MODELS FOR PREDICTING CHLORIDE INGRESS IN CONCRETE SAMPLES EXPOSED TO PRESSURE PENETRATION TEST (PPT) AND BULK DIFFUSION TEST (BDT)

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The experimental tests were carried out with the aim to develop a rapid procedure for predicting chloride penetration into concrete, without stimulating the migration of chloride ions with electricity. Pressure Penetration Test (PPT) results were compared with the results obtained using the standardized Bulk Diffusion Test (BDT). The testing was carried out on 15x15 cm concrete cubes. Chloride penetration into concrete samples was modeled by analyzing previous studies and selecting suitable mathematical models. The two models were modified by introducing chloride penetration coefficients, experimentally determined by comparing PPT and BDT chloride profiles. The study confirmed the possibility of applying the PPT procedure for the rapid prediction of chloride penetration into concrete.

Keywords: *concrete, chloride, diffusion, penetration, modeling, comparison*

List of abbreviations:, *BDT – Bulk Diffusion Test, CM – Concrete Mixture, PPT – Pressure Penetration Test, RC – Reinforced Concrete, RC – Storage in Air, RCPT – Rapid Chloride Permeability Test, RMT – Rapid Migration Test, SL – Service Life SPT – Salt Ponding Test, SW – Storage in Water*

1. Introduction

Investigations of mechanisms of chloride penetration into concrete are aimed at developing mathematical models for assessing the service life (SL) of RC structures. Therefore, the research was focused on defining the parameters that describe the properties of chloride penetration mechanism, the most important of which are the coefficient of chloride diffusion in concrete, the surface concentration of chloride, and the amount of free chlorides on the contact surface between the concrete and reinforcement. The reviews on the state in this area are presented in [1] and [2]. In the 1990s, extensive research programs were carried out. The most important were HETEK [3] and DuraCrete [4], whose analyses and proposed mathematical models have been used by researchers in the past twenty years as a starting point for modifying research in this area and designing new mathematical models.

Methods of testing the penetration of chloride into concrete, [5] and [6], are mainly developed with the aim to measure the diffusion of chloride ions. Time-consuming tests such as SPT and BDT provide the most accurate measurements of pure diffusion, with the need to improve the tests by monitoring and controlling the salt concentration in the solution [7]. The need to effectively describe the profile of chloride penetration into concrete has lead to the development of rapid tests based on the electricity-induced acceleration of chloride ion migration. The most commonly used rapid tests are the Rapid Chloride Permeability Test (RCPT) and the Rapid Migration Test (RMT). The studies have shown a better correlation between the RMT and BDT compared to the correlation between the RCPT and BDT tests [8]. Parameters for mathematical modeling of chloride profiles obtained by rapid tests fail to match the parameters of actual processes in aggressive environments, so they are corrected using experimentally obtained coefficients. They are often quantified on the basis of limited experimental research, carried out in local environmental conditions. In most cases, these researches were carried out using electricity-accelerated tests on small standard samples, so the question arises as to whether they match the penetration of chloride in massive concrete structures.

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Table 1

Composition of the concrete mixtures

Mixture	Cement (kg)	Water (kg)	w/c	Aggregate (kg)				Total (kg/m^3)
				0-4	4-8	8-16	16-32	
CM1	320	160	0,50	840	300	340	500	2.460
CM2	440	220	0,50	850	284	416	378	2.588
CM3	265	160	0,60	700	304	384	580	2.393

Table 2

Number of samples tested and sample marks

Mixture	SW	PPT	BDT	SA	**Total**
CM1	15	24	24	24	**87**
CM2	15	24	24	24	**87**
CM3	15	24	24	24	**87**

Table 3

Testing program for samples

Mixture	**PPT test**	**BDT test**	**SA test**
	Sample series / Test duration / Number of samples	Sample series / Test duration / Number of samples	Sample series / Test duration / Number of samples
CM1 **CM2**	I / 2 days / 4	I / 30 days / 4	I / 30 days / 4
	II / 4 days / 4	II / 45 days / 4	II / 45 days / 4
	III / 6 days / 4	III / 60 days / 4	III / 60 days / 4
	IV / 8 days / 4	IV / 75 days / 4	IV / 75 days / 4
	V / 10 days / 4	V / 90 days / 4	V / 90 days / 4
	VI / 10+SA / 4	VI / 90+SA / 4	VI / 90+SA / 4
CM3	I / 2d / 6	I / 30d / 4	I / 30d / 4
	II / 2d / 6	II / 45d / 4	II / 45d / 4
	III / 4d / 6	III / 60d / 4	III / 60d / 4
	IV / 1d / 6	IV / 75d / 4	IV / 75d / 4
		V / 90d / 4	V / 90d / 4
		VI / 90d + SA / 4	VI / 90d + SA / 4

