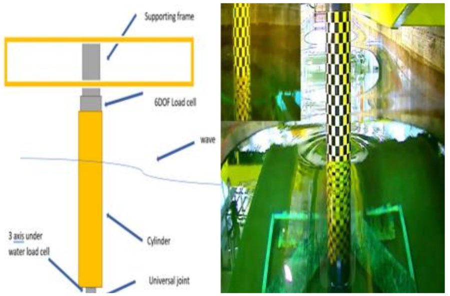
Extreme wave load on monopiles: overview of experimental activities within the Sea-Swallows consortium

Saishuai (David) Dai
Department of Naval Architecture, Ocean and Marine Engineering
University of Strathclyde

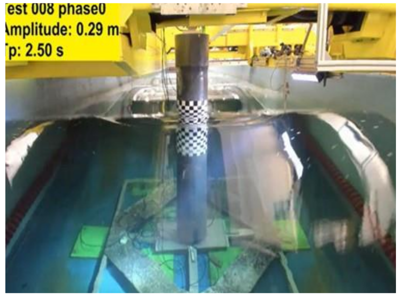
Timeline

2006

2009



2018

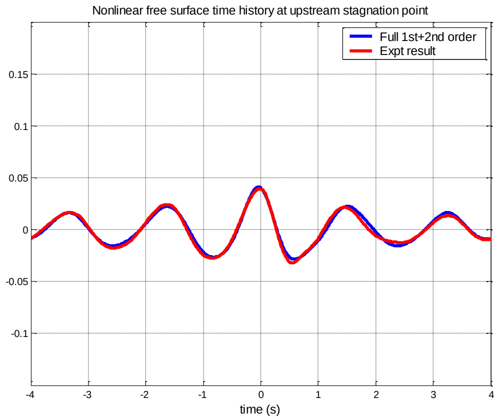


2022

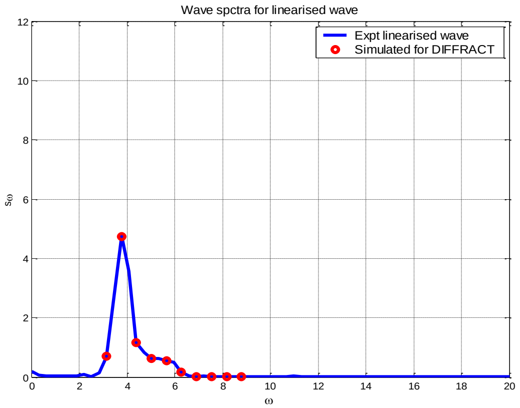
2024

DUT Flume

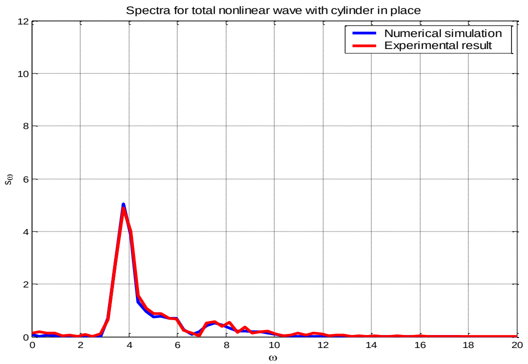
Flume: $69\ m\ by\ 3\ m$
Water depth tested: 0.5 m
Cylinder R: 0.125m
Max $\mathrm{k_p}A = 0.12$



Wave spectra



FFT

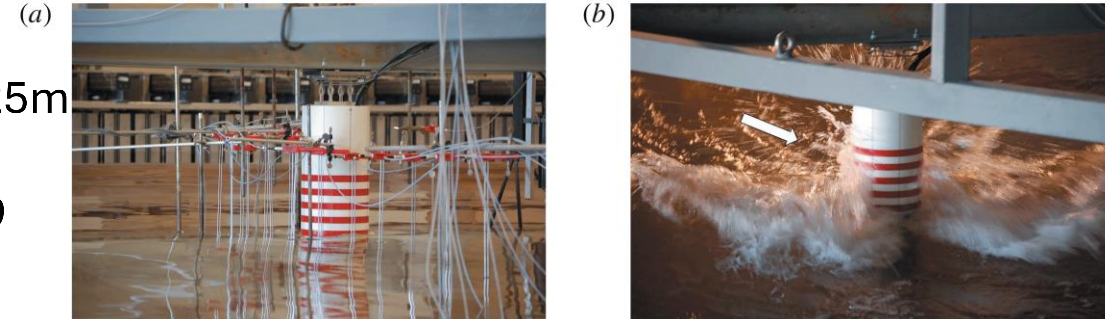


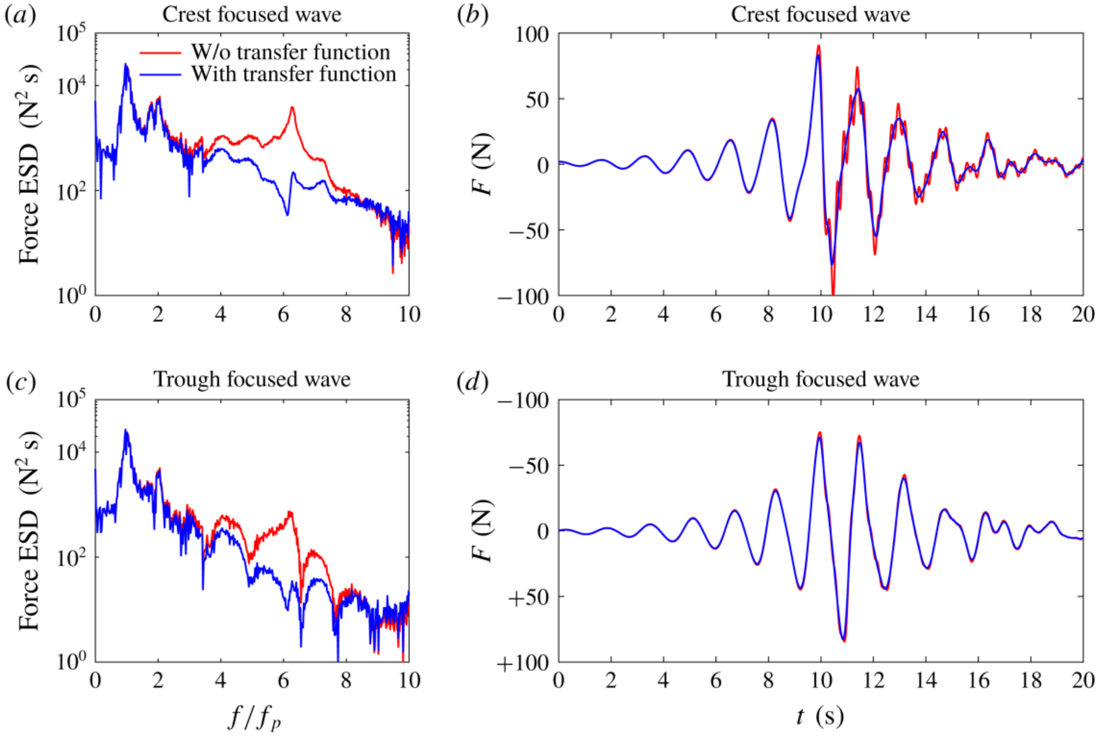
Zang, Jun, Liu, Shuxue, Taylor, Rodney Eatock, and **Paul H. Taylor**. "Wave Run-up And Response Spectrum For Wave Scattering From a Cylinder." *Int. J. Offshore Polar Eng.* 19 (2009)

