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DEVELOPMENT OF COMPOSITIONS AND RESEARCH OF PROPERTIES OF DRY CONSTRUCTION MIXTURES BASED ON EXPANDED VERMICULITE

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Abstract: This scientific text justifies the use of vermiculite-based dry building mixtures as an effective building material. Vermiculite is a type of rock with a unique structure that expands when heated, forming porous worm-like columns or thin filaments. Expanded vermiculite has a high porosity, low density, and is an excellent heat insulator, fire barrier, and sound absorber. Additionally, it is durable, chemically stable, and biologically resistant. The use of vermiculite-based thermal insulation plasters reduces construction costs, improves thermal and sound insulation, and allows for natural self-regulation of temperature and humidity. This technology is promising for energy-efficient residential houses and buildings, particularly in areas with significant temperature differentials between seasons.

Keywords: Vermiculite, dry building mixtures, thermal insulation, fire barrier, sound insulation, durability, chemical stability, biologically resistant, energy-efficient, residential houses, construction costs.

The purpose of this project is to justify the use of dry building mixtures based on vermiculite as an extremely effective building material. Vermiculite is a type of rock belonging to the group of hydrous mica in the class of silicates[1]. Unlike ordinary mica, it contains more water bonded in a crystal lattice and has a low level of bonding between the layers. In its natural state, it is a hard rock with a high density, which makes it difficult to abrade, but it is easily divided into plates. The melting point of the mineral is about 1350 °C. However, an intriguing feature of this mineral has been identified and exploited: when it is not melted but heated to about 900-1000 °C, the material undergoes a complete transformation of its crystal structure. The thin plates enlarge or swell 15 to 25 times, forming porous worm-like columns or thin filaments of golden or silver color. Presumably, this is where the mineral's name, vermiculite, comes from the Latin word "vermiculus," which means "worm.

Fig1: Pieces of mica turn into "worms"

Figure 1 shows how pieces of mica are transformed into layered "worms" during high-temperature firing. As a result, expanded vermiculite is a widely used material in various sectors of future construction, industry and agriculture. The air-filled structure of this material has a high porosity, which leads to a very low density - it is much lighter than water, and its specific weight varies from 60 to 130 kg/m3 [2]. At present the production of expanded vermiculite is carried out on an industrial scale.

Vermiculite is a very profitable material, widely used in the construction industry because of its unique qualities. Firstly, it has a low thermal conductivity coefficient, which makes it an effective heat insulator for building structures [3] . Secondly, it can withstand extreme temperatures from freezing below -200°C to heating up to 900-1000°C without emitting harmful gases or contributing to combustion. Therefore, vermiculite is used to create fire barriers and protect metal structures in buildings. Third, its granular and layered structure is ideal for sound insulation, absorbing both airborne and impact noise. Fourth, despite its seemingly unstable structure, vermiculite grains are highly durable and resistant to transportation, vibration, shrinkage, crushing and dusting. Fifth, vermiculite is chemically stable and absolutely inert, and can withstand all known acids, bases and organic solvents without loss of quality. Sixth, it can absorb water five times its weight and give it back to the atmosphere without losing its qualities. Finally, vermiculite has the highest biological resistance, it never decays, rots or decomposes. Thermal insulation plasters based on vermiculite have the additional advantage of being lightweight compared to traditional compositions.

Unlike conventional plasters, "warm plasters" have significantly higher thermal resistance characteristics. In fact, a mere 25-mm layer of "warm plaster" is comparable in its thermal properties to 100-150 mm of standard cement-sand plaster. It not only reduces the required thickness of the brick walls by about 25% without compromising the thermal insulation, but also improves their soundproofing qualities: the sound absorption coefficient ranges from 0.2 to 0.65. In addition, "warm plasters" of vermiculite have high vapor permeability, which allows normal self-regulation of temperature and humidity. When certain rules of preparation are followed, "warm plasters" create a natural golden or silver decorative effect, especially when exposed to sunlight, which makes them an attractive alternative to traditional methods of insulation. This technology reduces construction costs while providing buildings that are aesthetically pleasing, durable, warm and environmentally friendly, making it promising for small towns and buildings. In many cases, warm plasters are even more effective than other types of wall finishes.

The demand for energy-efficient residential houses and buildings is gradually rowing, especially in Nur-Sultan, the capital of Kazakhstan [4]. Nur-Sultan has a significant temperature differential between the seasons, with long, harsh winters and short, hot summers [4]. Although summer temperatures sometimes reach +35 ◦C, temperatures between mid-December and early March typically range from -20 to -35 ◦C, along with an average wind speed of 5.2 m/s, reaching 31 m/s. Because of these severe weather conditions, the cost of heating and cooling of houses and buildings constitute the main part of the operating costs in residential houses and buildings in Nursultan. For example, more than 30% of all energy is consumed by residential buildings, and heat consumption in Nur-Sultan has increased from 4,963 MW to 6,401 MW between 2010 and 2014. Moreover, up to 35% of heat losses occur through walls in existing traditional houses built in the 1990s. The use of appropriate building materials and the design of energy-efficient buildings can lead to significant savings for homeowners in terms of energy-related operating and maintenance costs.