Testing chloride penetration under pressure is a less used method because convection and diffusion, i.e. two mechanisms of chloride transportation occur when the chloride penetrates under pressure. In [9], it has been stated that the procedure of separation of the two aforementioned chloride ion transport mechanisms can be replaced by a single parameter that describes both mechanisms, the chloride penetration coefficient. The research included the analysis of the depth of chloride penetration under pressure compared to the depth of penetration of water, [10] and [11]. Penetration mechanisms are explained in [12]. By establishing a correlation between chloride penetration under pressure and pressure-free chloride penetration, this method enables the acceleration of procedure of estimating the chloride penetration profile over time, with limitation that pressures have to be over 1 bar, based on the results of testing chloride penetration under various pressures presented in [10].

This paper presents the experiment of comparative testing of 15x15 cm concrete cubes in a pressure testing chamber (PPT) and concrete cubes immersed in water (BDT), with the percentage of salt in water being the same in both tests. The aim was to develop a method of testing chloride penetration under pressure and define the chloride penetration process that matches the situation in real structures. This would enable the proposed accelerated method of testing without using electricity and define a procedure for testing concrete structures exposed to the action of the aggressive environment under pressure, such as structures immersed in salt water. Based on the test results, profiles of chloride penetration under pressure were defined. Modified mathematical models were proposed for the prediction of chloride penetration.

2. Experimental program

The research was carried out on three concrete mixtures, labeled CM1, CM2, and CM3. Recipes of the defined concrete mixtures are given in Table 1.

Mixtures CM1 and CM2 were made of the same type of aggregate and cement, while for mixture CM3 other types of concrete constituents were used. Mixtures CM1 and CM2 were designed using aggregate from the Bosna river, with cement type CEM II / B-M (S-V) 42.5N (Lukavac cement factory), while the water was taken from a well at the locality of the "Reweus" Lukavac concrete plant. In the case of mixture CM3, the aggregate was from the Drina river, with cement type CEM II / B-W 42.5N (Kakanj cement factory), while water was also taken from a well from the locality of the "TBG" Lukavac concrete plant. All samples of individual mixtures were made simultaneously in appropriate molds. The concrete was installed using a vibration needle. In order to control the quality of fresh concrete mixtures, consistency measurements were conducted prior to the preparation of samples using the method of settling. The concrete volume weight in a fresh state was also measured. 24 hours after placing the samples into molds, they were taken out and transported to the laboratory, where they were marked and cured by immersing in water of the temperature of 20 ± 2°C until the age of 28 days. Table 2 shows the number and marks of samples. SW samples were used to test the physical-mechanical properties. The BDT and PPT samples were used to test the penetration of chloride, while the SA samples were used as comparative samples. Before exposing the samples to the action of chloride, the sides of cubes were coated with the epoxy-based coating (SikaCor 277), except for the upper side to be exposed to the aggressive environment. The BDT samples were freely immersed in a 16.5% NaCl solution. The test was carried out in accordance with the NordTest NT Build 443 standard. For the needs of the PPT, a pressure testing chamber was designed, in which the samples were also immersed in a 16.5% NaCl (2.8M NaCl) solution. The PPT samples were exposed to the pressure of 2.0 bars. The test program is described in Table 3.

The chloride content in the depth was determined in a chemical laboratory using K_2CrO_4 and $AgNO_3$ solutions. The concrete powder is sampled in the depth by grinding with a diamond grinder. Using the $AgNO_3$ solution in the concentration of 0.1 M, the depth of penetration of chloride was identified.

