A Feasibility Study for Establishing A Regional Road Track Pavement Testing Facility in Wyoming

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1 INTRODUCTION

Evaluating the expected performance of pavement is crucial to improve roadway design and construction. Road testing provides a logical method to test pavement materials and structures under actual traffic loading and environmental conditions. While transportation agencies are facing limited funding for road maintenance and construction, engineers are expected to effectively design and maintain roadways in the most cost-effective manners. Therefore, collecting performance-related information of pavement through a real-world experiment can provide useful information for different design methods and specifications. Several experiments of road testing track have been designed to investigate expected pavement performances without laboratory scale extrapolations or lifelong field observations. These experiments are conducted in road track facilities that are developed by several states to test pavement using conventional and accelerated loading techniques. Figure 1 maps the contributing states of accelerated loading facilities and road tracks across the country.

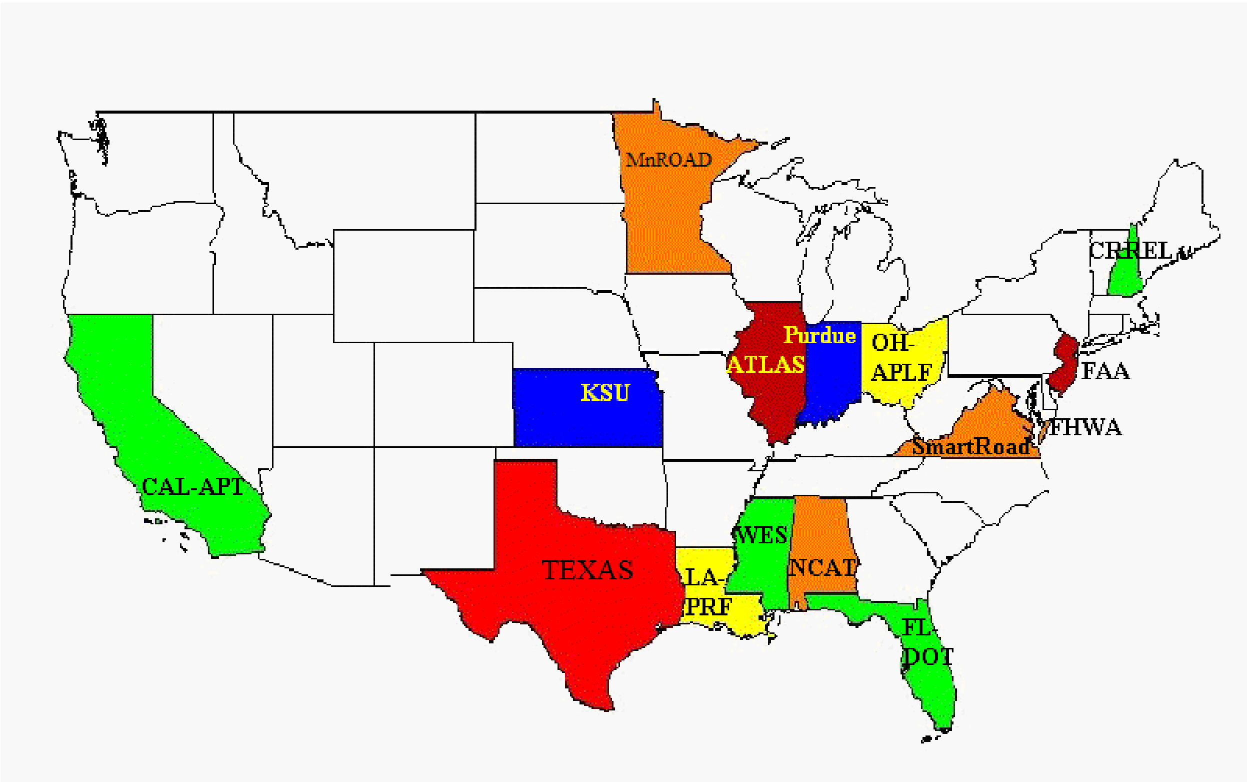

Figure 1. Accelerated Pavement Testing and Road Tracks in the United States (AFD40, 2019).

