



## Performance evaluation of organic coatings against corrosion in reinforced cement mortars

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### ABSTRACT

Protection against corrosion in reinforced concrete structures is commonly accomplished by the usage of organic coatings which are applied on the surface of the mortars. Nine coatings from five major categories produced in Greek industry were studied in order to evaluate their performance when applied on cement mortars and exposed to highly corrosive environment under the presence of chloride ions or carbon dioxide. An appropriate series of tests was conducted in order to examine and verify the protection of the coatings against corrosion. The implemented evaluation methods included: (a) half-cell potential measurements and linear polarization technique to determine the protection provided by coatings against chloride ions corrosion, (b) carbonation depth measurements, (c) estimation of the mass loss that steel rebars exhibit after the end of the experiment and (d) determination of liquid water and water vapour transmission rate for the coatings tested. The results suggest that acrylic coatings can offer a satisfying protection level against carbonation and elastomeric coatings can protect rebars from chloride ions corrosion.

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### 1. Introduction

Concrete has been the most widely produced material over the past years. Its strength when loaded in tension is low and therefore it is a common practice to reinforce it with steel for improving its mechanical properties. Embedded rebars in concrete structures are initially protected from corrosive factors by a passive oxide film which is formed around them when steel rebars are placed into concrete [1,2]. The film's creation is a result of the high pH value of concrete due to the presence of  $\text{Ca}(\text{OH})_2$ . Penetration of the protective layer indicates the commencement of corrosion and the creation of rust products, oxides and hydroxides, whose volume is two to four times greater than the parent's steel. Internal stresses appear and inevitably the concrete cover around rebars cracks and spalls. The two most common mechanisms of reinforcement corrosion are:

- Localized destruction of the passive film when diffused chloride ions reach the rebar's surface through porous concrete. Chloride ions penetrate the passive layer and cause pitting corrosion [1]. The harmful chloride ions originate from the environment in marine areas or directly from the concretes' constituents.

- Carbonation. Atmospheric  $\text{CO}_2$  reacts with  $\text{Ca}(\text{OH})_2$  under the presence of water and as a result the alkalinity value of concrete reduces down to 9. This pH value is leading to a general breakdown in passivity and as a result rebars are starting to corrode [3].

The synergism of the two mechanisms must be pointed out, as in concrete of a high pH value the concentration of chloride ions, needed for the beginning of the corrosion reaction, is very high compared to the one needed in an already carbonated concrete [4]. Regarding Greek area both mechanisms for rebars corrosion coexist. Corrosion of embedded steel by chloride ions is highly probable, especially in marine areas and carbonation probability is higher in urban areas [5]. Coatings applied in concrete's surface are one of the most widely used methods for rebars' corrosion control, as they offer a satisfying protection level and they serve decorative purposes as well, either for new constructions or for rehabilitation of deteriorated concrete structures [6]. An efficient organic coating should be able to confront the high alkalinity value of the concrete, the humidity exchange between the environment and the concrete interior and the rebar corrosion. An organic coating is demanded to withhold liquid water, since corrosive factors can be transported by it to the rebar's surface. Consequently, low liquid water transmission rate is needed. A high water vapour transmission rate is desired in order the contaminated water to be able to evaporate or to be maintained inside depending on environmental conditions. Coating systems are also required to exhibit

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high resistance against CO<sub>2</sub> and SO<sub>2</sub> penetration. Good adhesion on the concrete, high durability, UV and weather resistance are required as well [7]. Several types of coatings have been investigated regarding the protection they offer to reinforced concrete, including acrylic emulsions, epoxy resins, chlorinated rubber, elastomeric and polyurethane coatings. Elastomeric surface coatings were investigated regarding their ability to exclude water from carbonated components and to maintain their performance during the requested period [8]. Polyurethane and cement based coatings have also been tested in order to evaluate steel reinforcement corrosion control and to determine physical properties, such as water absorption, water permeability, chloride permeability and adhesion tests [9]. Acrylic resin based surface coatings were evaluated regarding their adhesion value and their chloride permeability [10]. In the present paper nine organic coatings including acrylic and emulsions paints, coatings with PVA copolymers, solvent based cement paints, elastomeric and silicon based coatings have been examined in order to be classified according to their protection level against chloride induced corrosion and carbonation. Liquid water and water vapour transmission rates for each organic coating were also measured, since the aforementioned properties are highly related with reinforcement's protection.

## 2. Materials and methods

### 2.1. Materials

#### 2.1.1. Cement mortar specimens

To evaluate chloride ions' corrosion, carbonation depth and coatings' properties, reinforced cement mortars were constructed. The specimens were cast using Cement II 32.5N, Greek quarry sand 250 μm–4 mm maximum grain dimension and drinkable water from NTUA water supply network, appropriate for preparing specimens according to ELOT 452 [11]. Steel rebars type B500C were used, having 12 mm nominal diameter and 100 mm length. The rebars meet Greek specifications of Hellenic Organization for Standardization ELOT 1421-3 [12]. The w/c ratio was 0.55. The specimens were cylindrical formed in 40 mm × 100 mm. Steel rebars were axial embedded in each one, located as shown in Fig. 1 and were cleaned prior their installation into the mortars according to ISO/DIS 8407.3 [13] and weighted to a 0.1 mg accuracy. The rebars were embedded 80 mm deep into the mortar and consequently 20 mm exerted. The specimens remained molded for 24 h stored in the curing room (20 °C, 100% humidity) and after removing the cast they were fully immersed in tap water for 24 h at 25 °C. They were left to dry for 8 days under laboratory conditions. In order to receive electrochemical measurements, a copper wire was enwrapped to each steel rebar. A mixture of two different epoxy resins was used aiming to protect the upper part of the rebar from atmospheric corrosion.

#### 2.1.2. Organic coatings

Organic coatings were applied by brush on the dried surface of the specimens at two layers, the second layer 24 h after the first one. A solvent based primer for exterior use was also applied before the coatings (solids b.w.: 26 ± 2%). The composition of the coatings used is given in Table 1. Dry film thickness of all coatings was measured using ultrasonic thickness gauge meter according to ASTM D 6132-08 Standard Test Method [14]. Regarding acrylic coatings, three different types were used. All of the coatings demanded the same dilution percentage in water. Acr1 and Acr2 are acrylic paints, whereas Acr3 is considered to be an acrylic emulsion. There are also differences in other technical characteristics such as in density or viscosity of every coating. Two different elastomeric coatings were also used in this study, Elast1 which was used without dilution and

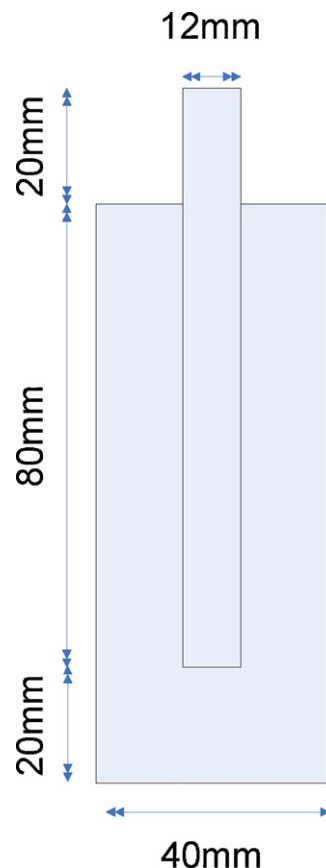


Fig. 1. Dimension of cement mortars specimens.

Elast2 diluted with water. The first elastomeric coating has also a significantly lower spreading rate contrary to the second one. For every evaluation methods 6 specimens were used for each coating. The average values and the corresponding standard deviation are also given in every test series.

### 2.2. Methods

#### 2.2.1. Electrochemical measurements

Cement mortar specimens were partially immersed in 3.5 wt.% NaCl solution. Coatings protection against chloride ions corrosion was evaluated with:

- Half-cell potential measurements:** for a period of 24 months steels' half-cell potential was periodically measured versus a SCE, according to ASTM C876-87 [15].
- Linear polarization technique:** Electrochemical parameters, such as corrosion current density ( $i_{corr}$ ) and polarization resistance ( $R_p$ ), were defined with linear polarization technique as described in ASTM G59-97(2009) [16]. Steel rebars represented the working electrode, SCE the reference electrode and a carbon bar served as the counter electrode. The potential scan range was ±10 mV from OCP and the scan rate was 0.166 mV/s. Corrosion current density ( $i_{corr}$ , μA/cm<sup>2</sup>) was calculated from Stern–Geary equation:

$$i_{corr} = \left[ \frac{\beta_a \cdot \beta_c}{2.303 \cdot (\beta_a + \beta_c)} \right] \cdot \frac{1}{R_p} = \frac{B}{R_p} \quad (1)$$

where  $\beta_a$ ,  $\beta_c$  are the anodic and cathodic Tafel slopes respectively and  $R_p$  is the polarization resistance (Ω cm<sup>2</sup>). For Stern–Geary constant  $B$  a value of 26 mV has been adopted for active corroding

**Table 1**  
Coatings applied on specimens.

Product	Nomenclature	Description	Thickness (μm)
Acrylic coatings	Acr1	Acrylic paint for exterior use, acrylic resin dispersion, solids b.w.: 61 ± 2.5%. Diluted 10% v/v with water. Density: 1.46 ± 0.05 g/ml, viscosity: 107 ± 13 KU, spreading rate: 9 m <sup>2</sup> /l	300
	Acr2	Acrylic water based paint for concrete surfaces, acrylic resin dispersion, solids b.w.: 69.5 ± 2%. Diluted 10% v/v with water. Density: 1.57 ± 0.05 g/ml, viscosity: 95 ± 10 KU, spreading rate: 9.2 ± 1 m <sup>2</sup> /l	280
	Acr3	Acrylic paint for exterior use, dispersion based on acrylic emulsion, solids b.w.: 58 ± 2.5%. Diluted 10% v/v with water. Density: 1.47 ± 0.05 g/ml, viscosity: 110 ± 15 KU, spreading rate: 8.5 ± 0.5 m <sup>2</sup> /l	220
PVA emulsion	PVA	Emulsion paint for interior and exterior use. Dispersion based on PVA copolymer, solids b.w.: 62 ± 3%. Density: 1.40 ± 0.05 g/ml, viscosity: 107 ± 13 KU, spreading rate: 9.5 ± 1 m <sup>2</sup> /l	230
Elastomeric paints	Elast1	Elastomeric, insulating paint for horizontal surfaces, acrylic resin dispersion, solids b.w.: 62 ± 1%. No dilution. Density: 1.37 ± 0.05 g/ml, viscosity: 107 ± 13 KU, spreading rate: 1.5 m <sup>2</sup> /l	270
	Elast2	Elastomeric insulating paint for vertical surfaces, acrylic resins dispersion, solids b.w.: 65 ± 2%. Diluted 5% v/v with water. Density: 1.36–1.46 g/ml, viscosity: 100–150 KU, spreading rate: 6 ± 1 m <sup>2</sup> /l	240
Silicon paint	Sil	Silicon acrylic water-repellent paint, for exterior use, silicon acrylic resins, solids b.w.: 64 ± 1.5%. Diluted 10% v/v with water. Density: 1.52 ± 0.04 g/ml, viscosity: 100 ± 6 KU, spreading rate: 8 ± 0.5 m <sup>2</sup> /l	200
Solvent based paint	SB	Solvent-based paint for cement surfaces, styrene copolymers and acrylic resins, solids b.w.: 73.5 ± 2%. Diluted 4% v/v with white spirit. Density: 1.48 ± 0.04 g/ml, viscosity: 9.5 ± 1.5 poise, spreading rate: 7.3 ± 0.8 m <sup>2</sup> /l	220
Latex paint	Lax	Latex paint for interior use, dispersion based on styrene–acrylic resins, solids b.w.: 58 ± 2%. Diluted 10% v/v with water. Density: 1.50 ± 0.05 g/ml, viscosity: 110 ± 5 KU, spreading rate: 9 ± 0.5 m <sup>2</sup> /l	250
Uncoated	Ref	Specimens without coating application	

