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PROGNOSIS OF LOW-STRAIN FATIGUE INDUCED DAMAGE IN REINFORCED CONCRETESTRUCTURES USING EMBEDDED PIEZO-TRANSDUCESRS

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ABSTRACT

Fatigue induced damage under low-strain conditions is a commonly encountered phenomenon in reinforced concrete (RC) structures subjected to continuous vibrations, such as bridges under vehicular loads, buildings under wind and structures directly supporting or in the vicinity of vibration emitting machinery. This type of fatigue tends to weaken the structure silently, and quite often, its timely cognizance is missed out in the life-cycle management of the structure. Among the various structural health monitoring (SHM) frontiers, very scarce research has been devoted to this kind of damage in RC structures. This paper covers a long-term experimental study related to low-strain fatigue damage monitoring encompassing a real-life sized RC structure. The experimental specimen was subjected to over eight million cycles of flexural loading with the maximum bending strain values restricted to 50 μm/m. The structure was instrumented with piezo-based composite concrete vibration sensors (CVS), which were embedded inside the beam near the surface. The CVS operated in dual mode, acting as sensor for the global vibration technique as well as the local electro-mechanical impedance (EMI) technique. As EMI sensors, they facilitated the determination of the equivalent stiffness parameter (ESP), and were found to be very expedient for damage detection as well as localization during the incipient stages of fatigue damage, coinciding with the appearance of first few cracks. The ESP served to represent the diminishing trend to actual residual stiffness fairly well during the initial stages. Acting in the global mode, determination of the overall stiffness of the structure by the same CVS provided an alternate damage measure, in terms of a realistic estimate of the overall residual flexural stiffness. This proved useful parameter during moderate to severe damage conditions, and in particular near the final failure of the structure. The monitoring paradigms presented in the paper pave way for effective prognosis of fatigue induced damage in real-life RC structures.

Keywords: Fatigue; residual stiffness; reinforced concrete (RC); low-strain; smart materials; electro-mechanical impedance (EMI) technique; concrete vibration sensor (CVS); piezoelectric ceramic lead zirconate titanate (PZT).

INTRODUCTION

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