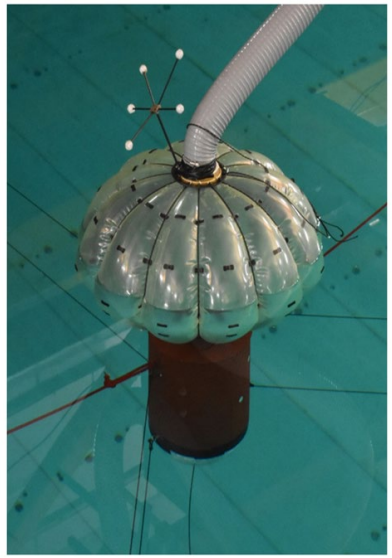
Supergen Offshore Renewable Energy

Flexible Responsive Systems in Wave Energy: FlexWave



Supergen ORE Hub: Fourth Annual Assembly, 18th –20th January 2022

Professor Deborah Greaves, Dr Martyn Hann, Professor Zhong You, Professor John Chaplin, Dr Shanshan Cheng, Dr Maozhou Meng, Professor Alistair Borthwick, Dr Robert Rawlinson-Smith, Dr Edward Ransley, Dr Siming Zheng, Dr Xinyu Wang, Jingyi Yang, Dr Krishnendu Puzhukkil

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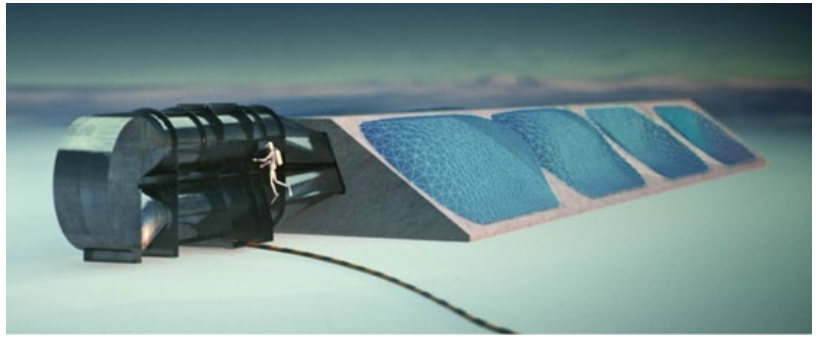
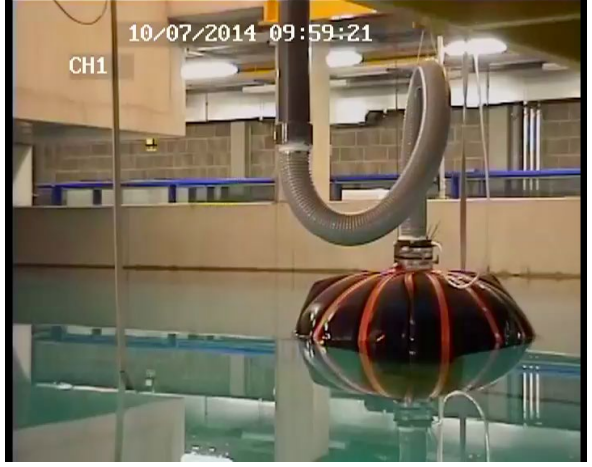
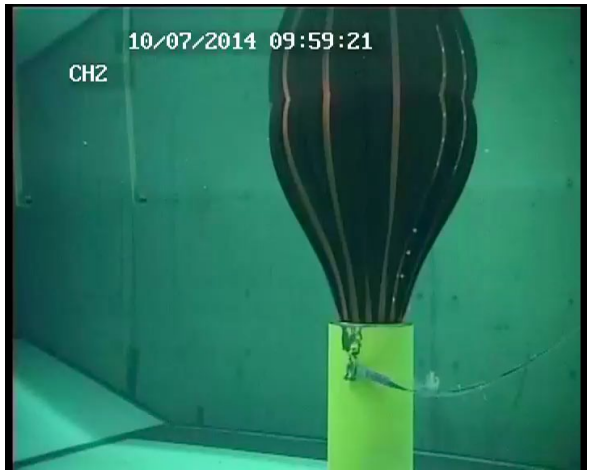
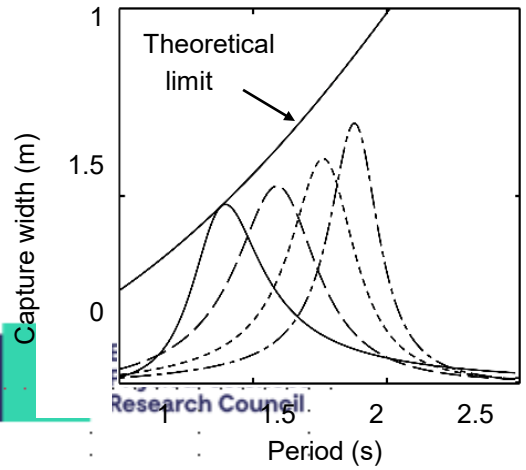


Why FlexWave?

