World Academy of Science, Engineering and Technology
International Journal of Structural and Construction Engineering
Vol:15, No:09, 2021

Application of Laser-Induced Breakdown Spectroscopy for the Evaluation of Concrete on the Construction Site and in the Laboratory

Authors : Gerd Wilsch, Tobias Guenther, Tobias Voelker

Abstract : In view of the ageing of vital infrastructure facilities, a reliable condition assessment of concrete structures is becoming of increasing interest for asset owners to plan timely and appropriate maintenance and repair interventions. For concrete structures, reinforcement corrosion induced by penetrating chlorides is the dominant deterioration mechanism affecting the serviceability and, eventually, structural performance. The determination of the quantitative chloride ingress is required not only to provide valuable information on the present condition of a structure, but the data obtained can also be used for the prediction of its future development and associated risks. At present, wet chemical analysis of ground concrete samples by a laboratory is the most common test procedure for the determination of the chloride content. As the chloride content is expressed by the mass of the binder, the analysis should involve determination of both the amount of binder and the amount of chloride contained in a concrete sample. This procedure is laborious, time-consuming, and costly. The chloride profile obtained is based on depth intervals of 10 mm. LIBS is an economically viable alternative providing chloride contents at depth intervals of 1 mm or less. It provides two-dimensional maps of quantitative element distributions and can locate spots of higher concentrations like in a crack. The results are correlated directly to the mass of the binder, and it can be applied on-site to deliver instantaneous results for the evaluation of the structure. Examples for the application of the method in the laboratory for the investigation of diffusion and migration of chlorides, sulfates, and alkalis are presented. An example for the visualization of the Li transport in concrete is also shown. These examples show the potential of the method for a fast, reliable, and automated two-dimensional investigation of transport processes. Due to the better spatial resolution, more accurate input parameters for model calculations are determined. By the simultaneous detection of elements such as carbon, chlorine, sodium, and potassium, the mutual influence of the different processes can be determined in only one measurement. Furthermore, the application of a mobile LIBS system in a parking garage is demonstrated. It uses a diode-pumped low energy laser (3 mJ, 1.5 ns, 100 Hz) and a compact NIR spectrometer. A portable scanner allows a two-dimensional quantitative element mapping. Results show the quantitative chloride analysis on wall and floor surfaces. To determine the 2-D distribution of harmful elements (Cl, C), concrete cores were drilled, split, and analyzed directly on-site. Results obtained were compared and verified with laboratory measurements. The results presented show that the LIBS method is a valuable addition to the standard procedures - the wet chemical analysis of ground concrete samples. Currently, work is underway to develop a technical code of practice for the application of the method for the determination of chloride concentration in concrete.

Keywords : chemical analysis, concrete, LIBS, spectroscopy
Conference Title : ICCRRR 2021 : International Conference on Concrete Repair, Rehabilitation and Retrofitting
Conference Location : Istanbul, Türkiye
Conference Dates : September 27-28, 2021