Damage Detection using Neutral Axis and Prestressing Force Distribution

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Abstract

Identification (i.e., detection, localization and quantification) of unusual structural behaviors of bridges represents an important aim of structural health monitoring (SHM). This paper proposes an SHM methodology based on loose structural analysis and on strain and temperature SHM data acquired by long-gauge fiber optic sensors. Pairs of long-gauge sensors are placed at key locations along a beam-like structure parallel to the centroid line. The position of neutral axis is evaluated from strain measurements using a novel algorithm. Change in the position of the neutral axis is then used to identify unusual behaviors that result in change in the position of the centroid of stiffness, such as partial loss of stiffness (e.g. damage). Effectiveness of prestressing force transfer is evaluated with another novel algorithm. The methodology was applied to two structures and successfully identified unusual structural behaviors.

Keywords: Structural health monitoring; prestressed concrete; neutral axis; damage detection; long-gauge; fiber optic sensors; strain

1 Introduction

Structural health monitoring (SHM) is defined as the process of implementing strategies and systems for structural damage identification [1]. This process consists of permanent, continuous, periodic, or periodically continuous monitoring of structural parameters, and analysis of recorded data to derive conclusions about structural performance and integrity [2]. SHM can provide information to increase safety of civil infrastructure, provide support for maintenance decisions and actions, assist with inspection after natural disasters, and ultimately create more resilient structures and cities.

The above can only be achieved with reliable SHM systems for damage detection, localization, and characterization. One particular challenge to damage detection in SHM is the trade-off between reliability and feasibility. Reliable early-stage damage detection and localization requires the use of dense arrays of sensors. Due to the nature of currently available sensing technologies, such a strategy is unfeasible because of the high costs it would incur and the complexity of implementation. A more feasible solution is the use of sparsely spaced but critically positioned sensors. However, this solution requires the use of complex algorithms to derive conclusions about locations that are not directly monitored. Additionally, the algorithms are challenged by varying environmental and loading conditions, which can result in compromising the reliability of such a system [3,4].

The two solutions discussed above feature deterministic approaches to SHM. Probabilistic

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