3. Experimental results

The regression analysis of measurements was carried out using the ‘genfit’ function from Mathsoft’s MathCAD. The ‘genfit’ function is capable of fitting an arbitrary equation to a set of data points. All the known variables for equation (1), the solution to Fick’s Second Law were defined through the program, with the chloride content listed as a percentage of concrete mass and the depth listed in millimeters. Subsequently, reasonable guesses were made for the diffusion coefficient and the surface chloride content. The function then determined the two unknowns using a minimization of the sum of the squares. There are three inputs required for the ‘genfit’ function [13]. The first is an array relating the chloride concentration, in percent, to the depth of the sample, in millimeters. The second is an array of guesses to start the curve fitting process, and the third is an array of three equations. These three equations include the solution related to Fick’s Second Law, equation (1), the partial derivation of equation (1) with respect to the parameter of surface chloride concentration (2), and the partial derivation of equation (1) with respect to the coefficient of diffusion (3).

$$C = C_0\left(1 - erf\frac{x}{2\sqrt{D_c \cdot t}}\right) \qquad (1)$$

$$\frac{\partial}{\partial C_0} = \left[1 - erf\left[\frac{1}{4}\cdot x \cdot \frac{4^{1/2}}{(D\cdot t)^{1/2}}\right]\right] \qquad (2)$$

$$\frac{\partial}{\partial D} = \frac{1}{4}\cdot\frac{C_0}{\pi^{1/2}}\cdot \exp\left(\frac{1}{4}\cdot\frac{x^2}{u_i \cdot t}\right)\cdot x \cdot \frac{4^{1/2}}{(D\cdot t)^{1/2}}\cdot t \qquad (3)$$

where:
C - concentration of a solution (kg/m³)
x - a linear distance (m)
t – time (sec)
D - diffusion coefficient (m²/sec)
C_0 – surface concentration of a solution (kg/m³)
erf - the error function

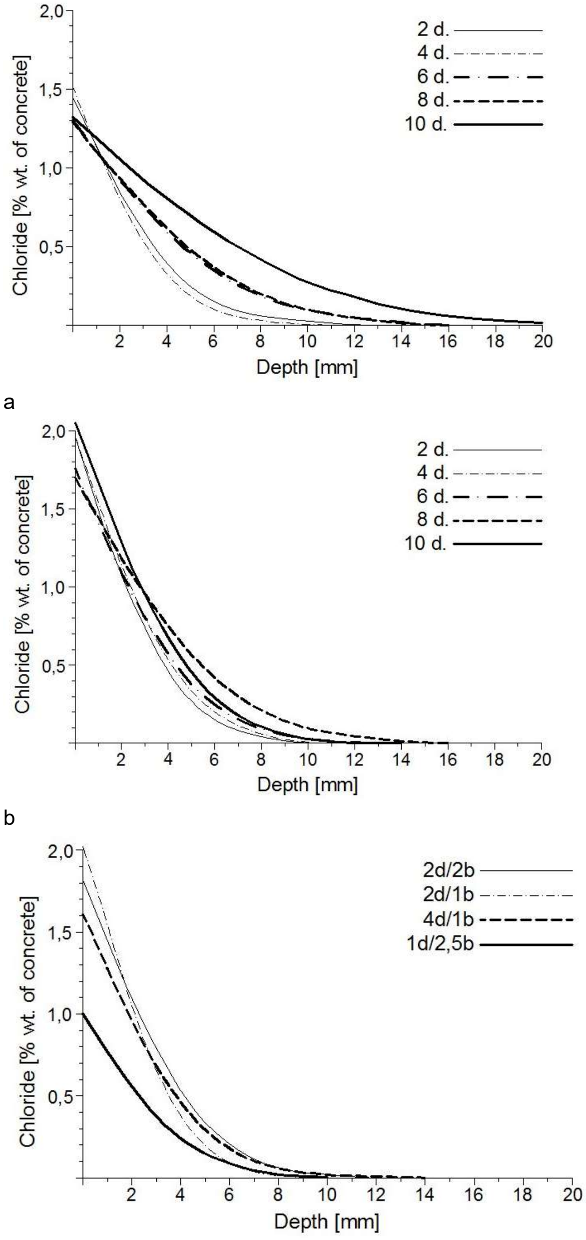

Fig. 1 - PPT chloride profiles: (**a**) CM1 mixture, (**b**) CM2 mixture, (**c**) CM3 mixture.

