ACCELERATED CORROSION TEST FOR THE QUALITATIVE EVALUATION OF CORROSION IN CONCRETE

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ABSTRACT

This paper is devoted to simulate the behavior of reinforced concrete in saline solution through the accelerated corrosion test. During this test, this method was evaluating the behavior of the steel bars that reinforce concrete for corrosion, according to the NACE 0775 standard. After the corrosion test, the steel bars were cleaned and dried according to the ASTM A380 standard and evaluated according to the NACE RP 0775, NACE SP0308, and NACE SP0187 standards. From the results obtained, the steel bars concrete showed high corrosion rates with structural impairment of the metal armor according to the NACE standards.

Key words: concrete, steel, accelerated corrosion test, electrochemistry

1 INTRODUÇÃO

For many years, it was believed that concrete with reinforcement structures would have a reasonable and durable life span. The conditions created by the concrete would have enough physical and chemical resistance against corrosion. However, recently the resistance and the durability of concrete are questioned due to the variety of exposure conditions. The main cause of problems in concrete structures is the corrosion on the steel bars, located inside reinforced concrete, which can consequentially decrease the mechanical strength of the reinforced concrete. Since the beginning of the last century, losses caused by decayed material, repairs to the structure, compromised structural stability, and high incidences of corrosion make that make corrosion armor a great pathological indicator.

This paper aims to simulate the behavior of reinforced concrete in marine environment, which is strongly corrosive, and to evaluate corrosion rates in the marine atmosphere.

Reinforced concrete is one of the most common materials uses in construction. Reinforced concrete differs from standard concrete because it receives a metallic armor that improves the strength of the concrete when it undergoes tensile stresses, while standard concrete resists compressive forces better. The connection made between the concrete and the steel bar is promoted by adhesion of the cement to the steel and various mechanical effects [13].

The electrochemical corrosion process of steel in concrete occurs for many reasons. In absence of external agents, the concrete layer acts as a protective cover for the alkaline steel and is involved with an intact passive layer. However, when there is an external agent interfering, the electrochemical stability is compromised, and thus signs of deterioration will be present [4-10].

The different chemical environments characterize the chemical factors, exhibiting a variety of corrosive chemical substances, such as sulfuric acid and hydrochloric acid [11-15]. Carbonation and chloride ions are the most common and destructive ways that induce corrosion to the steel bars.

The corrosion test is an accelerated corrosion [16,17] method developed by Lima [18], HELM / UFRGS, from a similar test conducted by Varela and Spinoza [19], and the test has undergone several modifications, as Seliestre et al [20, 21] Carvalho et al [22] and Kirchhein et al [23]. The corrosion test evaluates the effect of corrosion on a material by measuring the weight loss after the test. It also allows observation of the progression of the corrosion current, which is crucial in measuring the dynamics of the corrosion process.

2. Material and Methods

This experiment was executed using the accelerated corrosion test, which consists of a partial immersion of the concrete specimen, containing CA-60 steel bars with a diameter of 6 mm and a length of 17 cm, in a saline solution containing 35 grams of NaCl per liter of water, Fig. 1. A potential difference occurred between the steel bars in each specimen and a power supply, which provided a constant voltage. The cathode was generated in the steel bars, which promoted the migration of chloride ions from the solution to the area adjacent to the metal, where accelerated oxidation reactions happened by electron loss. In this experiment, it was shown that a constant 16.5 V over a period of 40 hours was enough to allow evaluation of weight and thickness loss in the metal bars.

Figure 1: (a) the sample with applied voltage - (b) The sample after 24 hours of testing

(a)   (b)

Source: applied research (2012)

After 40 hours, the specimen was cured in 20 days. After the curing process, the block was weighed, and then broken to analyze the metal bars. The specimen was cleaned using a solution of 23% sulfuric acid and then was ground, to determine how much material thickness was lost.

Fig. 2 shows the steel bar, which corroded more. This was due to greater contact with the saline solution that this bar was subjected to.

Figure 2: Sample after 40 hours of testing
Source: applied research (2012)

3. Results and Discussion

An analytical digital balance was used to evaluate the loss of mass. The initial weight of the concrete specimen was (3.56 ± 0.01) kg. After the corrosion test, the mass of the concrete was (3.50 ± 0.01) kg. It was shown that corrosion to the concrete was considerable as there was significant weight loss.

The steel used in this experiment was GG 60 steel, which had a caliper-measured dimension of (6.00 ± 0.05) mm diameter and $(170.00 \pm 0.05$ mm) mm length. After subjection to the corrosion test, the steel bars were ground and stripped. There was a decrease of

(1.22 ± 0.05) mm or Δm = 24.6 × 103 mg, which was directly from corrosion. To calculate the corrosion taxes, the following formula was first used to calculate the mass loss over time, as shown below.

$$mmpy = 13.56 \times \Delta m/(S \times t \times \rho)$$

Where: mmpy = loss in thickness, in mm / year; Δm = mass loss in mg; S= exposed area in inches; t = time of exposure in hours; ρ = specific mass of the material in g/cm3.

The loss of mass over time T = 267 mm/year was found, so it was possible to calculate the uniform corrosion rate that quantifies the loss in thickness, as shown below.

$$S = \Delta m \times 365/(At \times \rho)$$

Where : T: uniform corrosion rate; Δm: mass loss in mg; A: exposed area in mm2; t: exposure time in days; ρ: specific mass of the material in g/cm3; K: constant (87.6).

With this result, the level of corrosion suffered by the bar could be classified according to NACE standard (Table 1), which ranks by as severity of corrosion.

Table 1: The Standard NACE - RP0775 determines the classification of corrosivity:

Uniform Corrosion Rate (mm/Year)	Corrosivity
< 0.025	Low
0.025 a 0.12	Moderate
0.13 a 0.25	High
>0.25	Severe

Source: NACE Standard RP 0775[4]

4. Conclusion

The corrosion test provided the severity of corrosion of reinforced concrete at rate of 267 mm/year according to the NACE RP 0775 standard. This experiment proved the need to manufacture steel with a higher resistance to corrosion using additions of alloying elements, and the creation of new forms of protective coatings and inhibiting elements. Further possibilities of concrete can be subjected to the accelerated corrosion test, with new results that may be compared in future research.

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