Coratelli Mill: micro-geophysical investigations for structural diagnostics

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***Abstract* – The Social Innovation Project "IN-CUL.TU.RE. INnovation in Culture in Tourism and in the Restoration ", has had the aim of safeguarding and preserving the invaluable industrial heritage linked to the rural culture of Salento. In particular, we want to highlight in this contribution the results of the micro-geophysical investigations carried out within the structure called Molino Coratelli. The investigation campaign was aimed both at identifying the reinforcements and any forms of instability (voids and /or fractures) possibly present inside the reinforced concrete slab and their state of conservation**

I. INTRODUCTION

Important application of the micro-geophysical method related to monumental heritage diagnosis. The application to industrial archeology is particularly interesting. Here, ancient industries built in reinforced concrete are taken into consideration. Particularly self potentials (SP) methods can evidence the corrosion of reinforcement steel. Under normal conditions, reinforcement steel is protected from corrosion by a thin, passive film of hydrated iron oxide. This passive film decomposes due to the reaction of the concrete with atmospheric carbon dioxide (CO_2), or by the penetration of substances aggressive to steel, in particular, chlorides from de-icing salt or salt water. At the anode, ferrous ions (Fe++) are dissolved, and electrons are set free. These electrons drift through the steel to the cathode, where they form hydroxide (OH-) with the generally available water and oxygen. This principle creates a potential difference that can be measured by the half-cell method (Fig. 1).

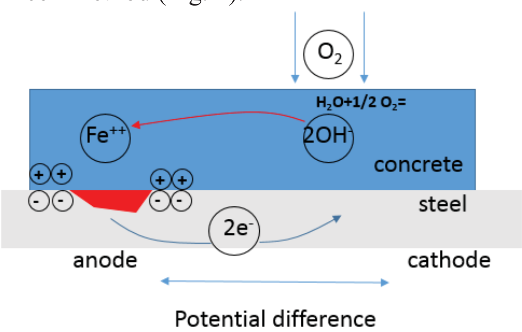

Fig. 1. Principle of steel corrosion in concrete

The basic idea of the SP measurement is to measure the potentials at the concrete surface to obtain a characteristic picture of the state of corrosion of the steel surface within the concrete. For this purpose, a reference electrode is connected via a high-impedance voltmeter to the steel reinforcement and is moved in a grid over the concrete surface (Fig. 2).

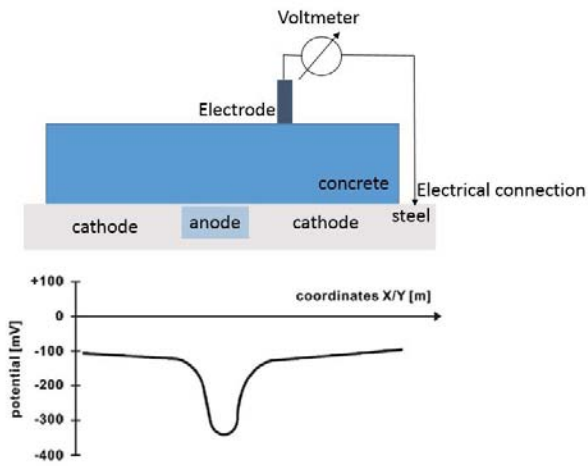

Fig. 2. Typical SP curve for moist carbonated concrete

The reference electrode is a Cu/CuSO4 half-cell. It consists of a copper rod immersed in a saturated copper-sulphate solution, which maintains a constant, known potential. Typical orders of magnitude for the half-cell potential of steel in concrete measured against a Cu/CuSO4- reference electrode are in the following ranges [1]:

- water saturated concrete without O2: -1000 to -900 mV
- moist, chloride contaminated concrete: -600 to -400 mV
- moist, chloride free concrete: -200 to +100 mV
- moist, carbonated concrete: -400 to +100 mV
- dry, carbonated concrete: 0 to +200 mV
- dry, non-carbonated concrete: 0 to +200 mV

II. SP DATA ANALYSIS

SP measurements were performed in an abandoned mill, which remained as a monument of industrial archeology. In this case, it was necessary to use methods that allow a high spatial resolution and the ability to highlight the state of conservation of the irons. ERT, together with SP methods, could guarantee a good compromise between resolution and the ability to identify the presence of a high degree of humidity and consequently underline the state of conservation of the investigated structure (Fig. 3).

