Wisconsin Department of Transportation Wisconsin Highway Research Program

Request for Proposals

Frost Susceptibility of Pavement Structures

Questions submitted to research@dot.wi.gov regarding the content of this RFP are due no later than 4:30 PM (CST) on January 3, 2022

Responses to questions will be posted to the WisDOT Research and Library website https://wisconsindot.gov/Pages/about-wisdot/research/researchers.aspx by 4:30 PM (CST) on January 14, 2022

Proposers must submit a PDF version of their proposal by 4:30 PM (CST) on February 4, 2022 to: research@dot.wi.gov.

Proposal Preparation Guidelines can be found at: Proposal Preparation Guidelines

Proposers will be notified by April 29, 2022

For more information regarding this RFP contact the WisDOT Research Program at: research@dot.wi.gov.

This RFP has been posted to the Internet at: https://wisconsindot.gov/Pages/about-wisdot/research/researchers.aspx

Wisconsin Highway Research Program
Geotechnical Technical Oversight Committee
Request for Proposals for

Frost Susceptibility of Pavement Structures

I. Background and Problem Statement

WisDOT adjusts permissible traffic loads on certain roadways during the year based on the condition of the pavement subgrade and subbase to extend the service life of the pavement while maintaining cost-effective transportation. During thawing periods, frost susceptible pavements are subject to potential premature deterioration due to cyclic traffic loads when the stiffness and strength of base and subbase layers are at their minimum. To reduce the premature deterioration of the roadway, WisDOT applies load restrictions on Class II and Posted Roads when the pavement structure is most susceptible to damage (i.e., WisDOT's frozen road declaration, midseason thaw, ending the declaration, and spring weight restriction decision process). However, knowing the precise time and location to impose these limitations is key for maintaining the transportation infrastructure while optimizing freight transportation costs. In Wisconsin, this problem is magnified on *secondary roads that carry heavy trucks that demand large load capacity in winter and early spring*. This study aims to critically assess the variation of stiffness, temperature and moisture throughout the base and subbase structure to better determine the capacity of roads as the seasons transition from winter to spring. Technologies such as frost tubes (currently used by WisDOT), as well as FWD (falling weight deflectometer), LWD (lightweight deflectometer), DCP (dynamic cone penetrometer), GPR (ground penetrating radar), MOTES (small wireless sensors), MEMS (microelectromechanical systems), TDR (time domain reflectometry), fiber optics distributed measurement, etc., may be proposed to improve the data collection and systemically and remotely monitor the condition of thawing pavements systems over large sections of roadways in order to promote data driven load restriction decision-making.

II. Objectives

The objectives of this projects are two-fold:

1. Critically assess the variation of temperature, moisture, stiffness and strength throughout the base and subbase structures during different driving seasons to better determine the capacity of roads from winter to spring to summer driving seasons.
2. Propose an interpretation and analysis protocol of continuously collected data to create a decision-making process for the frozen road declaration, midseason thaw, ending the frozen road declaration, and imposing and ending spring weight restriction in the State of Wisconsin.

III. Scope of Work

Task 1: Literature Review

The research team will perform a comprehensive literature review regarding the best practices across northern Departments of Transportation (DOTs) in the United States and Ministries of Transportation in Canada. Emphasis should be placed on rational and data-driven procedures for traffic load restrictions across seasons, including evaluation of moisture content, temperature, stiffness and strength estimation in bases and subbases of pavement systems thought different driving seasons. The use of weather data must also be captured. The research team must document procedures used by different entities to collect, manage, analyze, and implement the results of their observations in managing roadway assets.

The results of the Literature Review will be documented and presented to the Project Oversight Committee (POC) in an interim report.

Supporting Documents:

- WisDOT's frozen road declaration, midseason thaw, ending the declaration, and spring weight restriction decision process (Wisconsin Statue - for the State trunk highway system) https://wisconsindot.gov/Pages/dmv/com-drv-vehs/mtr-car-trkr/ssnl-wt-rsrctns/default.aspx
- Cetin, B. et al. (2021). "Environmental Impacts on the Performance of Pavement Foundation Layers". Minnesota Department of Transportation. URL: http://dot.state.mn.us/mnroad/nrra/structure-teams/geotechnical/environmental-impact-pavement-layers.html
- Miller, H., et. al (2020). "Demonstration and Inter-Comparison of Seasonal Weight Restriction Models-Phase II". Aurora Program (Iowa DOT, FHWA). https://intrans.iastate.edu/app/uploads/2020/12/seasonal_weight_restriction_models_phase_II_w_cvr.pdf
- Ghayoomi, M., et al. (2021) "Mechanistic Load Restriction Decision Platform for Pavement Systems Prone to Moisture Variations", National Road Research Alliance (MNDOT) (http://dot.state.mn.us/mnroad/nrra/structure-teams/geotechnical/load-restriction-decision-platform.html)

