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THE QUANTITATIVE SEISMIC ANALYSIS OF A PRECAST REINFORCED CONCRETE FRAME HALL AND THE ESTABLISHMENT OF RETROFITTING SOLUTIONS. PART I – THE DYNAMIC ANALYSIS OF THE EXISTING STRUCTURAL SYSTEM

BY

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Abstract. The ventilated facade is an external building envelope system, installed dry, in new constructions or on buildings undergoing renovation. This system is mounted outside the building, with a space in front of its perimeter wall. Its main role is to influence the heat exchange between the inside and outside of the building, with advantages over heat losses. A modern material used in ventilated facades is Corian, a composite material patented by DuPont in 1967, composed of acrylic polymer and alumina trihydrate (ATH) derived from bauxite ore. Its main use is for the finishing layer on the ventilated facades of buildings, and it requires knowledge of how it behaves under the action of temperature variations. This article presents the laboratory results recorded to assess the material's disturbed state under freeze-thaw cycles.

Keywords: corian, composite material, compressive strength, laboratory tests.

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1. Introduction

The thermal insulation of the building is an extensive topic analyzed both by the designers of new buildings, but also in frequently encountered situations, when rehabilitating existing buildings. Thermal insulation has numerous energy and economic benefits. Nowadays, there are various insulation materials and systems, each with its advantages and disadvantages. In general, thermal insulation is done at the level of the facade. Depending on the requirements it has to fulfill, when in addition to the thermal insulation function it is also necessary to solve the architectural aspect, the ventilated facade could be the perfect solution to replace the banal polystyrene and classic finishes.

The concept of ventilated facade was regulated in Romania in 2013 by a design code (NP 135, 2013) that establishes the materials, the structures required for assembly and the execution methods, so that the resulting facade should be energy efficient and has structural resistance and stability. The norm NP 135/2013, defines the ventilated facade as a facade system in which one of the components of the system is provided with a naturally ventilated air layer. The main role of the ventilated air layer is to ensure equalization of vapor pressure between the external environment and the facade system. According to the Romanian standard SR EN 13830, which establishes the requirements for such a thermal insulation system, ventilated facades must be capable of supporting their own weight as well as the weight of additional minimal elements. They must also withstand mechanical stresses from wind, earthquakes, and horizontal shocks, ensure maximum air permeability while remaining waterproof, provide excellent thermal and sound insulation, and meet a high fire resistance classification. The mounting elements that are part of this system must meet the same conditions, as well as the materials chosen for finishing, a choice that must be made for technical reasons, not just aesthetics.

In this paper, the influence of environmental cycling on the finish elements of a ventilated Corian facade will be presented, by identifying possible changes caused by ageing of the materials, (Pickering E. G. et al., 2017; Taurino R. et al., 2013). For this purpose, a series of material tests were carried out, involving preconditioning and exposure to freeze-thaw environmental conditions. The results obtained during the compression test showed how the material is affected by the action of 50 freeze-thaw cycles.

2. Equipment used and method

A Feutron Klimasimulation GmbH - Twin test climate chamber, (NP 135, 2013) was used to perform the test. It consists of two chambers, one cold and one warm, separated by a movable common wall where specimens for certain tests are mounted. The warm chamber allows the use of an indoor temperature between

5°C and 100°C and the cold chamber a temperature between -40°C and -100°C. It is also possible to set a relative humidity according to the test requirements. By using the programming functions for different temperatures and humidities, different cycles of environmental conditions can be achieved, including freeze-thaw variations. The device used to perform the test is shown in Fig. 1.



Fig. 1 – Feutron Klimasimulation GmbH - Twin test climate chamber - Test device.

To perform the freeze-thaw cycles, only the cold chamber of the device was used, in which the test samples were placed on horizontal grids. Temperature and time (duration) parameters were also set as follows, Fig. 2:

- The duration of a freeze-thaw cycle was set to 8 hours;
- In the first part of the cycle (4 hours) a temperature of 5°C was set so that in the first 30 min the target temperature was reached and then in the next 3 hours and 30 min the target temperature was maintained;
- In the second part of the cycle (4 hours) a temperature of -18°C was set so that in the first 30 min the target temperature was reached and then in the next 3 hours and 30 min the target temperature was maintained;
- In order to accurately observe the behavior of the material in such freeze-thaw cycles, a number of 50 cycles was set, Fig. 3.

