2401E3–Design of Surface Treatments with Reclaimed Asphalt Pavement Aggregates in Nevada

Submitted To:

Nevada Department of Transportation
Research Section
1263 S. Stewart Street
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June 19, 2024

Submitted By:

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1. TITLE–Design of Surface Treatments with Reclaimed Asphalt Pavement Aggregates in Nevada (NV).

2. PRINCIPAL INVESTIGATORS

This project will be collaboratively conducted by the UNR Team, which includes the University of Nevada, Reno (UNR) Pavement Engineering & Science (PES) Program, Idaho Asphalt Supply (IAS), and National Center for Pavement Preservation (NCPP)–Michigan State University (MSU).

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3. PROBLEM DESCRIPTION

Surface treatments (STs), including chip seals and slurry/microsurfacing, are effective methods for maintaining asphalt concrete (AC) pavements. Using reclaimed asphalt pavement (RAP) as aggregates for STs conserves natural resources and promotes the design and construction of sustainable pavements. However, related changes in mix design and construction must be addressed for effective implementation. Although some national research has been conducted on the use of RAP as ST aggregates, the unique characteristics of Nevada's asphalt mixtures, such as lime treatment and polymer-modified asphalt binders, limits the applicability of existing findings from the literature. Figure 1 shows typical RAP materials from northern and southern Nevada. The northern RAP material is darker due to higher asphalt binder content, while the southern RAP material is lower in asphalt binder. Thus, the availability of RAP binder and its impact on ST properties will vary based on RAP source. Thus, it is essential to develop mix designs and specifications that account for the specific properties of Nevada's RAP that will ensure effective, sustainable, and durable STs.

(a) Northern NV RAP.

(b) Southern NV RAP.

Figure 1. Typical RAP from NV.

4. BACKGROUND SUMMARY

The Nevada Department of Transportation (NDOT) does not allow the use of RAP as aggregates for AC pavement STs. Most NDOT's RAP is used in asphalt mixture or on shoulders. Using RAP can potentially enhance the performance of STs by improving moisture resistance and reducing oxidation of the asphalt residue, which leads to less chip loss in chip seals and reduced raveling of microsurfacing. RAP also offers economic and environmental advantages. Where it is possible the cost of RAP may be lower, and the need for virgin aggregate may be reduced.

A preliminary review of the use of RAP in chip seals and microsurfacing identified seven studies completed within the past 10 years. All studies evaluated the use of RAP in microsurfacing while only three investigated the use of RAP in chip seals. It is hypothesized that the greater efforts on the use of RAP in microsurfacing may be due to the availability of standard methods for evaluating the performance of microsurfacing recommended by the International Slurry Surfacing Association (ISSA)[1] while such methods do not exist for chip seals. Table 1 shows a summary of findings from precursory reviewed studies. These, studies, summarized in Table 1, concluded that microsurfacing with 100% RAP as aggregate can be designed following the ISSA method.

A recent study [Sayeh, W., et al. (2023), FHWA-ICT-23-016] that assessed the economic and environmental benefits of RAP in STs concluded: "*using RAP in preservation treatments would reduce the impact on the environment by reducing energy, global warming potential, and* *greenhouse gases while providing cost savings."* Table 2 summarizes agency practices on using RAP in STs based on published literature and conversations with agencies and contractors.

Table 1. Summary of Key Findings from Preliminary Literature Review.

Title	Key Findings
Robati, M., et al. (2013). "Incorporation of RAP and Post-Fabrication Asphalt Shingles in Microsurfacing Mixture," CTAA.	• Using 100% RAP has no impact on moisture sensitivity and raveling but increased the vertical and lateral displacement in the loaded wheel test.
Wang, A., et al. (2019). "Micro-surfacing mixtures with reclaimed asphalt pavement: Mix design and performance evaluation," CBM No. 201.	• Microsurfacing with RAP had improved resistance to skid and freeze-thaw cycling. • Rejuvenators improved mixing time and rutting resistance of microsurfacing with RAP.
Saghafi, M., et al. (2019). "Performance Evaluation of Slurry Seals Containing Reclaimed Asphalt Pavement," TRR Vol. 2673.	• Microsurfacing with RAP experienced 50% lower mass loss in the wet track abrasion tester (WTAT) than with virgin aggregate. • Microsurfacing with RAP exhibited higher resistance to rutting and skid resistance than with virgin aggregate. • Microsurfacing with RAP is 14% less expensive.
Poursoltani, M. and Hesami, S. (2020). "Performance Evaluation of Microsurfacing Mixture Containing Reclaimed Asphalt Pavement," IJPE, Vol 21, No. 12.	• Microsurfacing with RAP required 1% more emulsion but less additive than with virgin aggregate. • Microsurfacing with RAP had higher mass loss in the WTAT than virgin aggregate. • Microsurfacing with RAP showed better resistance to flushing in the loaded wheel sand adhesion test.
Duncan, G., et al. (2020). "Using Reclaimed Asphalt Pavement in Pavement-Preservation Treatments," Report No. FHWA-HRT-21-007.	• Using RAP reduced aggregate costs by up to 30%. • RAP containing soil or geotextile fabric is unsuitable. • RAP improved bonding, oxidation resistance, chip loss, and texture. • Preservation treatments with RAP performed similarly to those with virgin aggregate.
Ye, H. (2021). "Innovative Evaluation of RAP use in Slurry Seal Applications," MS Thesis, MSU.	• The rutting resistance measured in the Hamburg wheel track test (HWTT) of RAP mixtures is similar to that of 100 % virgin aggregate.
Robbins, M., et al. (2021). "Design of Microsurfacing and Chip Seal Mixes with RAP for Local Roadway Application," FHWA/OH-2021/26	• 100% RAP is a suitable alternative to virgin aggregate in chip seal and microsurfacing mixes. • Microsurfacing with RAP outperformed virgin samples. • Properly designed and constructed RAP chip seals can provide similar or better performance than conventional chip seals. • RAP costs $12 per ton less than virgin aggregate, offering 50% total cost savings in 100% RAP chip seal and microsurfacing.

Table 2. Summary of Agency Practices.

Agency	Treatments	Key Considerations
Arizona–City of Phoenix & surrounding municipalities	Slurry/ Microsurfacing	• 100% RAP in Microsurfacing on Arterials and above. • 100% RAP in Slurry for residential streets.
	Chip Seal	• 100% RAP Chip Seal mostly as an underlayment for HMA paving.
California	Chip Seal/ Microsurfacing	• Good performance of both STs after 10 years in service.
Kentucky	Microsurfacing	• Completed trial projects with RAP Blend. The leveling course is 100% RAP but the surface is a 50% blend with a non-polish resistant type D aggregate. • Planning projects with 100% RAP.
New Jersey	Microsurfacing	• Completed a study using 100% RAP. Developed draft specifications.
New Mexico	Chip Seal	• Same performance as with virgin aggregate. • Darker surface of RAP improved safety. • Easier to work with RAP for in-house crews. • Better adhesion between RAP and asphalt residue.
Ohio	Chip Seal	• Developed a design method for RAP as aggregate.
Ohio–City of Lancaster	Chip Seal	• Did a 100 % RAP Chip Seal with chips screened resulting from the process of making Microsurfacing aggregate.
	Microsurfacing	• Completed a Test Project with 100% RAP in 2022 and followed by multiple streets completed in 2023. More planned for 2024.
Pennsylvania	Chip Seal	• Developed a design method for RAP as aggregate.
	Microsurfacing	• Completed a test Project in 2023 with two lifts. Agency supplied the screened RAP from DOT stockpiles

5. PROPOSED RESEARCH

As stated in the Research Problem Statement, the following are the project's specific objectives:

- Develop and conduct laboratory and field tests/methods for the evaluation of RAP materials as aggregates for ST, using locally available sources from each of the three NDOT districts.
- Develop mix design methods/optimum limits for RAP use for ST with RAP aggregates using locally available sources from each of the three NDOT districts.
- Develop test methods for quality assurance of ST during construction.
- Develop specifications for material processing and construction of STs with RAP aggregates.
- Perform a feasibility and economic analysis to support the potential use of RAP in STs statewide.

To successfully achieve the study objectives, the following tasks and subtasks will be completed. The UNR Team and NDOT will have a kick-off meeting within 3 weeks of the contract's start date to discuss and clarify the proposed research plan. The UNR Team will then proceed with revisions according to NDOT feedback and with the execution of the research plan.

