MOISTURE CHANGING TENDENCIES IN WALLS ADDITIONALLY INSULATED FROM THE INSIDE

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MOISTURE CHANGING TENDENCIES IN WALLS ADDITIONALLY INSULATED FROM THE INSIDE

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1. Introduction

Nowadays, saving energy resources is becoming quite popular. One of the ways of saving fuel asigned to heating of accommodation is the improvement of thermal properties of walls.

Before the energy crisis all over the world, thermal insulation of walls, practically, depended on sanitary and hygienic requirements, ie the temperature of wall inside surface could not be lower than the temperature dew point in premises. The most important aspect was to save work expenses and materials at construction.

During the last three decades, the requirements of standard documents for thermal insulation were constantly increasing in the developed countries. The strictest requirements of Sweden according to standards 1985, where the thermal transmittance coefficient of walls and basement floor slabs was recommended - $0.3W/(m^2K)$, floor slabs - $0.2W/(m^2K)$, maximum permissible values of this coefficient for walls and floor slabs - $0.6W/(m^2K)$, basement floor slabs - $0.45W/(m^2K)$. In 1995, on the first of January in Germany, a new thermal saving resolution came into force. It was pointed out that the thermal transmittance coefficient of walls must not exceed $0.5W/(m^2K)$, basement walls and ceilings, and also ceilings under uninhabited lofts - $0.35W/(m^2K)$ [1].

In the standards of thermal technology, requirements for designed, constructed and reconstructed buildings are being presented, but a large amount of present buildings remains an urgent and unsettled problem.

Earlier the requirements for thermal resistance of enclosures were very low. Regarding the poor quality of work and materials used, thermal resistance of

building enclosures often did not meet the requirements which were valid before. In a very cold weather walls of some buildings even freeze.

Methods of insulation of external walls are examined and compared in [2],[3]. This article deals with construction insulation from the inside. The investigation should be helpful considering advantages and disadvantages of this method.

2. The analysis of moisture behaviour of structures insulated from the inside

The method of structure insulation from the inside is important from the point of view of moisture. As an insulating material is installed from the inside of accommodation, the temperature in the insulated enclosure does not even decrease in cold period, but at the same time moisture processes are changing. There is a possibility that an insulating material and enclosure may become moist, and also accumulate moisture at the junction of these materials. What conditions there should be and what factors might influence the formation of condensation in the above-mentioned places? An answer might be found evaluating qualities of materials, environment factors and the choice of a structure insulated from the inside.

Moisture movement in a material is determined by water vapour pressure difference at the both sides of enclosure, temperature differences, different moisture potentials of materials. The effectiveness of the above-mentioned process, and also moisture accumulation depend on the properties of material and their structure [4].

In construction, the majority of used materials always contain some moisture, which may change depending on the quantity of moisture in the air. This

feature of materials is called hygroscopic and is described as sorption curve. Though, not all hygroscopic materials equally accumulate moisture and give it the same opportunity to migrate. We can consider, for instance, expanded clay concrete and ceramic hollow brick masonry enclosures. If they have similar thermal properties, moisture permeability for expanded clay concrete is half as small as ceramic hollow brick masonry. When insulating the above-mentioned enclosures from the inside with mineral wool (non-hygroscopic material) [5], which thermal permeability is low and water vapour permeability is equal to air vapour permeability, we get different results.

Moisture and thermal changes, occurring in an enclosure, are interdependent and change with time. If during the cold weather, which lasts for about five months, the enclosure becomes moist, so for the rest of time of the year it is drying. According to the requirements of standards [6], the quantity of evaporated moisture has to be equal or bigger than the quantity of condensed moisture. Evaluating our conditions, when the temperature of the coldest five days is from -20^0C to -23^0C, and the average temperature of the coldest month fluctuates from -4^0C to -7^0C, at the junction of insulating materials and enclosures they can be positive and negative (Fig 1). It has some impact on occurring moisture processes, which intensity is influenced by this temperature fluctuation.

