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EPSRC Marine Wave Energy Programme

Bionic Adaptive Stretchable Materials for WEC (BASM-WEC), EP/V040553/1

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BASM WEC

Bionic Adaptive Stretchable Materials for Wave Energy Converters (BASM-WEC)

This project exploits the specific characteristic of flexible materials to adapt their shape to the loading conditions to design more reliable and efficient lightweight WECs.
Our project is one of two led by Strathclyde to be awarded a share of £7.5m funding
We are developing and testing cutting-edge new wave energy technologies to help the UK achieve its Net Zero goal

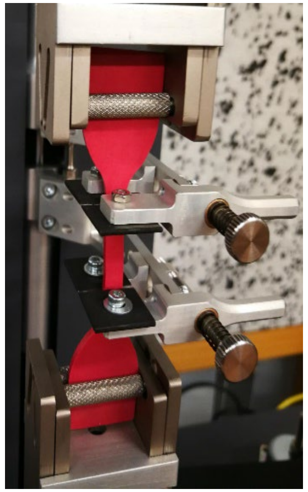
Project Overview

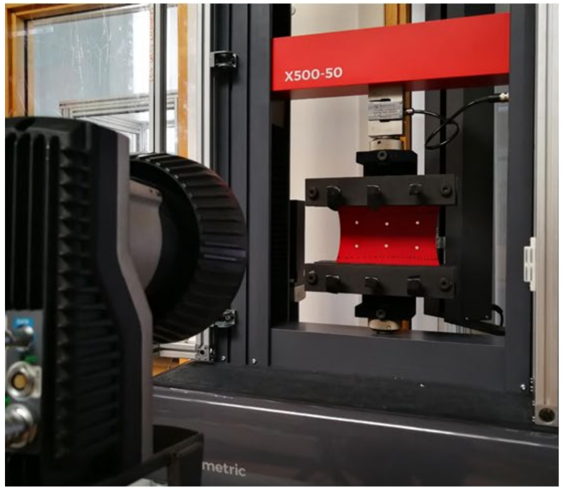
Technology	Funds	Duration	Start
Flexible material for Wave Energy Converter	£1 million	3 Years	12. November 2021

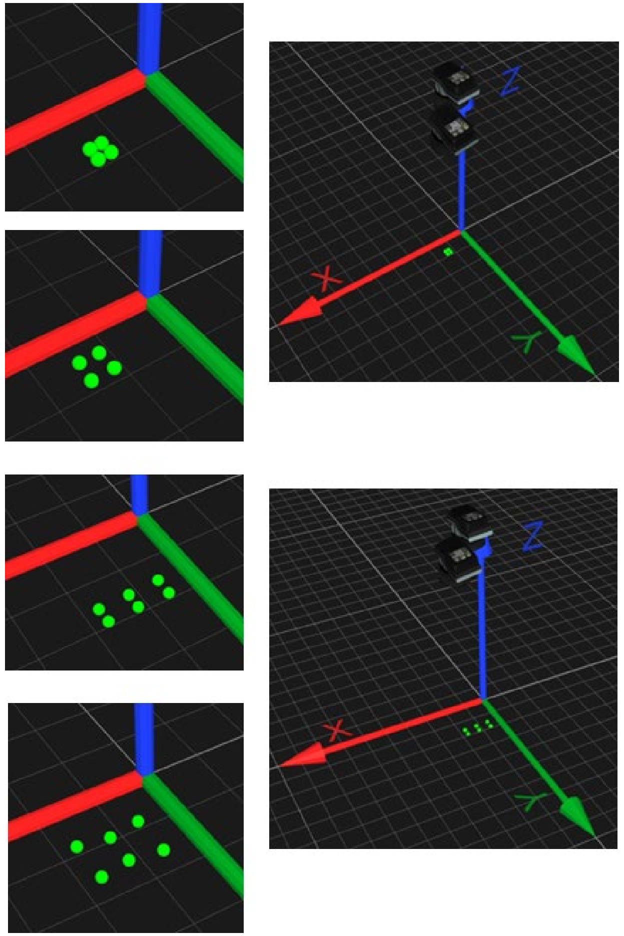
Materials characterisation

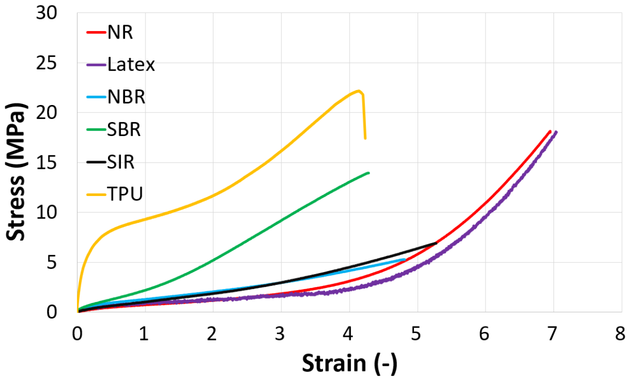
Numerical models are used to predict the structural response of WECs. However, the accuracy of any prediction will depend on the validity of the hyperelastic model employed and the reliability of the test data input into the chosen model.

