Exhibit D

Research Project Requirement Template

Multifunctional Geosynthetic-based Stabilization to Increase Coastal Infrastructure Resilience

Recipient/Grant (Contract) Number: 69A3552348306 (CY1-TTI-02)

Center Name: Southern Plains Transportation Center (SPTC)

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

Principal Investigator(s): Puneet Bhaskar, Texas A&M Transportation Institute

Project Partners: Texas A&M Transportation Institute

Research Project Funding: $89,712 (Match)

Proposed Start and End Date: 09/01/2023 to 08/31/2024

Project Description: Coastal communities of Texas and Louisiana primarily rely on road infrastructure for their transportation and access to goods and services. Due to surges in extreme rainfall and storm events because of climate change, coastal infrastructure is at pressing risk. The aggressive infiltration of water in the pavement due to frequent flooding declines its functional and structural performance gradually. Geosynthetics have been extensively used in pavement structures to enhance their bearing capacity and stiffness. Most of the commonly used geosynthetics do not help with subsurface drainage under pavements. A novel geotextile with special hydrophilic and hygroscopic wicking fibers is gaining popularity due to its multiple functions, including separation, reinforcement, gravity drainage, and capillary drainage through wicking action. Because of its versatility, it can potentially serve as a unified drainage and reinforcing element in a pavement.

This project aims to assess wicking geotextile as a resilient and sustainable adoption in coastal pavement infrastructure vulnerable to climate change impacts. The objectives of this research study are: (1) To understand the efficacy of wicking geotextile reinforcement in pavement infrastructure under extreme climate conditions; (2) To compare the overall performance of wicking geotextile with conventional geotextile reinforcement in coastal pavements.

To address these objectives, the following research tasks will be conducted: (1) Existing literature on novel geosynthetics and their characterization will be reviewed and summarized in progress reports and in the final report; (2) Moisture movements within a soil layer with wicking geotextiles and conventional geotextiles will be studied. Moisture probes or tensiometers will be installed in the large direct shear box, and moisture variation in compacted soil will be recorded for up to 7 days. This will help understand and compare drainage capabilities of conventional and wicking geotextiles under different normal loads; (3) Around 20 large-scale direct shear tests (apparatus shown in Figure 1) will be performed on soil with wicking geotextile and conventional geotextile to determine interface friction angle and cohesion. Tests will be performed at different normal loads after 3 and 7 days of drainage. The experimental results will potentially provide a degree of increase in the strength of the subgrade with an application of wicking geotextile; (4) A fully coupled finite element model of coastal pavement infrastructure reinforced with both geotextiles under different environmental stressors will be developed. Laboratory results will be used to develop a model in PLAXIS, and the performance of wicking geotextile in pavements will be assessed under extreme rainfall and flooding events.

Figure 1: Large-scale direct shear test apparatus

US DOT Priorities: The proposed project will address the USDOT strategic objectives of Safety and Climate and Sustainability. Both experimental and numerical results could be utilized for the performance prediction of reinforced pavement infrastructure under extreme environmental conditions. This project aligns well with the SPTC goal of "Improving Durability of Coastal and Tribal Infrastructure" through an innovative and sustainable method. Performance of a sustainable geosynthetic in coastal pavements impacted by climate change will be evaluated through large-scale direct shear testing and moisture migration studies by measuring interface friction angle and cohesion after 3 and 7 days of drainage. Furthermore, this project will also address diversity, equity, and inclusion as potential implementation of this idea by state DOTs which will provide durable road infrastructure to tribal and underrepresented communities for better access and transportation in coastal areas of Texas and Louisiana.

Outputs: This project will provide scientific data to assist the implementation of wicking geotextiles in coastal pavements for increased safety and sustainability through the final report. A coupled hydro-mechanical numerical model will be developed to design wicking geotextile reinforced pavement sections under different hydraulic and quasi-static loadings.

Outcomes/Impacts: This research will lead to a better understanding of working with wicking geotextiles in coastal environments where flooding is a major concern. It will highlight its benefits over conventional geotextile in terms of drainage and interface properties. The results of this proposed study will provide a framework for the implementation of wicking geotextiles in coastal infrastructure for more resilience and enhanced safety. The proposed research will potentially lead to improved resilience and safety of coastal pavements because of better drainage of subsoil layers and uniform moisture distribution. Additionally, it will help reduce maintenance and restoration costs of coastal pavement infrastructure often impacted by flooding events.

Final Research Report: