Finishing materials in construction using polymer composites

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Abstract. Polymer composite materials are increasingly replacing traditional composites such as wood, metal, and natural fibers from the world market of building materials. Polymer composite materials are widely used in the construction industry. Currently, the development of advanced polymer-based composites is a very relevant area. The promising method for modification of epoxy polymer composite with mineral filler shungite is considered. It was found that the introduction of mineral filler increases the composite resistance to impact forces. It is proved that shungite-filled epoxy composites have increased strength and performance properties, which is very important when they are used in the construction industry. After carrying out a number of physical, mechanical and operational studies, it can be concluded that polymer composite materials based on ED-20 resin with the content of mineral filler shungite have the best performance, compared to non-filled composite materials. Thus, the resulting PCM can be used in the construction industry as a finishing material, as it has the necessary complex of strength and performance properties.

1. Introduction

To date, there is not a single branch of human life where materials and products based on polymers are not used. The main consumer of polymer composites, over the past decade, is the construction industry [1]. This is due to the fact that polymer composite materials can be modified in various ways, which makes it possible to obtain construction materials with a wide range of necessary technological and operational properties, which vary simply [2, 3]. Improving previously used recipes allows creating materials for the construction industry with completely new and unique properties.

This interest in polymer-based materials is fully justified, as polymer composites have increased performance and strength characteristics. Such materials are able to maintain their properties in a wide temperature range, in various chemically aggressive mediums, as well as in various operating conditions: multiple loads and deformations [4]. That is why the construction industry needs to develop and improve finishing materials based on polymers, thereby making polymer composites very popular and promising materials [5].

2. Materials and methods

2.1. Materials

Polymer composite materials based on epoxy resin are widely used in the construction industry. For the production of a polymer composite, which will be used as a building finishing material, an epoxy
resin of the ED-20 brand was selected. This is due to the fact that this epoxy resin has a number of advantages over other brands [6]. It is characterized by low color (i.e. it is transparent), has no impurities and water inclusions, has high strength, excellent adhesive and water-proof properties, resistance to most chemically aggressive environments, a small mass of finished products, which is very important in the production of PCM for the construction industry [7].

It is worth noting that an important component in epoxy compositions is a hardener, the choice of which largely determines the future properties of the polymer composite [8]. Polyethylene polyamine (PEPA) was chosen as the hardener, as the introduction of this component gives the resulting composition a set of necessary properties.

In addition to the hardener, the polymer composite material includes a plasticizer, dibutyl phthalate as which was chosen. The introduction of this plasticizing additive allows reducing the viscosity of the composition, increasing its plasticity, thereby facilitating the processing of the polymer composition [9]. In addition, the introduction of plasticizer allows increasing the frost resistance of the product, which is very important when using materials in the construction industry.

However, despite the importance of the hardener and plasticizer in PCM, the most significant component in the epoxy composite is the filler. It is the introduction of this component that makes it possible to improve the strength, performance, and physical and mechanical properties of composite materials [10].

The introduction of filler into the polymer matrix is the most common way to change the properties of polymers purposefully [11]. Fillers are structurally active additives with a developed specific surface area, which can be used quite simply to vary the properties of the composition.

The most common fillers for PCM are mineral additives such as chalk, kaolin, and feldspar [12]. The introduction of dispersed fillers in a polymer composite material allows solving several problems simultaneously: reducing the cost of the composite; increasing its strength properties; changing the temperature range in which the product can be operated; increasing the performance properties [13].

In addition to these traditional mineral fillers, the natural mineral shungite has recently become very popular [14]. Due to its unusual and unique structure, shungite gives increased performance and technological properties to compositions where it was introduced as filler.

Shungite is an amorphous rock with an unusual structure. The structure of the mineral consists in the fact that allotropic carbon is found as a modification of fullerenes and fullerene-like forms [15]. This mineral is formed from organic deposits and has a gray-black color. The matrix of a shungite rock is a molecular crystal that is a transitional configuration between organic and inorganic matter (Fig. 1).

A characteristic feature of shungite crystals is the presence of fullerene-like structures, which increases the resistance to oxidation, heat and heat resistance of polymer composites where this filler was introduced [16]. The natural mineral shungite consists entirely of bipolar particles, due to this fact, this filler is quite simply combined with both polar and non-polar polymer matrices, which makes it easier to work with this filler [17].