One major factor affecting the expected performance of pavement is the surrounding climate condition (Daniel et al., 2013). Climate impacts the different pavement stresses, needs, and recommended maintenance treatments. Four main climatic zones were defined by the Federal Highway Administration (FHWA) during Long-Term Pavement Performance (LTTP) studies (Schwartz, et al., 2015). As shown in Figure 2, the dry freeze region covers a significant portion of the nation. Yet, no road track facility has been developed in that region for regional research. The state of Wyoming presents a unique opportunity to be the home for a regional facility of road testing track due to several reasons. Wyoming is located in the heart of the dry freeze region and building a road track can provide more practical and beneficial results not only for Wyoming but also for the surrounding states. In addition, road tracks should have enough traffic loads to produce accumulated damages within a reasonable study period of 5 years. Interstate 80 crosses Wyoming with approximately traffic loads of 2 million Equivalent Single Axle Load (ESAL) per year. Such high traffic volumes can cause accumulated damage on test sections in a timely manner.

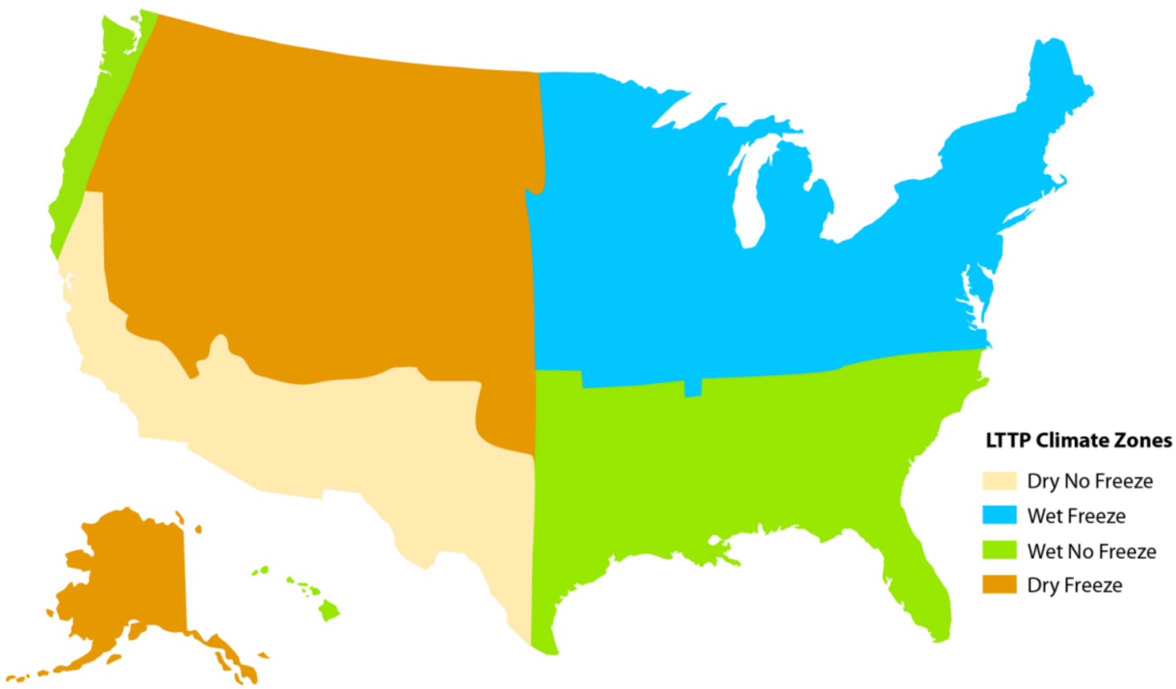

Figure 2. Long-Term Pavement Performance (LTPP) Climatic Zones. (FHWA, 2014)

This proposal identifies the feasibility of building a regional facility of road testing track on Wyoming's I-80. Several research studies can be investigated to assess the long-term pavement performance under full-scale experiments and accumulated loads. The proposal will identify potential experiments of cutting-edge investigations in materials, construction, and management considering the experience of research partners and regional research interests.

2 BACKGROUND

Over decades, numerous large-scale road track facilities were developed for pavement performance research. Other approaches are followed using in-service test sections on roads carrying conventional traffic. These sections reduce the costs of test vehicles since existing traffic is used for pavement loading. However, this approach may require longer time to reach the end of the service life of pavement. Some studies used an accelerated loading facility (ALF) using specific machines and equipment to simulate the effect of total accumulated traffic during the serviceable life span. The following subsections introduce brief descriptions of major road track facilities developed in the USA.

