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# New Additives to Increase Fire resistance of Building Constructions

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**ABSTRACT**: Based on the studies, a technology has been developed to produce effective composite additives from industrial waste - a mechanically-chemically activated mixture of ash from the Novo-Angren TPP + phosphogypsum. Taking into account the double effect on the cement of the mechanically chemically-activated mixture “YuUT-1” in the amount of 15-20% as an active mineral additive and a regulator of setting time instead of natural gypsum stone, its large-scale introduction is recommended.
**KEY WORDS:** cement, additive, ash and slag, phosphogypsum, activation, mixture, strength, heat resistance.

## I.INTRODUCTION

Today, with the development of the construction industry, the demand for cement is also increasing. In increasing the volume of construction, cement is one of the resources available at the price of finished objects is achieved through cost reduction due to the use in the construction of modern high-quality building materials and products with lower energy consumption and with improved

characteristics. Of particular importance is the production of effective cements based on industrial waste. On a global scale, special attention is paid to the development of new compositions of cements that increase the fire resistance of building structures and the most important task of research in this direction is the development of compositions based on industrial waste for Portland cement.

When developing composite additives and based on them new compositions of highly effective composite Portland cement, in this direction it is necessary to substantiate a number of the following scientific solutions, in particular: development of new methods for the production of effective types of building products based on composite additives; development of new compositions for the production of nanocements with the participation of secondary raw materials; increase of concrete strength indicators on sulfate-resistant cements; optimization of the composition of raw materials in obtaining energy-saving clinkers and cements; modernization of production technologies for white and decorative Portland cement;to increase the production of auxiliary cements, the use of alternative sources of active mineraladditives and filler additives.

In the Republic of Uzbekistan, large-scale measures for the production of high-quality cements are carried out, aimed at meeting the demand for cement, modernization of the economy and the creation of new production capacities are achieved. The Strategy for the Development of the Economy of the Country defines the tasks “development of production sectors, modernization and diversification of industry, in practice, apply methods of low-energy-saving technologies, production, modernization and diversification of industry, in practice, apply methods of low-energy energy-saving technologies, the development of the cement industry, the manufacture of import-substituting and export-oriented products." In this matter, scientific research aimed at the development of new compositions of composite additives based on industrial waste and new compositions of effective cements with their useis of great importance. Fire resistance is the ability of building structures to limit the spread of fire, as well as maintain the necessary performance at high temperatures in a fire [1].

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Heat-resistant concrete is a special type of material that, under the influence of high temperatures (up to 1800 ° C), is able to maintain its own physical and mechanical characteristics within establishedlimits. Heat-resistant mixtures are successfully used in all areas of industrial construction, in no way inferior to small-sized refractory materials. For example, heat-resistant concrete GOST 20910–90, in comparison with conventional refractory materials, do not need special preliminary firing. Heat treatment (firing), heat-resistant concrete, takes place duringlimits. Heat-resistant mixtures are successfully used in all areas of industrial construction, in no way inferior to small-sized refractory materials.For example, heat-resistant concrete GOST 20910–90, in comparison with conventional refractory materials, do not need special preliminary firing. Heat treatment (firing), heat-resistant concrete, takes place duringthe first heating of the finished structure, at the time of the start-up of the thermal unit [2].

Data on the limits of fire resistance and fire spread are used in the design of buildings and structures. The latter, according to regulatory documents, are divided by degree of fire resistance into five groups. For them, the required limits of fire resistance (minimum) and the spread of fire (maximum) of the main building structures are established. Depending on their type,the indicated limits of fire resistance vary from 0.25 to 2.5 hours, the limits of the spread of fire from 0 to 40 cm.The increase in fire resistance is achieved by fire protection metods.

To improve the structure of the cement composition and increase the strength of structures, mineral components (battle of magnesite or fireclay bricks, andesite, blast-furnace granulated slag, loess like loam, fly ash, etc.) are added to the binder, which have the necessary fire resistance. When heating reinforced concrete structures, destructive processes occur not only in cement binders, but also in the used aggregates. The occurrence of these reactions is explained by the uneven thermal expansion of the mineral aggregates. Therefore, you needto carefully approach the issue of choice of aggregates for a particular brand of heat-resistant concrete. We conducted studies to determine the possibility of the integrated use of mechanically chemically activated additivesof the YuUT series based on the ash and slag of the Novo-Angren TPP (thermalpower plant) and the phosphogypsum waste of Maham-Ammofos OJSC.The chemical compositions of the averaged samples of mechanochemically activated additives are shown in tabl.1.

The $SO_3$ content is 21.89% and 13.36% in YuUT-1 and YuUT-2, respectively, the results of chemical analysis of the mechanically chemically activated additives of the YuUT series indicate the possibility of their use as active mineral additives, and possibly a settingtime regulator in return gypsum stone for fire-resistant and heat-resistant cements, concrete andbuilding structures. According to table 2, in the initial stages of hardening, the strength of cements PYuUT-2-15, PYuUT-2-20, at the age of 7 days amounted to 26.8 MPa and 24.1 MPa, respectively, which practically does not differ from the strength of the control cement PC-A0 (26.8 Mpa).

