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Corrosion behaviour of metal inserts in simulated ancient masonry mortars

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HIGHLIGHTS

- Corrosion of metal inserts in aerial and hydraulic mortars was studied.
- Carbon steel, stainless steel and titanium inserts were considered.
- Mortar composition had a secondary effect on the corrosion rate compared to the role of moisture.
- High corrosion rate was measured only for carbon steel in mortars exposed to 95% RH or water suction.
- Mortar resistivity was found to be a reliable parameter to assess corrosion of embedded inserts.

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ABSTRACT

Corrosion of metal inserts may be detrimental to the durability of masonry. The paper discusses corrosion of carbon steel, stainless steel and titanium embedded in aerial and hydraulic mortars simulating those of ancient walls. The effects of temperature (5–40 °C), moisture (65–95% RH and water suction) and electrical resistivity of mortars on the corrosion of metal inserts are discussed. Results showed that the corrosion rate of embedded steel, regardless of the mortar composition, is negligible in mortars exposed to 65–80% RH (even at 40 °C) and modest even at 95% RH, while high values were obtained in the presence of water uptake.

1. Introduction

Metal elements are often present in ancient masonry, either due to an original design choice or as the result of later restoration works. The use of these metal elements may have different purposes (Fig. 1), e.g. improving the structural behaviour of buildings (chains and ties) or preventing the propagation of cracks, and they may be applied externally or embedded in the materials of the masonry (mortar, bricks, stone blocks, etc.). In the latter case, the presence of these inserts may be harmful for the durability of masonry, since their corrosion may produce deleterious expansive phenomena leading to the failure of the brittle porous materials in which they are embedded [1–11].

It is relevant to make a distinction between metal inserts dated to the erection of the original structure, normally embedded in the structural elements, and those applied later during restoration phases (most often bonded externally). While externally applied metal elements are directly exposed to the action of the atmosphere (either inside or outside the building), those embedded in the masonry may have a complex corrosion behaviour, which not only depends on the type of metal insert but also on the materials with which they are in contact (e.g. hydraulic mortars, gypsum or bricks) and their moisture content.

Corrosion is an electrochemical process which takes place in the presence of water (and usually oxygen), through an electrochemical mechanism [1], as depicted in Fig. 2.

Fig. 2a shows that the moisture present in the pores of the mortar (as well as of stone or burnt-clay blocks) is the electrolyte that allows corrosion of the metal insert, promoting the formation of expansive oxides that may eventually crack the masonry material.

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Fig. 1. Examples of use of metal inserts in cultural heritage buildings.

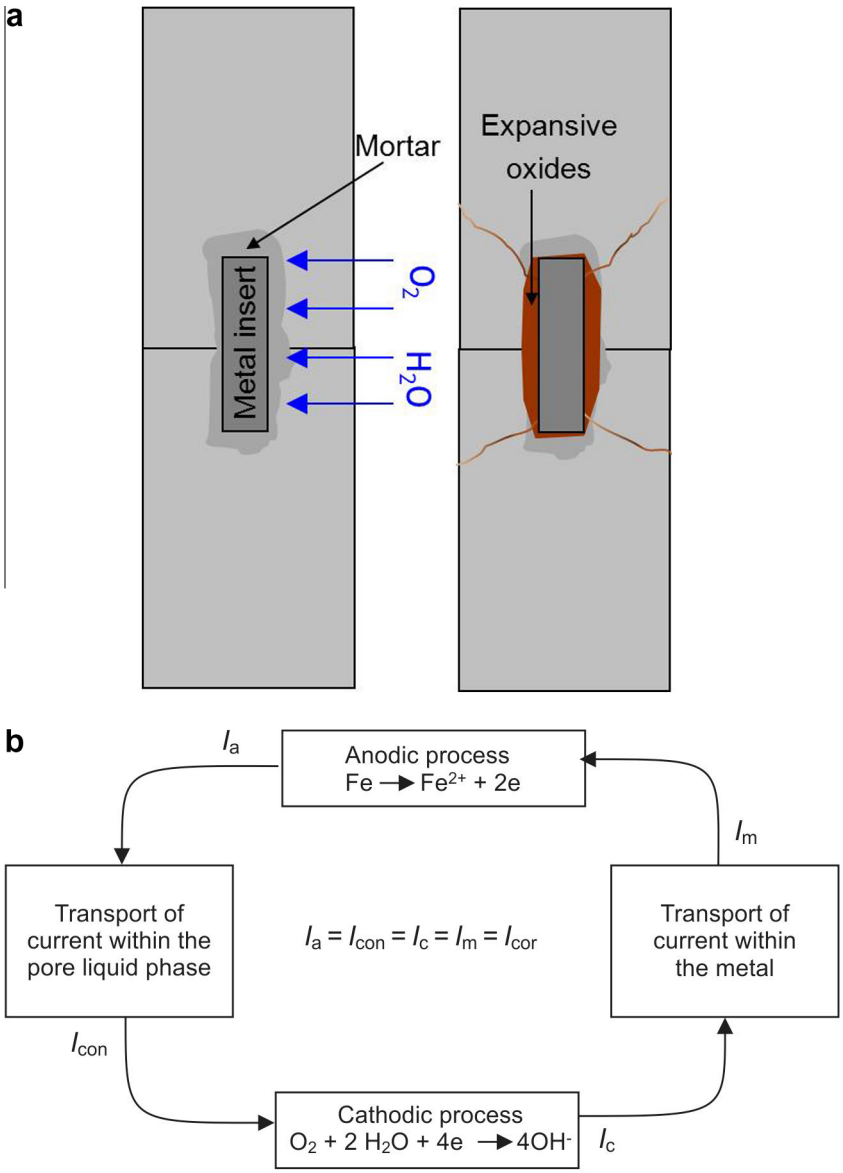

Fig. 2. Schematic representation of the corrosion process of a steel insert in masonry (a) and electrochemical mechanism (b).