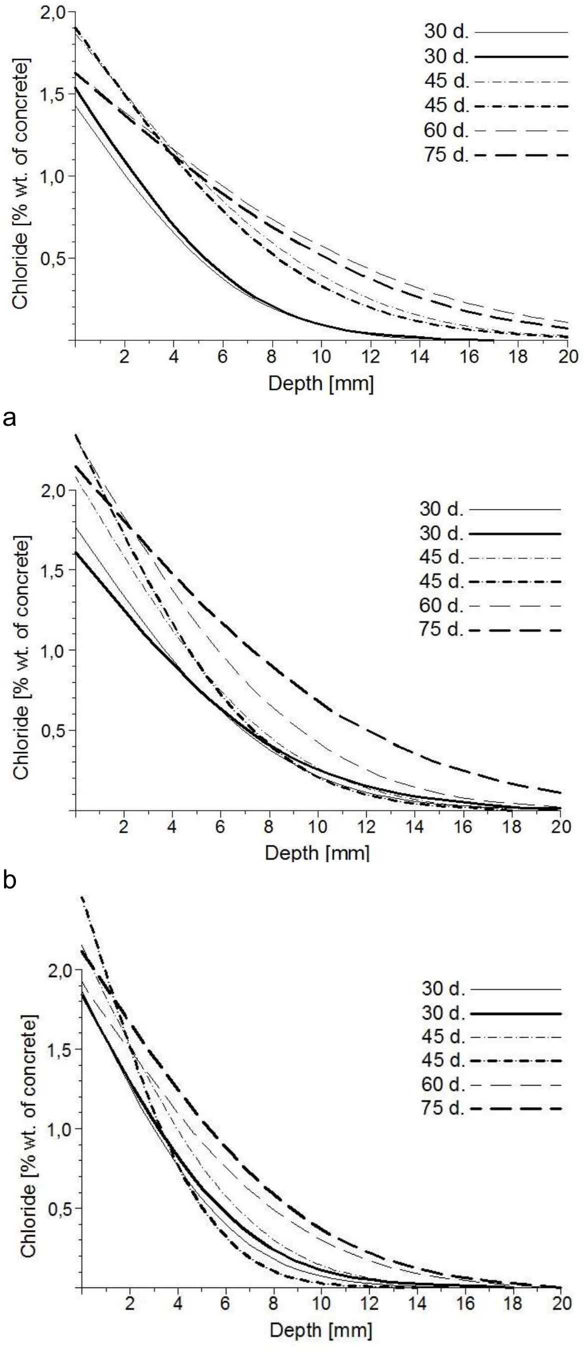

Fig. 2 - BDT chloride profiles: (**a**) CM1 mixture, (**b**) CM2 mixture, (**c**) CM3 mixture

Figure 1 shows the chloride profiles obtained by the regression analysis of PPT measurements, while Figure 2 shows the chloride profiles obtained by BDT measurements.

4. Numerical models

A comparative numerical analysis was carried out with the aim of verifying the possibility of using an alternative method of testing chloride penetration into concrete under pressure (PPT) for creating models of chloride penetration prediction. For the purpose of comparative numerical analysis, six mathematical models from papers [13] - [21] were used, marked as A - F, presented in Table 5. The mathematical models were selected in a way to cover the different approaches of individual researchers. Namely, the unification of the mathematical model of chloride penetration is still impossible, as the researchers' proposals are based on the approximate description of the complex mechanism of penetration of chloride in the stochastic environment. The only reliable way to test the proposed mathematical models and their possible modifications are to design an experimental program with recipes for concrete and environmental conditions that apply in particular regions. One specific mathematical model, determined by testing in specific environmental conditions at one specific location, cannot be used for other environmental conditions and locations without experimental verification.

The structure of mathematical **model D** was used to design a modified mathematical model for chloride penetration prediction based on the results of PPT. The coefficient of relative humidity $k_{RH} = 1$ has been adopted because they are laboratory tests, without significant losses of humidity. The parameter of temperature fails to affect the character of testing conducted in this study. Thus, k_T was adopted as $k_T = 1$. Based on the recommendations presented in [22] and [23], the value of exponent was adopted as n = 0.30. Note that changes in these values were analyzed since other values were used in the analysis of the Krk bridge [16]. Expressions from the model D were given for the coefficient of diffusion

Table 4

Representative values of parameters of chloride penetration

	PPT 2 days/2 bars	PPT 8 days/2 bars	BDT (average value)
Coeff. of diffusion (m^2/sec)	CM1 - 3,589 x10^{-11} CM2 - 3.167 x10^{-11} CM3 - 4.373 x10^{-11}	CM1 - 2,217 x10^{-11} CM2 - 1.874 x10^{-11} CM3 - 2.020 x10^{-11}	CM1 - 0,737 x10^{-11} CM2 - 0.665 x10^{-11} CM3 - 0.406 x10^{-11}
Surface concentration (%)	CM1 - 1,479 CM2 - 1.981 CM3 - 1.850	CM1 - 1,289 CM2 - 1.701 CM3 - 1.609	CM1 - 1,666 CM2 - 2.037 CM3 - 2.056
k_{PPT}, ξ_{PPT} (D_{BDT}/D_{PPT})	**CM1 - 0,205** **CM2 - 0.210** **CM3 - 0.093**	**CM1 - 0,332** **CM2 - 0.355** **CM3 - 0.201**	