steel bars and 52 mV for passive conditions. In the present work the values of  $i_{corr}$ , corresponding to rebars were calculated using constant  $B$  of 26 mV, assuming that steel rebars were in active condition.

### 2.2.2. Carbonation depth

After 6 weeks in an accelerated carbonation chamber in an environment of 7% v/v CO<sub>2</sub>, the specimens were split into two halves and a phenolphthalein indicator (1% phenolphthalein solution in ethanol) was sprayed onto their cut surfaces in order to visualize the carbonation front according to RILEM CPC-18 [17]. Purple colored areas indicate uncarbonated mortar specimen whereas carbonated areas remain colorless.

### 2.2.3. Mass loss of rebars

- Gravimetric mass loss:** To evaluate corrosion from chloride ions 6 mortar specimen for every coating were broken open and the final weight of the steels after de-rusting and cleaning was obtained. The average mass loss was calculated from the difference between the initial and the final mass of each steel bar.
- Calculated mass loss:** Mass loss for each rebar was also calculated via Faraday's Law and from the results given from linear polarization, according to the following equation:

$$m = \frac{M \cdot I \cdot t}{z \cdot F} \quad (2)$$

where  $m$  is the mass of steel consumed (g),  $I$  is the current corresponding to the exposure time (A),  $t$  is the time of exposure (s),  $F$  is 96500 (As),  $z$  is the ionic charge (2 for Fe → Fe<sup>2+</sup> + 2e<sup>-</sup>) and  $M$  is the atomic weight of metal (56 g for Fe).

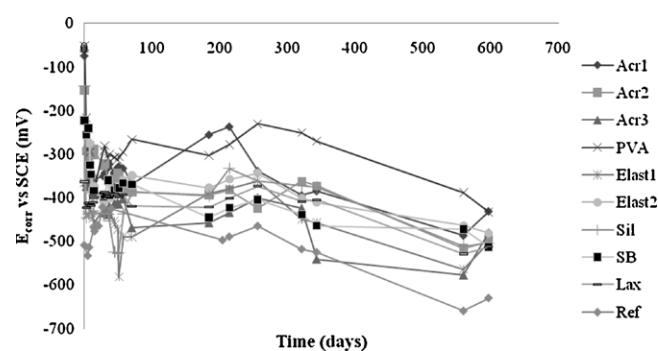
### 2.2.4. Water vapour and liquid water transmission rate of organic coatings

Water vapour transmission rate (WVTR) and liquid water transmission rate ( $w_t$ ) were determined according to DIN EN 7783-2:1999 [18] and DIN EN 1062-3 [19] respectively.

## 3. Results and discussion

### 3.1. Electrochemical measurements

The results of half-cell potential measurements are illustrated in Fig. 2. During the first 70 days of exposure all specimens show



**Fig. 2.** Half-cell potential as a function of exposure time for reinforced cement mortar specimens partially immersed in 3.5 wt.% NaCl solution.

a movement of reducing their corrosion potential to more electronegative direction and they indicate  $E_{corr}$  values up to -500 mV. Afterwards,  $E_{corr}$  values remain more or less stable between -500 and -300 mV. Finally, after 600 days in the corrosive environment the corrosion potential lays between -600 and -400 mV, depending on the type of the coating system. These values according to ASTM criteria for corrosion conditions, as shown in Table 2 [1], predict a high risk of corrosion with 90% probability.  $E_{corr}$  reduction to more electronegative values versus time is due to chloride induced corrosion and it is not surprising as it is in agreement with what reported by other authors [20,21]. Consequently all specimens exhibit similar behavior of half-cell potential versus time, except for specimens with the PVA emulsion coating which show a slightly lower corrosion tendency.