DHI shallow water basin

35 m in length
25 m in width
Water depth: 0.505 m

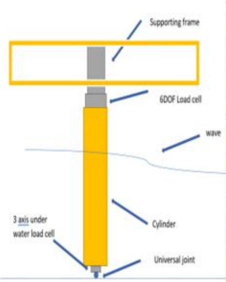
Cylinder R: 0.125m
Top fixed
Max $k_p A = 0.29$

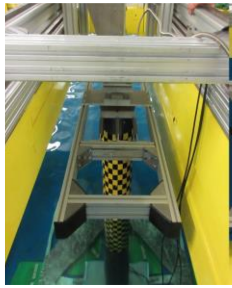


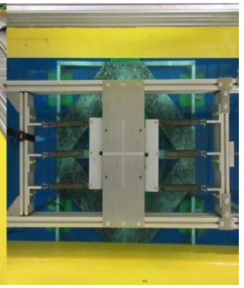


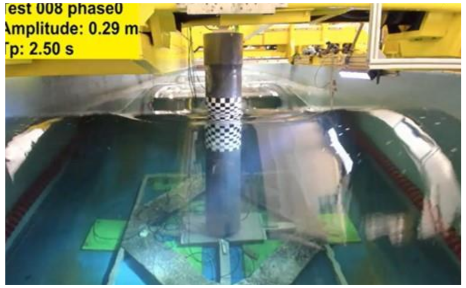
Chen LF, **Zang J, Taylor PH**, et al. An experimental decomposition of nonlinear forces on a surface-piercing column: Stokes-type expansions of the force harmonics. *Journal of Fluid Mechanics*. 2018;848:42-77. doi:10.1017/jfm.2018.339