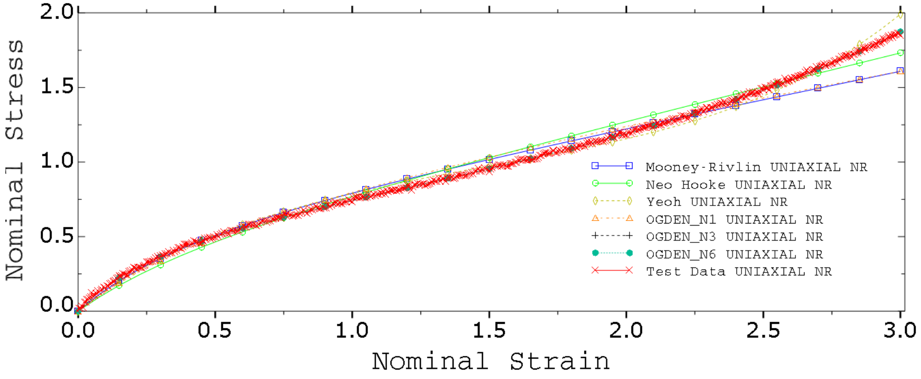
Plane stress | **Plane strain** | **Biaxial stress**





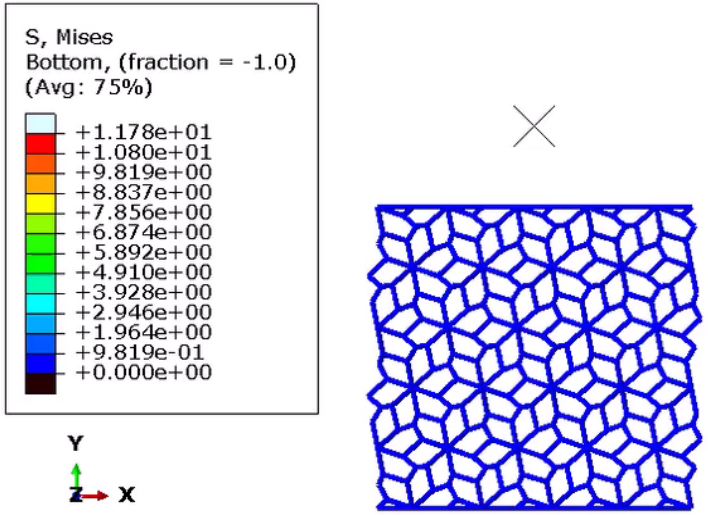


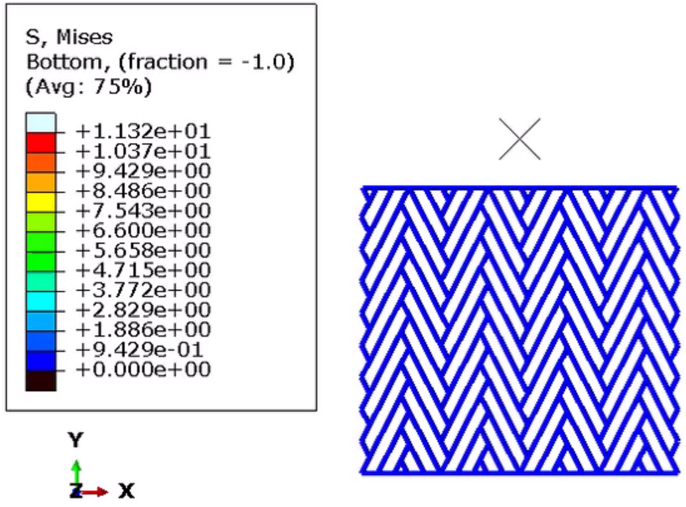


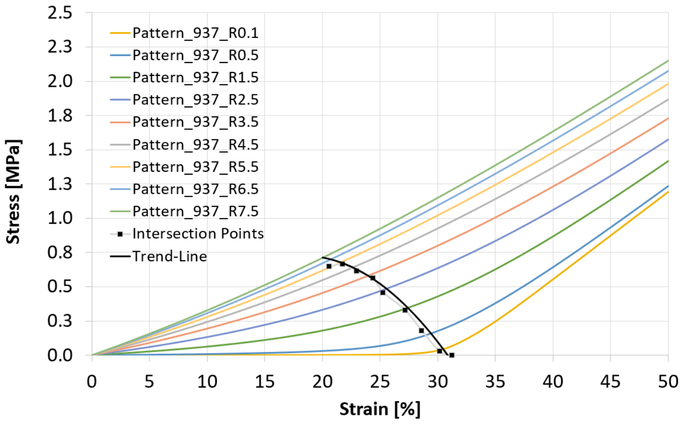


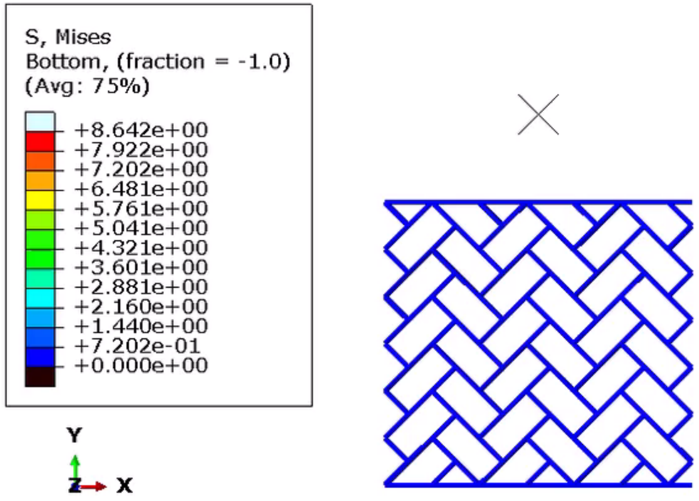
Elastomeric structured membranes

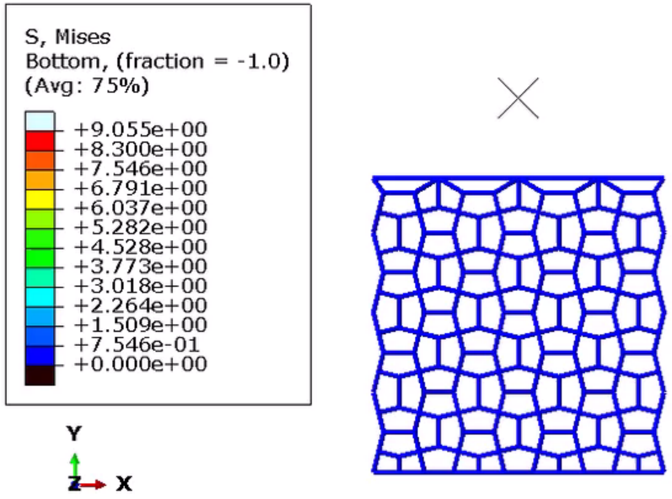
