# Pile installation via axial and torsional vibrations - the Gentle Driving of Piles method

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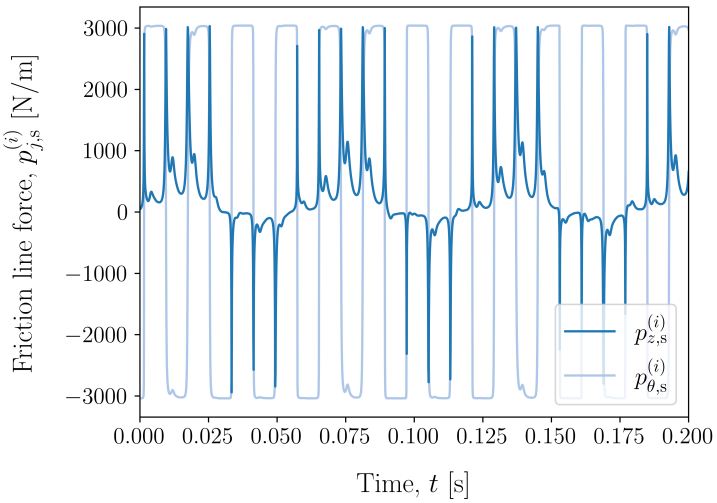
**Abstract**. This paper presents the study of a new pile installation technique that combines axial and torsional excitation, namely the Gentle Driving of Piles (GDP) method. Both numerical modelling and field tests are employed to analyse the mechanics of the GDP method. Furthermore, a three-dimensional numerical model for the analysis of the pile installation process is presented, comprised by a thin cylindrical shell (pile), a linear elastic layered half-space (soil) and a history-dependent frictional interface. The overall problem is formulated in a mixed time-frequency form and solved via an efficient approach based on the Harmonic Balance Method. The model predictions are compared against field data and the experimental findings are further analysed in order to shed light into the complex pile-soil behaviour during installation.

## Introduction

Presently, over 80% of the offshore wind turbines in Europe are founded on monopiles, which are commonly installed by impact hammering. However, this method generates significant underwater noise emissions, harmful to marine life. To this end, environmentally friendly alternatives are investigated for monopile installation, such as vibratory methods. Axial vibratory pile driving is used onshore for decades, with advantageous features such as high installation speed and low axial pile loading. However, its use in the offshore industry is limited, due to the lack of field data and knowledge gaps related to the complex pile-soil behaviour. To further the potential of vibration-based methods, the Gentle Driving of Piles (GDP) has been proposed by TU Delft [1]. The GDP method is based on simultaneous application of low-frequency axial and high-frequency torsional excitation and aims to improve installation performance and reduce underwater noise emissions.

(a)




(b)

Figure 1: (a) The GDP shaker connected to a test pile and (b) axial and circumferential friction forces at the pile-soil interface during pile installation.

## Results and discussion

Medium-scale field tests have been performed at Maasvlakte II site, at the port of Rotterdam, in which different installation methods were studied, with a focus on the GDP method. Based on these experiments, the proof of concept of the method was achieved and a set of field data were obtained to further analyse the installation tests. Furthermore, a new numerical model has been developed for the analysis of pile installation via the GDP method. A comparison of the numerical results with the field tests showcases the predictive capabilities of the developed model. The field observations are discussed on the basis of the newly developed model and the driving mechanisms are uncovered. Conclusively, the redirection of the friction force vector is identified as the main mechanism that enhances the installation performance by the introduction of high-frequency torsion.

## References

[1] Metrikine, A. V., Tsouvalas, A., Segeren, M. L. A., Elkadi, A. S. K., Tehrani, F. S., Gómez, S. S., Atkinson, R., Pisanò, F., Kementzetzidis, E., Tsetas, A., Molenkamp, T., van Beek, K. and de Vries, P. [2020], Gdp: A new technology for gentle driving of (mono)piles, *in* 'Proceedings of the 4th International Symposium on Frontiers in Offshore Geotechnics, Austin, TX, USA, 16–19 August 2020'.