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S. H. Bayramukov; Z. N. Dolaeva; N. I. Fomin ✉; M. M. Kidakoeva

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Evaluation of the Influence of Thickening Agent and Graving Reducer on the Technological Properties of DCM

S H Bayramukov[1,2,a)], Z N Dolaeva[1,b)], N I Fomin[3,c)] and M M Kidakoeva[2,d)]

[1]*North-Caucasian State academy, 36b, Stavropolskaya str., 369000, Cherkessk, Russia*
[2]*Nevinnomyssk State Humanitory and Technical Institute, 17, Bulvar Mira str., 357108, Nevinnomyssk, Russia*
[3]*Ural Federal University named after the first President of Russia B.N.Yeltsin, 19, Mira str., Ekaterinburg, 620002, Russia*

[a)] *salis_pochta@mail.ru*
[b)] *bdolaeva.zu@mail.ru*
[c)] *Corresponding author: nnimoff@mail.ru*
[d)] *dmeremhan2377@mail.ru*

Abstract. The study of the effect of thickener and retarder on the technological properties of the GPM START. Full-factor plans for a two-factor model have been developed, with a minimum (0.1%; 0.005%) and maximum (0.2%; 0.05%) dosage level of pore-forming and water-holding additives, respectively. The regression equations of the output parameters obtained in the form of a polynomial of the second-degree using regression and correlation analysis of experimental data. An analysis of the values of the partial correlation coefficients showed that the start of setting and expansion determined mainly by the moderator. With an increase in the dose of water-holding and pore-forming additives from 0.1% to 0.2% and from 0.005% to 0.05% of a binder, respectively, for all possible combinations of the dosage of thickener and setting retarder, an increase in setting time is observed by 10 ... 72%, and expansion by 33 ... 80%. The mixture in which the amount of thickener was 0.2% (at the upper level) and the amount of moderator was 0.04% (at the lower level) turned out to be the least sensitive to the increase in water-holding and pore-forming additives.

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INTRODUCTION

Currently, the composition of dry construction mixtures (DCM) has a large number of functional additives, thanks to which it is possible to dramatically affect the main technological properties of mortar mixtures [1-5]. Thus, it is the additives make the dry mixture attractive for performing a certain type of work in various conditions [3, 4].

This article presents a study of the effect of the thickener and setting retarder on the technological properties of gypsum plaster mixes (GPM) START.

To conduct a study of the influence of variable factors on the technological properties of GPM START, full-factor plans for a two-factor model (2×2) were developed, with a minimum ($X_2 = 0.1\%$; $X_1 = 0.005\%$) and maximum ($X_2 = 0.2\%$; $X_1 = 0.05\%$) the dosage level of the pore-forming and water-holding additives.

METHODS

The research plan is a matrix whose columns correspond to various combinations of factors. When compiling it, we proceed from the fact that the required dependences described with sufficient accuracy by a second-order polynomial [1], [2]. Based on the accepted hypothesis, as mutable factors we accept: X_3 – thickener; X_4 – setting retarder. Table 1 presents the plan of a two-factor experiment in two gradations (2×2), studies of the effect of the thickener and setting retarder on the technological properties of GPM START, with minimum and maximum values of water-holding (X_2) and pore-forming (X_1) additives.

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The resulting data array processed using the software package "STATISTIKA", "Analysis Package" and "Solution Search" in MS Excel.

RESULTS AND DISCUSSION

Mathematical processing of experimental data, using regression and correlation analysis, allowed us to obtain the regression equation of the output parameters (Y_1, Y_2, Y_3) in the form of a polynomial of the second degree:

- for a minimum dosage level of factors $X_2 = 0.1\%$; $X_1 = 0.005\%$

$$Y_1 = 104.56 + 63.13 \cdot X_3^2 + 10416.67 \cdot X_4^2 \tag{1}$$

$$Y_2 = 26.124 + 315.657 \cdot X_3^2 + 6250 \cdot X_4^2 \tag{2}$$

$$Y_3 = 10.239 - 18.182 \cdot X_3^2 - 107.143 \cdot X_4^2 \tag{3}$$

- for the maximum dosage level of factors $X_2 = 0.2\%$; $X_1 = 0.05\%$

$$Y_1 = 150.52 - 1010.1 \cdot X_3^2 + 20238.1 \cdot X_4^2 \tag{4}$$

$$Y_2 = 22.45 + 1010.1 \cdot X_3^2 + 10417.29 \cdot X_4^2 \tag{5}$$

$$Y_3 = 9.218 - 11.364 \cdot X_3^2 + 101.191 \cdot X_4^2 \tag{6}$$

TABLE 1. The Matrix of the initial data of studies of the influence of thickener X3 and retarder setting X4 on the technological properties of GPM START.

