

**WHRP Structures Technical Oversight Committee: Request for Proposal
Study of Fatigue Risks in the Connections of Sign Support Structures – Phase II**

Background and Problem Statement:

Wisconsin has recently encountered problems with the connections of their sign support structures. In one case, a structure was taken down because of excessive mast arm deflections. It was discovered that recently installed bolts were loose, leading to premature fatigue failure. In a second case, a routine inspection discovered a welded tube to plate connection that had failed over 50% of its diameter due to fatigue since the last scheduled inspection. The latest edition of the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals has provisions for fatigue design. However many in service structures were designed before fatigue provisions were a part of the code. Wisconsin is interested in the possible risk of fatigue failure to its existing structures that were designed before the latest revisions to the code.

Scope:

This is a three Phase study with Phase I currently underway. Phase I is focused on identifying welded and bolted sign connections commonly used in Wisconsin and using national research efforts to develop a testing matrix to evaluate potential for fatigue failure. Depending on the findings of Phase I, Phase II shall involve both laboratory fatigue testing of specific connections as well as instrumentation of several key structures throughout the WisDOT inventory to thoroughly understand the demand side and the resistance side of the fatigue performance function. The results of the testing shall include retrofit mitigation strategies (including but not limited to the possible effects of ultrasonic impact treatment of the welded parts), risk assessment, and inspection cycle frequencies for each connection type.

Phase II Scope:

- Utilize the recommendations provided in the Phase I report to refine and execute a work plan that shall include both laboratory testing and field instrumentation of pertinent connection types currently used by WisDOT to thoroughly understand the fatigue performance function.
- Development and implementation of a data collection system for field data obtained through instrumentation. The data collection system will be delivered to WisDOT at the end of Phase III.

Phase III Scope:

- Analysis of field and laboratory testing data from Phase II.
- Structural modeling, as appropriate, to verify the results of Phase II.
- Definition and evaluation of retrofit mitigation strategies, risk assessment, and life cycle cost frequencies for pertinent connection types.
- Development of a handbook detailing available retrofit strategies for a given connection, the risk associated with the connection, and the recommended inspection frequency of the connection.
- Recommendations for modifying current standard details used by WisDOT

Specific Results, Findings, and Conclusions:

- Implementation of state-of-the-art fatigue reliability analysis and current knowledge regarding fatigue lives of connections in a systematic assessment of fatigue-induced fracture risk in WisDOT's sign support structures
- Recommendation of the most effective retrofit strategies in instances where fatigue-induced fracture is likely
- Development of appropriate inspection cycle frequencies for these structures and their components
- Investigator will provide 40 printed copies of the final research report to be distributed to WisDOT (34) and WHRP (6), as well as one electronic copy of the final version of the report.

Length of Research Project and Approximate Cost to Complete:

It is anticipated that phase II of this project will take place over a 12-month period and cost no more than \$100,000. The Phase III budget is \$88,000 and will have a duration of 12 months. Award of Phase III will be evaluated upon the completion of Phase II. Proposals submitted by the researcher should include the scope for both phases of the project as well as a budget and schedule for each phase. The proposed schedule for each phase shall include a 3-month time frame for TOC review of the draft final report.

Urgency and Potential benefits:

There are very clear benefits to completing the proposed research effort. First and foremost, there is an unknown probability of future failures in mast-arm-to-pole connections typical of sign support structures in Wisconsin. This research will result in guidelines for inspection cycles, retrofit measures, or other changes in inspection or maintenance policy to assure the safety of the traveling public. Application of the results of the effort will reduce inconvenience to the motoring public through establishing rational inspection intervals for these structures. Furthermore, these relatively innocuous structures are sources of relatively severe failure consequences and regular short-interval inspection cycles to mitigate this risk have economic impact and the results of the present research effort will foster better use of public funds for ancillary structure inspection.

Wisconsin DOT Sponsor:

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