Fig. 3. A view of the mill

Therefore, 24 electrodes with variable interelectrode distance were used in a non-conventional array [1, 2] (Fig. 4). The distributions of the two parameters electrical resistivity and spontaneous potentials were estimated.

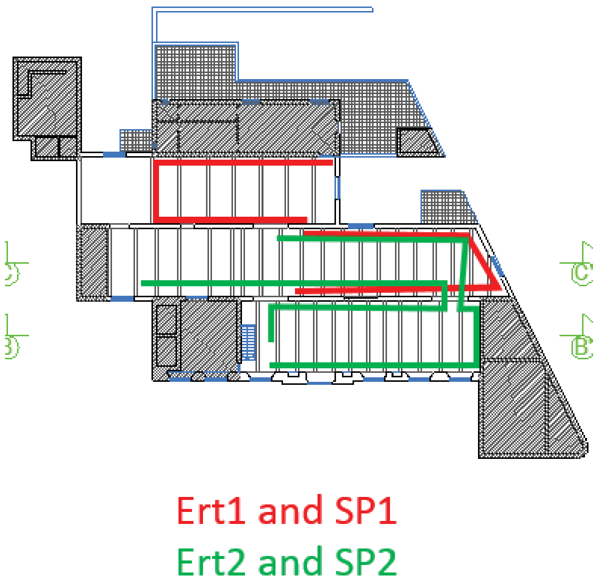

Fig. 4. The location of ERT and SP profiles

Resistivity and spontaneous potential maps were constructed using ERTLab software and a special algorithm implemented in the Matlab environment (Fig. 5).

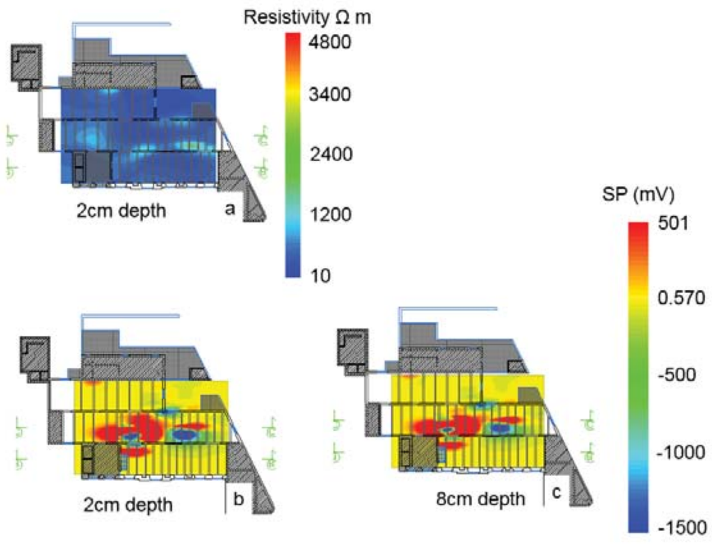

Fig. 5. Depth slices: (a) resistivity distribution at 2-cm depth; (b) self-potential distribution at 2-cm depth; (c) self-potential distribution at 8-cm depth

From the resistivity distribution model (Fig. 5a), the presence of an heterogeneous structure with resistivity values between 10 and 5,000 Ω m is evident. Note the presence an area (blue color) with low resistivity values between 10 and 50 Ω m, where there may be high water content. In the SP distribution maps (Figs 5b and c), there are three points (blue) in which there is a concentration of very high negative potentials (-1,000mV) which indicates the presence of water-saturated concrete. Around these areas (green color), the values of SP increase, reaching values between -600 and -400 mV. These values indicate the presence of CO_2. In the red areas, the values of spontaneous potential increase to a positive range (400-500mV) indicating the presence of dry concrete. Active corrosion can be expected at points where a negative potential is surrounded by increasingly positive potentials, i.e., points with a positive potential gradient. A potential gradient of about +100 mV, within a measured area of 1 m2, together with negative potentials, are a clear indication of active corrosion. So, it is likely that, in the blue areas surrounded by the red areas, there is an active corrosion phenomenon. This phenomenon has been confirmed by direct observation (Fig. 6).

Fig. 6. Photo of the degraded area

III. CONCLUSIONS

The micro-geophysical investigation has made it possible to obtain important information related to both the characterization of the reinforced concrete structure and its state of conservation. Through the analysis of spontaneous potentials it was possible to highlight the areas most at risk those in which there is a strong degree of corrosion of the irons.

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