Task 2: Proposed Field Monitoring

Based on best practices and additionally proposed techniques, the research team will develop a plan for the systematic measurements of freezing/thawing parameters along the pavement structure columns (from surface to subbase) across the State of Wisconsin. The proposed measurement system should be designed to inform the research team of the conditions of the pavement structure and shallow underlying embankment or native soils during different driving seasons. The research team will define in consultation with the POC the location of five to ten sites preferably along Class II or Posted Roads to deploy the field measurement stations. The geographic selection of these sites will be determined considering the diversity of shallow

subsurface conditions, including different soil types, and climatic zones within the State of Wisconsin. For reference, the state is divided into five zones for implementing seasonal load restrictions (refer to Figure 1), and it is expected that the majority of the monitoring sites will be located in the northern half of the state, and the minority of the monitoring sites will be located in the southern half of the state.

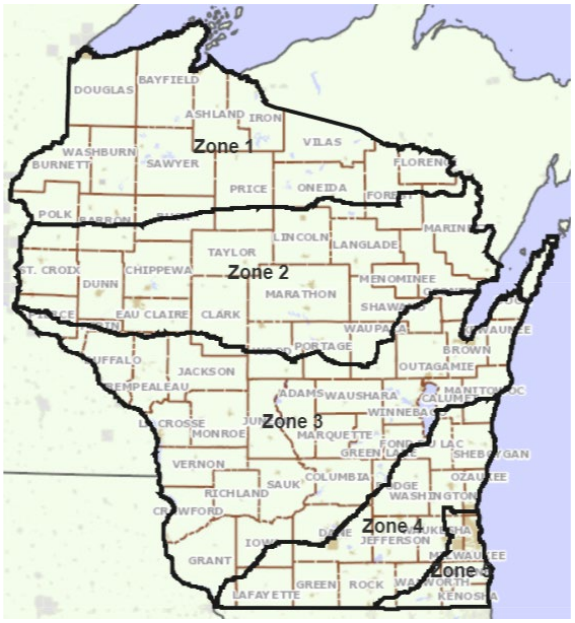


Figure 1 – Seasonal load limit zones of Wisconsin

At a minimum, the researcher will propose field measurement stations that periodically assess temperature, water content, stiffness, and strength of the pavement structure from the surface through the subbase and into shallow embankment or native soils. These measurements should also be correlated with weather data and physical parameters within the base and subbase columns. The research team will coordinate with WisDOT officials for opportunities for integrating their field measurement station with weather, pavement and subsurface temperature arrays and frost tubes measurement devices already deployed across the State.

The proposed Field Monitoring System will be presented to the POC for approval and deployment.

Task 3: Deploy and Monitor Measurement Systems

The research team will install and monitor for a minimum of a two-year cycle the field measurement stations across the State of Wisconsin. The collected data will be interpreted and critically assessed for variation of temperature, moisture, stiffness and strength throughout the base and subbase structures, and shallow embankment or native soils during different driving seasons.

Task 4: Assessment of Roadways Responses During Different Driving Seasons
The data collected in Task 3 will be compiled and critically assessed to develop a decision-making process for frozen road declaration, midseason thaw, ending the declaration, and spring weight restriction in the State of Wisconsin.

Task 5: Final Report
The research team will prepare and submit a draft final report that will include the design of the field measurement stations, data analysis, interpretation, and recommendations for decision-making process for frozen road declaration, midseason thaw, ending the declaration, and spring weight restriction in the State of Wisconsin. As part of this report, the research team will include Excel files with curated testing data for future use, analysis, and interpretation.

Note- The selected research team will negotiate a contract that will include a Data Management Plan (DMP) documenting all field/laboratory data and analyses to ensure accessibility and transparency of research data as required by the USDOT per the Public Access Plan (https://ntl.bts.gov/public-access/creating-data-management-plans-extramural-research). The DMP will include the following items:

- *The final research data to be produced during the project;*
- *The standards to be used for data and metadata format and content;*
- *Policies for access and sharing the final research data, including provisions for appropriate protection of privacy, confidentiality, security, intellectual property, and other rights or requirements;*
- *Policies and provisions for re-use, re-distribution, and the production of derivatives; and*
- *Plans for archiving final research data and other research products, and for preservation of access to them.*

A Data Management Plan is not required as part of the proposal submission.