2.1 The AASHO Road Test

The American Association of State Highway Official's (AASHTO) road test is one of the leading road track facilities developed in the mid of 1950s, in Ottawa, Illinois (FHWA, 2017). As shown in Figure 3, the road track facility includs 7 miles of two-lane pavements in the form of six loops and a tangent. In total, 836 test sections were tested under a wide range of surface, base, and subbase thicknesses. An accelerated traffic loading was applied with typical axle loadings from 1958 to 1960 to study the influence of different design parameters on the pavement performance. The AASHTO research efforts led to the concept of pavement serviceability metrics. The results formed the basis of the AASHTO design method (AASHTO, 1993).

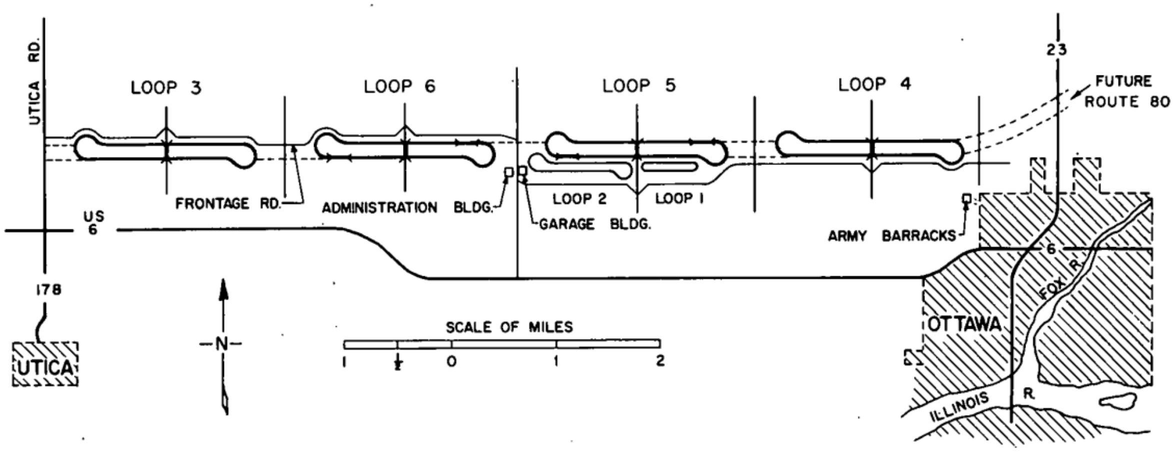

Figure 3. Map of the AASHO Road Test (NAS-NRC, 1962).

2.2 Minnesota Road Research Facility

The Minnesota Road Research Facility, known as MnROAD, was constructed by the Minnesota Department of Transportation (MnDOT), in 1991 (Tompkins and Khazanovich, 2007). The test track consists of a 3.5-miles on interstate roadway on I-94, and another closed loop track of 2.5 miles as a low volume test line, see Figure 4. To monitor the pavement response, over 4500 pavement sensors were installed on more than 50 test cells. The MnDOT partnered with the National Center for Asphalt Technologies (NCAT) Partnership to advance the pavement engineering expertise for each agency. Since 1993, several research projects have been sponsored by seven committed northern states including Colorado, Illinois, Michigan, Maryland, Minnesota, New York, and Wisconsin.

Figure 4. MnROAD Test Track in Minnesota (MnROAD, 2019).

The main focus of studies covers the development of pavement preservation techniques to extend the service life of pavement in both northern and southern climates. Another objective is to predict cracking for common distress found in North America by field monitoring the pavement condition. The research efforts were divided into two phases. The first phase focused on concrete and asphalt structural design parameters and pavement maintenance operations. The benefits from the first phase were estimated to save MnDOT hundreds of millions of dollars in rehabilitation and maintenance budgets (Tompkins and Khazanovich, 2007). The second research phase is still in progress focusing on the refinement of Mechanistic-Empirical Design method. MnROAD collects many types of data such as rutting, ride quality, cracking, and pavement strength. The pavement condition data provides beneficial information for the purpose of mechanistic-empirical evaluation of pavement performance under certain design conditions. Other innovative technologies in construction and maintenance will be investigated in the same phase.

2.3 The WesTrack Road Test in Nevada

The WesTrack Road Test was conducted from 1996 to 1999, southeast of Reno, Nevada. As shown in Figure 5, the facility had a 1.8-mile oval track divided into 34 test sections. Over two years, the track was loaded using an accelerated driverless vehicle technology (Mitchell, 1996). The results provided useful information to evaluate the change in materials and constructiuon properities on pavement perfromance. The results were also used for the Stratgeic Highway Research Program (SHRP) Superpave performance predicition models. Throughout the WesTrack project, signficant developments of perfromance-related specifications were added to the improvements in the quality of hot-mix asphalt construction.

