

UDC 666.972.16

IRSTI 67.09.33

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EFFICIENT DRY CONSTRUCTION MIXTURES WITH PERSPECTIVE MODIFICATION ADDITIVES BASED ON DOMESTIC RAW MATERIALS

Cite this article as: Baiserikova D.E., Kuatbaeva T.K., Uskenbayeva A.M. Efficient dry construction mixtures with perspective modification additives based on domestic raw materials. *Kompleksnoe Ispol'zovanie Mineral'nogo Syr'a*. 2019. 1. 62–67. <https://doi.org/10.31643/2019/6445.07>

Received: 25 December / Peer reviewed: 11 February 2019 / Accepted: 19 February 2019

Abstract. The article presents research on the development of effective dry building mixes with modifying additives based on domestic raw materials. The prospects of using local raw materials such as Ust-Kamenogorsk Portland cement, Novoalekseevsky sand (Almaty region), neutralized electrothermophosphoric slag of domestic production, wollastonite (Akmola region field) are shown. Wollastonite acted as a reinforcing ingredient that enhances the crack resistance of cement stone molded products. At the same time, the experiments carried out confirmed that hardening accelerators have a positive effect on the structure of cement stone at all levels: they increase the volume of micropores and reduce the volume of macropores with a slight change in total porosity. Studies have shown that the use of modifying additives from domestic raw materials can improve the technological properties of mixtures, namely, adhesion to mineral bases, high wear resistance and abrasion resistance, low shrinkage and sufficient elasticity.

Keywords: Dry mortars, modifying admixes, metakaolin, electrothermophosphoric slag, wollastonite.

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ОТАНДЫҚ ШИКІЗАТ НЕГІЗІНДЕГІ БОЛАШАҒЫ ЗОР МОДИФИКАТОРЛЫ ҚОСЫНДЫСЫ БАР ТИІМДІ ҚУРҒАҚ ҚҰРЫЛЫС ҚОСПАЛАРЫ

Түйіндемe. Мақалада отандық шикізат негізіндегі болашағы зор болатын модификаторлы қосындысы бар тиімді құрғақ құрылыс қоспаларды әзірлеу зерттемелері келтірілген. Жергілікті шикізат материалдарды яғни Өскемен портландцементі, Новоалексеевский құмы (Алматы облысы) отандық өндірістерінің залалсыздандырылған электротермофосфорлы коқыстардың (Ақмола облысының кен орындарының) қолдану тиімділігі көрсетілген. Арматуралау ингредиенті ретінде жергілікті волластонит қолданылды, ол цемент тасының сызатқа беріктік тұрақтылығын арттырады. Сонымен қатар өткізілген эксперименттер нәтижесінде қатты күйге әкелетін тездеткіштер, цемент тасының құрылысына жақсы әсер беретіні расталды яғни олар микрокеуектердің көлемін ұлғайтады және макрокеуектерді азайтатыны көрсетті. Зерттеулер көрсеткендей отандық модификаторлар қоспалардың қасиеттерін жақсартуға мүмкіндік береді яғни минералды негіздерінің адгезиясын жақсартады, үйкеліске төзімділігін арттырады және шөгү мен иілгіштік қасиеттерін жақсартады.

Түйін сөздер: құрғақ құрылыс қоспалар, модификаторлар, метакаолин, электротермофосфорлы коқыс, волластонит.

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ЭФФЕКТИВНЫЕ СУХИЕ СТРОИТЕЛЬНЫЕ СМЕСИ С ПЕРСПЕКТИВНЫМИ МОДИФИЦИРУЮЩИМИ ДОБАВКАМИ НА ОСНОВЕ ОТЕЧЕСТВЕННОГО СЫРЬЯ

Резюме. В статье представлены исследования по разработке эффективных сухих строительных смесей с модифицирующими добавками на основе отечественного сырья. Показана перспективность применения местных сырьевых материалов таких как Усть-Каменогорский портландцемент, Новоалексеевский песок (Алматинская область), обезвреженный электротермофосфорный шлак отечественного производства, волластонит (месторождение Акмолинской области). Волластонит выступал в качестве армирующей добавки, повышающего трещиностойкость цементного камня

формуемых изделий. Вместе с тем, проведенные эксперименты подтвердили, что ускорители твердения положительно влияют на структуру цементного камня на всех уровнях: они увеличивают объем микропор и уменьшают объем макропор при незначительном изменении общей пористости. Исследования показали, что применение модифицирующих добавок из отечественного сырья позволяют улучшить технологические свойства смесей, а именно, адгезию к минеральным основам, высокую износостойкость и прочность на истирание, низкую усадку и достаточную эластичность.