Temperature values at the junction of materials are defined by the thickness of insulating material, situation in insulating construction, external and internal temperature, enclosure thickness and its thermal permeability.
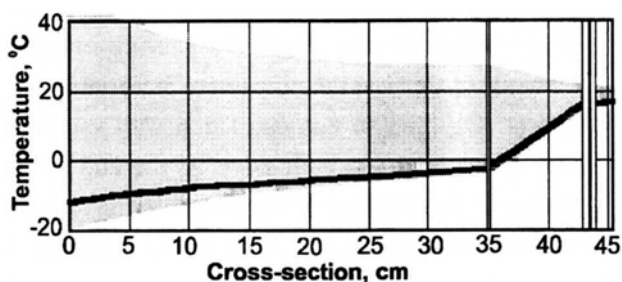

Fig 1. Temperature distribution in the external expanded clay concrete wall, insulated from the inside with 8 cm slabs from mineral wool with vapour barrier. Dark spaces show possible temperature change

Additionally from the inside insulated expanded clay concrete enclosure, the temperature at the junction of enclosure and insulating material is about 2 ^{0}C lower than in ceramic hollow brick masonry.

2.1. Moisture processes at the junction of enclosure and insulating material

Temperatures at the junction are above zero when the inside temperature is 18 ^{0}C and 60% RH, and external temperature corresponds to the temperature of the coldest month average temperature. Though these temperature values are lower than the temperature of dew point, and in the corner of construction in comparison with the middle one differ. It is possible to state that water vapour which penetrate from accommodation through the insulating construction and its non-hermetic places, might increase material moisture. Mineral wool also have some impact, because of its low density, which may cause moisture movement towards low temperatures, and air convection as well [3]. Because of its low sorption moisture, there is very little moisture in comparison with the enclosure material. These conditions help moisture to penetrate towards the enclosure and absorb into its material.

The moisture of enclosure increases when accommodation temperature and relative humidity increase as well. The moisture of enclosure depends on its vapour resistance. Though, we shall not notice, the formation of condensation at the junction of materials in short time, although, material moisture of enclosure corresponds to 90% sorption moisture [7]. The enclosure is not totally frozen and its bigger part participates in active moisture exchange. Ceramic hollow brick and expanded clay concrete have capillary pore structure, where moisture movement may occur in the form of vapour, water film and in fluid, ie being affected by capillary powers, it migrates deep into the material. Moisture process intensity, depending on the quantity of moisture, is characterised by its water vapour and fluid coefficients, as it is shown in (Fig 2), [7],[8],[9].

The described situation changes when enclosure freezes. At negative temperatures, the sorption humidity of material increases [10]. A part of water vapour which gets on a cold surface, has not enough time to
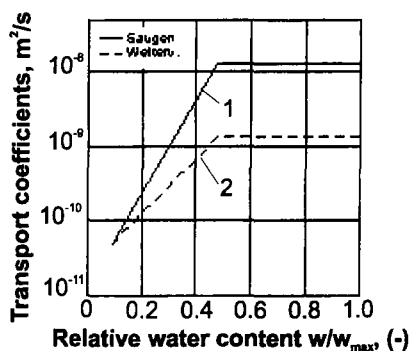
Fig 2. Expanded clay concrete, 1200 kg/m^3, fluid coefficients: 1 - capillary absorption, m^2/s; 2 - subsequent moisture distribution, m^2/s

be absorbed into material and in the form of hoarfrost may crystallise gradually. However, the area of negative temperatures is not only at the junction, but also in an insulating material. That is why part of moisture may freeze in mineral wool. When negative temperatures hold on for a longer time, this amount may increase. Growing warmer, the ice begins to melt and in the form of water drop it accumulates on the surface of enclosure, or in mineral wool. This causes a high relative air humidity and influences the moisture increase in enclosure material. During a moist season the accumulated moisture does not have time to evaporate, that is why the moisture of construction is the biggest at end of a season.

For predicting the above-described moisture processes, there was used the non-stationary moisture-thermal exchange program WUFI [8],[9]. Received results allow to draw the conclusion, that the above-mentioned processes are interdependent and have some impact on the moisture condition of an insulating material.