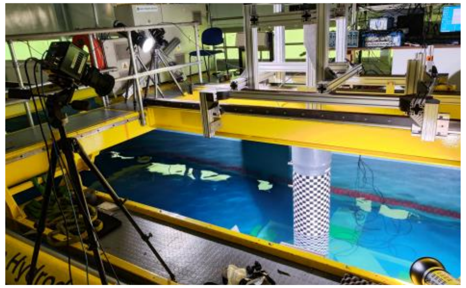
KHL







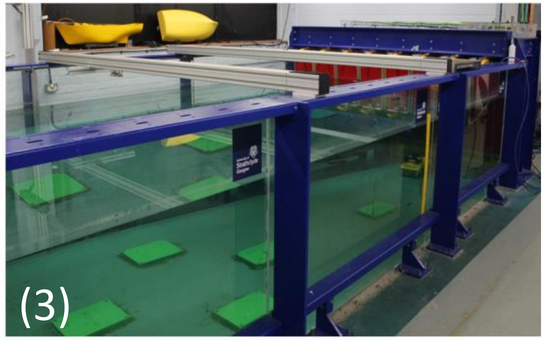


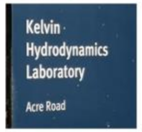


2018 2020 2022 2023

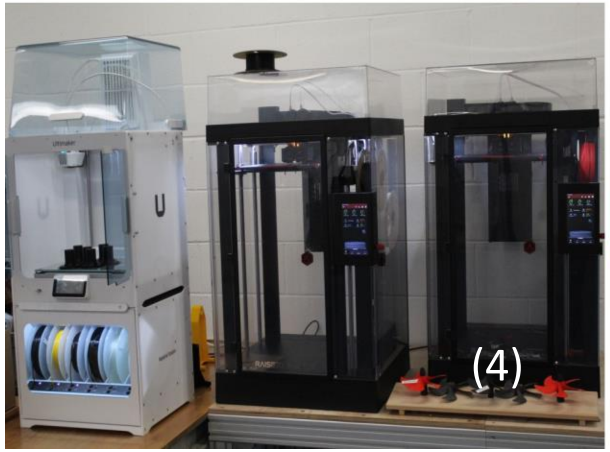
UK China ORE, UKCMER

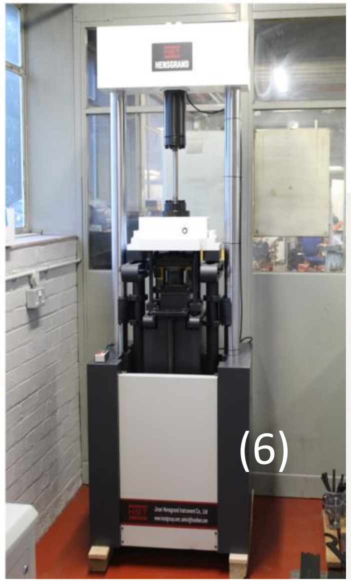
Sea-swallows

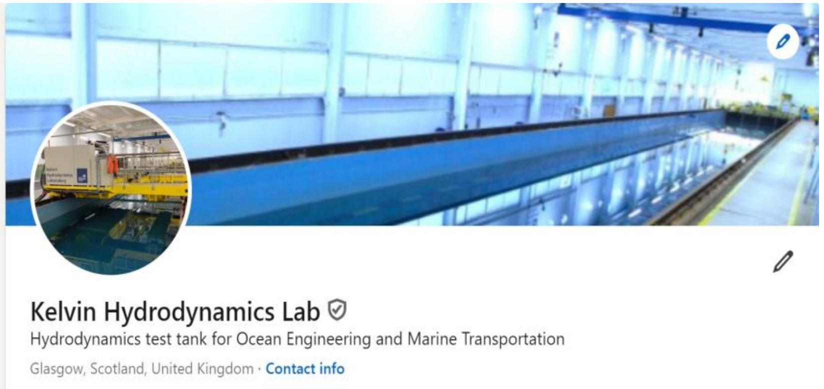


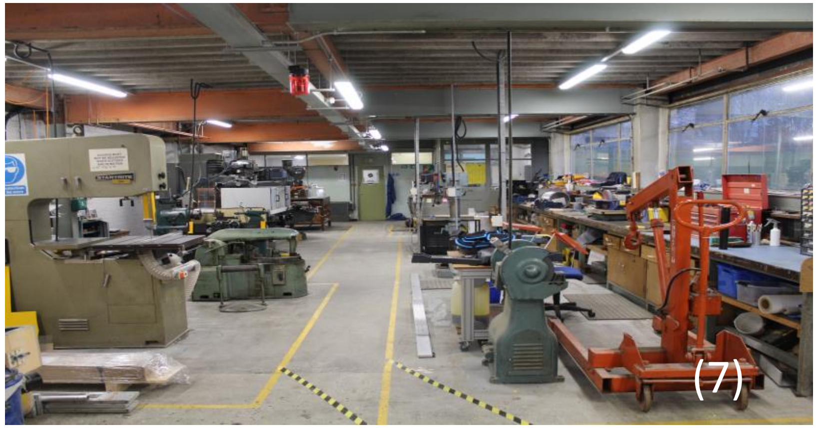


(1) Large towing tank
(2) Slime farm
(3) Compact wave tank
(4) 3D printers
(5) FTFC
(6) Resonant fatigue machine
(7) Workshop



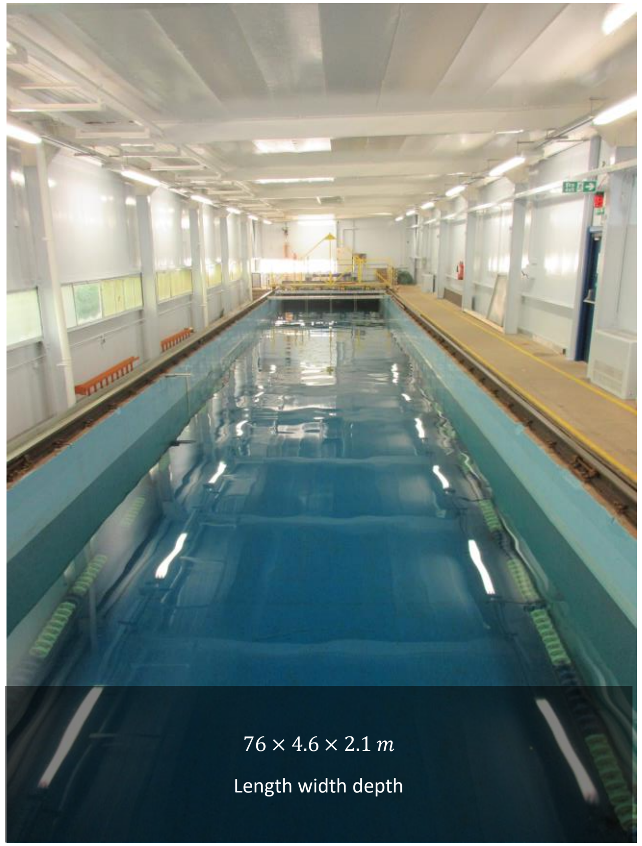






Kelvin Hydrodynamics Laboratory

2025


$76 \times 4.6 \times 2.1\ m$

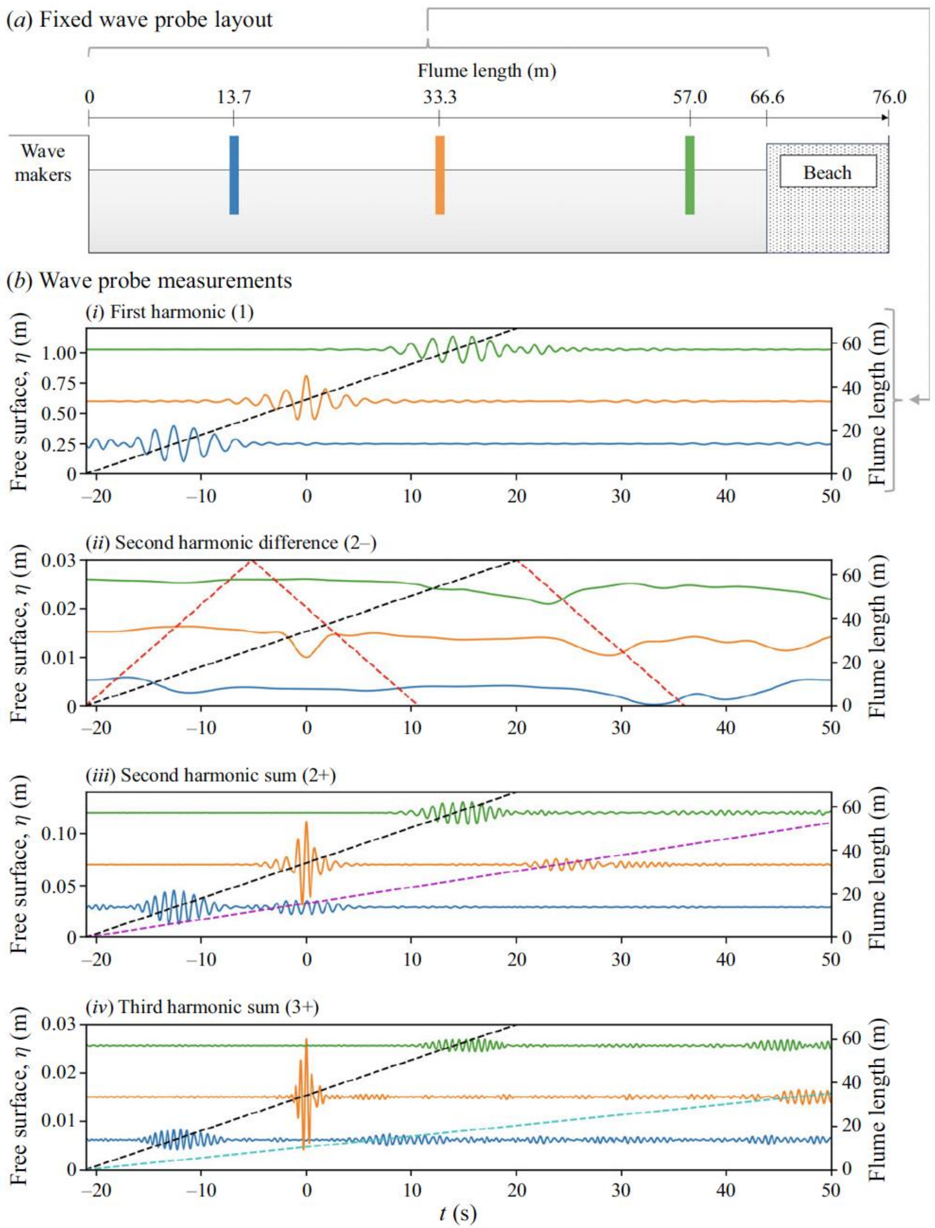
Length width depth


$Force\ feedback\ dry\ back\ flap\ type\ wave\ maker$


14 m slope type wave beach covered by porous media

Large Towing tank

Compact wave groups in a long towing tank?

