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Viatceslav Konkov, PhD in Engineering Science, associate professor, deputy director general, "Institute BelNIIS",RUE, Minsk (Belarus)
Yauhenlya Uretskaya, PhD in Chemical Science, assotiate professor, head of the scientific-research department, "Institute BelNIIS",RUE, Minsk (Belarus)
Elena Plotnikova, principal engineer, "Institute BelNIIS",RUE, Minsk (Belarus)

SOME ASPECTS OF MICROCLIMATE CONTROL IN CONCRETE BUILDINGS WHEN APPLYING PLASTERS WITH MOISTURE-REGULATING CAPABILITY

ABSTRACT

The analysis of foreign market of plaster compositions with high moistureregulating capability has been carried out. The article contains the information about the peculiarities of production of plasters with moisture-regulating capability. In order to produce a plaster with moisture-regulating capability as a filler quartz sand and special porous light fillers, mineral binder, modifying additives and agents that improve technical indexes of a final product were used. A very interesting method of a humidity control in residential units is the application of porous fillers that are able to absorb quickly, preserve and then slowly give the moisture back. The result of the research shows that it is possible to control the microclimate in residential and production units not only owing to the expensive conditioning systems that consume quite a lot of energy, but also owing to the use of construction materials that retain and give the moisture back easily. The research has been carried out and plaster compositions with moisture-regulating capability with the use of domestic components has been worked out. The plaster compositions allow to reduce the risk of steam condensation at walls and of occurrence of fungus and mould in a building inner space.

Keywords: moisture-regulating capability, plaster, porous filler, moisture sorption, moisture desorption, air entrainment

INTRODUCTION

Currently, the requirements for a healthy lifestyle, functionality and individuality of dwelling are significantly increasing. Accordingly, the indoor climate is a significant factor for the well-being and quality of human life. In this case, the specified parameters of the microclimate can be achieved not only through the operation of an expensive conditioning system, but also through the use of construction materials that retain and give moisture back easily.

The natural indoor microclimate is created by ensuring a given level of humidity. It is well known that by ensuring a sufficiently high steam permeability of the walls, it is possible to achieve comfortable conditions inside the building, get rid of moisture and mold, cut corners not only on heating, but also on conditioning. Excellent retaining capacity and steam permeability of plaster with a high moisture-regulating capability provide a balanced humidity in the inner space and a pleasant microclimate. Moreover, the higher the capability of walls and ceilings to retain heat, the more uniform and more comfortable is the temperature in the inner space. An essential condition for the "well-being" of a person is also the minimum difference between the inner space temperature and the wall surface temperature.

In a residential building, the process of moisture movement from the inside to the outside through the walls is constantly in progress when the outdoor temperature is below indoor temperature. The amount of flowing out steam depends on the difference in temperature and humidity outside and inside the inner space. In this case, the lower the humidity is, the less is the probability of internal condensate generation.

The relatively stable humidity in the inner space has a significant impact not only on the health of the dwellers, but also on the energy consumption in the house: the drier the air is, the less heat is needed to heat the inner space.

The use of innovative approaches, systems and materials in construction will provide an opportunity not only to improve existing ones, but also to create fundamentally new materials and technologies in this industry of construction.

PLASTERS WITH MOISTURE-REGULATING CAPABILITY

Most of the innovations that are currently being introduced in the construction industry are associated with the creation of new construction materials.

A very important indicator of construction material is its moisture sorption, as it is one of the main causes of damage and destruction of buildings.

Moisture causes or accelerates the following processes: electrochemical corrosion of metal products and parts; chemical damage to gypsum cladding, ceiling tiles, wooden materials; changing the color of the architectural details of the building; change in the volume of materials of structures (swelling, warping, shrinkage); biological damage (mold, plant growth, dust mites appearance).

Biological damage, mainly of fungal type, that occurs due to moisture, has recently been given particular importance, since these phenomena can affect people's health, the state of the structures and the appearance of buildings.

