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Salt-Resistant Concrete in Dry Hot Climates

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Abstract:

The article presents data from experimental studies of the effect of polymer additives POLY – ANS on capillary absorption of concrete. It is shown that under the influence of POLY– ANS additives, the density, water tightness of concrete increases and hydrophobization of the walls of pores and capillaries is ensured (the wettability of concrete decreases). It was found that for accelerated assessment of the degree of influence of POLY – ANS additives on the permeability of concrete, it is effective to use the criterion of a relative measure of hydrophobicity.

Keywords: capillary absorption, saline solutions, POLY – ANS polymer additive, pore hydrophobization, permeability, criterion of relative measure of hydrophobicity.

The corrosion resistance of concrete is known to be associated with the capillary permeability of concrete. At the same time, the capillary permeability of concrete depends on cement consumption, pore structure parameters, salt solution composition and test conditions. The degree of influence of chemical additives is determined by the mechanism of their action on the cement system and the pore structure of concrete.

Among the water-soluble polymers, the most relevant from the point of view of protection against corrosion of crystallization and the effects of a dry hot climate in the republic at the moment are additives of polymer gels. These are additives of a stabilizing effect that reduce the stratification (stratification) of the concrete mixture by changing the viscosity of the water. The degree of swelling of hydrogels in water is determined by the density of the polymer mesh set during synthesis.

In the conducted research, a polymer additive was used – polymer reagent POLY-ANS (polyacrylonitrile hydrolyzed stabilizing), manufactured on the basis of nitron fiber production waste.

Experimental studies have been carried out to establish the effect of the dosage of POLY–ANS additives on capillary absorption [2].

Highly concentrated solutions were used as working salt solutions: 5.5% Na2SO4; 2.5% Na2SO4 + 5.5% NaCl; 5.5% Na2SO4 + 5.5% NaCl, close to natural compositions (mineralized groundwater in the regions of Central Asia and Kazakhstan is characterized mainly by sulfate and chloride aggressiveness with a content of SO2-4 ions ranging from 6000 to 37000 mg/l and Cl from 2000 to 37000 mg/l).

The content of POLY–ANS additives is assumed to be 0.01 (POLY– ANS 1); 0.02 (POLY– ANS 2); 0.04% (POLY– ANS 3) by weight of binder and volume of concrete, respectively. The capillary absorption of concrete was studied using the developed analytical method for comparative assessment of the degree of influence of chemical additives on the capillary permeability of concrete [1]. The amount of aggressive solution absorbed by the concrete sample over a certain period of time (Wbc , %) is taken as an indicator of capillary absorption

The porosity of concrete samples is accepted as the criterion for assessing the defect of the structure [3].

According to the results of experiments, it was found that the capillary absorption of concrete naturally increases as the composition of the salt solution becomes more complex [2]. This can be explained by a higher concentration of ions in sulfate-chloride solutions and a relatively large accumulation of salts in the pores of concrete.

POLY– ANS additives reduce W_{bc} to the extent that they affect the reduction of the water demand of the concrete mix, the parameters of the pore structure and the water resistance of concrete.

According to the degree of reduction of the W_{bc} of concrete, the additives are arranged in the following decreasing series: POLY–ANS 3>POLY– ANS2>POLY– ANS 1.

The relative decrease in the Wdc of concrete in comparison with the standard is 3.1; 1.6 and 1.4 times, respectively. At the same time, the preliminary cyclic temperature effect (taking into account the effects of a dry hot climate) on concrete samples with POLY–ANS additives has a subtle effect on the capillary absorption of saline solution and Wbc changes by 1.09, 1.1 and 1.12 times (Fig.1).

