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Short Communication

Rational Solution to the Problem of Integrated Metallurgy and TPP Waste Utilization for the Development of "Green" Technology for the Production of Composite Portland Cements

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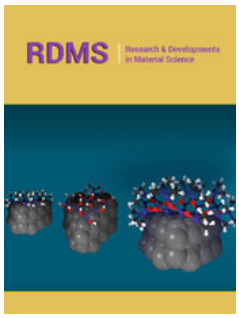

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Abstract

In order to ensure a clean "climate", environmental safety in the areas of thermal power plants and metallurgical production by involving large-scale disposal of their waste in the production of cement, the chemical and mineralogical compositions and physical and chemical properties of ash and slag mixtures of the Angren TPP and waste from the steelmaking production of Uzmetkombinat JSC - microsilica were determined, recycled steel, furnace, ladle slag. Their hydraulic activity was established according to the Student's criterion in order to determine their possibility as ingredients of "green" hybrid additives for the production of composite Portland cements and conclusion was issued on their compliance with the requirements of O'z DSt 901-2020 for additives suitable for use in the cement industry. With different combinations and ratios of Portland cement clinker, natural gypsum stone and new types of hybrid additives, composite Portland cements were prepared and comparative tests were carried out to determine their physical and mechanical properties. Based on the results of the strength indicators of "green" composites, the compositions of new types of composite Portland cements were optimized, which meet the requirements of the Standard of the Republic of Uzbekistan O'z DSt 2830:2014 "Portland cement with composite additives. Specifications" for Portland cement grades 400-450.

Keywords: Clinker; Man-made waste; Dry ash and slag mixture; Silica fume; Recycled steel slag; Furnace slag; Ladle slag; Recycling; Composite additive in cement; "Green" cement composite; Clinker saving

Introduction

One of the most effective areas of waste processing is their use as components for the production of building materials and products, since this direction allows you to dispose of almost all types of waste in large quantities to obtain high-quality products at low production costs. In turn, the most promising area of waste processing into building materials and products is the production of composite materials [1-7]. At the same time, special attention is paid to the disposal and processing of solid waste from metallurgy, energy and the chemical industry. Large-tonnage solid wastes include various types of slags from metallurgy and thermal power plants, with a rational approach to the processing of which they can serve as valuable raw materials for the production of cement clinker, additional, pozzolanic and composite Portland cements [8-13].

The purpose of the study is to develop scientific and applied foundations for the use of industrial waste from energy and metallurgy as ingredients of hybrid additives by examining their suitability and establishing compliance with the requirements of O'z DSt 901-2020 for cement additives, optimizing compositions and developing a technology for producing composite Portland cements with their use.

Method

Determination of the chemical composition of the starting materials was carried out in accordance with the requirements of GOST 5382-91 "Cements and materials for cement production. Methods of Analysis". The physical and mechanical properties of highly filled Portland cements were determined on small cube samples 2x2x2cm in size with a composition of 1:0. Portland cement grade PC400-Ad0 served as a base for comparison. The brand of new types of composite Portland cements with hybrid additives is determined in accordance with the GOST 310.4 methodology.

Results and Discussion

To study the effect of new types of hybrid additives on the physical and mechanical properties of ordinary Portland cements, Portland cement clinker JSC Bekabadcement was used as a matrix (Table 1).

Table 1: Chemical compositions of Portland cement clinker and gypsum stone

Name of the Materials	The Content of the Mass Fraction of Oxides, %						
	loss on ignition	SiO_2	$Al2O_3$	Fe_2O_3	CaO	MgO	SO_3
Clinker JSC "Bekabadcement"	0.36	56.40	6.27	4.77	2.79	1.00	0.37
Gypsum stone	13.60 under of 400 °C	2.11	0.49	0.15	31.08	3.79	38.09

Portland cement "green" composites contain hybrid additives from the compositions of Dry Ash and Slag Mixtures (DASM) of the Angren TPP and steel smelting wastes of Uzmetkombinat JSC: processed Steel-Smelting Slags (SSSl), Ladle Slags (LSl), Furnace Slags (FSl) and ferrosilicon production waste - microsilica (MS). The chemical compositions of these wastes are shown in Table 2.

