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INFLUENCE OF POLYMER ADDITIVES ON STRENGTH OF CEMENT STONE

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The article presents the results of strength tests of cement stone with polymer additives. It is established that polymer additives can both increase and decrease the strength and density of cement stone. It is shown that the polymer additive DLP2141 accelerates the set of strength of cement stone at the early stages of hardening.

The task of improving the physical and mechanical characteristics of concrete does not lose its relevance in modern construction. Numerous studies show the prospects of using polymer additives as modifiers of concrete. It is noted [11] that simplification of technology of polymers application in concrete and improvement of physical and mechanical characteristics make such concrete attractive for production of corrosion-resistant and high-strength products and designs. Polymer additives are widely represented in the construction market, but the issues related to the study of their impact on the strength of cement compositions require further study.

Physical and mechanical characteristics of cement compositions modified by polymers are influenced by a number of factors. The paper [1, 2, 3] presents the results on the influence of hardening conditions on the strength of cement-polymer compositions. It was found that at high temperatures a polymer with a high film formation temperature increases the strength characteristics of cement-polymer compositions, but reduces the deformation characteristics. Under normal conditions, the process of film formation in the cement-polymer stone ends within 48h hardening system. It has been determined [4] that the compressive strength of cement composites decreases as amount of polymer increases, as polymers delay the hydration of cement. It was found [5, 6] that part of the water – soluble polymer can concentrate at the interface of the "involved air-solution phases. Small, evenly distributed air has a plasticizing effect on cement dough, which results in an increase in the diameter of their melt. It is shown [7, 8] that the interaction of polymer additives with other starting materials can lead to capturing of a significant amount of air during mixing.

The study of the influence of polymer additives on properties of cement compositions is an urgent task, since polymer additives allow to adjust the mechanical characteristics and obtain materials with improved properties.

In this paper, we studied the effect of polymer additives on the strength of cement stone. For carrying out the research, TSEM I, 42,5 N cement of JSC Belarusian cement plant was applied, which met the requirements [9]. Physical and mechanical characteristics of cement are given in Table 1.

Table 1. – Physical and mechanical characteristics of cement

Type of cement and name of the manufacturer	Density, kg/m^3	NGCT, %	Setting time, h-min		Activity, MPa
			the beginning	the end	
Portland CEM I, 42,5 N, D0 G. Kostyukovichi	3200	25,0	3-10	4-50	45

Polymer additives Primal SM330, DLP2141 and DLP2000 were used as modifiers.

The main technical characteristics of polymer additives Primal SM330, DLP2141 and DLP2000 are given in Table 2.

Table 2. – The main technical characteristics of polymer additives Primal SM330, DLP2141 and DLP2000

The name of the polymer additive	Polymer base	Appearance	Residual moisture, max.%	Bulk density, g / ml (g/cm^3)	Ash content, %	Minimum film formation temperature (MFFT), ^{0}C	pH	Dry residue, %
DLP2141	Vinyl acetate-ethylene copolymer	White, free-flowing powder	2	0,400-0,550	10-14	0	7,5	-
DLP2000				0,375-0,525		3	6	-
Primal SM330	Acryl	Milk, white liquid	-	1,06	-	10	9,5-10,5	46.5 - 47.5

Dosages of polymer additives for construction mixtures on mineral binders are usually in the range of 1-5%. The optimal dosage is determined based on the need to achieve the maximum values of the useful property (or a set of basic properties) at minimum cost [5].

To determine the effect of polymer additives on the mobility of the cement paste and polymer, additives were introduced in amount of 1%, 3% and 5% by weight of the cement on a dry matter basis. Water-cement ratio is 0.5. Determination of the mobility of the cement test is carried out by the RICRC method [10], on a mini-cone. The 3 cm high mini-cone was filled with cement paste with polymer additive. After raising the mini-cone, cement dough spread, the value of the cone melt was determined in 2 directions by a metal ruler, with a division price of 1 mm, (Fig. 1).

