Three-dimensional scouring analysis for open channel pressure flow scour under flooded bridge decks

A three-dimensional stream bed scour modeling methodology was developed using well-benchmarked commercial Computational Fluid Dynamics (CFD) software to compute the bed shear stress distribution used to calculate bed displacements and to re-mesh the computational domain as the bed is displaced. This study extends a previously developed two-dimensional iterative scouring procedure to predict the final shape and size of the scour-hole under pressure-scour flow conditions for flooded bridge decks using commercial CFD software. The current approach uses single phase flow models with an assumed flat water surface using a symmetric slip top boundary to simulate a free-surface flow condition, quasi-steady simulation to obtain the bed shear, and a moving boundary formulation based on an empirical correlation for critical shear stress to iteratively deform the bed under supercritical shear conditions until an equilibrium scour condition is obtained. The model solves the flow field using Reynolds Averaged Navier-Stokes (RANS) equations and the high Reynolds number k?epsilon turbulence model using the commercial CFD software STAR-CD. A Bash script was developed to use a Python script to compute bed displacements from the computed shear stress distribution and generate a STAR-CD processor command file to displace the bed followed by a step using the STAR-CCM+ software to remesh the domain as the bed is displaced and bed shear distribution is recomputed in an iterative procedure until the equilibrium bed contour is reached. Simulations were performed for different inundation ratios and for mean sand diameters of 1 mm and 2 mm. The model agrees reasonablywell with limited experimental data for equilibrium scour shape and size with fully submerged cases compared to the cases where the bridge deck is partially submerged. This developed three-dimensional CFD scour computation procedure provides a basis for testing of additional scour related physical models while also providing an evaluation tool that can be used immediately by engineers engaged in scour risk analysis and assessment.

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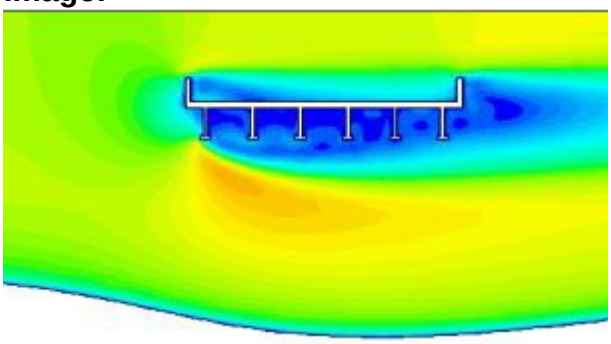

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