DEVELOPMENT OF DESIGN AND TESTING METHODS FOR THE USE OF RAP MATERIAL AS AGGREGATES FOR SURFACE TREATMENTS IN NEVADA

Submitted by:
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Texas A&M Transportation Institute

Title

Development of Design and Testing Methods for the use of RAP Material as Aggregates for Surface Treatments in Nevada

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Key Investigators

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Problem Description

The proposed research addresses the challenge of integrating Reclaimed Asphalt Pavement (RAP) materials as aggregates in Surface Treatments (STs) for the maintenance of Asphalt Concrete (AC) pavements in Nevada. The utilization of RAP in STs, comprising of chip seals, slurry seals, and micro-surfacing, holds significant potential for enhancing the performance and sustainability of AC pavements. The benefits encompass reduced aggregate costs, enhanced resistance to moisture damage and prolonged oxidation resistance; however, there are limited national efforts to use RAP as part of pavement ST. Furthermore, the unique characteristics of Nevada's asphalt mixtures, involving lime treatment and polymer-modified binders, necessitate a focused research effort to tailor the application of RAP in STs to the state's specific conditions.

The proposed research aims to develop comprehensive test methods and procedures encompassing materials selection, mix design, and quality assurance during construction. It seeks to establish the technical groundwork for implementing RAP materials in STs statewide, ensuring the feasibility and effectiveness of this sustainable approach. By addressing this research problem, Nevada Department of Transportation (NDOT) can contribute to the national effort to reduce the carbon footprint of road construction. RAP materials, already generated in rehabilitation projects, can be repurposed as aggregates for STs, offering a more sustainable alternative to traditional construction methods. The absence of national guidance necessitates a state-specific approach, and the successful completion of this research will empower NDOT to utilize RAP materials effectively in maintaining AC pavements. This, in turn, holds the potential for substantial annual cost savings, making it a critical and timely endeavor for the transportation infrastructure in Nevada.

Background

NDOT's Current Practice

Currently, NDOT does not allow the use of RAP as aggregates for STs. Instead, RAP is primarily utilized in Hot Mix Asphalt (HMA) or on shoulders. This restriction stems from a lack of comprehensive guidelines and technical specifications for incorporating RAP into STs. NDOT's current practice limits the potential benefits of RAP in STs, including cost savings, enhanced resistance to moisture damage, and reduced environmental impact.

However, NDOT's current Standards and Specifications for Road and Bridge Construction (NDOT 2014) covers various types of STs using virgin aggregate. These specifications include the particle size, fractured faces, cleanness value stripping and wear requirements for aggregates (screenings) used in chip seals. These specifications also include requirements for aggregate used in micro-

surfacing. The requirements in these specifications form the baseline for comparison between virgin aggregate and RAP using in STs.

Preliminary Literature Search

A preliminary literature search reveals limited national research efforts on the use of RAP as aggregates for STs, emphasizing the need for state-specific investigations. Existing studies, such as those conducted by Los Angeles County (LAC), San Bernardino County (SBC), and the New Mexico Department of Transportation (NMDOT), provide valuable insights into the benefits of using RAP in STs. Additionally, other state DOTs, including North Dakota and Pennsylvania, and local DOTs, including Owego, NY, and Trumball County, OH, used RAP in chip seals, while Texas DOT has used RAP in slurry seals (Duncan et al. 2020). However, these studies lack applicability to Nevada's unique asphalt mixtures, incorporating lime treatment and polymer-modified binders.

The proposed research leverages other states' experiences while acknowledging the need for a tailored approach to address Nevada's distinct challenges. The proposed research aims to build upon existing knowledge and develop comprehensive guidelines applicable to Nevada's asphalt mixtures by synthesizing information from localized studies. This approach ensures that the research does not duplicate prior efforts, but instead, fills a critical gap in national guidance, especially considering the absence of specific recommendations for using RAP in STs in Nevada.

Importance beyond Existing Research

Beyond existing research, NDOT's need for this study arises from the unique characteristics of Nevada's asphalt mixtures and the absence of national guidance on using RAP in STs. The limitations imposed by NDOT's prohibition on RAP in STs hinders the state from capitalizing on the economic and environmental advantages of this sustainable approach.

This research is imperative for NDOT to establish state-specific guidelines and procedures that accommodate Nevada's asphalt mixtures. Incorporating lime treatment and polymer-modified binders for Nevada's asphalt mixtures requires a tailored approach to materials selection, mix design, and quality assurance during construction. By addressing these specific needs, the research will provide NDOT with the technical foundation to implement RAP materials safely and effectively in STs statewide; thereby, contributing to the long-term sustainability and resilience of Nevada's AC pavements.