Task A: Critical Review of Literature and Specifications

A comprehensive critical analysis and review of relevant domestic and foreign literature, research findings, and information on using and testing RAP aggregate material in ST will be conducted. The NCPP's involvement in preservation activities will be utilized to gather up-to-date information on specifications, testing, best practices, anecdotes, in-service performance, and lessons learned. The UNR Team will leverage NCPP's regional partnerships and meetings to interact with agencies (local, state, Canadian provincial), industry, academia, FHWA, and relevant subject matter experts (SMEs). The Emulsion Task Force (ETF) will also be engaged for insights. Agency specifications on RAP in STs will be reviewed to identify relevant materials, mix design methods, construction specifications, and quality assurance systems. The UNR Team will contact Caltrans, other DOTs, and contractors with relevant experience. An interim report summarizing the findings from the literature and specification reviews will be submitted to NDOT for review and discussion.

Task B: Feasibility and Economic Analysis of Using RAP in STs in Nevada

RAP is managed differently, where some agencies may directly own it, others may own only a portion of it with the rest going to the contractor, and in other instances, it is the property of the contractors. Depending on where and how RAP is stored/stockpiled as well as managed at construction, there are varying costs for transportation, re-crushing, and screening of the material. Using RAP can introduce additional construction costs, such as the need for rolling, which may not be necessary with virgin aggregates. Accordingly, a feasibility and economic analysis on the potential use of RAP in STs statewide will be conducted. The aim is to assess the availability and economic impact of using RAP instead of virgin aggregate and to identify the most cost-effective approach for incorporating RAP in STs. This task will consider the following key factors specific to Nevada:

1. ***Project types.*** NDOT Maintenance Self-Performed versus Betterment.
2. ***Locations.*** NDOT OTC Districts and Zones, maintenance station locations, other NDOT material storage locations; and reasonable haul distance (radius) from commercially available RAP sources.
3. ***RAP Handling.*** Processing requirements for RAP in asphalt mixtures versus STs.
4. ***Financials.*** The economic value of RAP in asphalt mixtures versus RAP in STs.

Project types are included, as RAP procurement for NDOT Maintenance Self-Performed projects would likely occur through the Open Term Contract (OTC) process or simply the use of NDOT rehabilitation project generated millings, while for Betterment projects, contractors would purchase RAP from commercial sources. Additionally, NDOT could mandate that RAP from mill-and-fill or overlay projects be stockpiled at NDOT Maintenance facilities. **Location** is another important factor because of the cost and carbon footprint associated with haul distance. The benefits of using RAP could diminish with haul distance, especially as the distance from commercial RAP sources to project or storage locations increases. **RAP processing** requirements for use in asphalt mixtures versus use in STs will be different as <u>*RAP in STs will have to be finer*</u>, especially for microsurfacing. The finer RAP has higher surface area and higher asphalt binder content relative to coarser RAP. Thus, fine RAP has a greater value in asphalt mixtures than coarse RAP, which could impact its availability and potential use in STs. Some commercial asphalt mixture producers crush and fractionate RAP into coarse (+3/8") and fine (–3/8") RAP. This fractioning helps optimize the proportions of each in asphalt mixture using as much fine RAP as possible to minimize the amount of high-cost virgin asphalt binder. It may be economical for commercial RAP sources to re-circulate and crush the coarse fraction for STs. RAP asphalt content, processing requirements and cost, RAP haul distance, and quantity of RAP that would be used will collectively drive the **economics** for contractors.

The outcomes of items 1–4 are expected to establish a set of conditions to be considered for including or excluding RAP in NDOT Maintenance Self-Performed STs. For Betterment projects, a simple process would be to have contractors provide bids for STs with virgin aggregate and with RAP to NDOT for selecting the most economical option on a project-by-project basis.

<u>Task C: Development of Mix Design Methods</u>

This task will develop a mix design method for chip seals and microsurfacing while using RAP as aggregates. The successful completion of this task will require the conduct of the various subtasks discussed in the following sections.

Subtask C1: RAP Sources & Sampling

The UNR Team recognizes that any test methods and specifications developed for use of RAP as aggregates in STs must be applicable to the wide range of RAP and aggregate sources statewide. An examination of the various geological and commercial considerations has led to the seven locations presented in Figure 2 as potential sources for RAP materials and virgin aggregates to be evaluated in this study. The identified sources will be presented to NDOT for final approval. Once the sources are approved by NDOT, the UNR Team will complete all sampling activities.

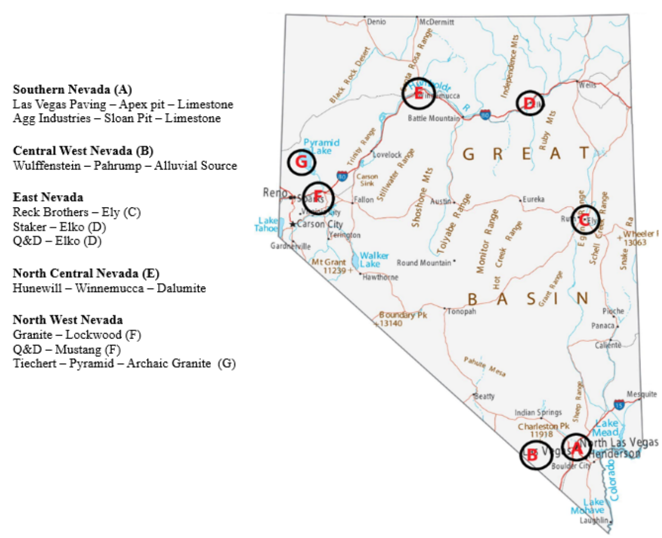

Figure 2. Proposed locations for sampling of RAP materials and virgin aggregates.

Subtask C2: Properties of RAP

This task will evaluate the suitability of RAP materials sampled in Subtask C1 for use as aggregates for chip seals and microsurfacing. Table 3 summarizes the NDOT specifications for virgin aggregates in STs. Ideally, the same testing requirements would apply to both virgin aggregates and RAP materials. However, some tests, such as fractured faces, plasticity index, liquid limit, and sand equivalent, may not be directly transferable/applicable to RAP material. The UNR Team aims to adopt most tests for RAP material, but if unsuccessful, performance testing will be used to indirectly assess certain properties during the development of the mix design procedure.

The physical properties of RAP aggregates could be evaluated after solvent extraction or ignition oven testing. However, performance testing of the STs would be more meaningful as it reflects in-service conditions of RAP-coated material. The stripping potential of RAP will be assessed using ASTM D3625-96 *Standard Practice for Effect of Water on Bituminous-Coated Aggregate Using Boiling Water*, with variations in boiling times and freeze-thaw cycles. During mix design process, the average and variability of RAP gradation, asphalt binder content, and theoretical maximum specific gravity (G_{mm}) will also be determined to ensure consistency from mix design to production.

Table 3. Properties of Virgin Aggregates Specified by NDOT.[(2)]

Mix Design Tests	Test Method	Chips Seals	Microsurfacing
Sieve Analysis	Nev. T206	–	–
Sampling Aggregate	Nev. T200	–	–
Fractured Faces	Nev. T230	90% Min. (2 Fractures min.)[(a)]	90% Min. (2 Fractures min.)[(a)]
Plasticity Index (PI)[(b)]	Nev. T212	–	3 Max.
Cleanness Value	Nev. T228	81% Min.	–
Stripping Test	Nev. T209	Satisfactory	–
Liquid Limit (LL)	Nev. T210	–	35 Max.
Sand Equivalent (SE)	Nev. T227	–	65 min.
Percentage of Wear (500 rev.)	AASHTO T 96	37% Max.	30% Max.[(c)]
Soundness Coarse Aggregate Fine Aggregate	AASHTO T 104	–	5 Cycles, Sodium Sulfate: 12% Max. Loss 15% Max. Loss

[(a)]Individual stockpiles; [(b)]Blending with sand to eliminate plasticity not permitted; [(c)]Test to be run on aggregate before crushing.

Subtask C3: Mix Design Procedures

This subtask will develop a mix design procedure for chip seals and microsurfacing using RAP as aggregates. While different, both STs share a common mix design property: the *compatibility of the asphalt emulsion with RAP materials*. The extensive experience of IAS with asphalt emulsions indicates that asphalt emulsions have a greater compatibility with RAP than virgin aggregates. The asphalt coating on the RAP slows the breaking of the emulsion due to the smaller exposed rock surface, allowing more time for the surface coating.

