STOWING MIXTURE ON THE BASIS OF MAGNESIAN BINDER

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СМЕСИ ЗАКЛАДОЧНЫЕ НА ОСНОВЕ МАГНЕЗИАЛЬНОГО ВЯЖУЩЕГО

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Аннотация. *В статье представлены исследования твердеющих закладочных смесей на основе магнезиального вяжущего. В качестве заполнителей для закладочных смесей использовали попутные породы, отходы добычи горные пород: базальт и доломит. Повышение водостойкости и придание гидравлических свойств закладочным смесям связано с применением раствора бикарбоната магния. Исследования свойств закладочных смесей при затворении раствором бикарбоната магния показало, что прочностные характеристики образцов на основе каустического магнезита с доломитом, а также с базальтом в качестве наполнителя имеют высокие значения, удовлетворяющие поставленным целям нашего исследования.*

Nowadays the main disposal methods for vertical shafts by backfilling with construction- and- repair work waste and burnt rock of mine dumps don't allow creating the shrink-proof and water-proof filling mass on the place of vertical shafts and, as a result, it leads to hydro-geological and environmental problems. When choosing a stowing mixture, it is necessary to consider physico-mechanical and operational characteristics, such as, compressive strength and flexural strength, density, capacity for soaking and leaching, water-resistance.

One of the most popular ways to dispose vertical shafts are the methods with the use of stowing mixture based on binding systems, where Portland-cement and mixtures with magnesian and dolomic binders are mainly used complying with the main requirements for stowing materials [1].

Magnesian binding grows in popularity as an alternative to the traditional stowing mixture on the basis of binding systems. Having unique properties it doesn't concede according to characteristics, and sometimes it surpasses them. However, the reason of limited usage of magnesian materials is due to low water resistance properties as magnesian binder belongs to an air- setting binder group. It is also connected with magnesium usage as additive component to salt solutions with the result that, in reaction products we receive water-soluble compounds, which are dissolved in water or due to the damp atmosphere, destroying the structure of a product and a composition in general.

The purpose of the research is to study the opportunity of receiving of waterproof and eco-friendly stowing mixture on the basis of magnesian binder for vertical shafts disposal. To achieve the purpose it is necessary to

solve the main objective, i.e to improve the water resistance properties of magnesian binder, which is achieved through the synthesis of water-soluble reaction products of caustic magnesian powder and mixing water.

The investigations to produce waterproof magnesian binder based on solution of magnesium bicarbonate have been conducted by the researchers of TPU [2]. First, hydration reaction occurs when caustic magnesian powder interacts with water solution of $Mg(HCO_3)_2$:

$$MgO + H_2O \rightarrow Mg(OH)_2 \quad (1)$$

Then, the obtained magnesium hydroxide reacts with magnesium carbonate according to the reaction:

$$Mg(OH)_2 + Mg(HCO_3)_2 + 2H_2O \rightarrow MgCO_3 \cdot Mg(OH)_2 \cdot 3H_2O + CO_2, \quad (2)$$

to form hydroxycarbonate hydrate of magnesium and carbon dioxide, which reacts with an excess of magnesium hydroxide to form a secondary BCM:

$$Mg(OH)_2 + 2CO_2 \rightarrow Mg(HCO_3)_2 \quad (3)$$

Again, secondary magnesium bicarbonate reacts with magnesium hydroxide due to the reaction (1) to form a new portion of magnesium hydroxycarbonate hydrate, which along with magnesium hydroxide forms primary hydration products of magnesium cement to provide its solidification during recrystallization of colloidal products in crystalline state. Consequently, as a result of consecutive and competing reactions (1, 2, 3) in cement rock, two major crystalline phases (magnesium hydroxide and magnesium hydroxycarbonate hydrate) are formed with the quantitative ratio determined by the content of magnesium bicarbonate in a liquid of mixing [3]. The resulting crystalline hydrates are practically insoluble in water and determine high water-resistance of magnesian rock [4].

In this paper we used caustic magnesite (grade PMK-75) on the basis of magnesite rock of Savinskoye field (Irkutsk region) as a source of caustic magnesian powder with active MgO of 75,64 wt. %, respectively (Table 1). These materials were obtained by firing the magnesian rocks at a temperature of 800 ° C at LLC «Siberian powders" (Irkutsk).