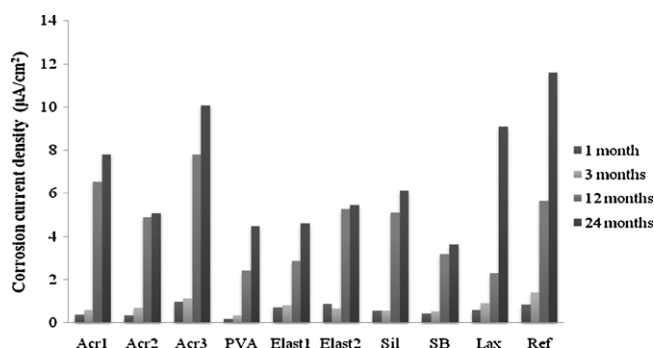
Linear polarization measurements were periodically performed to the six specimens for each coating and values of corrosion current density ( $i_{corr}$ ) corresponding to steel rebars were calculated from

**Table 2**  
Corrosion potential and corrosion condition.

Steel's corrosion potential vs SCE (mV)	Corrosion condition
> -126	Low (10% risk of corrosion)
-126 to 276	Intermediate corrosion risk
< -276	High (90% risk of corrosion)
< -426	Severe corrosion

**Table 3**  
Average values of corrosion current density,  $i_{corr}$  and standard deviations.

	1 month	3 months	12 months	24 months
Acr1	0.3685 ± 0.0697	0.5958 ± 0.0930	6.5362 ± 0.1074	7.8119 ± 0.1234
Acr2	0.3349 ± 0.098	0.6913 ± 0.1567	4.8988 ± 0.1457	5.0846 ± 0.0819
Acr3	0.9668 ± 0.0892	1.1264 ± 0.1495	7.7986 ± 0.1482	10.0863 ± 0.1225
PVA	0.1661 ± 0.0524	0.3224 ± 0.0269	2.4194 ± 0.1187	4.4705 ± 0.1530
Elast1	0.7016 ± 0.0054	0.7973 ± 0.0365	2.8666 ± 0.0922	4.5952 ± 0.1183
Elast2	0.8708 ± 0.0030	0.6548 ± 0.0701	5.2736 ± 0.0988	5.4517 ± 0.1202
Sil	0.5528 ± 0.1178	0.5684 ± 0.0818	5.1078 ± 0.1589	6.1314 ± 0.1288
SB	0.4204 ± 0.0366	0.5241 ± 0.0313	3.1828 ± 0.0692	3.6139 ± 0.1299
Lax	0.5791 ± 0.0398	0.9219 ± 0.0628	2.2842 ± 0.0648	9.1058 ± 0.1057
Ref	0.8427 ± 0.0889	1.4224 ± 0.07026	5.6370 ± 0.12434	11.5876 ± 0.1243



**Fig. 3.** Corrosion current density after 24 months of exposure to 3.5 wt.% NaCl solution.

polarization resistance ( $R_p$ ) according to Stern–Geary equation. The results of  $i_{corr}$  are presented in Fig. 3 and Table 3.

A progressively increasing  $i_{corr}$  value is observed from most of the coated samples due to the deterioration of the paints used. Coatings Acr1, Acr3 and the latex paint exhibited the highest  $i_{corr}$  values and are severely damaged as shown in Fig. 4. The need of repainting is essential for the long term behavior of the aforementioned coatings. In contrast, Elast1, PVA and SB exhibit better behavior since they demonstrate 60%, 60% and 70% lower current density values respectively compared to those of the reference specimens after 24 months.

