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AN ANALYSIS OF THE TECHNOLOGICAL PROPERTIES OF FACILITATED PLASTER SOLUTIONS MADE FROM DRY BUILDING MIXES

ANALIZA TEHNOLOŠKIH SVOJSTAVA OLAKŠANIH GIPSANIH RJEŠENJA IZ SUHIH GRAĐEVINSKIH MJEŠAVINA

Christina Moskalova, Oleg Popov

Preliminary communication

Abstract: *The paper deals with the development and optimization of the compositions of dry building mixes for heat-insulating plaster with improved technological properties and with the rational use of the modifying polymeric additives.*

Keywords: *dry building mixes, polymer, perlite sand*

Prethodno priopćenje

Sažetak: *U članku se razmatra razvoj i optimizacija sastava suhih građevinskih mješavina za toplinsko-izolacijske žbuke s poboljšanim tehnološkim svojstvima uz racionalno korištenje modificirajućih polimernih aditiva.*

Ključne riječi: *suhe građevinske mješavine, polimer, vulkanski pijesak*

1. INTRODUCTION

Nowadays the dry building mixes (DBM) are applied practically in all kinds of activities, but more often in the the external and internal finishing. Under the modern conditions, with the permanent increase of the cost of resources, the task is to reduce the operating costs of buildings at the expense of enriching the heat-protective characteristics of the enclosure walls. The reduction of heat loss through the walls of buildings can allow the reduction of the cost of the heating fuel and also of the emission of combustion products, which will cause a positive ecological effect. According to that, lightweight heat-insulation plaster solutions, the so-called warm plasters, are becoming more and more popular in the modern building market. The main objective of the research is to investigate the building mixes' rheological and mechanical behavior in their fresh state. As it will be discussed later, the mineral fillers and polymeric additives have a significant rheological influence on the building mixes, which over time becomes crucial to their durability behavior.

2. RESEARCH AND RESULTS

According to the State Standard (SS) 28013-98, lightweight plasters belong to the solutions with a density not more than 1500 kg/m^3 [1]. Literature [2] contains some information which indicates that in the case of lightweight plaster, it is right to consider that lightweight plaster whose density is not over 1300 kg/m^3 is the solution. As a result, the heat-insulating plaster solutions are characterized by the low parameters of compression strength, in the range of 3 MPa. Heat-insulating plasters are used as solutions with lightweight fillers and a large part of them are perlite. Apart from the low density, the particles of perlite, at the expense of the surface roughness, promote a stress relaxation on the border between the plaster and the basis, which is an important factor of the spalling avoidance [3, 4]. When analyzing the multi-component solutions of heat-insulating plasters, it is concluded that finished dry mixes of industrial preparation are more often used for their preparation.

Modern DBMs are a multi-component organic mineral system [5] where a high-molecular organic component is presented in a variety of materials:

- water-soluble, for example, methylcellulose;
- re-dispersible in water, in particular the copolymers of vinyl ester;
- waterproof, in particular the polymeric and cellulose fibers.

The rheological behavior of mixtures and mechanical characteristics of the composites received from the dry mixes with the cement binder, and also the influence on the yielded properties introduced in a DBM of organic compounding (polymers) and mineral fillers has been studied. One of the primary goals of the research is the reduction in the composition of the dry mixes of an expensive perlite at the expense of the introduction of the limestone coquina. At the same time, the required physical-mechanical performance and technological properties of the plaster obtainable from the DBM should be saved.

The base structure of the investigated dry mixes includes binder, mineral fillers and polymeric additives. The experiment was conducted under the optimal 18 points plan [6]. The following components such as the four factors of structure (in relation to 1000 m.u. dry mix) were used:

X_1 - limestone powder to S_{sv} = 400 m^2/kg, 80 ± 20 m.u.;

X_2 - circulated perlite sand of mark 100, 40 ± 10 m.u.;

X_3 - methylhydroxyethylcellulose Tylose 60010 (water-soluble, nonionic ethers of cellulose), 1.15 ± 0.15 m.u;

X_4 - polymeric re-dispersible powder Vinnapas RE 5034N (copolymer vinylchloride, ethylene and vinyllaurate), 1.5 ± 0.5 m.u.

Each investigated mixture had an identical flowability of 16-17 cm of flow at the expense of the selection of the quantity of mixing water. This condition was accepted by taking into account the typical technological working conditions of manufactured dry blends and equipment parameters.

