DESIGN AND CONSTRUCTION OF APPARATUS FOR MEASURING RATE OF WATER EROSION OF SEDIMENTS

PROBLEM STATEMENT

In spite of the numerous advances made in the understanding of bridge scour processes in recent years, many questions still need to be resolved. Early bridge scour research focused mainly on scour of cohesionless sediments around single, circular piers or columns. Now there are methods available to compute scour around not only non-circular pilings but also around complex structures, e.g., a column supported by a pile cap and a pile group. Researchers are now also able to predict the time varying rate of scour under both steady and unsteady flow conditions, such as occurs in tidal waters. In spite of all of these advances, there has been only limited research dedicated to the scour of erodible rock and cohesive materials.

The current method for estimating scour in rock or cohesive materials treats the material as if it were cohesionless. That is, the maximum depth of scour at piers in cohesive soil is assumed to be the same as in non-cohesive soils, differing only in the rate at which scour occurs. The equations used to approximate the scour depth in cohesionless materials are known to be conservative and are believed to be excessively conservative for erodible rock and cohesive sediments. Determination of (1) the rate at which the sediment erodes as a function of bed shear stress and (2) the predicted flows for the life of the structure would make possible accurate estimation of both the contraction and local scour of the bridge at the end of its life. This information would allow for significant reduction in the initial and maintenance costs of the bridge structure.

OBJECTIVES

The objective of this project was to construct two devices to measure the erosion rates of soft rock and cohesive and non-cohesive materials.

The first device, the RETA (Rotating Erosion Test Apparatus), circulates water around a cylindrical sample; the shear stress applied to the sample is correlated to the erosion rate. Five devices have been constructed, four of which are currently operational at FDOT’s State Materials Office in Gainesville.

The second instrument, the SERF (Sediment Erosion Recirculating Flume), can test a wide variety of materials. An electronic sensor array accurately measures the elevation of the test sample, which is positioned flush with the flume’s lower surface. As water flows over the sample, erosion of the surface is detected by the sensors; the device slowly moves the sample upwards until it is again flush with the surface. This automated operation is controlled by

LABVIEW software, which signals the stepping motor to raise the sample discrete distances or steps. The total number of steps is converted into a vertical distance and compared to the imposed shear stress on the sample, producing an erosion rate.

FINDINGS AND CONCLUSIONS

Data obtained from both units shows repeatable trend lines relating shear stress with erosion rates of various materials. The units perform as designed, and samples from around the state are being tested. It is expected that the accumulation of data obtained through these devices will provide ongoing and valuable information to bridge designers with regards to bridge scour susceptibility.

BENEFITS

Until now, bridge designers have had to assume that pile foundations located in soft rock were susceptible to scour on the same order of magnitude as those founded in sands. This assumption added substantial cost to projects, since pile lengths had to be long enough to accommodate possible great scour depths.

The RETA and the SERF enable designers to rapidly test actual foundation materials for new bridges and to predict long-term scour susceptibility. Based on a recent series of erosion tests, bridge designers were able to reduce the lengths of piles for a proposed bridge, resulting in substantial cost savings. It is expected that savings will continue to accrue as further data become available.

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