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ELABORATION OF NEW HIGHLY EFFECTIVE ADDITIVES TO IMPROVE FIRE AND HEAT RESISTANCE OF CONCRETE

Abstract: *The article discusses some of the possibilities of creating fire-retardant materials of a wide profile for concrete, reinforced concrete, facing and finishing materials. Concrete ways of practical application of new developments are given.*

Key words: *concrete, fire protection, heat resistance, polymer composition, plaster, finishing material, waste.*

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Introduction

Currently, in all developed countries, great importance is attached to studies of the fire resistance of building structures, the development of new materials with increased fire resistance, as well as the development of new methods and materials for protecting structures from fire. Such interest in this issue is caused by the constant increase in the number of fires in industrial and civil buildings in recent years. An increase in the number of storeys in construction also requires an increase in the reliability of structures in case of fire [1].

Elements of reinforced concrete structures that find themselves in the high temperature zone are heated quite strongly: in this case, both due to an increase in their temperature and due to changes in the metal structure, the strength characteristics decrease below the level at which the bearing capacity for design loads can be guaranteed.

Building standards of our republic, a number of European countries, the USA and Japan prescribe the protection of reinforced concrete structures with the help of fireproof coatings. These requirements apply to residential and administrative buildings, as well as to a number of engineering structures located in densely populated areas. However, the use of protective stains, coatings, etc. is accompanied by a deterioration in the sanitary and hygienic condition of workplaces, additional labor and material costs, sometimes a significant increase in the dead weight of structures, and also significantly increases the cost of work.

The use of reinforced concrete structures with strength characteristics normalized to a fairly high level during short-term heating during a fire in the temperature range 500-700 ° C allows to weaken, and in some cases eliminate, these negative circumstances. reinforced concrete structures with high fire resistance [2].

Reinforced concrete structures with sufficiently high strength under prolonged exposure to elevated temperatures - mainly heat-resistant steels - have been developed for such applications as tanks operating under high pressure in aggressive environments at high temperatures, boiler pipes, etc. These reinforced concrete structures are used for long-term service at elevated temperatures and differ from fire-resistant reinforced concrete structures, which must withstand fire for a relatively short time [3].

The main field of application of fire-resistant reinforced concrete structures in foreign countries is industrial and high-rise civil engineering, especially for areas with increased seismic activity, where the likelihood of fires is especially high, and the use of fire-retardant colors significantly worsens the environmental situation.

The use of reinforced concrete structures resistant to short-term exposure to high temperatures for the manufacture of metal structures of these structures can significantly reduce construction costs and increase the operational reliability of structures.

The specificity of the requirements for fire-resistant reinforced concrete structures is that these materials must ensure the operability of the reinforced concrete structures both under ordinary conditions (including at freezing temperatures) and under conditions of short-term heating of the reinforced concrete structures in the event of a fire. In this regard, fire-resistant reinforced concrete structures must also have a full range of mechanical and technological properties, the necessary building reinforced concrete structures and including normalized strength, plastic characteristics determined at normal temperature (+ 20 ° C), impact strength, determined at negative temperatures have sufficient technological ductility, guaranteed weldability.

The solution to the problem of introducing fire-resistant reinforced concrete structures in industrial and civil engineering necessitated extensive research related to the development and study of the properties of these new steels, studying the behavior of these reinforced concrete structures in building structures during heating, and determining the actual increase in fire resistance of structures made from new fire-resistant concrete structures, with the development and practical use of methods for testing new materials, and fire resistance assessments and methods of corresponding calculation.

The relevance of the research is due to the need to increase the fire resistance of reinforced concrete building structures, improve fire resistance methods, ways to regulate it and increase the operational reliability of reinforced concrete building structures in case of fire.

The aim of our research is to develop methods for evaluating the performance of fire-resistant reinforced concrete compositions in building structures, study the properties, determine the actual increase in fire resistance of structures made from new fire-resistant reinforced concrete structures, and identify areas of application for new materials [4].

To achieve this goal, we conducted studies to determine the possibility of the integrated use of mechanically chemically activated additives of the YuUT series based on the mechanochemical activation of ash and slag of the Novo-Angren TPP, phosphogypsum waste from Maham-Ammofos OJSC and cement baking dust. The chemical compositions of the averaged samples of mechanochemically activated additives are shown in table 1.

Table 1. Chemical composition of the components of the ash-slag + phosphogypsum mixture

Name of components	The content of the mass fraction of oxides,%							
	NN	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	P_2O_5
Ash and slag	7,97	54,82	21,34	3,18	5,72	1,30	0,56	0,14*
Phosphogypsum	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.								

