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Prestress Loss Monitoring Using Long-Gauge Fiber Optic Sensors

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Abstract

Prestressed concrete is an important building material due to its economy and superior performance compared to reinforced concrete. Given the current attention to infrastructure monitoring and condition assessment, creating methods for monitoring prestressed concrete specifically is increasingly important. Assessment of prestress losses in the field, an important parameter in prestressed concrete, is required in order to ensure safety, and allow designers to better understand the evolution of losses particularly as they pertain to new concrete mixes. This paper presents a method for the monitoring prestress losses using strain measurements collected from sensors embedded in the concrete. The method is applied to measurements from Streicker Bridge, a prestressed concrete bridge on the Princeton University campus. The method shows promising results and can be used for monitoring more complex beam-like structures.

Keywords: prestressed concrete; post-tensioning; structural health monitoring; fiber optic sensors; prestress loss.

1 Introduction

The use of prestressed concrete has seen a significant increase in recent years, owing, to a great extent, to its economy due to desirable properties that result from prestressing such as deflection and crack control. In fact, more than 45% of bridges built in the last five years in the United States were prestressed concrete bridges [1]. However, according to the National Bridge Inventory, prestressed concrete bridges also comprise a significant proportion of structurally deficient bridges, especially those built in the last five years (42% of deficient bridges aged five years or less are prestressed concrete bridges [1]). This implies that despite the superior properties of prestressed concrete, it is still vulnerable to malfunction in field conditions. Thus, monitoring of the structural condition of new prestressed concrete structures is important and recommended in order to guarantee structural safety, and Structural Health Monitoring (SHM) can be used for this purpose.

Successful SHM requires the identification of a damage-sensitive feature, as well as the design of a sensor network and analysis of measurements to accurately estimate the identified feature [7]. In the case of prestressed concrete, one of the most important damage-sensitive features is the prestressing force distribution along a structure [e.g. 2–3]. Adequate prestress force levels ensure that concrete tensile stresses are below cracking limits. Thus, it is important to ensure that prestressing levels do not decrease below design requirements. Since the prestressing force decreases throughout the service life of the structure due to concrete creep and shrinkage, as well as strand relaxation, time-dependent prestress losses must be monitored to provide

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