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# Macrocell Processes in Reinforced Concrete Structures

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## 1 Macrocell Currents Analysis

Reinforced concrete is the most used construction material worldwide due to its characteristics, mechanical properties, low-cost and durability. Durability parameter became a key aspect during design process since nineties. (Garcés *et al.*, 2008).

One of the most frequent problems that affects the durability of these structures is the corrosion of the rebars. During the last twenty years, a lot of corrosion measurement techniques have emerged to help detecting corrosion beforehand.

The main inconvenient of using isolated sensors is that it can be only measured the local corrosion. However, in structures, real corrosion is completely different to the local corrosion due to macrocell currents. Different parts of the reinforcements are electrically connected and macrocell currents generate become areas in anodes and cathodes.

Macrocell is the most important electronic transference process in corrosion (Andrade *et al.*, 1992). It is generated by the presence of great passive areas connected electrically to active areas, where corrosion phenomenon occurs. In this case, active zones are the anodes (electrons source), while the rest of the passive rebars are the cathode, and the porous dissolution of the cement matrix serves as the electrolyte. The macrocell current is measured with a Zero Resistance Ammeter (ZRA) (Andrade *et al.*, 2008).

Previously to this study, a macrocell analysis was performed using small specimens and an external cathode (Lliso-Ferrando *et al.*, 2019). In the present case study, the analysis is carried out on specimens where anode and cathode are embedded in concrete as a real situation.

After 28 days of casting and curing, specimens were exposed to accelerated carbonation process. Once rebars were depassivated, the specimens were submitted to four different atmospheres during 24 hours' periods: dry atmosphere (40ºC and 23% R.H.); saturated; 100% R. H.; and laboratory environment (65% R.H.). At the end of each cycle, corrosion potential and macrocell and corrosion currents were measured. During all the process, anode and cathode were electrically connected and just for measuring they were disconnected. Macrocell measurements were carried out with a ZRA.

The macrocell and local corrosion currents had a cyclic tendency related to the changes in the environment where test specimens are located. This is due to the fact there are different humidity levels in each environment. On the one hand, when specimens are in a 40ºC and 23% R.H. atmosphere, there is barely enough humidity for let ionic transfer between anode and cathode, and intensities show lower values. Otherwise, when specimens are located in humid environments, presence of water allows the ionic transfer and intensity values are doubling.

Figure 1 shows the average values of macrocell and local corrosion intensities measured in the different specimens analysed and the total corrosion intensity.

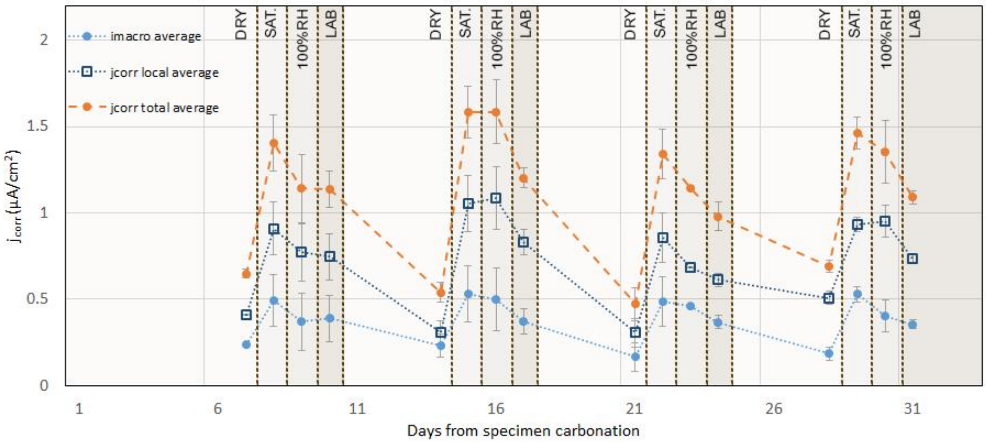


**Figure 1**. Macrocell and local corrosion intensities and the total corrosion intensity.

As shown in Figure 1, macrocell intensities ranged between 30%-40% from the total corrosion intensities. This fact highlights we must not underestimate the macrocell created in the reinforcements.

The experimental analysis has let to check the behaviour of macrocell and local corrosion intensities in different atmospheres. It has been possible to appreciate the relation of these parameters and the humidity/water presence in the cement matrix.

This study shows using sensors for analysing the local corrosion can lead to wrong results. Overlooking the macrocell currents it is possible to obtain corrosion values 30%-40% lower than the real corrosion intensities.

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