

Research corrosion of cements with a new hydraulic additive

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Abstract. Based on the above studies, the following conclusions can be made: The introduction of hydraulic additives into Portland cements increases their sulfate resistance, especially when cements have higher C₃A content. Cements with 30% tuffite give better strength than those with 20% tuffite. The least aggressive for pozzolanic Portland cements are 5% Na₂SO₄ solution, the most aggressive is 3% MgSO₄ solution, in which cements with hydraulic additives were more resistant than pure Portland cements, which is in agreement with the data of other researchers. For sulfate-resistant pozzolanic Portland cement maximum C₃A content in the original Portland cement can be increased up to 8%. **Keywords.** Hydraulic additives, tuffite, corrosion resistance, frost resistance, weatherability, aggressive mortar, strength.

1 Introduction

High degree of mineralization of soils and ground waters in most regions of the Republic of Uzbekistan causes the necessity to use special sulfate-resistant cements, as the usual Portland cement according to the existing standards cannot be used [1, 2]. In addition, harsh climatic conditions require cement to have sufficient weather resistance. To combine these qualities in one binder is not yet possible, increasing of salt resistance by introduction of active mineral additives is often accompanied by deterioration of weathering resistance, and the most weathering-resistant Portland cements do not have sufficient ability to resist chemical corrosion. Obviously, depending on the conditions of the structure and the aggressiveness of the environment - this must be addressed differently. The choice of cements for zones of permanent and full immersion in aggressive environment and zones of variable level of saline water or boundaries of saline groups - air should be carried out strictly differentiated [3, 4].

In connection with the above, the introduction of hydraulic additives in Portland cement increases its resistance against sulfate and magnesium-sulfate water, but at the same time increases the water demand, slows down hardening and reduces the strength in plastic

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solutions. In addition, it is known that the composition of clinker has a significant impact on the salt resistance of pozzolanic Portland cement [5].

Our study was devoted mainly to finding an effective hydraulic additive that ensures the resistance of Portland cement in conditions of sulfate and sulfate-magnesia corrosion, most often found in our country when exposed to aggressive waters.

2 Methodology

The setting time was normal for the three cements, and they passed the test for uniformity of volume changes by boiling in water vapor and in cold water.

For the study of mechanical strength, cements were made of cement mortar 1:3, prisms 1x1x3 cm and cubes 1.41x1.41x1.41 cm with a face area of 2 cm². Pressing pressure 40 MPa, storage of samples water [6-7].

The study of sulfate resistance was carried out by the method of changing the mechanical strength when immersed in aggressive solutions. For this purpose, prisms 1x1x3 cm were made from mortar with sand 1:3, as more sensitive to the destructive action of aggressors than cubes, due to the smaller cross-section. Sand was taken for the test of mechanical strength, having passed the sieve of 144 rf/cm² and remaining on the sieve of 256 rf/cm². The specimens were made of pure cements, cements with 20 and 30% tuffite fired at 600°C. The samples were pressed at 400 kg/cm² and stored for 28 days in a humid environment after fabrication, after which they were immersed in saline solutions and water.

3 Results and discussions

The results of strength tests of Portland cement in small samples are shown in Table 1.

Table 1. Strength of Portland cement, MPa.

Type of cement	Compressive strength. MPa					Flexural strength. MPa				
	Curing times					Curing times				
	days			months		days			months	
	3	7	28	3	6	3	7	28	3	6
Alite	21	23	32	34	35	4.9	5.1	5.1	6.0	6.2
Plain	17	21	30	34	35	4.2	4.3	5.0	6.0	6.1
Plain	11	15	23	30	35	3.0	4.2	4.5	5.1	5.9
Strength of Portland cement with 20% tuffite. MPa										
Alite	14	22	28	31	35	3.8	4.4	5.5	6.8	6.7
Plain	14	19	26	29	32	3.7	3.8	4.7	6.3	6.6
Plain	12	17	24	30	21	3.0	3.5	4.7	6.3	6.7
Strength of Portland cement with 30% tuffite. MPa										
Alite	14	15	26	32	33	2.5	4.2	5.1	7.1	7.3
Plain	10	14	22	30	30	2.1	3.5	4.8	7.0	7.3
Plain	10	13	21	26	27	3.0	3.0	4.9	6.6	6.6

From the data in Table 1 we can conclude that the strength of cements increases with increasing alite content in them and decreasing the content of whitewash. In the first periods of hardening, cements with high alite content sharply differ in strength from Portland cement (with 20 % and 25 % of white), but in a longer period the strength of all cements are close to each other. With respect to C₃A and C₄AF content the best results are shown by cements with the same 10% amount of both minerals.

Based on the data given in Table 1, we can conclude that the best strength with additives gives alitic cement (No.1), the closest to it in strength are ordinary cements (No.2 and No.3).

By 28 days the strength of pozzolanic cements approaches the strength of pure Portland cements, but this decrease is much less than the percentage of additive introduced. The long term strength of cements with 30% tuffite exceeds that of cements with 20% tuffite.

Table 2. Strength of Portland cements when stored in aggressive solutions.

