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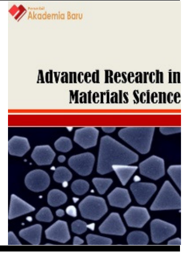

Test of a concrete bridge degraded by corrosion under the environmental effect

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ABSTRACT

The objective of the current study is to test the concrete bridge degraded by the environmental effects, especially by corrosion phenomenon. This work is located in the Wilaya of Oran the west of Algeria. The phenomenon of corrosion is influenced on the structures of reinforced concrete, the cycle drying wetting triggers this phenomenon by attacks, sulphates, diffusion of chlorine ions, perhaps by carbonation. The diagnosis of this degradation by the visual aspect is the expansion and scaling of the abutment wall and the bridge pile of this bridge, the test apparatus (corrosimeter, resistivitymeter) data of the results by the zonations which are proved That the effect of the affected environment has this degradation of the structure. The ASTM876-09 corrosive meter test assumes the probabilities of corrosion, the potential for exposed areas in the in situ tests and the cycles (age), accelerated laboratory tests, and the resistivity device according to the Rilem TC-154-EMC standard according to the resistivity in can classified the triggering of the corrosion. Finally, it gave special precautions to be taken for the rehabilitation of structures and the protection of new structures to control the environmental impact of products over their entire life cycle.

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1. Introduction

Concrete is the most widely used building material in the world. Reinforced concrete structures are designed and built to last but are degraded by the corrosion mechanism due to the aggressiveness of the environment to which they are exposed. The corrosion of steels in concrete is one of the main pathologies of civil engineering works. It involves very high maintenance and repair costs and can in certain cases jeopardize the safety of structures and users. Corrosion does not develop as long as the concrete provides physical or chemical protection to the frames. Indeed, the hydration of the cement produces a basic interstitial solution of high pH (about 13) which gives permanent stability to the rust layer adhering to the reinforcement embedded in the concrete, a phenomenon called passivation [1].

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The simplest and most effective way to predict the lifetime of structures is to evaluate the initiation (or incubation) phase of corrosion. For corrosion by penetration of chloride ions, it is necessary to define the time necessary for the first bed of the reinforcements to be exceeded. The coating, in addition to providing chemical protection to the reinforcement, acts as a physical barrier that limits the penetration of chloride ions.

2. Materials Used and Methods of Test

Electrochemical methods are very often used. The most commonly used method Measurement of corrosion potential. This method is based on the recommendations (ASTM and RILEM), but gives only a qualitative evaluation. Its use is, however, contested for certain particular applications, especially in the case of concrete in the presence of chlorides [3]. Another method for the measurement of polarization resistance has the advantage of providing more quantitative data than previously and providing information on the corrosion rate or the corrosion rate measured in mm / yr [4].

2.1 Corrosion Potential Measurement

To measure the potential of an electrode, it is necessary to introduce into the electrolytic solution a second electronic conductor which will constitute a second electrode. It is the difference of the internal potentials of the two electronic conductors which represents the potential of the electrode. Provided always that the same electrode is used as a reference electrode, it is possible, at a given temperature, to compare the potential of different working electrodes or to follow the potential of a system. There are several reference electrodes. In practice, three of them are used, the most stable being calomel. They have a defined potential with respect to the normal hydrogen electrode (EHN) at 20 ° C. (Table 1) [5].

Table 1
Reference electrode potential relative to hydrogen potential

Copper-copper sulphate saturated Cu/ Cu SO_4 (ESC)	+ 0,318 VEHN
Saturated Calomel Hg2 Cl2 (ECS)	+ 0,241 VEHN
Silver-saturated silver chloride Ag/ Ag Cl(ESS)	+ 0,199 VEHN

