any respect for any value of building heritage.

The aim is the selection of such a remedial treatment method, which in general and in its nature, will meet the needs of historical buildings construction and will also satisfy the methodological requirements of Monuments Board. Historic DPCs are those that belong to the original construction of the building, whereas modern DPCs are those that are installed as a later intervention due to the lack or failure of an original.

Retrofit DPCs can be classified into three broad groups [2]:

- **Direct methods**
  - Mechanical, chemical, electro osmosis, air insulated

- **Indirect methods**
  - Drainage, the landscape, ventilation, etc.

- **Supplementary methods**
  - Direct, indirect.

From a structural point of view and also from the point of view of cultural heritage protection, remedial treatments using the ventilated air insulated methods may be considered the best and most versatile method of all. With these remedial treatments we return to the methods and principles that the ancient Egyptians were already familiar with.

1.2. Air insulated methods

The basic principle of the function of air cavities used in dehumidifying masonry, generally lies in the separation of the building construction (masonry, floors) from the source of the rising water (adjacent soil), using a ventilated air gap, into which and out of which a continuity in the supply and exhaust of air is ensured.

Traditional buildings built in damp or potentially damp sites commonly included through-ventilated cavities. These types of structures are suitable mainly for historical buildings and buildings listed in the database of national monuments of the Slovak Republic.
Concepts of remedial treatments of historical buildings using ventilated air cavities (Figs. 1-4), with a few exceptions, are with considerable popularity preferred by the representatives of monument protection.

2. MODEL EXAMPLE FOR SIMPLE EVALUATION

A typical cross section of the historic building will be used as a model. External walls are built from full bricks. Wall thickness is 500 mm with plasters. Base of building is created by concrete with the height of 800 mm and width of 700 mm. Depth of foundation is 1900 mm below the surface. The floor and base bellow floor thickness are shown in Figure 5.

In the first stage, we entered into the calculation software the original model to determine the temperature condition of construction in the original condition of standard boundary conditions. Next, at this above mentioned initial model will be implemented ventilated air cavity below ground level as rehabilitation. As an example was used a vertical air cavity created by ceiling slab with the height of 900 mm and width of 600 mm.

Subsequently, this model of ventilated air cavity will implemented two variants of calculation to determine the possibility of ventilation of cavity. The difference between the variants is the location of inlet and outlet went holes. Inlet and outlet went holes were situated:

- **Variant No 1.1 (e-e):**
  - Inlet hole at exterior and outlet hole at exterior (Fig. 6).
- **Variant No 2.1 (i-e):**
  - Inlet hole at interior and outlet hole at exterior (Fig. 7).

These variants (Variant No 1.1 and Variant No 2.1) will be further disseminated to other alternatives (1.2, 1.3, 2.2, 2.3) (Figs. 10, 11, 13, 14). The difference between other variants is the location of thermal insulation (variants 1.1 and 2.1 are without thermal insulation) to improve thermal properties.
In calculations, boundary conditions were applied according to the standard STN 73 0540-3 [4] as follows:

- External temperature of air: \( \theta_e = -15°C \)
- Relative humidity of external air: \( \varphi_e = 84% \)
- Internal temperature of air: \( \theta_i = 20°C \)
- Relative humidity of internal air: \( \varphi_i = 50% \)
- Temperature of soil (in deep of 3 m): \( \theta_{gr} = 5°C \)

2.1. Calculation of initial construction

The main task of reconstruction by ventilated air cavity is the removal of moisture by air flow. Achievement the thermal requirements of the standard STN 73 0540-2 [3] is not a priority in this case. Important is only that we do not impair the original thermal state.

Suppose that the cavity is properly designed and lead away moisture. Another task of reconstruction is to achieve at least the same thermal state as the initial construction. For this purpose we need to determine properties of the original condition. We will assess the progress of temperature fields for individual variations.

The aim is to verify temperature at the base, thermal bridge in a horizontal corner and surface temperature of wall at 2 m height. For evaluation we use AREA 2002 computational program [5].

Figure 8 demonstrates 2D thermal field for a typical section of initial construction. There are shown above mentioned points. Numeric values of calculation are entered in Table 1.
2.2. Calculation of Variant No 1

For the original Variant 1.1 (Fig. 9) incoming cold air influences the ambient structures (wall, floor) and their interior temperature decreases by few kelvins. Incoming cold air also influences the foundations. To improve the thermal properties of a Variant 1.1 extended to other variants.

In another variant, add insulation thickness of 100 mm into the bottom of the cavity (Fig. 10) and subsequently around the perimeter of the cavity (Fig. 11), except for building walls in order to ensure evaporation of moisture.

2.3. Calculation of Variant No 2

For the original Variant 2.1 (Fig. 12) incoming warm indoor air warms the surrounding structures. This fact is favorable in terms of thermal bridges, but this improvement is at the expense of heat loss. For this reason, the original Variant 2.1 extended to other variants. Thermal insulation is first placed on the ceiling of cavity (Fig. 13) and than also around the perimeter of cavity (Fig. 14).
2.4. Results of calculation

Results of calculation are shown in the Figures 15-20. Figures 15, 16, 17 are shown 2D thermal fields of Variant No 1 and Figures 18, 19, 20 are shown 2D thermal fields of Variant No 2. Complete numerical results of calculation are included in the Table 1.

Variant No 1 (e-e) and its alternatives

Variant No 2 (i-e) and its alternatives

Fig. 15. Variant No 1.1 (e-e)

Fig. 18. Variant No 2.1 (i-e)

Fig. 16. Variant No 1.2 (e-e)

Fig. 19. Variant No 2.2 (i-e)

Fig. 17. Variant No 1.3 (e-e)

Fig. 20. Variant No 2.3 (i-e)
Table 1. Results of calculation

<table>
<thead>
<tr>
<th>Considered construction</th>
<th>Name</th>
<th>Temperature, °C</th>
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<tr>
<td></td>
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<td>horizontal corner</td>
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<tr>
<td>Initial</td>
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<td></td>
<td>1.2</td>
<td>10.03</td>
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<td></td>
<td>1.3</td>
<td>10.19</td>
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<tr>
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<td></td>
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<td></td>
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<td>14.19</td>
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2.5. Evaluation

Concepts of remedial treatments of historic buildings using ventilated cavities, with a few exceptions, are with considerable popularity preferred by the representatives of monument protection. The fact that they require small interventions in the masonry is of great benefit for compliance with the methodology of cultural heritage protection, as is the fact that such interventions do not compromise the structural analysis of buildings.

From Variant No 1 the best solution may be considered Variant No 1.2. With small amount of thermal insulation we have reached almost the same values as the initial construction has. Variant No 1.3 is a little better than Variant No 1.2, but this small difference is negligible compared with the consumption of thermal insulation.

From Variant No 2 the best solution may be considered Variant No 2.3. Using variations of 2.1 and 2.2 achieve excellent temperature values in a horizontal corner, but all at the expense of heat loss into the ground. Full cavity insulation will achieve excellent values of surface temperature and also to avoid redundant heat loss. The warmer air in the cavity, the moisture evaporation is more efficient.

CONCLUSION

The role of the designer is to choose the right way ventilation cavity. In ventilation (e-e) is necessary to insert insulation into the bottom of the cavity to prevent frost foundations. Thermal insulation will also help keep the surface temperature in a horizontal corner of the sufficient level. In ventilation (i-e) evaporation of moisture is more effective, but at the expense of heat from the interior. Heat losses avoided by inserting insulation around the perimeter of cavity. This variant is maintained in the cavity required high temperature without unnecessary heat loss.
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REFERENCES