Wisconsin Department of Transportation
Wisconsin Highway Research Program

Request for Proposal

Strength & Serviceability of Damaged Prestressed Girders

Questions submitted to research@dot.wi.gov regarding the content of this RFP are due no later than 4:30 PM (CST) on December 7, 2015

Responses to questions will be posted to the WisDOT Research and Library website http://wisdotresearch.wi.gov/rfps-and-proposals by 4:30 PM (CST) by December 14, 2015

Proposers must submit a PDF version of their proposal by 4:30 PM (CST) by January 22, 2016 to: research@dot.wi.gov

Proposers will be notified by May 1, 2016

For more information regarding this RFP contact the WisDOT Research Program at: research@dot.wi.gov. This RFP is posted to the Internet at: http://wisdotresearch.wi.gov/rfps-and-proposals.

Wisconsin Highway Research Program
Request for Proposals
Structures Technical Oversight Committee

Strength & Serviceability of Damaged Prestressed Girders

I. Background and Problem Statement

Prestressed concrete girders can be vulnerable to damage from a number of sources during their anticipated service life. The top flanges of girders can be damaged during the deck removal process of deck replacement projects. Prestressed girders can be damaged by vehicle impacts to the bottom flanges by over height vehicles. Damage to the girder flanges and webs can range from minor scrapes and spalls to significant loss of the top flange, cracks in the web, or complete loss of the bottom flange and the majority of the prestressed strands. When prestressed concrete girders are damaged, owners often have to evaluate the remaining strength, serviceability, loss of long-term performance of the damaged girders, and durability of the repairs.

Prompt inspection, evaluation and decisions need to be made about what to do in response to the damage. The decisions that owners are faced with may have significant impact to safety, operations, and cost associated with responding to the situations, maintaining operations and maintaining the bridge. These decisions include: doing nothing, superficial surface repair, major girder repairs, closing lanes directly above the damaged girder and closing the entire bridge to traffic above. These decisions may also include closing the roadway below and emergency removal of the girder due to concerns about its stability and safety. Decisions also need to consider if the girder can be repaired and the long-term performance of the damaged girder. Often, these decisions are based on experience and approximate analysis methods that may not capture the actual load distribution and function of the damaged girder/bridge system.

Bridge owners may also be faced with making decisions about the type of repair technique to use for a damaged girder. A desirable repair technique must be practical, restore lost strength, and perform well over time. Owners also need to know how a girder repair method may be affected by the operational factors of the bridge that may include girder stresses and deflections.

One challenge is to understand how damage to the girder influences the performance of the girder in the bridge system. For girders that experience loss of section and prestressed strands, the section properties and load paths for moment and shear forces may not be as designed. Secondary load paths or "load shedding" may come into play. One example of anticipated secondary load paths may be when a concrete parapet on the exterior of the deck carries load as a structural component because of loss of strength and stiffness of an exterior prestressed concrete girder. Understanding and quantifying these potential secondary load paths makes

evaluation complex and cumbersome and leads to delays and uncertainties in evaluation and decisions.

The evaluation typically includes assessing strength to determine structural capacity as well as recommending repair options, and estimating the remaining life of the girder based on those repair actions.

II. Objectives

The objective of this research is to develop recommendations and guidelines for the inspection, evaluation, and repair or other needed safety and operational response related to damaged prestressed concrete girders. These guidelines will aid the department in making prompt decisions about what to do when a girder is damaged. These guidelines will include actions and repair techniques that are based on the most common type and extent of damage that has been encountered in Wisconsin.

The objectives of the study include:

For top flange and web damage primarily due to construction operations:

- Recommend inspection techniques for identifying extent and nature of damage to girders as a result of construction deck removal operations.
- Research the behavior of girders damaged during deck removal with and without repairs implemented. This should include strength, serviceability, and long-term performance aspects.
- Examine recent WisDOT documented cases where top flange damage has been caused by construction. Provide commentary on analytic methods and results for these damaged bridges.
- Correlate analytical methods with actual behavior observed in the field through inspection and/or instrumentation.
- Outline methods for analytical evaluation of damaged girders for strength and serviceability.
- Develop recommendations and criteria for determining whether sufficient damage has occurred to require repair or replacement of damaged girder.
- Research common repair techniques and correlate with analytical results and field performance observations. Document methods for acceptable repair of damage, including:
    - Methods for evaluating service behavior of repaired girder including: estimating residual stresses in repaired girder, estimating stiffness of repaired girder, estimating future load sharing/load distribution in bridge with a repaired beam that has lower stiffness.

- Methods for evaluating remaining strength of girder (live load capacity) and service life of repaired girder.

