SPR RESEARCH PROGRAM
SECOND-STAGE PROPOSAL SUMMARY

PROBLEM NUMBER AND TITLE

24-44 A Low Carbon and More Economical Paving Strategy for Low-Volume Roads - Emulsified Asphalt Concrete with High Recycled Asphalt Pavement (RAP) Content

PROBLEM SUMMARY

If successful, this research will determine the effectiveness of emulsified asphalt concrete (aka cold mix asphalt) with high RAP content for paving low-volume roads. In addition, the performance of rejuvenators, highly polymerized binders and other additives on emulsified asphalt concretes will also be evaluated.

ODOT OBJECTIVES

ODOT primary objective is to identify appropriate additive that will result in cold-mix asphalt pavements that are durable and comparable in cost with traditional warm-mix asphalt mixes.

BENEFITS

Primary benefit for ODOT is to identify a cold mix formula that includes modern additives and recycled asphalt and results in asphalt pavements that perform comparably to hot-mix asphalt pavements. Cold mix asphalt technology enables incorporates benefits over traditional hot-mix asphalt such as significantly less carbon footprint and simplified construction logistics given the mobility of the mixing plant.

SCHEDULE, BUDGET AND AGENCY SUPPORT

Estimated Project Length: 24 months.
Estimated Project Budget: $285,000
ODOT Support
Chris Duman, Interim State Pavement Engineer
Justin Moderie, State Construction and Materials Engineer

FOR MORE INFORMATION

For additional detail, please see the complete STAGE 2 RESEARCH PROBLEM STATEMENT online at:
https://www.oregon.gov/odot/Programs/ResearchDocuments/24-44.pdf

SPR RESEARCH PROGRAM
SECOND-STAGE PROBLEM STATEMENT
FY 2024

PROBLEM NUMBER AND TITLE

24-44 A Low Carbon and More Economical Paving Strategy for Low-Volume Roads - Emulsified Asphalt Concrete with High Recycled Asphalt Pavement (RAP) Content

RESEARCH PROBLEM STATEMENT

According to the 2022 ODOT Pavement Condition Report (Coplantz, 2023), the current ODOT pavement program is significantly underfunded ($280M is needed while the expected funding for 21-24 STIP is less than $115M and 24-27 STIP is around $110M), which is expected to result in a decline in pavement conditions in Oregon within the next five years. It was also mentioned in the same report that *"Preliminary indications are that pavement funding levels for the 27-30 STIP may be as low as $65 million per year or even lower. Even before considering inflationary effects, this funding level is lower than it has been in decades"*. As a result of this reduction in overall state funding, there will be about a 25% reduction in the funding for the Maintenance program for fixing the low-volume roads in the 23-25 biennium. The reductions in funding in previous years have already started to show their effects as a decline in pavement network condition for all 5 regions in Oregon (see Figure 9 in the 2022 ODOT Pavement Condition Report).

According to the same report (Coplantz, 2023), the condition of low-volume roads has been declining, requiring extensive paving rather than continuous chip sealing to improve their condition. Although chip sealing has been an effective strategy for ODOT for maintaining low-volume roads, chip sealing is a pavement preservation strategy that does not improve the structural resistance of the pavements and should not be used on roads with poor surface or structural conditions. For these reasons, the effectiveness of low-cost and environmentally friendly options, such as cold-mix asphalt (mostly referred to as emulsified asphalt concrete (EAC) in Oregon) with high Recycled Asphalt Pavement (RAP) contents, should be evaluated to improve the structural resistance and condition of Oregon's low-volume roads. In addition, the effectiveness of using new emulsion types (highly polymerized asphalt binders and others), rejuvenators, and other additives to improve the performance of pavements with EAC in Oregon should be determined.

According to the 2022 ODOT Pavement Condition Report (Coplantz, 2023), *"About 95% of ODOT's state highway network is asphalt surfaced while the remaining 5% is concrete pavements"*. With the increases in paving costs due to the rapidly increasing asphalt binder costs and high inflation rates, EAC with high RAP contents (about 60-80% of the mix can be RAP) stands out as a cost-effective paving strategy for maintaining low-volume roads in Oregon. In addition, since EAC production does not require excessive heating of aggregates and the binder at an asphalt plant, production of EAC is significantly less carbon intensive than its Hot-Mix Asphalt (HMA) and Warm-Mix Asphalt (WMA) counterparts. Since mobile asphalt plants can be used to produce EAC, greenhouse gas (GHG) emissions can be further reduced due to reduced hauling distances (Diefenderfer et al., 2021). However, although comprehensive design and testing methods are currently being implemented and used by ODOT for HMA and chip seals, design and performance evaluation methods specifically for EAC currently do not exist in Oregon. Since the material properties of EAC mixtures are significantly different from other road construction materials, unique test and rapid quality assurance methods, specifications, and new strategies should be developed and implemented to achieve high-performance EAC mixtures with high RAP contents. The effectiveness of chip sealing on top of the new EAC layer with high RAP content to improve the overall longevity of both the EAC and the chip seal layers should also be investigated.

RESEARCH OBJECTIVES

This research study will have five major objectives: i) Develop laboratory and rapid field performance tests for process controls, product acceptance, and quality assurance for EAC; ii) Quantify the impact of aggregate gradation, binder content, and binder type on EAC performance; iii) Determine the impact of rejuvenators, highly polymerized asphalt binders, and other additives on EAC performance; iv) Develop strategies to incorporate high RAP percentages (60-80% by total weight) into the EAC mixtures without sacrificing long-term performance; and v) Develop and report a plan for the development and implementation of mixture design methods for EAC.

WORK TASKS, COST ESTIMATE AND DURATION

1) *Literature review:* A comprehensive literature review will be conducted to summarize the past and current research studies focusing on improving and evaluating EAC performance, especially the ones on EAC mixtures with high RAP. Existing laboratory and field test methods for EAC will also be summarized. A detailed investigation will also be conducted to report the current production procedures (including better RAP management procedures) followed for EAC mixtures.

   The research studies focusing on developing test and design methods for EAC are limited. The two major studies were the field test section constructions and long-term performance monitoring performed at the National Center for Asphalt Technology (NCAT) and Minnesota Department of Transportation, referred to as MnROAD, test tracks (Diefenderfer et al., 2021). Although these two research studies provided important information regarding the EAC, field test sections for both studies were in climates and traffic levels that were significantly different from Oregon. In addition, the properties of aggregates and emulsions significantly vary between different states due to different geological factors and different asphalt binder sources.

2) *Developing performance test methods:* Laboratory and field test methods for evaluating the fatigue cracking, deformation, raveling, and thermal cracking performance of EAC mixtures will be developed. Rapid field quality assurance and product acceptance tests for the measurement of in-situ EAC moisture content, evaporation rate, curing time (to determine when to start compacting and open to traffic), density, penetration resistance, and shear resistance will be developed. Several mixtures with different expected performance levels (high/low RAP, with/without rejuvenators, aggregates and binders with/without compatibility issues, etc.) will be tested with the most promising test methods to determine the effectiveness of the test methods in identifying differences in mixture properties.

3) *Developing strategies to increase RAP content without sacrificing performance:* Mixtures with various RAP contents, gradations, binder contents, rejuvenators, highly polymerized asphalt binders, and other additives will be tested using the selected test methods. Test results will be analyzed to determine the most effective methods for achieving high-performance EAC. The highest RAP content that can be achieved without performance issues will also be determined.

4) *Field construction and trials:* Based on the knowledge gained from tasks 1, 2, and 3, field test sections will be constructed using the most promising EAC mixtures and construction methods. The effectiveness of the field test methods developed in task 2 will also be evaluated and reported based on the findings from this task.

5) *Develop a plan for the development and implementation of mixture design methods:* Using the selected test methods from the previous tasks and the findings from the literature review, a plan for the development and implementation of EAC mixture design methods will be developed.

