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Ultrasonic Surface Measurements for the investigation of superficial alteration of natural stones

Thomas Meier (1), Michael Auras (2), Filiz Bilgili (1), Sandra Christen (1), Luigia Cristiano (1), Rolf Krompholz (3), Ilaria Mosca (4), and David Rose (1)

(1) Christian-Albrechts Universitaet zu Kiel, Kiel, Germany (luigia@geophysik.uni-kiel.de), (2) Institut für Steinkonservierung, Mainz, Germany, (3) GEOTRON-ELEKTRONIK,Pirna-Neundorf, Germany, (4) Ludwig-Maximilians-Universität, Munich,Germany

Seismic waveform analysis is applicable also to the centimeter and decimeter scale for non-destructive testing of pavement, facades, plaster, sculptures, or load-bearing structures like pillars. Mostly transmission measurements are performed and travel-times of first arriving P-waves are considered that have limited resolution for the upper centimeters of an object. In contrast, surface measurements are well suited to quantify superficial alterations of material properties e.g. due to weathering. A number of surface measurements have been carried out in the laboratory as well as on real structures in order to study systematically the information content of ultrasonic waveforms and their variability under real conditions. As a preposition for ultrasonic waveform analysis, reproducible, broad-band measurements have to be carried out with a definite radiation pattern and an about 1 mm accuracy of the measurement geometry. We used special coupling devices for effective ultrasonic surface measurements in the laboratory as well as at real objects. Samples of concrete with varying composition and samples of natural stone – marble, tuff, and sandstone – were repeatedly weathered and tested by ultrasonic measurements. The resistance of the samples to weathering and the penetration depth of the weathering are analyzed. Furthermore, material specific calibration curves for changes in velocities of elastic waves due to weathering can be obtained by these tests. Tests on real structures have been carried out for marble (Schlossbrücke, Berlin) and sandstone (Porta Nigra, Trier). Altogether, these test measurements show clearly that despite of the internal inhomogeneity of many real objects, their surface roughness and topography especially ultrasonic Rayleigh waves are well suited to study material alterations in the upper centimeters. Dispersion of Rayleigh waves may be inverted for shear-wave velocity as a function of depth.