Optimizing the Geometric Configuration and Manufacturing Process of High Mast Illumination Poles

Improving the mechanical and rheological performance of asphalt mixtures with high percentages of RAP by using different WMA technologies

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Galvanization is a widely used, effective method to protect steel from corrosion. However, in the past two decades, post-galvanizing inspections have reported the presence of cracks in high mast illumination poles (HMIPs), particularly at the toe of the welded connection between the pole and the base plate, on the pole. The main objective of this project is to provide guidance to engineers, galvanizers, and fabricators on how to minimize the likelihood of crack initiation during the fabrication process of high mast illumination poles (HMIPs). The research work includes the development of a finite element model that will account for the cumulative influence of welding and hot-dip galvanizing. This model will be used to conduct a parametric study in which the HMIP geometric configuration and parameters of the welding and galvanizing processes will be varied in order to determine their influence on the critical stress/strain demands that are induced during manufacturing. Different models will be evaluated corresponding to standard details used in Texas, Wyoming, and a historical socket connection that is present throughout the entire U.S. This information will be used to provide a better understanding of the root causes of galvanizing cracks in HMIPs, propose variations in the design and manufacturing practices of HMIPs with the aim of increasing their durability, and ensure safety for the traveling public.

Problem Statement

Galvanization is a widely used, effective method to protect steel from corrosion. However, in recent years, post-galvanizing inspections have reported the presence of cracks in high mast illumination poles (HMIPs), particularly at the toe of the welded connection between the pole and the base plate, on the pole. These flaws impose a risk to the public as they can propagate during service due to cyclic wind loads. In the past two decades, numerous fatigue failures of HMIPs have been reported by several state transportation agencies. To date, the root causes of these cracks remain poorly understood. Nonetheless, as each of the fabricating stages, i.e. cold working, welding, and hot-dip galvanizing, induce residual stresses in the steel, the crack formation phenomenon cannot be solely attributed to the galvanizing process. Thermal shocks occur at both welding and galvanizing and may be contributing to the formation of cracks. Hence, it can be inferred that the complex interactions between cold working, welding, and galvanizing are a potential source of the problem. Moreover, recent changes in steelmaking and galvanizing practices, in particular with respect to zinc bath composition, may also be contributing to the formation of cracks. Researchers have made efforts to track the mechanical behavior of HMIPs during galvanizing. However, the high temperatures of the hot zinc bath limit the stress, strain, and deformation measurements that can be recorded during galvanizing. In addition, there is little information on the literature regarding the influence of the welding procedure on the formation of the weld toe cracks. Hence, engineers, galvanizers, and fabricators are in need of guidance for adopting changes in the design of HMIPs and/or their galvanizing and welding practices that minimize the likelihood of crack initiation during the fabrication process of HMIPs.

Objectives

This research work will focus on developing a better understanding of the root causes of weld toe crack in HMIPs by capturing the cumulative effects of both welding and galvanizing. This research objective will be achieved by conducting three-dimensional finite element analyses, in which the geometric configuration of the HMIP and parameters of both welding and galvanizing will be varied in order to determine their influence on the crack formation phenomenon occurring post galvanizing. The potential variables include: (a) shape of the pole, (b) base plate thickness, (c) connection details (i.e. location and presence or absence of collar), (d) pole-to-base plate thickness ratio, (e) welding heat input and sequence, (f) dipping angle during galvanizing, (g) speed of immersion and extraction from hot zinc bath, etc. The effects of these variables on the likelihood of cracks developing during galvanizing will be quantified by comparing the magnitude of crack

indicator parameters that become available from the simulations, e.g. equivalent plastic strain. These results will be used to suggest recommendations, i.e., modifications to the design of HMIPs and/or the welding and galvanizing processes, to minimize the potential of galvanizing-related cracks. In order to make appropriate recommendations, the investigators will combine statistical analysis and curve fitting on the simulations results with engineering judgement.

Intended Implementation of Research

Education, Workforce Development and outreach activities: The implementation phase of the project will consist of four different activities: 1) elaborating a short document aimed at DOTs and practicing engineers detailing research findings, 2) presenting the results from the project in technical meetings, 3) developing of online-learning material and 4) curriculum improvements at UTSA.

The PIs will elaborate a short document containing the results of the parametric study, summarizing the variables that have the major influence on increasing the induced residual stresses/strains in HMIPs, and the proposed modifications to the design of HMIPs and galvanizing and welding practices. The PIs will obtain periodic feedback from fabricators, galvanizers and welders in order to ensure that the recommendations are practical and feasible. In addition, this research will provide a modeling methodology that will enable future research in this field. Hence, the PIs will publish the results of their work and make available sample simulations and guidelines on how to model the manufacturing of HMIPs on online platforms. The educational activities of this project will give students an additional edge in a highly competitive job market and provide continuing education opportunities for practicing engineers.

Anticipated Impacts/Benefits of Implementation

TThis project will benefit US fabricators and highways officials as its outcomes will contribute to decreasing maintenance and replacement-related costs of the HMIPs. This proposal addresses several FAST Act research priorities, improving the durability and extending the life of transportation infrastructure, and promoting safety. The potential societal outcomes and impact of this project include: 1) contribute to the resiliency of the transportation networks (Region 6), 2) ensure the safety of the traveling public by preventing that HMIPs collapse during service, 3) minimize the costs associated to detailed inspections of welded connections and financial losses incurred every time a damage connection is found, 4) minimize the loses associated with discarded poles or repair of cracks that manifest while in service. The educational activities of this project will give students an additional edge in a highly competitive job market and provide continuing education opportunities for practicing engineers.

Web Links

- TranSET's website (https://transet.lsu.edu/research-in-progress/)
- TRB's Research in Progress (RIP) database (https://rip.trb.org/View/1644429)

Tran-SET

Tran-SET is Region 6's University Transportation Center. It is a collaborative partnership between 11 institutions (see below) across 5 states (AR, LA, NM, OK, and TX). Tran-SET is led by Louisiana State University. It was established in late November 2016 "to address the accelerated deterioration of transportation infrastructure through the development, evaluation, and implementation of cutting-edge technologies, novel materials, and innovative construction management processes".

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For more information about Tran-SET, please visit Our Website, LinkedIn, Twitter, Facebook, and YouTube pages. Also, please feel free to contact Mr. Christopher Melson (Tran-SET Program Manager) directly at transet@lsu.edu.