As a result of the vital activity of people and various industrial processes in buildings, there are significant emissions of moisture. At the same time, the supply of steam from different sources is very different. So, for example, the steaming of a pool with heated water or the release of steam in paper production is much more than the release of moisture as a result of the presence of a small number of people in a fairly large inner space.

It should be noted that the relatively stable humidity in the inner space has a significant impact on the health of dwellers and energy consumption in the house. It is well-known that the drier air is, the less heat is needed to warming-up the inner space. At the same time, the dwellers feel better in dry air than in wet air.

Table 1 shows some sources of moisture and their values in buildings.

Table 1

The intensity of moisture in buildings

Moisture source	The intensity of moisture issuance, l/day
People (moisture issuance made by one person)	0.75 (sedentary work) from 1.2 to 5 (hard work)
Air humidifiers	from 2 to 20
Hot bath	from 2 to 20
Floor cleaning	0.2
Washing of dishes	0.5
Cooking for 4 people	from 0.9 to 2 (3 with gas accounting)
Automatic defrosting refrigerator	0.5
Washing/washing of hands (for 1 person)	from 0.2 to 0.4
Shower (for 1 person)	0.5
Seasonal water yielding capacity (or new construction materials)	from 3 to 8 (depending on the building structure)

While performing this research, much attention was paid to the moisture-retaining capability of plaster materials and the possibility of their drying.

In order to solve this problem, Sto AG (Switzerland) in collaboration with Etra, a Swiss federal laboratory for materials science and technology, developed a special plaster for walls.

A distinctive feature of this plaster is its capability to absorb moisture from the air much more efficiently than the vast majority of currently existing traditional lime plasters. While its creation, the developers adhered to the following criteria: plaster should be moisture-regulating, mineral-based,

easy to use and not too expensive compared to existing analogues.

This plaster for walls is capable of absorbing 90 grams of steam per 1 m^2, which is a third higher than the similar possibilities of the best clay-based plaster. According to the developers, in order to achieve the maximum degree of moisture absorption, moisture-regulating plaster should be applied onto the walls with a thickness of 10 - 20 mm. Using this product significantly reduces the risk of condensation of steam on cold walls. Moisture-regulating plaster drains the excess moisture from the air in the inner space and releases it back into the inner space after a few hours. It should be noted that the relatively stable humidity in the inner space has a significant impact on the health of dwellers as well as on the energy consumption in the house. It is well-known that the drier the air is, the less heat is needed to warm-up the inner space. At the same time, the dwellers feel better in dry air than in wet air.

The Schaefer Krusemark construction company (Germany) is widely known in the global construction market, and has also recently begun work on creating a moisture-regulating plaster.

For the production of the above-mentioned plaster, high-quality calcined sands and special granulated lightweight fillers, mineral binders, certain additives and tools that the improve technical indexes of a final product were used.

The above plaster compositions have the highest steam permeability and good adhesion. According to the developers, the higher the steam permeability rate is, the better the wall breathes, and the faster it dries.

An interesting, in our opinion, way of regulating moisture in residential premises is the use of porous fillers [1, 2, 3].

Porous fillers have the capability to quickly collect, preserve, and then slowly release moisture, smoothing out daily and seasonal differences in humidity. This plaster mixture should absorb a large amount of moisture, and then slowly give it away again. Thus, a fairly simple and inexpensive composition using various porous fillers will be very effective in maintaining the optimum humidity conditions in houses.

In connection with the foregoing, we used mineral binders (Portland cement M500 D 20, hydrated lime), modifying additives (methyl cellulose Mecellose FMS 2250, air entraining additive Berolan LPW 1), finely dispersed fillers (calcium carbonate, dolomite), filler (quartz sand), porous fillers (porover, expanded vermiculite, expanded perlite, expanded polystyrene granules, expanded clay sand) and Arbocel PWC 500 cellulose fiber in the present work of developing the moisture-regulating plasters.

