Sturdy mattress

Scour problem resolved at Kennedy Space Center

Channel stability at a bridge crossing depends on the stream system.

Natural and man-made disturbances may result in changes in sediment load and flow dynamics resulting in adverse changes in the stream channel at the bridge crossing. Scour can occur any time there is a natural or man-made structure, such as a pier, in a moving body of water.

In significant cases, such as a large storm event, flowing water approaching a pier will cause the water to move back and down, pushing the soil in the water away from the pier and creating a deep hole. Once this happens, it can expose the pier pilings. A pier piling is typically placed 100-150 ft into the earth under the water and is typically made up of steel sheet pilings or concrete columns. They are capped with a concrete encasement at the top of the pile for protection from exposure to the water.

Exposure to the steel sheet piles in the water will cause corrosion and is a threat to the piers if scour is not treated. Corrosion causes deterioration of the piling, undermining the substructure of bascule piers, causing the pier to shift or lean. This shift will cause the bridge to move, thus creating bridge failure and in worst cases, a collapse.

Each pier is holding up a certain amount of load pressure. If the soil loosens around the steel pipe supporting a single pier, load pressure is lost, placing additional load pressure on the other piers. This will cause the concrete to crack, which could again lead to bridge failure.

"Anytime you have a large storm event, a high frequency of large storm events or you have a high velocity of water flow at a bridge crossing, you should perform an evaluation to determine if scour protection is required," said Kim Rivera, P.E., of Jones Edmunds and Associates Inc., the design engineer for the project. "This can help avoid potential future bridge failures."

The project

NASA Kennedy Space Center (KSC) in Cape

Canaveral, Fla., battled scour problems around each bascule pier of four bridges throughout the KSC's channel and fender systems.

An underwater inspection was completed around all of the bascule and approach piers of the four bridges: The main entrance bridges to KSC in the Indian River, Banana River Bridge, Jay Jay Railroad Bridge and the Haulover Canal Bridge.

Two bridges in the large body of water in the Indian River provide the main public entrances into KSC and as such carry the largest amount of public vehicle traffic.

The Jay Jay Railroad Bridge dealt with the same water flow as the main entrance bridges because it was located in the Indian River as well. This bridge was strictly used for railcars.

The bridge in the Banana River was much smaller and was located in a smaller body of water. This bridge allowed no public traffic because it was for NASA and Cape Canaveral Air Force Station use only.

The Haulover Canal Bridge, connecting the Indian River to Mosquito Lagoon and the Jay Jay Railroad Bridge, was located in a narrower body of water, where water rushes through rapidly, creating deep scour pockets around the bascule piers.

All of the bridges and their piers were evaluated for potential scour by performing hydraulic modeling to predict scour depth. Large scour was predicted around the bascule piers of each bridge when tested during a 100-year and 500-year storm. What originally started out as a study quickly turned into a design to install scour protection.

Project challenges

Positioning and anchoring the scour protection system was challenging because the project involved installing the geosynthetic revetment system at depths of approximately 20 ft, amid high water velocities, with limited overhead clearance and poor visibility in the water. Narrow channels, strong currents and deep scour pockets demanded dredge-and-fill maneuvers or anchoring systems for slopes greater than 2-to-1.

Trying to place material underwater and get a specified thickness of material in adverse conditions can be difficult.

Three applications were evaluated when trying to find the best solution for NASA's KSC bridge scour problems: bank and shore rubble riprap, articulated concrete blocks and marine mattresses.

Riprap is made up of larger stones that vary in size, 1-3 ft in diameter. Its 3.6-ft thickness would have required excessive channel dredging to ensure the required U.S. Army Corps of Engineers' (USACE) approved depth of minus 18 ft.

Riprap was first considered because it is the most common method used for bridge scour protection. It has a simple installation method and is a readily available product. The scour protection already in place at Haulover Canal was riprap, so it was thought to be easier to place additional riprap to the current protection system already in place. However, riprap would have required more dredging of the soil to maintain the USACE's approved surface depth.

The articulated concrete block option was much more expensive and more technical in design. The blocks are honeycomb-shaped, so each block had to fit just right under the water, which would have been very challenging. It also couldn't be custom designed to fit the bridges' fender systems, which was an important factor to consider when comparing scour-protection systems.

The marine mattresses were a less expensive option than the concrete blocks and only required 1-ft-thick mats, so not as much dredging was required in order to meet the minus 18-ft depth requirement. Less material also was used and was therefore more environmentally friendly.

In the end, NASA selected Tensar's Triton Marine Mattress System for its challenging subaqueous scour protection project.

Leaning on mattresses

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using select grades of copolymer (high-density polyethylene [HDPE] and polypropylene [PP]) resins that are highly oriented and resist elongation (creep) when subjected to high tensile loads for long periods of time. Polymeric geogrids provide high resistance to installation damage and long-term chemical or biological degradation. With this geogrid, the mattresses had the strength and flexibility to armor the bridge piers without damaging them.

NASA and Jones Edmunds and Associates also selected the reinforcement systems because the units could be locally constructed and customized on shore prior to installation and could be conformed around fenders or circular piers.

In high-flow conditions, the marine mattresses tend to be very stable. Trying to place material underwater and get a specified thickness of material in adverse conditions is always difficult. Having a unit like the marine mattresses that goes in as a discreet size that can be positioned using GPS ensures the contractor and engineer know that what was specified is actually what was installed.

Six inches of bedding stone was laid down first at the bottom of the piers for leveling purposes. Bedding stones are small pebbles, so the shipping costs were much less than for the 300 lb of the limestone riprap. Lastly, the mattresses were assembled and placed using cranes by the piers.

The government appreciated the fact that an efficient bridge-scour protection was achieved at less than half the thickness of riprap and that mattresses are much easier to remove than riprap, a factor that also minimized the transition from surrounding grades. The government had to consider this, given the potential for future bridge-replacement projects.

During the KSC project, 1,281 marine mattresses were utilized with the geosynthetic revetment systems at depths of approximately 20 ft amid strong currents and with limited overhead clearance using GPS. Even in the most demanding conditions, the mattresses had the strength and flexibility to armor the bridge piers without damaging them.

Due to the capability of customizing, depending on the pier, different sized mattresses were used. All were 5 ft wide and they varied in length, 10-20 ft long.

"Currently the bridges are in good condition, and the mattresses are still intact," Rivera said. "No problems or damages have been reported." **R&B**

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