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IMPLEMENTATION OF VENTILATED AIR CAVITIES AND PROBLEMS WITH THERMAL BRIDGES

Historical buildings generally have no, or only have a passive protection of structures against the ingress of moisture in contact with soil. Materials embedded in structures of these buildings are often saturated with moisture. When reconstructing, we must apply a different methodology than when reconstructing the newer buildings. Differentiated treatment is affected by traditional construction technologies and also by the mechanical and physical properties of building materials. As regards listed historic monuments, special „barrier" is constituted by the monument protection office, or rather the opinion of the representative of the monument protection office. 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 and constructional possibilities of historic buildings. With respect to the abovementioned requirements, the acting humidity can be effectively removed, using ventilated air cavities. These are commonly used in connection with remedial treatments of damp masonry, especially in historic buildings.

1. Moisture and 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

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penetration, on the climatic conditions around the facility and the airflow around the wall, as well as the make-up of the wall surface [1].

2. Selection of remedial treatments and monument board

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 DPC.

Retrofit DPCs can be classified into three broad groups:

- direct methods (mechanical, chemical, electro osmosis, air insulated),
- indirect methods (drainage, the landscape, ventilation etc.),
- supplementary methods (direct, indirect).

Conservation professionals, faced with a scenario where rising damp has been offered as a cause but suspicious of or disagreeing with a proposed remedial solution, may want to investigate and negotiate. But they will remember that any standard remedial works can be highly destructive, can simply mask the problem and ultimately solutions would require listed building consent.

From a structural point of view and also from the point of view of cultural heritage protection, remedial treatments using the ventilated air cavities may be considered the best and most versatile method of all.

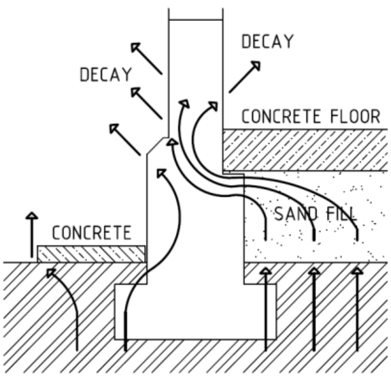

Fig. 1. After: concrete slabs prevent evaporation, so soil moisture is forced up the wall

Maintaining underfloor ventilation is an important part of controlling damp, as it allows soil moisture to evaporate beneath the floor and to pass out through the vents in the lower walls. Without this ventilation the moisture „stress” on the walls would be much greater. The concrete prevents evaporation and all the soil moisture rising beneath the building is now focused on the walls

(Fig. 1). Rising damp problems are almost guaranteed, whereas before there may have been no significant damp, even though the walls may have lacked effective DPCs (Fig. 2).

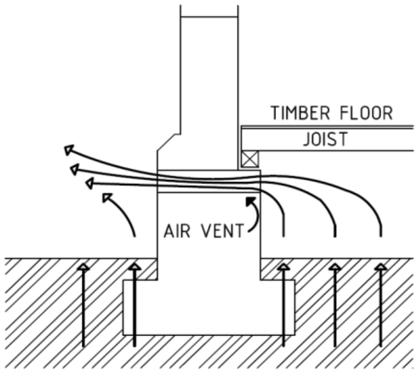

Fig. 2. Before: well-ventilated underfloor space allows soil moisture to evaporate to the open air

Ventilated floor air cavity is frequently use in the Slovak Republic to ventilate wet masonry, water vapour and gas Radon, from the soil.

According to the structure type we can differentiate two systems:

- a new ceiling load bearing structure (Fig. 3),
- a special shaped units IGLU (Fig. 4).

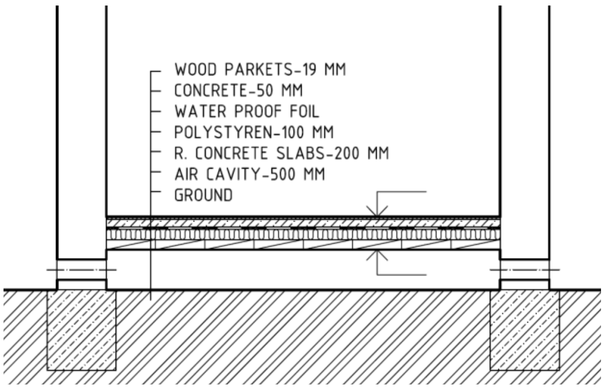

Fig. 3. Air cavity created by ceiling load bearing structure

The problem of rising damp and of the consequences for the internal working environment and the condition of the building has been faced since the days of the Ancient Romans, who raised the floors of their building by using amphora or low walls. In this way an empty space was created which was linked to the outside by ventilation grills to ensure air circulation. And so the cavity known today as healthy space was born.