The aim is to increase the survivability of the devices through stiffness percolation of the structured layer.

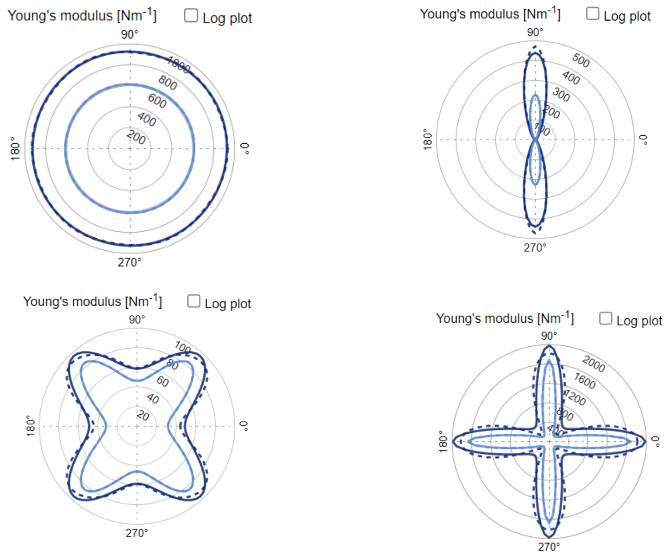












Structural Integrity (Structures functional specification)

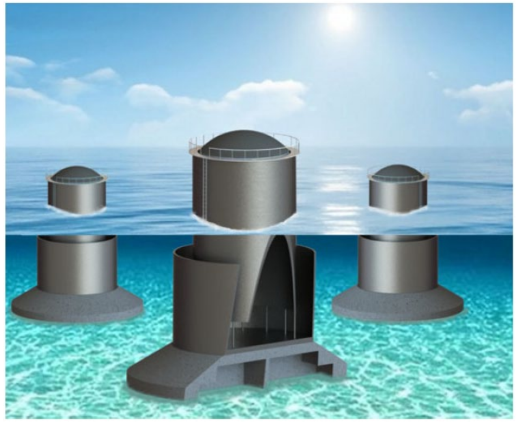
Structural Challenges:

- Load Definition
- Boundary condition
- Failure Modes
- Deformation range
- Pre-stretching
- Stress distribution

Materials Challenges:

