Determination of optimal technological parameters for the manufacture of small architectural forms of gypsum by dyeing in bulk based on an analysis of consumer preferences

A V Erofeev, V A Mikhaylov

Institute of Architecture, Construction and Transport, Tambov State Technical University, 112, Michurinskaya st., Tambov 392032, Russia

E-mail: AV.Erofeev@yandex.ru

Abstract. The paper describes the technology of manufacturing small architectural forms of gypsum. The required appearance (color) is achieved by coloring the product in bulk (adding color to the water, which is mixed with gypsum). The appearance of the products with different percentages of color in water is given. The method of expert evaluation revealed consumer preferences. Studies were conducted for three colors (red, blue, violet). The preferred tonality when dyed in bulk is the tonality obtained by adding 50% tint, and less preferred when adding 10%. The results of the study in three batches of samples showed that this consistent pattern does not depend on color. There is a consumer need for a wide range of tonalities within a single color scheme.

1. Introduction

Nowadays the thematic arrangement and internal housing is gaining popularity, it may be the arrangement and existence of Ancient Greece, medieval Europe and pre-revolutionary Russia. Today bas-reliefs, stucco moldings, pilasters and other decorative ornaments, called small architectural forms that can be made of plaster, are popular again. The G-16 brand is the most common among high-strength gypsum brands [1]. The use of grades G-2 to G-5 does not allow to obtain a product of the required strength [2].

In the manufacture of the product, it is initially necessary to determine the required gypsum mass, which depends on the volume of the future product. Next, the required amount of water is determined (based on the normal density of the gypsum dough). Then gypsum is added to water for 2 ... 5 s and mixed until a homogeneous mass [3-5]. Next, the resulting gypsum dough stows into the forms in which hardening occurs. Thus, a white gypsum article is obtained. There are cases when you want to get a product of a different color or imitated like natural stone, wood, etc [6-8].

2. Research methodology

One way to obtain a product color other than white is staining in the mass. In this case, the entire color of the finished product is given the desired color. This is achieved by the fact that color is added to the gypsum mass as a percentage. The required percentage of color that need to achieve the necessary tonality was determined on the basis of an experimental study. The essence of the study is that manufactured samples with a percentage of color from 10 to 70% with a step of 10% are divided by
tonality using the expert assessment method into the main groups and the optimal color content is established, leading to a preferred appearance [9,10].

To increase the reliability of the results, three colors were used: blue, red and violet. The processing of results (expert opinions) for each of color was carried out separately with subsequent comparison of the final result [11]. With an increase in the percentage of color, the physicomechanical characteristics of the finished sample begin to decrease. This is what determines the maximum percentage of color in 70%.

The obtained tonalities of the samples, depending on the percentage of tint, is shown in figures 1-3. The encoding number denotes the number assigned to the sample for its identification, hereinafter the sample number [12,13].

**Figure 1.** Appearance of samples stained in mass in red with a color content: a – 10%; b – 20%; c – 30%; d – 40%; e – 50%; f – 60%; g – 70%.

**Figure 2.** Appearance of samples stained in the mass in blue with the color content: a – 10%; b – 20%; c – 30%; d – 40%; e – 50%; f – 60%; g – 70%.
Figure 3. Appearance of samples stained in the mass in violet with the color content:

a – 10 %; b – 20 %; c – 30 %; d – 40 %; e – 50 %; f – 60 %; g – 70 %.

Due to the fact that it is impossible to quantify the tonality of the samples, or rather the preference of the tonality, the separation of the obtained samples into groups by tonality and the establishment of the optimal tonality for each color was carried out by the method of expert estimates, which is part of the representative measurement theory [14,15]. The method allows you to get expert opinions on an ordinal scale, while the aggregated (generalized) expert opinion was taken as the final result. Two methods of expert estimates were used:

1. the method of arithmetic mean ranks;
2. the method of median ranks [16].

The essence of the method consisted in ranking the keys of the samples depending on the preference of the expert, and the rank number should not be repeated. The most preferred key is assigned rank 1, the least preferred rank is 7, since the total number of samples is 7 pieces [17].

The expert group consisted of 15 people, and when selecting experts, they were required to be creative, constructive and self-critical. Due to the fact that men and women perceive color solutions differently, their ratio in the group was close to 1. To exclude the effect of pressure on the opinions of authority, the collection of expert opinions was carried out through individual questionnaires. The questionnaire template is shown in Figure 4 [18].

The results on the division of samples into groups depending on their tonality are summarized in table 1.

Using the arithmetic mean method, the sum of the ranks assigned to each sample was calculated. Further, it was divided into the number of experts, i.e. the arithmetic mean rank was obtained, according to which the final ranking was built, based on the principle - the lower the average rank, the more preferable the tonality. If the arithmetic mean rank is equal, they are assigned the same average rank [19].

The method of average arithmetic ranks has been known for more than 30 years, but experts consider it as not quite correct, since scores are measured on an ordinal scale. Therefore, in addition to this method, it is advisable to use the method of median ranks. Comparison of the results obtained by two different methods will allow you to get a result close to reality [20].
**Figure 4.** Questionnaire template.

**Table 1.** The Division of samples into groups depending on the percentage of color.

| Group number | Group name | Sample numbers | Percentage of color |
|--------------|------------|----------------|---------------------|
| 1            | 2          | 3              | 4                   |
|              | red        |                |                     |
| I            | Pale red   | 3, 5           | 10, 20              |
| II           | Red        | 1, 7           | 30, 40              |
| III          | Dark red   | 2, 4, 6        | 50, 60, 70          |
|              | blue       |                |                     |
| I            | Light blue | 7, 2, 3        | 10, 20, 30          |
| II           | Blue       | 5, 6           | 40, 60              |
| III          | Dark blue  | 1, 4           | 50, 70              |
|              | violet     |                |                     |
| I            | Light violet | 5, 1   | 10, 20              |
| II           | violet     | 3, 6, 7       | 30, 40, 50          |
| III          | Dark violet | 2, 4       | 60, 70              |
According to the method of median ranks, all ranks put by experts to a specific sample are arranged in non-decreasing order. Next is the median of this series, i.e. value standing in the center. The final ranking takes place according to the same principle - the lower the average rank, the more preferable the tonality. The final results are summarized, depending on the color in question, in table 2.

Thus, an analysis of Table 2 allows us to conclude that the result of determining consumer preferences may depend on the data processing method used: the final rank according to the arithmetic mean method for sample No. 7 is 2, while the same result for medians is 5. An analysis of the final ranks determined by the median method, namely, the coincidence of the ranks of 4 samples with a percentage of tinting of 30, 50, 60 and 70% suggests that there is no pronounced consumer preference, a request for different tones is observed reality. It should be noted that according to the final rank, determined by the arithmetic mean method, the percentage of 50% of the red color is most preferable, and the less preferred is 10%.

Table 2. Results of calculations using the arithmetic mean method and the median method for data.

| Red color | Blue color | Violet color |
|-----------|------------|-------------|
| Sample number (encoding number) | 1 2 3 4 5 6 7 | 1 2 3 4 5 6 7 | 1 2 3 4 5 6 7 |
| Percentage of color, % | 30 50 10 60 20 70 40 | 70 20 30 50 40 60 10 | 20 60 30 70 10 40 50 |
| Sum of ranks | 58 48 75 62 69 61 56 | 56 68 59 49 66 53 69 | 53 66 55 73 52 48 |
| Arithmetic mean of ranks | 3,86 3,20 5 4,13 4,60 4,06 3,73 | 3,73 4,53 3,93 3,26 4,40 3,53 4,60 | 3,53 4,40 4,46 3,66 4,86 3,46 3,20 |
| Total rank in arithmetic mean | 3 1 7 5 6 4 2 | 5 3 6 3 5 3 4 | 3 5 4 3 4 3 6 |
| Median of ranks | 3 3 6 3 5 3 | 3 3 | 3 3 6 |
| Total rank by medians | 1,25 1,25 7 1,25 6 1,25 5 | 1,25 1,25 7 | 3,33 6 3,33 1,50 3,33 1,50 |

3. Conclusion

For blue and violet, the final rank in arithmetic mean almost coincided with the final rank in medians, deviations are insignificant. The analysis of the final ranks, determined by the median method, namely, the coincidence of the ranks for the two samples with a percentage of blue color of 50 and 60%, as well as the coincidence for the samples with a percentage of 30 40 and 70%, suggests that the pronounced preference of consumers absent, there is a request for different keys.
An analysis of the final ranks determined by the median method, namely the triple coincidence of ranks for two samples with a percentage of violet colors of 40 and 50%, 20 and 60%, 30 and 70%, confirms the conclusion that there is no clearly expressed consumer preference, there is a request to different keys.

The preferred tonality is the tonality obtained by adding 50% color, and less preferred when adding 10%. The results of the study in three batches of samples showed that this pattern does not depend on color, which allows us to extend the results to other color solutions. An analysis of the final ranks by medians for three batches of samples (their frequent coincidence) will allow us to talk about the consumer's need for a wide range of tonalities within the same color scheme, as evidenced by the spread of expert opinion (variational range is 6, the average linear deviation lies in the range 1.07 to 2.89).

References

[1] GOST 125-2018 Gypsum binders. Specifications (Moscow) 2018
[2] GOST 23789-2018 Gypsum binders. Test methods (Moscow) 2018
[3] Mikhaylov V A, Mukhortov P A 2019 About the need for the production of artificial stone 6th international scientific and practical conference for young researchers "the world of science without borders" pp 136–138
[4] Mihaylov V A 2017 Technology of production of small architectural forms from gypsum View of the young generation on regional economy problems pp 176–179
[5] Derevyanko V N, Kondrat'eva N V, Hryshko A 2018 Hydration of gypsum systems Bulletin of Prydniprovs'ka State Academy of Civil Engineering and Architecture pp 42–53
[6] Mikheenkov M A, Kim V, Polyanskiy L I 2010 Manufacturing artificial plaster stone Construction materials 7 13–17
[7] Petropavlovskaya V B, Buryanov A F, Petropavlovskii K S, Novichenkova T B 2019 High strength gypsum materials Chemistry, physics and mechanics of materials 1(20) 3–13
[8] Shtuber M A, Sycheva L I 2018 Influence of parameters of producing gypsum bending on its properties. Success in chemistry and chemical technology 2(198) 191–193
[9] Orlovich R B, Gorshkov A S, Zimin S S 2013 2013 The use of stones with high voidness in the facing layer of multilayer walls Engineering and Construction Journal: Specialized Scientific Journal 8(43) 14–22
[10] Zimin S S, Chumadova L I, Chaikovsky A S 2013 Building materials and constructions. Stonematerials and designs Polytechnic
[11] Mikhaylov V A, Erofeev A V, Gorski D N 2019 Influence of parameters of dyeing of plaster products in red color on their external view Colloquium-journal 2-2(54) 134–137
[12] Beshelev S D, Gurvich F G 2003 Expert estimates (Nauka)
[13] Sokova S D, Smirnova N V 2018 Innovative technological solutions to ensure the reliability of operated buildings Journal MATEC Web of Conferences 251
[14] Kuzmin V B, Orlov A I 2007 Statistical methods for the analysis of expert assessments (Nauka) pp 220–227
[15] Sokova S D, Smirnova N V 2019 The choice of durable blocking waterproofing mathematical method Journal of Physics: Conference Series 1425
[16] Gutsikova S V 2011 Method of expert assessments. Theory and practice (Moscow)
[17] Litvak B G 2008 Expert information. Methods of obtaining and analysis (Moscow: Radio and Communications)
[18] Kitaev N N 2005 Group peer reviews (Knowledge)
[19] Tchegodaev A I 2010 Mathematical methods of expert estimation analysis Vestnik of Samara State University of Economics 2 130–135
[20] Bugaev Yu V, Nikitin B E, Mironova M S, Chaikovsky A S 2010 Processing of results of group expertise in a method of extrapolation of expert estimations Vestnik Voronežskogo gosudarstvennogo universiteta inženernyh tehnologij 2 73–75