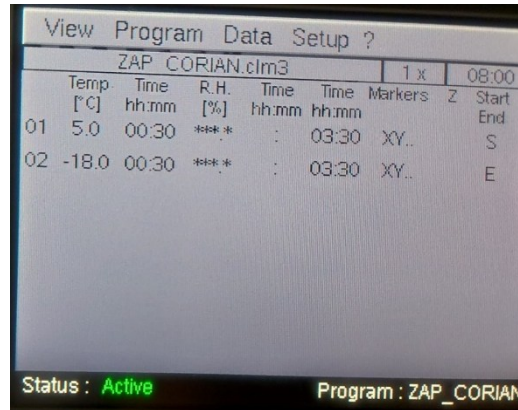


Fig. 2 – Setting of temperature and duration parameters.

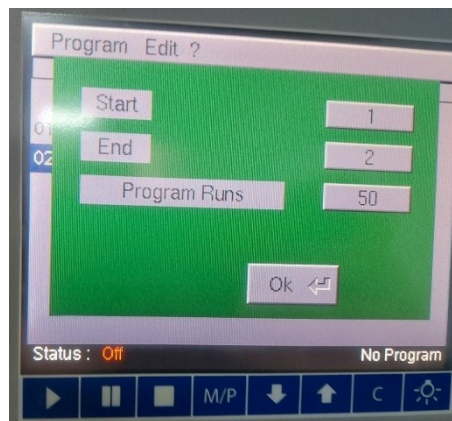


Fig. 3 – Setting the number of freeze-thaw cycles.

In the end, the compression tests were carried out on the Zwick/Roell Material Testing Machine BP1-F1000SN.M11.

3. Experimental tests

3.1. Experimental tests of Corian specimens subjected to freeze-thaw cycles

Since the Corian specimens subjected to freeze-thaw cycles will be tested for compressive strength performance at the end of the 50 cycles (400 hours equivalent to approximately 17 days), the size and shape of the specimens will be identical to that of the uncured specimens subjected to the same compressive strength test. The shape and size of the specimens used for the tests are shown in Fig. 4 and Fig. 5.

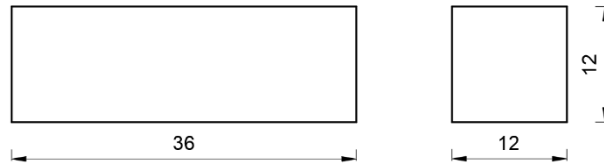


Fig. 4 – Standardized dimensions of compression specimens (mm).



Fig. 5 –
The specimen for
compression tests.

The preparation and placement of the specimens in the climatic chamber for the freeze-thaw cycles was carried out according to Figure 6 and Figure 7. According to the standard analyzed for the compression test, a minimum of 10 specimens is required.



Fig. 6 – Preparation of the corian specimens used for the determination of the compressive strength subjected to freeze-thaw cycles.



Fig. 7 – Positioning of the corian specimens in the climatic chamber used to determine the compressive strength under freeze-thaw cycles.

After performing the set freeze-thaw cycles, it was found that the specimens did not undergo any changes in shape or consistency, so the next step was taken, namely the determination of the compressive strength.

3.2. Determination of compressive strength

The experimental tests to determine the maximum yield failure force of the 10 manufactured specimens, both in the natural and in the disturbed state, were carried out on the Zwick/Roell Material Testing Machine BP1-F1000SN.M11. Load was applied constantly at a rate of 0.1 kN/s until specimen failure, as it is shown in Figure 8. The compression test methodology was

assimilated to the standardized one for specimens subjected to compression, (Isopescu et al., 2012). During the experimental tests it was found that the failure mode was brittle for both sets of specimens (control and subjected to freeze-thaw cycles).