![Figure 1. Matrix of shungite rock.](image)

Therefore, to obtain a polymer composite material, which will be used as a finishing material in the construction industry, the choice of raw materials was stopped on: epoxy resin of the ED-20 brand, the
hardener polyethylene polyamine, the plasticizer dibutyl phthalate and the natural mineral filler shungite.

2.2. Methods
As the resulting composite material will be used in the construction industry as a finishing material, it is necessary to this composite to have the necessary complex of strength and performance properties. That is why it is necessary to conduct a number of physical and mechanical tests of the resulting material to make sure that it is suitable for use in the construction industry [18].

The resulting composite material based on epoxy resin and the natural mineral shungite was subjected to a number of physical and mechanical tests, which were carried out according to GOST methods.

One of the important physical and mechanical indicators is the determination of the bending strength of the material. This test allows determining how well the material resists bending, that is, what is the rigidity of the material.

In addition to the rigidity of the material, its ability to restore its shape is also a very important indicator [19]. This ability of the material can be determined by examining the elastic modulus of the polymer composite. Determination of the elastic modulus in tension is carried out in accordance with GOST on a universal testing machine.

As PCM based on epoxy resin and shungite will be used as a building finishing material, it is highly likely that this composite will encounter chemically aggressive medium. That is why it is necessary to make sure that the resulting composite is resistant to alkaline and acidic aggressive medium. This study was conducted in accordance with GOST, holding samples in H₂SO₄ and KOH medium. The resistance of the material to chemically aggressive medium is determined by the mass that the sample loses during holding it in a solution of alkali or acid. The smaller the mass lost during the test, the more resistant the PCM is to a particular environment. This test helps determine whether it is possible to operate this polymer composite material in conditions where either alkaline or acidic components will be present.

It is also necessary to take into account the fact that if PCM is used as a building material, it will be in contact with moisture. That is why building finishing materials based on polymer composites must have water resistance. The ability of the material to be used in high humidity conditions is determined according to GOST. This method makes it possible to determine the water absorption of samples based on epoxy resin with the content of mineral filler shungite, as well as without the use of filler. Based on the data obtained, it is possible to conclude about the stability of PCM in environments with high humidity.

Carrying out all the above tests of the resulting composite material is a prerequisite for the analysis and study of strength, physical, mechanical and operational properties of PCM, which will be used in the construction industry as a finishing material.

3. Results
When conducting a study of the dependence of the bending strength of the material on the content of the filler, it was found that this indicator decreases with an increase in the content of the natural mineral shungite (Figure 2).
It is worth noting that the maximum value of the bending strength is achieved when the content of 5% mineral filler in the polymer composite, that is, with this content of filler, the material has the greatest rigidity.

When determining the dependence of the elastic modulus of tension on the content of the filler, it can be concluded that with an increase in the content of the filler in the composite, this indicator increases (Figure 3).

Based on the data obtained (Figure 3), it can be concluded that with an increase in the content of shungite, the ability of the epoxy polymer composite to restore its original shape increases.

When testing PCM for stability in aggressive environments, it was concluded that the introduction of a mineral filler in the epoxy composite provides its strengthening up to 25%, as well as an increase in the microhardness of the material up to 30% (Figure 4).
Figure 4. Influence of aggressive environment on composites with and without mineral filler.

Also, the introduction of shungite allows increasing the compressive strength without compromising the elasticity of the material, which provides increased adhesion strength of the material to the treated surfaces.

When determining the water absorption of the material, it was found that epoxy PCM filled with shungite have less water absorption, compared to samples without filler. This indicates that filled polymer composites have the highest resistance in conditions with high humidity.

Figure 5. Change in water absorption in epoxy PCM with and without filler

4. Discussion
After carrying out a number of physical, mechanical and operational studies, it can be concluded that polymer composite materials based on ED-20 resin with the content of mineral filler shungite have the best performance, compared to non-filled composite materials.

Thus, the resulting PCM can be used in the construction industry as a finishing material, as it has the necessary complex of strength and performance properties.

5. Summary
The introduction of natural mineral filler shungite in the epoxy polymer matrix allows obtaining a polymer composite material that has all the properties that are necessary for finishing materials used in the construction industry.

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