Proposed Research Plan and Methodology

The technical objectives of the proposed research are multifaceted, seeking to address the critical challenges associated with integrating RAP materials as aggregates in STs. Firstly, the research aims to establish standardized test methods for evaluating RAP materials' physical and chemical properties, by evaluating RAP from Nevada according to the current ASTM specifications and other promising methods arising from the literature review. These methods will form the basis for determining the suitability of RAP materials and understanding their impact on the performance of diverse ST applications, including chip seals, slurry seals, and micro-surfacing.

Secondly, the research will develop mix design methodologies tailored to incorporating RAP as aggregates in various ST types. This includes a comprehensive evaluation of the mechanical and rheological properties of the resulting mixtures, accounting for the specific characteristics of Nevada's asphalt blends. The third objective is to establish quality assurance protocols and test methods to monitor and verify the construction process of STs using RAP aggregates, addressing potential challenges associated with handling, compaction, and curing.

Furthermore, the research endeavors to develop a detailed specification encompassing both material and construction aspects of STs with RAP aggregates. This specification will serve as a guide for contractors and NDOT personnel, ensuring uniformity and adherence to best practices. A feasibility analysis will be conducted to assess the practicality and challenges of implementing RAP materials in

STs statewide, considering logistical, economic, and environmental factors. Finally, the research will culminate in producing a final report, consolidating findings, methodologies, and recommendations for immediate implementation by NDOT's Materials and Maintenance Divisions. These technical objectives collectively aim to provide NDOT with a comprehensive framework for successfully integrating RAP materials in STs, tailored to Nevada's unique asphalt mixtures and contributing to the long-term sustainability of AC pavements in the state.

Task 1. Project Management

The research team shall document all research findings from this project, submit quarterly progress reports (QPRs), and attend project progress meetings as scheduled by and in conjunction with NDOT.

The documentation/deliverables/meetings shall include:

- Kick-off and close-out meetings. The research team shall schedule meetings with NDOT.
- Progress meetings. Throughout the project, the research team and/or NDOT shall schedule meetings to discuss topics such as the status of the research, research results from the research plan, future activities, and issues that might have emerged since the last progress meeting.
- A Draft and Final Report that completely documents the work performed, methods used, and results achieved.

Deliverables: The research team shall submit Quarterly Progress Reports to the Research Division for distribution to the technical panel.

Task 2. Literature Review

The Research team shall determine the current state-of-the practice and emerging research to evaluate the suitability of RAP for various types of STs. The research team shall determine:

- The test methods and procedures (laboratory and field) for virgin aggregates in STs.
- The test methods and procedures for handling RAP in Nevada.
- The test methods and procedures for RAP as aggregate in STs, including mix design and Quality Assurance (QA), used during related studies in the US.
- The properties of STs, like resistance to stripping, bleeding, and aggregate loss that predicts in-field performance.
- The optimal tests to predict the long-term performance of STs exposed to changing climate conditions and repeated traffic loading.
- Material combinations, for example precoated aggregate which may be similar to RAP use with hot applied bituminous material verses emulsions.

The research team shall:

- Locate relevant work using searches of scientific and research publications and construction specifications employing the methods of Transportation Research Board Circular E-C194.
- Use the Transport Research International Documentation database to search scientific and research publications.
- Use the National Highway Specifications Website to search state and national specifications. Use FHWA technical advisory references to identify publications.
- Review procedures and specifications used in other States and internationally, including, but not limited to Texas, Australia, South Africa, and New Zealand, for evaluating aggregates for ST's.

- Review existing relevant Receiving Agency test methods, specifications, policies, and procedures and summarize their commonality and any deviations from other information in the literature for aggregates used in ST's.
- Review sources and availability of data used in decision making process when selecting RAP stockpile potential uses.

Task 3. Survey

The research team shall prepare and distribute a fact-based survey questionnaire to NDOTs to inquire about the state-of-practice regarding their experience and practices for the current use of RAP as well as STs.

Data/decision inputs include, but are not limited to:

- Extent of experience with various types of STs and common types of observed distresses.
- Current design and product selection procedures for STs, including:
    - Weather conditions,
    - Traffic loading,
    - Material availability,
    - Design speeds,
    - Annual daily traffic,
    - Location of project (urban/rural),
    - Project Geometry, and
    - Existing road and surface conditions.
- The current state of RAP use including:
    - Availability of RAP,
    - Current stockpiles of RAP,
    - Information about the source different RAP sources and mix composition, and
    - Current practices regarding RAP usage.

The research team shall design the survey to optimize responses by balancing the length and the level of detail of the survey with the respondents' willingness to complete the survey with useful information. NDOT will review a draft survey and provide comments to the research team. The research team shall finalize the survey based on the draft survey and NDOT's comments. The research team shall format the survey as an on-line survey using a web-based survey administration facilitator. The research team shall follow all Institutional Review Board (IRB) for Human Subject Protocols for the survey as appropriate.