The flowability of mortar mixes was defined under the European standard DIN 18555-2 [7] on a jolt-table as such technique, from our point of view, is more correct for a DBM heat-insulating facing plaster compared to the technique of SS 5802-86 [8]. According to the diameter of flow, the plasters' mortar mixes are divided into: rigid <14 cm; plasticity - 14-20 cm and soft >20 cm. On the basis of this, all investigated blends refer to the plastic mix. Nevertheless, despite the equal flowability of all mixes, their rheological properties essentially differed.

3. RESULTS AND ANALYSIS

Rheological tests were performed on a rotary viscometer RPE-1M; the viscosity of mixes has been analyzed at a speed of deformation from 0.045 c^{-1} to 5.705 c^{-1}. According to the data obtained from the viscometer, the measured was plotted versus the applied rotational velocity (ln γ') from viscosity (ln η). Figure 1 shows examples of the curves of deformations for compositions with 40 (a) and 20 (b) parts by mass units of perlite; curves represent a logarithmic dependence of the viscosity of the mixture of the speed of the deformations.

In each figure we can see two curves, one of them is on the top line and it describes the viscosity of a mix, and the second one, on the bottom line, shows the ability of a mix to restore the thixotropy of mixes. Firstly, it is important to note that the level of thixotropy of mixes at the structures with a considerable quantity of perlite is above the ones with a low content of perlite. This is evidenced by the differences of "straight" and "return" curved lines. The values of viscosity were obtained by using the Ostwald-de-Ville equation [9] $\eta = K\cdot(\ln \gamma')$ m, with the speed gradient ln $\gamma' = 0$ c^{-1}. For example, according to the curved lines in Fig. 1, it is possible to make the conclusion that the viscosity of mixes with the minimum quantity of perlite is equal to η =177 Pa·s or a little above, than in the mixes with the maximum maintenance of the given filling material (η =124.9 Pa·s), and with a lower ability of the structure for restoration. According to the 18 research data findings, an adequate experimental and statistical model was built, which describes the impact of variable factors on the viscosity of the mixture (an experimental error S_e= 38.1), see Eq. (1):

$$\begin{aligned}\eta\ (\text{Pa}\cdot\text{s}) = 399.0 \pm 0x_1 &- 89.3x_1^2 \pm 0x_1x_2 - 21.9x_1x_3 - 23.6x_1x_4\\ +41.7x_2 &- 57.3x_2^2 + 19.5x_2x_3 + 22.7x_2x_4\\ +27.2x_3 &- 114.5x_3^2 + 25.0x_3x_4\\ +69.2x_4 &\pm 0x_4^2\end{aligned} \quad (1)$$

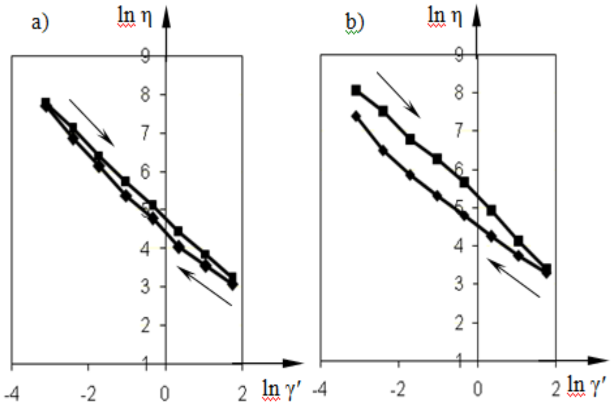

Figure 1. The curves of viscosity with an increasing and decreasing gradient of the speed of deformations for the compositions with the maximum (a) and minimum (b) contents of perlite

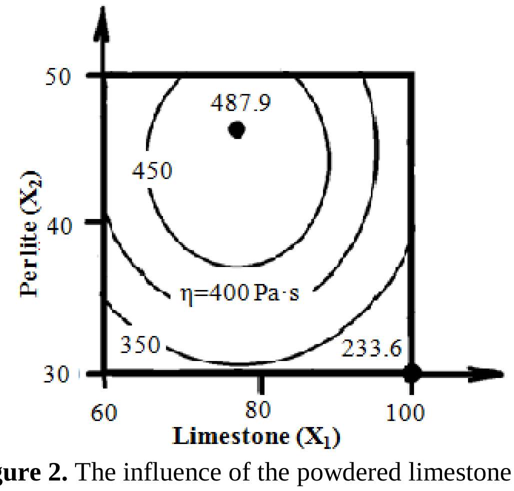

Figure 2. The influence of the powdered limestone and perlite on the viscosity of the mix

In accordance with this model, a diagram has been constructed. Fig. 2 illustrates the effect of the amount of the powdered limestone and perlite on the viscosity of the mix. The diagram is built for structures with an average quantity of methylhydroxyethylcellulose (x_3=0) and the maximum quantity of the re-dispersible powder Vinnapas (x_4 = 1). The analysis of the diagram allows us to say that the compositions with the average number of limestone (80 m.u.) and the amount of perlite about 45 m.u. are the most viscous. Therefore, at the observance of a constant flowability of a mix at the expense of a change of the quantity of a small filling material, it is possible to essentially change the viscosity of a mix.