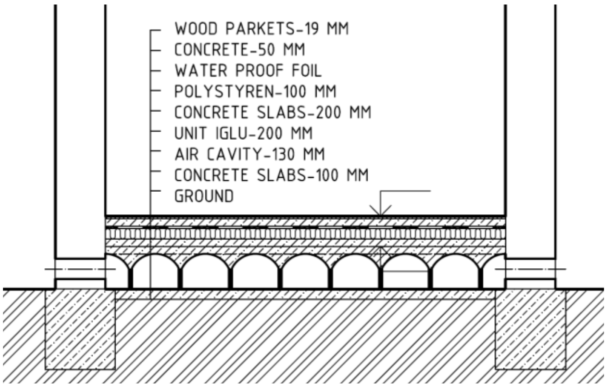

Fig. 4. Air cavity created by special shaped units IGLU

The approach adopted by the Romans influenced (Fig. 5a, b), and even inspired, technicians and designers of every subsequent age, who never hesitated to recommend and apply the same concept, both for new buildings and for reconstruction work on older ones.

a) b)

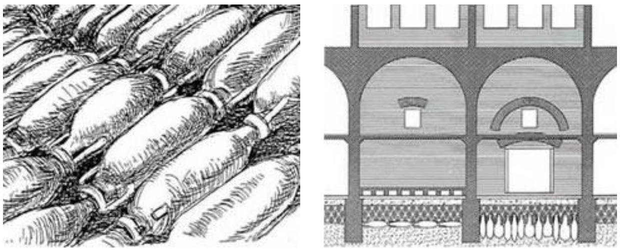

Fig. 5. System of Romans

a) b)

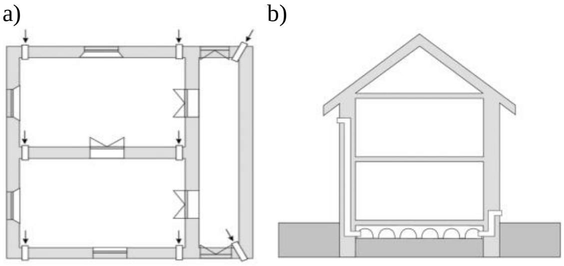

Fig. 6. System of IGLU

Modern structural components (Fig. 6a, b) have proven mechanical (recycled polypropylene) properties and strongly resist the aggressive environment. Their installation is quick and efficient. With these new technologies we return to the methods and principles that the ancient Romans were already familiar with.

3. Air cavities

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.

Choosing of the most appropriate cavity

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 historic buildings using ventilated air cavities (Fig. 7a, b) and ventilated air floors (Fig. 7c, d), 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. These concepts have gained great popularity also because they can be considered kind of a „return” to historical example.