The research team shall conduct the outreach and record the responses from participants. The research team shall identify and conduct follow-up interviews designed to further identify practices that have been successfully implemented, with key agency/entity personnel (if determined necessary).

Task 4. Laboratory Study

The research team shall develop a statistically valid laboratory study to integrate RAP material as aggregate for STs in Nevada. The research team shall use or modify existing procedures to minimize the cost of implementation of the testing. The laboratory study aims to establish a correlation between the properties of RAP and its performance when used in STs. The research team shall perform the following to achieve the objectives of this research study:

RAP Evaluation

Develop a comprehensive evaluation protocol to assess the suitability of a specific source of RAP, as sampled from the stockpile, for use in STs. Testing shall include gradation tests of black RAP aggregate with residual binder as well white aggregate after extracting the residual binder. Additionally, the binder shall be evaluated by extracting the binder by via ignition oven, before determining the penetration grade of the binder. As an additional evaluation of the binder, an Indirect Tensile (IDT) strength test can be performed on RAP specimens compacted at 158°F to provide an indication of how active the aged material is. Finally, the aggregate wear shall be evaluated using the LA abrasion test on RAP aggregates after binder extraction.

Mix designs

Evaluate the current mix design procedures for STs in Nevada using conventional aggregate and RAP as aggregate. The standard tests prescribed in ASTM D3910 shall be conducted on laboratory produced slurry seals with varying amounts of conventional screenings and RAP. The aim of this investigation is to determine if the current mix design procedures are appropriate for STs with RAP as aggregate.

Performance testing

Conduct laboratory performance testing on specimens produced from RAP and traditional aggregate to evaluate its suitability for in-field use. The main performance concerns for RAP as an alternative aggregate for STs is the loss of friction and texture. Therefore, this study aims to evaluate the friction loss of RAP aggregate compared to conventional aggregate using the Micro-Deval Abrasion test to measure the loss of friction with a Dynamic Friction Tester (DFT). Figure 1 shows the friction measurement of a ring constructed with aggregates that were subject to the Micro-Deval Abrasion test.

Figure 1: Friction measurement after Micro-Deval Abrasion

Changes in texture and aggregate loss shall be determined by preparing Hot Mix Asphalt (HMA) in a lab compactor and applying a surface seal as shown in Figure 2. These slabs can then be tested using the Three-Wheel Polisher to simulate traffic. After the specimen has been tested, the texture depth can be measured using the Circular Track Meter (CTM) and the number of dislodged aggregates can

be counted. This will allow a comparison of aggregate loss as well as texture loss of STs with and without RAP as aggregate. An example of the loss of aggregate for 3 different slabs is shown in

Figure 2: HMA slab with ST preparation.

Figure 3: Example of aggregate loss using the Three-Wheel Polisher

Laboratory Testing Summary

The laboratory testing factors are shown in Table 1 and the variables to be taken into account is shown in Table 2.

Table 1. Laboratory Testing Factors.

Factor	Proposed Test
RAP evaluation	• Black gradation • White gradation (after solvent extraction) • Binder content via Ignition Oven • Binder high- and low-temperature PG • Active RAP via IDT strength test • Degradation Wear at 500 revolutions – LA abrasion (ASTM C131/131M -20)

	• Striping test (Nev. T209 or)
Mix design (slurry seal or micro-surface)	• Consistency test (D3910 2015b) • Set Time (D3910 2015b) • Cure Time ((D3910 2015b) • Wet Track Abrasion (D3910 2015b) (ref ISSA Technical Bulletin No. 100) • Extraction test (ASTM D6307 2019b) • Loaded wheel test (ASTM D6372)
Laboratory mix Performance tests	Performance under traffic using: • Micro-Deval Abrasion of aggregates to measure loss of friction using the Dynamic Friction Tester (DFT) • Three-wheel polisher to simulate traffic in order to measure changes in texture depth using the Circular Track Meter (CTM). Allows measure of flushing and aggregate loss.

Table 2. Variables in Laboratory Study.

Variables	Tentative Values
Material	RAP sampled from at least 3 districts: • District 1, Las Vegas • District 2, Sparks • District 3, Elko Aggregate conforming to the NDOT specifications as the control for: • Single size screenings • Micro-surfacing aggregates
Surface treatment	• Chip seal • Slurry seal • Micro-surfacing
Binder type	Chip seal: • Conventional (CRS-2) • Modified (CRS-2HP or CRS-2P) Micro surfacing: • Conventional (MSE) Slurry seals: • Conventional (CQS-1H)
Mix designs	Chip seal application rate: • Bituminous Material application rate • Aggregate application rate Slurry / Micro-surfacing: • Binder content (choose 3 rates) Amount of RAP (% by weight) to be added to the surface treatment. Existing surface conditions

Task 5. Final Report

The research team shall use results from prior tasks to develop recommendations and guidelines in the final report for evaluating the suitability of RAP for STs. This research will conclude the laboratory prototype stage and will enable NDOT to commence with field demonstrations. The final report will detail the procedures, testing, results and evaluations done during the research and provide recommendations for further research and field implementation. Additionally, specifications will be developed for the use of RAP aggregates in STs.