Mix Design Procedure for Chip Seals. The objective of the chip seal mix design procedure is to determine the rates of asphalt emulsion application and aggregate spread. The Modified Kearby (used by Texas DOT) and the McLeod methods are commonly used. Both methods require the absorption capacity and specific gravity of RAP aggregates to be measured in addition to the properties listed in Table 3. The UNR Team will develop appropriate methods to measure these two properties of RAP and explore the potential use of the RAP aggregate effective specific gravity (Gse) in lieu of the bulk specific gravity. Any changes to the standard procedures will be documented.

The next major step is to identify applicable test methods for evaluating chip seals performance to allow the comparison of chip seals with virgin aggregates and RAP. Initially, two critical performance properties of chip seals are identified: **raveling resistance** and **chip embedment**.

Raveling of chip seals is controlled by the bond between the asphalt emulsion residue and the chips. This property is affected by moisture presence and aging of the asphalt emulsion residue. The UNR Team will evaluate the raveling resistance of chip seals with both virgin aggregates and RAP using the Vialit test (Figure 3). This test measures chip loss under impact load, with the sample placed on a frame with the chip seal facing downward and a steel ball dropped on the back panel. Chip loss, which represents the amount of raveling, is quantified by the weight difference in chip seal sample before (Figure 3b) and after (Figure 3c) testing. The chip seal samples will be subjected to both moisture damage through multiple freeze-thaw cycles and long-term oven aging before measuring their resistance to raveling in the Vialit test.

Embedment of chip seals is controlled by compaction efforts, traffic loads, and hardness of pavement surface. The UNR Team aims to use the Superpave Gyratory Compactor (SGC) to assess the embedment performance of chip seals with virgin aggregates and RAP as described below. Based on the findings, a mix design procedure will be developed and documented for chip seals with RAP.

- Typical asphalt mixture samples will be compacted in the SGC with PG64-28NV or PG76-22NV binders. The SGC samples will be long-term oven aged to simulate old pavements.
- A layer of NDOT open-graded mix will be applied over a group of the compacted asphalt mixture samples to simulate pavements with open graded friction course (OGFC).
- The chip seals with virgin aggregates and RAP will be applied over the SGC samples with and without OGFC.
- The SGC samples with the chip seals will be further compacted in the SGC and the embedment of the virgin aggregates and RAP will be measured after 25 and 50 gyrations using the sand patch test (ASTM E965).
- After 50 gyrations, the sample will be cut in half and the embedment of chips will be measured through optical scanning as shown in Figure 4.
- The data generated from this experiment will be analyzed to assess any differences in embedment between the chip seals with virgin aggregates and RAP.

(a) Test setup. **(b) Chip seal before testing.** **(c) Chip seal after testing.**

Figure 3. Vialit test for raveling of chip seals.

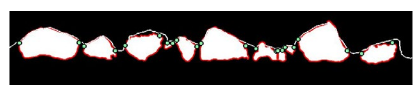

Figure 4. Chips embedment by optical scanning.

Mix Design Procedure for Microsurfacing. The objective of a microsurfacing mix design procedure is to determine the optimum emulsion content (OEC) of the mix. The ISSA recommends laboratory tests to be used in the design of microsurfacing.[1] In 2020, the UNR Team developed a mix design method for microsurfacing for the Carson City Public Works (CCPW) based on the ISSA tests.[3] The mix design method aims to determine the OEC based on optimizing the resistance of the microsurfacing mix to raveling and rutting/bleeding with the criteria presented in Table 4. Figure 5 presents the concept of selecting the OEC. The UNR Team proposes to use the mix design method developed for CCPW for this research effort. The following evaluations will be completed:

- Design microsurfacing mixtures using virgin aggregates and RAP obtained from the sources identified in Subtask C1.
- Assess the applicability of the test methods used in the CCPW mix design method to microsurfacing mixtures with RAP.
- If needed, adjust the test methods and/or criteria specified in the mix design method to be applicable for microsurfacing with RAP.
- Compare the performance properties of the microsurfacing mixtures with virgin aggregates and RAP in terms of their resistance to raveling, bleeding, and rutting. Figure 6 shows the Wet Track Abrasion Tester (WTAT) and the Loaded Wheel tests that will be used to evaluate the resistance of microsurfacing to raveling and bleeding/rutting, respectively.

- The data generated from this experiment will be analyzed to assess any differences between the performance of microsurfacing mixtures with virgin aggregates and RAP.

Based on the findings, a mix design procedure will be developed for microsurfacing with RAP. The procedure will incorporate full details for all methods recommended for the design of microsurfacing mixtures with RAP.

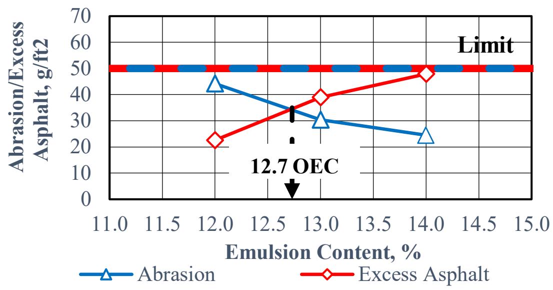

Figure 5. Graphical determination of optimum emulsion content (OEC).

(a) (b)

Figure 6. (a) WTAT; and (b) Loaded Wheel at UNR.

Table 4. Mix Design Requirements for Microsurfacing.

Property		ISSA Test	Specifications
Mix Time @ 25ºC (77ºF)		TB113	Controllable to 120 secs min.
Wet Cohesion	30 minutes (set time) 60 minutes (traffic time)	TB139	12 kg-cm min. 20 kg-cm min.
Excess Asphalt		TB109	538 g/m^2 ($50 g/ft^2$) max.
Wet Track Abrasion	One hour soak, loss Six-day soak, loss	TB100	538 g/m^2 ($50 g/ft^2$) max. 807 g/m^2 ($75 g/ft^2$) max.
Lateral Displacement	After 1,000 cycles@ 56.8 kg (125 lbs.)	TB147A	5% max.
Specific Gravity		TB147A	2.10 max.

Task D: Construction Specifications and Quality Assurance

This task will develop construction specifications and the quality assurance program for chip seals and microsurfacing with RAP. This task will require the conduct of the following two subtasks.

Subtask D.1: Construction Specification

Construction specifications for chip seals and microsurfacing using RAP will be developed. The chip seal specification will be based on current NDOT Standard Specification Section 408 Surface Treatment with virgin aggregates, with modifications for using RAP as aggregate.[2] Section 408 also references Sections 202, 633, 703, and 705 of the NDOT Standard Specification. The revised Section 508 specification will include modifications to items like material properties, job mix formula (JMF), field testing for acceptance, construction techniques, stockpiling to minimize clumping of RAP, and measurement and methods of payment that would be impacted by use of RAP in ST. The research team will request from NDOT any ST specifications currently used but not available in the NDOT Standard Specifications for STs other than Section 408. These will be revised like the description above for the Microsurfacing specifications.

Subtask D.2: Quality Assurance Program

This effort will include quality assurance (QA) provisions for chip seals and microsurfacing.

QA for Chip Seals. In addition to measuring the application rates for asphalt emulsion and the spread of aggregates, the depth of embedment is a critical element of QA for chip seals. The UNR Team is currently working on developing an automated system that measures the texture of chip seals at normal traffic speed.[4] The measured texture of the chip seal is then used to determine the depth of embedment. The time schedule of this effort coincides well with the schedule of the proposed research for NDOT, and the system being developed will be ready for incorporation into the NDOT QA for chip seals. It should be noted that the texture system under development will be applicable for chip seals with both virgin and RAP aggregates.

QA for Microsurfacing. The UNR Team recently developed a QA system for microsurfacing with virgin aggregates for the Regional Transportation Commission (RTC) of Washoe County and NDOT.(5) This effort will modify the current QA system for use with RAP. The developed QA system uses the ignition furnace to determine the asphalt emulsion residue content in the produced microsurfacing mix. Since RAP includes asphalt binder, an additional step is needed to identify the RAP binder content to ensure accurate measurement of the asphalt emulsion residue. This effort will identify the appropriate technology to determine the RAP binder content and consequently the asphalt emulsion residue of the produced microsurfacing mix for the modified QA system.