Figure 1. – Determination of cement paste melt with a polymer additive DLP2000

Cement paste melt without polymer additives amounted to 6 see. The results of the influence of polymer additives on the mobility of the cement paste are presented in Table 3.

Table 3. – Influence of polymer additives on the mobility of cement paste

The name of the polymer additive	Mobility of cement paste cm, with the introduction of additives in % by weight of cement		
	1	3	5
Primal SM 330	8	8,7-8,8	8,5-9
DLP2141	4,8	5,2	5,8
DLP2000	7,7	8,8	9,5

The study showed that the polymer additive DLP2141 1.2 times reduces the mobility of the cement paste. The introduction of polymer additives DLP2000 increases the mobility of cement paste by 1.45 times. By increasing the dosage of the polymer additive, the mobility increases. The addition of Primal CM330 increases the mobility of the cement paste by 1.42 times, but with the increase in the dosage further increase in mobility does not occur.

To determine the strength of cement, stone samples were made – cubes 20×20×20 mm (Fig.2). The samples were left to solidified for 24 hours in air-dry conditions at a temperature of t = 18-20 C , then for 2 hours the samples were subjected to temperature treatment at 60 C. After that they continued to harden in air-dry conditions at a temperature of t=18-20 C. The weight and geometric characteristics of the samples were determined before the tests. The strength of the samples was determined by the press PGM-500MG4A after 7 days (Fig.3).

Figure 2. – Samples of cement stone with polymer additive DLP 2141 (I-1%, III-3%, V-5%)

Figure 3. – Samples after testing (with 3% polymer additive Primal CM330)

The results of determining the strength of cement stone with polymer additives Primal SM 330, DLP2141 and DLP2000 are presented in Table 4.

Table 4. – Strength of cement stone with polymer additives

The name of the polymer Additive	Amount of additive, % by weight of cement	Compressive strength Rst, MPa (% $R_{st}^{test.}$)	Density, kg/m^3
Primal SM 330	1	9,48(37,98)	1508,75
	3	14,81(59,33)	1577,71
	5	18,36(73,56)	1597,50
DLP2141	1	38,23(153,16)	1820,63
	3	34,59(138,58)	1804,17
	5	24,89(99,72)	1776,25
DLP2000	1	19,28(77,24)	1697,92
	3	21,3(85,33)	1700,21
	5	21,91(87,78)	1724,58

The density of the control sample without polymer additive was 1670,31 kg/m^3, compressive strength $R_{st}^{test.}$=24.96 MPa.

According to the results of the study, it was found that polymer additives lead to a slowdown in the process of gaining strength of cement stone. Increasing the dosage of the polymer additive Primal SM 330 from 1% to 5% by weight of cement, leads to an increase in the strength of the cement stone at the age of 7 days. Thus, the strength at a dosage of 1% is 9.48 MPa; at a dosage of 3%-14.81 MPa; at a dosage of 5% -18.36 MPa, which was 73.6% of the strength of the control sample without additives. Polymer additive DLP2000 leads to a slight slowdown in the set of strength of cement stone, by the age of 7 days the strength reaches 83.45% of the reference value. Increasing the dosage does not significantly affect the intensity of the strength gain. The greatest effect on the intensity of the strength had an additive DLP2141. At a dosage of 1% by weight of cement strength at the age of 7 days reached 153.16% of the strength of the control sample; at a dosage of 3% -138.58%; at a dosage of 5%-99.72%. Cement stone, modified with addition of DLP2141, has a denser structure compared to the cement stone without additives.

Thus, it is established that the polymer additive DLP2141 based on vinyl acetate-a copolymer of ethylene accelerates the strength development of cement stone at an early age and contributes to the formation of more dense structure of cement stone. The dosage of the polymer additive DLP2141 should not exceed 3% by weight of cement.

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