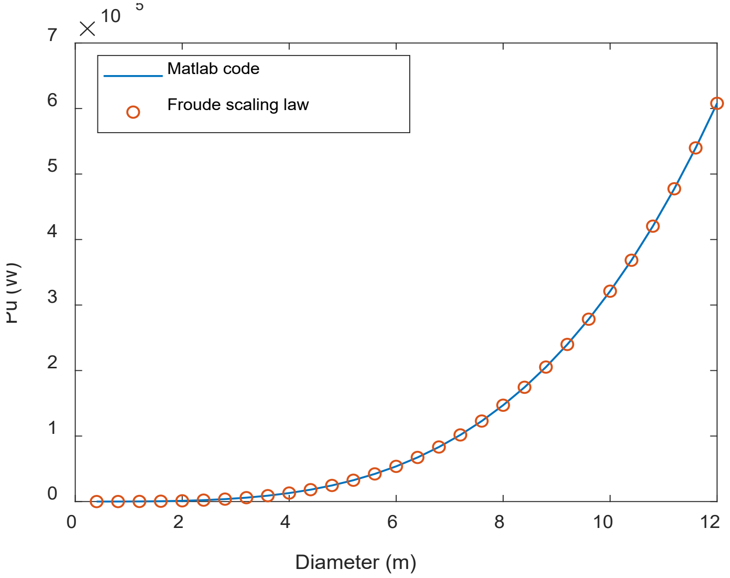
- Hysteresis
- Stress-softening
- Coating
- Strain crystallisation
- Ageing
- Submersion

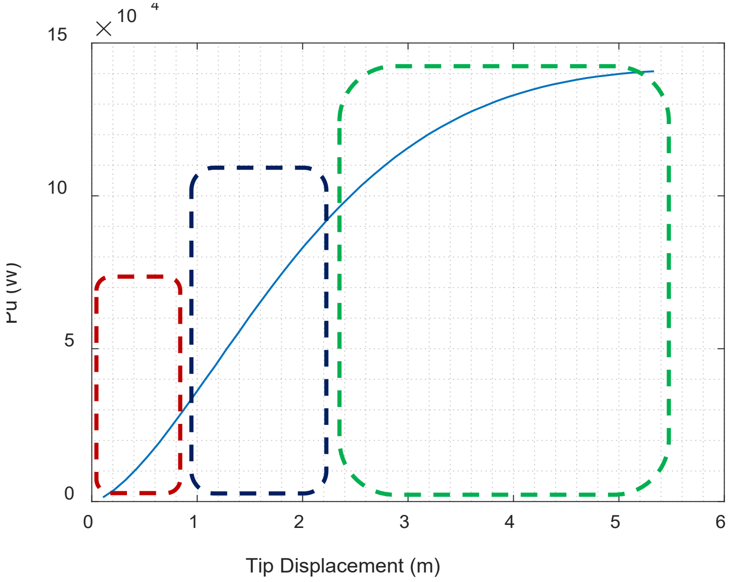
→ **Structural and material solutions**

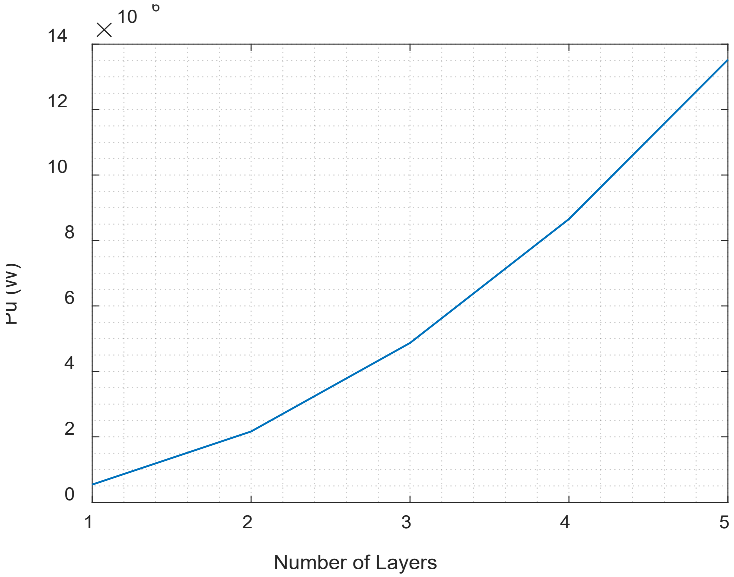


Geometry model
(Moretti et al., 2019)

The effect of different parameters on the produced energy:







Moretti, Giacomo, et al. "Modelling and testing of a wave energy converter based on dielectric elastomer generators." Proceedings of the Royal Society A 475.2222 (2019): 20180566.