Task E: Development of Test Methods and Specifications

Based on the outcomes of Tasks A–F, the UNR Team will draft specifications for mix design, quality assurance, material processing, and construction, following the NDOT Standard Specifications format. The UNR Team's collaboration with AASHTO, state and local agencies, and the Emulsion Task Force (ETF) has previously resulted in several AASHTO test methods and construction specifications. The specifications will consider implementation barriers (equipment availability, ease and speed of testing, analysis of results, availability of test standards, and other factors), and ensure compatibility with relevant NDOT specifications. The draft specifications will be shared with NDOT for review and will be revised to address feedback comments.

Task F: Report

A Final report following NDOT format documenting all the findings and recommendations from Tasks A–E will be prepared and submitted at the end of the project duration. A draft copy will be submitted to NDOT for review and comments. Tthe final report will be revised accordingly. In addition, the following documents will be delivered: (a) mix design method for chip seals with RAP; (b) mix design Method for microsurfacing with and RAP; (c) QA provisions for chip seals with RAP; (d) QA provisions for microsurfacing with RAP (format of these documents will likely be in NDOT Standard Specification, Special Provision, and Standard Test Method).

6. URGENCY AND ANTICIPATED BENEFITS

RAP contains valuable aggregate and asphalt binder that can significantly reduce NDOT maintenance ST costs and construction carbon footprint, while preserving natural resources (crude oil and aggregates). Implementing the use of RAP in ST will reduce cost since NDOT can obtain RAP from asphalt pavement rehabilitation projects, essentially at no or low cost, by retaining millings from projects in urban areas and rural areas while not having to haul it from urban areas. Because RAP aggregates are already coated with asphalt binder, which has a much larger carbon footprint than aggregate production, this will result in carbon footprint reduction as well as emulsion and aggregates cost savings. This research effort does not promote the use of RAP exclusively in ST, but it provides options for the use of excess RAP materials that are not currently used in asphalt mixtures. RAP materials can enhance the durability of STs when used appropriately in well-designed chip seal and microsurfacing mixtures, thus leading to better long-term performance and lower maintenance costs. Longer service lives, even if only months per treatment, will add up to significantly reduced costs and carbon emissions when applied systematically across the NDOT roadway network. At the same time, this will reduce the traveling public and maintenance worker safety risks due longer ST lives at the NDOT network level. Since this would be a new practice for NDOT the benefits of it would grow with time for the first several years leading to increased worker and traveling public safety, NDOT cost savings and carbon footprint reduction, and conservation of natural resources. In summary, while national relevant research provides a foundation, it does not fully solve the challenges unique to Nevada with using RAP in ST that will lead to cost, carbon footprint, worker and motoring public safety. This project aims to optimize the use of RAP by focusing on the specific properties and needs of Nevada's RAP materials, ultimately leading to more effective and sustainable pavement maintenance practices in the state; all positive impacts for NDOT.

7. IMPLEMENTATION PLAN

The products of the proposed research will be at stage 5: Specification & Standards with Full Corporate Deployment Stage. The final products will be directly and immediately implementable. No institutional, political, or socio-economic barriers to implementation of the anticipated research results/products are expected. Depending on NDOTs decision on how to procure RAP there could be a need to include RAP in the OTC program. Although this should not have to be implemented as NDOT could simply require a portion of RAP millings from future asphalt pavement rehabilitation and maintenance projects be left on projects as NDOT assets. The developed mix design methods will require minimal investments in laboratory testing equipment. The QA program for chip seals, if adopted, will require a small investment of about $12,000 to acquire a laser texture scanner (LTS) for measuring the embedment depth of chip seals. This is a link to an example of the type, size, and features of an LTS https://amesengineering.com/products/laser-texture-scanner-model-9400/.

The implementation plan will also include recommendations for field chip seal and microsurfacing pilot projects based on the new mix design, materials, test method, construction and quality assurance recommendations and documentation delivered under the research. This would be a first stage of implementation of the research that could be conducted in the first summer following completion of the research. Based on the pilot projects any items identified as needing revision could be made prior to full implementation the following construction season.

8. PROJECT SCHEDULE

The project duration will be 24 months per the schedule shown in Table 5 (anticipated start date Oct. 1, 2024). Quarterly progress reports will be submitted following NDOT format and schedule.

Table 5. Time Schedule of the Proposed Research Project in Months.

Tasks / Months	3	6	9	12	15	18	21	24
A: Literature & Specs Review		I						
B: Feasibility of Using RAP								
C: Mix Design methods								
D: Constructions and QA								
E: Specifications								S
F: Report								D, F
Meetings	K	M	M	M	M	M	M	M
Quarterly Reports		X	X	X	X	X	X	X

Notes: D=draft report; F=final report; I=interim report; K=kickoff meeting; M=progress meeting; S=specifications.

9. FACILITIES AND EXPERTISE

The UNR, IAS, and NCPP facilities are fully equipped and accredited to conduct the searches, evaluations, analyses, and documentation for the proposed research. The UNR Team has designed, constructed, monitored, and analyzed test sections in Nevada, and across the country. Team members have also developed, implemented, and updated a variety of specifications for Nevada and other agencies. Balancing technical expertise with on-the-ground experience is critical in successful long-term pavement studies. Each member of the UNR Team brings unique and beneficial qualities for the performance of the study (check Appendix A for resumes).

Peter E. Sebaaly, Ph.D., P.E. is a Professor in the CEE Department and Director of the WRSC at UNR specializing in pavements/materials engineering. He is a registered Professional Engineer (PE) in Nevada and Arizona. Dr. Sebaaly is working on research projects developing engineered materials to enhance pavement durability and sustainability, and incorporating these materials into design methods and specifications for pavement maintenance, rehabilitation, and reconstruction.

Elie Y. Hajj, Ph.D. is a Professor (2020) in the CEE Department at UNR. He has over 19 years of experience in academia and industry with an emphasis on sustainability of pavement systems, advanced materials evaluation, and advanced pavement design and analysis.

Adam J. Hand, Ph.D., P.E. is a Professor (2022) in the CEE Department at UNR. He has over 30 years of industry and academic experience in the paving materials and construction business. He is a registered PE in several States. Prior to joining UNR, he worked for Granite Construction Inc. for 16 years serving in several roles including VP of Quality Management.

Huachun (Dave) Zhai, Ph.D., P.E. is the VP of Product Quality and Innovation for IAS. He has 20 years of experience in conducting mix designs, providing field support, and analyzing project performance on more than 60 projects that use RAP in ST. He is a Registered PE in multiple states. Dr. Zhai and his team can conduct more than 100 AASHTO accredited binder, emulsion, mixture, and preservation tests, along with chip seal mix designs following states' specifications.

Bouzid Choubane, Ph.D., P.E. is the Director of NCPP with more than 35 years of experience in transportation and materials related areas and technologies at the national and international levels. Prior to joining NCPP, he served in different capacities and roles, including as State Bituminous Research Engineer, with the Florida DOT for 25 years.

Todd Shields, P.E. is the Transportation Assets Preservation Engineer at NCPP. Prior to joining NCPP, he worked for more than 28 years with the Indiana DOT, in different capacities and functional areas including Maintenance, Operations, Design, and Asset Management.

10. BUDGET

The estimated budget is $255,781 over the 24 months duration as summarized in Figure 7.

11. NDOT CHAMPION, COORDINATION, AND INVOLVEMENT

The project champions are Ms. Anita Bush, Chief Maintenance and Asset Management Engineer, abush@dot.nv.gov, and Dr. Charlie Pan, Chief of Materials Engineer, CPan@dot.nv.gov. The UNR Team reached out to both Ms. Bush and Dr. Pan to obtain clarification on questions encountered during the preparation of this proposal. The research team plans to seek input from the primary stakeholders for this study, which are NDOT Maintenance and Asset Management Division, Materials Division, and Construction Division during execution of the project.

REFERENCES

1. International Slurry Seal Association, Technical Design Bulletin, 2015.
2. Standard Specifications for Road and Bridge Constructions, NDOT, Carson City, NV, 2014.
3. Pavement Engineering & Science, University of Nevada, Reno, "Guide for Mix Design and Construction of Slurry Seals," Carson City Public Works, Nevada, 2020.
4. Pavement Engineering & Science, University of Nevada, Reno, "Chip Seal Mix Design and Embedment Evaluation," Research Project funded by Idaho Asphalt, 2023-2024.
5. Pavement Engineering & Science, University of Nevada, Reno, "Quality Assurance Plans for Slurry Systems and Cold in-Place Recycling," Report to Washoe RTC and Nevada DOT, 2023.