Table 1

The chemical composition of raw and calcined magnesian rocks deposit Savinskoye

Material	Oxides content wt. %							
	MgO	SiO_2	Al_2O_3	CaO	Fe_2O_3	MnO	$\Delta m_{пр}$	Сумма
raw	46,88	1,60	0,59	0,85	0,80	0,29	50,26	101,27
calcined at 800 °C	75,64	3,18	-	4,24	-	-	16,94	100

The aqueous solution of magnesium bicarbonate with a concentration of 13-19 g/l obtained by artificial carbonizing of suspension of caustic magnesian powder was used as a solvent in an autoclave at a pressure of CO_2. Basalt and dolomite with fraction of 0–5 mm were used as fillers. To study the effect of separate components the composition with a specific filler was prepared. The samples of molded cubes hardened during 28 days in various media: air, humid condition (in chamber of normal hardening) and in water, were formed. The test results are shown in Table 2 and 3.

Table 2

The composition and characteristics of stowing mixtures on the basis of basalt

Code mixture	Ratio of mixture, %		Density, kg/m^3			Compressive strength, MPa			Water resistance coefficient
	binder	filler	air	moist air	water	air	moist air	water	
B10	10	90	1,626	1,615	1,799	1,45	1,9	2,2	1,51
B20	20	80	1,74	1,795	1,79	3,5	8,7	7,6	2,17
B30	30	70	1,75	1,855	1,785	4,4	7,45	9,1	2,07
B40	40	60	1,788	1,834	1,81	11,3	17,1	17,1	1,51
B50	50	50	1,652	1,605	1,78	10,4	17,2	17,5	1,68

B60	60	40	1,705	1,725	1,73	15,7	20,9	21,2	1,35
B70	70	30	1,651	1,673	1,79	15,7	22,9	22,2	1,41
B80	80	20	1,581	1,703	1,78	19,4	27,9	31,5	1,62
B90	90	10	1,642	1,775	1,802	21,3	30,6	32,5	1,53

The studies of properties of the mixtures with stowing mixing with magnesium bicarbonate solution showed that the strength properties of the samples based on caustic magnesite with dolomite as a filler have higher values than the samples based on basalt caustic magnesite as a filler. During hardening in water the strength of the samples is higher compared to the samples hardened in air.

Table 3

Composition and characteristics of stowing mixtures on the basis of dolomite

Code of mixture	Ratio of mixture, %		Density, kg/m3			Compressive strength, MPa			Water resistance coefficient
	binder	filler	air	moist-air	water	air	moist-air	water	
D10	10	90	1,93	1,79	1,86	1,9	5,2	5,2	2,73
D20	20	80	1,79	1,85	1,83	7,9	11,5	13,2	1,67
D30	30	70	1,78	1,91	1,83	12,8	13,5	13,5	1,05
D40	40	60	1,81	1,83	1,84	14,8	22,4	23,8	1,61
D50	50	50	1,58	1,69	1,69	16,4	18,9	25,0	1,52
D60	60	40	1,63	1,68	1,74	18,1	20,5	25,4	1,40
D70	70	30	1,63	1,65	1,67	18,5	21,3	25,4	1,37
D80	80	20	1,60	1,67	1,66	19,0	26,9	27,2	1,43
D90	90	10	1,55	1,66	1,68	22,4	30,3	30,4	1,36

The stowage mixture based on magnesian binder obtained during the investigation refers to hardening stowing materials with relatively low requirements for compressive strength (at least 2 MPa). According to Table 3, the samples of stowing mixtures based on dolomite containing 10-30% magnesian binder have the compressive strength from 5 to 13 MPa, which satisfies and exceeds the condition the minimum value of the tensile strength and reduce expenses on magnesian binder. When crumb basalt is used as a filler, the necessary and sufficient binder component content is 20-30% with a corresponding compressive strength from 3,5 to 9,1 MPa. The increase of magnesian binder in the composition of filling mixture increases the compressive strength, which proves the possibility of its usage for important geological constructions of a complex.

Filling mixture's waterproof coefficient with dolomite as a filler is from 1,05 to 2,73; basalt is from 1,35 to 2,17.

In addition to water resistance, the hardened filling mixtures of these compounds show a high ecological compatibility, as the reaction products have a chemical composition which is similar to natural compounds of hydromagnesite rocks formed as associated rock of magnesia deposits.

REFERENCES

1. Kurilenko O.D. Quick reference to chemistry. Naukova Dumka 1974, pp 156–159.
2. Lotov V.A., Lotova L.G. RF Patent 2404144 magnesia astringent. Stated. 31.07.2009. Publ. 20.11.2010. Bull. Number 3.
3. Lotov V.A., Mitina N.A. (2010).Getting waterproof magnesia binder. Technique and technology of silicates, is. 17, no. 3, pp. 19–22.
4. Tsiganek I. (HSB, Czech Republic), (1993).Yarembash I.F. Selection of backfill material of liquidated vertical shafts. Ostrava.