OPTIMISATION OF SOIL TESTING PROCEDURE FOR MONOPILE FOUNDATION DESIGN OF OFFSHORE WIND FARMS

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Introduction

- Large diameter monopiles are currently the most popular foundation solution for offshore wind turbines. Prediction of foundation's performance under wind and waves during the design storms fundamentally relies on the results of soil laboratory investigations.
- Current laboratory testing practice employs quite simplified loading scenarios (cyclic triaxial tests and cyclic simple shear tests), more sophisticated apparatus, such as the hollow cylinder torsional apparatus (HCTA), is applied that can better replicate the stress conditions around the pile.
- This research has used an advanced 3D finite element model to investigate the stress paths induced by cyclic storm loading in different soil elements around the pile (Figure 1), in order to assess whether the current laboratory testing procedures closely align with field situations and how laboratory procedures could be enhanced to optimize the overall foundation design.

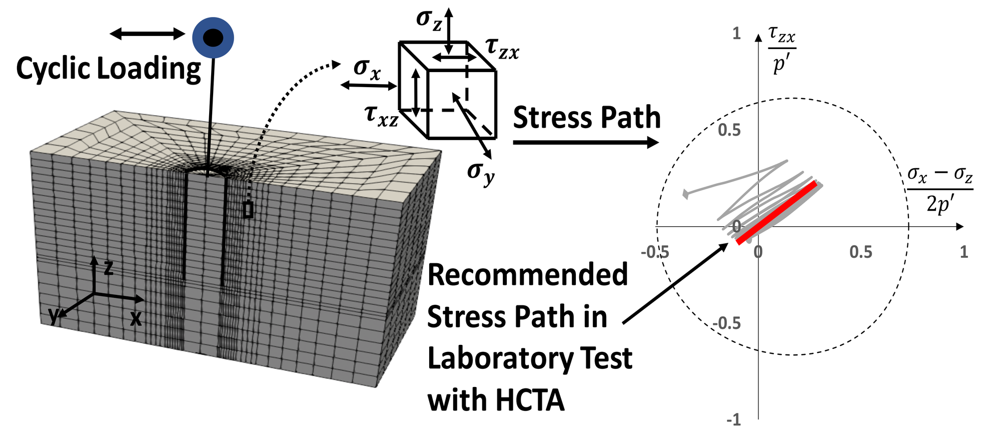

Fig.1 3-D Finite element model and stress path on soil elements.