Ключевые слова: сухие строительные смеси, модифицирующие добавки, метакраолин, электротермофосфорный шлак, волластонит.

Introduction. In recent years, there has been an increase in consumption and production volumes of dry building mixes based on cement binder.

Modern dry building mixtures in the performance of various masonry, finishing and installation work should significantly improve the quality and productivity, ensuring high performance characteristics of the finished product.

A wide variety of mixtures is based on a complex of their properties, i.e. determined by the use of modifying additives for various purposes. Accordingly, the use of building mixtures with effective modifying additives is an urgent task.

Today, many scientists are involved in this problem. For example, the study of the use of additives in concretes and modern dry mixes is presented in [1], where studies are presented on the development of effective dry building mixes with modifying additives based on highly dispersed active metakaolin, which served as an impetus to research of this kind.

In various studies of scientists [2-5], the key aspects of the stability of dry solution technology such as durability, quality and efficiency are shown.

At the same time, the production of modifying additives based on local raw materials will be one of the ways to solve this problem, which will make it possible to reduce the price and increase the competitiveness of domestic products, which was the purpose of the present work.

Experimental part and discussion. To obtain experimental dry building mixtures, Portland M400 (Ust-Kamenogorsk) was used as a binder; Novoalekseevsky (Almaty oblast) sand was used as aggregates, with a particle size modulus of $\approx 2.1-1.3$. To save cement, in the process of testing a decontaminated granulated electrothermophosphoric slag was used. The granulated electrothermophosphoric slag is a sandy material of gray color, with a porous structure. Petrographic studies indicate a glassy substance, which reaches 80-95 %, represents the bulk of phosphoric granulated slag; the rest of the mass is crystallized. The main crystalline phase of phosphoric granulated slag is pseudo-wollastonite (β -CaOSiO₂) in the form of prismatic crystals with light refraction indices $N_g=1.654\pm 0.002$, $N_p=1.610\pm 0.0015$; this phase amount in the slag is

3-4 %. The melilite availability Ca (Al, Mg, Si) Si₂O₇ was also detected. An increased content of phosphoric anhydride in the slag, make evident the silicocarnotite 5CaOP₂O₅SiO₂ availability with light refraction indices $N_g=1.656\pm 0.002$, $N_p=1.640\pm 0.0015$, which are not detected with a low P₂O₅ content, which is explained by the pseudo-wollastonite involvement was found. Fluorine-containing material is represented by fluorapatite - Ca₅FP₃O₁₂ with light refraction indices: $N_g=1.633\pm 1.01$; $N_p=1.630\pm 0.002$. Cuspidin - 3CaO·CuF₂·2SiO₂ is the second in amount in the slag. The chemical composition of phosphoric slag: SiO₂ - 40.7-42.5; CaO - 46.5-48.6; MgO - 3.0-3.5; Al₂O₃ - 2.0-2.5; Fe₂O₃ - 0.7-1.7; R₂O - 0.5-0.6; SO₃ - 0.3-0.5; P₂O₅ - 1.0-1.3; F₂ - 1.0-1.2; MnO - 3.8-4.5; LOI - 0.5-0.7.

The natural wollastonite (Akmola oblast field) was used as a reinforcing ingredient that increases the crack resistance of the cement stone of the moulded products. Wollastonite is a natural calcium silicate (48.3 % CaO, 51.7 % SiO₂) one of the non-metallic minerals that are widely used in many industries. The content of wollastonite in the rock is about 50 % of the total mass. The mineral composition of the rock is represented by wollastonite, calcite, quartz, graphite, pyroxene, and feldspar [6].

The content of wollastonite in the rock is about 50 % of the total mass. The mineral composition of the rock is represented by wollastonite, calcite, quartz, graphite, pyroxene, and feldspar [2].

Wollastonite is a calcium silicate with elongated tabular and needle crystals. Naturally, pure wollastonite is not found. It is always in paragenesis with relict grains of quartz, calcite, magnesite, garnets and other contact minerals. The availability of small needles of xonotlite was established when studying the skarn of wollastonite crystals [7]. The xonotlite is specified as a mandatory and common intermediate product arising from the hydrothermal synthesis of wollastonite.

Mineral composition, wt. %: Wollastonite β -CaSiO₃ 81-86, calcite 5-8, magnesite 1-4, garnets 1-3, pyroxene 1-2, feldspar is up to 2.