- Flexible fabric WECs can be smaller and lighter than rigid counterparts.
- May be tuned to suit incident wave conditions by controlling internal fluid pressure.
- Controlled non-linear deformation can accommodate or shed high loads, improving survivability and reducing installation and lifetime costs.
- A range of PTO types could be utilised, such as air turbine, electro active polymers or novel distributed embedded energy converters.
- Low risk option for co-location with offshore wind.



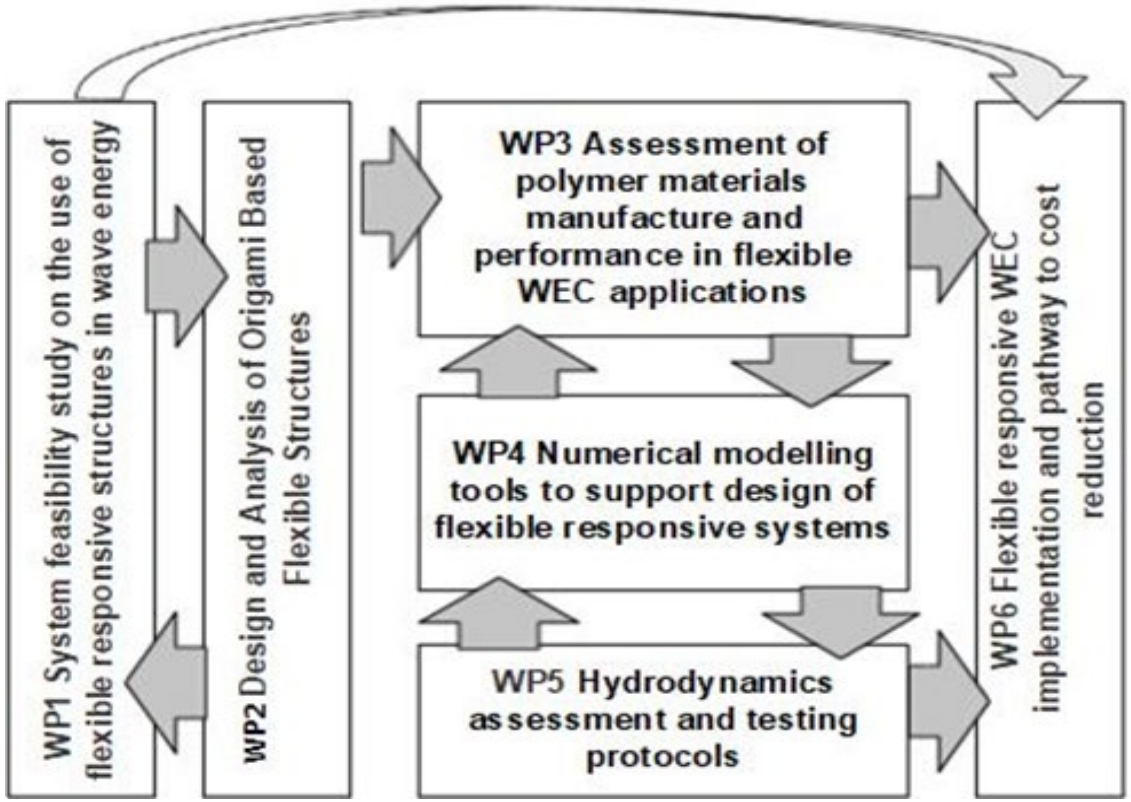




Kurniawan A, Chaplin J, Greaves D, Hann M., and Farley, F. Wave energy absorption by a floating air bag, Journal of Fluid Mechanics 812:294-320 2017.