Factors And functions response	Additives		Recorded Parameters					
Experience number	Thickener	Setting retarder	Setting start		Expansion		Material consumption per 1 m^2	
The code: X_0	X_3	X_4	Y_1		Y_2		Y_3	
Units	%	%	min		min		kg/m^2	
U. level	0.20	0.10	Value	percentage change	Value	percentage change	Value	percentage change
L. level	0.02	0.04						
M. level	0.11	0.07						
1	0.02	0.04	90 155	72	35 50	43	9.92 8.90	-10
2	0.20	0.10	180 285	58	100 180	80	8.30 9.30	12
3	0.02	0.10	240 380	58	90 120	33	9.30 10.70	15
4	0.20	0.04	155 170	10	50 70	40	9.48 9.40	-1

Note to table. The upper values in the cells of the recorded parameters correspond to the lower dosage level of factors X_2=0.1%; X_1 = 0.005%, lower values of the upper dosage level of the corresponding factors X_2 = 0.2%; X_1 = 0.05%.

The rather high values of the determination coefficients (0.81, 0.99, 0.97; 0.95, 0.98, 0.71, respectively) suggest that the factors under consideration (X3, X4) determine, mainly, the setting time, expansion and consumption. Analyzing the value of the partial correlation coefficients, it can be noted that the start of setting and expansion is determined mainly by the moderator (b · (x4) = 0.81, 0.92; 0.97, 0.9, respectively). [6-9]

The main indicators of correlation and regression analysis presented in table 2.

TABLE 2. The main indicators of correlation and regression analysis.

Name of indicator	Value		
	Start of setting Y_1, minutes	Expansion, Y_2, minutes	Consumption, Y_3, kg/m^2
Multiple correlation coefficient	0.810 0.950	0.999 0.980	0.970 0.710
Coefficient of determination (R^2)	0,660 0,910	0.998 0.960	0.944 0.510
Standardized Regression Coefficients (Beta): $b\cdot(x_3)$, $b\cdot(x_4)$	0.02 0,81 -0.21 0,92	0.23 0.97 0.40 0.90	-0.61 -0.76 -0.33 0.63
Standard approximation error	62.5 55.0	2.5 20	0.28 0.95
p-value			
A	0.341152 0.221678	0.060344 0.461180	0.017292 0.064957
X_3^2	0.974549 0.599696	0.125666 0.295167	0.236117 0.718376
X_4^2	0.394863 0.199199	0.030292 0.139209	0.192017 0.535331
t- statistics			
A	1.683944 2.754803	10.51830 1.130047	36.80756 9.766665
X_3^2	0.040000 -0.727273	5.000000 2.000000	-2.571430 -0.473684
X_4^2	1.400000 3.090909	21.00000 4.500000	-3.214290 0.894737
F- Fisher criterion	0.98 5.04	233.0 12.125	8.470 0.512
p	0.58 0.30	0.046 0.199	0.236 0.702

Note to table. The upper values in the cells of the recorded parameters correspond to the lower dosage level of factors X2=0.1%; X1 = 0.005%, lower values of the upper dosage level of the corresponding factors X2 = 0.2%; X1 = 0.05%.

In addition, it can noted that the start of setting is practically independent of the thickener, and the expansion has little relationship with the dose of the thickener. Variation in consumption by almost 60 ... 76% is determined by the thickener and retarder.

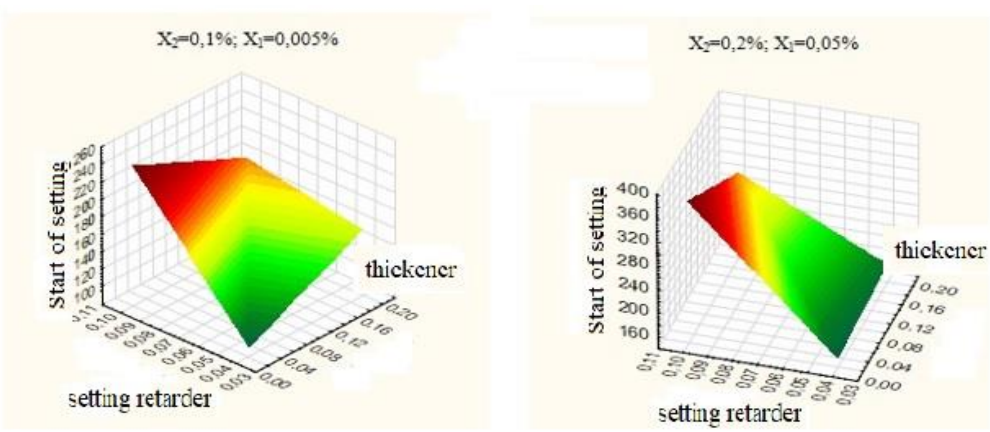

FIGURE 1. The surface of the response of the onset of setting (Y_1) at the lower level (X_2 = 0.1%; X_1 = 0.005%) and the upper level (X_2 = 0.2%; X_1 = 0.05%) of the dosage of water-holding and pore-forming additives, respectively.