Tabl.1.

The chemical composition of the components of the ash-slag + phosphogypsum mixture

| Name of components | Content of mass fraction of oxides,% | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | PC | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | CaO | MgO | $SO_3$ | $P_2O_5$ |
| zoloshlak | 7,97 | 54,82 | 21,34 | 3,18 | 5,72 | 1,30 | 0,56 | 0,14* |
| phosphogips | 19,61 | 3,04 | 0,74 | 0,78 | 29.44 | 0,25 | 43,22 | 2,42* |
| * Mass fraction of water-soluble phosphates,%, in terms of $P_2O_5$ | | | | | | | | |

Tabl.2.

Strength characteristics of cements containing mechanically chemically activated additives “YuUT”

| Cement designation | massa of a cement | Cone melt, mm | Tensile strength, MPa during bending and compression through: d / (% in 28 days undercompression). | | | | Cement grade |
|---|---|---|---|---|---|---|---|
| | | | 7d | | 28d | | |
| | | | Rbend | Rcomp | Rbend | Rcomp | |
| PC- 0 | 0,368 | 115 | 5,3 | 26,8 | 5,8 | 42,2/100 | 400 |
| PYuUT-1- 15 | 0,356 | 113 | 4,4 | 21,9 | 5,9 | 43,1/102 | 400 |
| PYuUT- 1- 20 | 0,362 | 113 | 3,8 | 18,2 | 4,2 | 26,8/63,5 | Not a match. |
| PYuUT- 2-15 | 0,356 | 112 | 4,9 | 26,8 | 6,2 | 47,8/113 | 400 |
| PYuUT - 20 | 0,356 | 113 | 4,4 | 24,1 | 6,2 | 50,8/120 | 500 |

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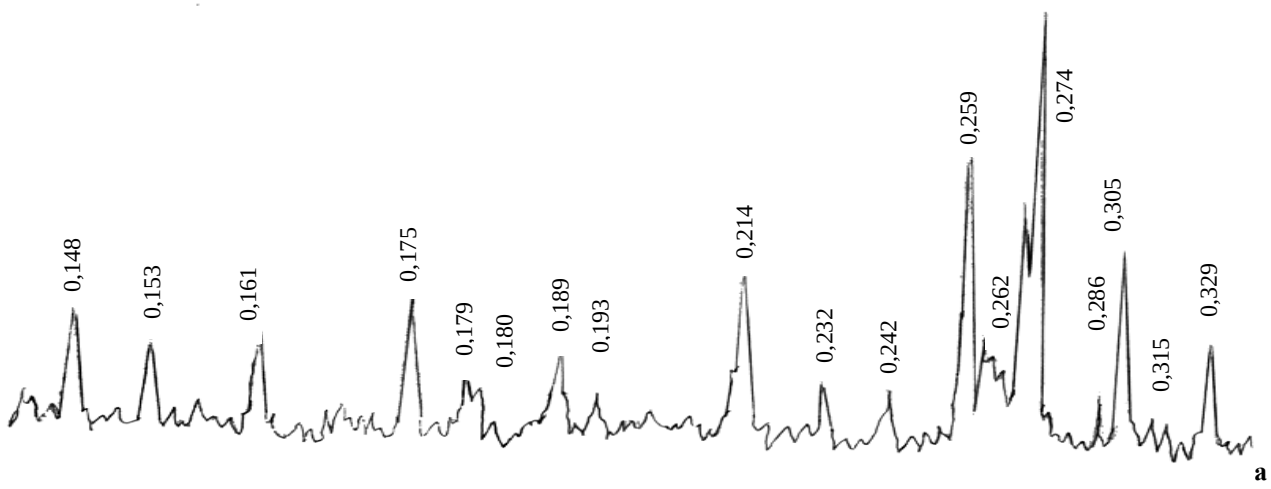
The chemical activity of the mechanically chemically activated additive "YuUT" in the absorption of lime was 54.5 mg, which corresponds to the minimum permissible activity characteristic of the group of artificial (technogenic) aluminosilicate hydraulic additives. Therefore, the YuUT additive is a chemically active mineral additive, and is classified by its origin (manufacture) as an artificial additive of technogenic origin, acidic in chemical composition,and hydraulic in chemical activity.

Despite the presence of many modern and interesting construction solutions with the “YuUT-1” on the based, traditional monolithic flat still has numerous followers. This is caused by a few different reasons. First and foremost, when building home flat and flooring, there is no need to use heavy equipment. Besides, construction materials necessary for building it can be acquired without problems – steel bars and concrete can be bought easily, while planks can be later used to build the roof. Furthermore, monolithic flat can be built in a variety shapes, also including atypical, with the “YuUT-1”. That and it is not too thick (from a few to a dozen or so centimetres) and is characterized by good acoustic and thermal insulation characteristics. If it is building according to the best construction practices, reinforced concrete flooring forms a smooth and even surface on both sides that is the floor and the ceiling. Unfortunately, they also have some disadvantages. First and foremost, they are relatively heavy and building them is labor-intensive with the “YuUT-1”, since they require full formwork and complicated reinforcement, constructed by a professional. Furthermore, there should be no stoppages during the works – after setting up the formwork and reinforcement with the “YuUT-1”, concrete should be poured immediately, of course while remembering to vibrate and cure it properly. Unassisted construction with the “YuUT-1” of such flooring is impossible and thus help of excellent professionals should be employed during the mentioned works.