Fig.2 Hollow cylinder torsional apparatus

Connection between soil elements and laboratory test

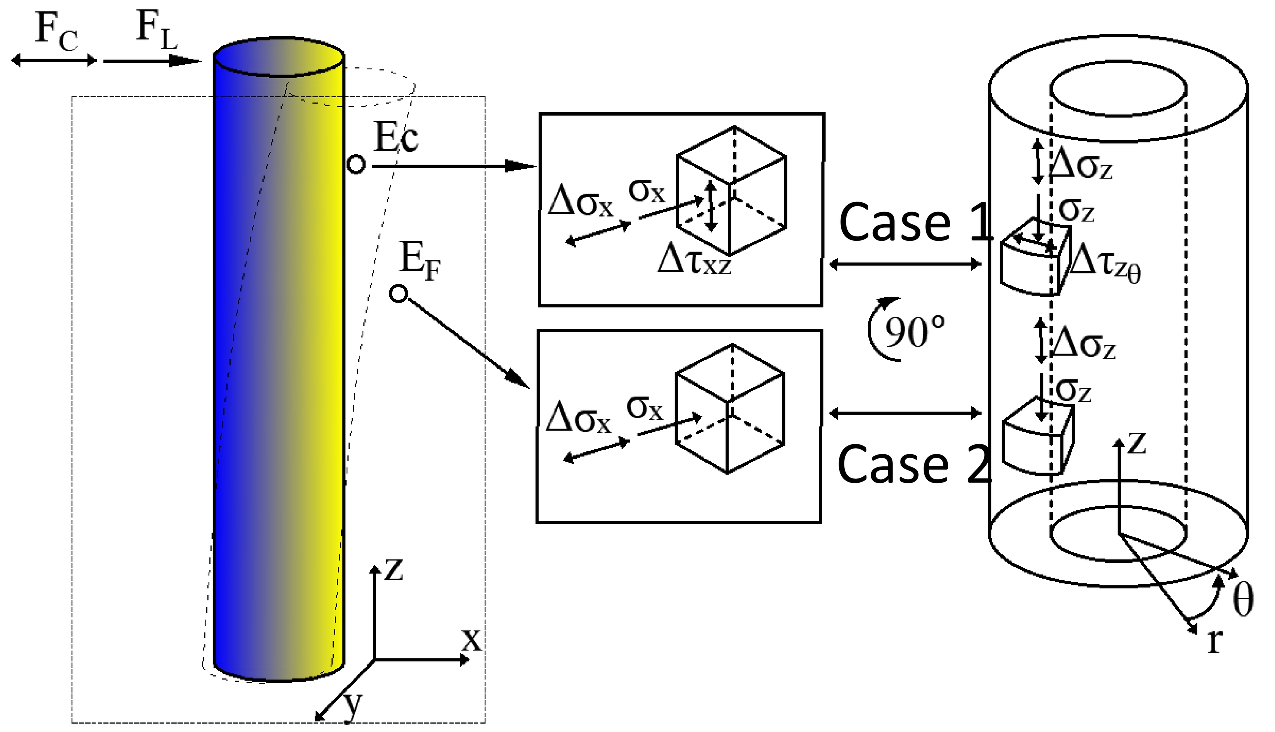

Fig.3 Schematic diagram of the pile-soil interaction with an HCTA sample positioned in front of the pile.