Table 5

Selected mathematical models

Models	Equations
Model A – Costa and Appleton [14]	$C(x,t)=C_1t^n\left(1-erf\left(\frac{x}{2\sqrt{D_1t^{1-m}}}\right)\right)$
Model B – Liu J. et al. [15]	$c_f(x,t)=c_{f,0}+\left(c_{f,s}-c_{f,0}\right)\cdot\left[1-erf\left(\frac{x}{2\cdot\left\{\frac{kD_0^*t_0^m}{1-m}\cdot\left[(t_0+t)^{1-m}-t_0^{1-m}\right]\right\}^{1/2}}\right)\right]$
Model C – Mejlbro, Poulsen, Frederiksen [13] and [16]	$C(x,t)=C_i+S_1\sqrt{t-t_{ex}}\left(\exp\left(-z^2\right)-z\sqrt{\pi}\cdot erfc(z)\right)$
Model D – DuraCrete model [4] and [17]	$C(x,t)=\left(C_{s,\Delta x}-C_i\right)\cdot\left[1-erf\left(\frac{x-\Delta x}{2\cdot\sqrt{t\cdot D_{eff}(t)}}\right)\right]+C_i$ $D_{eff}(t)=k_{RH}\cdot D_{RCM,0}\cdot k_t\cdot k_T\cdot\left(\frac{t_0}{t}\right)^n$
Model E – ClinConc model [18]	$\frac{c-c_i}{c_s-c_i}=1-erf\left(\frac{x}{2\sqrt{\frac{\xi_D D_{6m}}{1-n}\left(\frac{t'_{6m}}{t}\right)^n\cdot\left[\left(1+\frac{t'_{ex}}{t}\right)^{1-n}-\left(\frac{t'_{ex}}{t}\right)^{1-n}\right]\cdot t}}\right)$ $\xi_D=\frac{\left(0.8\cdot a_t^2-2\cdot a_t+2.5\right)\cdot\left(1+0.59\cdot K_{b6m}\right)\cdot e^{\frac{E_D}{R}\left(\frac{1}{293}-\frac{1}{T}\right)}}{1+K_{OH6m}\cdot K_{b6m}\cdot f_b\cdot\beta_b\cdot\left(\frac{c_s}{35.45}\right)^{\beta_b-1}\cdot e^{\frac{E_b}{R}\left(\frac{1}{T}-\frac{1}{293}\right)}}\cdot k_D$
Model F - Wang, Yu and Xue [19], [20] and [21]	$C(x,t)=C_0+\left(C_s-C_0\right)\cdot\left[1-erf\left(\frac{x}{2\cdot\sqrt{\frac{f(\delta)RD_0t_0^m}{(1-m)}t^{1-m}}}\right)\right]$

determined by the accelerated RCM migration test, and then the deviation from the natural diffusion was corrected with the coefficient k_t. As part of the numerical analysis of the BDT results, the multiplication $D_{RCM,0}$ and k_T was replaced by the coefficient of diffusion determined based on the BDT (D_{BDT}) while for the PPT the form of expression used to introduce the parameter - **coefficient of chloride penetration k_{PPT}** (see Table 4), by which the multiplication D_{PPT} and k_{PPT} was introduced in the expression in order to correct the parameters of the PPT pressure test in relation to natural diffusion BDT. Therefore, terms for D_{eff} in Table 5 take the following form:

for BDT samples: $D_{eff}(t)=D_{BDT}\cdot\left(\frac{t_0}{t}\right)^{0.3}$ (4)

for PPT samples: $D_{eff}(t)=D_{PPT}\cdot k_{PPT}\cdot\left(\frac{t_0}{t}\right)^{0.3}$ (5)

for in situ samples: $D_{eff}(t)=0.5\cdot D_{BDT}\cdot\left(\frac{t_0}{t}\right)^{0.65}$ (6)