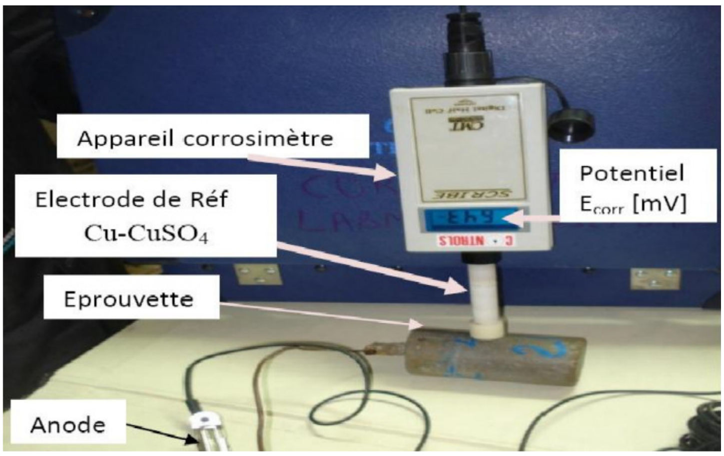

Fig. 1. Corrosimètre [2]

2.2 Measurement of Electrical Resistivity

As we have seen before, corrosion is an electro-chemical process. The flow of ions between the anode and cathode zones and, therefore, the frequency at which the corrosion can occur, is affected by the resistivity of the concrete.

The Werner probe is used to measure the electrical resistivity of concrete. A current is applied to the two external probes and the potential difference is measured between the two interior sensors. Resistivity $\rho = 2\pi aV / I$ [kΩcm] [5]. Empirical tests have yielded the following threshold values which can be used to determine the high probability of corrosion.

where: $\rho \geq 12$ kΩcm Unlikely corrosion

when $\rho = 8$ to 12 kΩcm Corrosion possible

when $\rho \leq 8$ kΩcm Practically safe corrosion

The electrical resistivity of the concrete coating layer decreases due to:

i. Increasing the water content of concrete
ii. Increasing the porosity of concrete
iii. The increase in temperature
iv. The increase in chloride content
v. The decrease in the depth of carbonation

When the electrical resistivity of the concrete is low, the corrosion rate increases. And also when the electrical resistivity is high, eg. in the case of dry carbonated concrete, the corrosion rate decreases [8].

3. Results and Discussions

We present in this chapter the results of the various tests carried out on the return bridge of rondpoint el bahia.These results relate to the various test zones by the corrosion measuring instruments on the pillar and bridge abutment.

3.1 Corrosion Test of Back Wall of Bridge Abutment

Figure 2 shows the potential test with the corrosimeter apparatus of the part of a bridge degraded by the corrosion of the wall in return of abutment according to the zones which influenced, distinguishes ten zones.

The simplest way to assess the degree of corrosion of steel is to measure its corrosion potential. This technique is well known and has been the subject of a procedure in the American National Standards under the reference ANSI / ASTM C876 [6]. The potential difference is measured between an ordinary portable half-cell, normally constituted by a reference electrode placed on the surface of the concrete on the zone exposed to corrosion, and the steel reinforcement underneath, the Results in Table 3.1 according to ASTM C876-09 [6].

