Exhibit D

Research Project Requirement Template

Greenhouse Gas Emissions Reduction and Durability of Sustainable Pavement Recycling and Stabilization Using Novel Materials

Recipient/Grant (Contract) Number: 69A3552348306 (CY1-TAMU-UTEP-01)

Center Name: Southern Plains Transportation Center (SPTC)

Research Priority: Improving the Durability and Extending the Life of Transportation

Principal Investigator(s): Nripojyoti Biswas, Texas A&M University; Rajib Mallick, University of Texas-El Paso; Anand J Puppala, Texas A&M University; Soheil Nazarian, University of Texas-El Paso

Project Partners: Texas A&M University and University of Texas-El Paso

Research Project Funding: Texas A&M University: $70,000 (Federal) and $5,022 (Match); University of Texas-El Paso: $65,000 (Federal) and $65,000 (Match)

Proposed Start and End Date: 9/1/2023 to 8/31/2024

Project Description: The objectives of this project are: (1) To compare the CO_2 (primary greenhouse gas) emissions from Full Depth Reclamation (FDR) mixes with a conventional asphalt emulsion, foamed asphalt, and High Yield Emulsion (HYE), through laboratory testing, analysis of data, and evaluate the durability of optimized HYE mix with accelerated loading and testing; (2) To evaluate the use of recycled concrete aggregate fines (fRCA) as a co-additive with cement stabilizer to treat problematic subgrade soils such as expansive soils through engineering, mineralogical, and chemical testing and embodied carbon analysis.

The following tasks will be pursued by the TAMU team: (1) Collect problematic soil; (2) Procure and characterize fines from recycled concrete aggregate (RCA); (3) Determine optimum dosages of stabilizers and co-additives; (4) Compare performance (untreated and treated soils containing fRCA); (5) Analyze mineralogical and chemical components; (6) Evaluate sustainability benefits; (7) Compare treatment alternatives. The UTEP tasks will include: (1) Collect asphalt and other materials from FDR projects; (2) Develop mix designs with different binders; (3) Collect and analyze fuel data from FDR projects; (4) Collect emission data for binder production; (5) Test the optimized mix for durability; (6) Analyze data and make recommendations on sustainability and durability. The results from this research will lead to a better understanding of critical sustainability and durability aspects of novel materials, consisting of FDR binders for base and RCA fines for subgrade stabilization. The observations from experiments will be translated to pavement performance under different environmental conditions, such as temperature and precipitation. The data could be utilized for the modeling and performance prediction of recycled/subgrade-treated pavements under extreme environmental conditions. The results will lead to the implementation of sustainable technology, savings in life cycle/life cycle cost, rehabilitation of a greater mileage of roads, and enhanced road safety. Implementation will include new specifications for FDR and the treatment of subgrade soils. Furthermore, the sustainability evaluation framework developed from this study will be available for implementation by the state DOTs in selecting novel materials in the future. The draft specifications and framework will be prepared for possible inclusion in state or federal specifications, as part of the deliverables. Descriptions of any impediments to the implementation of the specifications/framework and further work, if needed, will also be provided. The envisioned sustainability benefits will be in terms of reduced emissions, materials used, and reduced life cycle costs, which will be quantified from life cycle cost analysis, using the appropriate framework.

US DOT Priorities: The proposed project is in direct alignment with SPTC's topic "(2) Leveraging Novel Materials and Emerging Technologies and Tools to Enhance Durability, Sustainability, and Extend Infrastructure Life" and USDOT's statutory research priority "D: Improving the Durability and Extending the Life of Transportation Infrastructure." The project is aligned with the USDOT's strategic initiative on climate and sustainability, as it contributes directly towards greater recycling, reduction of the use of newly manufactured materials, including a reduction in the potential usage of Portland cement, and hence a significant reduction of greenhouse gas emissions, and consequent reduction of harmful effects on the climate.

The proposed project will address diversity, equity, and inclusion in three different ways. First, it will identify and justify the use of sustainable materials and processes, and hence reduce the negative impact of pavement construction which is often greater for underserved and overburdened communities. Second, the framework for evaluation of sustainability will allow the DOT to plan, construct, and manage roads with consideration of local conditions, such as environmentally sensitive rural areas and poverty-stricken areas. Lastly, since both FDR and the use of fRCA involve recycling, the project will lead to a significant reduction in landfilling of waste materials. By setting up a rational framework for selecting the most appropriate materials for recycling, the project will enable the DOTs to take a major step towards providing safe and healthy mobility and access for all. The activities will be aligned to strengthen diversity, equity, and inclusivity in the research work. The research team represents a very diverse group of students, researchers, and senior faculty members with different backgrounds. Effort will be made to foster a collaborative culture in the team, mentor and develop research leadership among the diverse group of students and advance them in their careers

Outputs: This research will generate critical data on the sustainability and durability of FDR binders and RCA fines/cement for use as co-additives for subgrade stabilization. A final report including draft specifications and the sustainability framework will be prepared.

Outcomes/Impacts: This project will advance the understanding of durability of different FDR binders and utilize novel materials in stabilizing problematic soils, such as expansive soils that are prone to shrinkage and swelling. In addition, it will explain the sustainability benefits of the stabilizers with recycled materials including fRCAs and FDRs. All these will lead to a greener transportation infrastructure system with fewer maintenance problems, reduced environmental concerns, and a greater positive social impact for all communities including underrepresented communities. The results from this study will be utilized for new specifications and sustainability framework for FDR and the treatment of problematic soils. The evaluation of sustainability will lead to more innovations in materials and processes and open possibilities of funding from, and partnerships with, the industry and SBIR/STTR funding from the National Science Foundation (NSF).

Final Research Report: