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INNOVATIVE SOLUTIONS TO IMPROVE THE PROPERTIES OF GYPSUM STONE USED IN ARCHITECTURAL DÉCOR AND WALL PRODUCTS

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Abstract *The article examines the results of research on the modification of artificial gypsum stone using a hydrophobizing solution created on the basis of calcium polysulfide and titanium dioxide. A comparison of the water absorption indicators of the initial and solution-impregnated samples is presented. It was established that hydrophobization with the help of the developed solution increases the softening factor of the products to values of 0.6...0.82, depending on the number of applied layers or the duration of impregnation.*

Studies have established a relationship between the change in the mass of samples and the depth of solution penetration with the number of coating layers. It has also been found that the addition of filler increases the strength of the material, with the type of filler selected depending on the intended use of the products, such as for wall elements or architectural decorative details.

Keywords: *gypsum stone, binder, titanium dioxide, sulfur, impregnation*

Introduction

In construction practice, gypsum binders have long been used because they are low-energy, quick-setting, and also make it possible to produce white products that can be given any other color and shade, and this is very interesting for architects and designers. However, their use is significantly hampered by very low water resistance and low strength.

During the last decades, scientists have studied various methods of increasing the water resistance of gypsum products. Such approaches as optimization of the composition of mixed binders, treatment of gypsum materials with water-repellent solutions, as well as the use of chemical and mineral additives [1-4] turned out to be the most effective.

Recently, research has been conducted on the creation of special solutions for

processing lightweight concrete using nanosized elemental sulfur [5]. However, such solutions have certain disadvantages, for example, the complexity of the technology and high cost. Studies of the toxicological safety of the production and operation of sulfur-gypsum composite products have shown that the use of sulfur in the production of construction products does not pose a potential threat to people and the environment [6, 7].

Today, there are many types of protective coatings for building materials, but most of them retain their properties only for 2-3 years, after which a new layer needs to be applied. This is confirmed by the need to regularly update protective coatings on building facades.

The main thing in the development of gypsum products is to ensure the necessary water resistance in order to avoid the destruction of the products from atmospheric influences and aggressive environments.

Main text

G5 grade gypsum binder was used to make the samples (DSTU B.V.2.7-82-2010. Construction materials. Gypsum binders. Technical conditions). To prepare the solution: titanium dioxide (GOST 9808 - 84. Pigment titanium dioxide. Technical conditions), calcium polysulfide (TU 2153-003-55841212-2003. Aqueous solution of calcium polysulfide. Technical conditions) manufactured by Svitlo LLC. The compressive and bending strength was investigated according to the standard method described in DSTU B V.2.7-82:2010 (Construction materials. Binding gypsum. Technical conditions), water absorption and frost resistance were determined according to DSTU B V.2.7-42-97 (Construction materials. Methods of determining water absorption, density and frost resistance of building materials and products).

A solution based on calcium polysulfide and titanium dioxide was used to increase the durability, strength, and water resistance of architectural decor elements based on gypsum binder [8]. Due to calcium polysulfide, this solution makes it possible to ensure water resistance and maintain the strength of artificial stone based on a gypsum binder, and since sulfur has a yellowish color, the addition of titanium dioxide ensures the white color of the product.

Processing was carried out at room temperature by impregnation by immersing the products in a chemical solution, spraying, applying the solution with a brush. Such methods ensure ease of processing and high efficiency.

This method of hydrophobization is universal and effective as a method of protecting building products and structures based on gypsum binder that are exposed to atmospheric influences [9]. The parameters of the sample made on the basis of gypsum binder after treatment with the resulting composition of the chemical solution are shown in Table 1.

Table 1 - Indicators of the sample made on the basis of gypsum binder after treatment with the resulting composition of the chemical solution

№	Physical-mechanical indicators	Control sample	6 layers of solution applied with a brush	Spraying	Immersion for 2 hours	Immersion for 4 hours	Immersion for 6 hours
1	Compressive strength, MPa	10,1	11,6	11,5	10,8	11,1	12,2
2	Flexural strength, MPa	4,5	4,8	4,9	4,8	4,9	4,9
3	Softening coefficient	0,5	0,81	0,81	0,63	0,82	0,83
4	Frost resistance	0	50	50	0	50	50

Author's development

The analysis of the data presented in Table 1 shows that the processing of the samples does not reduce the compressive and bending strength of the products based on the modified gypsum binder. This is important, because most solutions for processing reduce these indicators. The method of immersing products in the solution for 2 hours is the least effective. It has a minor effect on the softening factor of the products, that is, on their water resistance, and also does not affect the indicators of frost resistance. All other processing methods (applying the solution to the product with

a brush in 6 layers, spraying and immersing the products in the solution for 4 and 6 hours) significantly increase the softening factor of the products and ensure frost resistance up to 50 cycles of alternating freezing and thawing.

The use of this composition makes it possible to significantly simplify the material processing technology. First, impregnation of products can be carried out at room temperature and at atmospheric pressure. Secondly, the degree of impregnation can be easily adjusted by changing the duration and frequency of impregnation. It should be noted that impregnation with this composition does not cause additional stresses in the material, which can lead to a decrease in the strength of materials and the appearance of cracks in it.

The method of processing allows carrying out repair and restoration works in field conditions, is effective for long-term protection of structures from moisture, as well as for increasing the service life of products and structures.

It can be seen from Table 1 that the use of the developed solution allows to ensure water resistance of artificial stone based on gypsum binder, reduce water absorption and preserve the strength of the material.

Table 2 shows the dependence of the change in the weight of the samples and the depth of penetration of the solution into the gypsum stone structure on the number of coating layers. The depth of seepage was determined by splitting the samples.

Table 2 - The results of applying a sulfur-containing solution with a brush on 6 faces of cubic samples measuring 10x10x10 cm

№ Sample	Sample weight, g	Number of layers coating	Change weight, g	Change weight, %	Depth impregnation, mm
1	2228	-	-	-	-
2	2299	2	11	0,5	6,5
3	2305	4	17	0,76	9,8
4	2308	6	20	0,9	11,5
5	2310	8	22	1,0	12,7
6	2314	10	26	1,1	15,0

Author's development

Table 2 shows the high penetrating power of the chemical solution - with the sixth application of the solution, the penetration depth is up to 10 mm. Also, the composition has a high penetrability when processing gypsum products by immersing them.

It was found that the optimal duration of infiltration, from the point of view of the depth of penetration of the solution into the structure of the gypsum stone, as well as the technological conditions of the process, is 4-6 hours, which is sufficient for reliable and long-term protection of building products and structures from the influence of atmospheric and chemical factors. Table 3 shows the strength indicators of gypsum concrete on different aggregates.

Table 3 - Strength indicators of gypsum concrete on different aggregates

№	Type of placeholder	Material consumption per 1 m³ of gypsum concrete, kg		Compressive strength, MPa	Flexural strength, MPa	Density, kg/m³
		Developed binding substance	Filler			
1	Cenospheres	1000	500	16,7	8,9	1350
2	Cenospheres	780	780	16,0	8,9	1340
3	Cenospheres	570	1150	15,1	8,2	1250
4	Wooden shavings	860	860	14,6	7,6	1000
5	Wooden shavings	600	1200	14,1	7,0	800
6	Sand	920	460	16,2	8,8	1630
7	Sand	730	450	15,3	8,7	1620
8	Sand	470	400	12,1	7,3	1620

Author's development

Table 3 shows that the aggregate increases the bending strength within 12...16.7 MPa, and the aggregate itself is selected according to the purpose of the products: wall or architectural decor elements.

Conclusions

It has been established that products based on gypsum binder after treatment with a chemical solution based on calcium polysulfide and titanium dioxide provide

compressive strength in the range of 10...12.2 MPa, a softening factor of 0.8...0.83 and frost resistance up to 50 cycles.

The addition of titanium dioxide to the composition of the chemical solution allows you to preserve the white color of the products, which is especially important for elements of architectural decor.

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Анотація. *У статті розглянуто результати досліджень модифікації штучного гіпсового каменю за допомогою гідрофобізуючого розчину, створеного на основі полісульфіду кальцію та діоксиду титану. Проведено порівняння показників водопоглинання вихідного та просоченого розчином зразків. Встановлено, що гідрофобізація за допомогою розробленого розчину підвищує коефіцієнт розм'якшення виробів до значень 0,6…0,82 залежно від кількості нанесених шарів або тривалості просочення.*

Дослідженнями встановлено залежність зміни маси зразків і глибини проникнення розчину від кількості шарів покриття. Також встановлено, що додавання заповнювача підвищує міцність матеріалу, причому тип заповнювача обирають залежно від призначення виробів, наприклад, для стінових елементів або архітектурних декоративних деталей.

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