Cement plant baking dust trapped on electrostatic precipitators has the following chemical composition shown in Table 2. (according to the laboratory of the Kuvasay cement plant).

The results of chemical analysis show that if the bulk of calcium oxide is part of the clinker, then up to 10.0% of the oxide is in a free state. Given the possibility of direct use of free calcium oxide, as well as the possibility of displacing it from the corresponding carbonate compounds with stronger nitrite and nitrate anions, we thought it advisable to search for the use of caked dust as an additive to concrete.

Table 2. Chemical composition of caked dust of the Kuvasay cement plant

№	The composition of the baked dust, in terms of oxides	Amount, % the weight	Note
1.	SiO_2	14,10	Dust from the stove № 4 Kuvasay cement
2.	Fe_2O_3	3,38	
3.	Al_2O_3	3,30	
4.	CaO	46,28	

5.	MgO	1,55	the factory
6.	SO_3	5,00	
7.	R_2O, в т.ч. K_2O Na_2O	6,12 5,24 0,88	
8.	Loss on calcination	19,44	
9.	Unaccounted for losses	0,79	

The SO3 content is 21.89% and 13.36% in UUT-1 and UUT-2, respectively, the results of chemical analysis of the mechanically-chemically activated additives of the UUT series indicate the possibility of their use as active mineral additives, and possibly a time regulator setting instead of gypsum stone to obtain fire-resistant and heat-resistant cements, concrete and building structures [4].

As is known [5], marble chips consist mainly of calcium carbonates, magnesium and related impurities, which give marble color and shade. The activity of calcium and magnesium carbonates occupy almost the same absorption, they are equal with respect to caustic potassium 0.39 and 0.4, respectively. It can be seen that their activity, although 2 times lower than the activity of potassium oxide, in those cases when it is available and is a waste product, can be used to clean the exhaust gases from nitrogen oxides. In this case, the only expense item is the energy consumption for grinding crumbs to a finely divided state and calcination.

We have established [4] that the use of one or another type of aggregate depends on the established temperature regime of their operation:

1. At temperatures from 600 ° C to 800 ° C, rocks (basalt, andesite, diabase), granular blast furnace slag, porous aggregates from volcanic rocks, brick fight, porous artificial aggregates (expanded clay, vermiculite can be used as fillers) , expanded perlite, slag pumice, etc.).

2. For the operation of concrete structures within 1200 ° C – 1700 ° C, cement heat-resistant mortars are made with the addition of crushed refractory materials (magnesite, fireclay bricks, chromite, calcined kaolin, corundum).

3. In addition, special fillers are used, made by high-temperature firing of a mixture of magnesite and refractory clay - magnesium aluminum silicates, characterized by low temperature deformation, high refractoriness in a wide temperature range.

According to table 3, in the initial stages of hardening, the strength of cements PUUT-2-15, PUUT-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-D0 (26.8 MPa).

It has been established that heat-resistant concrete structures on aluminate cements without special additives can withstand temperatures up to 1300 ° C, and when adding the UUT-2 additive developed by us, the temperature regime rises to 1800 ° C and more.

To improve the structure of the cement composition and increase the strength of structures, mineral components were added to the binder (a battle of magnesite or fireclay bricks, andesite, blast furnace granulated slag, loesslike loam, fly ash, etc.), which possess the necessary refractoriness indices.

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 need to carefully approach the issue of choice of aggregates for a particular brand of heat-resistant concrete.

Fire-resistant structures prepared using the UUT additives we developed in aluminous cements can be exposed to high temperatures already after a day after manufacture. The optimal compositions of heat-resistant concrete on aluminate cements are shown below in Table 3.

Table 3. Some thermophysical properties of fire and heat-resistant concrete

Components of concrete	**Content by weight,%**	**Deformation temperature under load, ° C**		**Refractoriness,%**	**Linear shrinkage,%**
		Start	**End**		
Aluminous cement + YuUT-1 fireclay powder	20-15 80-85	1480-1520	1500-1600	1800	0,2-0,3
Aluminous cement + YuUT-1 chromite powder	15-7 85-93	1495-1560	1500-1600	1800	0,2-0,3

Aluminous cement fireclay powder	20-15 80-85	1200-1350	1300-1400	1500	1-2
Aluminous cement chromite powder	15-7 85-93	1280-1340	1380-1440	1600	1-2

CONCLUSION

Consequently, the dense heavy heat-resistant concrete developed by us can be used for the manufacture of fire-resistant building structures, and as a heat-resistant lining in thermal units: blast furnace recuperators, in chemical industry enterprises, in building brick kilns, in the construction of chimneys, etc.

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