Computational fluid dynamics simulation of scour processes

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INTRODUCTION

This Key Note will present highlights and progress gained over the past decade based on the authors' (with collaborators) experience in simulating scour around structures using computational fluid dynamics (CFD). Simulations utilize the fully-coupled hydrodynamic and morphodynamic "sediMorph" model, developed in OpenFOAM by Jacobsen et al. (2014). Emphasis will specifically be placed on new process knowledge gained directly from such CFD simulations. Existing challenges and potential future directions for CFD of scour will also be discussed.

RESULTS

Simulated (2D) scour beneath pipelines will initially be covered. Results demonstrate the ability to simulate both scour, as well as backfilling following a change in wave climate (Fuhrman et al. 2014). Simulated equilibrium scour depth during backfilling coincide closely to those expected for scour under the same wave climate, consistent with experimental observations. Simulations involving a large number of cases involving combined wave-plus-current scour will likewise be considered (Larsen et al. 2016). From systematic analysis of these, a generalized expression for the time scale of scour is developed, matching naturally previous expressions at both pure-wave and pure-current limits. Recent results involving scour beneath pipelines in tandem (Li et al. 2020a), as well as the effects of upward seepage (Li et al. 2020b) will also be presented.

Simulated (3D) scour around monopiles will likewise be covered, beginning with that induced by steady currents (Baykal et al. 2015). Results reveal that the equilibrium scour depth can be decreased by up to 50% when suspended sediment transport is not properly accounted for, while also demonstrating importance of large-scale counter-rotating streamwise vortices in the lee wake region. CFD involving tsunami-induced scour has likewise been conducted (Larsen et al. 2017). Results show that it is important to consider both current- and wave-like aspects of long (but unsteady) tsunami-induced flows; The latter can limit the thickness of the boundary layer (hence equilibrium scour depths) considerably relative to steady-current expectations. Simulations involving short wave-induced scour will also be presented, an example of which is depicted in Figure 1, demonstrating both local scour as well as development of bed ripples in the far field.

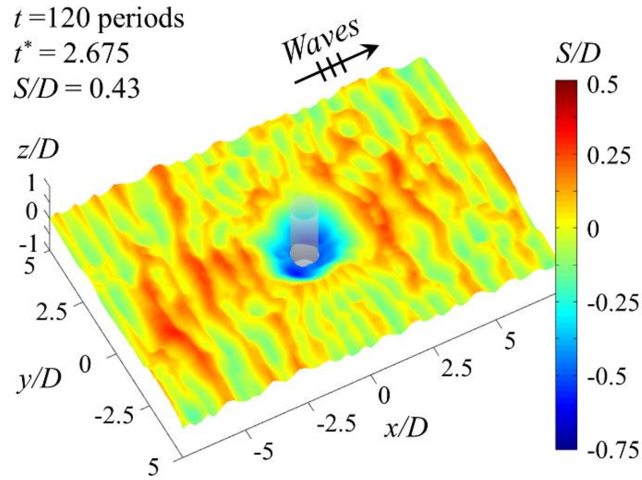

Figure 1. Simulated wave-induced scour around a monopile with Keulegan-Carpentar number KC=20. The scour depth (S) in front of the cylinder (normalized by the pile diameter D) **is indicated in the text. Reprinted with permission from Baykal et al. (2017).**

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