Task 5: Closeout Presentation
A closeout presentation (COP) will be scheduled within three months before the end of the contract. At least one representative from the research team is expected to present the results and recommendations from the project.

IV. Required Testing

At a minimum the following laboratory and field tests should be performed on the collected soil samples where applicable:

- Moisture Content and Density
- Atterberg Limits
- Grain Size Distribution
- USCS, AASHTO, and USDA Soil Classification
- Strength and stiffness measurements as a function of moisture content

The final list of tests will be defined in consultation with the POC.

V. WisDOT/TOC Contribution

WisDOT will provide the following support through the POC to support the successful completion of the project:

A. Work will be conducted with project oversight by the WisDOT Bureau of Technical Services/Bureau of Structures and WHRP Geotechnics Technical Oversight Committee (TOC).

B. The research team will not assume the availability of WisDOT staff or equipment in the proposal, beyond the following activities:
   - Soil borings (by WisDOT drill crew) at instrumentation installation sites (One 10-ft boring per site with Standard Penetration Test (SPT) sampling)
   - Falling Weight Deflectometer (FWD) measurements. (WisDOT will complete FWD testing along the test sections up to four times per year for two years; raw FWD data will be provided to the researcher for processing and interpretation)
   - Roadway Weather Information Systems (RWIS – Appendix A)

C. WisDOT staff/TOC members can be expected to contribute a maximum of 40 hours over the duration of the project.

D. The TOC and POC will coordinate access to applicable/available soil boring logs and project cross sections.

E. If field work on or around in-service facilities is anticipated to conduct this research then the researcher shall specify in the proposal the nature and extent of traffic control that will be required for this project including traffic flagging, signage, barricades, etc., as well as the duration needed (hours/day/location).

F. There also needs to be a discussion in the proposal of the specific traffic control support that is being requested from WisDOT. The researcher will need to coordinate the location of the project field work with the POC chair, WisDOT regional personnel and possibly county personnel. The researcher should make accommodations in their proposal budget for traffic control and should not assume WisDOT will fund traffic control expenses.

G. Researchers should not assume availability of contractors for sampling and testing.

VI. Required Travel

A. Travel is required for sampling/testing and installation/maintenance of sensors across the State of Wisconsin.

B. This project will require the principal investigator to deliver the Close-Out Presentation at the end of the project.

VII. Deliverables

A. Quarterly Progress Reports
   a. WHRP contracts require quarterly technical progress reports that serve both technical and administrative functions.
   b. Detailed information regarding the content of the progress report can be found at: Quarterly Progress Reports Guidelines

B. Invoices
   a. Invoices shall be submitted quarterly for partial payments on the project for authorized services completed to date. Invoices may be submitted four times per year, one partial invoice for each specified quarter.
   b. Detailed information regarding invoicing can be found at Invoicing Requirements
C. Interim Reports
   a. The research team is required to submit writing reports and give presentation as described in this Request for Proposal and in consultation with the POC.
D. Before Close-Out Presentation Report
   a. A Before Close-Out Presentation report is required to be submitted three months before the contract end date to allow time for review, revision, and scheduling of the project Close-Out Presentation.
   b. Reports are expected to have quality technical writing and proper grammar. It is acceptable to dedicate resources from your project for the services of a technical editor to ensure these requirements are met.
   c. The required elements of the Before Close-Out Presentation report can be found at Before Close-Out Presentation Requirements
E. Project Close-Out Presentation
   a. The Principal Investigator on the research team is required to give a presentation to the Technical Oversight Committee.
   b. Presentation and formatting requirements can be found at Close-Out Presentation Requirements
F. After Close-Out Presentation Report
   a. The After Close-Out Presentation Report is due within three weeks of the Close- Out Presentation for review and comments.
   b. This report details the results of the research project. The final report should be as concise as possible (e.g., a maximum of 50 pages plus supporting appendices) and follow the report guidelines and submission requirements After Close-Out Presentation Report Requirements
   c. After revision(s) and oversight committee chair approval, an electronic copy of the Publication-Ready Report must be delivered to WisDOT by the contract end date.
   d. Excel files with curated testing data for future use, analysis, and interpretation.

VIII. Schedule and Budget

A. Project budget shall not exceed $250,000. Matching funds will not be considered in the proposal evaluation process.
B. Proposed project duration is 36 months starting around October 1, 2022.

