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Self-Sensing Concrete Nanocomposites for Smart Structures

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Abstract : In the field of civil engineering, Structural Health Monitoring is a topic of growing interest. Effective monitoring instruments permit the control of the working conditions of structures and infrastructures, through the identification of behavioral anomalies due to incipient damages, especially in areas of high environmental hazards as earthquakes. While traditional sensors can be applied only in a limited number of points, providing a partial information for a structural diagnosis, novel transducers may allow a diffuse sensing. Thanks to the new tools and materials provided by nanotechnology, new types of multifunctional sensors are developing in the scientific panorama. In particular, cement-matrix composite materials capable of diagnosing their own state of strain and tension, could be originated by the addition of specific conductive nanofillers. Because of the nature of the material they are made of, these new cementitious nano-modified transducers can be inserted within the concrete elements, transforming the same structures in sets of widespread sensors. This paper is aimed at presenting the results of a research about a new self-sensing nanocomposite and about the implementation of smart sensors for Structural Health Monitoring. The developed nanocomposite has been obtained by inserting multi walled carbon nanotubes within a cementitious matrix. The insertion of such conductive carbon nanofillers provides the base material with piezoresistive characteristics and peculiar sensitivity to mechanical modifications. The self-sensing ability is achieved by correlating the variation of the external stress or strain with the variation of some electrical properties, such as the electrical resistance or conductivity. Through the measurement of such electrical characteristics, the performance and the working conditions of an element or a structure can be monitored. Among conductive carbon nanofillers, carbon nanotubes seem to be particularly promising for the realization of self-sensing cement-matrix materials. Some issues related to the nanofiller dispersion or to the influence of the nano-inclusions amount in the cement matrix need to be carefully investigated: the strain sensitivity of the resulting sensors is influenced by such factors. This work analyzes the dispersion of the carbon nanofillers, the physical properties of the fresh dough, the electrical properties of the hardened composites and the sensing properties of the realized sensors. The experimental campaign focuses specifically on their dynamic characterization and their applicability to the monitoring of full-scale elements. The results of the electromechanical tests with both slow varying and dynamic loads show that the developed nanocomposite sensors can be effectively used for the health monitoring of structures.

Keywords : carbon nanotubes, self-sensing nanocomposites, smart cement-matrix sensors, structural health monitoring
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