The final report shall include a detailed feasibility analysis of the implementation of RAP as aggregates for STs in the 3 main districts in Nevada.

As part of the final report, a manual shall be developed detailing the following:

- Sampling and test methods to evaluate RAP materials as aggregates for STs.
- Detail mix design procedures for STs with RAP aggregates.
- Provide guidance on quality assurance during construction of STs with RAP aggregates including recommendations on performance testing after construction.

Deliverables: The research team shall submit a Draft Final Report to the technical panel for review and comment. The research team shall make the necessary changes and submit the Final Report for publication and distribution.

Urgency and Anticipated Benefits

The urgency of this research lies in the immediate financial and environmental benefit of implementing this highly sustainable approach for maintaining AC pavements. As the national effort intensifies to reduce the carbon footprints associated with road construction, the use of RAP materials in STs emerges as a timely solution. RAP materials are already generated in abundance in every rehabilitation project, presenting a readily available resource that, if utilized in STs, could significantly reduce the environmental impact of mining new virgin aggregates.

The current literature underscores that experiences with RAP in STs are localized, lacking national guidance. Nevada, with its distinctive asphalt mixtures involving lime treatment and polymer-modified binders, necessitates specific design and evaluation techniques for the three most commonly used STs: chip seal, slurry seal, and micro-surfacing. The absence of national guidelines exacerbates the urgency for NDOT to take the lead in developing state-specific methodologies.

Anticipated benefits include substantial annual cost savings for NDOT, given that the majority of Nevada's roads are comprised of AC pavements. By successfully implementing RAP materials in STs, NDOT can reduce costs associated with new virgin aggregates and enhance the sustainability of road maintenance practices. The high-quality aggregate found in RAP materials produced in Nevada are expected to offer excellent performance when used as aggregates in STs, contributing to prolonged pavement life and minimizing the need for extensive rehabilitation.

In conclusion, the urgency of this research is paramount in aligning NDOT with national sustainability goals and optimizing the use of RAP materials for immediate and substantial benefits, including cost savings, enhanced environmental stewardship, and improved longevity of AC pavements.

Implementation Plan

The implementation plan for this research aligns with the five stages of research deployment and envisions seamless integration into the operations of the NDOT. The proposed research is strategically designed to result in deliverables that are ready for implementation, ensuring immediate applicability and impact.

The implementation plan unfolds in distinct stages, beginning with the development of standardized test methods and mix design methodologies. These stages encompass materials selection, evaluation,

and quality assurance protocols. Following this, the creation of a comprehensive specification for material and construction of STs with RAP aggregates will be undertaken.
Cost estimates beyond the research phase encompass the dissemination of guidelines, potential training programs for NDOT personnel, and communication strategies to promote awareness and adoption of the developed methodologies. These costs are anticipated to be moderate, primarily focused on knowledge transfer and ensuring a smooth transition to new practices.
The research will culminate in a task dedicated to crafting a detailed implementation plan specifically tailored for NDOT. This plan will outline a step-by-step approach for the integration of RAP materials in STs, providing guidance on logistics, training requirements, and potential challenges associated with the statewide adoption of these sustainable practices.
The identification of any institutional, political, or socio-economic barriers to implementation will be addressed in collaboration with stakeholders. Clear communication channels will be established, involving NDOT champions and a technical advisory committee to capture valuable input throughout the implementation phase. This proactive engagement aims to ensure a smooth transition and the sustained success of the proposed research outcomes.
In summary, the implementation plan is intricately designed to seamlessly integrate the research results into NDOT's practices, considering all necessary stages, potential challenges, and cost estimates to facilitate a swift and effective transition.

Project Schedule

Table 3. Project Schedule.

RESEARCH ACTIVITY	MONTH																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Task 1 - Project Management	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Task 2 - Literature Review	■	■	■	■	■	■																		
Task 3 - Survey		■	■	■	■	■	■	■																
Task 4 - Laboratory Study						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
Task 5 - Final Report																			■	■	■	■	■	■
Deliverables*																								
Quarterly Project Reports			■			■			■			■			■			■			■			■
Draft Final Report																						■		
Final Report with 508 Compliance																								■
Meetings																								
Kick-Off Meeting	■																							
Interim Progress Meetings						■						■						■						
Close-Out Meeting																								■

Facilities and Expertise

Since 1950, experts at the Texas A&M Transportation Institute (TTI) have developed solutions to the problems and challenges facing all modes of transportation. A member of The Texas A&M University System, TTI has a breadth and depth of programs, facilities, and capabilities unsurpassed by any other higher-education affiliated transportation research organization in the United States. The Institute's research and development program has resulted in significant breakthroughs across all facets of transportation. TTI research is widely known as an excellent value with a proven impact of saving lives, time, and resources.
The strategies and products developed through TTI's research have saved Texas and the United States billions of dollars and thousands of lives.
For more information about TTI, visit the Institute's website at tti.tamu.edu.

