Sulphate resistance of waterproofing compounds based on cement containing dry construction mixtures

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Abstract *The sulphate resistance of two waterproofing cement-containing compounds on the basis of dry construction mixtures "RM-W Plus" and "HydroLastic" was investigated. The test for first year has shown that both compositions are sulfate-resistant and refer to the III (highest) group for sulphate resistance in accordance with GOST R 56687-2015. The values of deformation of expansion and increment of sample mass are obtained depending on the type of corrosive medium (distilled water and sodium sulfate solution) and the time of its exposure. In the case of the elastic two-component "HydroLastic" composition containing the polymer component, compared with the repair composition "RM-W Plus", there was a higher expansion and less water absorption. Absorption of water samples of both compositions was more significant than absorption of sodium sulfate solution.*

Keywords: Dry construction mixtures, waterproofing compounds, water absorption, expansion, sulfate resistance

Content

1. Introduction

It is known that the concrete structure is subject to destruction due to the influence of physical, chemical and mechanical influences. The main factor in the destruction of concrete is the aggression of the aquatic environment. The operation of concrete elements in an aggressive environment requires reliable protection of concrete. In this case, the primary methods of concrete protection [1-6] (increasing its density and waterproofness) are supplemented by secondary measures [7] – waterproofing of the structure, which excludes the contact of the aggressive medium and concrete. Distinguish coloring, pasted, sprayed, lubricating, injection, impregnating, penetrating waterproofing [1, 7-11], each of which has its advantages and disadvantages. At present, the most common technology is the application of lubricating waterproofing compounds. To obtain lubricating waterproofing, dry building mixtures based on mineral or organic binders are widely used, containing fillers and functional additives for various purposes.

Based on the literature data, it can be concluded that waterproofing compositions based on bitumen are the most resistant to the influence of an aggressive sulfate medium. In work [12], a bituminous emulsion test was used to waterproof structures made of metal, bricks and concrete. The samples were tested in various aggressive media (hydrochloric, sulfuric, sodium) for 40 days. The result was the absence of external corrosion signs on the samples, which indicates the effectiveness of protecting the materials with bitumen waterproofing. However, the work did not provide numerical data on the change in mass or size of the samples, which makes it impossible to compare with other waterproofing materials.

In articles [13, 14] tests of concrete using waterproofing compounds of penetrating action ("Penetron", "Kalmatron") are considered. In experiments [13], samples were tested in neutral (distilled water) and aggressive (sulfate) media. X-ray diffraction (XRD) and differential thermal analysis (DTA) determined the change in the phase composition of the cement stone, the amount of ettringite and calcium hydroxide. When processing cement samples with the "Penetron" material, portlandite is bound to a less soluble calcium carbonate, as a result of which the cement stone is compacted and its reactivity decreases under the action of aggressive media. By the age of 90 days, the strength of the treated samples, compared with the control samples, was higher by more than 15%. At the end of the test, conclusions were drawn about the significant increase in corrosion resistance and durability of the material treated with "Penetron". The authors of the article [14] tested for watertightness, strength and frost resistance of samples with a penetrating "Kalmatron" additive in various dosages. The additive was introduced into the concrete mixture with kneading. It has been obtained that samples with a penetrating additive have a higher water resistance and frost resistance and less water absorption, which varies depending on the amount of penetrating additive and the conditions for hardening the samples. The influence of the "Kalmatron" additive on the resistance of concrete to the influence of the sulphate medium can be judged here by the indirect sign of increasing water resistance and reducing water absorption.

In addition to the known "Kalmatron" and "Penetron" additives, a new penetrating composition of Russian production based on modified slag cement with the addition of natural zeolites and a complex of electrolyte salts was investigated in [15]. The composition is intended for the protection of concrete in an aggressive environment. In the work, optimal dosages of additives in the penetrating composition for various types of aggressive media were established. It is shown that the new composition has a greater resistance to sulfate corrosion than "Penetron". Unfortunately, the results of this work do not allow us to determine the sulfate resistance class of the waterproofing composition itself.

A number of authors [16,17] examined the properties of coating waterproofing using the example of a two-component elastic composition based on a dry mixture and a modifying resin. It was shown that these materials have high adhesive properties, elasticity, water resistance and resistance to aggressive media. However, the advantages of the "MasterSeal 588" dry mortar [16] were not justified by experimental data. In [17] quantitative adhesion indicators of waterproofing composition and waterproofness of concrete samples with applied protective layer are indicated, however the absence of data on control samples does not allow to give a comparative evaluation of the effectiveness of waterproofing material.

