Project Summary

Texas Department of Transportation

0-6650: Fatigue Failure and Cracking in High Mast Poles

Background

High mast illumination poles (HMIPs) are important components of the highway infrastructure in Texas. These tall, slender structures are placed adjacent to major highways and interchanges throughout the state, and are most commonly found in major urban centers. HMIPs are supported at their bases on reinforced concrete foundations.

Research indicates that these types of structures are particularly susceptible to galvanization induced cracking near the weld that connects the pole shaft to the base plate (see Figure 1). Cracks can form during fabrication and crack propagation can be driven by repeated, cyclic wind loading. While there have been no reported failures of TxDOT owned and maintained HMIPs due to galvanization induced cracking, similar types of failures have been reported elsewhere.

What the Researchers Did

For this project, researchers:

1) Identified the primary sources of galvanization induced cracking of HMIPs based on an extensive survey of the existing literature on the topic.
2) Recommended methods to minimize the probability of galvanization induced cracking in HMIPs based on commonly reported best practices.
3) Evaluated the probability of failure of different in-service pole configurations in different locations throughout the state if pre-existing cracks are detected.
4) Evaluated the costs of repair and replacement of existing cracked HMIPs.

What They Found

The research indicates that galvanization induced cracking is a complex phenomenon that depends on various fabrication processes including material selection, cold working, welding, galvanization, and the interaction between these processes. Based on the literature survey, best fabrication practices were identified to help minimize the formation of galvanization induced cracks in new poles. Researchers also identified those practices that were expected to have the highest likelihood of success.

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Researchers conducted a structural analysis to evaluate the probability of failure of poles with pre-existing galvanization induced cracks at their bases.

This included a dynamic structural analysis to predict the response of different HMIP configurations under wind loading in five different urban centers throughout the state including Houston, Dallas, Austin, San Antonio, and El Paso. Researchers determined the magnitude of wind induced loads on the different pole configurations based on the current relevant AASHTO specifications. A fatigue analysis was conducted to determine the expected accumulated fatigue damage at the base of the poles due to wind loading throughout the expected service lives of the poles. Finally, a probabilistic analysis identified specific pole configurations that are particularly susceptible to unacceptable levels of damage due to wind loading.

What This Means

The analysis results indicate that the TxDOT ground sleeve detail is particularly effective at minimizing the accumulated fatigue damage at the base of the poles due to wind loading, even for poles with pre-existing galvanization induced cracks. The findings also indicate that the level of accumulated damage is sensitive to the pole configuration and to the location of the pole in the state. The research also indicates that the cost of repair of cracked poles is approximately 20 percent of the cost of pole replacement. As such, early detection of cracks is expected to significantly reduce the cost of maintenance of the TxDOT HMIP inventory. Researchers recommend conducting additional research regarding the fatigue resistance of pole base details with pre-existing galvanization-induced cracks to develop more accurate fatigue models for the pre-cracked details.

Figure 1. High Mast Illumination Pole Base.

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