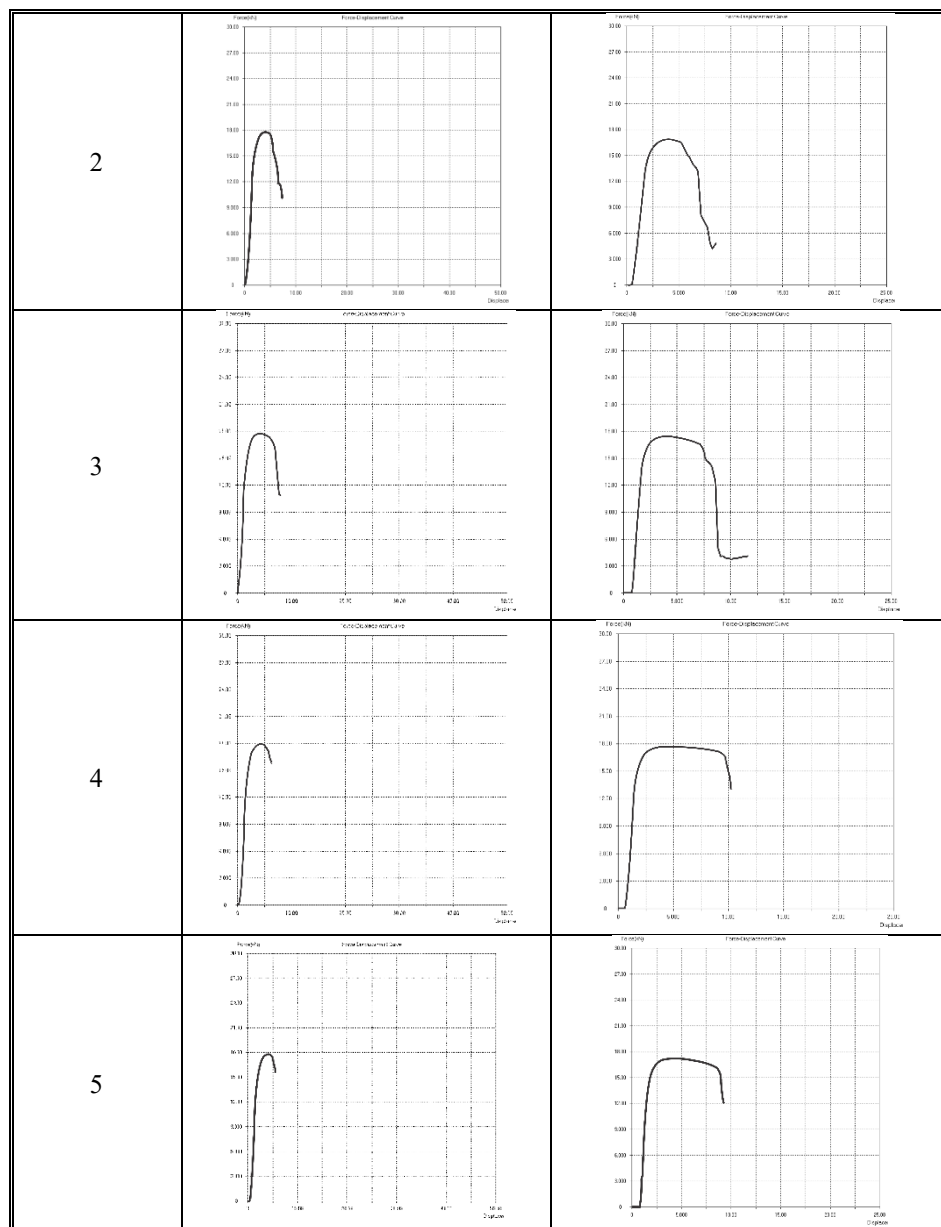


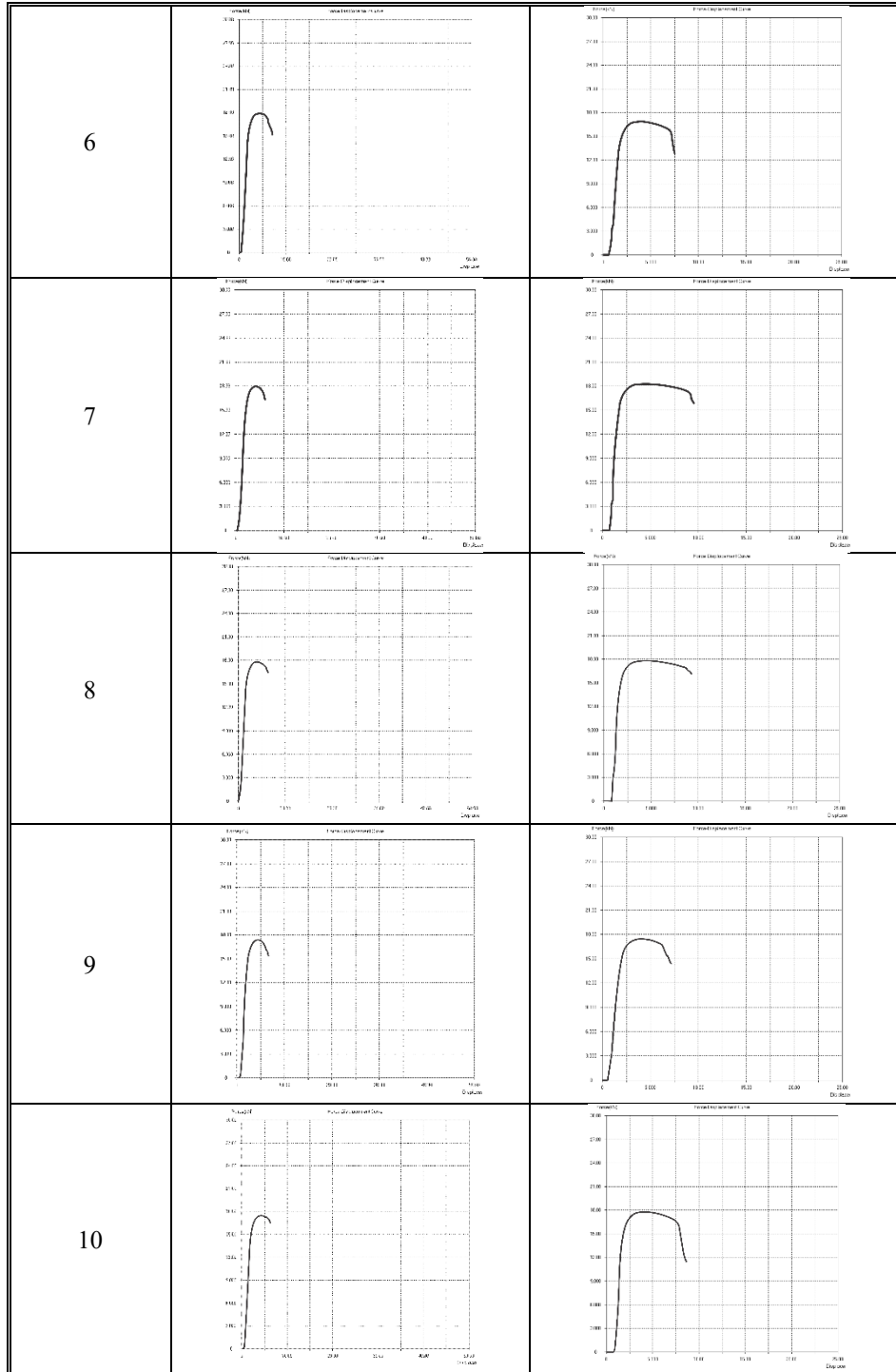
Fig. 8 – Testing procedure.

In Table 1, the force-displacement graphs for each set of specimens tested are presented.

