Towards the Determination of Chloride Profiles by means of Resistivity Measurements in Reinforced Concrete

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1 Introduction

The objective of this paper is to present the first results of the inversion programmed by Alhajj et al. (2020) for reinforced and unreinforced slabs subjected to an imbibition of a saline solution in the laboratory. The first part presents the measurement method and summarizes the inversion procedure. The second part details the experimental program. The third one shows the measurement results and the monitoring of resistivity profiles over time in both reinforced and unreinforced slabs.

2 Method used for Non-Destructive Evaluation

The selected non-destructive evaluation (NDE) method is electrical resistivity tomography (ERT) because it is very sensitive to the water content and chloride content of concrete.

The electrical resistivity method used is based on the Wenner principle for 4 electrodes regularly spaced (spacing a). The device used was developed by (Du Plooy et al. 2013). It consists of 14 inline electrodes, 2cm-spaced. This allows the implementation of 26 Wenner configurations with 4 different spacings. The raw results correspond to apparent resistivities at each level of spacing. They give information about the presence of a gradient in concrete.

The inversion of these raw results allows to obtain a resistivity profile according to the depth. An inversion process has been developed and is presented at the DBMC 2020 Congress by Alhajj et al. (2020). The finite element model may or may not take into account steel reinforcements present or not in concrete slabs. The resistivity profile obtained corresponds to the resistivity of the concrete material with a gradient of saline solution, independently of the conductive steel influence.

3 Experimental Program

Concrete is of type C30 containing ordinary Portland cement. We will study here 1 non-
reinforced slab placed in salt solution (noted 13-NS), 2 slabs reinforced with carbon steel placed in salt solution (noted 14-CS and 15-CS), and 1 reinforced slab with stainless steels (noted 18-SS). The dimensions of all the slabs are 90x75x13 cm. The reinforced slabs contain 1 single bed of rebars placed at 3 cm of depth, forming 4 meshes of 20x30 cm.

At the age of 9 months (T0 test time for imbibition process), the slabs were tested by non-destructive evaluation methods (NDT) and then placed in 1 to 2 cm of salt solution in pools, so that it can penetrate by imbibition on the reinforced side. Here, we present the results of the first 4 test times (T1 to T4).

4 Raw Results and Profiles of Resistivity versus Depth

The influence of the steel reinforcement on the apparent resistivity measurements is presented, first. Then, the inverted resistivity profiles are show in the 2nd and 3rd sub-sections.

For each test time, the apparent resistivities obtained for the unreinforced slab (13-NS) are inverted: (i) by using the free-access software RES1D from Loke (2001); (ii) by using the ISTTAR Program. The results of both inversion programs are in a good agreement especially at the 2 first test times. This can be explained by the ERT method, more informative about shallower volumes, thus less accurate for deeper volumes.

Figure 1-a makes it possible to compare the resistivity profile obtained for unreinforced slab (13-NS) and reinforced slab (14-CS). Figure 1-b presents the resistivity profiles obtained for the 3 reinforced slabs. The profiles in non-reinforced and reinforced slabs are very similar for T1, T2 and T3 (Fig. 1-a). The discrepancies between the profiles are of the same order of magnitude as the ones between the profiles of the 3 reinforced slabs (Fig. 1-b).

![Figure 1](image-url)

**Figure 1.** Comparison of resistivity profiles corresponding to salt solution ingress in non-reinforced and reinforced concrete slabs -a- Slabs 13-NS and 14-CS (line with marks) -b- Slabs 14-CS, 15-CS and 18-SS.

References

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