Research Project Name: COLLABORATIVE: Quantifying erosion and load transfer mechanisms of geosynthetic reinforced coastal pavement subgrades and embankments during inundation events (TAMU/TXST)

Improving the Durability and Extending the Life of Transportation Infrastructure

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Project Description: Transportation infrastructure in coastal regions is highly susceptible to soil erosion and subgrade degradation under frequent inundation events caused by storm surges. Fines within the subgrade are washed out due to flood-induced subsurface flow, while overflowing water along embankments results in overtopping and eventually leads to surficial erosion and complete collapse. These processes result in embankment and pavement failures; addressing these issues requires novel and innovative infrastructure durability solutions. One approach that combines hydraulic protection of subsoils with reduced soil erosion and provides drainage to recede floodwaters from infrastructure is geosynthetics. Geosynthetics, like geocomposites and turf-reinforced mats (TRMs), are often used to control erosion in slopes and levees from overtopping and rainfall. Also, the use of geosynthetics is increasingly growing for pavement reinforcement applications. These well-established benefits of geosynthetics can be combined and effectively applied for coastal transportation infrastructure that often sees failures following inundation events. Hence, this research study focuses on evaluating geosynthetics to solve both embankment erosion and maintain drainable and resilient subgrade foundations to support coastal transportation infrastructure.

Geosynthetic Reinforcement of Coastal Embankment Slopes: TRMs and geocomposites will be studied for this application. TXST will measure the erosion characteristics of the test materials using the erosion function apparatus (EFA). The EFA will quantify the erosion rates of the soil with and without the protection of these geosynthetic layers under varying hydraulic stresses, providing insights into soil erodibility and material performance. TAMU will conduct small-scale flume erosion studies on model embankment slopes using a coastal, sandy soil. Flume studies on embankment slopes built with and without geosynthetic reinforcements will be subjected to overtopping and inundation flow conditions for various time periods. Erosion patterns will be studied via laser and digital image scans. These data will also assess the role of geocomposites and TRMs on mitigating soil erosion and enhancing slope stability.

Geosynthetic Reinforcement of Coastal Pavement Subgrade Foundations: TAMU flume study results will yield erosion patterns, more specifically void patterns, that will be used to create an "eroded" pavement structure. These artificial voids will be created inside a large box setup, with 12 to 18 in. of subgrade supporting a flexbase aggregate base layer. These box samples will be instrumented with moisture probes, pressure cells, and MEMS deformation sensors. Each model pavement will be subjected to cyclic plate load tests to study and evaluate the load-bearing capacity and load transfer mechanism from repeated loads to the underlying subgrades. The same tests will be performed on the samples after they are inundated. The role of geocomposites both before and after exposure to moisture inundation, as well as load transfer mechanisms on subgrades with erosion-simulated voids, will be evaluated.

This is a collaborative project between Texas A&M University (TAMU) and Texas State University (TXST). Flume and large-scale box studies will be performed at TAMU Galveston campus and Center for Infrastructure Research (CIR) laboratories, respectively. TXST will perform the EFA with geosynthetic layers experiments. EFA studies focus on evaluating the critical shear stresses (i.e., hydraulic shear stresses at which soil erosion initiates) of the reinforced/unreinforced subsoils. Changes in critical shear stress at discontinuities such as gravel/sand interfaces will be of particular interest. These combined results will generate a comprehensive understanding of the potential improvements of embankment and foundation reinforcement using advanced geosynthetic materials in providing resilient support to transportation infrastructure in coastal corridors. The results of this project will be used to design Phase II with coastal railroad track embankments.

US DOT Priorities: *Section left blank until USDOT's new priorities and RD&T strategic goals are available in Spring 2026.*

Outputs: The project will establish the beneficial aspects of incorporating geosynthetic solutions for addressing inundation and flooding-driven issues, like coastal embankment slope erosion and soft and eroded subgrades in coastal pavements. EFA test results will provide key insights into the critical hydraulic shear stresses at which the erosion initiates, and by comparing these values with those obtained from geosynthetic reinforced soils, a clear quantification of improvements is possible. Also, the erosion patterns obtained from the model studies through flume testing, complemented with laser scanning, will be of great value extending the findings to real-world implementation of the technology. The load-transfer mechanisms of soft and eroded coastal subgrades with and without geosynthetics, along with detailed quantification of improvements in the load-carrying capacities, help provide valuable design guidelines for resilient coastal pavements. The results from all the research works performed through this study will be documented in the final report and will also be made available through journal and conference publications.

Outcomes: The anticipated outcomes of this research will include a better understanding of erosion processes of geocomposites and TRMs reinforced subsoils, as well as the development of performance-based design-relevant parameters for pavement and embankment infrastructure situated in flood and inundation-prone coastal regions. In addition, limited life cycle cost analysis studies will be incorporated to assess the benefits of using geosynthetics for embankment and pavement subgrade reinforcements.

Final Research Report: URL to final Report will be provided upon completion.