Standard Budget Itemization for Department Research Projects

Project Title: 2401E3–Design of Surface Treatments with Reclaimed Asphalt Pavement Aggregates in Nevada
Project Duration: October 1, 2024 to September 30, 2026 (Total of 24 months)

Name and/or Position(1)	Salary (Hourly)	Wage	Fringe Benefit	Total Year 1 (12 months)
Peter Sebaaly (Professional Faculty)	$178.51	$8,033.02	$2,538.43	$10,571.46
Elie Hajj (Professional Faculty)	$117.94	$2,358.78	$745.37	$3,104.15
Adam Hand (Professional Faculty)	$144.97	$2,899.32	$916.19	$3,815.51
Graduate Student (Graduate Assistant)	$20.77	$21,600.00	$3,261.60	$24,861.60
				$0.00
Year 1 Totals		$34,891.12	$7,461.59	$42,352.71

Name and/or Position	Salary (Hourly)	Wage	Fringe Benefit	Total Year 2 (12 months)
Peter Sebaaly (Professional Faculty)	$178.51	$8,033.02	$2,538.43	$10,571.46
Elie Hajj (Professional Faculty)	$117.94	$2,358.78	$745.37	$3,104.15
Adam Hand (Professional Faculty)	$144.97	$2,899.32	$916.19	$3,815.51
Graduate Student (Graduate Assistant)	$20.77	$21,600.00	$3,261.60	$24,861.60
				$0.00
Year 2 Totals		$34,891.12	$7,461.59	$42,352.71

	Year 1	Year 2	Year 3	Year 4
A. Personnel	$42,352.71	$42,352.71	$0.00	$0.00
B. Travel	$0.00	$0.00	$0.00	$0.00
C. Operating Costs	$3,500.00	$3,500.00	$0.00	$0.00
D. Final Report Preparation and Submission	$0.00	$0.00	$0.00	$0.00
E. Equipment	$0.00	$0.00	$0.00	$0.00
F. Other Costs	$0.00	$0.00	$0.00	$0.00
G. Subcontracts (1st $25,000 w/indirect costs)	$37,310.24	$12,689.76	$0.00	$0.00
H. Subtotal of Direct Costs (sum of A thru G)	$83,162.95	$58,542.48	$0.00	$0.00
I. Total Indirect Cost (% at current rate) **47%**	$39,086.59	$27,514.96	$0.00	$0.00
J. Student Tuition and Fees (if applicable)	$6,084.00	$6,390.00	$0.00	$0.00
K. Subcontractor (w/o Indirect Cost)	$10,913.92	$24,086.08	$0.00	$0.00
L. TOTAL PROJECT COSTS PER YEAR (sum of H thru K)	$139,247.46	$116,533.52	$0.00	$0.00
TOTAL PROJECT COST	**$255,780.98**			

Figure 7. Proposed UNR Budget.

APPENDIX A – PROFESSIONAL RESUME

Peter E. Sebaaly, UNR, Professor, Director of Western Regional Superpave Center (WRSC), (775) 784-6565, psebaaly@unr.edu

Experience

- Director of Pavement Engineering & Science Program and WRSC, and Professor, Dept. of Civil Eng., Univ. of Nevada, Reno, Since July 1, 1998.
- Associate Professor, Dept. of Civil Eng., Univ. of Nevada, Reno, July, 1993 to June 1998.
- Assistant Professor, Dept. of Civil Eng., Univ. of Nevada, Reno, August 15, 1990 to June 30, 1993.
- Research Assistant Professor, Pennsylvania Transportation Institute, the Pennsylvania State University, August 1987 to August 15, 1990.

Director of the Western Regional Superpave Center (WRSC)

WRSC (www.wrsc.unr.edu) is one of five national centers established by FHWA to assist highway agencies and private industry in the implementation of the Superpave system.

WRSC conducts research and training activities for states and private industry in the western and rocky mountain regions. Research includes: states and federal sponsored projects, WesTrack, and NCHRP sponsored projects. Training include: the Superpave Binder Grading System, the Superpave Volumetric Mix Design, and the Superpave Mixtures Analysis System.

Invited Keynote Lectures (within past 5 years)

1. 7Th International Conference on Bituminous Mixtures and Pavements: *"Designing High Performance Asphalt Pavements,"* Thessaloniki, Greece, June 12-14, 2019.
2. 32nd Rhode Island Transportation Forum: *"Effective Design for Durable Asphalt Pavements,"* University of Rhode Island, October 25, 2019.
3. Asphalt Rubber Conference 2022: *"Rubber Modified Asphalt: Performance + Sustainability"*, Malaga, Spain, June 27, 2022.
4. Chilean Asphalt Congress: *"Designing Durable and Sustainable Asphalt Pavements"*, Santiago, Chile, March 30, 2023.

Selected Recent Publications

- A. Hand, R. Prathapan, N. Elias, E. Hajj and P.E. Sebaaly. Evaluation of Low Volume Roads Surfaced with 100% RAP Millings. *MDPI Materials 15, 7462*, 2022.
- P. E. Sebaaly, S. Khalil, E. Hajj, and A. Hand. Pushing the Limit on Recycling Old Tires in Asphalt Mixtures. *Asphalt Rubber Conference*, Malaga, Spain, June 26-30, 2022.
- P.E. Sebaaly, J. Dib, E. Hajj, A. Hand. Engineering and Performance Characteristics of Cold In-Place Recycled Materials. *4th IRF Asia Pacific Regional Congress & Exhibition*, Kuala Lumpur, Malaysia, October 11-13, 2022.
- F. Ayala, P.E. Sebaaly, A. Hand, E. Hajj, and G. Baumgardner. Performance Characteristics of Cold In-Place Recycling Mixtures. *ASCE Journal of Materials, Civil Engineering 33(10),* 2021.
- C. Castillo, A. Hand, P.E. Sebaaly, and E. Hajj. Evaluation of Cracking Resistance of Tire-Rubber modified Asphalt Mixtures. *ASCE Journal of Transportation Engineering, Part B Pavements, 147(3),* 2021.

- M. Carvayal, M. Piratheepan, P.E. Sebaaly, E. Hajj, and A. Hand. Structural Contribution of Cold In-Place Recycling Base Layer. *MDPI Civil Engineering*, 2021.
- J. Thavathurairaja, A. Hand, M. Piratheepan, P.E. Sebaaly, and E. Hajj, E. Method to estimate design resilient modulus (Mr) of unbound materials for rehabilitation in M-E design. *Journal of Construction and Building Materials, 267,* 2020.
- J. Habbouche, E. Hajj, P.E. Sebaaly, and M. Piratheepan. Mechanistic-based verification of a structural layer coefficient for high polymer-modified asphalt mixtures. *Journal of Road Materials and Pavement Design,* 2020.
- G. Bazi, J. Gagnon, P.E. Sebaaly, and P. Ullidtz. Effects of Rayleigh Damping on the Subgrade's Apparent Non-Linearity. *ASCE Journal of Transportation Engineering, Part B: Pavements, 146(3),* 2020.
- J. Habbouche, E. Hajj, M. Piratheepan, P.E. Sebaaly. Impact of high polymer modification on reflective cracking performance life of asphalt concrete overlays. *International Journal of Pavement Research and Technology*, 2020.
- R. Chkaiban, E. Hajj, M. Sime, G. Bailey, and P.E. Sebaaly. Asymmetric Logistic Model for Estimation of Mileage-Related Vehicle Depreciation Function of Roadway Characteristics. *Journal of the Transportation Research Board*, 2020.
- Habbouche, J., Hajj, E., Piratheepan, M., Sebaaly, P. E., Morian, N. (2019). Field Performance and Economic Analysis of Rehabilitated Pavement Sections with Engineered Stress Relief Course Interlayers. *Journal of the Transportation Research Board, 2673(5).*
- Bazi, G., Mansour, E., Sebaaly, P. E., Ji, R., Garg, N. (2019). Instrumented Flexible Pavement Responses under Aircraft Loading. *International Journal of Pavement Engineering*.
- Sebaaly, P. E., Ortiz, I.A., Hand, A. J., Hajj, E. (2019). Practical method for in-place density measurement of cold in-place recycling mixtures. *Construction and Building Materials, 227*.
- Sebaaly, P. E., Hajj, E., Piratheepan, M. (2019). Engineering Behavior of Warm Mix Asphalt Mixtures. *Trends in Civil Engineering and its Architecture*.
- Sebaaly, P. E., Thavathurairaja, J., Hajj, E., Stolte, S. (2019). *Determination of Resilient Modulus for Mechanistic-Empirical New Flexible Pavement Design*. Geostructural Aspects of Pavement, Railways, and Airfields.
- Sebaaly, P. E., Hajj, E., Piratheepan, M. (2019). *Fatigue Characteristics of Tire Rubber Modified Asphalt Mixtures*. IRF R2T Global/International Road Federation.
- Habbouche, J., Hajj, E., Sebaaly, P. E., Piratheepan, M. (2018). A critical review of high polymer-modified asphalt binders and mixtures. *International Journal of Pavement Engineering*.
- Habbouche, J., Hajj, E., Sebaaly, P. E., Morian, N. (2018). Damage Assessment for ME Rehabilitation Design of Modified Asphalt Pavements: Challenges and Findings. *Transportation Research Record, I-14*.
- Sebaaly, P. E., Hand, A. J. (2018). Engineering Behavior of Modified Warm Mix Asphalt Mixtures. *Civil Engineering Research Journal, 4*(2).