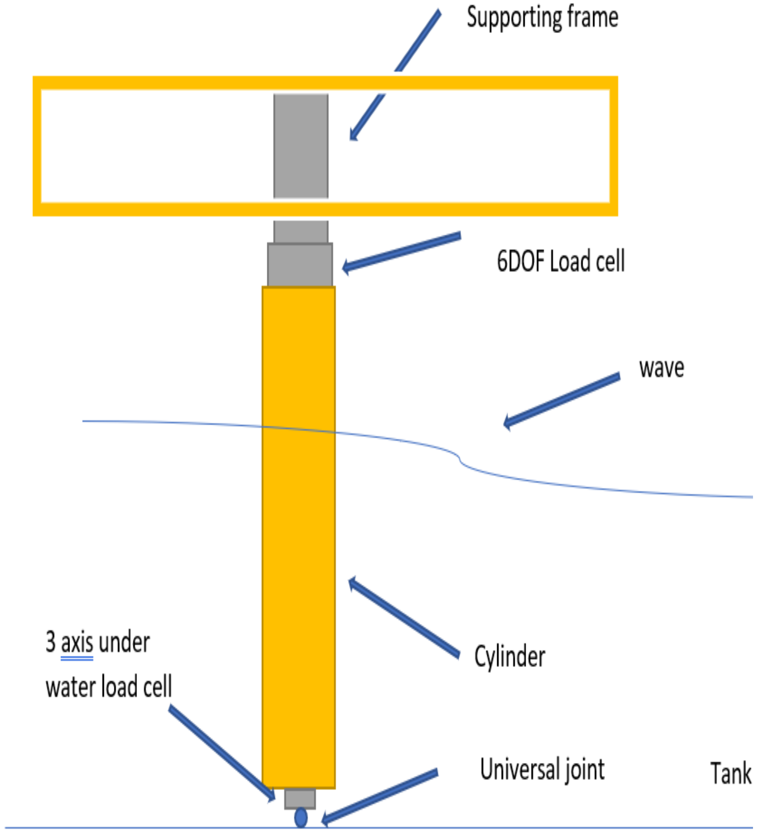


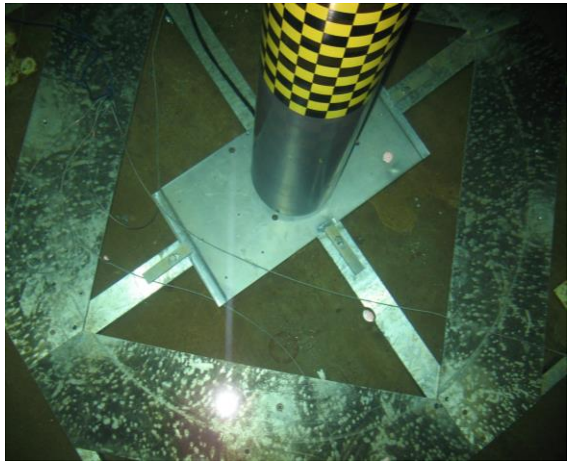
Is a long towing tank suitable for ocean engineering experiment?

Error waves from first order wave generation?

Archer, A. J., Taylor, P. H., Wolgamot, H., Orszaghova, J., & Dai, S. (2025). Harmonic decomposition of forces and estimates of reduced mean flow in jackets subjected to waves and current. Journal of Fluid Mechanics, 1009, Article A7. https://doi.org/10.1017/jfm.2025.180

