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DETERMINATION OF STRENGTH CHARACTERISTICS OF HEAT-RESISTANT CONCRETE ON ALUMINA CEMENT

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Abstract: The article presents the results of experimental studies of the strength of heat-resistant concrete on alumina cement. The maximum size of grains of aggregates of sand and crushed stone, the results of cement tests, as well as the strength and deformation characteristics of concrete at normal temperature are given, which made it possible to calculate the strength of prototypes with high accuracy.

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Keywords: *concrete, chamotte crushed stone, sand, concrete cubes, dehydration of aluminates, strength.*

Research methods. As part of comprehensive research, the strength of heat-resistant concrete with fireclay fillers and alumina cement was experimentally studied. For heat-resistant concrete, alumina cement from the Pashiysky plant with an activity of 48.4 MPa was used as a binder. The fillers were fireclay crushed stone with a maximum size of up to 20 mm and fireclay sand of a fraction of 0-5 mm from class B fireclay (Tables 1 and 2). Also, during the study, the scientific works of scientists were considered [1-21].

Table 1. Grain composition of fireclay crushed stone

Maximum grain size of filler, mm	Total residue in % by weight on a sieve with clear openings in mm		
	20	10	5
20	0-5	30-60	90-100

Table 2. Grain composition of fireclay sand

Dimensions of sieve openings in the clear, mm	5	1,25	0,14
Total sieve residue, % by weight	0-15	20-55	85- 100

The consumption of materials per 1 m3 of heat-resistant concrete is accepted as follows: aluminous cement - 400 kg; fireclay crushed stone - 720 kg; fireclay sand - 720 kg; water - 280 l. Heat-resistant concrete: density 2120 kg/m3 and W/C - 0.70.

Table 3. Cement test results

The name of indicators	Aluminous cement from Pashiy plant
Normal dough consistency	29,5 %

Start of setting	1 hour 28 minutes
End of setting	4 hours 40 minutes
V/C	0,39
Cone spread, mm	115,115
Cement activity, MPa	48,4

Materials were dosed by weight with an accuracy of ±0.5 kg. The concrete mixture was prepared in a forced-action concrete mixer with a capacity of 250 liters.

To determine the physical, mechanical and deformative properties, concrete cubes with an edge of 10 cm and prisms of 10x10x40 cm were made. On the second day after concreting, the surface of the cubes and prisms was covered with wet sawdust and moistened for 6 days. On the 8th day, all samples were stripped and stored in the production workshop. Cubes and prisms, intended to study the influence of elevated and high temperatures on the strength and deformation properties of concrete, after stripping, were placed in a normal hardening chamber, where they were stored for 28 days, then in the conditions of the production workshop.

Results. Testing of cement, cubes and prisms was carried out in full accordance with the recommendations of current standards. Cubic strength and tensile strength when splitting concrete of natural hardening at normal temperature were determined at the age of 3, 7, 28 days. and by the time of testing prototypes. The cube strength of concrete and tensile strength were determined in a cooled state after heating. Cubes and prisms were heated in an electric oven at a rate of 100°C per hour to temperatures of 70,100,150,200, 300, 400, 500,600, 700 and 800°C, kept at a given temperature for 2 hours, then cooled along with the oven.

The prismatic strength and modulus of elasticity of heat-resistant concrete based on naturally hardening alumina cement were determined at normal temperature at the age of 28 days. and when heated to 100, 300, 450, 700 and 800°C by the time the prototypes were tested. At each temperature, 3 prisms were tested.

Heat-resistant concrete based on alumina cement, when heated to 2000C, sharply reduces its compressive strength, but at heating temperatures above 10000C it has the least decrease in strength. Compressive strength in the range of 100-4000C decreases by 35-60%. This is explained by the completion of complete dehydration of aluminates in this temperature range. At heating temperatures above 4000C, the decrease in concrete compressive strength slows down and when heated to 6000C it is 38-64%, when heated to 8000C - 36-60%.

The tensile strength Rbttem of heat-resistant concrete on alumina cement of natural hardening when heated to 300-10000C is almost the same, it is 50-55% of the control. Strength and deformation characteristics of concrete at normal temperature

Concrete	Curing conditions	Возраст (сут)	R MPa	R_b MPa	R_{bt} MPa	$E \cdot 10^3$ MPa	$\mathcal{E}_b^{np}$ $1 \cdot 10^5$	ν_b	w %
Heat-resistant on alumina cement	natural hardening dried	3	31	-	-	-	-	-	-
		7	33	-	-	-	-	0,69	-
		28	40,5	35	3,6	24,7	280	-	5,8
		125	41	35	3,6	-	-320	0,62	-
		-	30	26	2,4	320			-

Short-term heating to 1000C causes a sharp decrease in the compressive strength of heat-resistant concrete based on alumina cement of natural moisture. The cubic strength of concrete after heating to 1000C is reduced by 53%. After heating to 2000C, cubic strength decreased by 37% and after heating to 3000C - by 60%. The reason for such a sharp decrease in the strength of heat-resistant concrete is the endothermic effects observed when heating hydrated aluminous cement at temperatures close to 100 and 3000C, associated with the loss of free and bound water by the cement stone and disruption of the structure due to the difference in temperature deformations of the aggregate and the cement stone.

In the temperature range 400-7000C, the cubic strength of heat-resistant concrete on alumina cement of natural humidity is 43-52% of the control. After heating to 8000C, the cubic strength of alumina cement was 36% of the strength at normal temperature. The cubic strength of dried heat-resistant concrete based on alumina cement when heated to 5000C decreases smoothly and to a lesser extent than that of concrete with natural moisture.

The prismatic strength of heat-resistant concrete based on alumina cement when heated has approximately the same character of change as the cubic strength. When heated to 1000C, the prismatic strength decreases by 56%, and at 3000C – by 49%. When heated to 700 and 8000C, it decreases by 56 and 59%. The ratio Rbtem/Rtem when heated to temperatures of 100, 300, 450, 700 and 8000C was 0.85, 1.04, 0.79, 0.88 and 0.97, respectively, which indicates a decrease in the difference between the prismatic and cubic strength of concrete at high temperatures.

Conclusion. The tensile strength of heat-resistant concrete based on alumina cement after heating to temperatures of 100 and 3000C is reduced by 54 and 65%, respectively. In the temperature range 400-6000C, the tensile strength remains almost unchanged; it averages 42% of the control strength at normal temperature. Heating to 700 and 8000C causes a decrease in tensile strength by 66 and 68%.

Determining the actual values of the characteristics of heat-resistant concrete made it possible to calculate the strength of prototypes with high accuracy.

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