

Smart Installation and Monitoring System for Large Anchor Rods of Support Structures for Highway Signs, Luminaries, and Traffic Signals

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Anchor rods are critical structural components of support structures for highway signs, luminaires, and traffic signals (SLTS). The collapse of SLTS structures has frequently been attributed to anchor rod failures, often due to loose nuts. Departments of Transportations struggle to adequately inspect all anchor rods in SLTS structures, either due to inadequacy of resources or personnel. This study aims to develop an inexpensive, sensor-based system for monitoring tension in anchor rods in SLTS structures to address the limitations of current practices for bolt installation and inspection. Therefore, this research addresses an important, nationwide problem. The sensing washer system provides accurate readings of the tension forces experienced by anchor rods, which can help tell if the rod is correctly tightened or has come loose. The sensing washer system is based on fundamental capacitance properties, relying on the relationship between capacitance and a varying distance between two electrodes. The system is composed of a DTI washer and plain washer with copper rings attached, acting as the primary capacitors of the system. A smaller-diameter middle spacing washer and rubber ring in the middle of the two washers act as the dielectric material to measure capacitance. When related to tension, the capacitance provides a direct indication of the “tightness” of the nut, enabling easy sensor-based inspections. The sensor system has been tested at a singular anchor rod level (fully-tightening tests), as well as at the structural level (multiple anchor rods in static and fatigue tests). Data from tests has been utilized to calibrate the performance of the system, in preparation for implementation in the field. The system will be battery-free, connected to a low-cost, passive radio frequency readout device (RFRD), which is integrated wirelessly using a radio frequency (RF) reader. This allows inspections to occur from a distance, such as from any passing agency vehicle, thus expediting the inspection process and reducing maintenance costs. The proposed system aims to follow current anchor rod installation procedures and does not require extra equipment, allowing an effective and easy installation. The sensor system has great potential to substantially reduce inspection costs and significantly improve safety by providing a more time-sensitive inspection method and more quantitative installation method. The current system can be modified in the future, allowing for use in other types of bolted critical connections (e.g., bridges, buildings, wind turbines).

Keywords: Smart installation and monitoring system; Capacitance-based sensor; Large anchor rods; Support structures; Signs, luminaires, and traffic signals