Overview of TTI Research Facilities

Research is how we will know more tomorrow than we do today; laboratories—indoors and in the field—are where we will make and validate those discoveries. TTI pavements, materials and structures researchers work in the 138,000 square-foot Center for Infrastructure Renewal (CIR), a state-of-the-art research center that is a leading source for developing transformative infrastructure solutions. Located at the RELLIS Campus in Bryan and operated by TTI and the Texas A&M Engineering Experiment Station, the center provides 10 laboratories that focus on the development of transformative infrastructure solutions, innovating new materials, technologies, and processes to create solutions that last longer, lower costs and save time.

TTI Divisional Research Facilities

The Materials and Pavements division has extensive laboratory and field-testing equipment. The laboratory equipment is housed in the Center for Infrastructure Renewal (CIR) https://cir.tamu.edu/research-areas/.

Center for Infrastructure Renewal

The 138,000 square-foot Center for Infrastructure Renewal is a state-of-the-art research center that is a leading source for developing transformative infrastructure solutions. Located at the Texas A&M University System's RELLIS Campus in Bryan and operated by TTI and the Texas A&M Engineering Experiment Station, the center provides the facilities and the multidisciplinary research environments for attracting significant cross-industry and government agency participation, as well as educating the 21st century workforce needed to build and operate this new infrastructure. The research conducted at the CIR improves the safety, security, longevity, efficiency, performance, resiliency, financial feasibility, and sustainability of state and national infrastructure. Ten laboratories focus on the development of transformative infrastructure solutions, innovating new materials, technologies, and processes to create solutions that last longer, lower costs and save time.

Communications and Technology Transfer

TTI Communications has provided a full spectrum of communications services supporting transportation-related technology transfer for more than 25 years. Demonstrated excellence in technical writing, editing, and graphic design of print and online products; video and multimedia production; online webinar developments and meeting support; and integrated social media/web marketing and technology transfer reflect the breadth and depth of its staff.

In-House Writing and Editorial Services

TTI writers and editors work with researcher/authors and their support staff to develop high-quality documents on a timely basis. Full-time TTI editors have a combined work experience of more than 30 years and edit more than 200 research documents a year for both federal and state sponsors. They are certified by the Microsoft Corporation as specialists in Microsoft Word 2010, are trained in Information Mapping (a research-based methodology of analyzing, organizing, and presenting information), and are experienced in various citation styles.

Section 508 Compliance and Web Content Accessibility

All electronic products developed comply with Section 508 and the Web Content Accessibility Guidelines (WCAG) (version 2.0). Additionally, practices from the Web Accessibility Initiative Accessible Rich Internet Applications Suite (WAI-ARIA) are incorporated to further make web content structures comprehensible to individuals with disabilities (as well as to search engines, when appropriate).

TTI has also been involved with preparing state and federal documents for web display since 2004 and is closely familiar with the guidelines and templates for complying with individual research program requirements. TTI researchers and staff regularly team to prepare deliverables on sponsored research for electronic publication. Work includes preparation of alternative text for

graphics, accessibility work on PDF and other files, and performing the full HTML conversion of documents to ensure 508 and WCAG 2.0 compliance.

Table 4 includes a list of projects the research team is working on or have completed.

Table 4. Research Team Accomplishments.

Sponsor/ Project No.	Project Title	Period	Budget	Role
TxDOT 0-7105	Measuring Seal Coat Rate Field Adjustments	9/21-11/24	$450k	PI: Goehl
TxDOT 0-7106	Quantify Maximum Accumulated Seal Coat Layers for Stability	9/21-11/24	$449k	PI: Goehl R: Bierman, Nyamuhokya
TxDOT 27510	Seal Coat Performance Improvement Program	9/21 – 8/24	$2,196,681	R: Goehl
TxDOT 32432	Pavement Testing and Forensic Support, NDT, WIM for TxDOT Districts	9/23 - 8/26	$3,420,000	PI: Goehl
TxDOT 0-6989	Update Seal Coat Application Rate Design Method	9/18 - 11/19	$125k	PI: Goehl
TxDOT 0-6985	Perform Feasibility Study on Use of Innovative Tools and Techniques to Accelerate Pavement Construction	9/18 - 8/21	$480k	PI: Goehl
TxDOT 5-6963-01	Implementation of Seal Coat Binder Rate Adjustments using LiDAR Data	4/19 - 4/21	$216k	PI: Goehl
TxDOT 0-6963	Planning the Next Generation of Seal Coat Equipment	8/17 - 8/18	$84k	PI: Goehl