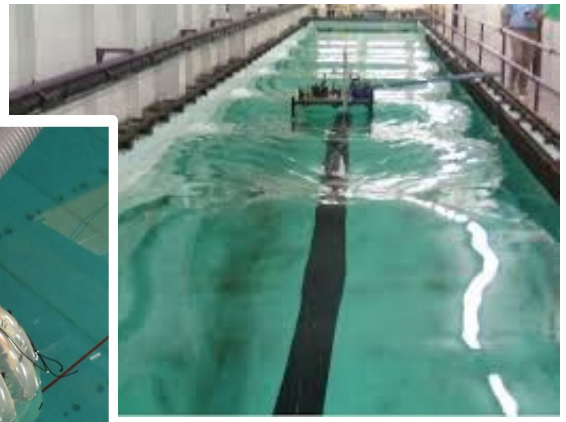
FlexWave Aims

- To demonstrate a step change reduction in cost of energy through the use of Flexible Responsive Systems in Wave Energy.
- To develop fundamental knowledge in hydrodynamic performance, structural design, material use and manufacture, alongside new modelling tools, and a novel origami approach to shape selection for resilient WEC designs.

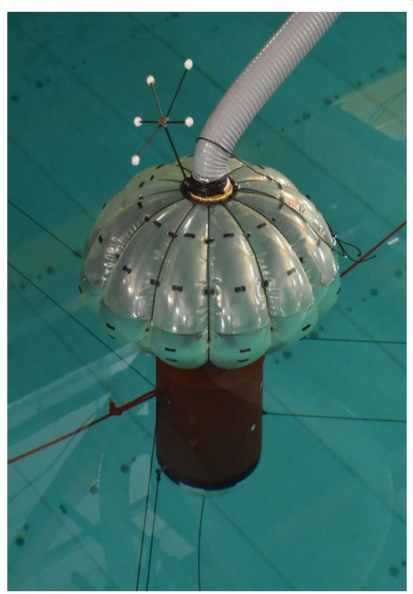


System feasibility study on the flexible responsive structures

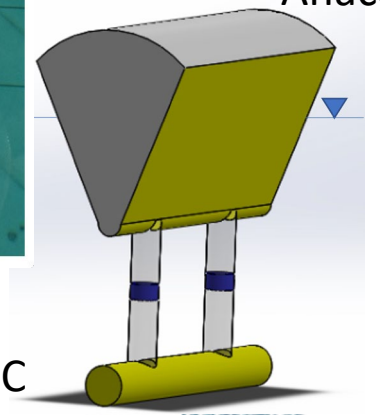
Selected WEC configurations



Anaconda



SQ1



Clam-WEC

Potential PTO systems

- Air-turbine generator
- Dielectric elastomer generators (DEG)
- Triboelectric Nano generators (TENG)

Numerical modelling tools

Ansys FEA, WAMIT, WEC-Sim, FlexWEC

- Finite element analysis (mode shapes)
- Frequency domain analysis (hydrodynamic coefficients)
- Time domain hydrodynamic analysis (dynamic responses, loads & stresses)

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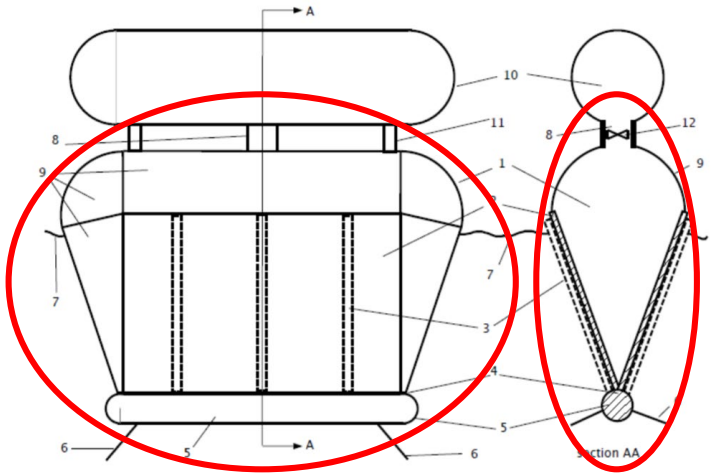
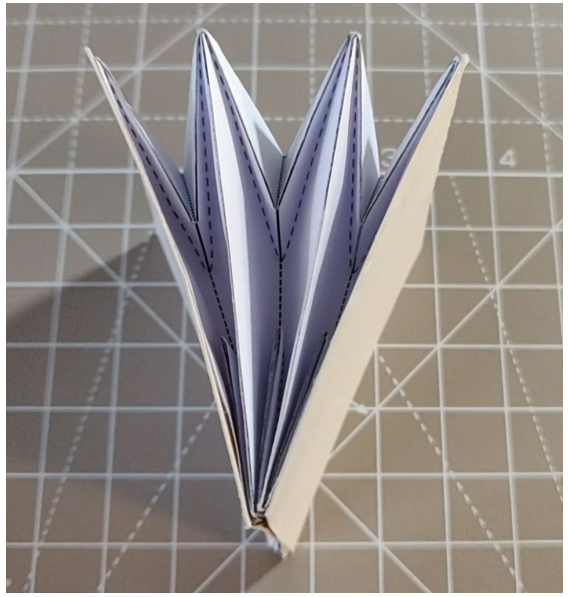
Design and Analysis of Origami Based Flexible Structures



