Measuring Field Performance of High-Modified Hot-Mix Asphalt Material over Rubblized Base

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University

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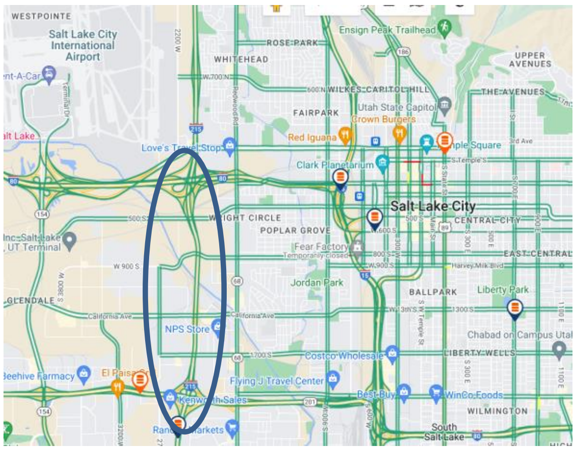
Research Needs

High-modified hot-mix asphalt mixtures (High-Mod HMA) have the potential to **transform** the way pavements are designed, constructed, and maintained. Trial sections done at the Wendover Port of Entry and at the West Davis Corridor in Utah have demonstrated the ability of this mix to resist rutting, cracking, while significantly reducing the cost of construction. Given the success of these trial sections, a new application of this mix is being planned on Interstate I-215, west side, in Salt Lake City, UT during Fall 2025. This location is shown in Figure 1.

This application involves rubblizing the existing concrete pavement (i.e., breaking it into small pieces) and applying a 6-inch-thick layer of High-Mod HMA on top. This is an innovative approach to pavement construction since it repurposes existing materials while leveraging them to provide support for the new structure. The design specifies a relatively thin HMA layer for an interstate highway section, therefore it is essential to properly understand and verify its actual behavior to allow for potential nationwide implementation of this **transformative** technology capable of modernizing the transportation system of the future. The expectation for the system is that the rubblized base will provide sufficient stiffness to support the pavement structure, and despite the likelihood of high strains in the asphalt mixture, the high binder content and polymer modification in the new High-Mod HMA will produce a strain-tolerant system.

This **transformative** pavement system needs to be properly understood and its performance documented to ensure success in future designs and applications that incorporate this mix/process into the mechanistic-based design of pavements. Knowing the actual strains and deformations from the different traffic loads will lead to a better understanding of how to meet the challenges of the present pavement design using these mixes and ensure future success. This will result in designs that **transform the way pavements are constructed.** At the same time, the ability to reuse the existing concrete layer with a relatively thin HMA layer application will result in potential cost savings in materials and construction that would lead to **resilient and sustainable designs** that will benefit and protect communities.



a) Location of project in Salt Lake City, Utah

b) Image of concrete pavement to be rubblized on I-215

Figure 1: Proposed Rubblization and High-Mod HMA project location (Google Maps)

Research Objectives

The objectives of this research are to: (1) measure the mechanical response to traffic loads of the High-Modified Hot-Mix Asphalt over rubblized concrete base, (2) document the short-term performance of the system, and (3) verify the models and assumptions used to design this pavement section by comparing the predictions to actual measurements.

At the conclusion of this project, pavement and materials engineers will have a better understanding of the behavior, and thus the applicability, of high modified hot-mix asphalt mixtures to high-value roads. Such innovation will result in a **transformation** of the hot-mix asphalt construction industry.

Research Methods

The proposed research project will rely on field instrumentation to record the strains and deformations caused by actual loads on a novel pavement system. These measurements will be compared to existing models used for pavement design and maintenance decisions. By comparing the measured values to the modeled ones, we will gain insights into the performance of this novel pavement system, enabling potential future applications at both regional and national levels.