MAIN CHARACTERISTICS OF PLASTERS WITH MOISTURE-REGULATING CAPABILITY

In our opinion, moisture-regulating plaster wall covering should meet the following requirements:

- air entrainment of the mortar mixture should be at least 20%;
- the porosity of the plaster should be at least 45%;
- adhesion strength with wall material should be not less than 0.2 MPa;
- the average density of the solution should be not more than 1100 kg/m^3;
- steam permeability coefficient of plaster layers should be at least 0.06 mg/m h Pa;
- moisture absorption should be about 90 g/m^2;
- moisture recovery of plaster coating should be carried out during a few hours.

This article presents the results of studies of various compositions of moisture-regulating plasters. In particular, tests of the strength characteristics of cement binder with different content of finely dispersed fillers (dolomite, calcium carbonate) were carried out.

As a result of the tests, it was established that in case of the content of calcium carbonate and dolomite of not more than 20 mass %, the compressive strength does not change. With increasing dolomite content, the strength characteristics of the binder decrease. The increase in the content of

calcium carbonate in mixtures of more than 20 mass % leads to a slight decrease in compressive strength.

Therefore, the use of calcium carbonate as a filler in a moisture-regulating plaster is preferred.

In addition, as a result of the tests, it was found that in case of using of dolomite as a fine filler, the formation of efflorescence on the plaster is possible.

For further optimization of plaster solutions, the following methods were used to create a porous structure of materials:

- air entrainment and the formation of air pores directly in the solution;
- preparation of the solution with the introduction of a light porous filler.

For the pores formation in the plaster solutions by entraining air and the formation of air pores directly in the solution, "Berolan LPW 1" blowing agent was used, which stabilizes the mechanical trapping of air in an amount from 0.01 to 0.06% of the weight of the dry mixture.

It is established that the air entraining increases to 20% if the content of the blowing agent content in the solution is not less than 0.02%.

In the present work, cellulose derivatives, namely, methyl cellulose Mecellose FMC 22501 (MC), were used to prevent the "drying out" effect and increase of the air entrainment. It was established that with the introduction of the above additive into the plaster mixture, the air entrainment reaches a value of 14-15%.

One of the main components in the development of moisture-regulating plaster are porous fillers. The type of porous fillers is determined by the maximum size and shape of the grains, grain composition, the content of fine particles and porosity.

The main indicator of the quality of the solutions when using these fillers is a decrease in the density of plaster solutions.

Artificial porous fillers differ from fillers obtained from industrial wastes with the stability of the composition and properties, and therefore fillers of this category are recommended for use in building mixtures for obtaining moisture-regulating plaster.

The following porous fillers were used in this work:

- expanded perlite grain composition of not more than 1.5 mm and a bulk density of not more than 100 kg/m^3;
- expanded vermiculite grain composition of not more than 1.5 mm and a bulk density of not more than 150 kg/m^3;
- expanded clay sand of grain composition not exceeding 5 mm and a bulk density of 640 kg/m^3;
- expanded polystyrene is a granular bulk material obtained from expandable polystyrene, into which the air pores former is being introduced, with the bulk density of 35 kg/m^3;
- porover, which is a specially processed, granulated glass, inflated in the form of small balls with a dispersion of 0.1-0.3 and 0.2-0.5; it is light, strong, chemically resistant and not combustible material.

The filler has a significant impact on the setting time of the construction mixture. The filler introduced into the cement paste due to the appearance of surface forces shortens the structure formation period, and the higher the fillers content and its specific surface are, the greater its influence is.

The presence of the filler significantly affects the hardening conditions of the cement stone. In the building mortar, the interaction of cement with water and its hardening occur in thin layers between the grains of the filler with constant interaction with it. The filler increases the water-holding capacity of the cement paste, limits shrinkage deformations, promotes the formation of the crystalline framework of the cement stone, and influences the change in temperature and humidity in hardening cement stone.