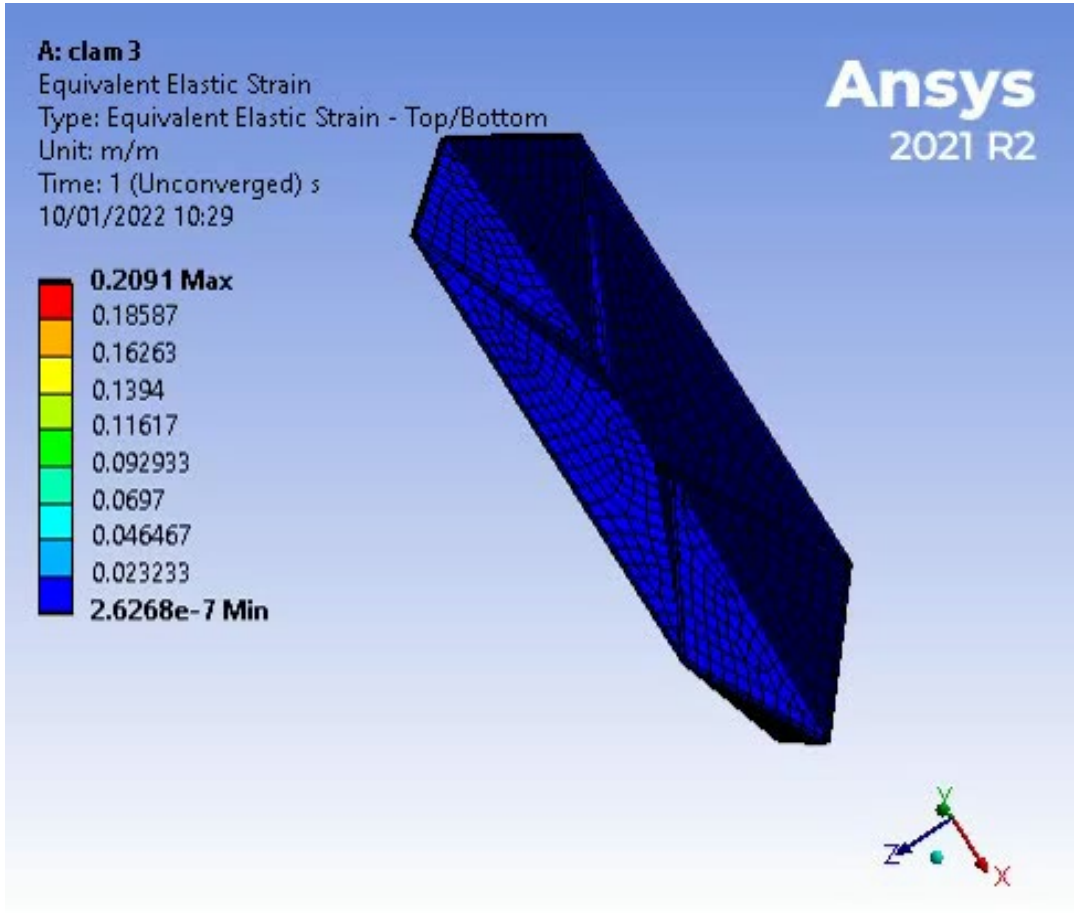
Front view



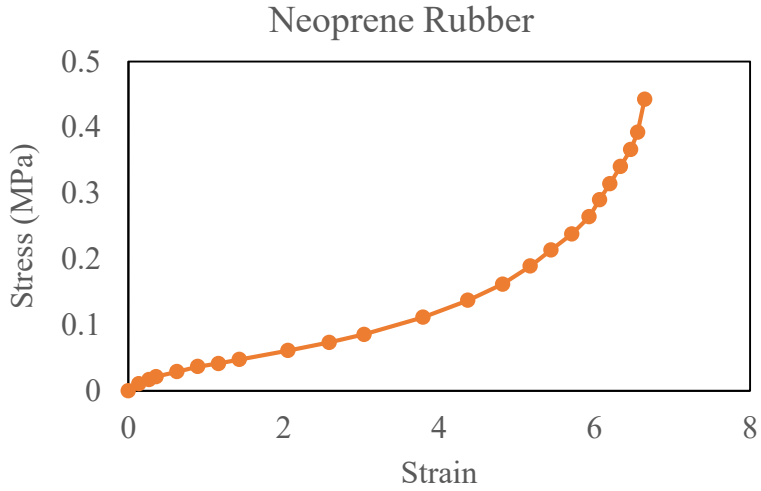
Deforming the card model resulting in volumetric change video

- Origami-based design for the clam concept.
  - Large volumetric change with acceptable strain level
  - Surface stretching on a designed region
- Experimental validations
  - Small scale physical models to validate the folding patterns and deformation modes
  - FEA for the full scaled model
  - Physical model can be made by flexible material with thickness

FEA of the folding process



- Folding with neoprene rubber

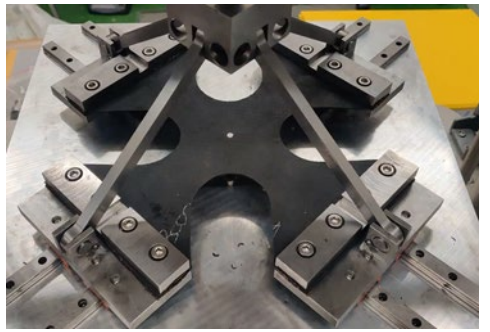


- Element type: shell181
- Maximum strain: 0.2091

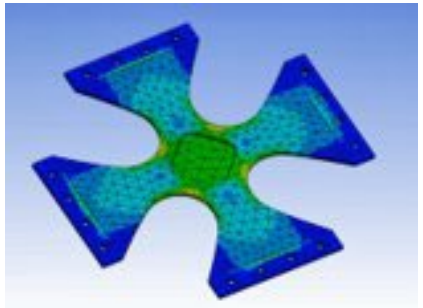
Assessment of materials manufacture and performance in flexible WECs

- Material selection
  - Fabric reinforced elastomer (nature rubber + nylon fabric)
  - Remarkable fatigue life in marine environment
  - Low cost & environmental-friendly