It is interesting to extract part of the expression of the **model E** in Table 5,

$$\frac{\xi_D D_{6m}}{1-n}\left(\frac{t'_{6m}}{t}\right)^n \tag{7}$$

which describes the principles of changes occurring in the coefficient of diffusion for the process of natural diffusion of chloride in concrete. Since the coefficient of diffusion D_{6m} is determined by the accelerated migration test RCM, the role of the factor ξ_D is to link the conditions of the RCM test with chloride diffusion in real conditions. Parameters in the expression for determining ξ_D describe the dependence of the chloride diffusion process on the water-cement ratio, concentration of hydroxyl ions, amount of cement gel, porosity of concrete, and the chloride binding processes. Given the limited scope of testing carried out in this study in a limited period of time, the form of the ClinConc model was tested in the way that the expression from Table 5 was modified as follows:

$$\frac{c-c_i}{c_s-c_i}=1-erf\left(\frac{x}{2\sqrt{K_{PPT}\cdot K_T}}\right) \qquad (8)$$

$$K_{PPT}=\frac{\xi_{PPT}D_{PPT}}{1-n}\left(\frac{t'_{PPT}}{t}\right)^n \qquad (9)$$

$$K_T=\left[\left(1+\frac{t'_{ex}}{t}\right)^{1-n}-\left(\frac{t'_{ex}}{t}\right)^{1-n}\right]\cdot t \qquad (10)$$

where:

ξ_{PPT} - **chloride penetration factor** that links the PPT test with the natural process of diffusion (BDT) (see Table 4),

D_{PPT} - coefficient of diffusion measured by PTT test in the duration of t'_{PPT}.

Thus, the mathematical model was modified in terms of the introduction of the **chloride penetration factor** ξ_{PPT}, which contains all the aforementioned effects, as well as the influence of another transport mechanism, convection, which occurs in pressure tests.

A comparative numerical analysis was carried out for models of chloride profiles prediction after 5 and 20 years of exposure to chlorides in laboratory conditions. The comparison of the results for the tested concrete mixture CM1 is graphically presented in Figure 3.

5. Discussion

The presented diagrams show a good matching between the results of selected mathematical models. It has been shown that the alternative method of chloride penetration testing under pressure (PPT) can be used to design models of chloride penetration prediction, and thereby to define the service life of structures. The deviation of models A and C is visible in all comparative diagrams, which is a consequence of the introduction of a time-variable surface concentration of chloride in the mathematical model presented in this study. However, the results of all mathematical models, including the modified D and E models, are grouped at a depth of 25 mm and provide a satisfactory accuracy (match of results). At these depths the scattering of the results for all comparative mathematical models is up to 30% which is acceptable given that the proposed mathematical models were developed within different limited research programs. Here, it is important to emphasize that the scattering of the results of up to 30% includes the results of 2-day and 8-day PPT tests. If we consider only the results of one of the two PPTs, the difference between the results of the two proposed modified models (D_{PPT} and E_{PPT}) is up to 10%, which can be seen as acceptable accuracy. Matching the results can be considered acceptable for the analysis of prediction models in engineering practice given that in large number of cases the thickness of the protective layer of concrete is 25 mm or more. In the CM1 mixture, a deviation occurred in the model B, which is the consequence of the application of exponent ***m*** according to the formula offered in the proposed model, which indicates that modeling based on this mathematical model requires a more detailed analysis of exponent ***m*** in future research.

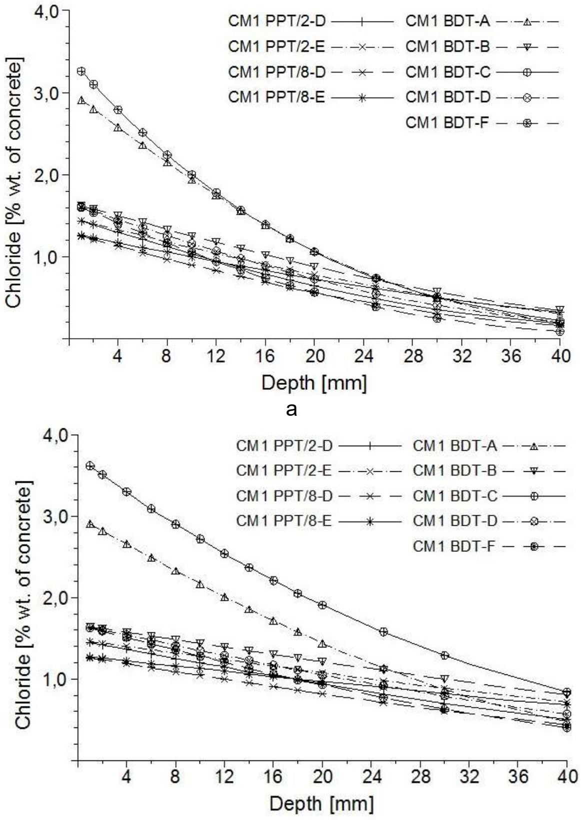

Fig. 3 - Models of chloride penetration prediction for the CM1 concrete mixture: (**a**) 5 years of exposure to chlorides, (**b**) 20 years of exposure to chlorides.