Numerical Results

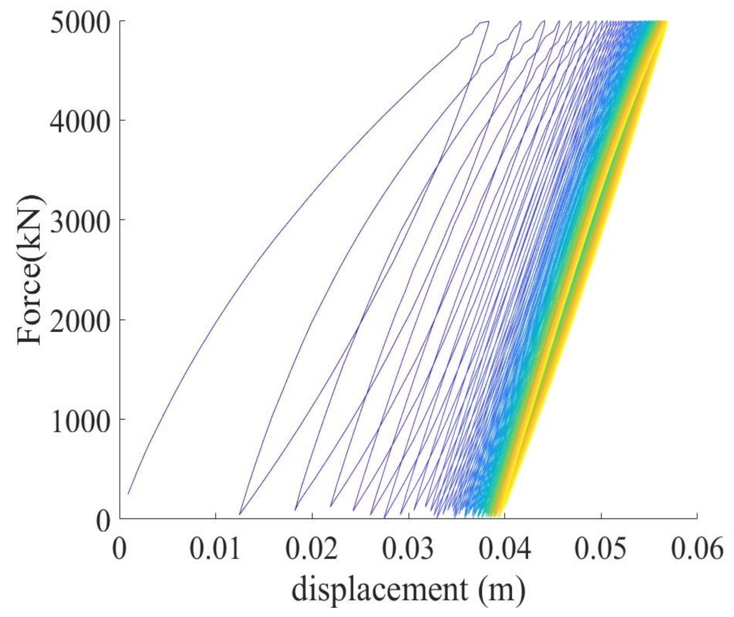

Fig.4 Pile reaction

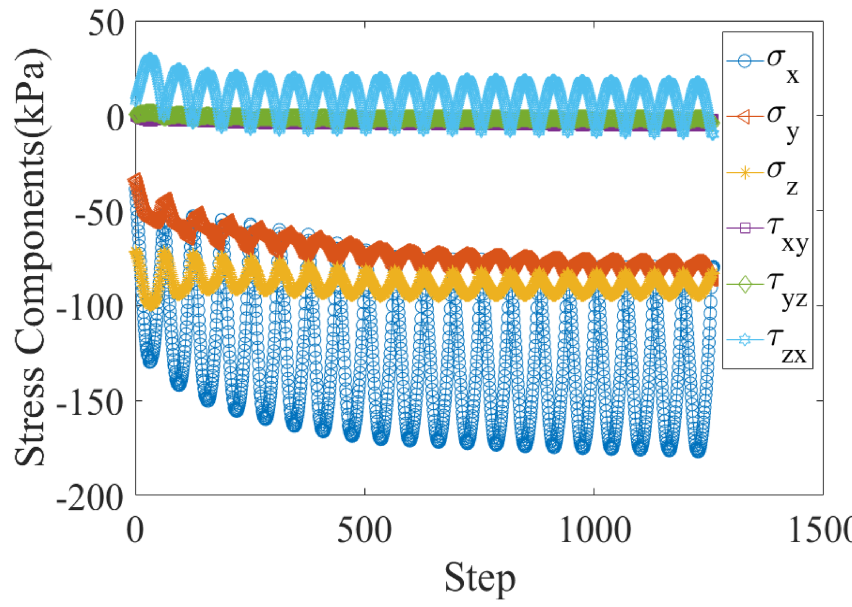

