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Influence of coupling substances in the measurement of ultrasound velocity in stone materials

Beatrice Giuzio (1), Monica Alvarez de Buergo (2), Rafael Fort (2), and Nicola Masini (3)

(1) Università degli Studi della Basilicata, Potenza, Italy, (2) Instituto de Geociencias (CSIC,UCM), Madrid, Spain (alvarezm@geo.ucm.es), (3) Istituto per i Beni Archeologici e Monumentali (IBAM-CNR), Potenza, Italy

Ultrasonic (US) testing is widely applied in many fields (i.e. aviation, petrochemical, power engineering, construction and metallurgical industries). In the field of built cultural heritage and science conservation, US testing can provide the quality of the historic building materials (physic-mechanical properties), their heterogeneity/homogeinity and anisotropy, in terms of materials characterization, but also how deterioration processes can affect their quality (either after natural decay or simulation ageing tests in the laboratory). Moreover, US testing is a useful technique in evaluating the effectiveness of conservation and restoration techniques such as assessing the compatibility among original and restoration materials, identification of original quarries, and the success or not in the increase of a material cohesion when applying consolidating products.
In order to obtain precise, real and reliable measurements, coupling substances between the material surface and the ultrasonic sensors are frequently used, to provide a proper contact between the transducer and the material, to assure the perfect transmission of the ultrasonic wave. Various coupling agents can be applied for this purpose. According to Wesolowski (2012), the choice of the coupling agent significantly affects the measurement of propagation velocity in material samples and, as a consequence, the US test results.

In this paper, the effect of six coupling agents (medical gel used for ultrasonography, gel + parafilm, plasticine, honey, glicerine and a plastic material provided for ultrasound measurement by Panametrics) on ultrasonic measurements conducted on specific building materials is investigated on two different types of building stones (granite and dolostone from the area of Madrid, traditionally used in the construction of the built heritage, 4 stone specimens for each rock variety, 20 x 6 x 8 cm). Direct and indirect modes measuring were performed, the first one with the transducers in opposite and parallel faces of the specimens (using 500 KHz transducers), and in the second one, with both transducers in the same side (using 1 MHz transducers). In the indirect mode measurements, the distance between transducers was not fixed, but varied (5, 10, 15, 20 cm). In all cases the longitudinal wave or P wave was measured (Vp) and only in others, the transversal or S waves were registered.
Furthermore, in order to assess eventual changes in the surface texture of the examined materials due to the use of the aforesaid coupling agents, and considering the specific field of cultural heritage, in which non-destructive techniques are recommended, chromatic and surface roughness tests have been performed. In this case, non destructive techniques have been used (portable spectrophotometer and optical 3D roughness meter devices).
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