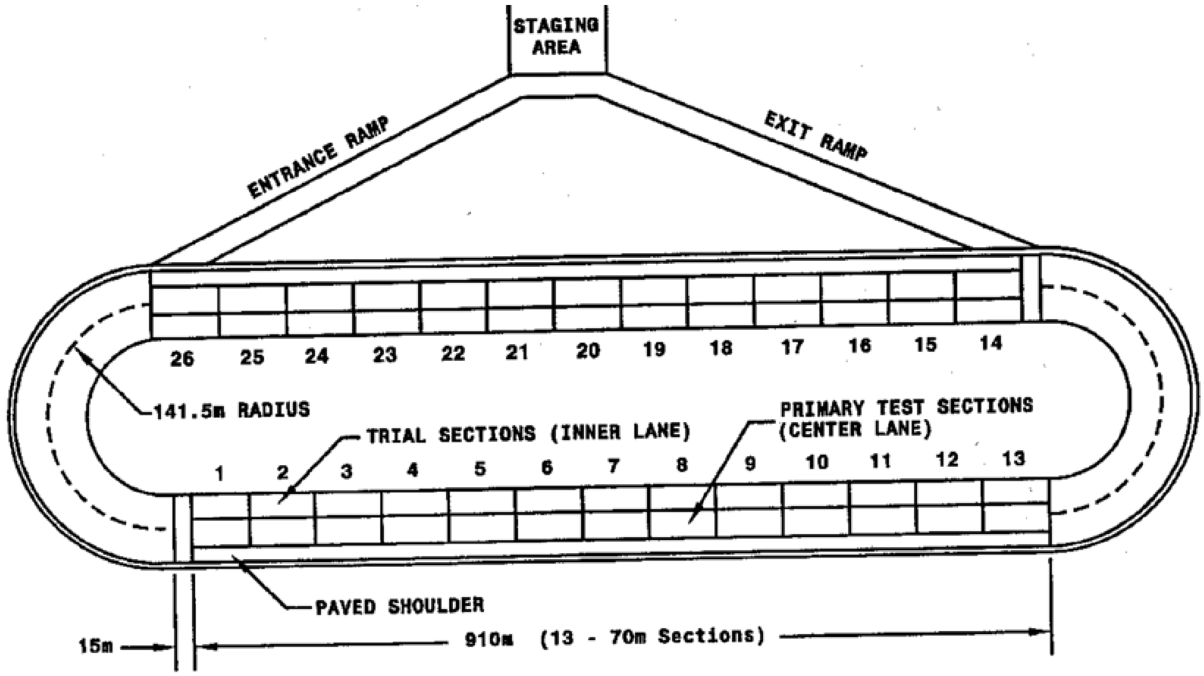

Figure 5. The WesTrack Test Facility (Kim et al., 2002).

2.4 National Center for Asphalt Technology Test Track

In the State of Alabama, the NCAT test track was developed in 2000. The track was designed with 26 tangent sections and 20 curve sections as shown in Figure 6. Different research studies are adopted to explore optimum flexible pavement designs, and improve materials and testing specifications. The projects are sponsored by National Cooperative Highway Research Program (NCHRB), FHWA, and numerous individual state DOTs in Florida, Georgia, Indiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, and other corporations. The results provide refined specifications and improved pavement design for sponsoring agencies (West et al., 2018).