Carl Bierman, P.E. – Associate Transportation Researcher

Key Qualifications

Carl Bierman is an Associate Transportation Researcher at the Texas A&M Transportation Institute, specializing in Full Depth Reclamation (FDR) and Cold In-place Recycling (CIR) projects, as well as surface seal design. He is a registered professional engineer in the state of Texas. With a dedicated focus on sustainable pavement solutions, Mr. Bierman's expertise encompasses a wide range of topics including foamed asphalt, pavement rehabilitation, alternative materials, and the application of innovative pavement recycling technologies.

Mr. Bierman's extensive academic background includes a Bachelor of Engineering degree in Civil Engineering from Stellenbosch University, South Africa, awarded in 2015. He furthered his education at the same institution, completing a Master of Engineering in Civil Engineering in 2018.

Throughout his career, Mr. Bierman has been actively engaged in advancing the field of FDR. He has successfully developed predictive design functions to assess the long-term performance of FDR materials, a testament to his in-depth understanding of pavement mechanics. His experience is truly global, having contributed to FDR projects across multiple continents, including Africa, Europe, Asia, and the Americas. From feasibility studies to construction supervision, his involvement spans every critical project stage.

Prior to joining the Texas A&M Transportation Institute, Mr. Bierman held a pivotal role as a Site Engineer at Roadmac Surfacing Cape (Raubex) in Cape Town, South Africa. His contributions to major road rehabilitation projects exemplify his practical expertise in FDR implementation. Furthermore, his tenure at BVi Consulting Engineers (Loudon International), also in Cape Town, underscored his commitment to advancing sustainable transportation solutions through cutting-edge design and engineering practices.

Mr. Bierman's reputation in the industry is further bolstered by his membership in the Full Depth Reclamation committee and Full Depth Reclamation of the Asphalt Recycling & Reclaiming Association (ARRA). This affiliation demonstrates his dedication to staying at the forefront of advancements in FDR and related fields.

With a robust background in FDR, global project exposure, and an innate ability to bridge academic insights with real-world application, Mr. Bierman is poised to lead the proposed synthesis on FDR practices. His deep understanding of varied specifications, construction methods, and laboratory tests uniquely positions him to drive this project to a successful conclusion.

Relevant Employment History

Dates	Position(s)	Organization
2023–Present	Assistant Transportation Researcher	Texas A&M Transportation Institute
2020-2023	Civil Engineer	BVi Consulting Engineers
2017-2020	Site Engineer	Roadmac Surfacing Cape

Darlene Goehl — Associate Agency Director / Research Engineer

Key Qualifications

Ms. Goehl joined the Texas A&M Transportation Institute (TTI) in November of 2016 after retiring with 28 years of service from the Texas Department of Transportation (TxDOT). She is a registered professional engineer in the state of Texas. Ms. Goehl received a B.S. in Civil Engineering from Texas A&M University in 1988.

Ms. Goehl is currently working on pavement forensic and corridor analysis studies through TxDOT's Maintenance Division. She teaches the Seal Coat workshops (MNT702 and MNT703), and Pavement Design workshops to the TxDOT districts. She is working with several TxDOT districts on various forensic and research projects. She is currently PI for 3 TxDOT research projects. She completed a project with the Strategic Highway Research Program 2 (SHRP 2), R06D project with both TxDOT and New Mexico Department of Transportation (NMDOT) evaluating non-destructive testing capabilities for identifying asphalt pavement delamination.

Prior to joining TTI, Ms. Goehl was employed by TxDOT. While at TxDOT, Ms. Goehl worked in several areas including design, construction, and maintenance. When she retired, she was Area Engineer in the Bryan District's Huntsville Area Office. Ms. Goehl managed 85 employees as Area Engineer and was responsible for construction and maintenance of roadways in Walker, Madison, Leon, and Freestone Counties. She managed a construction budget of over $114,000,000 and was responsible for the maintenance of over 1374 centerline miles of highways. Before becoming Area Engineer, Ms. Goehl was the Bryan District's pavement and materials engineer for 17 years. In this position, her experience was in pavement design (rigid and flexible), pavement management, pavement forensic investigations, materials testing and material design. Ms. Goehl was responsible for the management of the districts wet surface crash reduction program including developing the annual reports and reviewing aggregate selection. Ms. Goehl was responsible for recommending and reviewing projects for the Bryan District 4-year plan (a $30 million annual program) which included chip seal, overlay, and rehabilitation projects. She wrote several special specifications such as Fine Graded Surface Mixes to implement innovative new methods and materials. Ms. Goehl was also a technical advisor to the 2014, "Texas DOT Standard Specifications for the Construction of Highways, Streets, and Bridges" specification updates for the 200's and 300's Items.

