



A Pavement Management System for Wyoming County Roads

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Research Needs

Pavement management system (PMS) is an asset management tool that helps decision makers determine the best strategies for maintaining pavements in good condition over a specific period. A comprehensive PMS entails a historical pavement condition database, pavement condition prediction models, and maintenance and rehabilitation (M&R) prioritization models at project and network levels (Haas et al., 1994). The majority of highway agencies throughout the United States have established pavement management systems (PMS) for proficiently and effectively manage their pavement assets on state roads. However, in contrast to the state level, most local agencies administering county roads have not yet established PMS (Anderson & Wilson, 2005;

Vasquez, 2011). This is mainly due to lack of resources and technical expertise, limitations in data availability and quality (Wolters et al., 2011), as well as shortage of funds.

The state of Wyoming boasts an extensive network of county roads, spanning over 2,300 miles and encompassing more than 1,900 pavement segments, which are distributed across its 23 counties (Wyoming Technology Transfer Center, 2022). The majority of road sections are located in Park, Laramie, Fremont and Lincoln counties. It was observed that a significant portion of Wyoming county roads exhibit poor condition in terms of surface roughness and percentage of cracked roads (Wyoming Technology Transfer Center, 2022). This issue could be attributed to an ineffective pavement management and the insufficient funding. Hence, it is indispensable to develop a comprehensive PMS for Wyoming county roads in order to maintain their roads in a satisfactory condition by optimizing the M&R treatments within the available budgets.

Wyoming counties are transitioning to adopt a new 0-5 integrated condition indicator known as the pavement quality rating (PQR). This rating represents the surface roughness, rutting, faulting and cracks present in pavements (Wyoming Department of Transportation, 2022; Wyoming Technology Transfer Center, 2022). However, a PQR threshold needs to be practically determined and used in making cost-effective decisions and choosing the most suitable M&R treatments for pavements, whether at project or network levels. PMS should encompass databases containing information on pavement condition and M&R costs, along with decision trees utilized in choosing the most cost-effective M&R treatments for pavements. Decision trees designed for state roads can be applied to local roads, but they are likely to be less efficient. Wyoming counties lack a county-specific M&R decision trees for their roads, which impedes decision-makers from making cost-effective and informed decisions.

Most highway agencies develop their pavement M&R schedules according to the existing and predicted future pavement conditions in an objective manner. Nevertheless, final decisions are typically made with a certain degree of subjectivity. Experts prioritize M&R projects based on several subjective factors, including land use and traffic volume. Therefore, it is expected that the implemented decisions are likely diverge from the planned M&R schedules, diminishing the efficiency of the PMS. Hence, the subjective perspective of decision-makers should be incorporated into PMS to guarantee generating more practical M&R schedules.

As part of the proposed PMS for Wyoming county roads, it is necessary to estimate the financial requirements to assist highway agencies in their efforts to request adequate funding for maintaining roads in a state of good repair. The financial needs are typically estimated based on the current and future pavement conditions, M&R alternatives, rigorously constructed PQR cut-offs, and the eventual M&R schedules. In addition, it is imperative to regularly revise and update the financial estimate on an annual basis to align with the actual decisions made and the observed pavement conditions.

Research Objectives

In order to develop a PMS for Wyoming county roads, this proposed research project will achieve the following set of objectives:

- Review the relevant state of art and established practices.

- Identify the typical M&R treatments used in Wyoming counties.
- Explore the unit cost of M&R treatments.
- Design PQR thresholds based on IRI, rutting and percentage of cracking.
- Develop a subjective score for pavement M&R prioritization.
- Estimate the relative weight of the subjective score compared to the objective pavement condition.
- Adjust the WYDOT decision trees to suite county roads and to consider PQR, percentage of cracking, IRI, rutting, and road width.
- Develop an M&R treatment prioritization framework considering the subjective score and pavement condition.
- Assess future financial needs.

Research Methods

Figure 1 illustrates the proposed methodology for achieving the main goal of this research project. It is crucial to investigate the existing body of literature and established practices to guide the achievement of the research objectives. A preliminary investigation will be undertaken by engaging in discussions and consultations with the subject matter experts of Wyoming county roads. The purpose of these discussions is to emphasize the significance and practicality of this research work, as well as to devise a questionnaire to gather data required for this project from all counties within the state of Wyoming.