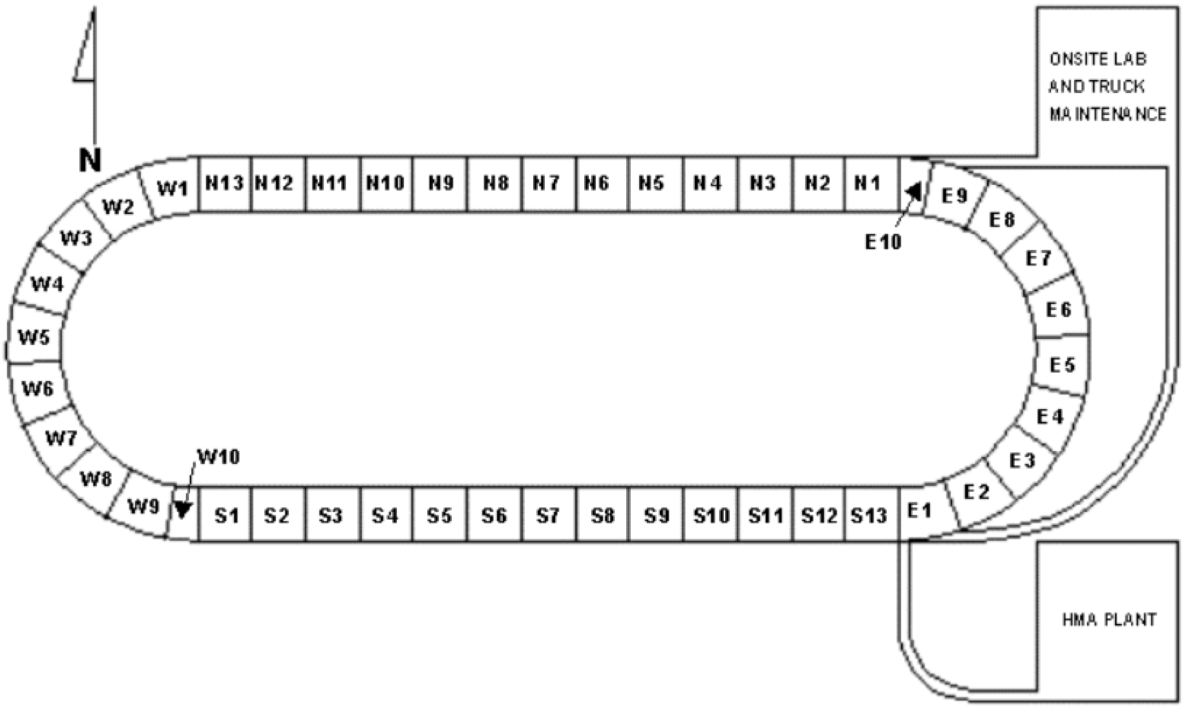

Figure 6. The NCAT Road Test Track (Brown et al., 2002).

3 STUDY OBJECTIVES

The main objective of this study is to evaluate the effectiveness of constructing a state of the art pavement testing facility in Wyoming to conduct research studies for the dry freeze region. The following tasks will be performed to fulfill the objective:

- Identify effective framework of building a transportation infrastructure testing facility for the dry freeze climatic region in Wyoming.
- Define methods to share resources and expertise to expand the evaluation of pavement performance in the region.
- Document best practices of design, construction, and instrumentation of pavement test sections.
- Identify and prioritize the research needs currently urgent for the improvement of pavement performance in Wyoming and surrounding states.
- Determine the feasibility of the testing facility in terms of expected benefits and associated costs.

4 EXPECTED BENEFITS

The results from the feasibility study will provide several benefits for regional stakeholders on both short-term and long-term time frame. The primary benefits would include:

- Provide a closed testing environment to enhance the pavement design and specifications in Wyoming and surrounding states.
- Deliver a historical background of testing facilities to support potential research activities. This includes a well-description of existing facilities and details of operations and management.
- Provide reliable technical information for the proposed regional facility, as well as beneficial pavement testing research proposals.
- Measure the level of readiness for building and implementing a proposed road track pavement testing.

The long-term benefits will be achieved when operating the testing facility after construction. These benefits will include the following:

- Develop more realistic pavement performance models to enhance pavement management and design methods.
- Implement the different findings directly to the pavement specifications and practices of the partners to provide practical solutions and enhance the pavement performance of roadways in the region.
- Provide feasible opportunities for manufacture to investigate innovative materials and maintenance techniques using real-world evaluation and unbiased testing.
- Provide many educational benefits to elevate pavement engineers' knowledge and experience.
- Educate future engineers to provide WYDOT and the transportation industry in Wyoming and the region with potential candidates to fill future positions in the pavement area.

Moreover, future benefits will be obtained from comprehensive analysis and future research of other infrastructure experiments including applications in Intelligent Transportation System (ITS). Important research studies can be investigated for in-vehicle performance systems and crash avoidance. Also, the interaction of vehicle to infrastructure (V2I) can be evaluated using intelligent signals and others. These studies will contribute in the enhancement of safety, mobility, and efficiency of transportation systems in the region.

5 STUDY METHODOLOGY

Due to the uncertainty of pavement performance, the need for pavement testing has been increased using real and long-term pavement monitoring and analysis. The full-scale construction of pavements under a representative climate and normal traffic loading provides more reliable pavement performance results.

5.1 Types of Test Loading

Ultimately, any loading identified for road testing track should successfully provide the same accumulated damages within the study period as predicted in the real service of roadways. There are two types of pavement test loading described in the following subsections.