Elie Y. Hajj, UNR, Professor, Associate Director of Western Regional Superpave Center (WRSC), (775) 784-1180, elieh@unr.edu

Experience

- Full Professor, Department of Civil & Env. Eng., UNR (07/20-present)
- Associate Professor, Department of Civil & Env. Eng., UNR (07/16-06/20)
- Assistant Professor, Department of Civil & & Env. Eng., UNR (07/11-06/16)
- Research Assistant Professor, Department of Civil & Env. Eng., UNR (02/06-06/11)
- Nevada Technology Transfer Center, Engineer and Trainer (02/06-09/11)
- Laboratory Supervisor, Terracon Consulting Engineers & Scientists, NV (05/05-01/06)
- Research/Teaching Graduate Assistant, University of Nevada, Reno (08/01-04/05)
- Field Site Engineer, Campenon Bernard SGE-France, Egypt Branch (99-00)

Education

- Ph.D.Civil Engineering, University of Nevada, Reno 2005
- M.S.C.E.Civil Engineering, University of Nevada, Reno 2002
- B.S.C.E.Civil Engineering, Lebanese University, Lebanon 1999

Qualifications

Dr. Hajj has over 21 years of experience in academia and industry with an emphasis on asphalt pavement technologies. He authored/co-authored over 120 publications in journals, national and international conferences, and technical reports. He made more than 150 presentations in professional meetings, conferences, and workshops. Dr. Hajj is successful in establishing and leading internal (colleges of engineering, business, and science) and external (consulting, manufacturing firms, etc.) collaborations and teams with members from diverse expertise and disciplines.

Dr. Hajj served as a PI or Co-PI on multiple projects for FHWA, FAA, State DOTs, and local governments. He is currently the PI for several projects such as the FHWA Cooperative Agreement No. 693JJ31850010 and No. 693JJ32350026 Development and Deployment of Innovative Asphalt Pavement Technologies (09/18–03/24; 10/23–10/28) (total of $10.5M). Under his supervision and leadership, the project team developed and published over 40 products (e.g., technical briefs, reports, instructional videos), conducted multiple workshops and peer-to-peer exchanges, and delivered over 13 webinars.

Dr. Hajj is currently a member of Association of Asphalt Paving Technologists (AAPT), Academy of Pavement Science and Engineering (APSE), American Society of Civil Engineers (ASCE), International Society for Asphalt Pavements (ISAP), and Transportation Research Board (TRB). He serves as a member of the board of directors and as a Vice Chair of ISAP. Dr. Hajj serves as a member of two TRB committees and chaired the TRB AFK50 committee "Structural Requirements of Asphalt Mixtures" for 6 years. Dr. Hajj served on the advisory board of the international research project ALLBACK2PAVE: "Toward a sustainable 100% recycling of reclaimed asphalt in road pavements," led by Technische Universität Dresden in Germany, together with the University of Nottingham in the UK and University of Palermo in Italy. He is a founding member for the Academy of Pavement Science & Engineering (APSE) and associate editor for the International Journal of Pavement Engineering (IJPE). Dr. Hajj provided technical review service for multiple national and international journals and granting agencies (e.g., NSF, Ministry of Science and Innovation-New Zealand). He served on NSF Site Visit Review Team (pre- & post-award) of a Gen-4 Engineering Research Center (ERC).

Selected Publications

1. Hajj, E., Aschenbrener, T., & Nener-Plante, D. (2022). Examples of Successful Practices with State Implementation of Balanced Design of Asphalt Mixture. Transportation Research Record, 2676 (5), 44–66.
2. Chkaiban, R., Hajj, E., & Hand, A. J. (2022). Influence of Balanced Mix Design Approaches on Pavement Design Making Through an Illustrative Example. Transportation Research Record, 2676 (10), 495–506.
3. Ayala, F., Sebaaly, P. E., Hand, A. J., Hajj, E., & Baumgardner, G. (2021). Performance Characteristics of Cold In-place Recycling Mixtures. ASCE Journal of Materials in Civil Engineering, 33(10), Article 10.
4. Meneses, J. P. C., Vasconcelos, K., Bernucci, L., & Hajj, E. (2021). Compaction methods of cold recycled asphalt mixtures and their effects on pavement analysis (sup 1). 22(sup 1), S154–S179.
5. Habbouche, J., Hajj, E. Y., Sebaaly, P. E., & Hand, A. (2020). Fatigue-based structural layer coefficient of high polymer-modified asphalt mixtures. Transportation Research Record, 2674 (3), 365–375.
6. Kaseer, F., Bajaj, A., Martin, A. E., Arámbula-Mercado, E., Hajj, E. (2019). Strategies for Producing Asphalt Mixtures with High RAP Content. Journal of Materials in Civil Engineering, American Society of Civil Engineers, 31(11).
7. Sebaaly, P. E., Ortiz, J. A., Hand, A. J., Hajj, E. (2019). Practical method for in-place density measurement of cold in-place recycling mixtures. Construction and Building Materials, 227.
8. Habbouche, J., Hajj, E. Y., Piratheepan, M., Sebaaly, P. E., & Morian, N. E. (2019). Field Performance and Economic Analysis of Rehabilitated Pavement Sections with Engineered Stress Relief Course Interlayers. Transportation Research Record.
9. Pournoman, S., Hajj, E. Y., Morian, N., & Martin, A. E. (2018). Impact of Recycled Materials and Recycling Agents on Asphalt Binder Oxidative Aging Predictions. Transportation Research Record, 2672(28), 277–289.
10. Habbouche, J., Hajj, E. Y., and P. E., Sebaaly (2016). Laboratory and Economic Evaluations of Thin Lift Asphalt Overlay for Pavement Preservation. Advances in Civil Engineering Materials, Vol. 5, No. 1, pp. 303-324.
11. Lo Presti, D., Jiménez del Barco Carrión, A., Airey, G., and E. Y., Hajj (2016). Towards 100% recycling of reclaimed asphalt in road surface courses: binder design methodology and case studies. Journal of Cleaner Production, Vol. 131, pp. 43-51.
12. Sanjeevan, S., Piratheepan, M., Hajj, E. Y., and A., Bush (2014). Cold-in-place Recycling in Nevada: Field Performance Evaluation over the Past Decade. Transportation Research Record: Journal of the Transportation Research Board, No. 2456, Transportation Research Board of the National Academies, Washington, D.C., pp. 146–160.
13. Hajj, E. Y., Loria, L. G., Sebaaly, P. E., Cortez, E., and S. Gibson (2013). Effective Timing for Two Sequential Applications of Slurry Seal on Asphalt Pavement. Journal of Transportation Engineering, ASCE, Vol. 139, No. 5, pp. 476-484.
14. Hajj, E. Y., Sebaaly, P. E., West, R., Morian, N., and L., Loria (2012). Recommendations for the Characterization of RAP Aggregate Properties Using Traditional Testing and Mixture Volumetrics. Journal of RMPD, Vol. 13, Supp. 1: AAPT, pp. 209-233.
15. Hajj, E. Y., Loria, L., Sebaaly, P. E., Borroel, C. M., and P. Leiva (2011). Optimum Time for Application of Slurry Seal to Asphalt Concrete Pavements. Transportation Research Record: Journal of the Transportation Research Board, No. 2235, pp. 66–81.