The solution of these problems remains relevant today. This can be seen in the publications of recent years, devoted to the study of the possibility of using vermiculite sand as an aggregate for light plaster mortars, which can reduce the thermal conductivity and increase the vapor permeability of the mortar [5]. In recent years the number of publications on additives influencing the strength and resistance of mortars to the external environment and on the rheological properties of mortar mixtures has increased significantly. An effective mineral additive, the main part of which is highly active amorphous silica, is ultradispersed dust from electrostatic precipitators of ferrosilicon furnaces. Foreign researchers have noted the positive effect of this additive on the formation of structure, strength and durability of heavy mortars. Among polymeric additives in modern construction industry cellulose ethers and redispersible polymeric powders are widely used. These polymeric additives can significantly increase water retention capacity and improve rheological characteristics of mortar mixture, compressive strength, bonding strength with the base and frost resistance of mortars. However, the mechanism of joint action of mineral and polymeric additives in the light plaster building mortar on the properties of mortars and mortar mixtures has not been studied sufficiently and requires additional research.

Unlike mortars prepared according to traditional technology, dry mixtures are delivered to construction sites in a dry form and mixed with water immediately before use. The technology of dry mixtures makes it possible to obtain mixtures with an optimum particle size distribution of aggregates with a precise dosage of the mixture's constituents. Initially, dry mixtures were used when it was difficult or uneconomical to deliver mortars to construction sites. As a result of the development of new additives and production technology for dry mixtures we managed to obtain compositions with original properties compared to conventional ones. Dry mixture on construction sites can be stored for a long time without changing its properties and used in small portions as needed [6].

World and domestic experience of using dry mixtures has shown their high efficiency:

increase in labor productivity by 1.5...5 times depending on the type of work, mechanization, transportation, etc.;

reduction of material consumption compared to traditional technologies by 3...10 times depending on the type of work

stability of compositions and, as a consequence, increasing the quality of construction work;

storage time without changing the properties and consumption as required; possibility of transportation and storage at subzero temperatures. Dry mixes are a mixture of binders, aggregates and various additives [7]. Most of the starting materials are produced by domestic industry. The exceptions are dispersed polymeric powders, high viscosity methylcellulose, etc. In general, the presence in Russia a powerful industry for the production of binding materials, combined with rich natural reserves of minerals, is a powerful base for the development of domestic production of dry mixtures. The widespread introduction of modified dry mixtures per capita in Russia is still insignificant - less than 2 kg/person (in Germany - about 80, Finland and Sweden - about 60). This is explained by the general crisis in the economy and the cheapening of plastering works due to the use of cheap lime-sand mixtures, which are far from the requirements of modern construction. Potential demand in the market is almost five times higher than the achieved level of production. Therefore, further growth in the production of dry mixes will continue in the following years.

One of the reasons for the poorly developed production of dry mixes is the lack of functional domestic additives suitable for the preparation of dry mixes. Influence of mineral additives on the formation of cementitious stone structure. The introduction of additives rightly belongs to one of the most universal, accessible and flexible ways to control the technological properties of building materials and regulate their most important properties.

Purpose of work: development of effective building vermiculite-containing mortars with mineral and polymer additives intended for finishing the external surface of walls made of cellular concrete blocks. In the course of research the following practical results are expected to be found:

1.formulation of dry mortar mixture including Portland cement, ground quicklime, microsilica, cellulose ether, redispersible polymer powder, superplasticizer and expanded vermiculite;
2.the results of research of mineral and polymeric additives influence on the main properties of mortar mixtures and mortars;
3.obtained mathematical models of changes in the properties of mortar mixtures and mortars depending on the ratio of the components;
4.results of research of mineral and polymer additives influence on the formation of cement stone phase composition;
5.features of the structure of vermiculite-containing mortars with mineral and polymeric additives;

In conclusion, vermiculite-based dry building mixtures are an effective building material with unique properties that make it ideal for various sectors of construction, industry, and agriculture. Its expansion when heated creates a highly porous and lightweight material with excellent thermal and sound insulation, fire barrier, durability, chemical stability, and biologically resistant qualities. Vermiculite-based thermal insulation plasters also allow for natural self-regulation of temperature and humidity, reducing construction costs while providing aesthetically pleasing, durable, warm, and environmentally friendly buildings. This technology is particularly promising for energy-efficient residential houses and buildings in areas with significant temperature differentials between seasons, such as Nur-Sultan, the capital of Kazakhstan.

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