Table 2: Chemical compositions of technogenic wastes used in the formation of hybrid additives for composite Portland cements

Name of the Materials	The Content of the Mass Fraction of Oxides, %							
	п.п.п	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	others
Microsilica	2.79	90.84	1.51	1.59	0.56	1.00	0.23	1.48
Ladle slag	1.49	35.93	7.56	2.79	33.06	6.04	0.78	12.35
Furnace slag	-	31.34	9.57	20.78	15.97	4.23	1.19	16.92
Processed steel-smelting slags	9.78	27.92	9.10	10.93	25.73	10.43	1.03	5.08
DASM	3.0	62.02	23.55	4.32	3.0	-	1.28	0.8

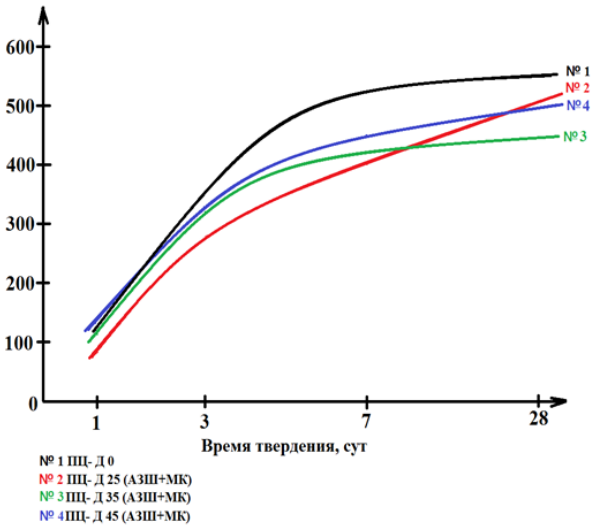

Figure 1: The kinetics of the increase in the strength of PC, depending on the dose of the hybrid additive "activated ash + microsilica".

Studies conducted on the possibility of a certain part of high-temperature and expensive Portland cement clinker with available and cheap secondary resources of Uzmetkombinat JSC showed that replacing 25% of the clinker component in Portland cement with a hybrid additive, including DASM + MS, in the initial hardening period (up to 7 days) slows down the set its strength. By the 28th day, strength development accelerates, and the index of the cement composite reaches the index of the matrix PC-Ad0 (Figure 1). DASM+MS, an increase in the content of the additive has almost no effect on the rate of the process and curing of the PC up to 3 days, and by the 7th day, the process slows down and the hydraulic activity of the composite for 28 days is significantly lower than that of the matrix. Some slowdown in the hardening process of the modified PC containing 45% of the hybrid additive was also noted up to 7 days, then an acceleration of strength development is observed, the indicators of which approach the strength indicators of PC-Ad0 and C-Ad 25 (DASM + MS) by 28 days.

The introduction of (25-45)% of the hybrid additive of the composition DASM + SSSl contributes to the smooth flow of the process of hydration of the binder composition and, consequently, the strength gain of "green" composites, the indicators of which by the 28-day period are slightly inferior to the strength indicators of PC-Ad0 (Figure 2). The same strength results were achieved with the addition of 25–35% of the hybrid additive DASM+ FSl to the PC-Ad0 composition, an increase in the content of which to 45% significantly reduces the strength of the matrix during all hardening periods (Figure 3).

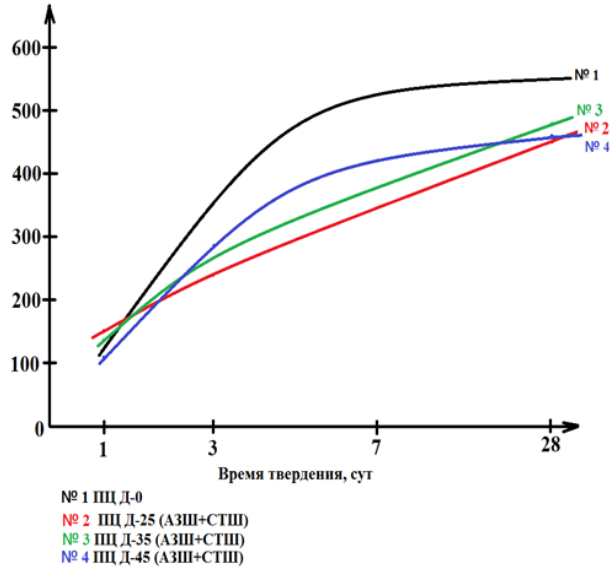

Figure 2: Kinetics of PC strength growth depending on the dose of the hybrid additive "activated ash + steel slag".