Adam J.T. Hand, UNR, Professor, (775) 784-1439, adamhand@unr.edu

Experience

- Professor, University of Nevada Reno, 2022-Present
- Associate Professor, University of Nevada Reno, 2016-2022
- Vice President, Quality Management, Granite Construction Inc., 2010-2016
- Director of Quality Management, Granite Construction Inc., 2009- 2010
- Engineering Services Manager, Granite Construction Inc., 2006-2009
- Alternative Procurement Pavement Designer, Granite Construction Inc., 2003-2006
- Quality Systems Engineer, Granite Construction Inc., 2000-2003
- Assistant Professor, Purdue University, Civil Engineering, 1998- 2000
- Research Faculty, Western Regional Superpave, University of Nevada, 1994-1998

Education/Licensure/Certification

- Ph.D., Civil Engineering, University of Nevada, Reno, 1998
- M.S., Civil Engineering, University of Nevada, Reno, 1995
- B.S., Civil Engineering, University of Nevada, Reno, 1993
- Registered Professional Engineer: Indiana, Nevada, New Mexico, Oregon
- Six Sigma Black Belt Certified, CS International Inc.
- Certified Professional Winemaker, University of California, Davis

Qualifications

Dr. Adam J.T. Hand has over 30 years of experience in industry and academia working for general and heavy civil contractors, and two universities with leading pavement and materials programs. His construction management experience includes vertical construction projects, heavy civil individual business unit, engineering services group, forensic investigation teams, alternative project development (APD) design teams, and corporate roles with matrix reporting structure and staff across the U.S. of up to 250 people with multibillion-dollar budgets. In addition to formal education, Dr. Hand experienced several business management and leadership programs for managers and executives including Gallup Great Manager, Executive Supervisory Program, Leveraging Talent in Teams, Lean, and Six Sigma. These were each several months to 1-year programs. He has served as a technical expert for multiple claims, disputes and trials providing depositions or testimony for arbitrations, dispute resolution boards, and trials. In the VP Quality Management role at Granite Construction Inc., he had responsibility for over a dozen AMRL accredited labs in vertically integrated businesses in the Western US with annual budgets up to $15M. He also had APD heavy civil project QM responsibility across the country with individual projects having up to $125M QM budgets.

Dr. Hand has served as a PI or Co-PI on multiple projects for NCHRP, FHWA, State DOTs (including Pooled Fund Study), and local governments. Dr. Hand is an active member of the technical community, having delivered over 150 invited presentations and with over 100 publications. He is a member of ASCE, ASTM, ASQ, AAPT, NAPA, and NSPE. He serves as chairman of the State of Nevada Public Works Board (Gubernatorial Appointment), is a past president of the board of directors for AAPT and one of the four founding board of directors of the Greenroads Foundation. He is chairman of the TRB AKC60 Asphalt Pavement Construction and Rehabilitation committee and a member of the AKC30 Construction Quality Assurance Committee, a member of the FHWA Asphalt Technical Feedback Committee, a member of the NAPA Committee on Asphalt Research and Technology, and Chairman of the NAPA Net Zero Committee.

Selected Recent Publications

- Hand, A.J.T. and T. Aschenbrener (2023), "Case Studies of Practices and Lessons Learned When Using Reclaimed Asphalt Shingles in Asphalt Mixtures," Transportation Research Record (TRR) 01-13, https://doi.org/10.1177/03611981231186601.
- Rodriguez, R.L., P. Sebaaly, E. Hitti, E. Hajj, and A. Hand (2023), "Impact of Modified Post-Consumer Plastic (MPCP) Toner on Asphalt Binder Properties," TRR, https://doi.org/10.1177/03611981231187387.
- Chkaiban, R. E.Y. Hajj and A. J.T. Hand (2022), "Influence of Balanced Mix Design Approaches on Design Making Through an Illustrative Example," TRR, Volume 2676, Issue 10 https://doi.org/10.1177/03611981221090238.
- Habbouche, J., Boz, I., Diefenderfer, B. K., Jones, D., and Hand, A.J.T. (2022), "Laboratory Performance Evaluation of Asphalt-Treated Cold Recycled Mixtures Using Existing Practical Tests," TRR, https://doi.org/10.1177/03611981221137591.
- A. Hand, R. Prathapan, N. Elias, E. Hajj and P.E. Sebaaly. Evaluation of Low Volume Roads Surfaced with 100% RAP Millings. *MDPI Materials 15, 7462*, 2022.
- Elise, N., A.J.T. Hand, P.E. Sebaaly, E.Y. Hajj, M. Piratheepan, S. Gibson (2021), "Local Agency Transition to Balanced Mix Design," International Journal of Pavement Engineering (IJPE), GPAV 1978441, https://doi.org/10.1080/10298436.2021.1978441.
- Hand, A.J.T., I. Boz, M. Piratheepan, F. Hierholzer, B.K. Diefenderfer, D. Jones, J. Habbouche, and S. Louw (2021), "Ruggedness Evaluation and Precision Estimates for Newly Developed Test Methods for Asphalt-Treated Cold Recycled Pavements," Transportation Research Record: Journal of the Transportation Research Board. https://doi.org/10.1177/03611981211017142.
- Hand, A. J., T. Aschenbrener, N. Tran, F. Leiva (2021), "Achieving Asphalt Pavement Density with Minimal Mat Defects," Transportation Research Record: Journal of the Transportation Research Board. doi.org/10.1177/03611981211020003.
- Diefenderfer, B.K., I. Boz, J. Habbouche, D. Jones, and A.J. Hand (2020), "Development and Assessment of Rapid Tests for Construction of Asphalt-Treated Cold Recycled Pavement," TRR: Journal of the Transportation Research Board, Volume 2674, Issue: 3.
- Hand, A.J. (2019), E-C249, Key Elements of Construction Quality Assurance for Implementation, "Example Best Practices in Construction Quality," Transportation Research Circular, Transportation Research Board, Washington, D.C., pp. 32-27.
- Wielinski, J., A.J. Hand, and D.M. Rausch (2010), "Laboratory and Field Evaluation of Foamed WMA," TRR 2126, pp. 125-131, TRR, TRB, Washington, D.C.
- Hand, A.J. (2009), "Materials and Construction of the Ideal Asphalt Pavement, Journal of the Association of Asphalt Paving Technologists, Vol. 78, pp. 777-806, Association of Asphalt Paving Technologists, St. Paul, MN.
- Hand. A.J. (2006), "Contractor's Perspective on the PWL Challenge'" Journal of the Association of Asphalt Paving Technologists, Vol. 75, pp. 955-984, Association of Asphalt Paving Technologists, St. Paul, MN.
- Hand, A.J.T. and J.A. Epps (2006), "Fundamentals of Percent Within Limits and Quality Control-Quality Assurance Compaction Specifications," Transportation Research Circular E-C105, pp. 140-162, Transportation Research Board, Washington, D.C.
- Haddock, J.E., A.J. Hand, H. Fang, and T.D. White (2004), "Determining Layer Contributions to Rutting by Surface Profile Analysis," Journal of Transportation Engineering, ASCE, JTPEDI, Vol. 131, Issue 2, pp. 131-139, 2004.

Huachun Zhai, IAS, Vice President, (208) 442-7742, hzhai@idahoasphalt.com

Experience

- Vice President of Product Quality and Innovation, Idaho Asphalt Supply, Inc., Nampa, 2018-Present
- Director of Technology, Idaho Asphalt Supply Inc., 2016- 2018
- Technical and Quality Manager, Idaho Asphalt Supply Inc., 2005-2016
- Laboratory Manager, Idaho Asphalt Supply Inc., 2001-2005
- Research Assistant, University of Wisconsin, Madison, 1996-2001

Education/Licensure/Certification

- Ph.D., Civil Engineering, University of Wisconsin, Madison, 2001
- M.B.A., General Business, University of Wisconsin, Madison, 2001
- M.S., Polymer Physics and Chemistry, Chinese Academy of Sciences, Beijing, China, 1996
- B.S., Polymer Chemistry and Physics, Nankai University, Tianjin, China, 1993
- Registered Professional Engineer: Idaho, Utah, Nevada, Montana, Wyoming, and Colorado
- Certified Pavement Inspector, Asphalt Institute.

Qualifications

Dr. Zhai has more than 25 years of experience in the physical and chemical properties of asphalt materials (both polymer-modified asphalt and emulsified asphalts) and asphalt mixtures. He has spent close to 20 years conducting mix designs, providing field support, and analyzing project performance on more than 60 state projects that use RAP in surface treatments, such as slurry seals, micro-surfacings, scrub seals, and chip seals. He published over 30 peer-reviewed papers in different journals and participated in multiple state and Federal sponsored research projects.