2.2. The impact of vapour barrier on the external wall insulated from the inside

A vapour barrier has a noticeable impact on moisture condition of enclosure and an insulating material. Its existing does not allow these materials to become moist fiercely. Moisture at the junction of two materials changes little. In this way it prevents moisture accumulation at the junction of two materials. Though during the dry season in this construction moisture can practically evaporate only through the external side of enclosure. It extends the time of mois-

ture evaporation, which depends on moisture qualities of enclosure material. That is why in summer season an opposite process is noticeable when moisture of mineral wool increases at the junction of vapour barrier, and there may appear a short-term condensation (Fig 3).
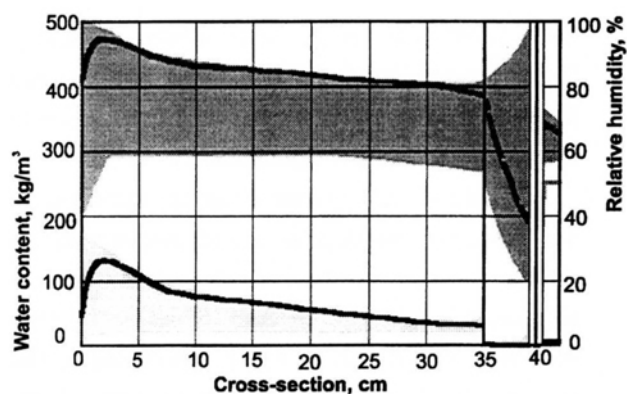

Fig 3. The external expanded clay concrete wall insulated from the inside with 4 cm mineral wool slabs with vapour barrier, the calculation results of five years. Dark areas show changes of relative humidity (above) and moisture quantity (below)

In an insulating construction (8 cm mineral wool) without vapour barrier and there being 18^{0}C and 60% RH in an accommodation, it is noticed a greater amount of moisture together with a possible short-term appearance of condensation. The enclosure of ceramic hollow brick masonry becomes moist more intensively than that of expanded clay concrete. A danger of appearing condensation at the junction of two materials decreases, when an enclosure is insulated from the inside with a thinner (4 cm mineral wool) layer of insulating material (Fig 4). That is why in the expanded clay concrete enclosure air relative humidity of 100% at the junction of materials does not appear. Contrary to a construction with vapour barrier, drying occurs in both sides. At the end of drying season at the junction of enclosure and an insulating material, moisture is less than in the enclosure with vapour barrier.

Though in premises where air relative humidity reaches 90%, moisture condensation at the junction of materials is unavoidable. It is noticeable in the course of first year of construction life.
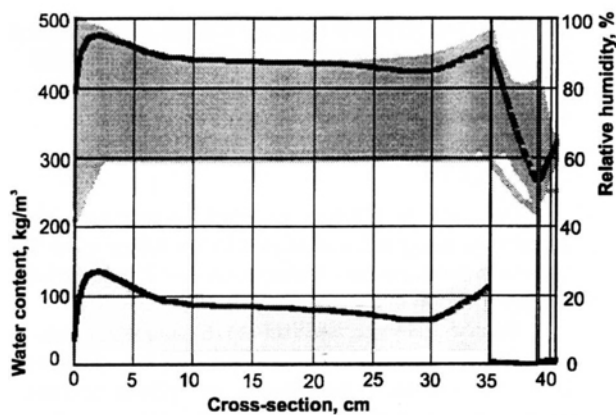
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Fig 4. The external expanded clay concrete wall insulated from the inside 4 cm with mineral wool slabs without vapour barrier, the calculation results of five years. Dark areas show the changes of air relative humidity (above) and moisture quantity (below)
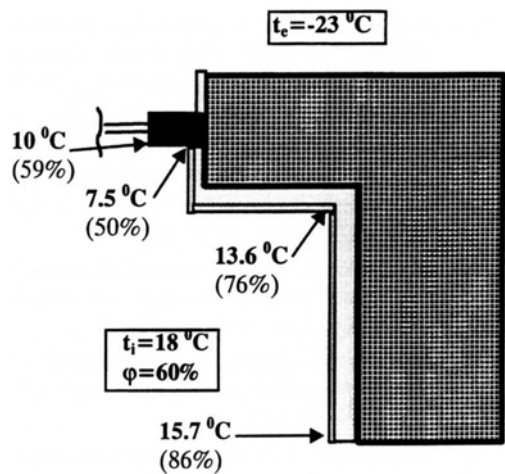