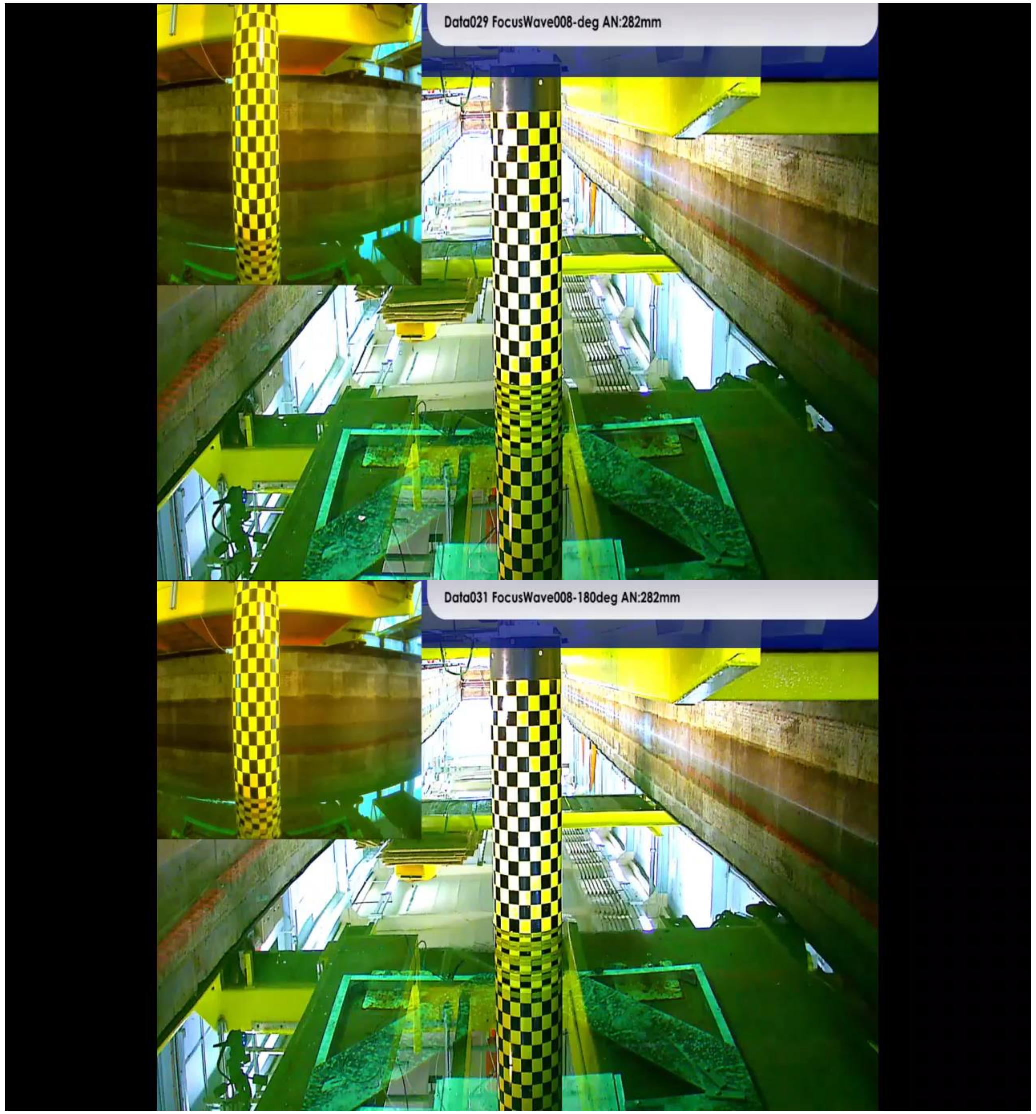
Top and bottom fixed



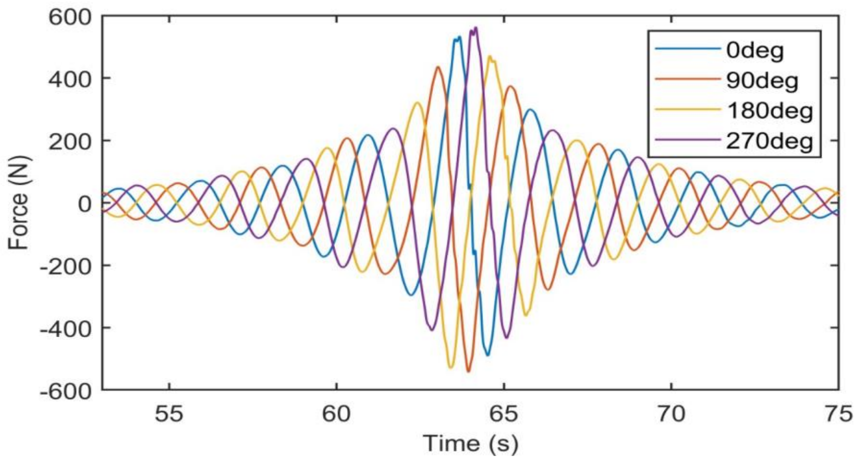


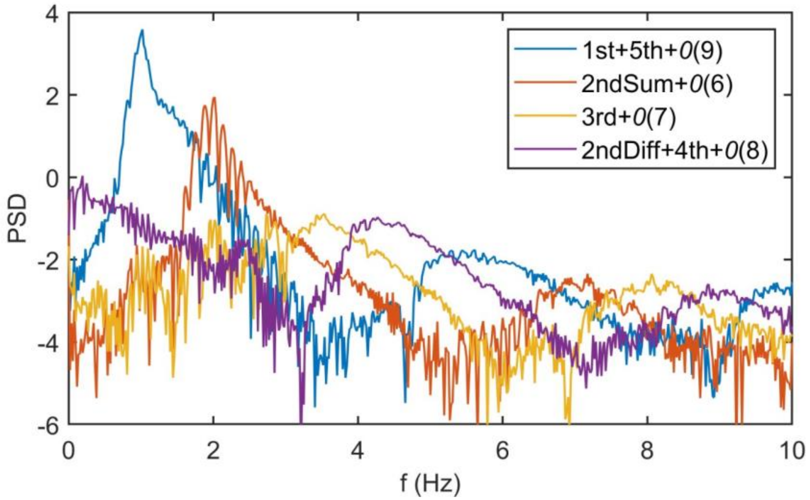
- Cylinder R: 0.1575 m
- Water depth 1.8 m
- Top and bottom fixed
- Global force and moment
- 4 phase focus wave (0,90,180,270)