Dr. Zhai and his team in Nampa, Idaho can conduct not only more than 100 AMRL-accredited tests on aggregate, asphalt cement, emulsified asphalt, asphalt mixture, pavement preservation, and asphalt mixture tests, but it can also run RAP aggregate properties, RAP binder recovery, and chip seal mix design tests following multiple states' specifications. He manages five AMRL-accredited laboratories across the Western US. Dr, Zhai is familiar with the highway agencies' specifications and various testing methods on RAP and RAP related pavement preservation applications. He is a Registered Professional Engineer in Idaho, Nevada, Montana, Wyoming, Colorado, and Utah. He is also a member of ASCE, AAPT, ASTM, ASQ, and RILEM. Dr Zhai is also the contact person who represents Idaho Asphalt Supply in AEMA, ISSA, ARRA, and AI.

Doug Olsen, IAS, Director of Technical Marketing, (775) 420-1518,
dolsen@westernemulsions.com

Experience

- Director of Technical Marketing, Idaho Asphalt Supply Inc., 2018- Present
- Regional Sales Manager, Western Emulsions, Inc., 2012-2018
- General Manager, Intermountain Slurry Seal Inc., 1995 - 2012
- Project Manager, California Pavement Maintenance, Inc. 1988 – 1993
- Foreman, Graham Contractors, 1982 - 1987

Education/Licensure/Certification

- General Engineering Contractor license (Class A) (Nevada)

Qualifications

Doug has been in the Pavement Preservation Industry for over 40 years, starting with actual placement, to source discovery, project development, and specification adoption. As a foreman and then a Project Engineer for 20 years in his career, Doug has managed more than 100 asphalt paving and maintenance projects from the Mexican Border to the Canadian border, and from Colorado to Alaska. In his current career as the Director of Technical Marketing, Doug is actively promoting and developing performing products that support and continue to perform for the industry.

In Nevada, Doug is uniquely qualified to vet and source materials that prove to perform in very diverse climate conditions. Doug has personally helped to commercialize aggregate sources from Las Vegas to Elko to Reno for pavement maintenance treatments. Doug's efforts are still used today throughout the state. Doug has helped establish pavement maintenance programs in the state of Nevada that are still in place after 30 years of annual utilization, (Las Vegas, Henderson, Washoe County, RTC, Reno to name a few). Doug was instrumental in guiding and establishing specifications used by NDOT for Chip, Scrub, Micro, Slurry and has developed a reputation as a valuable resource for the State of Nevada.

Doug's career has allowed him to be exposed to several conditions that affect communities in search of better ways to maintain infrastructure investment, his exposure to Recycling, Micro-surfacing, Slurry Seal, Chip Seal, Scrub Seals, Fog Seals has enabled him to help agencies from the federal level down to the smallest county level. He has presented at more than 100 conferences and trade shows and conducted dozens of invited training courses to personnel from agencies and trade associations on best practices in constructing paving preservation projects. He is the founding member of the Nevada Asphalt Conference and was a member of the Board of Directors of both AEMA and ISSA.

Alejandro Rosales, IAS, Regional Technical Manager, (208) 442-7742, arosales@idahoasphalt.com

Experience

- Regional Technical Manager, Idaho Asphalt Supply, Inc., Nampa, ID, 2021-Present
- Technical Services Manager, Idaho Asphalt Supply, Inc., Nampa, ID, 2018-Present
- Research/Field Engineer, Idaho Asphalt Supply, Inc., Nampa, ID, 2015-2018
- Research Assistant, Modified Asphalt Research Center (MARC), University of Wisconsin, Madison, WI, 2012-2014

Education/Licensure/Certification

- M.S., Civil Engineering, University of Wisconsin, Madison, 2014
- B.S., Civil Engineering, Boise State University, Boise, 2013
- B.S., Physics, College of Idaho, Caldwell, 2012
- B.A., Mathematics, College of Idaho, Caldwell, 2012
- B.A., Spanish, College of Idaho, Caldwell, 2012
    - Western Alliance for Quality Transportation Construction (WAQTC), Qualification Number: 23502 : Aggregate Testing/Asphalt Testing
- Asphalt Institute
    - National Binder Technician Certification (NBTC)
    - National Emulsion Technician Certification (NETC)
    - Mix Design Technology Certification (MDTC)

Qualifications

Alejandro has more than 10 years of experience in the Pavement Preservation Industry with extensive experience in producing micro-surfacing and slurry seal mix designs for customers across the western U.S. As a research/field engineer, Alejandro participated in formulating specialty emulsion products for use in state and federal projects that use RAP such as CIR, FDR, and RAP micro-surfacing/slurry seals. As a field engineer, Alejandro provided onsite customer support during the construction of HMA, FDR, CIR, chip seals, scrub seals, and RAP micro-surfacing/slurry seals. In his role as a Technical Services Manager, Alejandro is responsible for overseeing the production, testing, and troubleshooting of mix designs for customers in micro-surfacing, slurry seal, chip seal, scrub seal, FDR, and CIR projects. As a Regional Technical Manager, Alejandro oversees the quality of manufactured products at two asphalt terminals that produce over 100,000 combined tons of asphalt and emulsion products that ship to five state agencies and multiple municipalities. Alejandro has delivered close to 20 presentations at multiple technical conferences. He is a member of the Association of Asphalt Paving Technologists (AAPT), the Asphalt Emulsion Manufacturers Association (AEMA), and the International Slurry Seal Association (ISSA).

Bouzid Choubane, NCPP, Director, (517) 432-8220, choubane@egr.msu.edu

Qualifications

Dr. Bouzid Choubane will coordinate all the NCPP team's activities. For more than 35 years, Dr. Choubane has been actively involved in transportation and materials related areas and technologies at the national and international levels. He is presently the Director of NCPP. In this role, he directs and leads NCPP to fulfill its mission with the endgame of advancing and enhancing the state of practice and knowledge to preserve our nation's transportation infrastructure. He is currently leading the NCPP activities to manage the AASHTO's Transportation System Preservation Management Program. He is serving as a PI for TPF-5(522) National Partnership to Improve the Quality of Preventive Maintenance Treatment Construction and Data Collection Practices. He was also the PI for the newly completed NCHRP Project 20-44(26) to facilitate the implementation of AASHTO Guide specifications for pavement preservation technologies.

Prior to joining NCPP, Dr. Choubane served in different capacities and roles, including as State Bituminous Research Engineer, with the Florida Department of Transportation (FDOT) for 25 years. Prior to that, he was a Research Associate at the National Research Council (NRC) of Canada. In addition, he was a Courtesy Professor at the Department of Civil and Coastal Engineering of the University of Florida.

Dr. Choubane is a member of TRB Infrastructure Executive Board. He is the past chair of the TRB Section on Pavements and the Ad Hoc Committee to Advise Federal Highway Administration (FHWA) Long-Term Pavement Program. He is also past chair of ASTM International Committee on Pavement Management. He was a guest on a live NPR news show to discuss transportation preservation strategies (a link to the segment: https://www.wbez.org/reset-with-sasha-ann-simons/2022/03/14/whats-the-worst-pothole-in-the-chicago-area). He conducted a week-long seminar on pavement materials testing, evaluation, design, and management at Harbin University (China). He was a guest/keynote speaker at several conferences abroad including Spain, Costa Rica, and South Africa. He authored or co-authored over 80 peer-reviewed technical papers and served as the editor for two Special Technical Publications on pavements and materials-associated issues and technologies. He is a registered Professional Engineer (PE) in the State of Florida.

Todd Shields, NCPP, (517) 432-8220, shiel118@msu.edu

Qualifications

Mr. Shields is the Transportation Assets Preservation Engineer at NCPP. He also worked for more than 28 years with the Indiana Department of Transportation (INDOT), in different capacities and functional areas including Maintenance, Operations, Design, and Asset Management. In all his roles, he has shown strong records of developing, leading, and implementing infrastructure preservation-related initiatives and programs. He drafted INDOT's first specs for micro surfacing, ultrathin bonded wearing course, and full depth reclamation. He participated in the publication of several related refereed studies with Purdue University including Performance Evaluation of Seal Coat Materials and Designs, and Treatment Guidelines for Pavement Preservation.

He is an active member of several professional organizations including the respective TRB Committees on Pavement Preservation and Pavement Maintenance as well as the AASHTO Committee on Maintenance. Mr. Shields is magna cum laude graduate of Rose-Hulman Institute of Technology and a registered professional engineer.