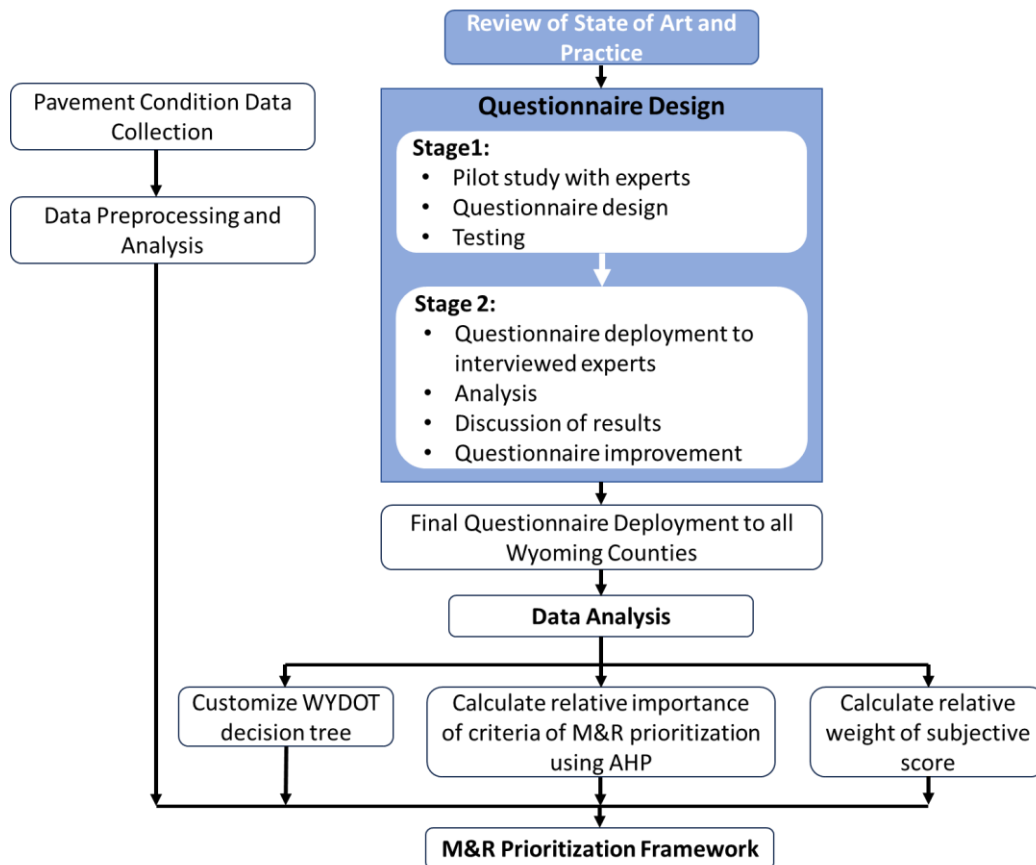


Figure 1. Proposed research methodology

The primary method to gather data on M&R treatments and their costs in Wyoming will be a questionnaire survey. This survey will be used to determine the threshold values of different pavement condition indicators and distresses, identify subjective criteria of M&R prioritization, and calculate the relative weight of expert opinion in comparison to pavement condition in M&R project selection. The questionnaire will go through a two-stage process of design and testing before it is ready for deployment to Wyoming county roads professionals. The initial phase will involve a pilot study and evaluation of the initial questionnaire's clarity, accuracy, efficiency, and completion time. The second phase entails distributing the questionnaire to the county road experts who were interviewed in the pilot study stage. Subsequently, the collected responses will be analyzed and reported. Experts will be interviewed again to discuss and review the questionnaire's results and make any necessary improvements. After that, the final version of the questionnaire will be deployed to all Wyoming counties to gather their responses and collect all required data.

The data obtained from the completed questionnaire survey will be analyzed to calculate the mean and standard deviation of costs and pavement condition cut-offs across Wyoming counties. The anticipated outcomes will aid in creating a decision tree for M&R treatment selection specifically designed for Wyoming county roads. An analytical hierarchy process (AHP) will be utilized to assess the relative importance of the potential factors influencing experts' decision-making in prioritizing M&R projects. This project aims to develop an M&R prioritization framework that will be employed to evaluate and rank pavement segments using a blend of an objective pavement condition data and a subjective score developed within this research project. This framework will also be used to estimate the future financial needs for upkeeping county roads in a satisfactory condition state.