5.1.1 Accelerated Pavement Testing

Accelerated pavement testing (APT) is implemented on road tracks to reach the end of pavement service life within a short period of time. In this method, the track sections are exposed to heavily loaded trucks travelling or circling the track. The trucks are traveling with specific rate to produce totally accumulated ESAL of about 10 million by the end of the study period. The accelerated loads represent about 20 years of traffic on typical rural interstate highways. Other experiments are conducted in the lab using an accelerated loading facility (ALF). The traffic loading is simulated by machines of rolling wheels applied on pavement test lanes with specific axle configuration and wheel loads. Figure 7 shows an example of ALF machines sponsored by FHWA. Multiple APT experiments have contributed to the development and verification of new specifications, designs, and test procedures for rigid and flexible pavements. However, the accelerated techniques does not fully address the effect of long-term pavement performance for age hardening and environmental variability.

Figure 7. Two ALF loading machines at FHWA's APT site (FHWA, 2019).

5.1.2 Conventional Traffic Loading

Another approach of pavement test loading is the use of conventional traffic instead of test vehicles or loading machines. Using this methodology, the biggest pavement evaluation study was developed by FHWA and SHRP, and was known as the Long-Term Pavement Performance (LTPP) program (Elkins et al., 2003). For more than 20 years, the pavement performance data has been collected on nearly 2,200 in-service test sections throughout the United States and Canada. All of these sections are subjected with real-life traffic loading. The main advantage of considering conventional traffic in pavement testing is the use of realistic traffic volumes with actual combinations of axel loads and configurations. In addition, the experiments minimizes the cost of loading pavements using testing vehicles and ALFs. On the other hand, the normal traffic loading generates additional costs for traffic monitoring and vehicle weighing such as weight stations and weight-in-motion (WIM) devices. It also requires long-term pavement monitoring to reach the end of the pavement service life through normal rates.

5.2 Pavement Performance Measurement

The success of testing road tracks depends mainly on the extensive and the high-quality data being collected throughout the study. Different equipment and methods are followed to measure the pavement performance data. They vary from destructive to non-destructive testing according to the type of pavement condition indices and research needs. Below is a list of some of these tests that are important for road track facilities:

- Geotechnical boring logs for subgrade evaluation.
- Binder and volumetric mixture design testing.
- Falling-Weight Deflectometer (FWD) data collected periodically to monitor the field strength of pavement structure.
- Laboratory testing of materials using core sampling.
- Strain gauges and temperature and moisture content sensors in the pavement sections.
- Field pavement survey, including visual distress, transverse and longitudinal profiling, ride quality, and friction.

6 STUDY ORGANIZATION

The proposed testing facility will require a significant investment in infrastructure and management. It is essential that this feasibility study is performed to identify potential needs and requirements to ensure the success of the proposed facility. Hence, the study will be divided into two phases which are described in the following subsections.

6.1 Phase I

The first phase will focus on the feasibility study to obtain sufficient relevant information for building and operating the regional testing facility in Wyoming. The purpose is to establish a preliminary understanding of the road track and pavement testing in the region. The study will also ensure that all stakeholders and partners are well coordinated to present beneficial participation. In this phase, pavement types, structures, and materials will be investigated to prioritize suitable design of experiments according to the scope of the regional research. Information about the geometric design of pavement will be collected including road track lengths and the number of test sections recommended for pavement testing in Wyoming. The duration to finish proposed studies will be estimated depending on the time of monitoring the pavement performance of test sections and rate of deterioration expected. In addition, potential locations of the testing facility will be determined where the choice should be appropriate for the availability of funds and the nature of the project under consideration. Another important pre-study is cost estimate verification which will be conducted in this phase. All necessary information of costs associated with constructing and operating the testing facility will be secured. This information will be used to assess the benefit-cost impact of the proposed road track. The results from the feasibility study are expected to provide informed decisions for the implementation of pavement testing of the regional facility in the second phase.

6.2 Phase II

The actual construction of the testing facility will be adopted in this phase. All proposed experiments will be implemented to field monitor the test sections. The pavement performance data will be compiled and analyzed to document the pavement testing results. The contribution from main findings will be disseminated to all participating partners to increase the pavement performance of their roadways. This phase is expected to provide necessary adjustments to enhance the pavement design and material specifications in Wyoming. It will also allow further development of pavement treatment and preservation strategies using cost-effective and innovative solutions.