While at TxDOT, Ms. Goehl was heavily involved in the research program. She served as chair of the Technical Advisory Panel (TAP) for Pavement, Construction and Maintenance area. She received several awards, 2005 M.D. ("Mac") Shelby Award (Presented by The Center for Transportation Research, the University of Texas at Austin), 2011 AASHTO President's Transportation Award for Research and 2011 TxDOT Research Program Outstanding Project Director. She was involved in research areas such as pavement management (including equipment), hot mix, seal coat, concrete, construction methods, maintenance methods, full depth reclamation, and pavement design. She was involved with over 30 TxDOT research projects.

Relevant Employment History

Dates	Position(s)	Organization
2016–Present	Associate Agency Director/Research Engineer	Texas A&M Transportation Institute
1989-2016	Pavement Engineer Area Engineer	Texas Department of Transportation

Tito Nyamuhokya — Assistant Research Scientist

Key Qualifications

Dr. Nyamuhokya has master's and Ph.D. degrees from the University of Texas (UT) at Arlington, specializing in pavement, materials, and geotechnical engineering. Currently, he is an Assistant Research Scientist at TTI. He has over 18 years of work experience in pavement, construction, and materials. Since joining TTI in 2016, he has been actively involved in field work for routine performance evaluation (pavement, mixtures, and traffic) and laboratory design of asphalt mixtures and testing to assess performance such as resistance to cracking, rutting, skid resistance, durability, and moisture damage. Some of the projects he worked on are unique. The projects include designing, constructing, and implementing the APT machine (Accelerated Pavement Testing Machine) stationed at Arlington, Texas. Despite being hands-on, Dr. Nyamuhokya supervises 2-5 student workers (mostly graduate students) throughout the year to execute research work. Dr. Nyamuhokya is a Principal Investigator of Project BE965, Green Bike Lane Evaluation for Florida Pavements, sponsored by the Florida Department of Transportation. He is evaluating the performance of materials for marking bike lanes, their durability in traffic conflict zones, and best construction practices that will ensure longer life. Lately, he has worked on the following projects; TxDOT 5-6744-01: Implementation of the HMA Shear Test for Routine Mix-Design and Screening, TxDOT 22231: Balanced Mix Design System for Superpave Hot-Mix Asphalt Mixtures with RAP. FDOT BE719: Development of a Laboratory Testing Protocol to Evaluate Alternative Materials for Use in Modifying Asphalt Binders and Alternative Materials for Use in Modifying Asphalt Mixtures. FDOT Project BEA88: Evaluation of Pavement ME Design Software for Flexible Pavements, TxDOT 0-7142: Develop Safety Scoring Tool for the Wet Surface Crash Reduction Program, TxDOT 0-7148: Develop Design Details for CRCP Whitetopping at Intersections, TxDOT 0-7153: Develop Design of Hot-Mix Cold-Laid Mixtures with the Superpave Gyratory Compactor, TxDOT 0-7110: Develop Cost Effective Design and Rehabilitation Strategies for Permeable Friction Courses (PFC's), TxDOT 0-7106: Quantify Maximum Accumulated Seal Coat Layers for Stability.

Before joining TTI, he briefly worked with ECS, a geotechnical engineering and construction service company in Dallas, Texas. At ECS, he mostly worked in the field, ensuring the contractor followed specifications and designs. In addition, he performed field soil tests and concrete tests and supervised the drilling and casting of belled and straight piers.

Internationally, Dr. Nyamuhokya also worked in Tanzania for three and a half years. He worked as a Public Works Engineer responsible for designing, training, and supervising local communities undertaking engineering projects, including the construction of schools, earth and gravel roads, roadside drainage system, and more. He also worked for a civil engineering consulting firm. His roles included soil investigation, field survey, design, and drawing and detailing bridges and roads.

Relevant Employment History

Dates	Position(s)	Organization
2016–Present	Assistant Research Scientist	Texas A&M Transportation Institute
2014-2016	Field Technician	ECS

Budget

Attachment D

Standard Budget Itemization for Department Research Projects

Project Title: Design of Surface Treatments with Reclaimed Asphalt Pavement Aggregates