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Structural Integrity (Experimental setup)

Main purposes of designing the test rig:

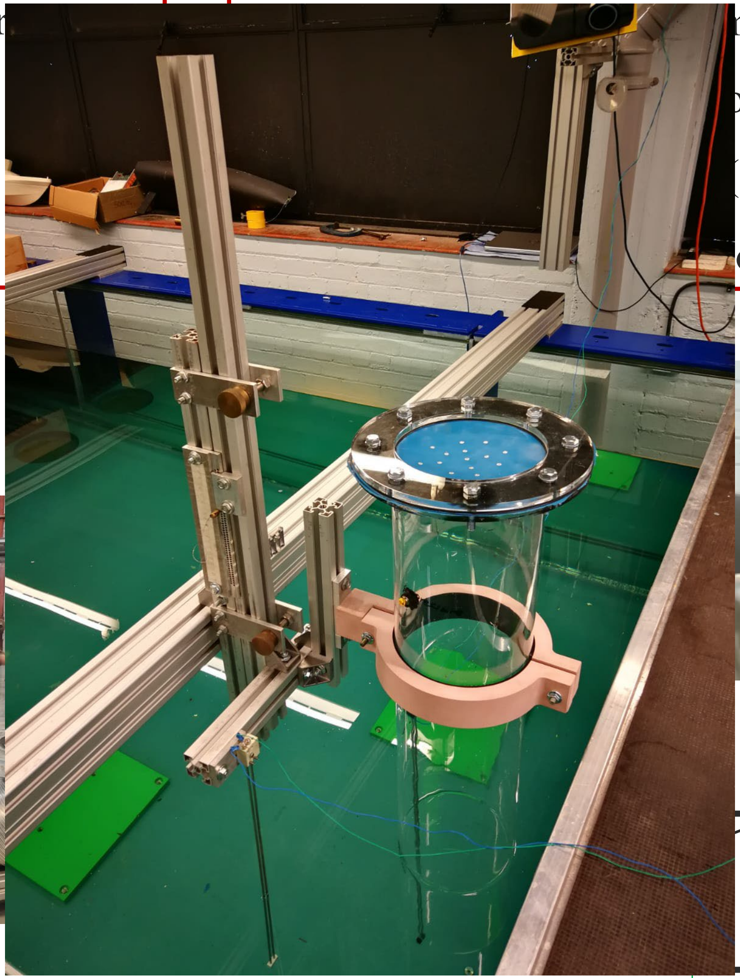
- The assessment of the PTO perfor
- Structural and material solutions
- Study on scaling
- Pre-stretching effects

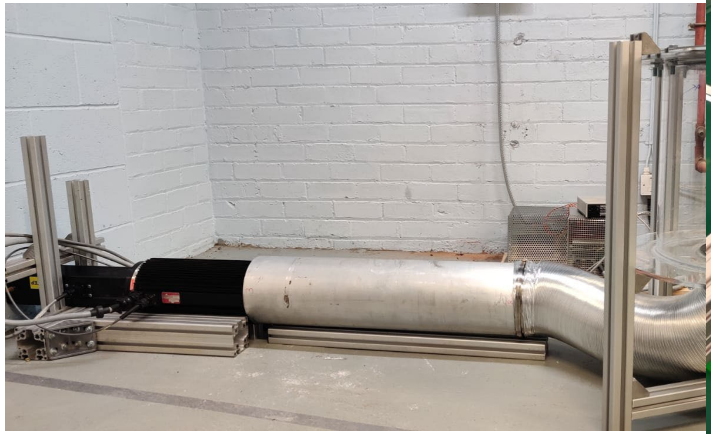
nbrane (D_m): 20~40cm

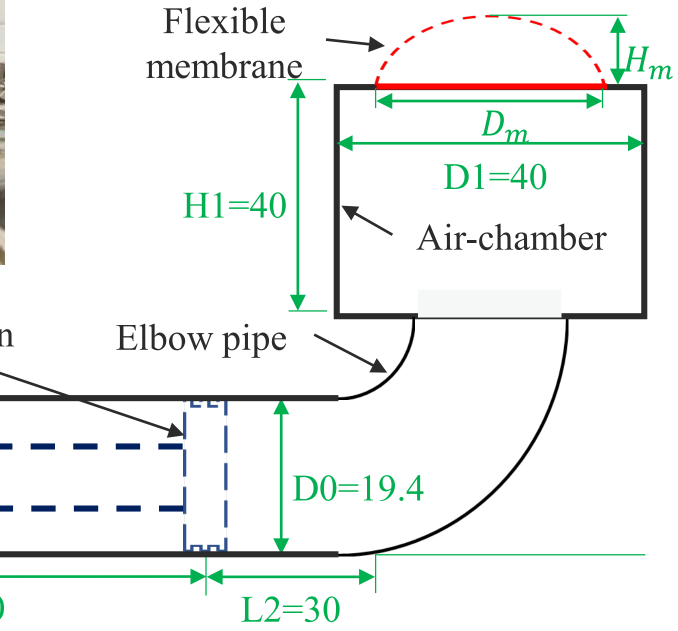
ormation (H_m): 0~20cm

(P_a): 0~20kPa

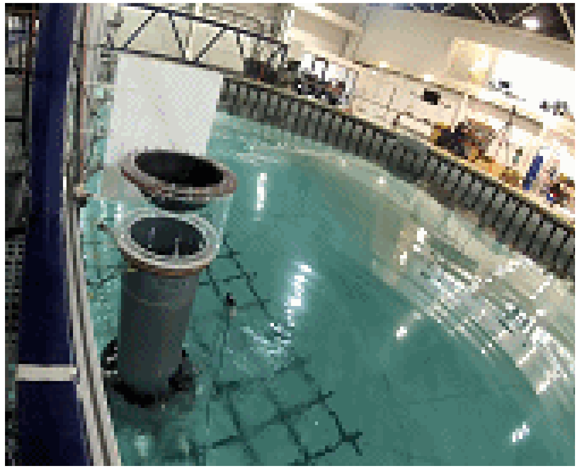
on (f_p): 0.4~1.2Hz



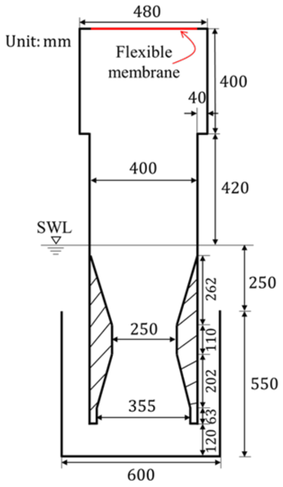




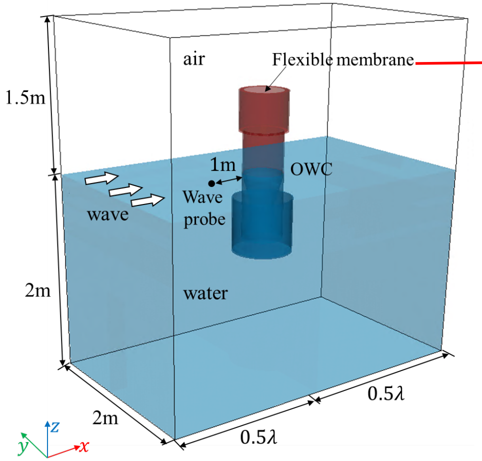
Numerical modelling for flexible OWC



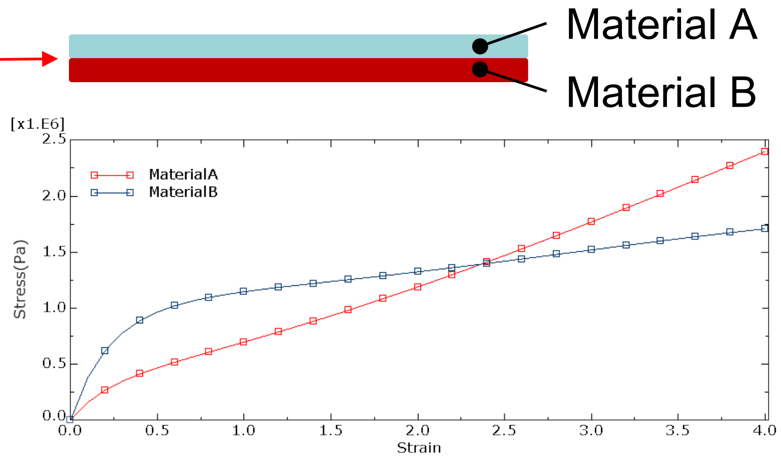
Model test of flexible OWC
(From YouTube)



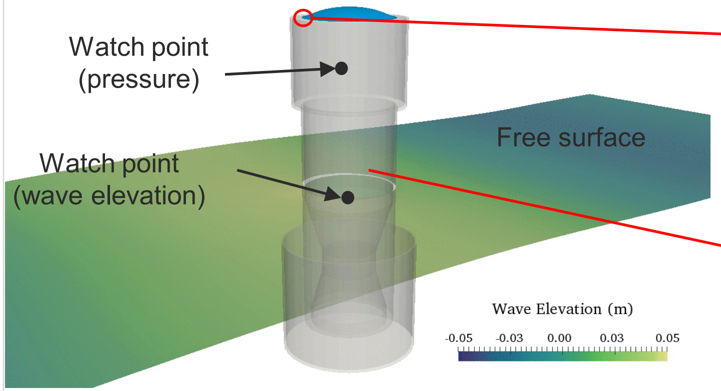
Geometry model
(Moretti et al., 2019)

