Optimization of the Synthesis Additive on the Basis of Amorphous Aluminosilicates

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Abstract. The article presents information on the possibility of applying additive based on amorphous silicates in the lime dry construction mixtures. The methods of synthesis additive on the basis of amorphous aluminosilicates are investigated. Using the method of mathematical planning of the experiment, the optimal mode of synthesis additive was chosen. The compressive strength of lime samples with an additive based on amorphous aluminosilicates obtained at different synthesis times and the ratio of the solid and liquid phases is calculated. The studies and calculations show the effectiveness of the use of amorphous aluminosilicates in lime composites as a structure-forming additive. The lime mixture with the use of amorphous aluminosilicates is characterized by good workability and a high value of compressive strength equal to 2.4 MPa.

1. Introduction

Modern direction in the field of building materials is the development of building materials with improved performance properties. This can be achieved through the targeted formation of the structure of the material by introducing various types of modifying additives into its structure [1-8].

In Russia, a wide range of modifying additives for dry construction mixtures (DCM) is presented, but the vast majority are imported. In this regard, it is proposed to use amorphous aluminosilicates to expand the range of modifying additives of domestic production for DCM. Earlier studies have shown the feasibility of using an additive based on amorphous aluminosilicates in the recipe of cement and lime DCM [9-13].

Analysis of the scientific literature [14, 15] revealed a variety of methods for producing amorphous aluminosilicates. To obtain the proposed additives considered a patent [16], in which the synthesis of the proposed additive consists in mixing microdispersed powders of aluminum and sodium liquid glass at \( t = 60-90 ^{\circ} \text{C} \) for 30-120 minutes.

To ensure the effectiveness of the proposed inorganic nano-dispersed additive in the recipe of lime DCM it is necessary to choose the optimal synthesis mode. For this purpose, a full factorial experiment with a quadratic model was designed in [17].

2. Research Objectives

The aim of the work is to select the optimal mode of synthesis of the additive based on amorphous aluminosilicates for lime dry building mixes. To achieve the goal it is necessary to solve the following tasks:
– to study methods for optimizing the synthesis of additives;
– explore modes of additive synthesis;
– develop a plan for experimental research;
– establish the dependence of the change in compressive strength of the lime composite on the technological factors of the synthesis of the additive;
– select the optimal mode of synthesis of aluminosilicate additives.

3. Theoretical Part
The optimization parameter is chosen for the compressive strength of lime samples. For the factors that have an effect on the change in strength of the lime composite are taken: $x_1$ - the ratio of solid: liquid phase and $x_2$ - the time of synthesis of the additive. In the Table 1 presents the conditions for changing variables.

| Name        | Coded designation | $x_1$, % | $x_2$, min |
|-------------|------------------|----------|------------|
| Lower level | -1               | 0,045    | 60         |
| Main level  | 0                | 0,09     | 90         |
| Upper level | +1               | 0,135    | 120        |
| Variation interval | $\Delta$ | 0,09 | 30 |

The homogeneity of the variances was checked by the Cochren criterion, the adequacy of the model was checked by the Fisher criterion, and the significance of the coefficients by the Student criterion. After processing the obtained experimental data and excluding insignificant coefficients from the regression equation, the model described by equation (1) is considered adequate. The obtained results allowed us to obtain a quadratic model:

$$R_{com} = 1,9 + 10,78x_1 + 4,98x_2 - 0,0988x_1^2 - 3,77x_2^2$$

(1)

Graphic interpretation of the model is presented in Figure 1.

![Figure 1. Dependence of compressive strength of a lime composite on technological factors of additive synthesis.](image)
When analyzing the obtained quadratic model, the extremum points were revealed. The proposed model allows you to choose the optimal content of the components.

Using the obtained quadratic model (1), we calculated the compressive strength of lime samples with an additive based on amorphous aluminosilicates, obtained at different synthesis times and solid: liquid phase ratio (Table 2).

### Table 2. Compressive strength of lime composite, water / lime = 1.25.

| The ratio of solid: liquid phase, % | Synthesis time of the additive, min. | Compressive strength of lime compositions, MPa |
|-----------------------------------|-------------------------------------|-----------------------------------------------|
| 0,045                             | 60                                  | 2,125                                         |
| 0,135                             | 60                                  | 1,201                                         |
| 0,045                             | 120                                 | 2,355                                         |
| 0,135                             | 120                                 | 1,419                                         |
| 0,026                             | 90                                  | 1,11                                          |
| 0,15                              | 90                                  | 1,009                                         |
| 0,09                              | 48                                  | 1,757                                         |
| 0,09                              | 132                                 | 2,213                                         |
| 0,09                              | 90                                  | 2,12                                          |

The German standard DIN EN 998-1 establishes that durability and resistance to external influences are ensured if the plaster mortar has compressive strength $R_{com} = 2 - 5$MPa [18]. Solutions with such strength characteristics are able to adapt to small deformations and resist cracking.

### 4. Summary

Based on the data of the mathematical model and the previously obtained data on the porosity of the samples based on the aluminosilicate additive [19, 20] and also taking into account the requirements of the DIN EN 998-1 standard, the optimal synthesis mode was chosen. The synthesis mode consists in adding microdispersed aluminum powders to sodium liquid glass at a temperature of 60°C for 90 minutes. In this case, the ratio of the components is: aluminum powder: liquid glass: water in a ratio of 1:8:14.

The lime mixture with the use of amorphous aluminosilicates is characterized by good workability and a high value of compressive strength equal to 2.4 MPa.

Thus, the studies and calculations indicate the effectiveness of the use of amorphous aluminosilicates in lime composites as a structure-forming additive.

### 5. References

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