The use of magnesium-silicate rocks in building material production

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Abstract. Magnesium-silicate rocks are widely distributed all around the world, though they are barely used. It is shown that they can be applied in building material production. Adding magnesium-silicate rocks into binding compositions allows enhancing their physical and mechanical parameters. Using them as coarse or fine aggregate, as well as a reinforcing component, enhances performance characteristics of concretes. Adding batch to the composition allows optimizing process parameters for obtaining ceramic materials and improving their quality. Practically all magnesium-silicate rocks are located in overburden dumps. Their involvement into production cycle will allow for not only solving environmental problems but also expand the list of raw materials applicable in construction industry.

1. Introduction

Magnesium-silicate rocks, formed in the process of magma crystallization, are widely distributed all around the world. Though forming the major part of the earth's surface, they are barely applied anywhere. During mineral deposit development they get displaced into dumps and inflict harm to the environment. Among the whole volume of these rocks, serpentinite and basalt are of utmost interest, meanwhile other rocks do not get due attention. The goal of this paper is to provide a review of application of magnesium-silicate rocks (serpentites, basalts) in building material production, as well as describe the perspective of using other rocks, namely dunites, in this industry.

2. Main body

Building materials include wide range of products. The most consumable are cements, concretes and ceramic products. Let us have a more detailed review of how magnesium-silicate rocks are used in each of these products.

2.1. Cements

As we know, cement production is an expensive and environmentally hazardous process. It consumes a big volume of high-quality raw materials and emits a huge amount of carbon dioxide and dust into the atmosphere. These indexes can be reduced by using various mineral admixtures, in particular, magnesium-silicate rocks.

It is showed that involvement of basalts into process technology allows adjusting the composition of raw material mixture, reducing the content of natural resources. Properties of the obtained portland cements comply with requirements of technical specifications [1].

Introduction of basalt admixture to the composition of cements results in reduction of water to cement ratio and enhancement of their physical and mechanical parameters [2,3]. Using silt left from basalt extraction as a binding component allows obtaining water resistant material with low saturation coefficient [4]. Replacing part of Portland cement with basalt powder improves rheological properties and strength of cement mortar [5]. And adding a filler in the form of fine ground basalt fiber in the amount of 2,5% together with chemical admixture to the binder composite's content favors for enhancement of its performance characteristics [6].

When preparing binding compositions, magnesium hydrosilicates can be used in the form of talcum or serpentinite. Mixing of talcum with natrium polyphosphate solution at joint presence of magnesia allows obtaining materials of enhanced strength [7]. Material obtained during mixture of orthophosphoric acid and fine ground serpentinite possesses binding properties and accumulates sufficient strength [8]. And addition of serpentinite to the composition of magnesium cement enhances its longecity [9].

Aside from the abovementioned rocks, dunites as well are a prospective raw material for production of cements [10]. Using them as mineral admixture enhances performance characteristics of obtained materials (Table 1).

Table 1. Physical and mechanical parameters of cements.

Parameters	GOST requirements 10178-85	Portland cement M400D0	Cement with dunite admixture
Initial setting	not earlier than 45 minutes	3 hours 20 minutes	4 hours 10 minutes
Final setting	not later than 10 hours	5 hours 20 minutes	6 hours 20 minutes
Cone flow diameter	-	114	113
Compressive strength, MPa	not less than 39,2	40,2	43,0
Flexural strength, MPa	not less than 5,4	6,8	7,9
Compressive strength after steam curing, MPa	more than 27	28,8	31,8

Presented results show that physical and mechanical characteristics of cements with dunite admixture comply with GOST requirements. They can be applied when producing structures and conducting construction works.

2.2. Concretes

More than 80% of concrete volume is composed by aggregates. Therefore, magnesium-silicate rocks are used as coarse or fine aggregates. Using basalt as fine aggregate allows improving strength characteristics of concretes, as well as enhances their frost resistance due to consolidation of the obtained material's structure [11,12]. Using basalt as coarse aggregate leads to improvement of mechanical parameters of concretes, as well as to enhancement of their fire resistance, water resistance, weather resistance, and acid resistance [13-15].