### 3.2. Carbonation depth

Carbonation damage occurs when there is little concrete cover over the reinforcing steel. However, carbonation can occur even



**Fig. 4.** Cement mortar specimens after 24 months partially immersion in 3.5 wt.% NaCl solution. From left to right: SB, Lax, Acr3.

when the concrete cover depth to the reinforcing steel is high. This may be due to a very open pore structure where pores are well connected together and allow rapid  $\text{CO}_2$  ingress. Generally, carbonation threshold for the initiation of reinforcement corrosion is when carbonation depth exceeds the concrete or cement mortar cover [1]. Carbonation in concrete proceeds mainly by diffusion. The carbonation depth that was measured after the exposure of the specimens to an accelerated carbonation chamber was used to calculate the carbonation coefficient  $K$  according to Eq. (3) as follows [22]:

$$x = K\sqrt{t} \quad (3)$$

where  $K$  is the carbonation constant ( $\text{cm/s}^{0.5}$ ),  $x$  is the carbonation depth (cm) and  $t$  is the time (s).

If uncoated and coated cement mortar surfaces are exposed to  $\text{CO}_2$  environment for the same period of time, then:

$$t_0 = t \Rightarrow \frac{1}{K^2}x_0^2 = \frac{1}{K^2}x^2 + \frac{1}{K^2} \frac{2D}{d}x \quad (4)$$

where  $t_0$ ,  $t$  are the periods of time (s) for uncoated and coated cement mortar specimens, respectively and  $x_0$ ,  $x$  are the carbonation depths (cm) for uncoated and coated cement mortar specimens, respectively,  $D$  is the diffusion coefficient ( $\text{m}^2/\text{s}$ ) which in carbonated cement mortars equals to  $2.4 \times 10^{-8} \text{m}^2/\text{s}$  [23] and  $d$  is the total diffusion coefficient of the coating (m/s). Equation (4) is leading to:

$$d = \frac{2 \cdot D \cdot x}{x_0^2 - x^2} \quad (5)$$

It is usual to compare the resistance of the coating with the resistance of another layer, composed of an imaginary air layer. The diffusion equivalent air layer thickness  $s_d$  (m) can be calculated from:

$$s_d = \frac{D_{air}}{d} \quad (6)$$

where  $D_{air}$  is the free-air diffusion coefficient which equals to  $153 \times 10^{-7} \text{m}^2/\text{s}$  [23]. Diffusion resistance number  $\mu$  (unitless) for each coating can be calculated from:

$$\mu = \frac{s_d}{S} \quad (7)$$

where  $S$  is the thickness of the coating (m).

The results are given in Table 4. The most effective coatings against carbonation appear to be Acr1 and Acr2, as they present the highest  $s_d$  values.

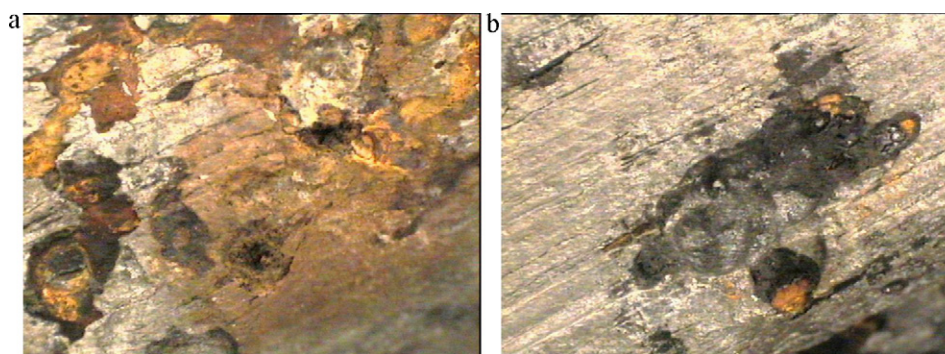
### 3.3. Mass loss

The results of gravimetric and estimated weight loss of steel rebars after 24 months of partial immersion in 3.5 wt.% NaCl solution are given in Table 5. For every coating 6 specimens were used in order to obtain the following results. The rebars of the cement mortar specimens that were covered with coatings Elast1 and SB