Four phase decomposition



- 4 phase Focus wave test
- Max $k_p A$=0.21
- Cylinder R: 0.157 m

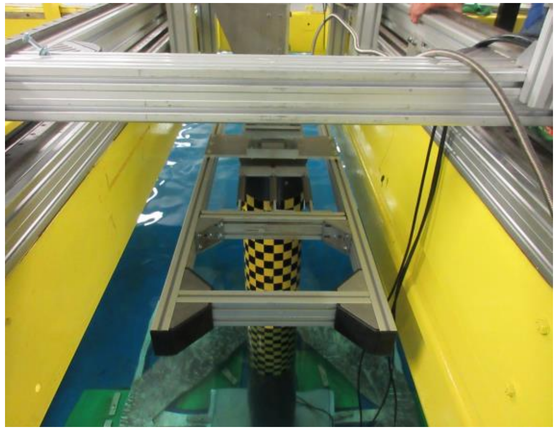


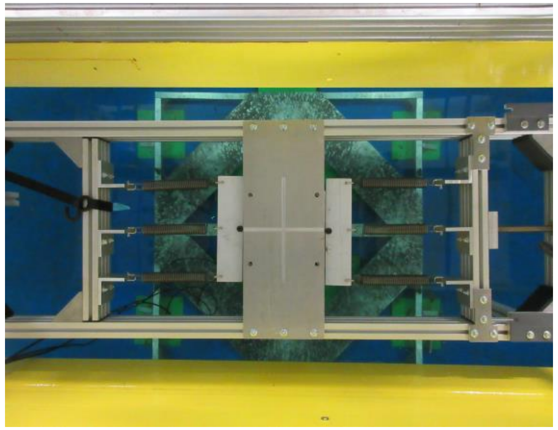


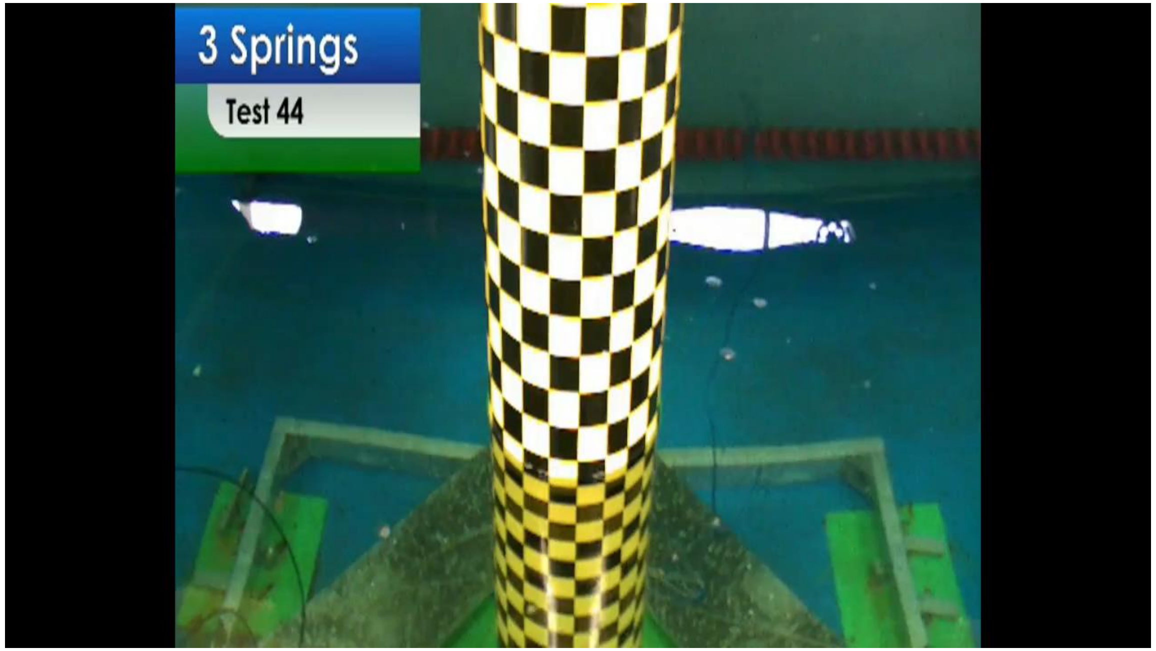
Feng, X., Taylor, P. H., Dai, S., Day, A. H., Willden, R. H. J., & Adcock, T. A. A. (2020). Experimental investigation of higher harmonic wave loads and moments on a vertical cylinder by a phase-manipulation method. *Coastal Engineering*, *160*, Article 103747. https://doi.org/10.1016/j.coastaleng.2020.103747

Compliant cylinder test

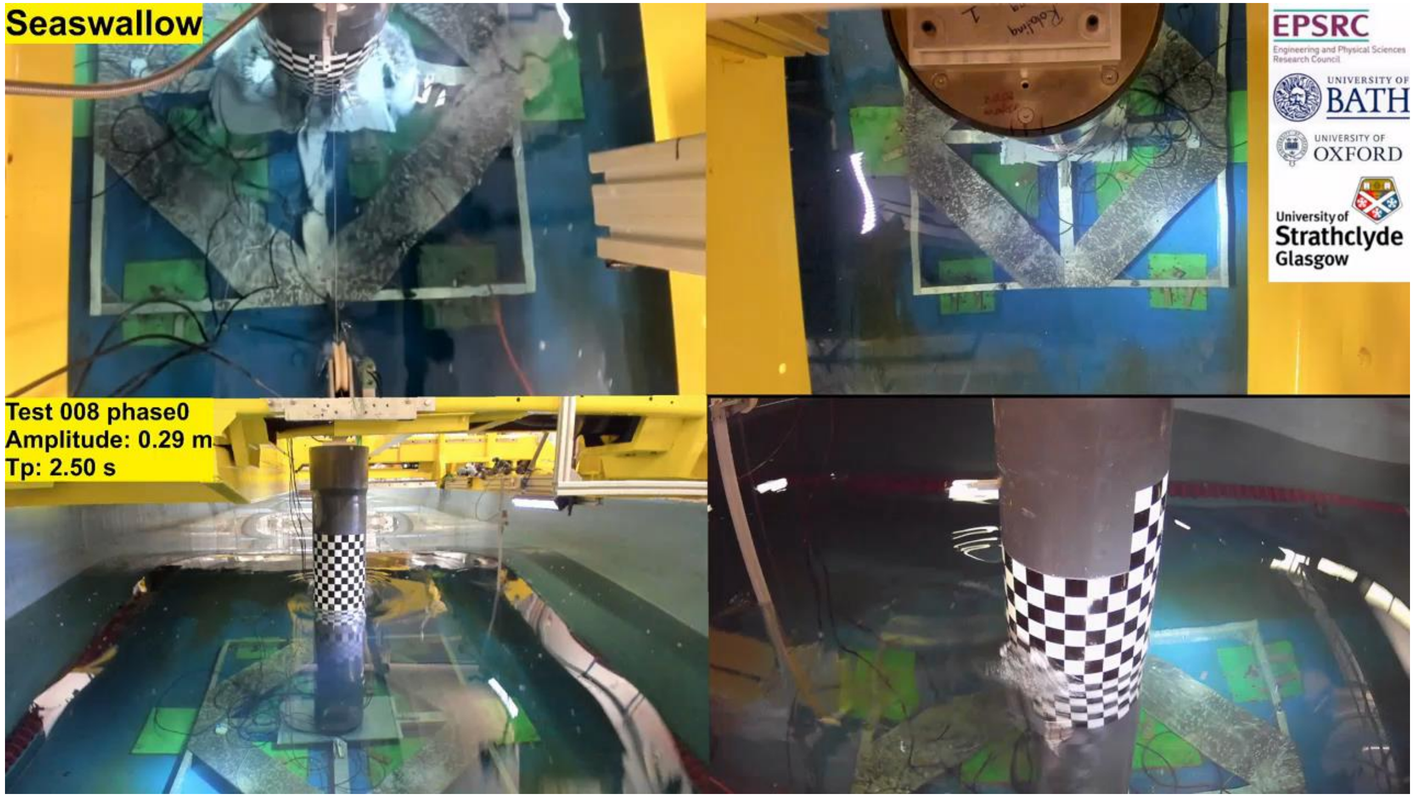
- 315mm diameter
- Force measurement
- Springs to model different stiffness



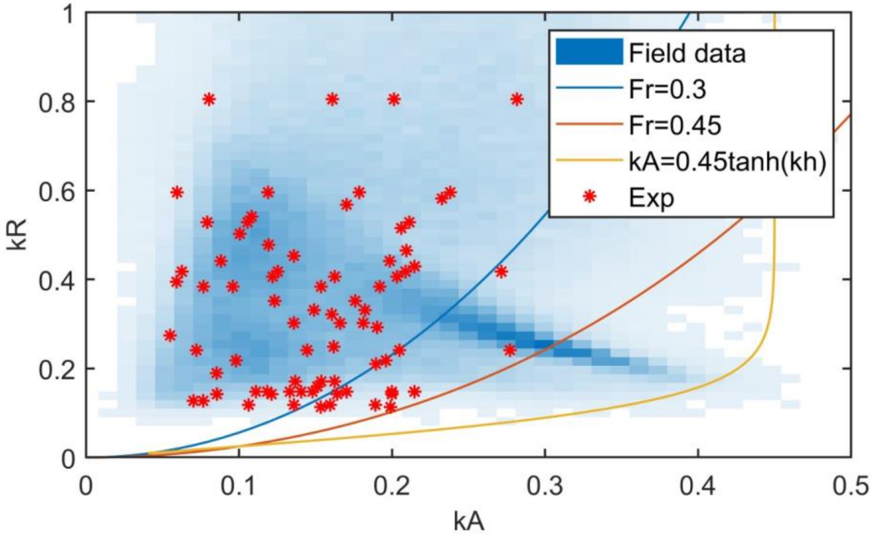




Sea-Swallows



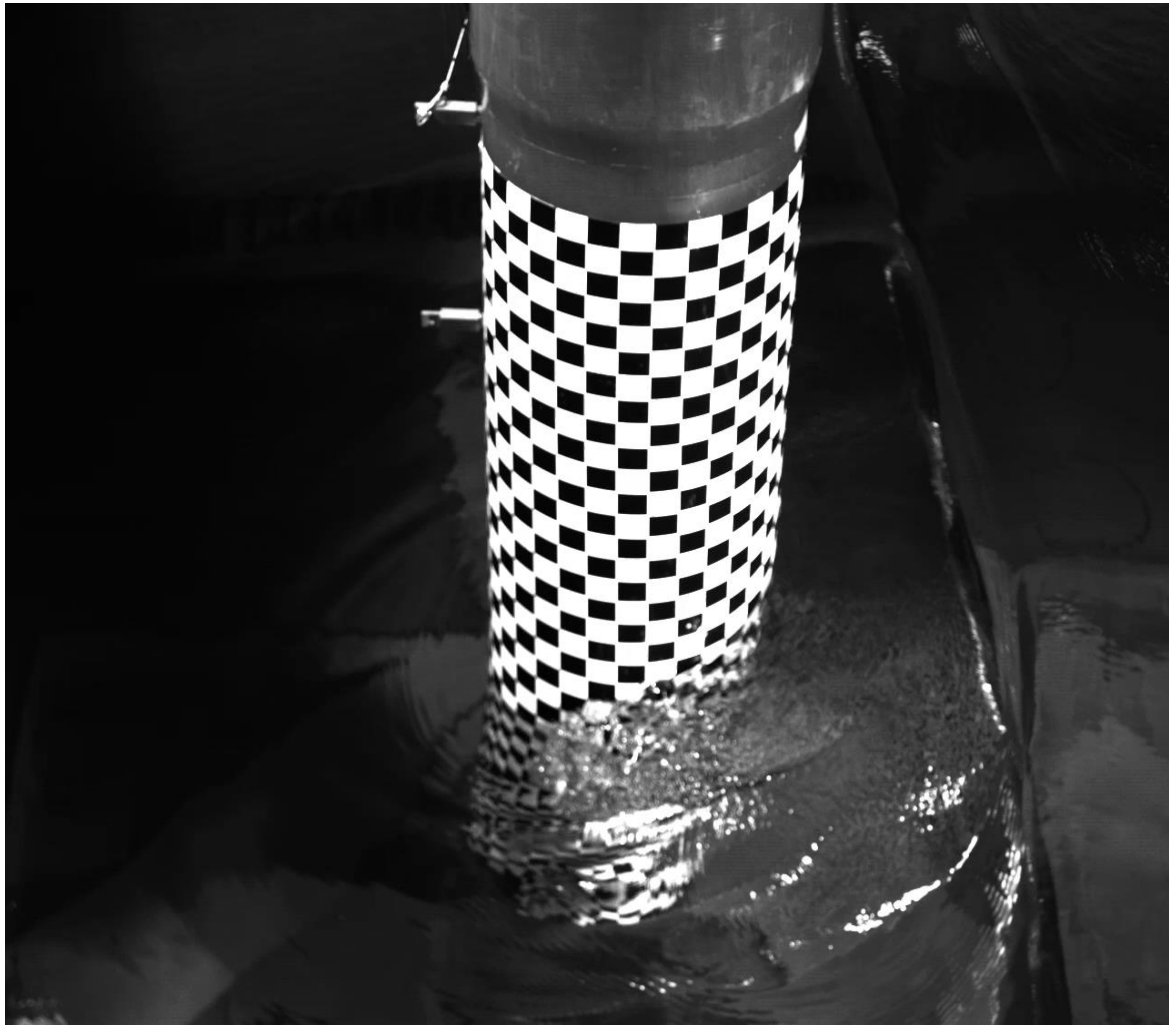
- Non-breaking focus wave tests
- Wider range of test conditions

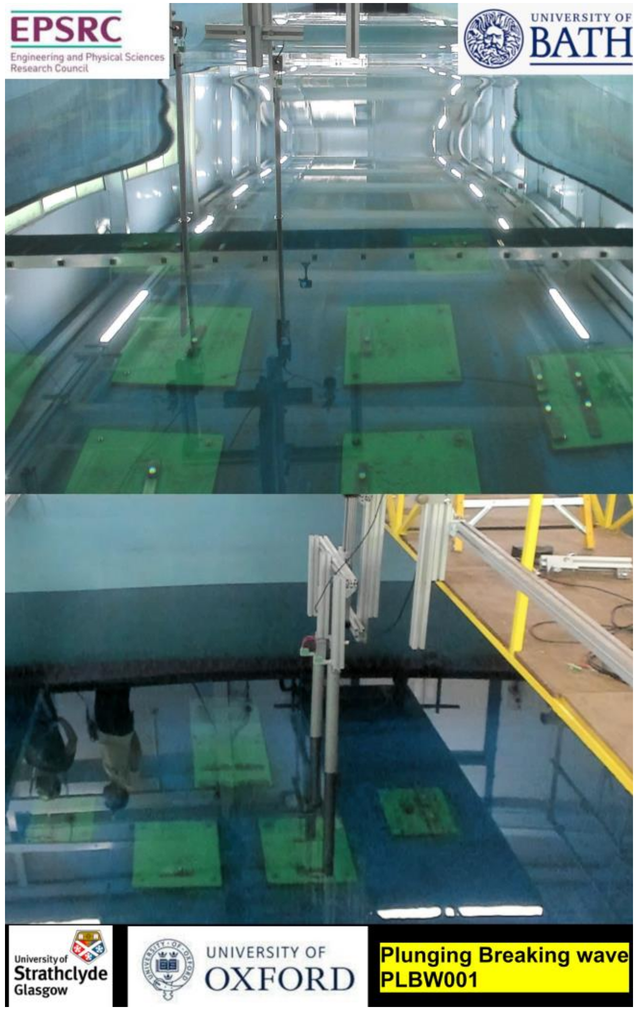


- Cylinder R: 0.2 m
- Water depth 1.8 m

Tang, T., Ding, H., Dai, S., Chen, X., Taylor, P. H., Zang, J., & Adcock, T. A. A. (2023). Data informed model test design with machine learning - An example in nonlinear load on vertical cylinder. In *ASME 2023 42nd International Conference on Ocean, Offshore and Arctic Engineering: Volume 5: Ocean Engineering* Article OMAE2023-102682 https://doi.org/10.1115/OMAE2023-102682

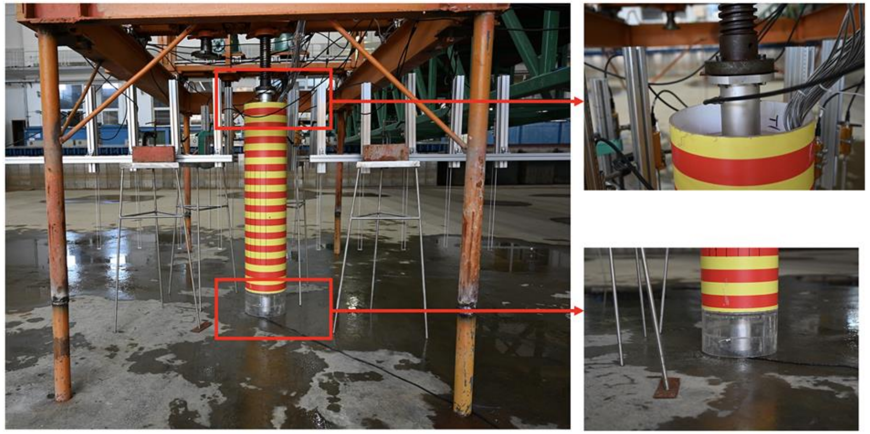
Breaking wave





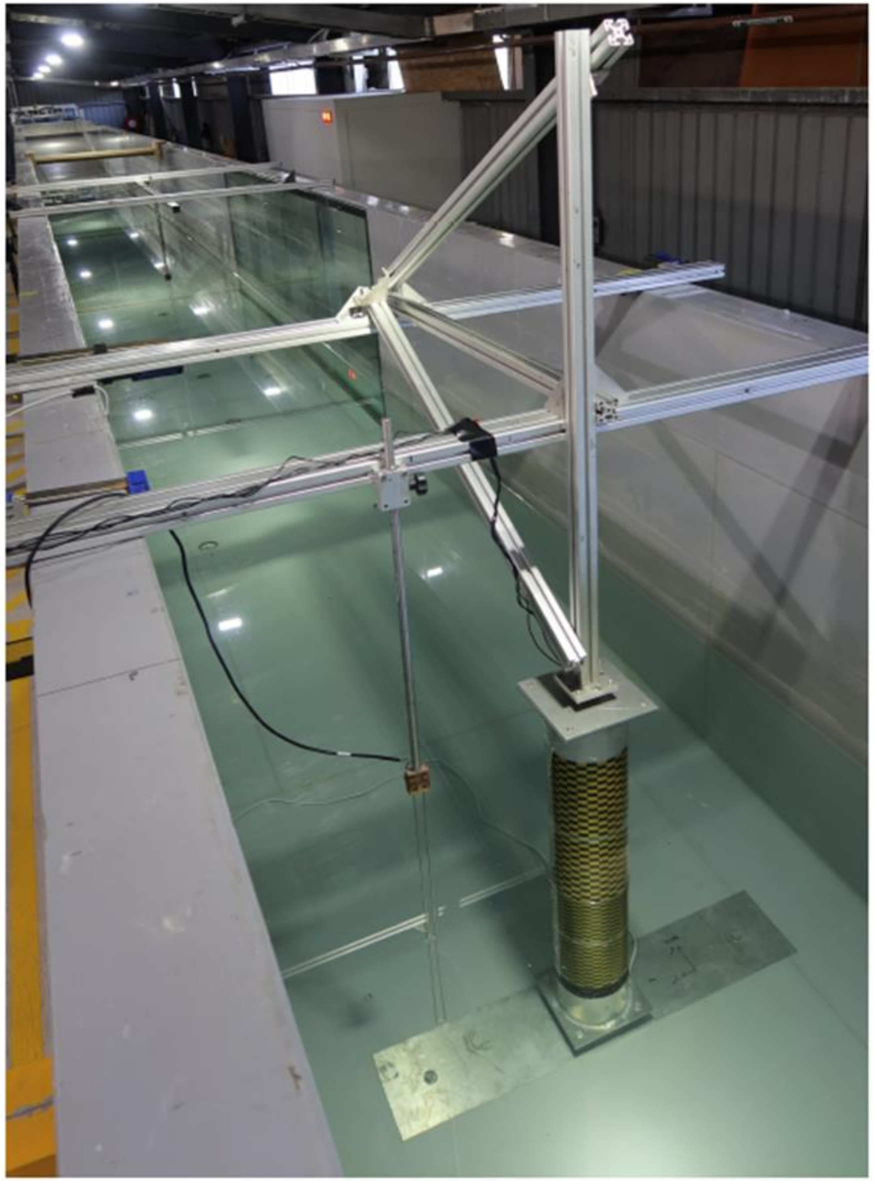
State key laboratory of coastal and offshore engineering, DUT

54 m in length:
34 m in width:
Tested water depth: 0.5 and 0.7 m
Cylinder R: 0.125 m



Ding, H., Zhao, G., Tang, T., Taylor, P., Adcock, T. A. A., Dai, S., Ning, D., Chen, L., Li, J., Wang, R., & Zang, J. (2025). Experimental investigation of nonlinear forces on a monopile offshore wind turbine foundation under directionally spread waves. *Journal of Offshore Mechanics and Arctic Engineering*, *147*(4), Article 042002. Advance online publication. https://doi.org/10.1115/1.4067116

UWA



Tests performed by Jana Orszaghova at UWA entirely independently of Sea-Swallows

The large Scale Wave Flume measures

54 m in length
1.5 m in width
1.1 m in water depth

Unique facility with piston wavemaker at one end and flap type wave maker at the other end.

Programmed the wave maker to eliminate the 2 order difference and sum error waves.

Thank you!