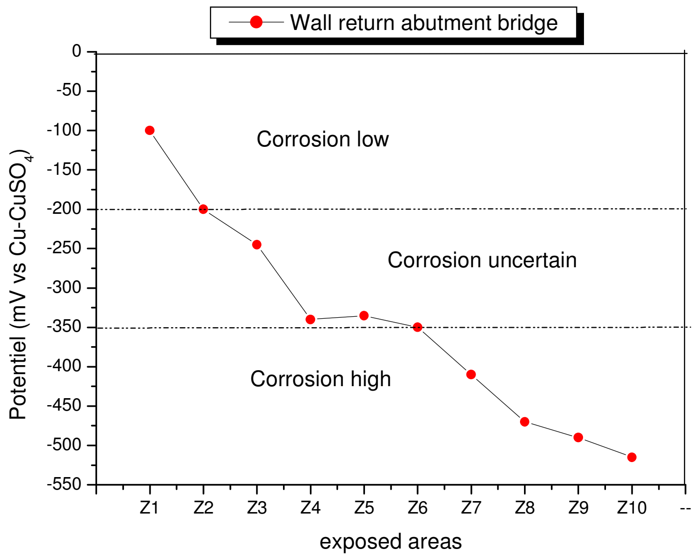

Fig. 2. Variation of potential in function of tested zones of wall in return

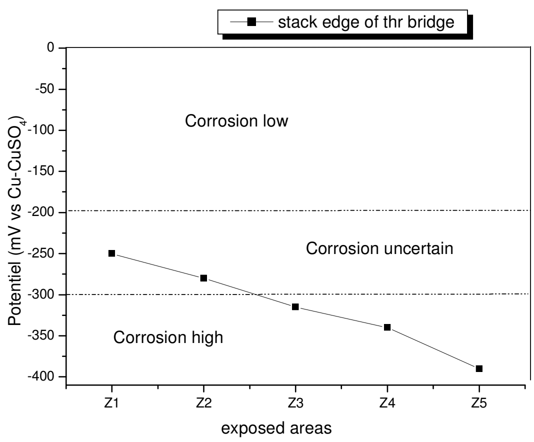

Fig. 3. Variation of potential in function tested zones of the stack

Table 2
Probability of corrosion

Corrosion potential mV vs ECS	Corrosion potential mV vs Cu-CuSO4	Probability of corrosion
> - 126	> - 200	Low (<10%)
-126 à - 276	-200 à - 350	Uncertain (50%)
< -276	< -350	High (90%)

It is found that from the second zone Z2 to Z5 the corrosion is uncertain, from the sixth zone, the high corrosion for Z6 to Z10.

3.2 Corrosion Test of the Bridge Rim Pile

As shown in Fig. 3, the measurements with the corrosimeter apparatus are high corrosion from third zone Z3 to Z5 by comparing with Table 3.

3.3 Corrosion Testing of the Edge Pile and the Abutment Wall by the Resistivity Meter

As can be seen in Figure 3.3, all zones tested Z2, Z3, Z4, Z5 are corrosive and high corrosion and in zone Z1 there is possible corrosion; In short, that when the electrical resistivity of the concrete is low, the corrosion rate increases.

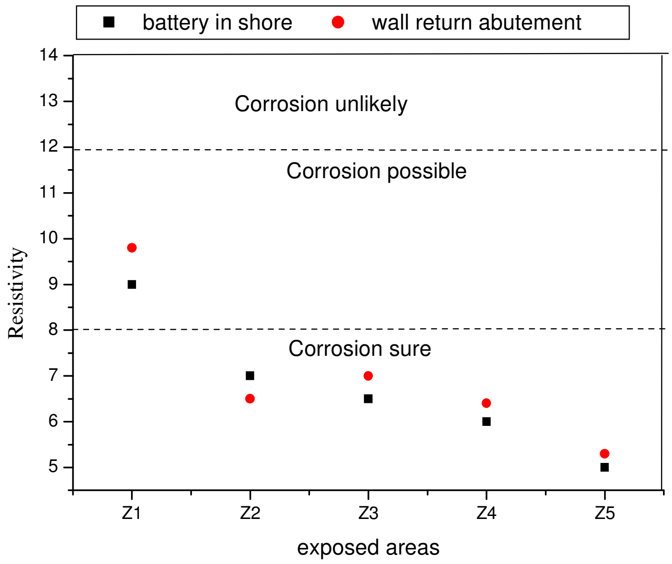

Fig. 4. Variation of the resistivity according to exposed areas of the shore pile and the back wall of the abutment

4. Conclusion

The main interest which has been the origin of this study is the usual field diagnosis generally makes it possible to locate zones at risk of corrosion [7], within the framework of long-term predictions it would be useful to be able to quantify this corrosion . However, according to the corrosion rate measuring apparatus used, considerable deviations of results are often observed.The RILEM TC-154-EMC Recommendation [5], devoted to polarization resistance measurements (Rilem 2004), indicates corrosion density thresholds to be associated with corrosion levels of reinforcements. The reading of the measurement results may therefore prove difficult depending on the apparatus used, and the conclusion of the diagnosis can vary significantly. It also seems clear that the diagnosis is more difficult to establish in the case of carbonate concretes, which are often very resistive.

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