Air entrainment and moisture sorption for 3 hours of exposure at a humidity of (98 ± 2)% and

a temperature (20 ± 2) °C of moisture-regulating plasters on a cement binder with various lightweight fillers are presented in Figure 1.

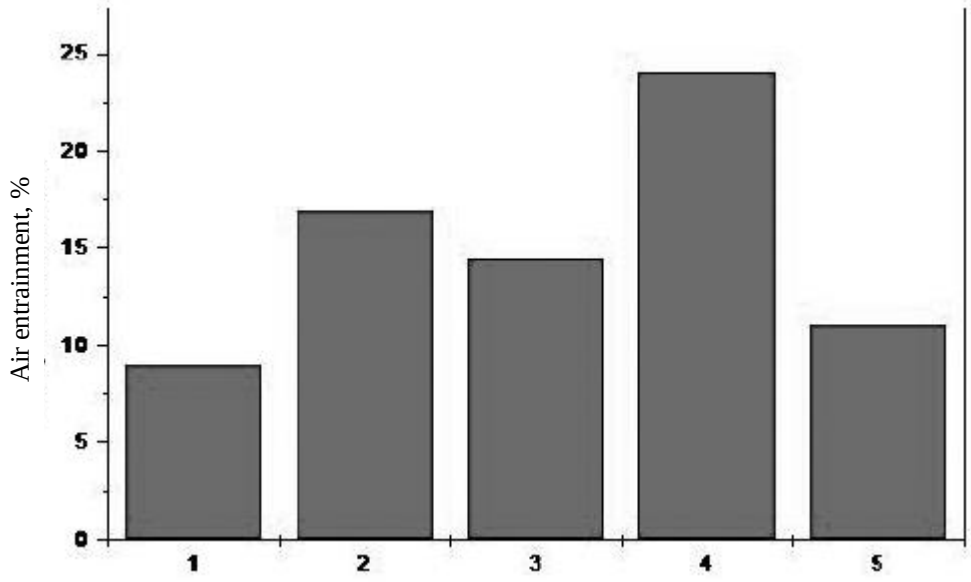

Figure 1. Air entrainment of moisture-regulating plaster on cement binder with lightweight fillers

1. - control composition;
2. - 10% expanded perlite;
3. - 20% porover;
4. - 10% expanded vermiculite;
5. - 5% expanded polystyrene.

It should be noted that in this case the moisture-regulating plaster, where the expanded vermiculite is used as a porous filler, has the highest air entrainment.

The pores and capillaries of the absolutely dry material are filled with air. However, if the construction material is in the air containing steam, a certain amount of steam penetrates the material's air pores and condenses on their walls until an equilibrium moisture is established, which depends on the partial pressure of steam in the ambient air.

The change in the content of steam in a moisture-regulating plaster on a cement binder is presented in Figure 2.