Fig.5 Soil reaction

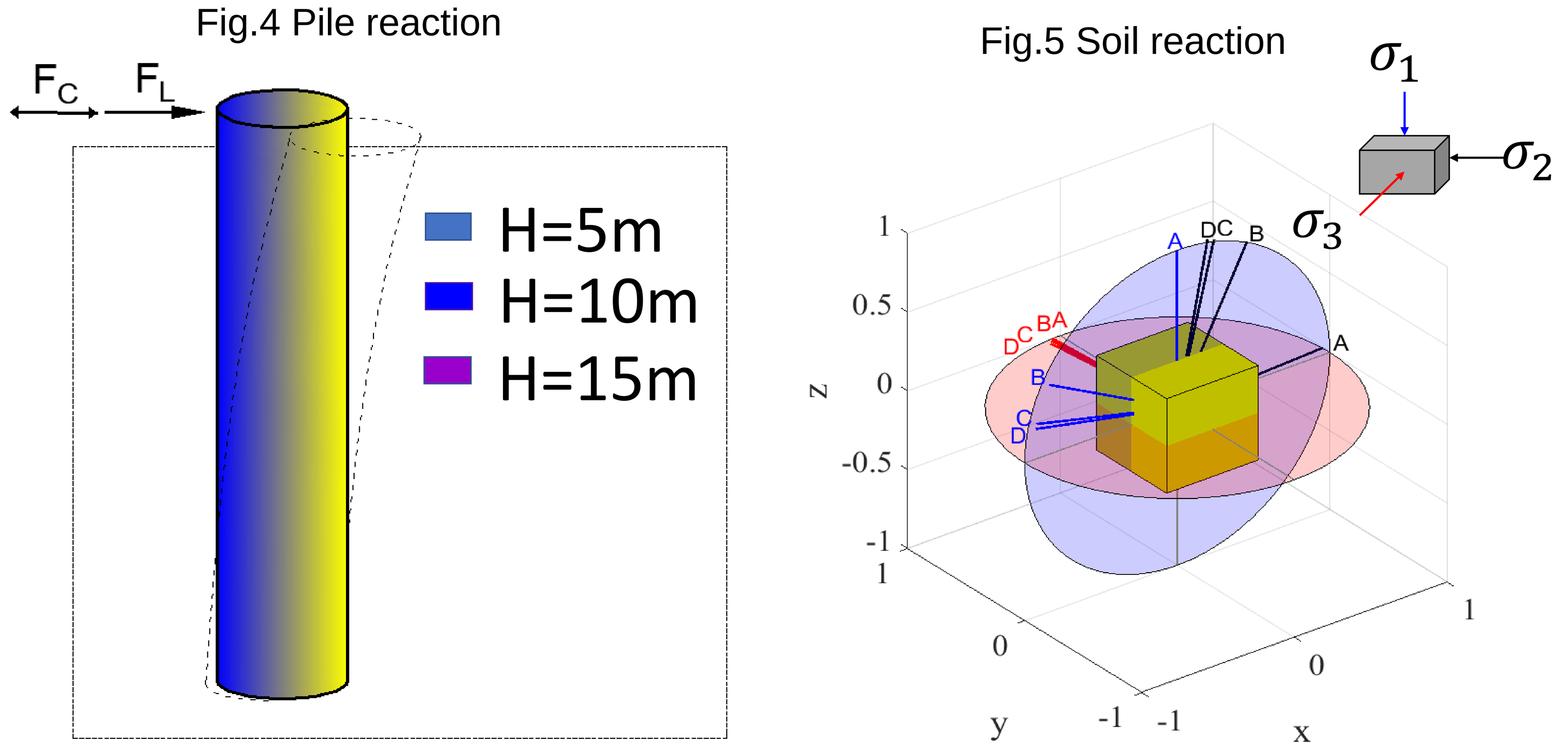

Fig.6 Principal stress direction of soil element in spatial coordinates.

