Reducing the Effect of Sulphate Damage in Conservation Mortars

Dr Ioannis Karatasios
Institute of Materials Science, NCSR Demokritos, Athens, Greece

Professor Belinda Colston
School of Life Sciences, University of Lincoln

Dr David Watt
Hutton+Rostron Environmental Investigations Ltd

Today, with the majority of cement-based mortars having been proved to be incompatible with ancient and historic building materials, the development and study of compatible conservation lime-based mortars with enhanced durability are issues with a wide range of applications in the field of cultural heritage conservation.

This research programme deals with the analysis of original Byzantine mortars and the study of new compatible lime-based mixtures for conservation purposes, which present enhanced resistance against sulphate compounds. The work focuses on the potential impact of barium hydroxide [$Ba(OH)_2$] as an additive material, both to the physico-chemical properties, and the durability, of conservation mortars.

The main objectives of the project were to:

- consider the synthesis and technology of original, historic mortars;
- consider the physico-chemical properties and microstructure of the original mortars;
- confirm the criteria and methodology for the production of new conservation mortars, based on the results of the original historic mortar analysis;
- produce new conservation mixtures containing different amounts of barium hydroxide; and
- determine whether the addition of barium hydroxide in conservation mortars resulted in increased resistance to sulphate attack.

The historic mortars analysed were sampled from mosaic pavements found in two different archaeological sites – Thebes (Theva) and Nea Anghialos – both located in central Greece (Figure 1). Samples were collected from three different mosaics at each site, representing 4th, 5th and 6th centuries AD.

Figure 1: Map of Greece, indicating the archaeological sites selected for sampling.

Conservation mortars were prepared, closely matching the properties of the historic mosaic mortars. Barium hydroxide was added to the mortars, in varying proportions (0, 10 and 25%), replacing the lime content. The physico-chemical and mechanical properties of the mortars were determined, and acid rain simulation tests run to establish durability against sulphate attack (Figure 2).

Figure 2: Experimental setup for simulating the flow of acid rain solution over the surface of mortars.

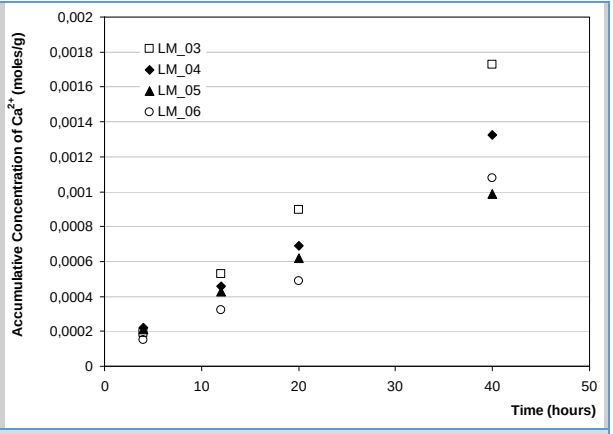

Figure 3: Cumulative concentration of calcium ions (moles/g of specimen) leached from the mortar mixtures during acid rain simulation test. Sample LM-03 was a pure lime mortar; LM-04 contained 10% $Ba(OH)_2$; LM-05 contained 25% $Ba(OH)_2$; and LM-06 contained a saturated $Ba(OH)_2$ solution (15%).

The acid rain simulation test showed that the durability of the mortar towards sulphate attack increased with increasing $Ba(OH)_2$ (Figure 3). Furthermore, elemental mapping by SEM, showed that the sulphated surface layer was reduced by half when 25% $Ba(OH)_2$ was incorporated into the mortar mix (Figure 4).

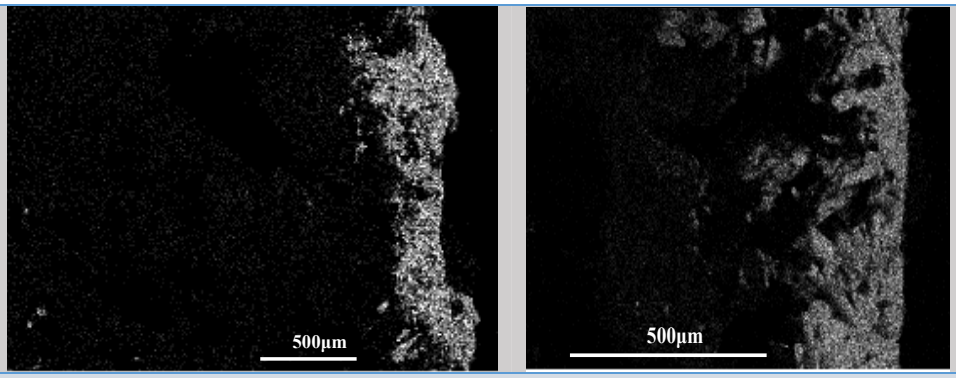

Figure 4: Elemental mapping from SEM-EDX shows distribution of sulphur in mixtures LM-03 (left) and LM-05 (right). The depth of the sulphated layer in mixture LM-05, containing 25% $Ba(OH)_2$, is half that of the one formed in LM-03, a pure lime mortar.

Publications from research

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