Project Duration: 24 Months

Name and/or Position[1]	Salary (Monthly or Hourly)	Wage	Fringe Benefit	Total Year 1
Carl Bierman	$ 81,876.70	$ 49,120	$ 15,876	$ 64,996
Darlene Goehl	$ 22,665.24	$ 13,547	$ 3,286	$ 16,833
Tito Nyamuhokya	$ 9,794.46	$ 11,765	$ 3,558	$ 15,323
Tony Barbosa	$ 7,506.36	$ 13,503	$ 4,518	$ 18,021
Tobey Lindsey	$ 7,803.90	$ -	$ -	$ -
Michelle Benoit	$ 9,651.78	$ -	$ -	$ -
Teresa Boriski	$ 6,208.32	$ 1,855	$ 674	$ 2,529
Graduate Student	$ 2,433.39	$ 8,755	$ 1,277	$ 10,032
Undergraduate Student	$ 1,488.57	$ 5,355	$ 161.00	$ 5,516
Year 1 Total		**$ 103,900**	**$ 29,350**	**$ 133,250**

Name and/or Position[1]	Salary (Monthly or Hourly)	Wage	Fringe Benefit	Total Year 2
Carl Bierman	$ 9,119.53	$ 54,717	$ 16,978	$ 71,695
Darlene Goehl	$ 25,247.83	$ 15,091	$ 3,590	$ 18,681
Tito Nyamuhokya	$ 10,910.49	$ 13,105	$ 3,822	$ 16,927
Tony Barbosa	$ 8,361.67	$ 15,041	$ 4,821	$ 19,862
Tobey Lindsey	$ 8,693.12	$ 2,048	$ 647	$ 2,695
Michelle Benoit	$ 10,751.55	$ 2,657	$ 779	$ 3,436
Teresa Boriski	$ 6,915.73	$ 2,186	$ 757	$ 2,943
Graduate Student	$ 2,710.66	$ 9,752	$ 1,307	$ 11,059
Undergraduate Student	$ 1,658.19	$ 5,355	$ 161.00	$ 5,516
Year 2 Total		**$ 119,952**	**$ 32,862**	**$ 152,814**

Name and/or Position[1]	Salary (Monthly or Hourly)	Wage	Fringe Benefit	Total Year 3
Year 3 Total		**$ -**	**$ -**	**$ -**

Name and/or Position[1]	Salary (Monthly or Hourly)	Wage	Fringe Benefit	Total Year 3
Year 4 Total		**$ -**	**$ -**	**$ -**

		Year 1	Year 2	Year 3	Year 4
A. Personnel		$ 133,250	$ 152,814	$ -	$ -
B. Travel[2]		$ 8,982	$ 8,982		
C. Operating Costs		$ 2,227	$ 2,339		
D. Final Report Preparation and Submission		$ -	$ 50		
E. Equipment					
F. Other Costs		$ 5,250	$ 7,800		
G. Subcontract (1st $25,000 w/Indirect Cost)					
H. Subtotal of Direct Costs (sum of A thru G)		$ 149,709	$ 171,985	$ -	$ -
I. Total Indirect Cost (% at current rate)	**52.5%**	$ 77,428	$ 91,609	$ -	$ -
	54.0%				
J. Student Tuition and Fees (if applicable)					
K. Subcontract (w/o Indirect Cost)					
L. TOTAL PROJECT COSTS PER YEAR (sum of H thru K)		**$ 227,137**	**$ 263,594**	**$ -**	**$ -**
TOTAL PROJECT COST[3]			**$**		**490,731**

Notes:

(1) Categories can be added and, with the exception of personnel and fringe, removed as best fits the proposed research.

(2) Department only pays for travel that is essential for the completion of the project and at costs per GSA rates and Department policies. Travel costs to professional and other meetings are not allowed. Travel outside of Nevada requires written Department approval in advance.

(3) The budget will be tracked according to the categories identified herein. Invoicing is expected to match, within reason, these categories for accurate budget tracking.

NDOT Champion, Coordination and Involvement

The success of this research initiative hinges on the collaboration and support of the Nevada NDOT to can provide valuable insights and coordination. While the assistance required from NDOT is limited, it is crucial for providing specific district-level information and facilitating the coordination of essential tasks.

The involvement of NDOT is primarily sought for the provision of detailed information on specific districts and materials that should be targeted in this study. This information will ensure that the research is tailored to the specific needs of NDOT.

NDOT's champion will play a pivotal role in coordinating the sampling of RAP materials from stockpiles in various parts of Nevada. This coordination is essential for obtaining a representative and comprehensive dataset that reflects the variability in asphalt mixtures across the state. The champion will also act as a liaison between the research team and relevant stakeholders within NDOT, ensuring smooth communication and collaboration throughout the study.

The involvement of internal and external stakeholders will be crucial for the success of the research. Internally, collaboration with NDOT's Materials and Maintenance Divisions will be essential for accessing district-specific information and coordinating sampling efforts.

A communication plan will be established to capture and utilize the input of NDOT's champion and the technical advisory committee. Regular updates, meetings, and feedback sessions will be conducted to ensure that the research remains aligned with NDOT's objectives and addresses any emerging challenges promptly.