Key Deliverables: i) Laboratory and field test methods for evaluating EAC mixture performance; ii) Rapid field quality assurance and product acceptance tests for EAC; iii) Production and mix design recommendations and strategies to reach 60-80% RAP content without sacrificing long-term performance; iv) A plan for development and implementation of EAC mixture design methods.

Estimated Project Length: **24 months**
Estimated Project Budget: **$285,000**

IMPLEMENTATION

The following products will be developed and implemented in this research study: i) Laboratory and field test methods for evaluating the fatigue cracking, deformation, raveling, and thermal cracking performance of EAC mixtures; ii) Rapid field quality assurance and product acceptance tests for the measurement of in-situ EAC moisture content, evaporation rate, curing time (to determine when to start compacting and open to traffic), density, penetration resistance, and shear resistance; iii) Production and mix design recommendations and strategies to increase the RAP content of EAC mixtures without sacrificing performance; iv) Recommendations regarding the benefits of constructing a chip seal layer on the newly constructed EAC layers with high RAP; v) Guidelines regarding the use of rejuvenators, new emulsion types, and other additives to improve EAC performance and increase the RAP content; and vi) A detailed plan for the development and implementation of EAC mixture design methods with performance tests.

POTENTIAL BENEFITS

Since 1999, ODOT has gradually changed the definition of low-volume roads from *"roads with traffic levels less than 1,000 average daily traffic (ADT)"* to *"roads with less than 5,000 ADT and less than 3 million 20-year equivalent single axle truck loads (ESALs)"*. These changes moved several statewide highways into the low-volume road category. As a result of those changes, **about 45% of the state highway mileage falls into the low-volume road category today** (in central and eastern Oregon, these routes are approximately **70% of non-interstate highway miles**). This significant percentage points out the importance of low-volume roads in Oregon. Any significant reduction in the condition of low-volume roads due to delayed maintenance, *which is inevitable in the long run due to inadequate funding levels and increasing cost of paving,* can cause structural pavement failures, which will require costly rehabilitation or reconstruction.

Asphalt binder costs increased from about $320/ton to about $700/ton in the last two years due to the significant increase in oil prices. This significant increase in binder costs, combined with the high inflation, started to increase the importance of recycling and lower-cost options for pavement preservation. Due to the possibility of using high RAP contents in EAC (about 60-80% of the mix can be RAP) with the help of new additive technologies, the **cost of high RAP EAC is going to be significantly less than HMA**. In addition, the use of high RAP, potential reduction in hauling distances, and significantly reduced asphalt production temperatures for the EAC make it an exceptional choice for **reducing carbon emissions**.

Since a high percentage of low-volume roads generally exist in rural areas or connect rural areas to urban regions, improving their condition directly affects those living in rural regions. For this reason, this research study addresses the **equity and inclusion priorities of ODOT**. In addition, since EAC does not require excessive heating, it can be quickly produced even in the off-construction season (Fall and Winter), which makes it an essential alternative for **rapid construction and recovery after a natural disaster.**

PEOPLE

ODOT champion(s):

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REFERENCES

Coplantz, J. (2023). *2022 ODOT Pavement Condition Report.* Oregon Department of Transportation, Pavement Services Unit and Pavement Management Team.
Diefenderfer, et al. (2021). *Proposed AASHTO Practice and Tests for Process Control and Product Acceptance of Asphalt-Treated Cold Recycled Pavements.* NCHRP 960, Washington, DC.

STAFF REVIEW PAGE

Literature Check

TRID&RIP

☒ A review of TRID & RIP databases found no existing research that answers the research question

Technology & Data assessment

☒ No Identified T&D output

☐ At the end of this project, the implementing unit(s) within ODOT will need to coordinate the adoption of new technology or data in order to realize the full potential of this research.

Cross-agency stakeholders

- List stakeholders or impacted units
    - Pavement Services

- Identify any issues of concern raised by an ODOT stakeholder. Note expected mitigation
    - No issues were identified.