Monday 3/13/2017

9:45–11:15 a.m.

Bridge & Offshore Structure Scour

Chairs: Cheng Lin, Terracon Consultants Inc.; Fayun Liang, Tongji University

Effect of Level of Compaction on Internal Erosion Potential for Granular Soils

Jahanzaib Israr, Buddhima Indraratna, and Cholachat Rujikiatkamjorn, University of Wollongong

Internal erosion occurs when the seepage forces wash out the fines of a non-uniform soil along the pre-existing openings (e.g. cracks and voids), resulting into substantial increase in permeability. Given that the drainage characteristics of soils are significantly influenced by the shapes, packing arrangement and size distribution of their particles, the erosion of fines can alter the drainage characteristics. The assessment for internal erosion potential is normally obtained based on grain size distribution ignoring the effect of compaction and particles' shapes. In this study, the experimental results of hydraulic gradient controlled erosion tests, conducted over a select range of compacted soils, were used to compare with the internal erosion assessments from some of the existing criteria. Consequently, a new approach that considers the shapes, packing arrangement and size distribution of particles for assessing their internal erosion potential is proposed that showed highest success rate compared to the rest.

Comparison and Estimation of Local Scour Depth around Pile Groups and Wide Piers

Chen Wang and Xiong (Bill) Yu, Case Western Reserve University; Fayun Liang, Tongji University

Experiments of local scour around pile groups and wide piers are carried out under steady currents. Piers with large diameter and pile groups were arranged properly so that the scour process and maximum scour depth could be compared. Although numerous empirical formulas have been proposed to predict equilibrium scour depth around various bridge piers, there is still no general formula that satisfies all conditions. In addition, the scour characteristics of different types of structures are not clearly understood. This study observed the dynamic scour process and the scour depth of every case was determined. Comparisons of pile groups and wide piers were made to aid in the determination of the influence of several foundation types.

Experimental Study of Pier Streamlining Effect on Bridge Local Scour Under Clear-Water Conditions

Junhong Li and Junliang Tao, University of Akron

A series of experimental tests were conducted to investigate the effect of pier streamlining on bridge local scour under clear-water conditions. A total of four testing cases were included in this study. Test conditions in all cases were kept the same except that the pier geometry in each case had sequentially increased extents of streamlining. These streamlining features were adopted from a previous numerical study by the authors. This paper compared the time evolution of local scour among cases. Contour maps of the scoured bed were obtained using the Structure from Motion (SfM) technique. The streamlined piers generally showed advantage over the traditional oblong pier in terms of the scour rate, the maximum scour depth and the total scoured volume at equilibrium. This study suggests that streamlining can be a viable scour countermeasure, but more real-life scenarios including variabilities in soil and flow properties need to be further investigated.

Modified Strain Wedge Calculation of a Laterally Loaded Pile in Sand Considering Scouring

Chenrong Zhang and Xiaofeng Yang, Tongji University

A modified strain wedge model is presented to calculate the effect of scouring on the responses of a laterally loaded pile. The strain wedge (SW) model is capable to derive a p-y curve for the analysis of a vertical beam on a nonlinear foundation. To improve the SW method, a modified strain wedge(MSW) model is developed by assuming a nonlinear lateral deflection of pile to get the nonuniform soil strain in the passive wedge. Treating the soil weight above the scour bottom as a vertical load, an equivalent depth is obtained in the MSW model to consider scour hole dimensions. The applicability of the MSW model in the problem of a pile under scouring is proved by comparing with a model test and also the FEM results. It is found that the deflection ratio at the ground surface maintains 1.8 and 3.0 under large load level for scour depth as Sd =3.2D and 6.4D respectively and the scour induced change on the soil reaction modulus under small load is obvious in the model test and MSW analysis, while negligible in the FEM analysis.

Study of the Particle Shape Influence on Soil Erodibility using the Coupled CFD-DEM Modeling

Yuan Guo and Xiong (Bill) Yu, Case Western Reserve University

Researches show erodibility of sand is mainly determined by the grain size, or the mass median diameter. The influence of particle shape on sand erodibility has been neglected for simplification. Here using a coupled CFD-DEM method, the influence of sand particle shape on soil erodibility has been analyzed. The model was built prototyping from the Erosion Function Apparatus (EFA) developed by Briaud, where soil sample inside a Shelby tube is extruded into a rectangular flow channel with an extrusion height of 1 mm, and subjected to the erosion of flowing water. Critical shear stress and erosion rate of the soil sample can be obtained through the EFA test. In the simulating cases, spherical particles and non-spherical particles with aspect ratios of 1.10, 1.20 and 1.30 have been tested and compared. The results show grain angularity plays an important role in the formation of erosion resistance. For spherical particles, due to the lack of rolling resistance, no critical velocity has been observed. For non-spherical particles, with the increase of aspect ratio, the critical velocity increases indicating a higher erosion resistance. Erosion rate increases linearly with flow velocity, which is consistent with experimental studies.

Two Dimensional Soil Erosion Profile Using Electrical Resistivity Surveys

Md Zahidul Karim and Stacey Tucker-Kulesza, Kansas State University

Various soil characteristics that affect the erosion of soil also influence in situ bulk electrical resistivity measurements. The objective of this study was to develop two dimensional soil erosion profiles correlating the in situ electrical resistivity of soil with the erodibility measurements from the Kansas State University Erosion Function Apparatus (KSU-EFA). Electrical resistivity surveys were conducted at ten bridge sites. Five samples were collected at each site and tested in the KSU-EFA. Erosion potential profiles were created using the subsurface electrical resistivity distributions. This study showed that the rapid in situ data obtained from an electrical resistivity survey can predict the presence of highly erosive soils. As such, electrical resistivity surveys may be used to identify where further testing is necessary to measure the scour potential or determine which existing bridges should be closed or closely monitored for scour potential during a flood event.