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REDUCTION CAUSES TO COMPRESSIVE STRENGTH IN THE CASE OF CERAMIC ELEMENTS FOR MASONRY SUBJECT TO THE CRYSTALLIZATION PHENOMENON

D. CLIM (PEGESCU- CLIM)[1] L. DIACONU[1]

Abstract: *Following the experimental carried out studies [1], a significant influence of the crystallization phenomenon of soluble salts on the physical and mechanical characteristics of ceramic elements for masonry was found. The research activities have highlighted the studied ceramic element compressive strength reduction, the factor determining these changes in the resistance characteristics having to be established: is it the amount of crystallized salts in the pores of the material or the micro-cracks resulting from the crystallization pressure? Thus, the paper presents the experimental study that answers the previous question. The tests were carried out on 12 assay-samples extracted from masonry ceramic elements. These were subjected to the crystallization phenomenon in sodium chloride solution, with a 20% concentration. 7 saturation-drying cycles were performed, some of the array-samples being washed afterward in order to remove the crystallized salts in the pores. Next, we determined the compression strength, the obtained results confirming that the reduction of the mechanical characteristics was due to the salt content within the pores of the ceramic materials.*

Key words: *compression strength, cristallyzation, soluble salts, pores*

1. Introduction

The fact that ascensional moisture causes significant degradations in old buildings is well known [2].

The water ascension phenomenon through the capillaries of the building elements is a complex one [3], being influenced both by the nature of the materials brought home and by the external factors to which they are subjected, such as freeze thaw, chemical and biological attack, aging, pollution and so on.

The level of rising damp in the old building walls varies according to the season and the groundwater hydrostatic level. Even though water evaporates during the warm season, it leaves behind soluble salts that crystallize and accumulate within the pores from one cycle to the next one.

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[1] "Gheorghe Asachi" Technical University of Iaşi, Faculty of Civil Engineering and Building Services

Based on the nature and concentration of the saline solutions (NaCl, Na_2SO_4, $CaSO_4$, $CaCl_2$), the effects on the physical and mechanical properties of the materials may vary [4]. Another factor that influences the degradation severity is the crystallization pressure [5], which may cause cracks in the material matrix.

Regarding the influence of soluble salts on the resistance characteristics of the building elements, according to the specialty literature, the significant reduction of compressive strength in the ceramic elements for masonry can be noted [1]. We still have to investigate whether these changes are caused by the presence of salts within the pores or by the degradations suffered by the material matrix.

Thus, understanding the crystallization phenomenon of saline solutions is essential for the preservation and restoration of historic buildings [6], since some intervention types can aggravate the degradation status of old edifices in the presence of soluble salts [5].

2.2. Research Methodology

The study was carried out on 12 array-samples extracted from masonry ceramic elements (Figure 1), with a side of 63 mm. The array-samples were dried on the table in the ventilated shelf dryer at + 105°C ± 5°C (Figure 2), and then 9 of them were immersed in sodium chloride solution with a 20% concentration and 3 were kept as reference samples.

Fig. 1. *Array-samples extracted from masonry ceramic elements*

Fig. 2. *Ventilated shelf dryer*

A 20% concentration sodium chloride solution was prepared and 9 samples were placed on supports in a recipient, adding up solution to ¼ of the array-sample height. These were left in the solution for 24 hours, after which the solution level was supplemented to ½ of the sample height. After another 24 hours, the solution level was supplemented until it exceeded the sample height by 2 cm, process that ensures the replacement of the air within the material pores with calcium chloride solution, thus ensuring sample saturation.

The array-samples were left in solution for 48 hours, under laboratory conditions (Figure 3), and then taken out, the surplus solution was removed by wiping with a wet cloth and the saturated array-sample mass was recorded. The array-samples were dried at constant mass in the ventilated shelf dryer at + 105°C ± 5°C for 24 hours. After the weight of the dry samples was recoreded, they were left to cool in the laboratory, the immersion process having to be resumed. 6-7 complete drying-wetting cycles were carried out.

In the compressive strength determination preliminary stage, 3 array-samples from the solution were dried at constant mass- with dried salts, 3 other samples were left in solution- wet, with salts, and 3 were kept for 24 hours in water, and then dried at constant mass, becoming without salts, in dry state.

Fig. 3. *Array-samples in 20% concentration NaCl solution*

After these processes, the final weight of the array-samples was recorded (Figure 4) and the compressive strength was determined (Figure 5).

