

Performance Enhancement of Multibody Wave Energy Converters using an Efficient Numerical Modelling Technique

Model Outline:

- Commonly used time-domain modelling techniques are slow for optimisation problems.
- In this work, much faster, **frequency-domain** models have been developed within WAMIT, using **generalised modes** of motion to avoid the need for post-processing.
- Maximal efficiency:** Number of modes of motion = Number of Degrees of Freedom
- Constraint forces** on the device can also be modelled using generalised modes.
- For all but the simplest geometries and mode shapes, computation of the M_{ij} and C_{ij} terms introduced by the generalised modes is **not straightforward**.

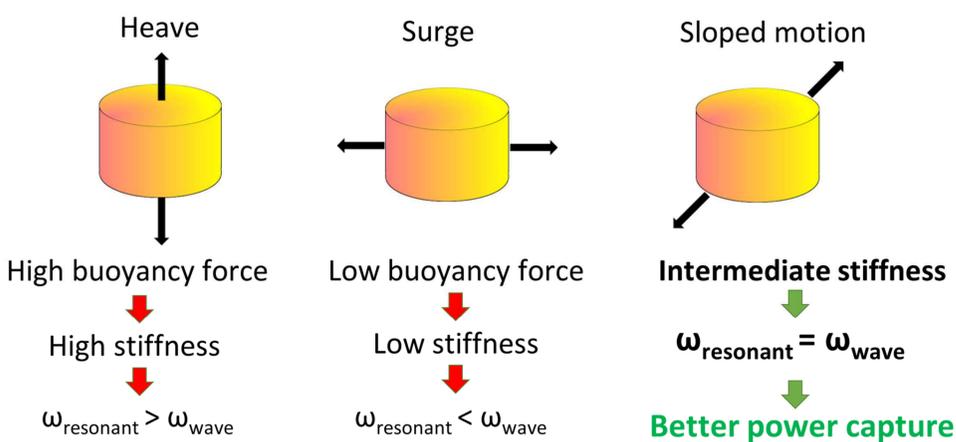
'N' degrees of freedom

Solve for device motions

$$\sum_{j=1}^N [-\omega^2 (M_{ij} + A_{ij}) + i\omega B_{ij} + C_{ij}] \xi_j = X_i \quad (1)$$

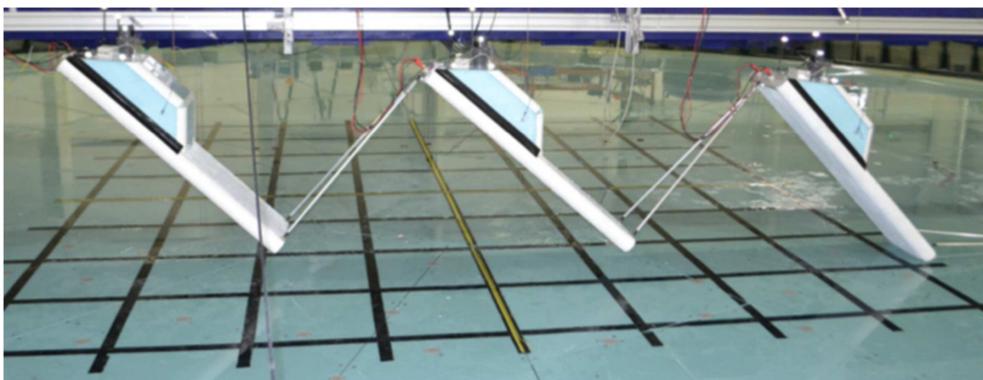
***Hydrodynamic coefficients**

Application 1: WaveTrain WEC



- This concept aims to extend the promise of sloped buoys into deep water environments – the device is **freely-floating**.
- Mechanical struts and rotational joints between modules prevent unwanted, **excessive pitching**.
- An **oscillating water column** in each module facilitates power capture.
- Single- and multi-objective **genetic algorithms** have been used to investigate the merit of different design types.

Below: Scale model of the WaveTrain¹ concept in FloWave Test Tank.



Right: Early artist's impression of a spine of Salter Ducks.



Application 2: Spine of Salter Ducks

- In a freely-floating spine, **full control** would be had of **most, but not all** degrees of freedom of the spine, via hydraulic systems.
- Investigation of the control forces required for optimal power extraction is imperative prior to deployment.
- The various forms of **complex conjugate control** (an analytical method) are applicable as a result of the motions being encapsulated entirely within the boundary element method.
- Of particular interest are **oblique sea states**, and what the nature of the **forces demanded and/or imparted** on the system are, under optimal or sub-optimal power extraction.
- The use of an **heuristic optimisation routine** may be necessary for certain kinds of irregular sea.

References

- N. Wells, 2013, "Performance of the JOULES Wavetrain WEC", MARINET Infrastructure Access Report
- S. Salter, "Wave Power", Nature Vol. 249, 1974