Evaluation of Concrete Structures using RF Tomography Techniques

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Inspections and repair work of reinforced concrete constructions are very important to avoid tragedies such as the Kasago tunnel (2013) and the I-35W Mississippi River bridge (2007). In general, inspections of structures would require Non Destructive Testing in addition to visual inspections. One potential weakness of buildings is due to cracks and voids caused by corrosion material that accumulates on the rebar. The corrosion causes spalling, which in turn eventually causes cracks. Usually acoustic or electromagnetic inspection techniques are used to evaluate the health of constructions. In particular, Ground Penetrating Radar (GPR) using pulse signals are very popular.

We propose the use of RF Tomography (RFT) to investigate cracks in a concrete structure. RFT has been developed for the detection of underground cavities and the use of multi-static sensor configuration allowing for an improved accuracy and resolution with respect to the multi-monostatic configuration typical of GPR surveys. (L. Lo Monte, D. Erricolo, F. Soldovieri, M.C. Wicks, "Radio Frequency Tomography for Tunnel Detection," *IEEE Trans. Geoscience and Remote Sensing*, Vol. 48, No. 3, Mar. 2010, pp. 1128-1137). The mathematical model of RFT is based on an electric integral equation, where the unknown quantity is the complex permittivity of the volume under investigation. The solution of the integral equation is a non-linear problem, so that, to reduce the difficulty, the integral equation is linearized using the Born approximation. The resulting linear equation allows for the use of regularization techniques such as the Conjugate Gradient, Algebraic Reconstruction Technique and Singular Value Decomposition. The results are given in terms of spatial maps of the electromagnetic anomalies providing indications of the presence, location and geometry of the buried targets.
In this work, we investigate the benefits of spatial and frequency diversity for detection and imaging of cracks inside concrete materials. Preliminary measurements will examine both reflection and transmission configurations and the joint exploitation of them.