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A new methodology for the diagnostics of architectural elements in historical buildings

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A new methodology is presented consisting of a multi-step procedure based on the integrated application of different diagnostic techniques aimed at recognizing altered and unaltered parts of architectural elements of ancient buildings and at identifying zones where structural damage has occurred on their surface. The methodology was tested on a historical building of the monumental compound in Piazza Palazzo in the historical center of the town of Cagliari (Italy).
Three types of carbonate building materials have been used historically to construct ancient monuments in the historical center of Cagliari, which in order of increasing hardness are: Pietra Cantone, Tramezzario and Pietra Forte. Our methodology begins with an accurate microscopic examination of petrographic thin sections and scanning electron microscope (SEM) analysis of the above carbonate materials in order to identify their textural characteristics and especially the nature and distribution of their porosity. Other rock properties such as wet and dry bulk density were calculated from saturated and dry mass and volume respectively. In a second step we used a Leica HDS-6200 terrestrial laser scanner (TLS) to 3D model some building of the studied monumental compound (Piazza Palazzo). Surface geometrical anomalies have been modeled for the most interesting architectural elements, such as a Pietra Cantone portal in Late Gothic style inside the Antico Palazzo di Città, a historical building that hosts the civic museum bearing the same name. Since TLS technology is characterized by high productivity but is unable to investigate the inner parts of the studied materials, a third step of our procedure was complemented by several ultrasonic in situ and laboratory tests in the 54kHz - 82kHz range. The ultrasonic parameters, especially longitudinal and transversal velocities, can be measured very accurately and correlated with various material properties with reasonable confidence. This task has two objectives: one is to compare the petrographical and petrophysical rock properties with the elastic-dynamic ones, while the other is to compare TLS geometrical anomalies with the anomalies of the velocity field detected with ultrasonic methodology, which is very effective in detecting altered and/or damaged zones both on the surface and inside the building materials of architectural elements. Analogies between TLS surface geometrical anomalies and the ultrasonic velocity field are evident at the surface and in shallow parts of the investigated architectural elements, as in the mentioned Pietra Cantone ancient portal. This study illustrates how the integrated application of TLS technology and the ultrasonic method contributes in overcoming ambiguities in the interpretation of the individual dataset. Therefore the methodology proposed in this study has proved to be effective in giving useful indications aimed at formulating a recovery and preservation plan for a monumental structure and to monitor its conservation status in time.

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