As the results of the literature review show, the attention of researchers is mainly given to the influence of the aggressive environment on the protected concrete and to a lesser extent on the protective material. The evaluation of such materials is mainly based on watertightness. However, no less important characteristic of waterproofing materials is their corrosion resistance. In the case of cement-containing compounds, the effect of the sulfate medium is a serious danger for waterproofing.

The purpose of this work is to study the sulfate resistance and water impermeability of two types of coating waterproofing on the basis of dry construction mixtures produced by the company "HydroShield".

The object of research:

1. Two-component elastic waterproofing "HydroLastic";
2. Non-shrinking repair composition with increased water resistance "RM-W Plus".

Two-component elastic waterproofing "HydroLastic" consists of high-quality Portland cement and water-based elasticizer. Elasticizer enhances adhesion properties, increases resistance to cracking and moisture penetration. Repair composition "RM-W Plus" contains high-quality cement, quartz sand and special additives with a polypropylene fiber content, which is characterized by high tensile strength, resistance to moisture and heat resistance.

2. Methods

In connection with the lack of regulatory documents for determining the corrosion resistance of waterproofing materials, we used a technique similar to the corrosion resistance test of concrete samples for State Standard R 56687-2015. Two series of beam samples with dimensions of 25x25x285 mm for 12 examples were made of the two types of waterproofing in each series, which have been tested in the laboratories of the Peter the Great Saint-Petersburg Polytechnic University. Stainless steel frames were embedded in the manufacturing process to measure the linear expansion along the ends of the beams. After 28 days of hardening under normal conditions, the samples were placed in the test liquid medium on the supports, so that the liquid layer above the samples was not less than 2 cm. Half of the samples from each series (basic samples) were hold in a 5% solution of sodium sulfate, the other half samples (control samples) was placed in distilled water. The samples were held in the appropriate environment for 12 months at a temperature of (20 ± 3)°C. Periodically, at first once a week, and then once a month, the aggressive environment and distilled water were replaced with fresh portions. With the same frequency measurements were made of the mass and linear expansion of the samples. Figure 1 shows a measuring device with a calibration rod. The increment in the length of the sample was measured by a dial gauge with a fission rate of 1 micrometer. Figures 2 and 3 show samples of two test compounds in a bath with an aggressive solution.

Figure 1. Device for measuring linear expansion

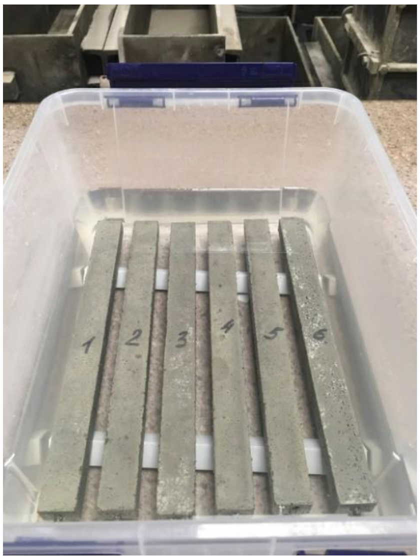
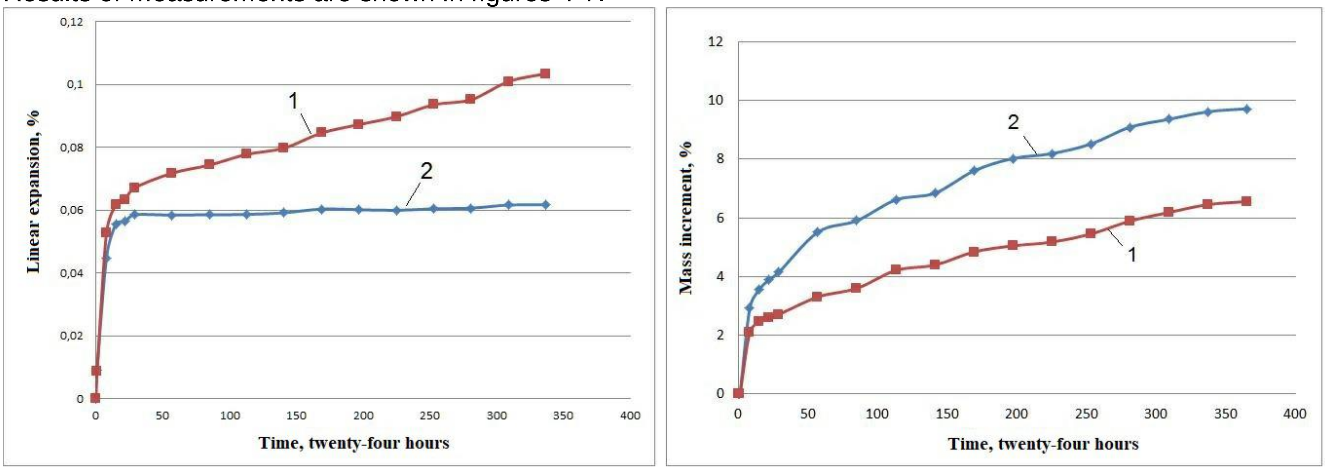


