RESEARCH SUMMARY

Fatigue Resistant Design Criteria for MD SHA Cantilevered Mast Arm Signal Structures

WHAT WAS THE NEED?

Over the past two decades, wind induced fatigue cracking of highway signs, luminaires, and traffic signal support structures have been increasingly reported all over the United States. While fatalities associated with these failures have been limited, the nuisance of dealing with a large number of fatigue cracks in the sheer volume of these structures in the national inventory, along with the cost of inspecting, repairing and/or replacing the cracked structures, has been substantial. As such, a reliable assessment of the fatigue performance of these structures and their improved cost-effective design of fatigue critical details are of great importance. The fatigue design of the mast arm structures and connections vary significantly based on the Category of Importance factor adopted and the load cases for fatigue design loads. Consideration should include the cost and size of the structures for both urban and rural applications, and the type of vibration mitigation devices to be adopted for use on cantilevered mast arm structures.

WHAT WAS THE GOAL?

Significant changes in the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals have led to changes in the fatigue design criteria of these structural supports. The goal of this project focused on defining the fatigue resistance of various connection details in these subject structures. Finite and infinite life resistances were established by fatigue testing of full scale galvanized specimens.

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PRINCIPAL INVESTIGATOR:
Dr. Chung C. Fu, P.E.
University of Maryland,
College Park
ccfu@umd.edu

WHAT DID THE RESEARCH TEAM DO?

This study began with a national survey of the current state-of the-practice methods for fatigue design criteria and mitigation devices. Eight cantilevered master arm signal structures (four level and four curved cantilevers with the arm lengths of 50’, 60’, 70’, and 75’) with different pole mounting, and arm attachment details were studied. Fatigue details are shown in Figure 1.1, where the pole mounting, arm attachment, and access hole (all circled) were the concerns for fatigue details and relevant costs. To get a more accurate cost comparison, fabricators were consulted for cost analysis and an economical and fatigue resistant design was recommended. Cost analysis of a 60’-arm length pole was studied for reference.

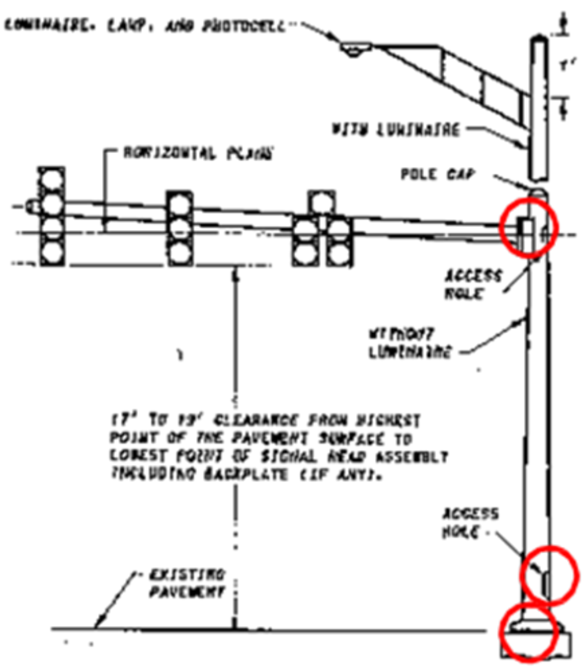

Figure 1.1 - Cantilevered Mast Arm Signal Structure and Its Fatigue Detail Locations

WHAT WAS THE OUTCOME?

Complete model analysis of traffic signal structure, including structure foundation, was conducted using ANSYS and SABRE programs and self-developed Excel calculation sheets. Recommendation of current Maryland structure design was then proposed.

HOW WILL SHA USE THE RESULTS?

The latest fatigue design in AASHTO LRFD Specification for structural support and different types of mitigation devices were surveyed and studied. Twenty-seven (27) out of 50 state DOTs replied to the 21-question signal structure questionnaire. Information about other states’ practices and current mitigation devices was also gathered for reference. The following are the new criteria adopted by the State of Maryland:

- Using Importance Category II with mitigation device in the fatigue design for galloping and Importance Category I without; using Category I for other fatigue loading
- Using 50-year design life
- Applying grove welds for both arm and pole connections
- Adopting AASHTO built-up box type
- Using signal head back plate
- Using non-stiffened pole base (as currently practiced)
- Using 6-bolt pattern for both arm and based connection plates
- Adopting PennDOT 24”x24” wind plate as the mitigation device
- Using 100-mph wind speed for LTS-6 design (as currently practiced).

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