It is also evident that a good matching of the results is obtained for the 2-day and 8-day PPT test. However, it can be considered that more reliable results in determining the chloride profile can be obtained when the PPT test lasts longer with the greater depth of chloride penetration, which enables more accurate modeling of the chloride profile.

6. Conclusions

The proposed standardized methods of quantification of penetration of chloride into concrete are long lasting procedures (e.g. BDT testing) or accelerated procedures that are based on the electricity-induced migration of chloride ions. Assessing the resistance of concrete against penetration of chloride using the above-mentioned methods is based on relatively small, standard samples. In addition, the offered mathematical models, which describe these accelerated tests, introduce parameters of reduction as the result of measurements from small etalon samples to the samples that are freely immersed in the saline solution of the specific concentration. This paper presents the experimental and numerical investigations conducted with the aim of developing a proposal for an accelerated procedure for determining the profile of chloride penetration into concrete using concrete samples of larger dimensions. A PPT has been proposed as an accelerated procedure for determining the profile of chloride penetration into concrete and verified by comparing it with the standardized BDT in accordance with ASTM C1556. For this purpose, a testing chamber (PPT chamber) was constructed. By analyzing the results of BDT and PPT, modified mathematical models were proposed. Through a comparative numerical analysis of the selected and modified mathematical models, the possibility of using the PPT method for the creation of chloride profiles prediction was confirmed, which is the basic input data for modeling the service life of concrete structures. Therefore, the PPT procedure of accelerated determination of chloride profile, along with the proposed modified mathematical models, can be recommended for application in engineering practice when conducting a calculation procedure for the quantification of the durability of concrete structures.

The proposed PPT procedure can be used to determine the durability of concrete structures directly exposed to salty water under pressure, which is particularly significant for the area of the city of Tuzla and similar environments located on salt deposits. The proposed PPT procedure can also be used for testing under the pressure of other solutions that are possible in engineering practice, as it is the case with hydro-mechanical facilities.

As part of the activity, a limited amount of experimental and numerical research was carried out. Based on the research, some conclusions could be drawn as a result of the conducted analysis. The results are also supported by a number of previous studies. This indicates the great possibilities in applying the proposed procedure and mathematical models. Of course, a large field of research possibilities still remains open in terms of increasing the database for calibrating the accuracy of the proposed procedure and mathematical model. In order to further develop the proposed procedure, and define the corrosion process in concrete more accurately, the research should focus on:

- Defining the transport mechanisms of chloride ions in the surface layer, up to 5mm of the protective concrete layer, where the percentage of cement gel is higher;
- Analyzing individual chloride ion transport mechanisms within the concrete pore structure with a special emphasis on the chemical process of binding products of hydration of cement and chloride ions;
- Defining the coefficients of penetration and parameters of chloride penetration in different concrete mixtures and different environmental conditions;
- Analyzing chloride penetration for a wider range of pressures and exposure conditions.

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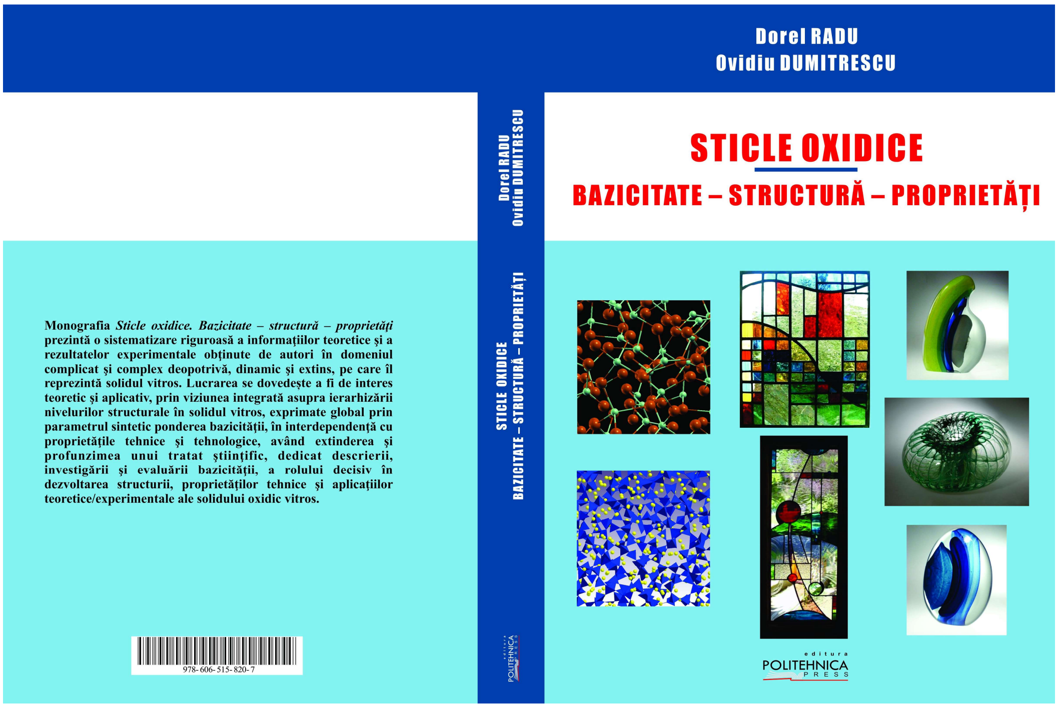

