NUMERICAL EVALUATION OF A TEFOLON BASED PIEZOELECTRIC SENSOR EFFECTIVITY FOR THE MONITORING OF EARLY AGE CONCRETE STRENGTHENING

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ABSTRACT

Piezoelectric materials and especially piezo-ceramic Lead Zirconate Titanate, commonly known as PZT, have been successfully implemented both as sensing and actuating devices in monitoring of concrete dynamic behavior and structural integrity. In most of concrete related monitoring cases PZT elements have the shape of patches or small plates and either attached surficial on structural members or embedded in concrete mass. Present paper investigates the effectivity of an innovative Teflon based PZT Sensor (TPS) which is embedded in mass of a concrete cubic specimens and perform monitoring of early age strengthening procedure. Teflon is used for the fabrication of a durable casing aiming to the protection of PZT ceramic patch both from concrete moisture and loading due to strengthening conditions. The evaluation of mechanical interaction between TPS electrical response and concrete structural conditions is achieved by applying Finite Element Method (FEM) numerical analysis. Concrete strengthening structural influence is introduced to FEM modelling as time-depended changing of Young Modulus, adopting a proposed by Eurocode 2 model that correlates empirically Young modulus with concrete age. Observation of changes that TPS-acquired Electro-Mechanical Impedance (EMI) frequency response signature emerges, due to concrete Young modulus age-related evolution, can establishes a diagnostic methodology for the evaluation of concrete strengthening procedure.

Finite Elements analysis aims to the enhancement of Teflon casing design and properly selection of PZT adhesive materials in order to be achieved the optimum dispersion of PZT generated mechanical energy in concrete mass. A major problem that usually encountered in concrete dynamic response based structural control is the high, comparing to metallic structures, amount of mechanical energy that required for the efficient excitation of a concrete member. High attenuation and local stiffness that concrete exhibit, inhibit the mechanical energy to stimulate vibration modes that will give detectable peaks in EMI signatures. So the detection of structural integrity deterioration by observing signature peaks changes becomes seriously restricted.

From the results of FEM modeling derives that the sensors which are embedded in concrete mass acting like concrete’s aggregates and has the ability to spread their effectiveness in a greater area of concrete than those sensors which are surficial attached. The changes in EMI signatures can be manipulated for the evaluation of early age concrete Young modulus alteration during strengthening procedure. Finally numerical results give essential information concerning the optimal mechanical properties of adhesive material which are used for the attachment of PZT inside Teflon casing.

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