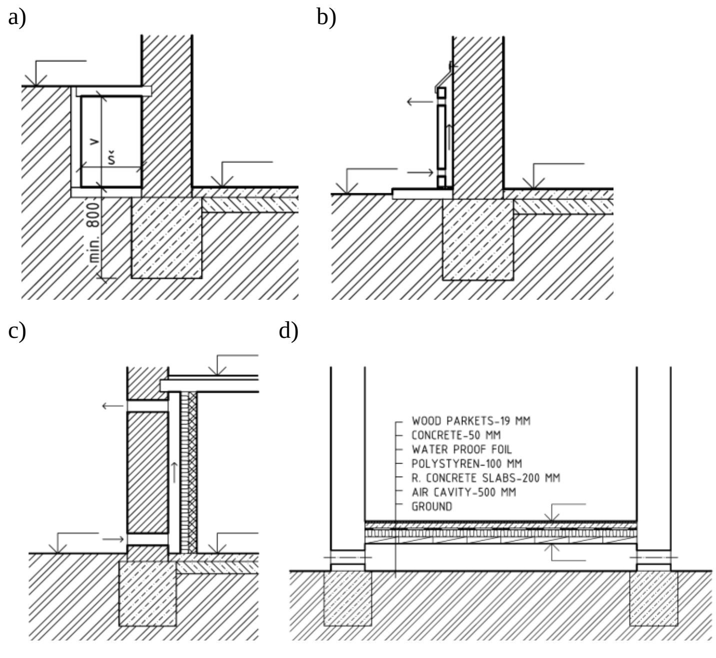

Fig. 7. Examples for some gas insulated methods

For evaluation both of case we was used AREA 2002 [2] computational program. In calculations, boundary conditions were applied according to the standard STN 73 0540-3 [3], ass follows: External temperature of air θ_e = –15°C, relative humidity of external air φ_e = 84%, internal temperature of air θ_i = 20°C, relative humidity of internal air φ_i = 50%, temperature of soil (in deep of 3 m) θ_{gr} = 5°C.

4. Initial construction

Before implementation of ventilated air cavity

External walls are built from full bricks. Wall thickness is 500 mm together with plasters. Base of building is created by unreinforced 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 Fig. 8. Thermal field is in Fig. 9.

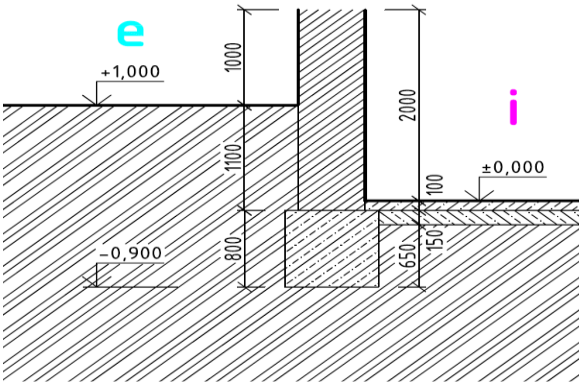

Fig. 8. Scheme of initial construction before implementation of air cavity

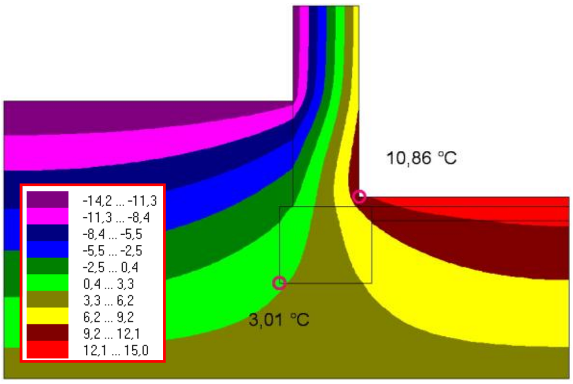

Fig. 9. Thermal field of initial construction before implementation of air cavity

Before implementation of ventilated air floor

The walls are the same as described above. We assume that depth of foundation is sufficient. The thickness of the insulation in the floor is 50 mm. Fig. 10 demonstrates 2D thermal field for a typical section of initial constructions before implementation of ventilated air floor. We will evaluate the surface temperature and temperature at the base (Fig. 11). The aim of reconstruction is to remove moisture and not worsen the original thermal state.

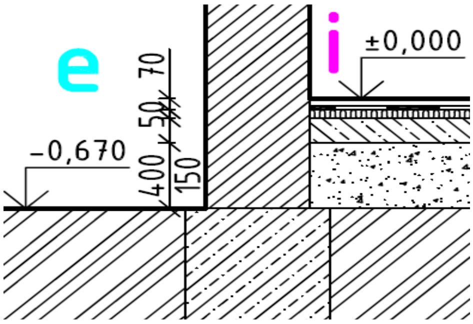

Fig. 10. Scheme of initial construction before implementation of air floor

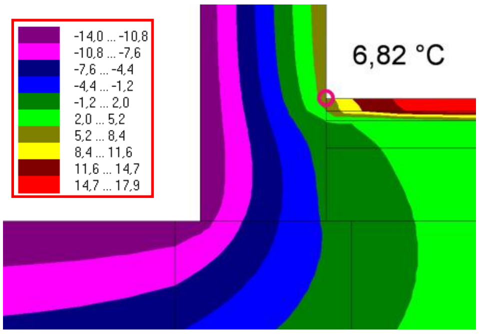

Fig. 11. Thermal field of initial construction before implementation of air floor

5. Implementation of air insulated methods

Implementation of ventilated air cavity (Fig. 12)

Figure 13 shows that the temperature of the outer corner of the base is close to zero (almost freezes) and also that the surface temperature in a horizontal corner fell. This documents the need to isolate bottom of the cavity. Thickness of insulation must be such that the soil under the foundation not freezing. In this case it wills 100 mm (Fig. 14).