Fig 5. An insulated expanded-clay concrete from the inside with 6 cm thick mineral wool slab. A part of the wall near the window frame from the internal and external side is insulated with 2 cm thick mineral wool slab

3. The disposition of temperature fields

The disposition of temperature fields in insulating constructions is partly reviewed while describing the moisture condition of enclosures. At the junction of an insulating material and in the rest of an insulating construction, temperature values depend on the same above-mentioned condition. A detailed investigation of temperature fields in ceramic hollow brick masonry and expanded-clay concrete constructions is examined in [2]. Therefore we shall mention only some important moments.

When there exists the coldest five days temperature in non-insulated expanded-clay concrete and ceramic brick masonry structures, two spots are noticed, where temperatures are lower than that of an accommodation dew point. Depending on the type of structure and changing the thickness of an insulating material, temperature values can also differ.

For instance, in order to increase temperatures in the corner near the window frame, part of the wall near the window frame and the rest of enclosure must be insulated with mineral wool layer of the same thickness. If it is possible to increase the thickness of mineral wool layer near the window frame, results are better (Fig 5).

4. Conclusions

- The better properties of thermal insulation an insulated enclosure possesses, the greater possibility exists for insulating it from the inside;

- while insulating enclosures from the inside, the best effect is achieved when the thickness of an insulating material during the whole perimeter of an insulating enclosure is the same, because the distribution of temperature fields is equal;

- mineral wool may become moist in a frozen enclosure, where moisture content quantity during maintenance may be bigger than a permissible one. That is why under inclement climatic conditions vapour barrier impact is more meaningful. Its necessity is determined by accommodation purpose, the thickness of an insulating material, thermal and moist properties of an enclosure material;

- if air relative humidity of accommodation does not exceed 60%, vapour barrier cannot be installed; in this case the thickness of an insulating material has to be not bigger than 40 mm;

- evaluating the fact, that there occur complex thermal and moisture processes in structures insulated from the inside, it is recommended to examine thermal and moisture condition of the present enclosure before insulation and accomplish temperature fields calculations.

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DRĖGNUMO KITIMO TENDENCIJOS ATITVAROSE, PAPILDOMAI APŠILTINTOSE IŠ VIDINĖS PUSĖS

A. Čekanavičius

Santrauka

Drėgmės ir šilumos pokyčiai, vykstantys atitvaroje, tarpusavyje susiję ir laikui bėgant kinta. Mūsų šalies klimato sąlygomis temperatūros šiltinamosios medžiagos ir atitvaros sąlytyje gali būti teigiamos ir neigiamos.

Išorinėje sienoje, apšiltintoje iš vidaus su garo izoliacija, drėgmė gali pasišalinti tik per išorinę atitvaros pusę. Todėl vasaros metu pastebimas atvirkštinis procesas, kai sąlytyje su garo izoliacija padidėja mineralinės vatos drėgnumas ir gali atsirasti trumpalaikis kondensatas.

Šiltinamojoje konstrukcijoje be garo izoliacijos pastebimas didesnis drėgnumas ir gali trumpai atsirasti kondensato. Tikimybė atsirasti kondensatui dviejų medžiagų sandūroje sumažėja, atitvarą apšiltinus iš vidaus plonesniu šiltinamosios medžiagos sluoksniu. Priešingai konstrukcijai su garo izoliacija, čia džiūvimas vyksta į abi puses.

Geriausias efektas atitvaras šiltinant iš vidaus gaunamas, kada šiltinamosios medžiagos storis per visą šiltinamos atitvaros perimetrą yra vienodas, nes temperatūrinių laukų išsidėstymas tolygesnis.

Apie garo izoliacijos būtinumą turi būti sprendžiama atlikus apšiltintos atitvaros konstrukcijos šiluminius-drėgminius balanso apskaičiavimus.

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