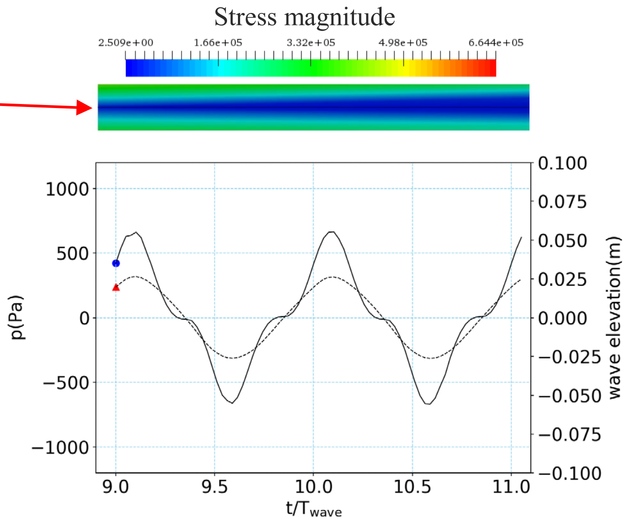


Schematic diagram of computational domain in numerical simulations



Stress-strain curve of different materials



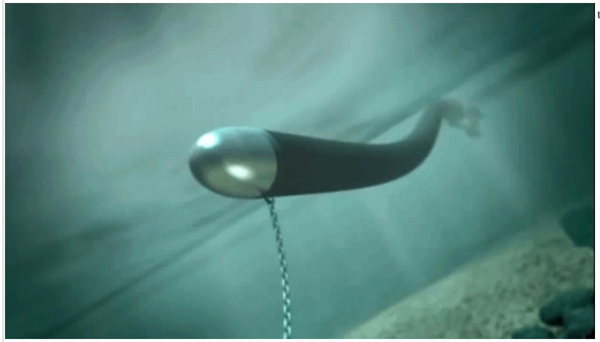


Incident wave
- **Regular wave** (Stokes II)
- Wave period (T_w): 1.95s
- Wave height (H): 0.1m

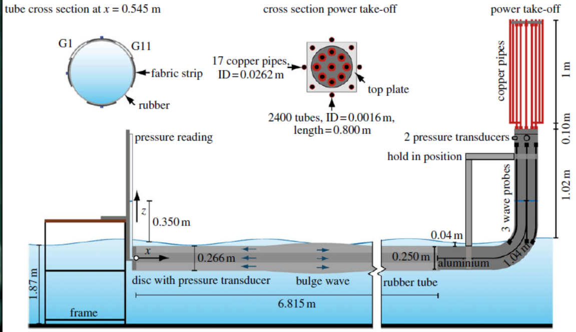
Material properties
- **Hyper-elastic material**
- Polynomial, N=2

Moretti G, Rosati Papini G P, Daniele L, et al. Modelling and testing of a wave energy converter based on dielectric elastomer generators[J]. Proceedings of the Royal Society A, 2019, 475(2222): 20180566.

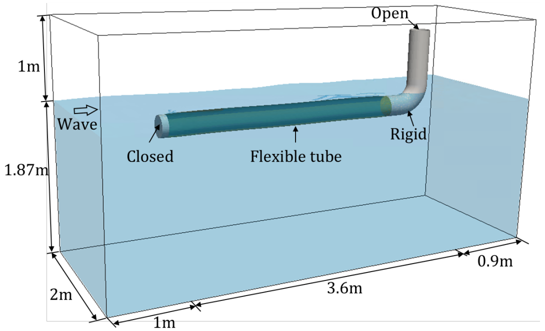
Numerical modelling for Anaconda WEC



Anaconda WEC concept
(From YouTube)



Experimental arrangement of Anaconda WEC model test (Chaplin et al., 2012)



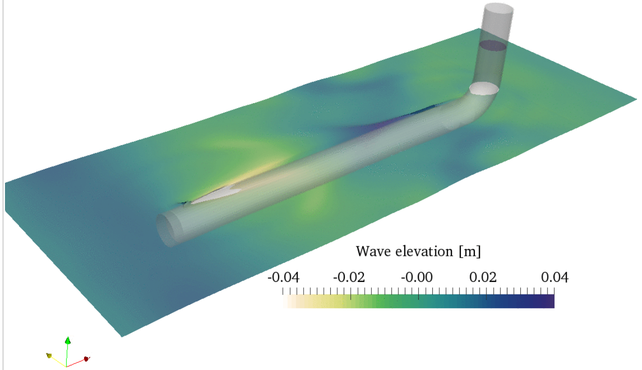
Schematic diagram of computational domain in numerical simulations