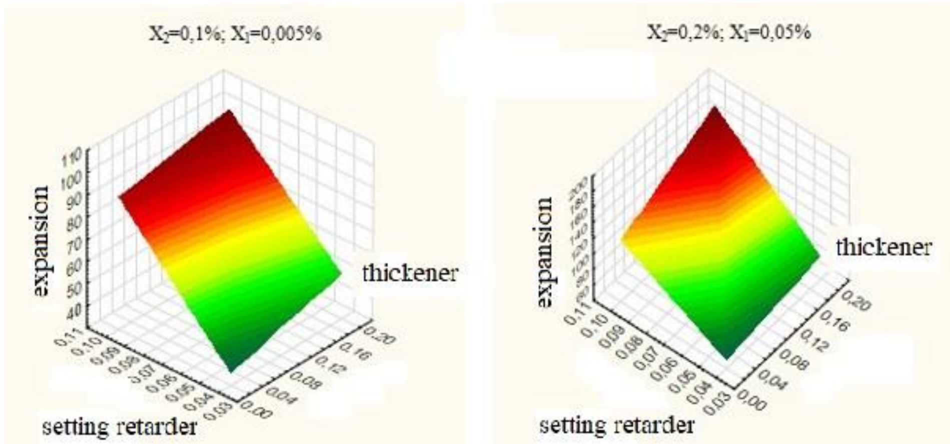

FIGURE 2. The expansion response surface (Y2) at the lower level (X2 = 0.1%; X1 = 0.005%) and the upper level (X2 = 0.2%; X1 = 0.05%) of the dosage of water-holding and pore-forming additives, respectively.

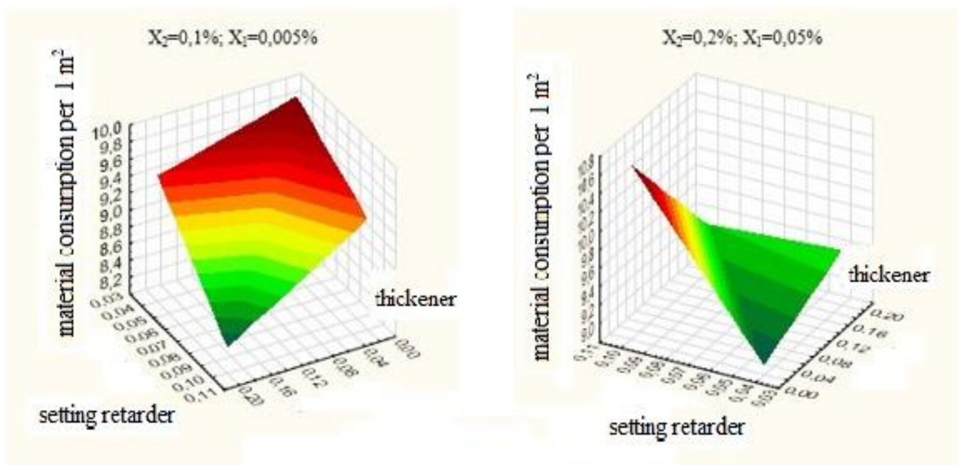

FIGURE 3. The surface response of the consumption of material per 1 m2 (Y3) at the lower level (X2 = 0.1%; X1 = 0.005%) and the upper level (X2 = 0.2%; X1 = 0.05%) of the dosage is water-holding and pore-forming additives, respectively.

Moreover, the negative value of the regression coefficients in solution consumption indicates the negative effect of increasing the dosage of the thickener and setting retarder on the consumption of the solution, i.e. an increase in these additives in the solution leads to a decrease in the consumption of the solution.

The response surfaces of the obtained regression equations presented in the figure in figures 1 ... 3.

SUMMARY AND RECOMMENDATIONS

The results of the studies allow us to draw the following conclusions:

1. Sufficiently high values of the determination coefficients indicate that the dosage of the thickener and setting retarder determines mainly the setting time, expansion and consumption.

2. With an increase in the dose of water-holding (X_2) and pore-forming (X_1) additives from 0.1% to 0.2% and from 0.005% to 0.05% of a binder, respectively, for all possible combinations of the dosage of thickener (X_3) and setting retarder (X_4) there is an increase in setting time by 10 ... 72% and expansion time by 33 ... 80%.

3. The mixture in which the amount of thickener X_3 = 0.2% (at the upper level) and the amount of setting retarder X_4 = 0.04% (at the lower level) turned out to be the least sensitive to the increase in water-holding and pore-forming additives.

4. The material consumption is practically at the same level, and for various combinations of thickener and setting retarder, it changes by 10 ... 15%, both downward and upward. A 10% reduction in consumption observed in the recipe when the dose of both thickener $X_3 = 0.02\%$ and setting retarder $X_4 = 0.04\%$ is at a lower level.

At a dosage of $X_3 = 0.2\%$, $X_4 = 0.04\%$, a change in material consumption is practically not observed. For other combinations of doses of thickener and setting retarder, an increase in the consumption of material by 12 ... 15% observed.

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