Closure to “Local Scour Mechanism around Dynamically Active Marine Structures in Noncohesive Sediments and Unidirectional Current”

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Discussion: by Dawei Guan and Yee-Meng Chiew: WWENG-1562R1

Closure: The discussers and the writers agree that the effects of structural movement need to be considered when estimating seabed scour around monopile foundations. This applies both to self-excited and forced motions. However, the discussers understate the main contribution of the paper as “additional data supplementing understanding of vibration effects”, whereas the paper introduces a new mechanism that is capable of generating scour depths significantly greater than reported by previous authors and predicted by conventional approaches. This mechanism is caused by repeated periods of structural movement interspersed with periods without motion, as is experienced by offshore structures subject to a series of winter storms.

The discussion states that structural vibration can steepen the slope of the scour hole and reduce scour depth. It is important to correct this statement: evidence from previous authors and in the present paper shows that vibration causes the slope to be shallower.

The writers are grateful to the discussers for referring to the sub-surface convective cells which are an integral part of the processes controlling the slope and lateral extent of the scour hole around a monopile subject to structural movement. A similar process of sub-surface movement was also observed by one of the writers (Al-Hammadi, 2018) in tests performed on rock armour around monopile foundations undergoing forced movement. In these laboratory tests, the rock elements acted as tracers, showing the extent of the sub-surface cells.

The discussers mention the effects of densification. Tests done by the writers and reported in the paper (figure 2 of the original paper) suggest that densification does have the initial effect of slowing the rate of scour development. However, it had no effect on the equilibrium depth of scour.

The 2-stage tests commented on in the discussion led to a 10% increase in scour depth and were a crucial step in understanding the processes of scour with and without structural movement, in particular, the increase in lateral extent of the scour hole. However, it is the repetition of the 2-stage tests, as shown in figure 5 and figure 6 of the original paper, that demonstrates the far greater scour depth (>20% in the present tests) that could occur during a series of storms.

The writers agree that measurement of the flow dynamics within the scour hole around a dynamic monopile could provide a better understanding of the mechanisms explained in the present paper. The possibility of turbulence being enhanced by the vibrations and structural movement is an interesting concept. Whitehouse and Damgaard (2000) investigated the effects of externally generated turbulence on sediment dynamics and showed that shear stresses can increase significantly, offering the potential for scour to be enhanced by this process.

The discussers raise the challenging issue of scale and the various parameters requiring conflicting scaling relationships to reproduce prototype conditions in an experimental model. The paper does not claim to give an accurate description of field conditions to scale. It describes laboratory tests performed at two different scales and demonstrates that similar results are observed in both cases. However, the writers agree that field scale observations are desirable to confirm the range of applicability of the mechanism described in the paper.

Finally, the writers agree with the discussers that the processes described in the paper as relevant to marine structures will apply equally to river flows around bridge piers.

References

Al-Hammadi, M.R.S.A. 2018 “Scour and scour protection around dynamically active marine structures.” Ph.D. thesis, Department of Civil, Environmental and Geomatic Engineering, UCL (Univ. College London).

Whitehouse, R. and J. Damgaard. 2000. “Assessing bed stability at coastal structures with external turbulence.” In 27th Int. Conf. on Coastal Engineering, edited by B. L. Edge, 3008–3020. Reston, VA: ASCE.