World Academy of Science, Engineering and Technology
International Journal of Civil and Architectural Engineering
Vol:12, No:06, 2018

Analyzing Concrete Structures by Using Laser Induced Breakdown Spectroscopy

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Abstract : Laser-Induced Breakdown Spectroscopy (LIBS) is a combination of laser ablation and optical emission spectroscopy, which in principle can simultaneously analyze all elements on the periodic table. Materials can be analyzed in terms of chemical composition in a two-dimensional, time efficient and minor destructive manner. These advantages predestine LIBS as a monitoring technique in the field of civil engineering. The decreasing service life of concrete infrastructures is a continuously growing problematic. A variety of intruding, harmful substances can damage the reinforcement or the concrete itself. To insure a sufficient service life a regular monitoring of the structure is necessary. LIBS offers many applications to accomplish a successful examination of the conditions of concrete structures. A selection of those applications are the 2D-evaluation of chlorine-, sodium- and sulfur-concentration, the identification of carbonation depths and the representation of the heterogeneity of concrete. LIBS obtains this information by using a pulsed laser with a short pulse length (some mJ), which is focused on the surfaces of the analyzed specimen, for this only an optical access is needed. Because of the high power density (some GW/cm^2) a minimal amount of material is vaporized and transformed into a plasma. This plasma emits light depending on the chemical composition of the vaporized material. By analyzing the emitted light, information for every measurement point is gained. The chemical composition of the scanned area is visualized in a 2D-map with spatial resolutions up to 0.1 mm x 0.1 mm. Those 2D-maps can be converted into classic depth profiles, as typically seen for the results of chloride concentration provided by chemical analysis like potentiometric titration. However, the 2D-visualization offers many advantages like illustrating chlorine carrying cracks, direct imaging of the carbonation depth and in general allowing the separation of the aggregates from the cement paste. By calibrating the LIBS-System, not only qualitative but quantitative results can be obtained. Those quantitative results can also be based on the cement paste, while excluding the aggregates. An additional advantage of LIBS is its mobility. By using the mobile system, located at BAM, onsite measurements are feasible. The mobile LIBS-system was already used to obtain chloride, sodium and sulfur concentrations onsite of parking decks, bridges and sewage treatment plants even under hard conditions like ongoing construction work or rough weather. All those prospects make LIBS a promising method to secure the integrity of infrastructures in a sustainable manner.

Keywords : concrete, damage assessment, harmful substances, LIBS
Conference Title : ICCBM 2018 : International Conference on Construction and Building Materials
Conference Location : Copenhagen, Denmark
Conference Dates : June 11-12, 2018