**Table 4**  
Calculation of the equivalent air layer thickness,  $s_d$ .

Coating	$x_0$ (mm)	$x$ (mm)	$d$ (m/s)	$D$ (m <sup>2</sup> /s)	$S$ (μm)	$\mu$	$s_d$ (m)
Acr1	8	1.11	$8.50 \times 10^{-7}$	$2.4 \times 10^{-8}$	300	60,000	18
Acr2	8	1.32	$10.20 \times 10^{-7}$	$2.4 \times 10^{-8}$	280	53,571	15
Acr3	8	2.61	$21.86 \times 10^{-7}$	$2.4 \times 10^{-8}$	220	31,818	7
PVA	8	2.33	$19.13 \times 10^{-7}$	$2.4 \times 10^{-8}$	230	34,782	8
Elast1	8	1.51	$11.77 \times 10^{-7}$	$2.4 \times 10^{-8}$	270	48,148	13
Elast2	8	2.11	$17.00 \times 10^{-7}$	$2.4 \times 10^{-8}$	240	37,500	9
Sil	8	2.94	$25.50 \times 10^{-7}$	$2.4 \times 10^{-8}$	200	30,000	6
SB	8	2.61	$21.86 \times 10^{-7}$	$2.4 \times 10^{-8}$	220	31,818	7
Lax	8	1.63	$12.75 \times 10^{-7}$	$2.4 \times 10^{-8}$	250	48,000	12

**Fig. 5.** Fiber optical microscope images after 24 months partially immersion in 3.5 wt.% NaCl solution (a) Acr3, (b) Elast1, rebar's surface morphology (50×).

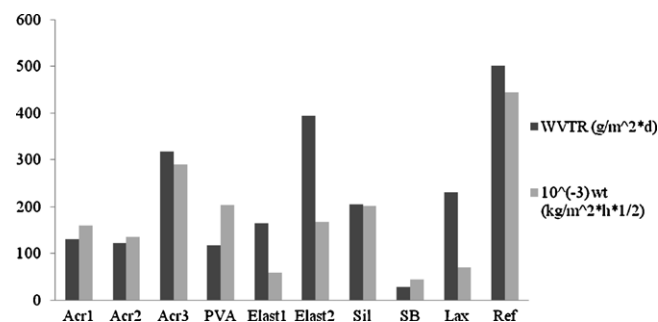
indicate about 75% lower mass loss values compared to reference specimens.

Calculated mass loss from Faraday Law and LPR technique is overestimated compared to the actual mass loss that steel rebars presented. This represents a reasonable approximation and an overestimate of corrosion rate corresponds to an early indication of potential damage. It must also be noted that the LPR technique displays the instantaneous corrosion rate periodically updating and this must be ascertained on site by a detailed visual inspection [21,24,25].

From fiber optical microscopy it can be observed that the rebars of the cement mortar specimens that were covered with coatings Acr3, demonstrated pitting corrosion more extensively than the reinforced cement mortar specimens coated with Elast1 which exhibited substantially better performance against chloride ions corrosion. Pitting on the surface of steel rebars was observed to be the major form of corrosion as shown in Fig. 5a and b. Briefing examination of the steel surface indicated that pits were formed under the rusted surface. These points are most likely to be the sites where electrolyte is formed due to the adsorption of moisture and condensation in the presence of chloride compounds.

**Table 5**  
Average gravimetric and calculated mass loss for rebars after 24 months of partially immersion in 3.5 wt.% NaCl solution.