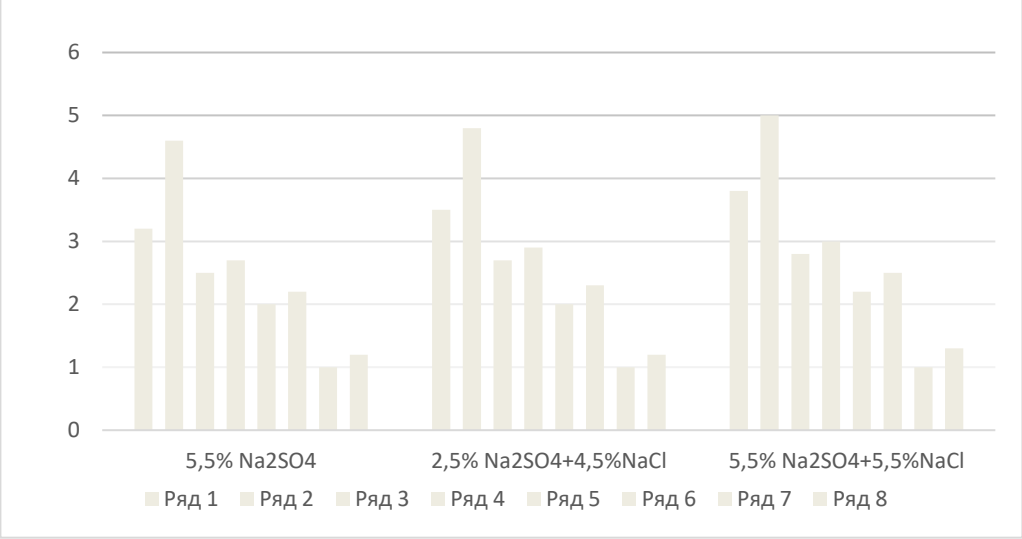

Figure-1.The effect of POLY–ANS additives on capillary suction: 1,2 –reference concrete; 3,4,5,6,7,8 – concrete with additives, respectively, POLY– ANS1; POLY– ANS2; POLY– ANS 3; -normal hardening; -after a preliminary cycle. temperature effect.

The established decrease in the Wbc of concrete is due to the fact that under the influence of POLY–ANS additives, the density, water resistance of concrete increases and hydrophobization of the walls of pores and capillaries is ensured. Or, in other words, the wettability of concrete

decreases. As is known, the value of cos θ (the wetting edge angle) associated with the surface tension at the boundary of the three interface surfaces touching along the wetting perimeter is taken as a measure of wettability (Ms) [4]:

$$M_c = \cos\theta = \frac{\sigma_{тг} - \sigma_{тж}}{\sigma_{жт}} \qquad (1)$$

To assess the hydrophobic properties of the concrete surface, this criterion is not acceptable, since hydrophobicity can be assessed only in limited cases when: θ>90°. In addition, the value of the wetting measure thus acquires a negative value.

The concept of hydrophobicity measures (Mg) is introduced [2], which characterizes the hydrophobic properties of the concrete surface and is determined by the formula:

$$Мг = 1 - \cos\theta \text{ или } Мг = 1 - \frac{\sigma_{тг} - \sigma_{тж}}{\sigma_{жт}} \qquad (2)$$

There is the following relationship between the hydrophobicity measure (Mg) and the wetting measure (Ms):

$$Мг = 1 - M_c \qquad (3)$$

With regard to concrete surfaces, it is difficult to determine the measure of hydrophobicity according to formula (3), since it is almost impossible to determine its components by known classical methods due to the porous structure of the material. Based on this, an analytical method is proposed for calculating the measure of hydrophobicity of concrete by the value of capillary suction, which allows for a comparative assessment of the effect of POLY–ANS additives and other prescription and technological factors on the change in the relative measure of hydrophobicity, taken according to the formula:

$$ОМ_г^д = 1 - \frac{\cos\theta^д}{\cos\theta^\circ} = 1 - \frac{\tan\varphi^д \cdot r^\circ}{\tan\varphi \cdot r^д} \qquad (4)$$

Where $\tan\varphi^\circ$ - is the tangent of the angle of inclination of the straight line in coordinates $\frac{1}{H}$;

$\frac{dH}{d\tau}$ - is for concrete without additives;

$\tan\varphi^д$ - is the same for concrete with an additive;

r° - is the average radius of capillaries of concrete without an additive;

$r^д$ - is the same for concrete with an additive.

The calculation results are shown in Table 1.

Table-1 The values of the relative measure of hydrophobicity of concrete with POLY–ANS additives when testing samples for capillary absorption of salt solutions.

Type of additive	Average pore radius for concrete with cement consumption, кг/м^3			Values of the relative measure of concrete hydrophobicity with cement consumption, kg/m^3 when tested in saline solutions (numerator – sulfate, denominator – sulfate-chloride		
	290	360	430	290	360	430
No additive	96,5	92,4	90,8	-	-	-
POLY– ANS1	83,4	80,2	78,6	$\frac{0,46}{0,61}$	$\frac{0,50}{0,62}$	$\frac{0,61}{0,65}$

POLY– ANS2	78,3	76,1	74,2	$\frac{0,60}{0,70}$	$\frac{0,67}{0,73}$	$\frac{0,76}{0,78}$
POLY– ANS3	69,1	66,2	64,0	$\frac{0,82}{0,89}$	$\frac{0,87}{0,90}$	$\frac{0,91}{0,93}$

Conclusions:

According to Table 1. 〖OM〗_g^d of concrete with POLY–ANS 3 additives naturally increases with increasing cement consumption and decreasing average pore radius. Thus, to quickly assess the degree of influence of POLY-ANS (and others) additives on the permeability of concrete, it is effective to use the criterion of a relative measure of hydrophobicity, which makes it possible to solve the problem relatively simply and with high accuracy.

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