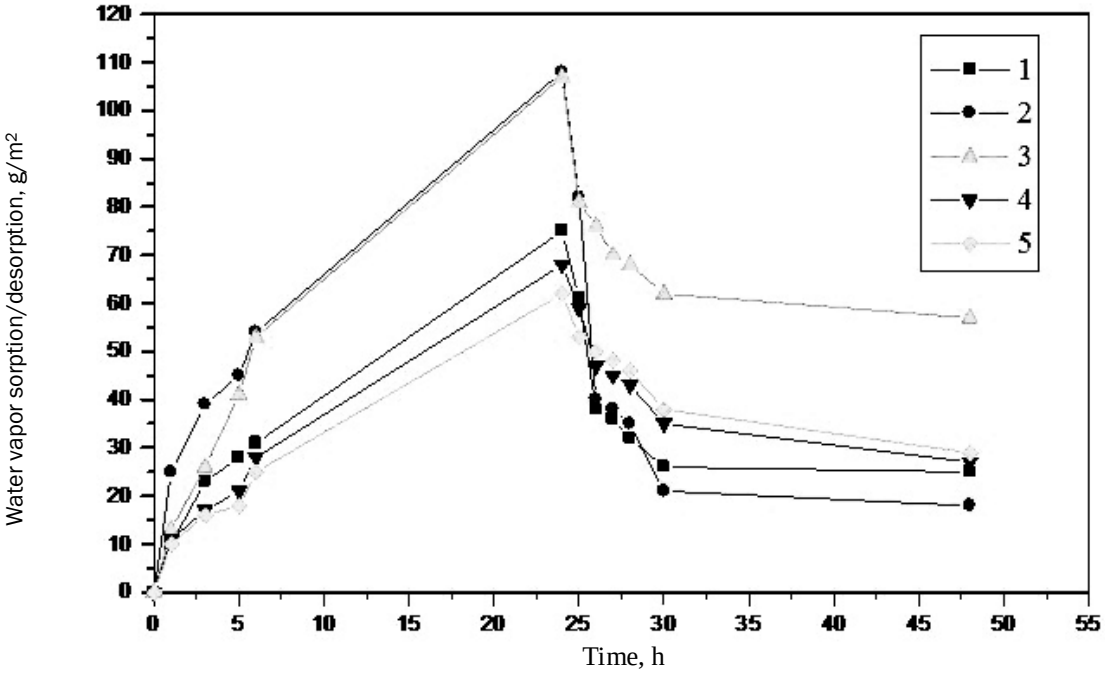

Figure 2. The change in the content of steam in the plaster from the exposure time: (1-24) h - moisture sorption at (98±2)% of humidity; (24-48) h - moisture desorption at (60 ± 5)% of humidity

1. - 10% expanded perlite + 0.1% MC;
2. - 10% expanded vermiculite + 0.1% MC;
3. - 10% expanded vermiculite + 0.3% MC;
4. - 20% porover + 0.1% MC;
5. - 5% expanded polystyrene + 0.1% MC.

Thus, it was found that the composition of a moisture-regulating plaster containing 10% vermiculite is optimal as a result of scientific research.

In order to optimize the composition of moisture-regulating plaster further, Arbocell PWC 500 cellulose fibers made from natural raw materials were used. In this work, the fibers of "Arboce1 PWC 500" were used as a thickener, a reinforcing agent and an adsorbent.

The dependence of the air entrainment of moisture-regulating plaster with expanded vermiculite from the content of the abovementioned cellulose fiber is shown in Figure 3.