Fig. 4. *Dried array-samples*

Fig. 5. *Determining the compressive strength*

3. Results

3.1. Array-sample Mass Variation During Drying-Wetting Cycles – Phase II

A linear, upward variation in the mass of array-sampled subjected to drying-wetting cycles is noted. This fact is due to soluble salt crystallization within the pores of the materials, a part of the crystallized solution remaining in the pores, from one cycle to another, and reducing their size. Thus, the mean final array-sample mass in the 20% concentration sodium chloride solution increases by 21.35% (Figure 6).

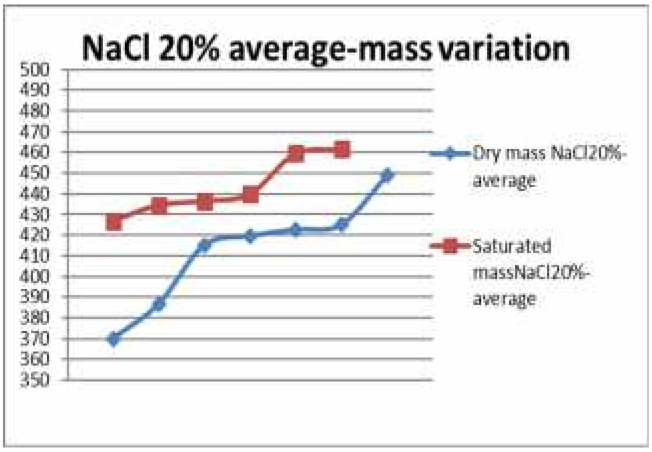

Fig. 6. *Mean variation of the array-sample mass immersed in 20% concentration sodium chloride solution*

3.2. Determining the Compressive Strength for Ceramic Array-Samples Subjected to Crystallization of Soluble Salts Within the Material Pores – Phase II

Following the experimental tests, it was found that compressive strength in the case of ceramic array-samples subjected to the crystallization of the soluble salts within the pores of the materials, undergo changes (Figure 7) as follows:

- in the case of the array-samples immersed in a 20% concentration sodium chloride, dried with salts, there is a decrease in the compressive strength mean value by 40.97%, compared to the reference value;
- in the case of array-samples immersed in a 20% concentration sodium chloride solution, wet, with salts, there is a decrease in the compressive strength mean value by 0.41% compared to the reference value;
- in the case of array-samples immersed in a 20% concentration sodium chloride solution, washed, without salts, in dry state, there is an increase in the compressive strength mean value by 13.77%, compared to the reference value.

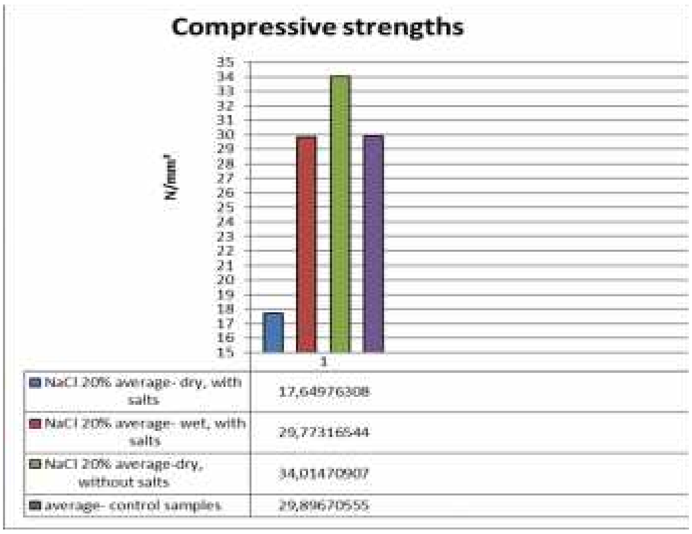

Fig. 7. *Values obtained for the compressive strength of the tested array-samples*

4. Conclusions

Based on the results obtained in the laboratory, it can be stated that the salts contained in the microstructure of the materials reduce the most the compressive strengths of these materials. Contrary to expectations, the salt array-samples, in a wet state, recorded higher strengths than those in dry state.

The dried array-samples, in dry state, recorded the best compressive stress behavior, result which suggests that the matrix of ceramic elements did not suffer degradations following salt crystallization.

Thus, the results of the study demonstrate the significant influence of rising damp on the mechanical properties of ceramic masonry elements.

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