At the present time, demand for special concretes with enhanced properties is increasing. Magnesium-silicate rocks are a prospective raw material for their acquisition. For example, basalts are frequently used when producing fiber-reinforced concrete. Application of fibers obtained out of basalt melt allows replacing various types of currently used fiber. At that, basalt fiber-reinforced concretes are environmentally safe; they possess chemical resistance to aggressive mediums and have a high modulus of elasticity [16]. Adding fine basalt fiber to their composition leads to enhancement of

reinforcement ratio [17]. Using basalt fiber instead of iron bars for reinforcement of concrete blocks allows obtaining lighter and cheaper products [18]. Joint presence of milled fiber in the composition of concrete mixture imparts enhanced bending strength to materials [19].

Moreover, adding basalt fibers or chrysotile into the composition of raw mixture will allow producing finely-grained decorative concrete with high performance characteristics [20].

Serpentinites are used in production of protective concrete cover. They show ability to chemically bind a big amount of water in its composition. This feature allows obtaining radiation protective concrete. Adding superplasticizing agent as well as calcium oxide to its composition favors an increase of the content of chemically bound water [21].

Lately, various admixtures has been adding to concrete's composition with the purpose to improve its quality. The use of nano-sized serpentite admixtures allows significantly reduce water absorption, as well as enhance mechanical properties of concretes [22].

Dunites, which are waterless magnesium silicates, are prospective for the use as coarse and fine aggregates [23]. Concretes on their basis possess good physical and mechanical parameters (Table 2).

Table 2. Physical and mechanical parameters of concretes based on dunite.

Type of coarse aggregate	Type of fine aggregate	Compression strength (MPa) at age of		Density, kg/m^3
		7 days	28 days	
dunite	quartz	18,3	28,8	2874
	dunite	21,9	32,8	2998
granite	quartz	16,0	27,3	2396
	dunite	17,3	28,4	2519
gravel	quartz	15,8	26,2	2546
	dunite	16,9	27,8	2764

As we can see from Table data, using daunite in concretes' composition promotes enhancement of their density and strength. Moreover, the concretes possess enhanced frost resistance and sulphate resistance. This allows using them when producing special structures which operate in aggressive mediums.

2.3. Ceramic materials

Basalts are prospective raw material for obtainment of various types of ceramic materials. Using basalt wastes as an admixture to batch allows reducing the time length of drying as well as reduces shrinkage of produced items [24]. Adding basalt to the composition of slip-cast ceramics for protective elements enhances wear resistance and expands temperature interval of its application [25].

These rocks can also be involved in production of glass-ceramic materials, used in solid oxide fule cells [26]. Materials, produced out of crystallized basalt melts and ceramic wastes, possess high rate of hardness, are resistant to exposure to water, and possess enhanced bending strength [27, 28].

Adding basalt fiber in the amount up to 25% to the composition of materials obtained by semidry pressing allows reducing the temperature of ceramic fragments baking as well as enhancing its density [29].

Moreover, basaltic tuffs, which get disposed into dumps during extraction of basalts, can be used for production of facing ceramic tiles. Adding them to batch composition as an independent component, as well as in a mixture with basalt, allows obtaining finished products with dense homogenous structure and required performance characteristics [30].

Serpentinites are also a prospective raw material for producing ceramic materials. On their basis, high-temperature fireproof materials can be produced, and foresterite ceramics and cordierite ceramics can be obtained [31-33].

Magnesium-silicate rocks in the form of dunites can be applied when producing building ceramics [34]. Bricks with added proportion of dunite compiling 50%, produced by the method of semidry

pressing and burned at the temperature of 950 o, possess physical and mechanical parameters that comply with required state standards (Table 3).

Table 3. Physical and mechanical parameters of dunite-based ceramic bricks.

Parameters	GOST 530-2012	Bricks
compressive strength, MPa	not less than 2,5	12,6
flexural strength, MPa	-	2,8
water absorption, %	not less than 6	6,9
frost resistance, cycle	not less than 25	50
density, kg/m^3	-	2643
fire shrinkage, %	-	1,7

Using dunites in the process of building ceramics production allows reducing the amount of clayish raw material and obtaining ceramic bricks for laying and facing of outer and internal walls of buildings and structures.

3. Conclusion

Thus, magnesium-silicate rocks are prospective raw material for production of building materials. Their application in binding compositions enhances rheological properties and performance characteristics of cement mortars. Using them as coarse and fine aggregates in concretes favors for improvement of physical and mechanical properties of finished products. And adding them to the composition of ceramic materials allows not only obtaining high-quality products but also improving process regimens of their production.

It should be noted that practically all magnesium-silicate rocks are located in overburden dumps. Their involvement into production cycle will allow for not only solving environmental problems but also expand the list of raw materials applicable in construction industry.

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