Coatings	Gravimetric mass loss (g/cm <sup>2</sup> )	Calculated mass loss (g/cm <sup>2</sup> )
Acr1	0.0276 ± 0.0123	0.1351 ± 0.0017
Acr2	0.0199 ± 0.0124	0.0880 ± 0.0058
Acr3	0.0424 ± 0.0071	0.1745 ± 0.0092
PVA	0.0309 ± 0.0174	0.0770 ± 0.0038
Elast1	0.0120 ± 0.0024	0.0795 ± 0.0026
Elast2	0.0189 ± 0.0044	0.0943 ± 0.0019
Sil	0.0197 ± 0.0149	0.1061 ± 0.0065
SB	0.0121 ± 0.0023	0.0625 ± 0.0045
Lax	0.0222 ± 0.0137	0.1575 ± 0.0075
Ref	0.0466 ± 0.0011	0.2005 ± 0.0033

**Fig. 6.** Water vapour and liquid water transmission rate for coatings used.

### 3.4. Water vapour and liquid water transmission rate

The results for water vapour transmission rate (WVTR) and liquid water transmission rate ( $w_t$ ) of all types of coating systems are presented in Fig. 6. The best combination for an effective coating is to exhibit high WVTR and low  $w_t$  values. According to ASTM standards [18] coatings Acr3 and Elast2 can be classified to Category I (high water vapour permeability), while coating SB to Category II (medium water vapour permeability). Coatings Lax, Elast1 and SB can be considered as water-repellent coatings, since they present very low liquid water permeability. According to ASTM standards [19], they can be subsumed to Category III (low liquid water permeability). In contrast, coating Acr3 demonstrates the highest  $w_t$  values and can be assigned to Category II (medium liquid water permeability). Consequently Elast1 exhibit the best balance between liquid water and water vapour penetration.

## 4. Conclusion

In the present paper nine organic coating systems were studied regarding their protection level against corrosion by chloride ions and carbonation, which are the two most common mechanisms of reinforcement corrosion. In marine areas there is a significant

probability for rebars to be corroded by chloride ions, while carbonation problem exists in rural environment and in the interior of the structures. Water vapour and liquid water transmissions rates were also determined as they affect the process of the corrosion.

From the results, the following can be drawn:

- In every case, covered specimens behave better than reference specimens regardless of the evaluation method used.
- Solvent based cement paint can be characterized as water-repellent coating as it demonstrated the lowest  $w_f$  value. It also exhibited the most protective behavior against chloride induced corrosion as it presented the lowest  $i_{corr}$  value and very low mass loss values. The low water absorption rate of solvent based coating impedes chloride ions from the environment to insert into the cement mortar specimens through penetrated water leading thus to high protection efficiency against chloride corrosion of these coatings. Regarding *WVTR* SB paint presented the lowest value of all coatings and finally exhibited low protection against carbonation.
- Elastomeric coatings can provide a satisfying level of protection against chloride corrosion since they presented low  $i_{corr}$  and mass loss values. They also have the best balance between liquid water and water vapour penetration. A comparison between them leads to the fact that Elast1 is better than Elast2 in the majority of the tests conducted.
- The PVA copolymer paint presented low resistance against water and  $\text{CO}_2$  penetration and low *WVTR* values. However its behavior towards chloride ions corrosion can be considered satisfying.
- Acrylic paints and especially Acr2 exhibited satisfying protection level against chloride ions corrosion. Their behavior against carbonation was the best among all coatings. However they cannot be characterized as water-repellent coatings and their *WVTR* values were rather low. The acrylic emulsion demonstrated very high  $i_{corr}$  and mass loss values and regarding penetration of  $\text{CO}_2$  and water its behavior was not satisfying compared to the other coatings. High *WVTR* value was noticed for the acrylic emulsion.
- Silicon coating is the weakest coating against carbonation, since it exhibited the lowest  $s_d$  value. Moreover it cannot be characterized as water-repellent and did not present satisfying behavior against chloride ions corrosion.
- Latex paint was rather weak against chloride ions corrosion but presented high resistance against water and  $\text{CO}_2$  penetration and high *WVTR* value. The good balance between *WVTR* and  $w_f$  is an important parameter that should be taken into account. Overall, the results of this study revealed that water based coatings can be considered as durable as solvent based coatings against corrosion.
- Moreover, the results thus obtained can be used for further evaluation in the process of environmental friendly coating formation with improved anticorrosive properties.

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