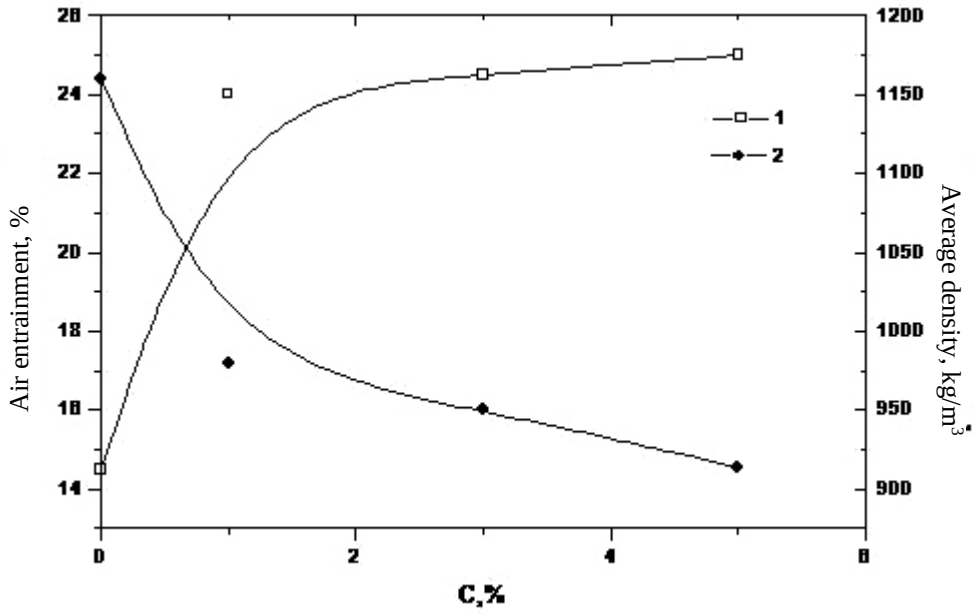

Figure 3. Dependence of air entrainment (1) and average density (2) of moisture-regulating plaster with expanded vermiculite from the content of cellulose fiber

The changes in steam content in a moisture-regulating plaster containing expanded vermiculite, methyl cellulose of Mecellose FMC 22501, air entraining additive of Berolan LPW 1, cellulose fiber of Arbocel PWC 500 are shown in Figure 4.

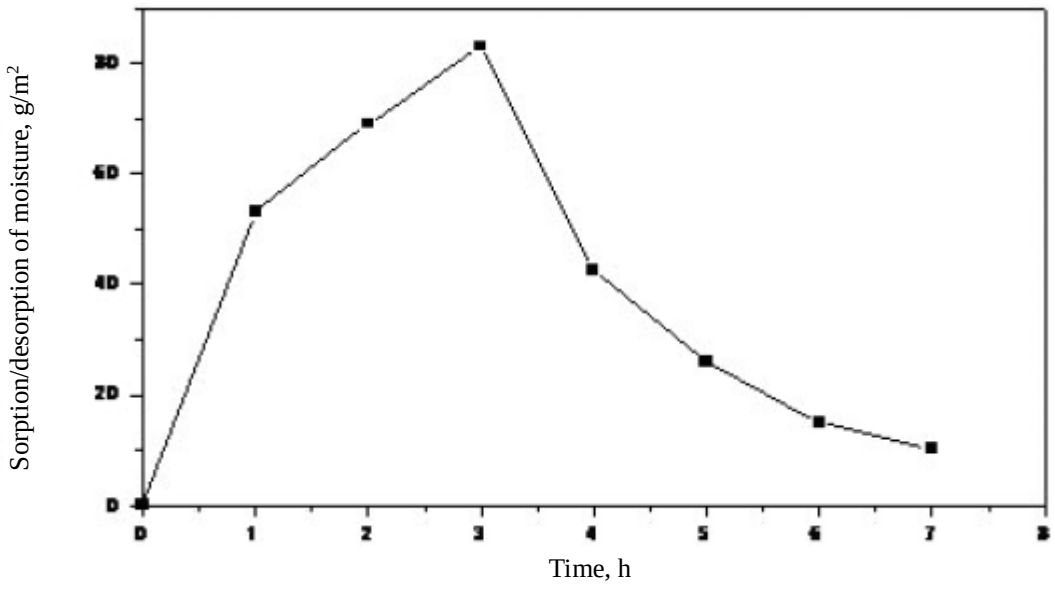

Figure 4. Changes in steam content over time: exposure (0-3) hours - moisture sorption; exposure (3-7) hours - moisture desorption

Thus, when performing this study, it was established that plasters with a high moisture-regulating capability have a number of advantages as compared with traditional cement plasters. First of all, these plasters are actively "breathing". Their capability to absorb moisture from the air is significantly better than the one of traditional plasters.

CONCLUSION

An analysis of world engineering practice has shown the feasibility of controlling the microclimate in the premises of residential and industrial assets not only due to the operation of expensive air conditioning systems that consume a significant amount of energy, but also through the use of construction materials that retain and give moisture back easily.

Studies have been carried out and plaster compositions have been developed with a moisture-regulating capability using domestic components, which allow to reduce the risk of condensation of steam on the walls and the occurrence of fungus and mold in the inner space.

The development of plaster compositions with high moisture-regulating capability in the Republic of Belarus was carried out for the first time.

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