Monografia *Sticle oxidice. Bazicitate – structură – proprietăţi* prezintă o sistematizare riguroasă a informaţiilor teoretice şi a rezultatelor experimentale obţinute de autori în domeniul complicat şi complex deopotrivă, dinamic şi extins, pe care îl reprezintă solidul vitros. Lucrarea se dovedeşte a fi de interes teoretic şi aplicativ, prin viziunea integrată asupra ierarhizării nivelurilor structurale în solidul vitros, exprimate global prin parametrul sintetic ponderea bazicităţii, în interdependenţă cu proprietăţile tehnice şi tehnologice, având extinderea şi profunzimea unui tratat ştiinţific, dedicat descrierii, investigării şi evaluării bazicităţii, a rolului decisiv în dezvoltarea structurii, proprietăţilor tehnice şi aplicaţiilor teoretice/experimentale ale solidului oxidic vitros.

Anul universitar 2018-2019 reprezintă anul cu semnificaţie specială pentru o serie de structuri ale Universităţii POLITENICA din Bucureşti. Astfel, UPB aniversează **200 de ani** de atestare documentară, iar actuala facultate de „Chimie Aplicată şi Ştiinţa Materialelor", ca parte componentă a UPB, înregistrează **8 decenii** de existenţă. Totodată, în cadrul acesteia, departamentul „Ştiinţa şi Ingineria Materialelor Oxidice şi Nanomateriale" (SIMONa) aniversează **70 de ani** de la înfiinţare. Cu această ocazie, **prof. dr. ing. Dorel RADU** şi **prof. dr. ing. Ovidiu DUMITRESCU** au avut ideea de a elabora o lucrare care să conţină contribuţii ştiinţifice ale membrilor colectivului de Chimia şi Tehnologia Sticlei pe o temă fundamentală a domeniului: bazicitatea şi corelaţii ale acesteia cu structura chimică şi proprietăţile sistemelor oxidice vitroase. Lucrarea **STICLE OXIDICE: BAZICITATE – STRUCTURĂ – PROPRIETĂŢI** îşi propune să alăture o serie de articole sau părţi ale acestora publicate prin timp în literatura de specialitate, având ca autori cadre didactice şi doctoranzi din departamentul SIMONa, referitoare la tematica de interes. De asemenea, lucrarea cuprinde şi o serie de paragrafe, scrise de autori, care văd lumina tiparului pentru prima dată. Cartea a fost tipărită în **septembrie 2018** la **Editura POLITEHNICA Press** şi are următoarele capitole: Cuvânt-înainte; Introducere; Cap. I. Solide vitroase; Cap. II. Obţinerea sticlelor oxidice; Cap. III. Bazicitatea sistemelor oxidice; Cap.IV. Structura chimică a sistemelor oxidice vitroase; Cap. V. Implicaţii temperatură – structură – bazicitate în sistemele oxidice vitroase; Cap. VI. Proprietăţi termodinamice ale sistemelor oxidice versus bazicitate; Cap. VII. Implicaţii compoziţie – bazicitate – structură – proprietăţi; Cap. VIII. Modelarea matematică optimă. Modele matematice de proiectare compoziţională optimă a sistemelor oxidice, ţinând cont de bazicitate; Lucrările ştiinţifice utilizate în realizarea cărţii.

Recenzie elaborată de autor, profesor Ovidiu Dumitrescu