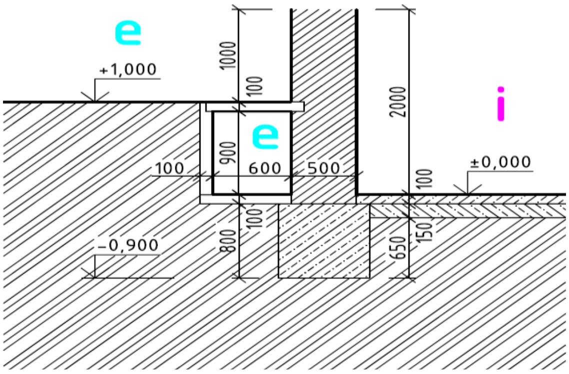

Fig. 12. Scheme of ventilated air cavity

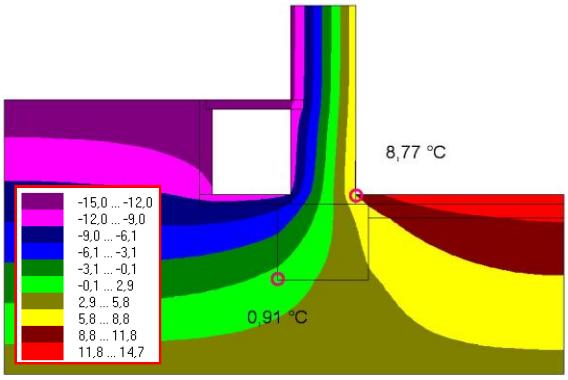

Fig. 13. Thermal field of ventilated air cavity

Implementation of ventilated air floor

Figure 15 also shows a decrease in temperature in a horizontal corner. Temperature on the inner surface θ_{Si} must be greater than the critical surface temperature $\theta_{Si,N}$. Therefore, with the approval of Monuments Board, the internal plaster will replaced by a new the thermal insulation plaster mixtures of thickness 50 mm. Additional thermal insulation from the outside of wall can not be applied – listed building and ineffective.

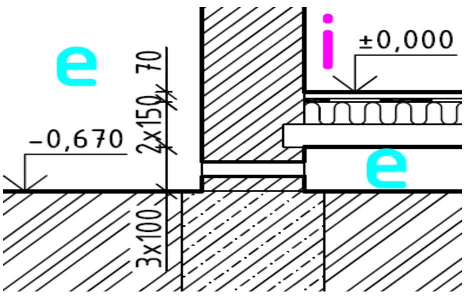

Fig. 14. Scheme of ventilated air floor

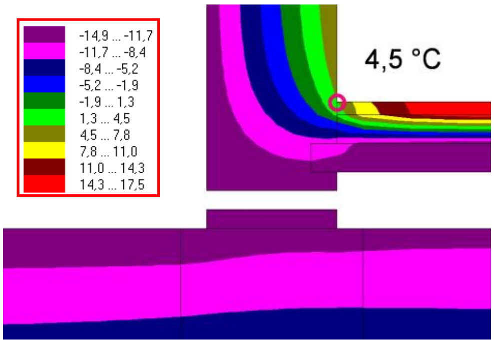

Fig. 15. Thermal field of ventilated air floor

6. Simplest solutions of problems

Solution of problem of ventilated air cavity

After inserting insulation into the bottom of cavity was a rise in temperature at the base and horizontal corner (Fig. 16). Thermal field is in Fig. 17. Next, does not make sense to add new insulation on the remaining sides of the cavity or increase the thickness of the thermal insulation of bottom of the cavity. Rise in temperature would be minimal.

