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Use of non-standardised micro-destructive techniques in the characterization of traditional construction materials

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The characterization of material properties and the diagnosis of their state of weathering and conservation are three of the most important steps in the field of cultural heritage preservation. Several standardised experimental methods exist, especially for determining the material properties and their durability. However, they are limited in their application by the required size of test specimens and the controlled laboratory conditions needed to undertake the tests; this is especially true when the materials under study constitute immovable parts of heritage structures. The current use of other advanced methods of analysis, such as imaging techniques, in the aforementioned field of research offers invaluable results. However, these techniques may not always be accessible to the wider research community due to their complex nature and relatively high cost of application.

This study presents innovative applications of two recently developed cutting techniques; the portable Drilling Resistance Measuring System (DRMS) and the scratch tool. Both methods are defined as micro-destructive, since they only destroy a very small portion of sample material. The general concept of both methods lies within the forces needed to cut a material by linear (scratch tool) or rotational (DRMS) cutting action; these forces are related to the mechanical properties of the material and the technological parameters applied on the tool. Therefore, for a given testing configuration, the only parameter influencing the forces applied is the strength of the material.

These two techniques have been used alongside a series of standardised laboratory tests aiming at the correlation of various stone properties (density, porosity, dynamic elastic modulus and uniaxial compressive strength). The results prove the potential of both techniques in assessing the uniaxial compressive strength of stones. The scratch tool has also been used effectively to estimate the compressive strength of mud bricks. It therefore follows that both micro-destructive techniques may prove useful in the physico-mechanical characterization of materials which demand in-situ measurements or allow very limited sampling.

Moreover, both techniques have been used, for the first time, to map the distribution of salts in building stone in the laboratory; micro-drilling was also applied in the same context in-situ. The results of the laboratory tests performed on limestone impregnated with sodium and magnesium sulfate confirm that both the scratch tool and the DRMS may successfully detect the location of the salt front, as they respond to pore clogging by salt crystals by providing increased scratching/drilling resistance values. Drilling and scratching of duplicate samples treated with a hydrophobic product show the sensitivity of both techniques as they clearly detect changes to the salt front location (i.e. cryptoflorescence) caused by surface treatments. Both techniques were also successful in highlighting the difference in the crystallisation location and pattern of magnesium sulphate and sodium chloride. In-situ application of the micro-drilling test demonstrated its potential for use in the assessment of masonry salt weathering; the results suggest that this technique may, in fact, be useful as a preventive measure against salt damage.

Last but not least, both aforementioned novel micro-destructive techniques have been used to assess the effectiveness of commercially available consolidants. The results of the scratch tool have also been utilised to develop a tomography image of the samples under test. Scratching tomography may potentially be combined with in-situ micro-drilling tests to evaluate the effectiveness of consolidation treatments applied on monuments and historic buildings.