IX. Implementation

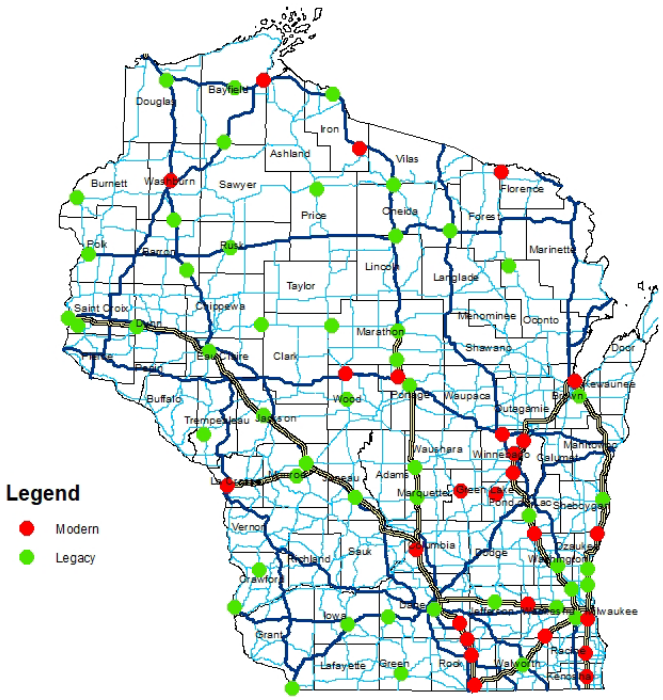
A. Propose an interpretation and analysis protocol of continuously collected data to create a decision-making process for frozen road declaration, midseason thaw, ending the declaration, and spring weight restriction in the State of Wisconsin.

B. The research team should discuss the access and storage of completed project data and analyses in a brief data management plan.

Appendix A: Road Weather Information Systems (RWIS)

WisDOT has a network of 75 Road Weather Information Systems (RWIS). It includes 25 modern sites and 50 legacy sites (see map below).

WisDOT RWIS Locations



Each type of station is configured differently, though the basic output from them is similar. All sites provide the following information:

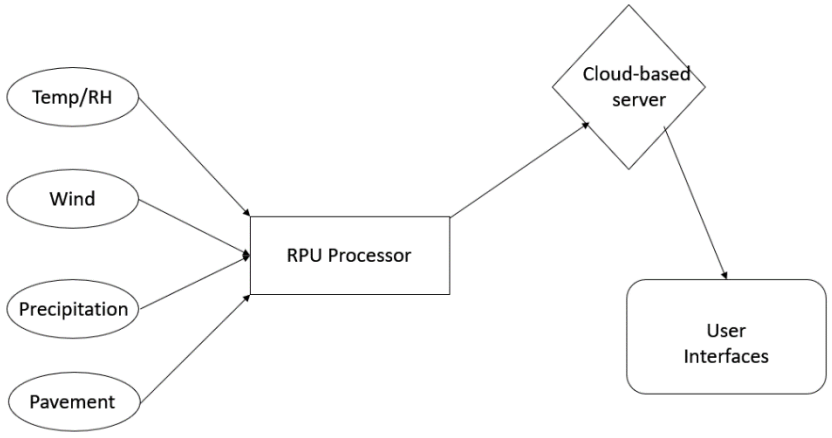
- Air temperature
- Relative humidity
- Wind speed/direction
- Precipitation
- Road surface temperature
- Road surface status (wet, dry, icy, etc.)
- 18-inch subsurface temperature

Modern sites also provide the following:

- Precipitation type/intensity
- Visibility
- Subsurface temperatures every 3 to 6 inches down to 5 feet
- Barometric pressure

All sensors are connected via cables to the RPU processor. The RPU collects the data and transmits it every 15 minutes to a cloud-based server. This is accomplished via cellular modem (modern sites) or

landline (legacy sites). The server then processes the data for user interfaces. These are a website and a direct download capability. See schematic below.



WisDOT plans to upgrade the legacy stations in the next year, but for planning purposes, the modern sites are much more conducive to use in this project.

The winning proposer will be permitted to use the RWIS infrastructure to transmit data via cellular modem. They will also be permitted to connect to the RWIS commercial power meter/breaker pedestal. Note that the researcher will be required to submit a detailed instrumentation plan for WisDOT review describing how their system would integrate with the RWIS system. Any electrical connections to the RWIS system will need to be made by a licensed electrician (costs to be included in the researcher's budget) with appropriate WisDOT staff or contracted RWIS maintenance provider present during any work involving RWIS systems.