Relevance to Strategic Goals

The primary goal of this proposed project is to develop a pavement management system (PMS) tailored for Wyoming county roads. This system will assist decision-makers in making cost-effective choices to ensure that their roads are well-maintained and in a good condition, despite budget limitations. This will aid policymakers in preserving their current transportation systems in an economic and sustainable manner. Moreover, improving the condition of pavements across Wyoming counties will lead to a reduction in traffic accident rates and a boost in customer satisfaction. Hence, the proposed system aims to assist highway agencies in effectively implementing pavement preservation plans that align with the USDOT's strategic goal of Economic Strength and Global Competitiveness while also achieving socio-economic objectives.

Educational Benefits

The development of pavement management system (PMS) for Wyoming county roads will offer several educational opportunities for students specialized in civil engineering, transportation engineering, pavement engineering, or related areas at the University of Wyoming. The anticipated benefits to be attained are as follows:

- **Infrastructure asset management concept:** The proposed PMS will introduce and familiarize students with infrastructure asset management, covering data collection and management, pavement condition assessment, prioritization of pavement maintenance and rehabilitation treatments, decision-making, trade-off, lifecycle cost analysis, and financial needs assessment.

- In-class case studies: The University of Wyoming offers courses such as Transportation Engineering (CE3500), Pavement Management Systems (CE5585), Transport Network Analysis (CE5545), Transportation Planning (CE5570), and Intelligent Transportation Systems (CE5575). The suggested PMS for Wyoming county roads could be tailored to serve as a case study in various courses, offering students insights into real-world applications.
- Software proficiency: The creation of PMS will involve specialized software for managing, analyzing, and reporting data, planning future projects, and making decisions. This will provide students with practical training and exposure to using such software.
- Research opportunities: Data that is gathered and analyzed through the process of developing PMS can be utilized for further research purposes, aiding students in the creation of new research ideas or the enhancement of existing research ideas that are pertinent to transportation asset management, pavement engineering, and transportation planning.
- Industry relevance: Understanding of PMS is crucial for many industries, particularly the transportation industry, and thus students ought to be equipped with the necessary skills and hands-on knowledge of PMS to enhance their chances in securing professions in transportation.

Outputs through Technology Transfer

The results and products of this project, such as developed optimization models, decision trees, will be disseminated through peer-reviewed journal articles and showcased at scientific research conferences like the Transportation Research Board Annual Meeting. This will help in transferring methodologies, results, and products to the national and international pertinent research communities. Workshops, seminars, and webinars will be arranged to further disseminate the research findings and communicate its outcomes with professionals, practitioners, and highway agencies. The incremental results and progress of this project will be consolidated in a semi-annual progress report. Upon the completion of this project, it will be synthesized along with recommendations and guidelines in a technical report.

Expected Outcomes and Impacts

At the conclusion of this research project, customized M&R decision trees will be developed specifically for Wyoming county roads. Additionally, an M&R prioritization framework will be created to efficiently automate the selection of M&R treatments and prioritize treatment projects. This will facilitate the accurate assessment of future financial needs. This project will also furnish pavement managers with the alternatives and costs of M&R treatments presently adopted by Wyoming counties, which should be updated annually or whenever new data becomes accessible. Essentially, a comprehensive pavement management system (PMS) will be developed for Wyoming counties, which will incorporate historical pavement condition data, alternatives and costs of M&R treatments, decision trees for effective treatment selection, and prioritization framework for M&R treatment scheduling, and financial requirement assessment. This PMS will aid Wyoming counties in making cost-effective and efficient decisions, and ultimately maintaining their roads in a state of good repair, while utilizing the limited resources effectively.

Work Plan

The timeline for the proposed research project is provided in Figure 2. This will be the primary timeline, but certain tasks will be ongoing throughout the project. A literature review will be conducted to incorporate recently published information. New research methodologies will be monitored to enhance the proposed methodology and ensure precise and applicable results.

Task	2024		2025			
	Q3	Q4	Q1	Q2	Q3	Q4
Task 1. Literature Review	■	■				
Task 2. Preliminary Analysis of Pavement Condition Data	■					
Task 3. Pilot Study and Questionnaire Development		■				
Task 4. Deployment of Questionnaire to WY Counties			■			
Task 5. Analysis of Questionnaire Responses				■		
Task 6. Development of Decision Trees					■	
Task 7. Financial Needs Assessment					■	
Task 8. Recommendation and Guidelines						■
Task 9. Preparing Final Report						■

Figure 2. Suggested timeline for proposed research project

Project Cost

Total Project Costs:	\$202,410
CTIPS Funds Requested:	\$101,048
Matching Funds:	\$101,362
Source of Matching Funds:	Wyoming LTAP

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