The results of electron microscopic analysis of the YuUT additive confirm the formation of a crystalline structure during the autoclave treatment of a mixture of phosphogypsumand ash and slag, and that it is similar to the structure of hardening cement paste in the early periods of hardening and is represented mainly from hydrated sulfate-containing minerals and neoplasmsin the form of hydrosulfoaluminate and low basic hydrosilicate compounds (Fig.1).

When “YuUT” additives are introduced into the cement, these hydrated neoplasms play the role of crystalline seeds — “crystallization centers”, which initiate the emergence of new nuclei of the hydrosulfoaluminate and hydrosilicate type neoplasms, accelerate theircrystallization and the formation of the crystalline skeleton of the hardening cement dispersion, and as a result intensify the processes of hydrolysis and hydration of aluminate andsilicate minerals of clinker PC.



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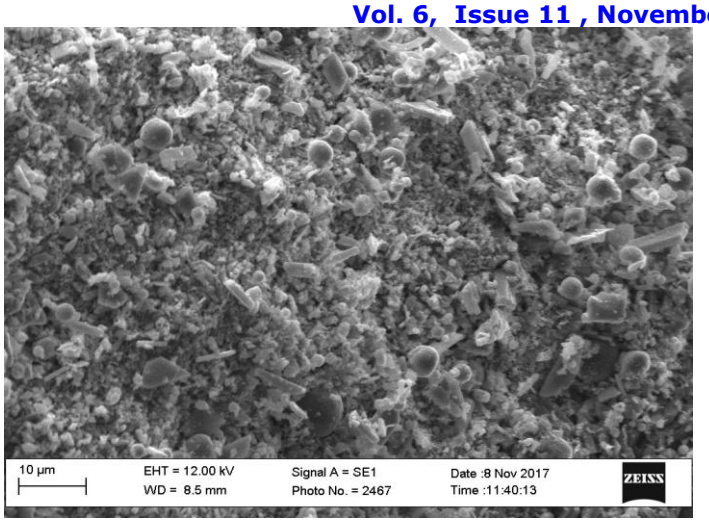


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Fig. 1 X-ray diffraction pattern (a) and electron micrograph
(b) of the additive “YuUT-1”x500

To study the effect of the additive “YuUT-1” on the physic-mechanical properties of the PCs of JSC “Bekabadcement”, blends were prepared including “65-85% PC clinker + 15-35%“YuUT-1”, and for comparative tests -“ 95% PC clinker + 5% gypsum stone.

The additive "YuUT-1" was introduced into the raw material charge taking into account the content of 8.56% SO3. It has been established that in the presence of “YuUT-1” additive, the grindability of mixtures is increased compared to grinding clinker PC with 5% gypsum stone: with a constantly fixed time (40 min), the fineness of grinding cements with “YuUT-1” determined by the residue on sieve No. 008, varies within (2-6)% compared with 10% of the remainder of PC-D0. Cements with the addition of “YuUT-1” meet the requirements ofGOST 10178 on the content of SO3 (2.33-3.80%), because for ND, the optimal $SO_3$ content in the PC should be at least 1.0% and not more than 4.0% by weight. The rates of initial reactions of cements with the addition of “YuUT-1” with water are little different from the ratesof reactions of a non-additive PC. The process of starting the setting of cements PC-F15, PC-F20, PC-F 25 is extended by (15-30) min.

The increase in water demand of additional PCs is explained by the increased content of aluminate phases in them and a finer degree of grinding in comparison with PC-D0 cement.In accordance with the data in table 4, the strength of cement with the addition of 15% “YUT-1” (PC-F15), both at the age of 28 days of normal hardening, and with longer curing (3 months) practically do not differ from the strength of cement PC-D0.

Constructions with a new fire additive all over the world rely on concrete as a strong material that provides fire safety and is easy to handle. It can be found in almost all building types – residential, oil and gas reservoirs storage, multi-flat and even in municipal infrastructure. Despite its wide range of use, many of its users still do not know about the fire matteryals with the “YuUT-1” directly connected to ensuring the endurance and high quality of concrete. The term “concrete strength class” means the endurance of concrete against compression, no more, no less. It determines the amount of stress the material can take. Concrete strength is determined by measuring the crushing strength of cubes or a cylindrical sample made from a pre-prepared mixture. After the measuring and strength determining, concrete is assigned a strength class.

Based on the studies, a technology has been developed to produce effective composite additives from industrial waste - a mechanically-chemically activated mixture of ash from the Novo-Angren TPP + phosphogypsum. Taking into account the double effect on the cement of the mechanically chemically-activated mixture “YuUT-1” in the amount of 15-20% as an active mineral additive and a regulator of setting time instead of natural gypsum stone, its large-scale introduction is recommended.

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