Cement number	Flexural strength. MPa					
	Curingtime					
	3 days	7 days	28 days	3 months	6 months	1 year
Water						
1	4.2	4.8	6.3	6.2	6.1	5.8
2	4.4	5.2	5.9	6.0	6.2	6.3
3	2.8	4.8	5.4	5.9	5.9	6.0
5% Na ₂ SO ₄						
1	4.3	4.9	6.3	5.8	4.8	4.2
2	4.4	5.2	5.9	5.8	4.3	3.8
3	2.8	4.4	4.8	4.6	4.0	3.6
3% MgSO ₄						
1	4.2	4.8	6.3	5.0	4.4	3.5
2	4.4	5.2	5.9	4.9	4.0	3.1
3	2.1	4.4	5.0	4.5	4.0	3.4

Storage was carried out in desiccators, the amount of solution per sample was taken 100 ml, solutions were replaced every 2 months. As aggressive solutions were used: 5% Na₂SO₄ solution, 3% MgSO₄ solution and tap water. The results of testing the strength of Portland cement during storage in aggressive solutions are given in Table 2.

Table 3. Portland cement stability coefficient for storage in aggressive solutions.

Cement number	3 days.	7 days.	28 days.	3 months	6 months.	1 year
5% Na ₂ SO ₄						
1	1.02	1.02	1.0	0.9090	0.7979	0.7070
2	1.0	1.0	1.0	0.95	0.7070	0.6161
3	1.0	0.92	0.882	0.7878	0.6969	0.6060
3% MgSO ₄						
1	1.0	1.0	1.0	0.8080	0.7272	0.6161
2	1.0	1.0	1.0	0.8181	0.6565	0.5050
3	0.75	0.92	0.98	0.7676	0.6868	0.5757

Table 4. Strength of cements with 20% tuffite when stored in aggressive solutions.

Cement number	Flexural strength. MPa					
	Curing time					
	3 days	7 days	28 days	3 months	6 months	1 year
Water						
1	3.8	4.7	5.7	5.9	6.8	7.0
2	3.5	4.5	5.5	6.3	6.6	6.9
3	2.2	3.3	5.2	5.9	6.1	6.7
5% Na ₂ SO ₄						
1	3.8	4.8	5.6	5.8	6.7	6.0

2	3.6	4.5	5.5	6.2	6.5	5.9
3	2.5	3.3	5.3	5.7	5.9	6.1
3% MgSO ₄						
1	3.8	4.7	5.3	4.7	5.2	4.9
2	3.6	4.5	5.4	5.0	4.9	4.7
3	3.1	3.9	4.4	4.7	4.3	4.6

Table 5. Resistance coefficient of cements with 20% tuffite when stored in aggressive solutions.

Cement number	3 days.	7 days.	28 days.	3 months	6 months.	1 year
5% Na ₂ SO ₄						
1	1.0	1.02	0.98	0.97	0.96	0.84
2	1.02	1.0	1.0	0.95	0.92	0.85
3	1.13	1.0	0.98	0.9.96	0.8989	0.80
3% MgSO ₄						
1	1.0	1.0	0.91	0.8787	0.8383	0.8080
2	1.02	1.0	0.90	0.8585	0.8383	0.8181
3	1.0	0.97	0.8989	0.8383	0.8181	0.7979

Table 6. Strength of cements with 30% tuffite when stored in aggressive solutions.

Cement number	Flexural strength. MPa					
	Curing time					
	3 days	7 days	28 days	3 months	6 months	1 year
Water						
1	4.1	5.1	5.7	6.5	7.3	7.5
2	3.8	4.9	6.1	7.0	7.2	7.4
3	2.5	3.8	5.8	6.2	6.7	6.9
5% Na ₂ SO ₄						
1	4.1	5.3	5.6	6.0	6.8	7.1
2	3.9	5.0	6.2	6.6	7.0	7.1
3	2.8	3.8	5.8	6.1	6.3	6.4
3% MgSO ₄						
1	4.1	5.2	5.7	5.9	6.6	6.8
2	3.9	5.0	6.1	6.1	6.3	6.7
3	2.5	3.7	4.4	5.5	5.6	5.8

Table 7. Resistance coefficient of cements with 30% tuffite MPa when stored in aggressive solutions.

Cement number	3 days	7 days	28 days	3 months	6 months	1 year
5% Na ₂ SO ₄						
1	1.0	1.03	0. 98	0.92	0.90	0.94
2	1.02	1.02	1.01	0.95	0.95	0.95
3	1.12	1.0	1.0	0.98	0.94	0.91
3% MgSO ₄						
1	1.0	1.02	1.0	0.90	0.89	0.90
2	1.02	1.02	1.0	0.87	0.86	0.89
3	1.0	0.97	0.85	0.88	0.81	0.84

Based on the data given in Tables 2-7, the following conclusions can be made: The introduction of hydraulic additives into Portland cements increases their sulfate resistance, especially when the cements have higher C3A content. Cements with 30% tuffite give better strength than those with 20% tuffite. The least aggressive for pozzolanic Portland cements

are 5% Na_2SO_4 solution, the most aggressive is 3% MgSO_4 solution, in which cements with hydraulic additives were more resistant than pure Portland cements, which is in agreement with the data of other researchers. For sulfate-resistant pozzolanic Portland cement maximum C_3A content in the original Portland cement can be increased up to 8%.

4 Conclusions

The most important for the sulfate resistance of Portland cement has a content of C_3A , with increasing content of which the sulfate resistance of Portland cement decreases rapidly. The maximum content of C_3A in the sulfate-resistant Portland cement - 5%.

The introduction of hydraulic additives to Portland cements of different mineralogical composition increases their sulfate resistance, especially when the latter have an increased content of C_3A , in such cements with hydraulic additives sulfate resistance may be slightly increased.

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