Resilient Structures and Sustainable Construction
Edited by Pellicer, E., Adam, J. M., Yepes, V., Singh, A., and Yazdani, S.

ISBN: 978-0-9960437-4-8

EVALUATION OF CRYSTALLINE WATERPROOFING ADMIXTURE ON PORTLAND CEMENT CONCRETE

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The search of reduction for the permeability of concrete structures, and consequently, increase in the durability of the structural elements has led to develop products for this purpose. One of the options is the use of crystalline waterproofing admixture (CWA). This research evaluated the influence of the use of crystalized admixture for waterproofing on the Portland cement concrete porosity. Water absorption and compressive strength of concretes with crystalline waterproofing admixture at the dosage recommended by the supplier were evaluated and the results were compared with regular concrete, without addition of admixture. The results show a reduction of porosity with reduction of absorption from 3.30% to 0.32% at 56 days of age after specimens molding. A reduction of compressive strength by 7.89% in concrete with admixture was also observed.

Keywords: Strength, Absorption, Voids index.

1 INTRODUCTION

Concrete structures have been considered as eternal, but the increase of their use has brought about early appearance of pathological manifestations, as well as structures with severe degradation in a short period, mainly the damages caused by the percolation of water. Several solutions are available in the market, from painting with petroleum products to the application of rigid films made with polymers, presenting itself as the ideal solution for the problem of percolation. However, the use of these waterproofing systems does not end with the problems caused by water, besides constituting an additional stage in the construction process.

Innovative solutions that are faster, have satisfactory performance, and have the same durability as the design life, are a constant search of the builders. Among the different types of innovative systems proposed by the manufacturers, the use of crystalline waterproofing admixture (CWA) in fresh concrete promises superior performance to the others protect systems, which is achieved because the material being an integral product of the concrete structure (Maki *et al*. 1991).

The objective of this work was to evaluate the influence of the use of a crystalline waterproofing admixture during the homogenization of a concrete with of 30 MPa. In the fresh state were evaluated the slump, and in the hardened state, the compressive strength and the permeability also were evaluated.

2 RESEARCH METHOD

Concrete is a permeable material, since the manufacturing process makes it practically impossible to fill all voids formed between the aggregates and the cement paste during mixing (Petrucci 1979). Another factor that contributes to the formation of voids in the concrete is the need to use more water than necessary to hydrate the cement compounds to reach the desired fluidity, which after evaporation will cause the formation of voids (Petrucci 1979). The permeability of concrete depends mainly on the water/cement ratio (which determines the size, volume and continuity of the capillary spaces) and the maximum size of the aggregate (which influences the microcracks in the transition zone between the coarse aggregate and the cement paste) (Andrade 1997).

The porosity of the concrete is given by the number of voids present in the hardened mass, the absorption is influenced by the formation of pores that have communication with the exterior, and the permeability is given by the continuity of the all voids of concrete (Petrucci 1979). The permeability is the main property that influences the durability of the concrete structure during its design life because water is the main transport vehicle of aggressive agents to concrete (Andrade 1997).

Several factors influence the permeability of concrete, such as the materials used, the age of the concrete, the curing process. The aggressive substances for the concrete (chlorides and sulfates) are transported by the water entering the concrete hardened by the interconnected voids, causing damage to its structure, thus compromising its durability (Nepomuceno 2005).

Waterproofing systems are methods to promote a barrier to water or any other fluid (Salgado 2014). It is a layer resulting from a set of components and constructive elements (or services) that aim to protect constructions against the deleterious action of fluids, vapors and humidity according to NBR 9575 (ABNT 2003).

The use of crystalline waterproofing admixture is defined as a physical-chemical process, which fills the pores and capillaries with insoluble salts, resulting from the reaction between water and the admixture, preventing the penetration of water, supporting positive and negative hydrostatic pressures and using the porosity characteristics and inert chemicals present in the concrete (calcium hydroxide, mineral salts, mineral oxides, and non-hydrated cement particles) (Maki *et al*. 1991). It is dosed together with the concrete at the same time of its manufacture. Because it is an integral part, they are more resistant to weathering and are not easily damaged as formed films systems.

3 RESEARCH METHOD

For the evaluation of the performance of the crystalline waterproofing admixture, a concrete with admixture (0.8% content) was used and a reference concrete (without additive) according to the concrete mixing proportions is shown in Table 1. It was utilized pozzolanic Portland cement (CP IV - 32 - RS), with a density of 2.76 g/cm^3, natural medium sand with density of 2.63 g/cm^3 and granite coarse aggregate of density of 2.64 g/cm^3.

The 44 cylindrical specimens of 10 cm diameter and 20cm height were molded, according to Table 2. Parts of the specimens were kept in an external environment, without temperature and humidity control and another part was kept in an environment with humidity and temperature control. The specimens which hardened in a controlled environment followed the guidelines established in standard NBR 5738 (ABNT 2015). The specimens with external cure were placed in an open courtyard, exposed to the climatic conditions that occurred during the test period, without any control or interference, to simulating the environment of the construction site.

Table 1. Concrete mixing proportions.

	REF	T 0.8%
Cement	1	1
River Sand	1.11	1.11
Coarse aggregate	1.87	1.87
w/c	0.39	0.39
CWA	-	0.08

Table 2. Identification and quantitative of tests samples.