For bottom flange and web damage primarily due to vehicle impact:

- Recommend inspection techniques for identifying extent and nature of damaged girders
- Research the behavior of damaged girders with and without repairs in regard to strength and serviceability, and long term performance.
- Examine recent WisDOT documented cases where damage has been caused by over height vehicles. Provide commentary on analytic methods and results for these damaged bridges.
- Outline methods for analytical evaluation of damaged girders' strength
- Develop a method and criteria for determining whether sufficient damage has occurred to require:
  - Closure of lanes on the bridge above the girder(s)
  - Closure of lanes on the road below the girder to protect traffic
  - Splicing of strands
  - Reinforcement of the flanges or web of the girder to ensure adequate performance
  - Replacement of girder
- Research common repair techniques. Document methods for acceptable repair, including:
  - Methods for evaluating service behavior of repaired girders including: estimating residual stresses in repaired girder after repair, estimating stiffness of repaired girder, estimating future load sharing/load distribution in bridge with a repaired girder that has lower stiffness
  - Methods for evaluating remaining strength of repaired girder and capacity of bridge (vehicle capacity) if load distribution has changed due to repair, or if strands are damaged and not repaired.

These objectives will be achieved by:

A. Conducting a literature review and assessment of current practices at various other state DOTs to identify what tools and policies exist.
B. Looking at case study examples of damage to girders to quantify the nature of damage that has occurred for Wisconsin and other states as available. Case studies will be supplied by WisDOT Bureau of Structures and include both construction top of girder damage and vehicle impact bottom of girder damage.
C. Conduct field review of case studies locations provide by WisDOT.
D. Conducting analysis (Line Girder, Grid and FEM) to determine what the structural load distribution mechanisms are for a damaged girder/bridge system. This would include various scenarios to determine thresholds of acceptable damage and decision points. Provide commentary on analytic methods and results for these damaged bridges.
E. Review of industry methods of repair.
F. Examine past repairs of damaged girders to determine performance issues.

III. Scope of Work

A. Review of recent WisDOT in-service prestressed concrete girder bridges that have been damaged to assess the nature of these issues.
B. Research and document the current practices, guidance, and other relevant information related to damage and repair of prestressed concrete girder bridges.
    1. Literature sSearch and review of current practices at other state DOTs.
    2. Industry tools and repair techniques.
C. Analytic Modeling (Conventional Line Girder, 2-D Grid Analysis and Complex Method (FEM)).
D. Field review, inspection, instrumentation, and measurements of bridges that have been damaged and repaired.
E. Develop recommendations and guidelines in a format consistent with WisDOT Bridge Manual. This will include criteria that relate the type of damage to analytic considerations and methods, which determines the appropriate response, and which provides suitable repair methods and materials.

IV. WisDOT/TOC Contribution

WisDOT will provide recent documented cases, as well as some effort by WisDOT Regional Bridge Maintenance Engineers

A. Work will be conducted with project oversight by the WisDOT Bureau of Structures and WHRP Structures Technical Oversight Committee (TOC).
B. The research team will not assume the availability of WisDOT staff or equipment in the proposal. If WisDOT or another entity donates equipment, a letter of commitment must be included in the proposal.
C. Expected level by staff/TOC members: Maximum of 40 hours. Project Oversight Committee (POC) members will consult with research team in selection of project sites.
D. This project will require travel for a meeting to finalize the work plan with the POC, and travel to Madison is required to report the results of the study to the TOC. Other interim reporting is also expected.
E. If field work on or around in service facilities is anticipated by the research, the proposal will need to discuss the nature and extent of needed traffic control and support assistance that will be requested from the WisDOT. The researcher will need to closely coordinate with WisDOT regional personnel and possibly the county personnel where project fieldwork is being conducted. For WisDOT planning purposes, the Principal Investigator shall specify in his or her proposal, as practical, what specific traffic control

will be required for this project, such as traffic flagging, signage, barricades, etc., as well as the duration needed (hours/day/location).

V. Required Travel

This project will require travel for a meeting to finalize the work plan with the POC and the researcher's fieldwork. Travel is also required to deliver the final presentation.

VI. Deliverables

A. Reporting Requirements: Seven (7) hard copies and an electronic copy of the final report delivered to WisDOT by the contract end date. This includes the report, special provisions, and structural details. Please refer to the Implementation section for further details.

B. Presentation Requirements: All projects require the PI to give a closeout presentation to the TOC after submittal of the draft final report.

VII. Budget and Schedule

A. Project Budget shall not exceed **$200,000.**

B. Proposed project duration is **24 months.**

- Deadline for submittal of draft final report is three months prior to contract end date to allow for report review activities.
- Deadline for research close out presentation is 4-6 weeks prior to contract end date.
- Deadline for submittal of the Final Report is the contract end date.

VIII. Implementation

Successful implementation of this research will be achieved through the development of the following items:

- Inspection guidelines for damaged prestressed girders.
- Guidance to support decisions on actions to be taken when girder damage occurs. These guidelines are expected to be used by field inspection staff, bridge structural engineers, and contractors in assessment and decision-making.
- Guidelines for methods to be used to accurately analyze damaged prestressed girders that include consideration of likely load re-distribution.
- Guidance on the on appropriate repair actions to be employed to repair damaged prestressed girders.