Application in HCTA

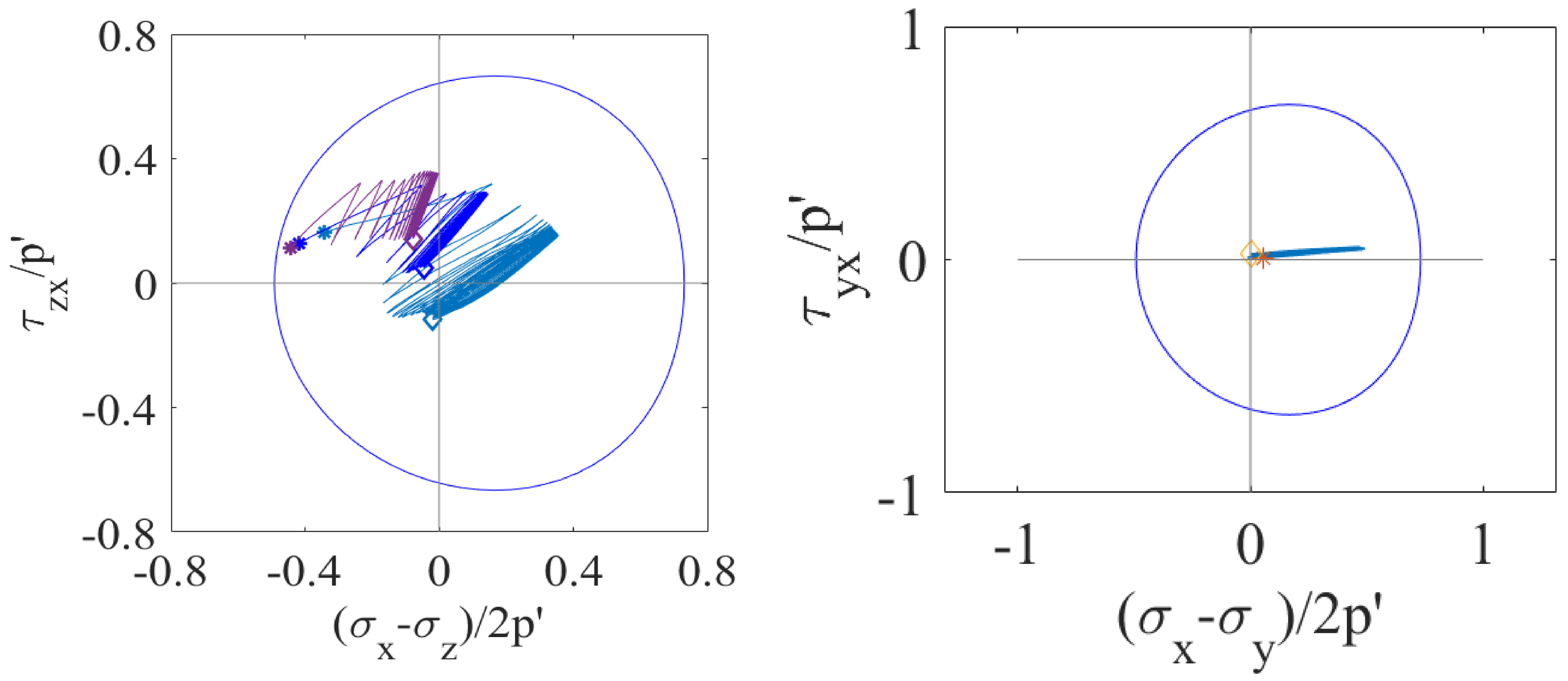

Fig.7 Normalised shear stress against deviatoric stress plot with results from soil element.(**Numerical results**)

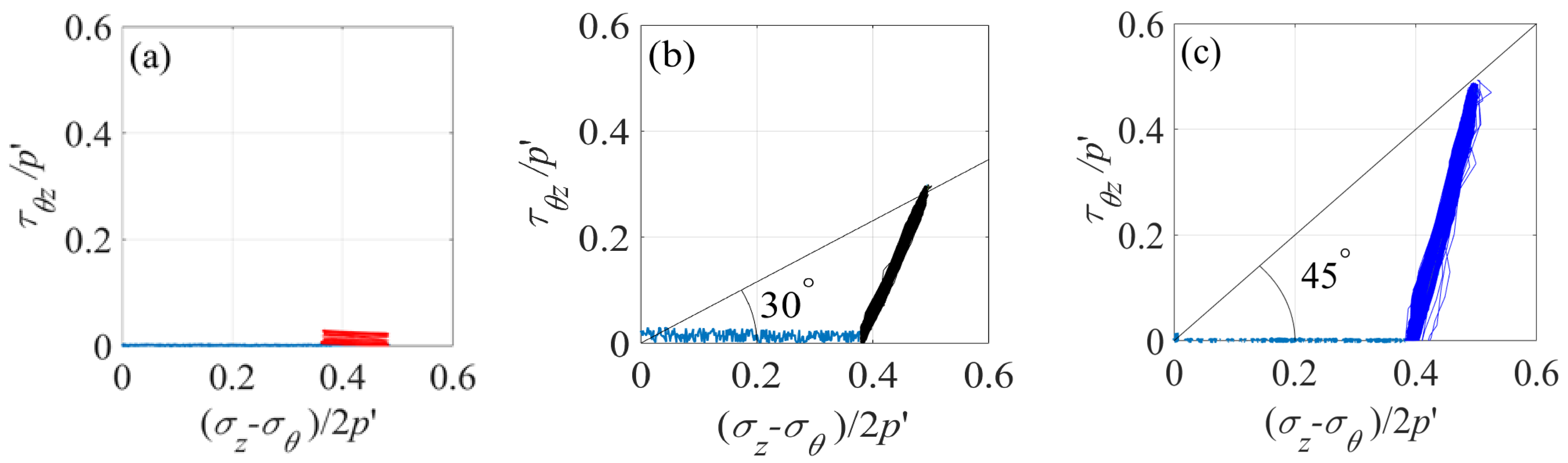

Fig.8 Stress paths in the normalised shear stress deviatoric stress plane for (a) $\alpha_{\sigma c}$ =0°; (b) $\alpha_{\sigma c}$ =15°; and (c) $\alpha_{\sigma c}$ =22.5°. (**Laboratory test results**)

Conclusions and Future Work

- Stress paths experienced by different soil elements around the pile have been investigated and related to HCTA stress conditions.
- Recommendation on stress path to be applied in laboratory to more appropriately mimick field conditions have been developed, such as the stress path schematically reported in red in Figure 1.
- The benefit of these laboratory recommendations on the prediction of cyclic monopile response will be tested in future work by analysing a wide range of typical design scenarios.

References

Liu, H.Y., Abell, J.A., Diambra, A. and Pisanò, F., 2019. Modelling the cyclic ratcheting of sands through memory-enhanced bounding surface plasticity. Géotechnique, 69(9), pp.783-800.