Figure 2. Samples of the repair composition "RM-W Plus"

Figure 3. Samples of elastic two-component waterproofing "HydroLastic"

3. Results and Discussion

Results of measurements are shown in figures 4-7.



a b

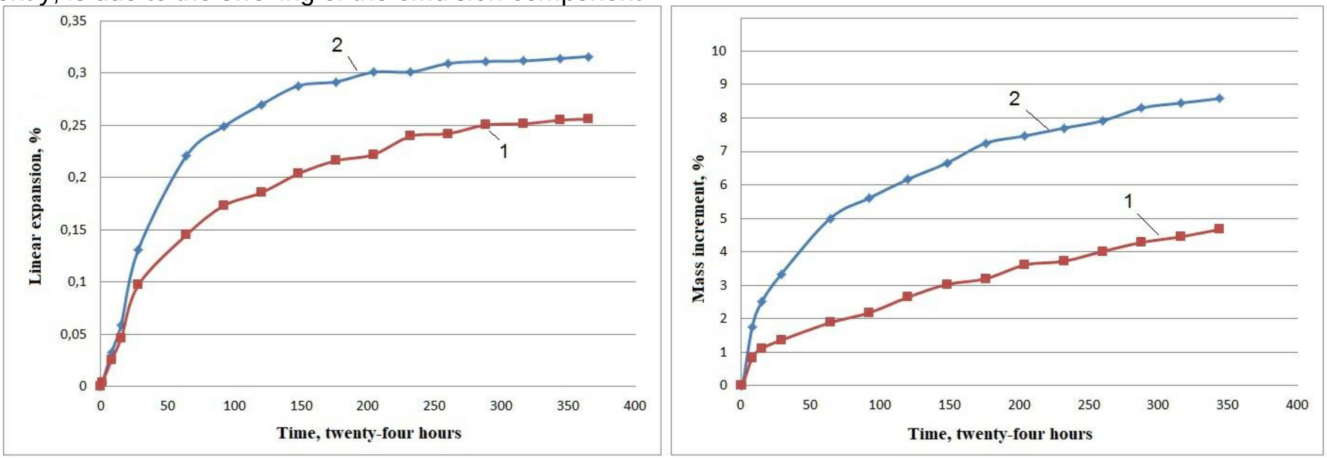
Figure 4. Linear expansion (*a*) and the mass increment (*b*) of samples of repair composition "RM-W Plus" for hardening: 1 - in a 5% solution of Na_2SO_4; 2 - in distilled water

From Figure 4-a it is visible, that expansion of repair structure "RM-W Plus" in test environments can be conditionally divided into two periods. In the initial period up to 7 days, the expansion occurs very intensively, both in the Na_2SO_4 solution and in distilled water, which can be explained by the rapid absorption of water by the gel and the usual swelling of the samples. The sharp slowing down of the process in the subsequent period is explained by the saturation of the gel. Dimensions of samples in distilled water almost ceased to grow, while in Na_2SO_4 solution their growth continues and occurs almost linearly in time. This growth is obviously associated with the formation of calcium hydrosulfoaluminate [19-22].

When comparing the results of absorption of distilled water by control samples (Figure 4-b) and their extensions, it can be seen that in the second period the mass of samples grows and the swelling is almost absent. We can offer the following explanation for this phenomenon. Water is primarily absorbed by the gel, causing a significant expansion in the initial period. When the gel swells, the thickness of the water membranes increases, and the wedging pressure decreases, tending to zero. After saturation of the gel begins the flow of water into larger pores and capillaries. The resulting capillary pressure causes compression of the structure, compensating for its expansion.

Figure 4-b also shows that the increment in the mass of the samples in the solution is less than in distilled water. Probably, the formation of gypsum and the growth of ettringite crystals in the surface layer make it difficult for water to enter the samples and fill large pores.

