Vibratory pile driving and lateral stiffness of monopiles

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Summary
Due to its many advantages, vibratory pile driving is expected to play a stronger role in future offshore wind farms. Two recent models for the vibratory pile driving prediction and the lateral pile-soil stiffness from in-situ data were checked for general plausibility. In addition to the prognosis for both individual aspects, a decisive step in optimizing the foundations will be seen in the future above all in describing the effect of vibratory pile driving on the pile-soil stiffness.

1. Vibratory pile driving

1.1 Basic approach and phenomena
The one dimensional wave equation analysis is used for vibratory pile driving prediction. The initial resistance to vibratory driving and its development during the pile driving are modelled individually for comprehensive mapping of the soil-mechanical phenomena. The initial pile shaft resistance of vibratory pile driving is appr. 1.5 to 3.5 times lower than that of impact pile driving. The initial pile tip resistance for vibratory pile driving may be derived as one fourth of the cone tip resistance in CPT. Once the pile tip has passed an imaginary soil element, the pile resistance at this depth decreases in the course of further penetration (“pile length effect”).

1.2 Results
The individual modelling of the initial resistance and the pile length effect resulted in an improved coincidence of calculation results and measurement data, as represented by the black line and the grey line in (Fig. 1), see [1] and [3].

2. Pile-soil stiffness in non-cohesive soil

2.1 Use of in-situ data
The approach is based on in-situ data to enable its use for future site-specific monitoring of foundation structures. The shear modulus derived from seismic cone penetration tests (SCPT) as a measure for the stiffness at very small shear distortions, was implemented together with a distortion-dependent reduction into the existing bedding approach of Sørensen et al. [2], see (Fig. 2).

2.2 Results
Previous comparative calculations for small foundation loads provide reasonable agreement with other calculative approaches for modified p-y curves and make the further development of this model appear promising.

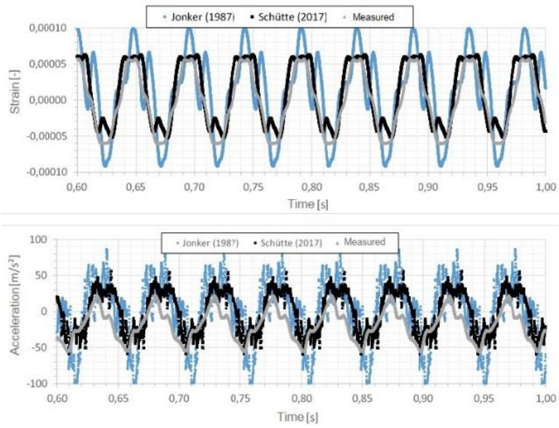

Fig. 1: Comparison of simulation and measured data

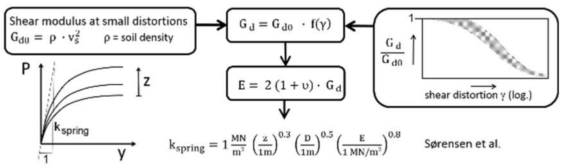

Fig. 2: Basic flowchart of pile-soil stiffness approach

3. References

[1] Schütte J. Prognoseberechnungen zur Installation von Offshore-Gründungsrohren mittels Vibrationshammer. Pfahlsymposium 2017, Braunschweig
[2] Sørensen S P H, Augustesen A H. Small-displacement soil-structure interaction for horizontally loaded piles in sand. Proc. NGM 2016, Reykjavik
[3] Wiemann J, Fischer J, Schütte J. Zur Prognose der Bettungssteifigkeit und Pfahlinstallation von Monopiles, HTG Kongress 2017, Duisburg