7 WORK PLAN

The objectives of the first research phase (Phase I) will be achieved by performing the following tasks:

Task 1. Select a Study Advisory Group

The first task will set up a study advisory group to develop a strategic accelerated pavement testing plan. The group will advise and support all the research stages of the proposed regional track facility. This group should consist of highway experts to provide better understanding and clearer perspective for the design of the experiments. In addition, the advisory group is expected to provide directions for the research team.

Task 2. Identify the Research Facility Partnership

The collaboration between different partners is essential to transfer knowledge, innovation, and resources for the research development. This second task will identify potential partners of the proposed track facility. Numerous partners can be involved to improve their experience and research efforts. They are included in three main categories. The first category includes associations, universities, government entities, entrepreneurs, and consultants within the state of Wyoming. Several partners will be considered under this category which are:

- Wyoming Contractor Association (WCA)
- Wyoming Department of Transportation (WYDOT)
- Federal Highway Administration (FHWA)
- Wyoming Association of County Engineers and Road Supervisors (WACERS)
- Wyoming State Transportation Innovation Council (STIC)
- University Transportation Centers (UTC)/ Mountain Plain Consortium (MPC)

The second category seeks the potential collaboration of the surrounding states, including Montana, Idaho, Utah, Colorado, Nebraska, Washington, and South Dakota. The third category will connect to the asphalt and concrete pavement industry partners to provide engineering support. This would benefit the industry through shared information and practices. Multiple partners can be defined under this category such as Asphalt Institute (AI), National Center for Asphalt Technology (NCAT), American Concrete Pavement Association (ACPA), and others.

Task 3. Perform a Literature Search

In this task, a comprehensive literature search will be conducted to find key concepts of pavement testing facilities currently existed across the country. The literature review will investigate the previous research efforts to study the long-term performance of pavement test sections. It will also define the main issues considered when selecting the number of test sections and testing equipment. An insightful review will be conducted to prioritize the different methods that are suitable for the proposed testing track in Wyoming. Real-world testing will be investigated to enhance

Task 4. Identify Potential Testing of Other Transportation Infrastructure

This task will search for the application and development of effective transportation infrastructure testing that can be adopted on the proposed regional testing facility. There are multiple potential infrastructure which can be tested in the proposed facility to enhance safety, mobility, and efficiency of transportation systems in the region. The following shows some of these infrastructures:

- **Connected vehicle technology and crash avoidance**: In an intelligent transportation system, the vehicle to vehicle (V2V) technology develops effective interaction between vehicles for better communication. Real-world testing experiments can be adopted on the proposed regional facility to test different scenarios such as transferring data for road conditions, weather conditions, and lane keeping assist testing. The different experiments under various conditions of weather, traffic, and pavement types are expected to address drivers' behavior and vehicle sensor performance for improving both safety and efficiency of roads. Such testing will supplement ongoing research in this area.
- **Road safety features**: Since roadway features contribute in 33 percent of traffic fatalities, important features can be tested in the regional facility. These features might include many items affecting the safety of transportation systems such as: guardrails, snow fences, side slopes, signs, median barriers, rumble strips, etc. The experiments will determine the effectiveness in reducing severity of crashes by conducting before-after studies. Another objective of testing these features will be monitoring the performance of these features under adverse weather conditions and high traffic volumes.
- **Smart infrastructure systems**: Many technologies are being developed to collect and provide transportation system-level condition assessments and predictions to improve safety and mobility. Several approaches can be investigated in the proposed regional facility to accelerate the deployment of intelligent transportation system in the region. The proposed experiments will assess the interaction between vehicles and smart features such as adaptive signal control and smart streetlights. In addition, smart electronic tolls can be tested for traffic data collection and congestion verification.
- **Pavement marking and sign retroreflectivity**: The performances of pavement marking and sign retroreflectivetty are affected over time by environmental factors (i.e., sun exposure, dirt, ice, wind, etc.) and impacts from traffic (i.e., vehicle's tires and headlights). By using the proposed testing facility, the performance of these features can be analyzed showing the deterioration characteristics with respect to traffic and environment in the dry freeze region. Studies can be conducted to develop performance

models that will assist highway agencies in managing the maintenance of these features at the optimum time.

- **Bridge management**: Monitoring and inspections are important to achieve bridge performance objectives and goals, and maximize returns on investment. While promoting the use and understanding of bridge management systems, the proposed regional facility can include bridges with detailed inspection programs. These programs will help determine the causes of deterioration and strain, and recommend necessary corrective actions and maintenance. Other experiments will evaluate the cost-effectiveness of using innovative techniques for bridge inspection such as real-time monitoring sensors and unmanned aerial systems (UASs). These experiments can be implemented with various structural features and design spans depending on the regional research needs.