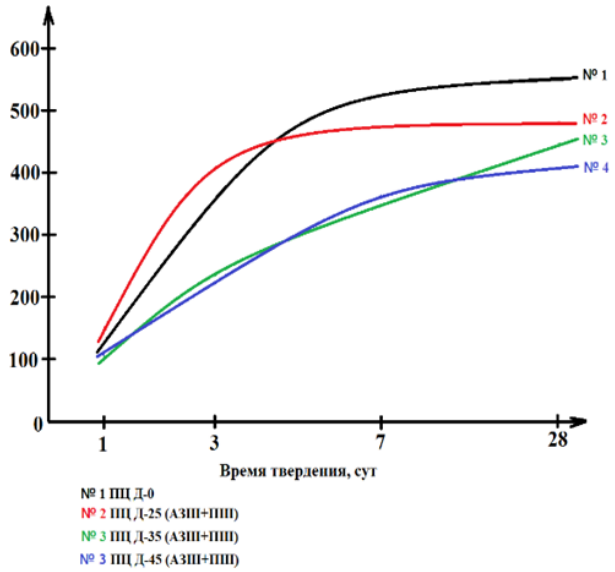

Figure 3: The kinetics of the increase in the strength of PC depending on the dose of the hybrid additive "DASM+FSl".

The introduction of a 25% additive from DASM + LSl does not have a negative effect on the hardening process PC-D0 and the cement composite after 1 day of hardening has the same strength as it has (13.0MPa). By the 3rd and 7th days, its value is slightly lower than that of PC-Ad0, and by the 28th day, the process of strength development of the composite accelerates sharply, and, reaching 60.0MPa against 54.0MPa of the matrix PC, the indicators exceed its hydraulic activity at 6.0MPa (Figure 4). At a content of 35% additive DASM+LSl, the strength of the composite is almost 2 times higher than that of the matrix, however, by the 3rd and 7th days, a slowdown in the process of strength development was noted, which is much lower for a stone based on PC-D0. At the same time, by the 28-day period, the process is observed to accelerate the process of hydration and hardening of the composition "PC + DASM+LSl ", as a result, the strength of the composite based on it will reach (55.0MPa) the level of the strength index PC-D0 (54.0MPa). Increasing the amount of added additive to 45% reduces the hydraulic activity of composite Portland cement during all periods of hardening [14,15].

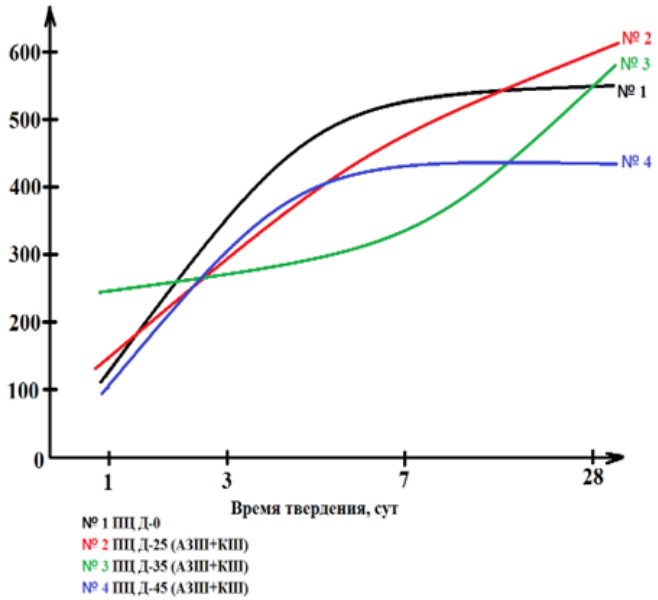

Figure 4: The kinetics of the increase in the strength of the PC, depending on the dose of the hybrid additive "DASM+LSl".

Determination of the strength indicators of the developed "green composites" in accordance with the requirements of GOST 310.4 showed their compliance with grade 400 according to GOST 10178 and class 32.5 according to GOST 31108. The results of control tests conducted in the laboratory of Bekabadcement JSC showed that by the 3rd days of hardening, new types of composite Portland cements containing 25-35% MS and steelmaking slags are characterized by hydraulic activity values from 30.6 MPa to 32.4 MPa, which by 28 days exceed the strength of the control Portland cement PC400-Ad0.

Conclusion

The chemical and mineralogical compositions of technogenic wastes of energy and metallurgy were determined: Angren TPP and JSC "Uzmetkombinat", their hydraulic activity in terms of compressive strength and compliance of their values according to the student's criterion with the requirements of RD for active mineral additives were established. Based on the data obtained, a conclusion was made about the possibility of their use as ingredients for the production of hybrid additives for Portland cement.

The ratio gradient and optimal doses of "green" hybrid additives in composite cements have been established. Their physico-mechanical properties are determined depending on the type and dose of the introduced hybrid additives. It is noted that, despite the decrease in the proportion of high-temperature Portland cement clinker in their composition by 25-35% than that of the matrix, the hydraulic activity of the developed composite Portland cements ensures their grade 400 and higher.

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