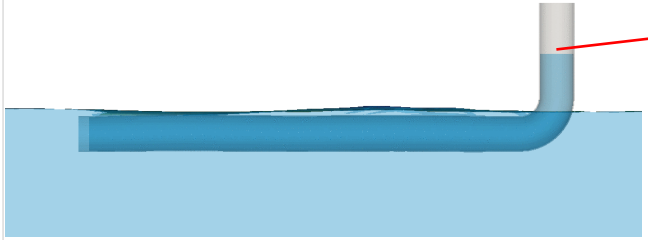
Incident wave

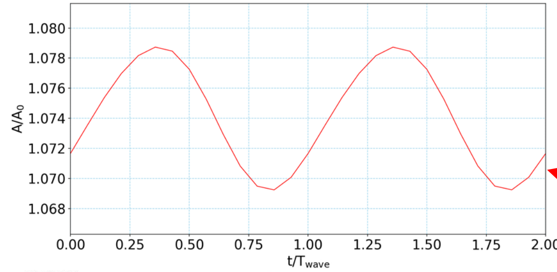
- **Regular wave** (Stokes II)
- Wave period (T_w): 1.4s
- Wave height (H): 0.04m

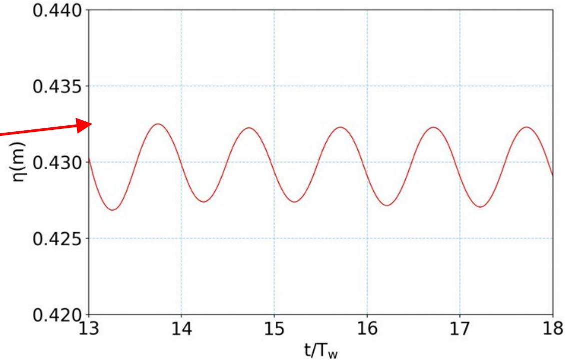
Material properties

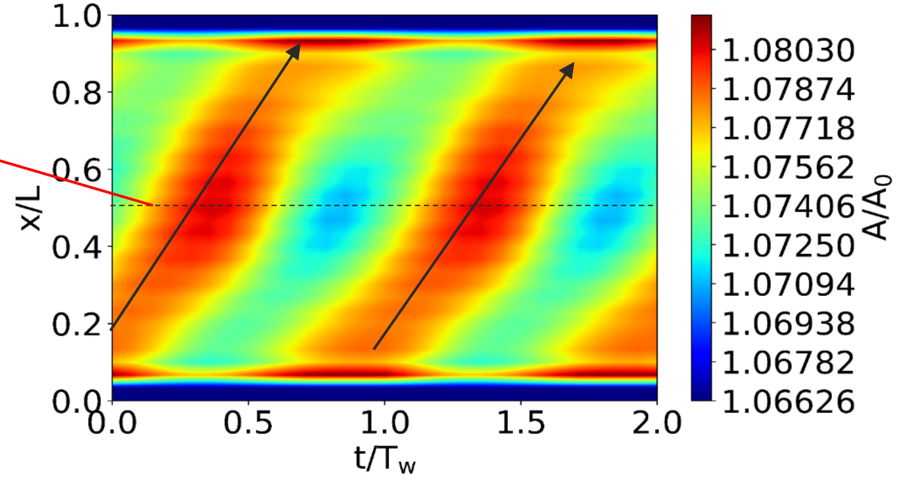
- **Elastic material**
- Young's modules: 1.6MPa
- Poisson's ratio: 0.5











Time and spatial distribution of the area of cross sections

Chaplin J R, Heller V, Farley F J M, et al. Laboratory testing the Anaconda[J]. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 2012, 370(1959): 403-424.

Work plan and outputs

- To validate the hyperelastic models based on the mechanical properties of the material, a case of study will be proposed combining testing and modelling. Additionally, a lifecycle assessment under different tests condition will be conducted for the material selected.
- Different parameters will be evaluated to improve the stiffness percolation of the structured membranes, considering isotropic and anisotropic behaviour. In addition, the synergic provided by the material response and pattern effect will be assessed.
- After finishing the functional specification, we will study the structural solutions using numerical solutions and the test rig.
- More features about the Fluid-Structure Interaction (FSI) analysis tool, including a power generation module and a six-degree-of-freedom (6DoF) motion module, will be will be developed.

COMING JOURNAL PAPERS

1. New passive/active stiffness elastomeric structured membranes for WECs devices. Journal: Smart Materials and Structures.
2. Geometry Optimization of The Oscillating Water Column Wave Energy Converter with Dielectric Elastomer Generator.
3. Numerical analysis of flexible OWC WEC with multi-layer material using CFD-FEA method

COMING CONFERENCES

1. Hyperelastic modelling of commercial elastomers for WECs. 42nd International Conference on Ocean, Offshore and Arctic Engineering (OMAE 2023) in Melbourne, Australia from June 11 - 16, 2023.
2. Improving Structural Integrity of Circular Diaphragm Dielectric Elastomer Generators for Wave Energy Converter. 42nd International Conference on Ocean, Offshore and Arctic Engineering (OMAE 2023) in Melbourne, Australia from June 11 - 16, 2023.
3. CFD analysis of flexible tube wave energy converter. 42nd International Conference on Ocean, Offshore and Arctic Engineering (OMAE 2023) in Melbourne, Australia from June 11 - 16, 2023.

Thanks

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