Research Project Name:
COLLABORATIVE: SEAHIVE® solutions to mitigate bridge scour – Phase I

Improving the Durability and Extending the Life of Transportation Infrastructure

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Project Partners: UM / TXST

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Project Description:

Scour remains the primary cause of bridge failure. It can occur locally around an abutment/pier or in between foundation elements. Scour is difficult to predict as there is no unified method based on soil properties and complex hydrological flow profiles to understand soil erodibility. Once bridges are installed, changes in the hydraulic load from the foundation obstructions constructed in the flow path, natural river meandering (i.e., direction change) or unprecedented loading from extreme events can further alter bridge scour predictions. The objective of this research project is to show a proof-of-concept of using innovative hydraulic load dissipating elements, known as SEAHIVE®. This is a modular engineered protection system composed of concrete perforated hexagonal prisms. Perforations on the side faces of the elements provide passage for water flow dissipating the energy within the system while also adding structural complexity which improves its potential for habitat creation. SEAHIVE® has been under research and development at the University of Miami for wave energy dissipation and habitat enhancement with three pilot installations completed. This UTC study will investigate the performance of the SEAHIVE® system in mitigating bridge scour. This project has the potential to create a consortium-wide effort for implementing the SEAHIVE® system into practice and creating transformational change in how we design bridge foundations considering scour.

It will consist of three phases at the University of Miami. The first one (year one) will be devoted to the characterization and production of the SEAHIVE® elements using industrialized technologies. We have currently identified four possible methods to manufacture SEAHIVE® elements. The first-year phase one will focus on externally prestressed elements given the mass production and scaling-up advantage. Externally prestressed (by Glass FRP rovings) units produced by dry cast with the same equipment used to produce concrete pipes. The most significant advantages of this construction method are: a) speed of production of fully cured units at a rate of five or more per hour; b) elimination of internal reinforcement; and, c) the leanest possible concrete mixture. The unit's length would be limited to a maximum of 8-ft.vc Other potential fabrication techniques include, precast internally reinforced wet-cast or longitudinally prestressed production based on existing pile production methods for longer units, and 3D construction printing for more complex multi-unit combinations.

Texas State University (TXST) will focus on evaluating the potential for bridge scour mitigation in highly erodible sediment in year one. This will be achieved using flume tests and a calibrated numerical model. A coupled hydrodynamic-morphodynamic model in Open FOAM will be first used to optimize the SEAHIVE® element for bridge scour energy dissipation. A model test in

the flume will then be conducted on the optimized SEAHIVE® monopile element with several layers of instrumentation. The hydrodynamic-morphodynamic model will then be calibrated with the monopile flume data. We will then consider two additional experimental setups: a SEAHIVE® skirt around the monopile and SEAHIVE® riprap against the monopile. Again, these data will be used to calibrate the model, to numerically investigate the efficacy of SEAHIVE elements in suppressing scour under different flow conditions, and to optimize the configuration and number of SEAHIVE® elements.

US DOT Priorities: Bridge scour is the number one cause of bridge failure. If we are able to mitigate or eliminate bridge scour using SEAHIVE elements, bridge *durability* will be greatly enhanced which is the CREATE Center US DOT priority. This research integrates the centers RD&T strategic goal of *Equity* through recruited graduate and undergraduate researchers from underserved demographics. Furthermore, when roads are closed due to bridge failures there is an inequitable and disproportionate impact on rural communities, seniors, and low-income commuters. As bridge scour is the number one cause of bridge failure, mitigating scour improves *Safety* of our infrastructure and works towards the grand challenge of zero transportation related fatalities. Numerous drivers have perished due to bridge scour when the bridge failed while in use. The use of SEAHIVE® elements to mitigate bridge scour is potentially *Transformative* as this would change the way we design bridge foundation support. Finally, this advances the goal of *Climate and Sustainability* as mitigating bridge scour will lead to more sustainable and resilient infrastructure. Overall, decreasing bridge scour using an effective and ecofriendly system will make coastal, estuarine and riverain bridges more durable while promoting habitat creation.

Outputs: The first-year Phase-one will have tech transfer primarily targeting material selection, construction methods, and data to guide a prototyping project. There will be the engagement of a company potentially interested in the manufacturing of SEAHIVE® units. We will seek partnerships with our DOTs (Florida and Texas) to identify partnership opportunities for a prototype on a scour critical bridge that can be instrumented to evaluate the full-scale efficacy in a phase II project. Concurrently, the PIs will engage state and local bridge owners to explain and market the potential benefit of this technology. Even though the initial focus is scour protection, the potential of this technology has immediate applications in shoreline and port facility protection. Thus, practitioners and owners will be engaged in conversations to explore other uses.

The potential partners envisioned for this project are: a) FDOT/TxDOT as bridge owners in both states are interested in demonstration projects utilizing the proposed technology; b) FSC Technologies LLC is a company interested in developing a partnership with UM for the manufacturing and distribution of SEAHIVE® elements using the dry-cast concrete technology; and, c) local communities and stakeholders from South Florida.

Outcomes/Impacts:

SEAHIVE® is a registered UM trademark. It is expected that a patent application will be filed soon SEAHIVE® elements using the dry-cast concrete technology.

According to the FDOT, *bridge scour is the largest cause of bridge failure in the United States and a major factor that contributes to the total construction and maintenance costs of bridges in the United States.* Therefore, reducing and preventing scour using an efficient and eco-friendly sustainable system such as SEAHIVE® can have great positive impact in the transportation system all across the United States.