It is known that traffic loads result in cracking and rutting of a pavement leading to a poor state of repair; and that these distresses are the result of deformation and strains within the pavement [1], [2]. In particular, cracking is the results of excessive repeated strains at the bottom of the bound (asphalt concrete) layer, while rutting is the result of vertical deformation in any layer of the pavement system [3]. This research will install strain sensors in the wheel path of the asphalt concrete layer to measure the response to actual loads. The sensors will be installed during the construction process, prior to the application of the High-Mod HMA layer. Once in placed, the measured values will be analyzed and used to evaluate the effectiveness of existing designs. This knowledge will be used to transform the way pavements will be design in the future.

Based on a comprehensive review of previous field studies as well as current instrumentation available [4], [5]; it is proposed that a set of transducers capable of withstanding the paving operation be installed after the pavement has been rubblized and before the High-Mod HMA is applied. The sensors will be placed on two different lanes along the wheel path preceded by a load sensor gauge. A picture of the strain transducer and its installation is shown in Figure 2.

a) Asphalt Strain Transducer

b) Installation of strain gauges prior to paving operation

Figure 2: Measuring Strain in Asphalt Pavements (Photos from BDI Test Systems)

The annual average daily traffic (AADT) in 2022 for this pavement section was reported as 124,295 vehicles, with approximately 15% trucks [6]. These values make this project an ideal situation to study the effects of traffic loads on road performance. It is known that most trucks do not travel in the outside (left most) lane. Therefore, to properly capture the traffic loads, the sensors will be installed at two locations in the outside wheel path of the inner (rightmost) lane and at two other locations on the inside wheel path of the middle lane as shown in Figure 3. Four sensors will be placed in the longitudinal direction and another four will be placed in the transverse direction. The number of sensors was selected based on budget constraints while providing for redundancy to account for sensor failure and data reliability.

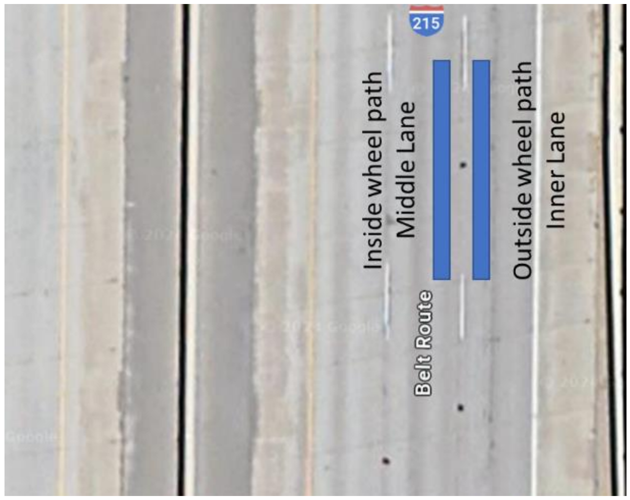


Figure 3: Proposed Sector Location Shown in Blue

The actual site (i.e., milepost) where the sensor will be installed will be selected once the construction contract has been advertised to ensure the cooperation with the contractor. The primary factor to consider will be safe access to the site during and after construction; other factors include availability of power (solar power is being considered), and traffic representation and expected speed based on distance to any on-ramps.

Relevance to Strategic Goals

As previously described, the proposed project is directly linked to the **Transformation** in pavement design. A better understanding of the strains and deformations in a pavement system will allow for longer lasting design and better performance predictions capable of modernizing the transportation system of the future. A secondary benefit would be demonstrating that High-Mod HMA over a rubblized base is a viable alternative that results in resilient designs that use in-place materials, thus potentially reducing greenhouse emissions related to transporting material to the site. This will result in a sustainable system that addressed **Climate and Sustainability.**

Educational Benefits

This CTIPS project will fund one student for a year while the companion UDOT project would fund the second year. Students will be directly involved in the installation of the sensors and corresponding monitoring of data. Their learning experience will result in countless educational benefits. Additionally, the lessons learned as part of this project will be incorporated into future teaching lectures.

The asphalt paving industry is also very interesting in learning about High-Mod HMA and its applications. This work will greatly expand the knowledge of this material beyond academia into practice.

Outputs through Technology Transfer

Technology transfer is a key component of this work. Multiple avenues for technology transfer will be incorporated throughout the project; this includes a seminars and presentations to researchers and practitioners, as well as serving as a significant step towards further development into guidelines related to the application of High-Mod HMA and novel pavement construction. The guidelines and specifications are expected to **transform** pavement design; that is the relevant contribution of this project.

In terms of the proposed seminar and presentations, among a number of alternatives, the research team might accomplish the following:

- Seminar as part of UDOT's Continuing Education program using a hybrid format with participants joining in person and online. Such seminars are widely attended by practitioners from the agency as well as consultants in the area, both within the state and regionally.
- Webinar for practitioners through the Transportation Learning Network.
- Conference presentation to disseminate the outcomes of the project, with a main target being TRB's Annual Meeting. Likewise, FHWA asphalt technical working group, local and regional Asphalt User-Producer groups, and other technical committees are an open avenue for such presentations.

Enhancements from the proposed project will allow the research team to disseminate the research outcomes through avenues discussed in coordination with UDOT. Thus, the outcomes of the project will have further potential to reach practitioners and researchers through the recommendations and specifications to be developed which will be directly available through a site provide by UDOT.

Expected Outcomes and Impacts

The overall project will provide quantifiable data regarding the strains and deformations within the asphalt concrete layer caused by actual traffic loads in a novel pavement system. This information is critical for the adoption of High-Mod HMA since it will allow for significant advances in modeling, construction practices, and procedures for mechanistic pavement design and maintenance. Based on the expected results from this work, the application of novel pavement system in which rubblization and special HMA is used can be extended to projects outside the region. This will allow the project to have a greater impact.

Beyond the research report, the data from this research will promote a more economical and durable system and could produce changes to the AASHTOWare Pavement Design software (or its application). In addition to that, it will give better understanding of sensors to measure pavement data, and construction guidelines.

Work Plan

Given the fact that the proposed project involves field measurements, close coordination with Utah Department of Transportation and Contractors will be necessary. The following are considered the major task for this project.

Task 1 – Selection and evaluation of sensors

1.1 Review available sensors and their capabilities

1.2 Acquired sensors and create a laboratory mockup to ensure sensor capabilities

1.3 Create a draft report documenting sensor capabilities

Task 2 – Determination of sensor location

2.1 In cooperation with UDOT and the contractor, the location of the sensors will be determined. The location will be based, first and foremost, on safety and access and then on availability of power, location of on ramps, and construction schedule.

Task 3 – Installation of Sensors

3.1 Schedule a meeting with the contractors to ensure proper coordination

3.2 Install sensors after pavement has been rubblized but before leveling layer of High-Mod HMA is applied

3.3 Verify sensor operation once High-Mod HMA layer has been applied

Task 4 – Data Collection

4.1 Develop a Safety Plan and provide training to ensure a safe operation

4.2 Collect data during pavement operation. This will include temperature, load, and strains.

Task 5 – Analysis

5.1 Analyzed collected data

5.2 Compare measured data and modeled data and recommend adjustments

Task 6 – Report

6.1 Prepare a draft report

6.2 In coordination with CTIPS, a seminar, webinar, or similar information dissemination method will be scheduled. Dissemination also includes journal articles.

6.3 Prepare a final report

The proposed timeline is shown on Table 1. Construction for this road is scheduled for Fall 2025, therefore, there are constraints on certain activities and times might need to be adjusted.

Table 1 – Proposed Timeline Based on Quarters from the Start of Contract.

	Q1	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**
Task 1	■	■	■	■						
Task 2				■	■					
Task 3					■	■				
Task 4						■	■	■	■	
Task 5								■	■	
Task 6										■

Project Cost

Total Project Costs:	$190,000
CTIPS Funds Requested:	$ 95,000
Matching Funds:	$ 95,000
Source of Matching Funds:	Utah Department of Transportation

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