Table 1
Experimental test results

Specimen set	Force-displacement graph	
	Control specimens	Specimens subjected to the freeze-thaw cycle
1		





In Table 2 are presented the failure forces for each samples set. The average failure force was found 17.819 kN for the control specimens, and 17.532 kN for the specimens exposed to freeze-thaw cycles. The decrease in average compression failure force is around 1.61%, which means that the material tested has a good behavior when it is exposed to freeze-thaw cycles.

As is known, freeze-thaw cycles have significant effects on the physical and mechanical parameters of materials. Previous studies have shown that uniaxial compressive strength decreases exponentially with increasing freeze-thaw cycles. In addition, the porosity or water content of the specimens have a great influence on the degree of damage caused by freeze-thaw cycles. In general, there is a certain connection between the macro-mechanical properties of the tested material and its internal micro-characteristics. The process of damage and destruction is actually the process of changing the pore structure in the material. Starting from these general observations, it can be seen that in the case of the tested material (Corian), the porosity of the material is very low, so the effect of freeze-thaw cycles is reduced.

Table 2
The failure force values of specimens subjected to compression

Set	Control specimens		Specimens subjected to 50 freeze-thaw cycles	
	F (kN)	F _{average} (kN)	F (kN)	F _{average} (kN)
1	17.64	17.819	18.02	17.532
2	17.79		16.84	
3	17.71		17.44	
4	17.93		17.68	
5	17.78		17.23	
6	17.90		16.84	
7	17.98		18.27	
8	17.88		17.82	
9	17.77		17.41	
10	17.81		17.77	

From Table 2 it is observed also, that the compressive failure force values of the control samples range from 17.64 kN to 17.93 kN, and the similar values of the samples subjected to 50 freeze-thaw cycles range from 16.84 kN to 18.27 kN.

The wide range of values of the samples subjected to freeze-thaw cycles, highlights the fact that the parameters which define the internal structure, in the present case, the porosity, can influence the behavior under mechanical stress. On the average, it is conducted that the tested corian specimens were not strongly

affected by the exposure to the outdoor environment cycles, due to its compact structure (in eight cases from ten).

4. Conclusions

The research carried out in the case study presented in the paper served to understand the influence on the mechanical properties of the material, Corian, used for the finishing layer of the ventilated facades, which undergo freeze-thaw cycles. Also, the research conducted focused on highlighting the variation rules for compressive stress.

The evolution of the mechanical properties of the tested material was elucidated from the experimental results. These key findings may provide new contributions to engineering construction in regions with temperatures that produce seasonal frosts.

The Corian, a manufactured synthetic material, behaves well in cyclic freeze-thaw actions and, from this point of view, can be used in the composition of ventilated facades.

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EVALUAREA SEISMICĂ CANTITATIVĂ A UNEI HALE
PREFABRICATE TIP CADRU DE BETON ARMAT ȘI STABILIREA UNOR
SOLUȚII DE RETROFITARE. PARTEA I – ANALIZA DINAMICĂ A
SISTEMULUI STRUCTURAL EXISTENT

Structurile prefabricate tip cadru de beton armat proiectate și executate în perioada comunistă în România dețin un loc de frunte în lista clădirilor industriale/ comerciale/ sociale/ culturale. În acest studiu de cercetare se analizează o structură de acest tip. În partea introductivă a studiului se evidențiază tipurile de sisteme prefabricate tip cadru din beton armat specifice zonelor seismice cât și elemente componente ale acestora. În partea a doua se arată principalele deficiențe structurale ale sistemelor prefabricate solicitate la cutremure de pământ. În capitolele următoare se dezvoltă analiza dinamică aferentă structurii studiate cât și o verificare a rigidității laterale. Astfel, s-a constatat faptul că structura prefabricată tip cadru din beton armat dezvoltă deplasări laterale superioare limitei admisibile. În aceste condiții, se propun și câteva soluții de retrofitare a sistemului structural utilizând contravântuire metalice verticale, pereți structurali din beton armat, stâlpi armați cu armătură rigidă (din oțel laminat – beton armat) și grinzi metalice pe direcția traveelor.