- Material testing
  - Uni- & bi-axial fatigue test
  - Sea water immersion test
- Material characterising
  - Composite interface investigation
  - Life cycle analysis
  - Provide data for FEA modelling validation

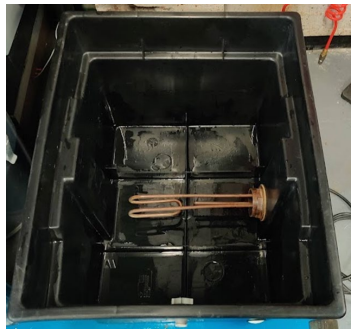
Nylon fabric



Fatigue test

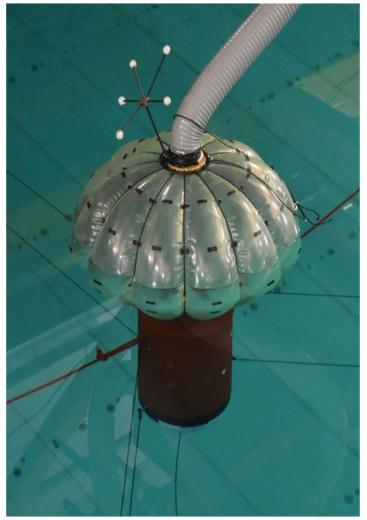


FEA modelling



Hot bath: sea water immersion setup

FlexWave Project Progress and Future work



- Three flexible WEC configurations selected
- Crease patterns are proposed for clam concept with various design parameters
- Natural rubber + nylon fabric composites have been studied
- Numerical modelling tools to study different WEC configurations explored

- Filler design need to be improved
- Thermoplastic elastomer will be investigated
- Finite element analysis for the actual scaled model
- Hydro-elastic tank testing on different polymer materials planned

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