Wollastonite was grinded in a rod mill to a specific surface of 250, 350, 450 m² / kg. The main set of experiments displayed the fineness grinding of wollastonite by the residue on sieve № 008 was 4 %, the specific surface area was 350 m² / kg.

An effective hardening accelerator sodium sulfate (CH) - non-caking colorless Na₂S₂O₃ crystals, well soluble in the water was used to speed up the hardening rate of the cement system. The recommended dosage is 1-3 % by weight of cement.

Additives, enter into reaction with the mineral binder materials make hardly soluble or slightly dissociated complex compounds.

The admixes interaction with clinker minerals lead to double salt-hydrates formation. The components of cement and sodium thiosulfate reactions of addition result in an increase in the strength of hardening structures and impermeability of concrete. This is due to the rapid formation of the primary structural framework of the double salts of hydrates and hydroxy salts, which then overgrow with calcium hydrosilicates. The presence of a structural framework facilitates crystallization of the main silicate components of the cement stone from double salts on the matrix phase, which contributes to an increase in the strength of the material. The research results confirmed that hardening accelerators have a positive effect on the structure of cement stone at all levels: they increase the micropores range and reduce the macropores range with a slight change in total porosity [5-12]. The water was used for gauging the mortar mixture, that meets the requirements of GOST 23732. Water should not contain sulphates of more than 2700 mg/l (in terms of SO₄) and all salts more than 5000 mg/l.

Raw materials met the requirements of the relevant standards. The dosage of the additive was 6-8 % by weight of the binder. Effective dry building mixes were obtained with the developed modifying additives.

Table 1 sets out the compositions of admix obtained during the experimental tests, the dry mortars compositions are in Table 2.

Effective dry mortars were obtained by comixing cement, sand and admixes in a forced-action mixer of the rotary type. The following technological processes were included in the technology of the dry mortars production: the dosing of components using electronic scales and special containers; feeding the components into the receiving bin of the mixing plant, then from the receiving bin with the aid of an auger to the mixer, where the mixing lasted for 5-6 minutes; the finished products were unloaded into the storage

bunker, from which the finished products were further sent for packaging.

Table 1- Admixes compositions for the dry mortars

Admix type	Content, mass %	
	Wollastonite	Decontaminated granulated phosphoric slag
KM-4	-	-
KM-4B	8-10	-
KM-4III	-	25-30

