DTU Library

Experimental and Numerical Study of Wave-Induced Backfilling Beneath Submarine Pipelines

Bayraktar, Deniz ; Ahmad, Joseph; Larsen, Bjarke Eltard; Carstensen, Stefan; Fuhrman, David R.

Publication date:
2016

Document Version
Peer reviewed version

EXPERIMENTAL AND NUMERICAL STUDY OF WAVE-INDUCED BACKFILLING BENEATH SUBMARINE PIPELINES

Deniz Bayraktar, Technical University of Denmark & Istanbul Technical University, bayraktard@itu.edu.tr
Joseph Ahmad, Technical University of Denmark, josepha2102@gmail.com
Bjarke Eltard Larsen, Technical University of Denmark, bjelt@mek.dtu.dk
Stefan Carstensen, Technical University of Denmark, scar@mek.dtu.dk
David R. Fuhrman, Technical University of Denmark, drf@mek.dtu.dk

Through complementary experimental and numerical efforts, the present paper aims to make a significant contribution to the overall understanding of backfilling processes beneath submarine pipelines. For this purpose, we aim to simplify the experimental backfilling process to an elementary two-stage process: (1) initial scour induced by a pure current, followed by: (2) backfilling induced by pure waves. A steady current is introduced via a re-circulating pump, and is kept constant with a cross-sectional velocity of $V = 0.48$ *m/s* until an initial equilibrium scour depth, S_0, is reached. Then, the current is stopped and waves (characterized by their Keulegan-Carpener number *KC* and Shields parameter θ) are introduced to initiate the backfilling process, which is maintained until a new equilibrium scour depth, S_f, is reached. The time at which waves are introduced will be denoted as $t = 0$. For the backfilling process both regular and irregular waves are used during the experiments. As a demonstration of the initiated two-stage (scour followed by backfilling) process, bed profiles based on video recordings from a case having $KC = 9.7$ *and* $\Theta = 0.195$, are depicted at selected stages in Figure 1. Figure 1 (upper left) depicts the current-induced equilibrium scour hole in the near vicinity of the pipe at $t = 0$, with the profile approximated as the dashed red line. Similarly, Figure 1 (upper right) depicts the new equilibrium scour profile (approximated as the full blue line) that has developed under wave-induced backfilling, corresponding to $t = 60$ min. To ease comparison, the dashed red and full blue lines from these plots are additionally combined onto Figure 1 (bottom).

The experimental campaign has additionally been complemented with similar numerical simulations (using regular waves), based on a fully-coupled hydrodynamic and morphodynamic CFD model (Jacobsen et al., 2014), extending previous pipeline scour-related applications of Fuhrman et al. (2014) and Larsen et al. (2016). Comparison of the numerical and experimental results demonstrate the ability of the CFD model to reasonably simulate the current-to-wave backfilling process, both in terms of the achieved new wave induced equilibrium scour depths as well as the corresponding backfilling time scales. Figure 2 depicts a summary of both experimental and numerical backfilling time scale T_b versus Shields parameter θ. As can be seen, both experimental as well as numerical results match the regression equation: $T_b = 0.3\theta^{5/3}$ quite closely (solid line in Figure 2).

The first author gratefully acknowledges the support of a Posdoctoral grant from The Scientific and Technical Research Council of Turkey (TUBITAK, grant no. 2219). The third and last authors additionally acknowledge support from the EU project ASTARTE (FP7-ENV-2013.604-3, grant no. 603839).

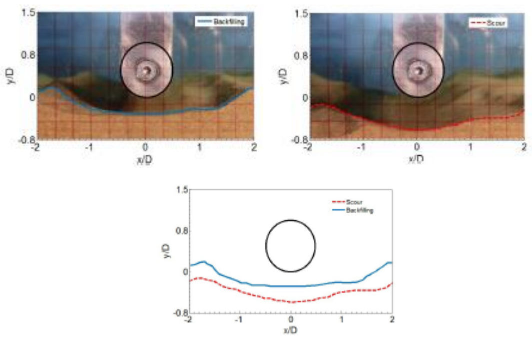

Figure 1: Example showing the profile developed under initial current-induced (upper left), followed by wave-induced backfilling (upper right). Both are compared in the bottom sub-plot.

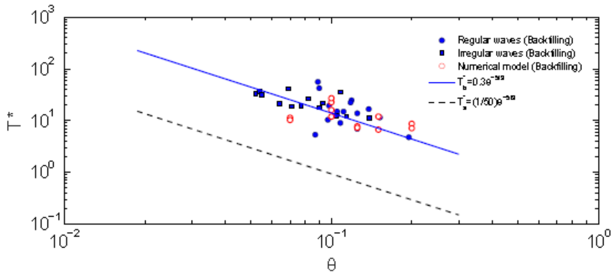

Figure 2: Comparison of measured (closed symbols) and computed (open circles) non-dimensional backfilling time scales versus Shields parameter θ. The dashed line represents the regression equation for the scour time scale (Fredsøe et al. 1992), included as a reference.

REFERENCES

Fredsøe, J., Sumer, B. M., Arnskov, M. M., 1992. Time scale for wave/current scour below pipelines. Int. J. Offshore Polar Eng. 2, 13-17.

Fuhrman, D. R., Baykal, C., Sumer, B. M., Jacobsen, N. G., Fredsøe, J., 2014. Numerical simulation of wave-induced scour and backfilling processes beneath submarine pipelines. Coast. Eng. 94, 10-22.

Jacobsen, N. G., Fredsøe, J., Jensen, J. H., 2014. Formation and development of a breaker bar under regular waves. Part 1: Model description and hydrodynamics. Coast. Eng. 88, 182-193.

Larsen, B. E., Fuhrman, D. R., Sumer, B. M., 2016. Simulation of wave-plus-current induced scour beneath submarine pipelines. J. Waterw. Port Coast. Ocean Eng.-ASCE, article no. 04016003.

Sumer, B. M., Fredsøe, J., 1990. Scour below pipelines in waves. J. Waterw. Port Coast. Ocean Eng.-ASCE 116, 307-323.