In the case of the "HydroLastic" composition, both the expansion and the increment in the mass of the samples occur more significantly in distilled water (Figure 5). In this composition, the second component is not water but an aqueous emulsion of a polymeric substance, up to 33% by weight. The presence of this, less hydrophilic, component retards the processes associated with the absorption of water and the Na_2SO_4 solution. Therefore, the increment in mass of the samples is smaller here than in the case of "RM-W Plus", however, the expansion is larger, and this, apparently, is due to the swelling of the emulsion component.



a b

Figure. 5. Linear expansion (*a*) and the mass increment (*b*) of samples of repair composition " HydroLastic " for hardening: 1 - in a 5% solution of Na_2SO_4; 2 - in distilled water

The difference in the test compositions in the ability to wet and absorb water is confirmed by the results of determining the equilibrium moisture and water absorption (Table 1). All samples, after testing for sulfate resistance (in water and aqueous sodium sulfate for 1 year), stayed in the air for 3 months in the room with a relative humidity of about 30%. The equilibrium moisture of the samples was determined by drying at 90 ° C and weighing before and after drying. Immediately after this, one series of dried samples (12 samples.) Was placed in water, the remaining 12 samples. - in a 5% solution of Na_2SO_4. At the same time, each series contained 6 samples of repair composition "RM-W Plus" and 6 samples of "HydroLastic" composition. Each 6 samples of this and the other composition included 3 samples, kept earlier in distilled water and in Na_2SO_4 solution.

Table 1. Results of determination of equilibrium humidity in air and water absorption of samples after the sulfate resistance test.

Sulfate testing environment	Water absorption test environment	RM-W Plus		HydroLastic	
		The equilibrium humidity, %	Water absorption by weight, %	The equilibrium humidity, %	Water absorption by weight, %
Distilled water	Distilled water	4.10	13.20	1.61	2.87
	Na_2SO_4 solution.	4.11	11.31	1.52	2.44
Na_2SO_4 solution	Distilled water	5.16	12.86	1.38	3.36
	Na_2SO_4 solution.	5.12	13.42	1.51	2.61

From Table 1 it can be seen that the composition of "RM-W Plus" is superior to "HydroLastic" in terms of equilibrium moisture content, and therefore, hydrophilicity 2.5-3.7 times more, water absorption 3.8-5.1 times more. Water absorption in 3 cases out of 4 turned out to be higher in water than in Na_2SO_4 solution.

According to the results of linear expansion in accordance with State Standard R 56687-2015, the repair composition "RM-W Plus" and waterproofing "HydroLastic" are sulfate-resistant and belong to the III (highest) group for sulfate resistance.

4. Conclusions

1. The sulfate resistance of two waterproofing cement-based compounds based on dry construction mixtures "RM-W Plus" and "HydroLastic" was investigated. The test for 1 year has shown that both compositions are sulfate-resistant and refer to the III (highest) group for sulphate resistance in accordance with State Standard R 56687-2015.

2. The values of deformation of expansion and increment of sample mass are obtained depending on the type of corrosive environment (distilled water and sodium sulfate solution) and the time of its exposure. In the case of the two-component "HydroLastic" composition containing the polymer component, compared with the repair composition "RM-W Plus", there was a higher expansion and less water absorption.

3. Absorption of water samples of both compositions was more significant than absorption of sodium sulfate solution.

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Сульфатостойкость гидроизоляционных составов на основе цементосодержащих сухих строительных смесей

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Аннотация

Исследована сульфатостойкость двух гидроизоляционных цементосодержащих составов на основе сухих строительных смесей "RM-W Plus" и "HydroLastic". Испытание в течение одного года показало, что оба состава являются сульфатостойкими и относятся к III (наиболее высокой) группе по сульфатостойкости согласно ГОСТ Р 56687-2015. Получены значения деформации расширения и приращения массы образцов в зависимости от вида агрессивной среды (дистиллированная вода и раствор сульфата натрия) и времени ее воздействия. В случае двухкомпонентного эластичного состава "HydroLastic", содержащего полимерную составляющую, по сравнению с ремонтным составом "RM-W Plus" имело место более высокое расширение и меньшее водопоглощение. Поглощение воды образцами обоих составов оказалось более значительным, чем поглощение раствора сульфата натрия.

Ключевые слова: Сухие строительные смеси, гидроизоляционные составы, водопоглощение, расширение, сульфатостойкость

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