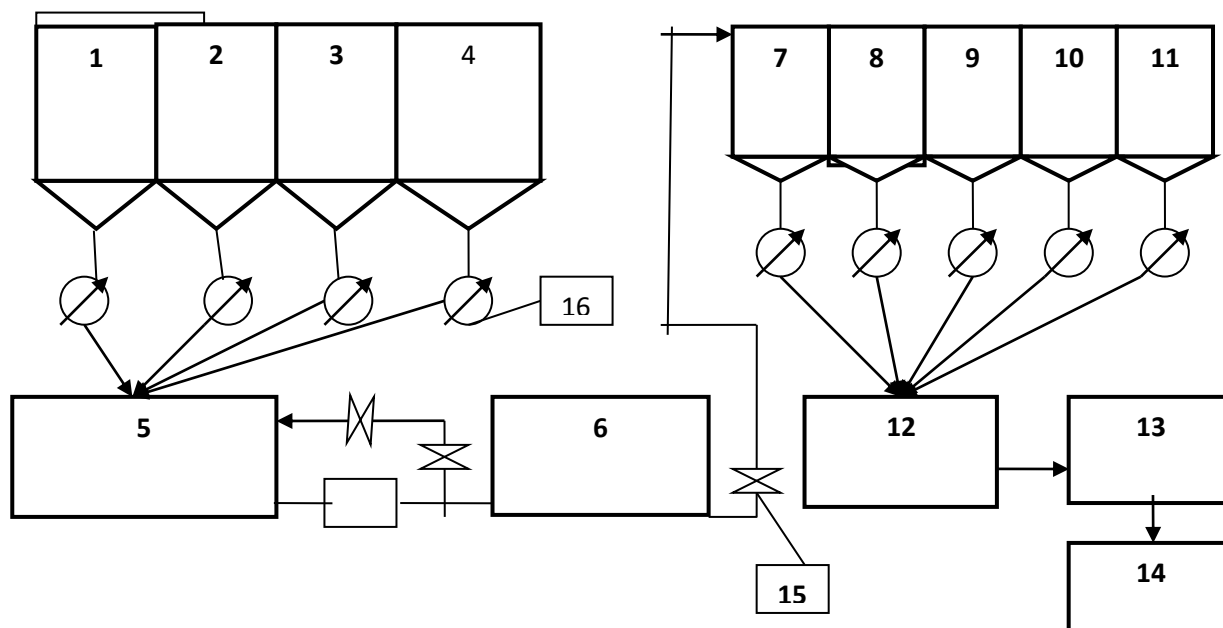
Table 2 – Dry mortars composition

Materials	Content, mass %		
	Compositions		
	1	2	3
Portland cement M400	21-24.5	19-22.5	15-18.5
Quartz sand (0,05-1,2)	67.95-57.9	67.95-57.9	53.95-43.9
Tylose	0.05-0.1	0.05-0.1	0.05-0.1
Multicomponent inoculant KM-4	6-8	6-8	6-8
Wollastonite	-	8-10	-
Decontaminated granulated phosphoric slag	-	-	25-30

The technological scheme of admixes production in granular is shown in Figure 1. Initially, oil-in-water emulsion was obtained, for which the acidic tar of raw benzene, an aqueous solution of soda ash or lime milk was used. The acid tar bunkers of the raw benzene rectification and BRSFA (1 and 2) are equipped with a heating device. The components were fed to the dispersing mixer after dosing (5) with heating to 60-70 °C, where the components were combined with stirring for 2-3 minutes until a homogeneous mixture was formed. Then, the received emulsion was combined with other ingredients in order to obtain granular complex modifiers. The combination of the emulsion with the components was performed in a mixer (12), where a homogeneous mixture was obtained within 2-3 minutes and then fed to a granulator (13). After drying, the finished granulated admix was fed to the finished goods warehouse (14).

Physical and technical and operational characteristics studies of received dry mortars were carried out, whose results are shown in table 3.

The moisture content of the finished dry mortar was 0.6-0.8%. Visually, the mortar was homogeneous.



1 - acid tar hopper; 2 - BRSFA bunker; 3 - water; 4 - sodium sulfate; 5 - emulsifier; 6 - finished emulsion reservoir; 7 - emulsion reservoir; 8 - metakaolin bunker; 9 - ash bunker; 10 - wollastonite bunker; 11 - decontaminated granulated phosphoric slag hopper; 12 - mixer; 13 - granulator; 14 - supplement warehouse; 15 - valves; 16 – dosage devices

Figure 1 – Process Flow Chart of receiving admixes

Table 3 - Physical and technical and operational characteristics of dry mortars

Parameters	Composition			
	test	KM-4	KM-4B	KM -4III
Mortar mixes				
Fluidity, sm	7-9	6-8	6-8	6-8
Stratification, %	4	2	2-3	2-3
Water retaining capacity	96	98	97-98	97-98
Mortar stones				
Compressive resistance, MPa	30,0	38,8	36,5	37,3
Dynamic modulus of elasticity, kN/mm ²	28,0	36,0	34,6	30,8
Shrinkage, mm/m, after 90 days of common weather conditions	1.2	1.02	1.12	1.08
Adhesion concrete strength, MPa	0.80	1.12	0.98	1.04
Wearing capacity, g/sm ²	0.70	0.24	0.28	0.25

At the result of the tests, the received compositions of dry mortar have demonstrated to possess the good technological properties, adhesion to mineral bases, high wear resistance and abrasion resistance, low shrinkage and enough elasticity.

In Conclusion. The possibility of obtaining effective dry building mixtures based on domestic raw materials represented by the components: a binder, a filler and modifying additives.

Provided by the technological scheme of obtaining additives.

It has been established that the introduction of modifying additives based on domestic raw materials with wollastonite (the field of Akmola region) leads to an increase in the adhesion strength of the hardened solutions, which contributes to an increase in the adhesion strength. Such reinforcing fibers inhibit the development of microcracks.

The importance of the role of modifiers was confirmed, and the effectiveness of dispersed reinforcement of dry construction mixtures depends on the compatibility of the fibers with the mineral matrix, the percentage of reinforcement, the uniform distribution of fibers in the bulk of the material and the operating conditions of the products.

It is shown that the use of local raw materials and modifying additives allows to obtain effective dry building mixtures with the required characteristics.

Dry mix mortars present a great opportunity for Kazakhstan to raise standards for the building industry in a sustainable manner. Dry mortars also offer a potential solution for the region to meet quality and durability requirements for buildings in the region. In addition, dry mortar based applications can offer a more sustainable solution for constructing buildings: as described in this report there are many parameters of dry mortar technology can contribute to more sustainable design.

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