Kansas Department of Transportation

TECHNICAL SUMMARY

Investigation of High Mast Illumination Pole Handhole Cracking

Report Number: KS-24-02 ▪ Publication Date: March 2024

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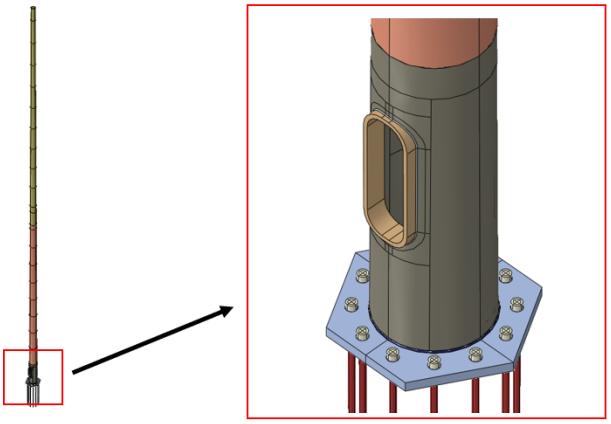

Finite Element Model of HMIP Original Design (pre-2019)

Introduction

High mast illumination poles (HMIPs) experience cyclic loading from wind, which can cause large deflections at the top of the pole, amplified by the mass and geometry of the luminaire. As a result, large stresses can develop at the handhole and base plate connections. These details are especially susceptible to fatigue cracking due to the combination of welding, galvanizing, and geometry causing stress concentrations at the welds. After a "bomb cyclone" winter storm impacted the state of Kansas in February 2019, multiple HMIPs that had been recently erected were identified to have visible or potential cracking and subsequently removed from service.

Based on this experience, the University of Kansas (KU) worked with the Kansas Department of Transportation (KDOT) to explore the potential cause of the premature failures, and to provide input on design modifications to prevent future HMIPs from failing well before their expected lifespan.

Project Description

This report describes an investigation in which four poles removed from service were studied to determine potential origins and driving factors of the handhole cracking. Each pole was cut and processed so that the crack surfaces could be examined. Sub-sized Charpy V-Notch (CVN) specimens were sampled from each pole and tested to estimate the toughness of base metal used.

Additionally, the effects of varying the design parameters of the pole, handhole, and base plate were explored in a parametric study using finite element modeling. The computational work performed included: varying pole, hand hole, and base plate geometries; performing a comparison between the original reinforcing rim handhole detail and a proposed doubler plate handhole detail; and an analysis of a new HMIP design proposed by KDOT. The finite element analyses were performed using both design-level fatigue loading and a loading estimated from the large-amplitude first mode displacement shown in the video during the "bomb cyclone" weather event.

Project Results

Major findings from the study include: 1) the partial penetration weld connecting the reinforcing rim and the pole displayed a lack of fusion at the weld root that reduced the effective strength of the weld; 2) cracking around the handhole weld did not show clear fatigue growth, but the cracks that grew horizontally into the pole were due to fatigue; 3) use of a thicker pole, a thicker reinforcing rim, a narrower handhole, and full penetration welding can be expected to reduce the structural hot-spot stress at the handhole detail; and 4) use of a thicker pole, a thicker base plate, a thinner reinforcing rim, and a smaller base plate hole can be expected to reduce the structural hot-spot stress at the base plate detail.

Project Information

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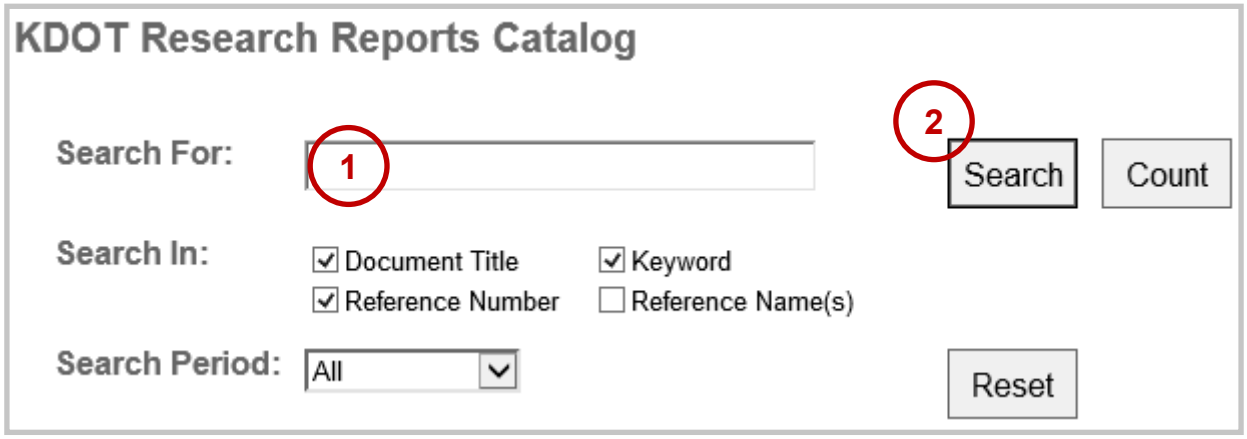

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