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HEAT-RESISTANT CORUNDUM CONCRETE REINFORCED WITH ALUMINUM OXIDE FIBERS SYNTHESIZED WITHIN A MATRIX DURING FIRING. PART 4. CHOICE OF RATIONAL CORUNDUM CONCRETE COMPOSITION[1]

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Mathematical planning of an experiment is used to determine optimum relationships between fractions of filler, high-alumina cement, and mixing water in corundum concrete. Characteristics of density, ultimate strength in compression, and concrete structural quality factor are obtained.

Keywords: fractional composition, optimum relationships, filler packing density, totally factored experiment, statistical treatment, regression equation.

Filler of three fraction grain size composition has been studied in order to prepare concrete with good physicotechnical properties. This composition is most technologically efficient in manufacturing refractory concrete objects. Fractionation of corundum grade K object scrap is accomplished through a standard set of screens with cell sizes of 5.0, 1.25, 0.63, and 0.14 mm. Residues on each of the screens (partial residues) specifying filler grain size composition were labelled with letters. Residue on a screen with cell size 1.25 mm *C*, 0.63 mm *B*, and 0.14 mm *A*.

Provision of minimum intergranular space and correspondingly maximum average filler mix density was achieved by mixing grains of different size in prescribed ratios. Results of experiments are given in Table 1 and shown in a diagram Fig. 1.

It follows from the data obtained that the greatest filler bulk density applies to compositions in the range 50 – 65% *A*, 10 – 30% *B* and 10 – 40% *C*. In order to select the optimum ratio between filler, high-alumina cement, and mixing water in refractory concrete studies were carried out by a completely factored experiment plan (1, 2, 3) of eight tests.

TABLE 1. Filler Grain Size Composition and Average Bulk Density

Composition number	Filler composition, wt.%			Average bulk density, kg/m^3
	A (0.14 mm)	*B* (0.63 mm)	*C* (1.25 mm)	
1	100	—	—	2270
2	80	20	—	2320
3	60	40	—	2320
4	40	6	—	2300
5	20	80	—	2190
6	—	100	—	2100
7	80	—	20	2310
8	60	20	20	2340
9	40	40	20	2320
10	20	60	20	2220
11	—	80	20	2090
12	60	—	40	2330
13	40	20	40	2330
14	20	40	40	2260
15	—	60	40	2200
16	—	40	60	2220
17	20	20	60	2200
18	40	—	60	2070
19	20	—	80	2070
20	—	20	80	2000
21	—	—	100	1790

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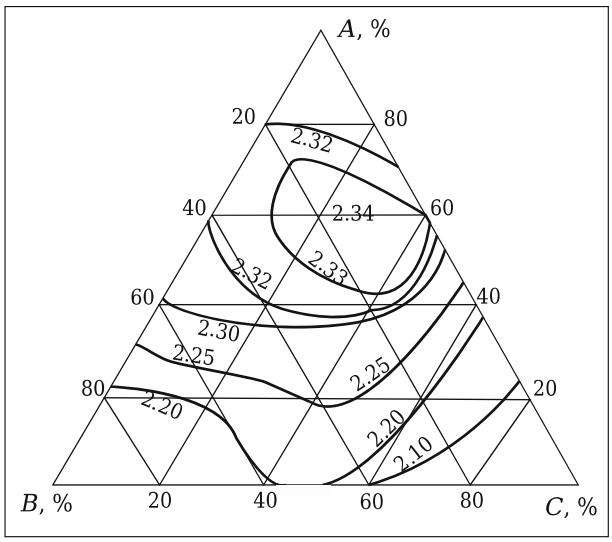

Fig. 1. Filler composition — bulk density diagram.

TABLE 2. Variable factors and Levels of Component Variation

Factor	Variation range	Lower level		Upper level	
		natural value	coded value	natural value	coded value
X_1	15	10	–1	40	+1
X_2	5	15	–1	25	+1
X_3	0.05	0.4	–1	0.5	+1

TABLE 3. Experiment Planning Matrix

Experiment number	X_0	X_1	X_2	X_3	X_1, X_2	X_1, X_3	X_2, X_3	X_1, X_2, X_3
1	+	+	+	+	+	+	+	+
2	+	–	+	+	–	–	+	–
3	+	+	–	+	–	+	–	–
4	+	–	–	+	+	–	–	+
5	+	+	+	–	+	–	–	–
6	+	–	+	–	–	+	–	+
7	+	+	–	–	–	–	+	+
8	+	–	–	–	+	+	+	–

For reliability of the results obtained average values of parameters in each experiment were calculated from the results of measuring 12 specimens.

TABLE 4. Optimized Concrete Composition and Properties

Concrete	Composition, %			W/C	Ultimate strength in compression, MPa
	fraction 1.25 – 5.0 mm	fraction 0.14 – 1.25 mm	cement		
1	40	35	25	0.5	24.70
2	10	66	25	0.5	16.66
3	40	45	15	0.5	20.12
4	10	75	15	0.5	18.82
5	40	35	25	0.4	20.46
6	10	65	25	0.4	22.50
7	40	45	15	0.4	17.90
8	10	75	15	0.4	18.68

The following factors were varied: X_1 is amount of filler, kg; X_2 is amount of high-alumina cement, kg;, X_3 is water-cement ratio (W/C).

Values of variation factor levels and step are provided in Table 2, and a planned experiment matrix is given in Table 3. As a result if implementing the experimental plan values of parameters provided in Table 4 were obtained.

Statistical treatment of results was carried out. Numerical average line-by-line dispersion and verification for uniformity showed that results are reproducible. Coefficients of regression equations were calculated for the average values of parameters. Finally equations were reduced to the form:

$$y = \alpha_0 = \alpha_1 x_1 + \alpha_2 x_2 + \alpha_3 x_3 + \alpha_{12} x_1 x_2 + \alpha_{13} x_1 x_3 + \alpha_{23} x_2 x_3 + \alpha_{123} x_1 x_2 x_3,$$

$$y = 19.9 + 0.81 x_1 + 1.09 x_2 + 0.09\, x_3 + 0.68 x_1 x_2 + 1.52 x_1 x_3 + 0.49 x_1 x_3 + 0.51 x_1 x_2 x_3.$$

According to the equations obtained the optimum concrete mix composition is as follows, %: coarse filler fraction 5 – 1.25 mm 62, fine fraction 1.25 – 0.14 mm 20; high-alumina cement 18, concrete water-cement ration 0.43.

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