Durability cannot be considered a basic property for lightweight mortars, however, this figure should be provided at a sufficient level for this material. On the base of a similar model (1), a diagram shown in Fig. 3 has been built. It shows the influence of the quantity of the limestone and perlite by the amount of the compressive strength for structures, which is identical by quantity to the methylhydroxyethylcellulose and Vinnapas that are presented in Fig. 2.

As it is possible to notice from the diagram, more viscous structures also show more durability. Generally, within the factorial space of the experiment, under the influence of a variation of factors of the structure, the durability of a plaster mix changes two times from 2.4 to 4.3 MPa. Thus, the structures with an average quantity of a limestone demonstrate the strongest character (about 80 m.u.). At the same time, the quantity of perlite at which the material reaches its maximum strength depends on the dosage of Tylose. Therefore, with a higher level of the factor x_3, and a larger number of perlite (x_2), we can observe the maximum strength.

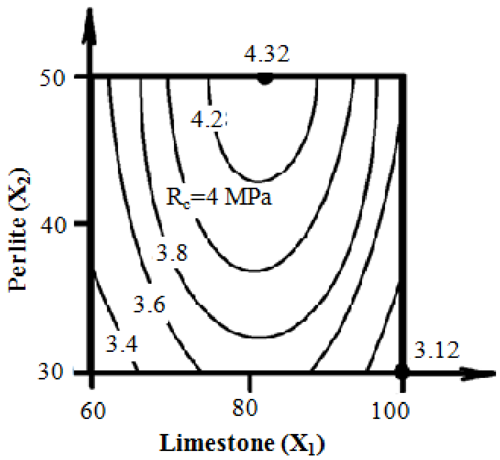

Figure 3. The influence of a ground limestone and perlite on the compressive strength

The frost resistance of a lightweight plaster mix is also included in the complex of the investigated properties within the limits of a given work. The results of research have shown that the compositions with an equal or above average quantity of methylhydroxyethylcellulose and Vinnapas (1.15 and 1.5 m.u.) respectively show frost resistance not below 50 cycles, which is a sufficient level for the given type of material.

Density can be considered as the most important property of lightweight plaster mixes because this indicator defines their heat-protection ability. The analysis of hardened composites has shown that at equal or above average quantity of methylhydroxyethylcellulose and Vinnapas, the values of the density of facing plasters do not exceed 1200 kg/m^3, which is more preferable in comparison with the 1500 kg/m^3 described as the standard, and even 1300 kg/m^3 which has been recommended. Moreover, it is possible to notice that with the increase of the quantity of the ground limestone from 60 to 80 m.u., the density of plaster mixes did not raise practically in any of the experimental factor space.

4. SUMMARY AND CONCLUSIONS

The above described effects can be explained as the changes of the mineral framing of packing particles; however, it cannot be assumed that the composites durability is provided by the low-strength perlite and limestone. The indirect proof of this is that the strongest solutions (above 4.2 MPa) turn out in the area with the maximum quantity of the re-dispersible powder Vinnapas and methylhydroxyethylcellulose, which are in a greater degree the factors that influence the cement matrix.

Thereby, the carried out analysis of the influence of the composition of the lightweight plaster mix on their indicators of quality - viscosity, durability, frost resistance and density, allows for the recommendation to use dry building mixes with a higher quantity of methylhydroxyethylcellulose and Vinnapas at up to 80 m.u. of the powdered limestone. Thus, the quantity of perlite as a part of a plaster mix can be lowered from 50 to 40 m.u. without any deterioration of the basic quality indicators.

5. REFERENCES

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Contact addresses

Popov Oleg, Phd, Vice-rector
Odessa State Academy of Civil Engineering and Architecture
Didrihsona str. 4
Odessa 65029
Ukraine
e-mail: prorector_npr@ogasa.org.ua

Moskalova Christina, Phd
Odessa State Academy of Civil Engineering and Architecture
Department of International Relations
Didrihsona str. 4
Odessa 65029
Ukraine
e-mail: intercom@ogasa.org.ua