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Fuhrman, David R.; Eltard-Larsen, Bjarke; Baykal, Cüneyt; Sumer, B. Mutlu

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TSUNAMI INDUCED SCOUR AROUND MONOPILE FOUNDATIONS

David R. Fuhrman,Technical University of Denmark, drf@mek.dtu.dk
Bjarke Eltard Larsen, Technical University of Denmark, bjelt@mek.dtu.dk
Cuneyt Baykal, Middle East Technical University, cbaykal@metu.edu.tr
B. Mutlu Sumer, Technical University of Denmark, bms@mek.dtu.dk

While the run-up, inundation, and destructive potential of tsunami events has received considerable attention in the literature, the associated interaction with the sea bed i.e. boundary layer dynamics, induced sediment transport, and resultant sea bed morphology, has received relatively little specific attention. The present paper aims to further the understanding of tsunami-induced scour, by numerically investigating tsunami-induced flow and scour processes around a monopile structure, representative of those commonly utilized as offshore wind turbine foundations. The simulations are based on a model solving Reynolds averaged Navier-Stokes (RANS) equations, fully coupled with turbulence closure, bed and suspended load sediment transport descriptions, and a seabed morphological model. The model was developed and utilized in simulating breaker bar morphology by Jacobsen et al. (2014); It has been additionally been used in simulating wave induced scour beneath pipelines by Fuhrman et al. (2014) and Larsen et al. (2016) as well as scour around a monopile by Baykal et al. (2015).

Due to the large computational expenses it is presently only feasible to simulate such scour processes around a monopile at model (laboratory) spatial and temporal scales. Therefore, prior to conducting such numerical simulations involving tsunami-induced scour, it is necessary to first establish a methodology for maintaining similarity of model and full field scales. To achieve hydrodynamic similarity we will select the flow parameters such that we maintain similarity in terms of the diameter-based Froude number, as well as the boundary layer thickness-to-diameter ratio δ/D. Equating the Froude number ensures that the adverse pressure gradient induced by the presence of the structure itself will be similar at both model and field scales, i.e. that the ratio of the excess stagnation pressure head in front of the monopile will be maintained. Similarly, by maintaining similarity in δ/D, we ensure that the relative size of the horseshoe vortex, which is expected to largely govern the scouring process, will be similar at both model and full scales. This strategy also yields reasonable similarity in the expected tsunami period-to-scour time scale ratio.

As an example, three full tsunami periods have been simulated in succession, taking a full scale period of 13 min. Snapshots of the computed scour hole at selected times when the flow is rightward (left sub-plots) as well as leftward (right sub-plots) are depicted Figure 1. These snapshots illustrate the generally stepwise build-up of scour on the two opposing sides of the monopile during each successive half-cycle of the simulated tsunami. A complementary, simple and practical engineering method for predicting tsunami-induced scour is likewise developed, founded upon existing experimentally-based expressions for use in steady current scour, but invoking the boundary layer thickness and Shields parameter expected from tsunami wave events i.e. it effectively combines both current-like and wave-like properties of tsunamis (see e.g. Williams and Fuhrman, 2016).
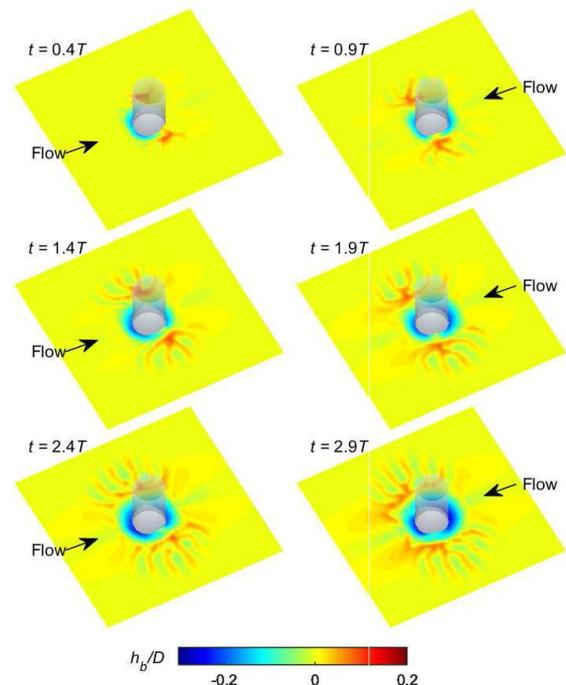

Figure 1 – Snapshots of a computed tsunami-induced scour hole at selected times.

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