# Fatigue Life and Reliability Estimation of a Traffic Signal Structure using Long-Term Monitoring Data

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**ABSTRACT:**
Recent failures of cantilevered-arm traffic signal structures have revealed the vulnerability of such structures to wind force. The heavy mast arm causes high stress at the pole-to-arm connection during the wind-induced vibration, and because of low mechanical damping, stress cycles accumulate and eventually cause fatigue damage at the pole-to-arm connection. Many failures have been reported in the United States, creating a need to study the fatigue performance of cantilevered-arm traffic signal structures. In this study, a holistic framework was proposed for estimating fatigue life and reliability of a traffic signal structure, based on the long-term monitoring data. Interestingly, the monitoring data associated with the August 2020 Iowa Derecho was also included, representing the case for the more extreme wind conditions. The monitoring stress data at the mast-arm base was used to build a fatigue-damage fraction function showing the relation between fatigue damage and mean wind speed. Fatigue life at a specific location was then estimated by combining the damage fraction function and the local wind probability. This method bypasses the complexity and uncertainties of simulating the wind-induced stress response of a traffic signal structure. In reliability analysis, uncertainties considered were the wind probability, the fatigue resistance of the pole-to-arm connection, and the value of Miner's sum. Monte Carlo simulations were conducted to generate a probability-of-failure curve. The proposed framework could be widely used on other structures suspected of fatigue damage due to wind-induced vibration, and the results from reliability analysis can serve as a reference in determining the period of regular maintenance for such structures.

*Keywords: traffic signal structures, wind engineering, long-term monitoring, fatigue life, reliability analysis*

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