Task 5. Conduct a Partner Survey

In conjunction with the literature search, a survey will be sent out to all potential partners defined previously in the second task. The main objective of the survey is to secure feedback about the research interests and needs for the Wyoming regional track facility. The results from the survey are expected to measure the level of partners' interests for the different type of research studies recommended regionally for Wyoming road track facility. The contribution from study partners will enable research team to ensure that the research interests and challenges are addressed. In addition, the survey will include questions about the design of experiments, loading mechanism, types of materials, etc. The survey will also identify building facilities proposed for the road track. These buildings may include pavement materials lab, vehicle maintenance unit, storage building, and building operations and monitoring control. Such information is critical to produce a reliable road track facility that provides beneficial and practical results while monitoring the performance of pavement in Wyoming.

Task 6. Organize Field Visits

Field visits of the nation's major accelerated pavement track experiments are important to consult about the best practices and research needs. Professional organizations will demonstrate to the research team these facilities to increase the engagement and gain more effective learning. This task provides a unique opportunity to see innovation at work. The outcomes will be documented for the benefits of design, construction, and instrumentation of the proposed regional track in Wyoming. The number of visits will be determined based on the budget allocated for travel in this study.

Task 7. Identify Potential Locations for the Road Test Track

After getting all related information to build an effective test track, the Principal Investigators will work closely with WYDOT to find an appropriate location of the facility on I-80. The potential locations will be identified according to several parameters. First, the proposed regional facility should be located in a representative climate zone with adequate right-of-way. In addition, the variation in pavement materials and subgrade soil types will be considered to study the pavement performance under diverse structural conditions. The track facility should also be able to produce results within 5 years of operation using either an accelerated load mechanism or accumulated traffic loads currently existed on I-80.

Task 8. Estimate the Costs of the Test Track Facility

This task will assign a dollar value on the proposed regional road test track. A detailed cost information will be estimated for both constructing and operating the regional facility. Such information will be collected from contractors and associations that will be responsible for building the road track. The cost information will include initial design, construction of track's foundation and pavement structure, pavement sensors and data collection equipment. Also, costs of building on-site facilities will be investigated such as laboratories, truck maintenance facility, etc. Other important components of the facility will be identified according to previous experiences derived from site visits and partners' knowledge.

Task 9. Perform a Benefit Cost Analysis for the Facility

After determining the costs of the road test track, a benefit-cost analysis will be conducted to determine if the regional facility is financially feasible. A comprehensive evaluation will be performed for all potential costs and revenues that will be gained from the research efforts of the road track. The process of testing pavement under actual conditions of loading and climate will develop more representative pavement performance. This will lead to important adjustments in the maintenance and design policies of pavement to reduce distresses/cracking and increase pavement service life. It will also provide opportunities for integrating innovative pavement treatments and materials. The outcomes of these efforts will be evaluated in forms of cost savings while design and maintaining roadways.

Task 10. Outline the Relationship between WYDOT and University of Wyoming

The potential relationship between WYDOT and the University of Wyoming will be investigated to explore the effective manners to run the proposed facility. In addition, the expected benefits of jointly operating this research will be documented, including the educational benefits for graduate/undergraduate pavement engineers who will have better employment opportunities for WYDOT.

Task 11. Prepare a Final Report

A final report will be prepared summarizing all findings of the tasks. The report will also develop detailed recommendations regarding the implementation of the proposed road testing track in Phase II.

8 BUDGET AND TIMELINE

This study is expected to be completed in 2 years. The tasks of this research require the contributions of a graduate student, a faculty member, and a postdoc. Table 1 summarizes the budget of this study. The overall cost of the study to WYDOT will be $102,002.

Table 1. Budget of the Project.

Categories	WYDOT Cost
Center Director Salary	
Faculty Salaries	$9,600
Engineer/ Post Doc	$9,500
Faculty/Engineer Fringe Benefits (43.3%)	$8,270
Student Salaries	$29,000
Student Fringe Benefits (3.9%)	$1,131
Total Personnel Salaries	$48,100
Total Fringe Benefits	$9,401
TOTAL Salaries & Fringe Benefits	**$57,501**
Travel	$12,000
Equipment	$0
Supplies	$4,000
Contractual	
Construction	
Other Direct Costs (Specify)*	$11,500
TOTAL Direct Costs	**$85,001**
F&A (Indirect) Costs	$17,000
TOTAL COSTS	**$102,002**

* Graduate Students Tuition and etc.

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