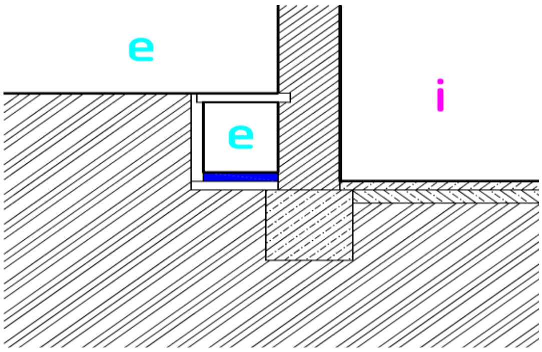

Fig. 16. Scheme of ventilated air cavity after placing the thermal insulation

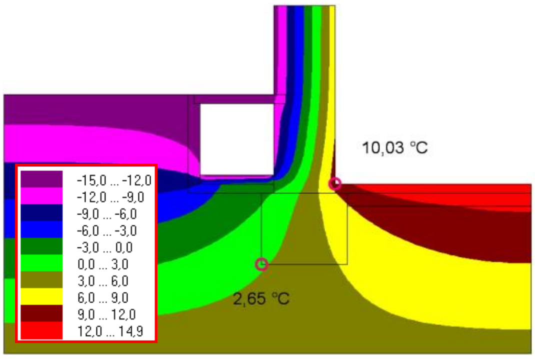

Fig. 17. Thermal field of ventilated air cavity after placing the thermal insulation

Solution of problem of ventilated air floor

After replacing the old plaster with a new one, there was a rise in temperature in a horizontal corner (Fig. 18). 2D thermal field is in Fig. 19. This solution is essentially the only effective option, when we take into account fact that we can not interfere with the external façade and building static. Thermal insulation placed at the ceiling of the cavity temperature to increase by only 0,5°C. Other effective options no exist, given that this is a historically protected building.

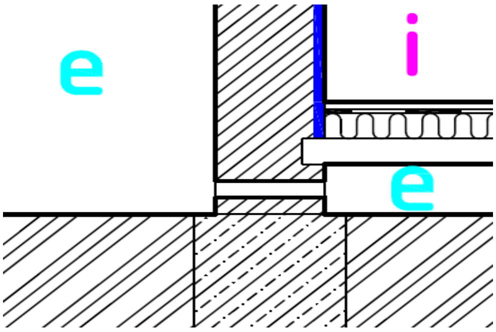

Fig. 18. Scheme of ventilated air floor after placing the thermal plaster

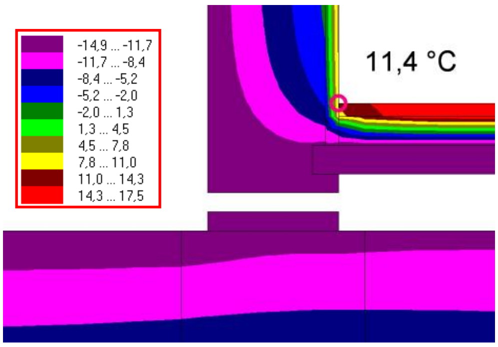

Fig. 19. Thermal field of ventilated air floor after placing the thermal plaster

7. Conclusion

Heat bridges arising in the contact detail of the outer wall, foundation and floor construction in the past paid no significant attention in many cases, completely lacking any insulation in this detail. Elimination of thermal bridges is one of the most important measures in the design of structures, because structural detail of the lower structure significantly enters into problem of energy.

To assess a risk of surface condensation on walls, we must calculate the surface temperature θ_{Si} of the wall and compare it with the standard one $\theta_{Si,N}$.

For the internal surfaces of rooms with computer temperature θ_i = 20°C and relative humidity φ_i = 50% it is the minimum surface temperature after the inclusion of the safety margin set at $\theta_{Si,N}$ = 13,12°C. We see that we have not reached this criterion.

We must take into account the fact that the buildings with traditional structures are not usually reach the limit criteria necessary energy for heating and health criterion (critical surface temperature $\theta_{Si,N} = \Delta\theta_{Si} + \theta_{Si,80}$). Therefore, the reconstruction or rehabilitation of historic buildings we have to consider a failure criteria of standard STN 73 0540-2 differently [4].

In the design of structural details of lower construction is necessary to take into account the specificity of the proposed building. In all of that there is the emphasis on the methodology of preservation of historical monuments and constructional possibilities of historic buildings. In this case the priority of reconstruction was to remove moisture and not worsen the original thermal state. This goal was achieved.

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References

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[2] Calculation software, AREA 2002.

[3] STN 73 0540-3:2002. Thermal performance of building constructions and buildings: Thermal protection of buildings. Part 3: Properties of structures.

[4] STN 73 0540-2:2002. Thermal performance of building constructions and buildings: Thermal protection of buildings. Part 2: Requirements.