		Nº of specimens to Strength Test				Nº of specimens to Absorption Test
		Age (days)				
Id	Description	7	14	28	56	
RC	Controlled cure reference with saturation cycle	2	2	2	2	8
RS	Noncontrolled cure reference	2	2	2	2	-
R	Reference without saturation cycle	-	-	-	2	-
AS	Concrete with 0.8% ADW without saturation cycle	-	-	-	2	-
AD	Concrete with 0.8% ADW with saturation cycle	2	2	2	2	8

At the ages of seven, 14 and 28 days, the specimens from each group were tested for axial compression to determine the concrete strength, according to NBR 5738 (ABNT 2015) and NBR 5739 (ABNT 2007). To verify the strength of the concrete, 18 specimens (six of each group) were molded to be compression tested at seven days, 14 days and at 28 days. One specimen from each group was tested at the end of the saturation tests, thus providing comparative data between samples that underwent saturation cycles, samples that remained in a controlled environment, and samples that remained in an environment without temperature or humidity control. The specimens, until the age of rupture, were kept in a humid chamber, under conditions determined by NBR 9479 (ABNT 1994). The bases of the samples were prepared using diamond grinding wheel as established in NBR 5738 (ABNT 2015).

After 28 days of age, the test specimens (eight test traces of the concrete reference (no crystallizing additive) with controlled cure and eight samples of concrete with admixture also with controlled cure) were submitted to according to NBR 9778 (ABNT 2005). At the end of the four saturation cycles, at 56 days, all test specimens were tested under strength, and this result was used to verify the influence of the saturation/drying process and the use of the crystalline waterproofing admixture.

4 RESULTS

4.1 Strength

In the strength tests, the reference specimens kept in a humid chamber had a higher strength at 28 days of age, whereas the specimens with crystalline waterproofing admixture had a lower resistance than that observed in the reference specimens with controlled cure (Table 3).

Through the results, it can be seen, at 56 days, that controlled cure of the concrete causes the concrete to develop 13.24% greater resistance than concrete without controlled cure. The effect of the saturation cycle, it was observed that the resistance did not present significant difference when compared with concrete with controlled cure. The curing process is responsible for maintaining the water necessary for the hydration of the cement inside the concrete mass, allowing the continuous formation of the gel that makes the strength higher (Bauer 1994). The deficiency in the curing process favors the formation of retraction cracks and prejudices the complete hydration of the cement grains, which impairs the concrete's resistance (Petrucci 1979).

Table 3. Strength test results.

		Strength [MPa]			
Id	**Description**	**7 days**	**14 days**	**28 days**	**56 days**
RC	Controlled cure reference with saturation cycle	20.8	25.2	33.8	35.5
RS	Noncontrolled cure reference	18.1	21.8	29.3	30.8
R	Reference without saturation cycle	-	-	-	35.6
AS	Concrete with 0.8% ADW without saturation cycle	-	-	-	33.1
AD	Concrete with 0.8% ADW with saturation cycle	19.2	23.2	31.2	32.7

The use of the crystalline waterproofing admixture caused a reduction of 7.89% in the compressive strength when compared to the reference concrete with controlled cure. This behavior is different from that expected since the admixture works by forming insoluble salts that close the voids when the admixture reacts with the water that entering in the cement matrix, closing the voids and cracks. It is believed that the admixture damages the formation of hydrated products and impairs the formation of hydrated products, which results in lower strength (Ramachandran 1995).

4.2 Water Absorption Tests

The results of the water absorption test are shown in Table 4. It was observed that the decrease of the absorption in the crystallizing additive samples already in the first saturation cycle, as well as a lower voids index. The specimens without crystalline waterproofing admixture had an average absorption of 3.330% while the specimens with crystalline waterproofing admixture had an average absorption of 3.109%. In the fourth cycle of saturation, the reference concrete had an average absorption of 3.319% while the specimens with admixture had an average absorption of 0.316%.

Table 4. Water absorption and voids index results.

			Average Values [%]	
Nº saturation cycle	**Id**	**Description**	**Absorption**	**Voids Index**
1	RC	Controlled cure reference with saturation cycle	3.330	7.494
	AD	Concrete with 0.8% ADW with saturation cycle	3.109	7.011
2	RC	Controlled cure reference with saturation cycle	3.329	7.492
	AD	Concrete with 0.8% ADW with saturation cycle	2.176	4.953
3	RC	Controlled cure reference with saturation cycle	3.330	7.494
	AD	Concrete with 0.8% ADW with saturation cycle	1.044	2.404
4	RC	Controlled cure reference with saturation cycle	3.319	7.470
	AD	Concrete with 0.8% ADW with saturation cycle	0.316	0.735

The average water absorption for the reference concrete in the first saturation cycle was 7.494% and for the concretes with samples with crystalline waterproofing admixture was 7.011%. In the fourth saturation cycle, the reference concrete had the mean void index of 7.470% while the concrete with admixture had the mean void index of 0.735%.

The reduction in water absorption and void index can be justified by the formation of crystals within the pores of the hardened concrete, thus preventing the penetration of water in the concrete

(Maki *et al*. 1991). The crystalline waterproofing admixture reacts with water and forms crystals inside the pores with each new contact of percolated water (Penetron 2016). The reference concrete, which did not use the admixture, presented during the cycles of tests, the same result of absorption and voids index tests.

5 FINAL CONSIDERATIONS

The objective of this research was evaluated the influence of the use of crystalline waterproofing admixture on Portland cement concrete in the strength, the water absorption and the voids index. The results show that the crystalline waterproofing admixture is a viable alternative to the traditional waterproofing methods and also allows its use as an auxiliary way to guarantee greater waterproofing of the reinforced concrete structures.

It was observed that the crystalline waterproofing admixture provided a considerable reduction in voids and water absorption to the hardened concrete, which proves the beneficial action of crystal formation within the pores of the hardened concrete. Also, was observed a continuous formation of crystals by each saturation cycle due to reduction in void index and water absorption.

For the strength test, the concrete with crystalline waterproofing admixture presented lower results than the reference concrete.

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