Effect of Seepage on Incipient Motion and Rheology of Cohesionless Soil

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2021

Abstract

The phenomenon of soil erosion due to seepage flow is still difficult to predict because of its location at the boundary between soil mechanics and hydraulics, and it cannot be handled accurately by either approach. The understanding of the seepage flow effect both on the individual soil particle movement and the fluidized movement of a large number of soil particles is essential to address soil erosion comprehensively. Experimental investigations are conducted to address the soil erosion problem. In the experiment, an apparatus which is similar in construction to erosion function apparatus is used to investigate the injection effect on the erosion of individual soil particle subjected to surface flow. In another experiment, the rheology of sand at its surface under low confining stress is investigated by using FT4 powder rheometer to understand the erosion of an aggregate of soil particles.

An acrylic closed conduit with a rectangular cross section was prepared, and a section of the channel was made an erosive zone with the help of seepage box containing cohesionless soil particles. Particle image velocimetry (PIV) was used to analyse the flow dynamics responsible for incipient motion (dimensionless critical bed shear stress) in the form of pick-up rate due to upward seepage flow (injection) on both the erosive zone and upstream edge of erosive zone. The experimental results revealed that the dimensionless critical bed shear stress acting on the cohesionless soil particles decreased slightly as the upward seepage flow was increased on the upstream edge of erosive zone. Moreover, the dimensionless critical

bed shear stress decreased sharply as the upward seepage flow was increased on the erosive zone.

The effect of injection on the bed shear stress, mean velocity profiles, turbulence intensities, Reynolds shear stress, and higher-order moments of the closed conduit flows on both the erosive zone and upstream edge of erosive zone was examined. The bed shear stress estimated by the Reynolds shear stress approach was found to be more appropriate than that estimated by the usual logarithmic law approach. However, a fluctuation in the bed shear stress was noticed as the injection intensity was increased. Injection was seen to decrease the velocity near the bed and to increase the velocity near the center of the apparatus in comparison to the no injection condition in both zones. However, the injection resulted in more of a decrease in bed stability on the erosive zone as the injection intensities were increased in comparison to the upstream edge of the erosive zone. The introduction of injection increased the magnitudes of the various turbulence parameters in the erosive zone in comparison to the no injection.

An experimental investigation was conducted to investigate the effect of low stress on shear strength parameters of sand using a FT4 powder rheometer. In addition, the viscosity coefficient was also determined during fluidized state with the help of aeration control unit. The results show that the angle of internal friction decreases and cohesion increases as the consolidation stress increases. It was also found that the failure line in the high stress condition can be applied in the low stress condition. In the aeration test, the result shows that the viscosity coefficient decreases as the air velocity and the tip speed increase.