A New Clustering Method for Damage Assessment of Fiber Reinforced Concrete Using Piezoelectric Transducers and a Wireless Impedance-Admittance Monitoring System

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Abstract

Nowadays there is an extended need for real-time applications of Structural Health Monitoring in existing concrete structures. This paper deals with the application of a new, low-cost and wireless SHM system that utilises small-sized piezoelectric transducers for continuous damage assessment of Fibre Reinforced Concrete specimen. A PZT-based Wireless impedance-Admittance Monitoring System used for detection of damage degree due to concrete cracking. The Electro-Mechanical Impedance signatures of an array of externally bonded PZT sensors in FRC specimen subjected to four-point bending in several damage states. Quantitative damage evaluation is achieved using the frequency signal measurements of the PZT transducers and comparisons of several commonly statistical indexes. Further, a new damage index based on k-means clustering methods that provides more reliable results on damage identification is also proposed and evaluated herein.

Keywords: structural health monitoring; Electro-Mechanical Impedance; lead zirconate titanate (PZT); fibre reinforced concrete; damage detection.

1. Introduction

Climate change affects the ability of Reinforced Concrete (RC) structures to expand their lifespan. Sustainable development invigorates crucial importance to the design, construction, rehabilitation, and refurbishment of concrete structures. Fiber Reinforced Concrete (FRC) constitutes a solution, which has shown superior mechanical properties, and mainly, greater durability [1-3]. Especially for the latter, the ability of the structures to withstand structural degradation due to environmental agents is improved with the application of synthetic fibers in comparison to the steel ones, thanks to the greater corrosion resistance properties. Therefore, FRC materials have expanded their applications in the construction industry [4-7].

Structural Health Monitoring (SHM) has strong potential to expand the lifespan of RC structures by regular evaluation of their structural integrity. In real-life applications, SHM's aim is to prevent sudden collapse and even heavy structural damage through a prompt damage detection. For the aforementioned reasons, SHM systems must be capable of operating on a real-time basis to prevent extensive damage. In Electro-Mechanical Admittance (EMA) and its inverse Electro-Mechanical Impedance (EMI) method, the use of Piezoelectric ceramics and particularly lead zirconate titanate (PZT) patches is advantageous because of their active-sensing capability, small size, and inexpensive cost [8-10].

https://doi.org/10.2749/nanjing.2022.1177
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