EPSRC Marine Wave Energy Programme

Bionic Adaptive Stretchable Materials for WEC (BASM-WEC)

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Flexible Materials in WECs

Steels

Concrete

→ Backbone (frame)

Articulations (joins) →

Elastomers and Composites

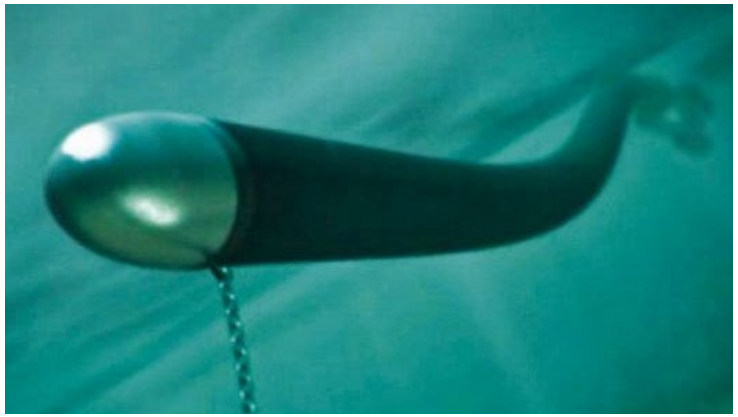
Shell

Submersible Buoyancy

Mooring

PWP - Rigid

Anaconda - Flexible



Logistics costs ↓: Modular Building

Load Shedding ↑: Elastomers have demonstrate advantage in load shedding

Device mass ↓: Elastomers and composites have a considerable low density.

Fatigue life ↑: Elastomers have high fatigue life and resilience

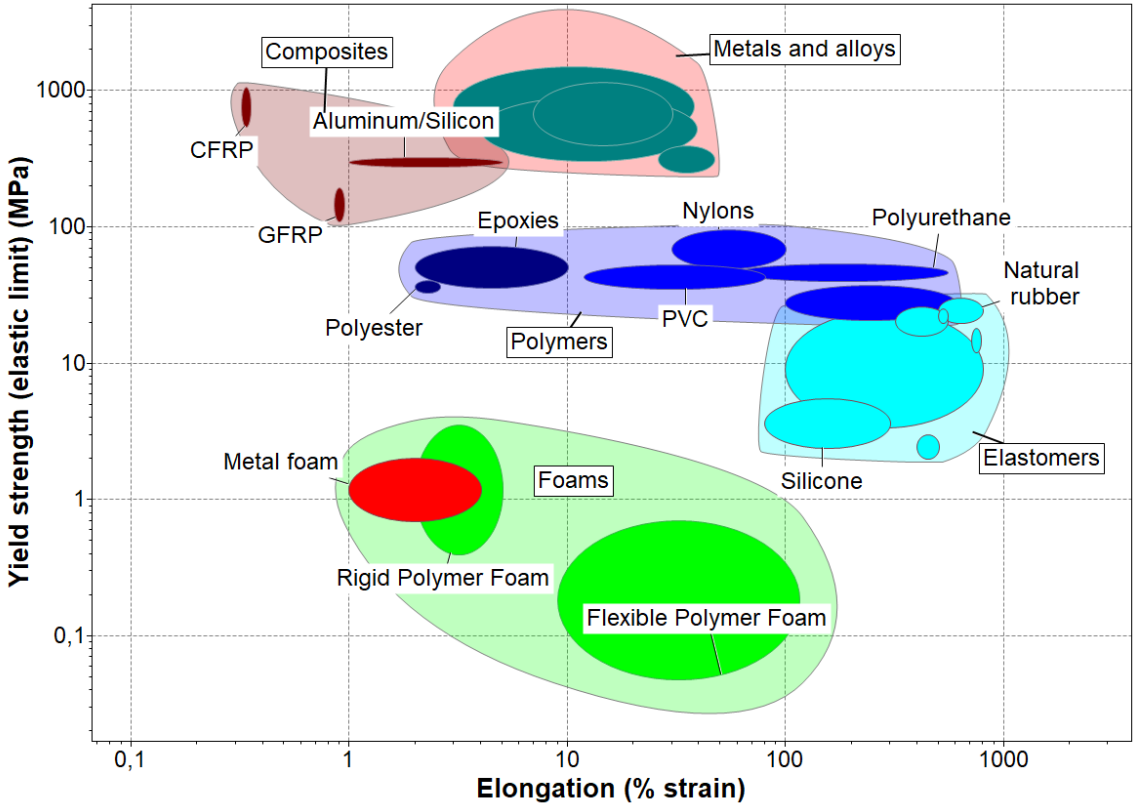
Joins ↓: Less joins keeping degrees of freedom (survivability)

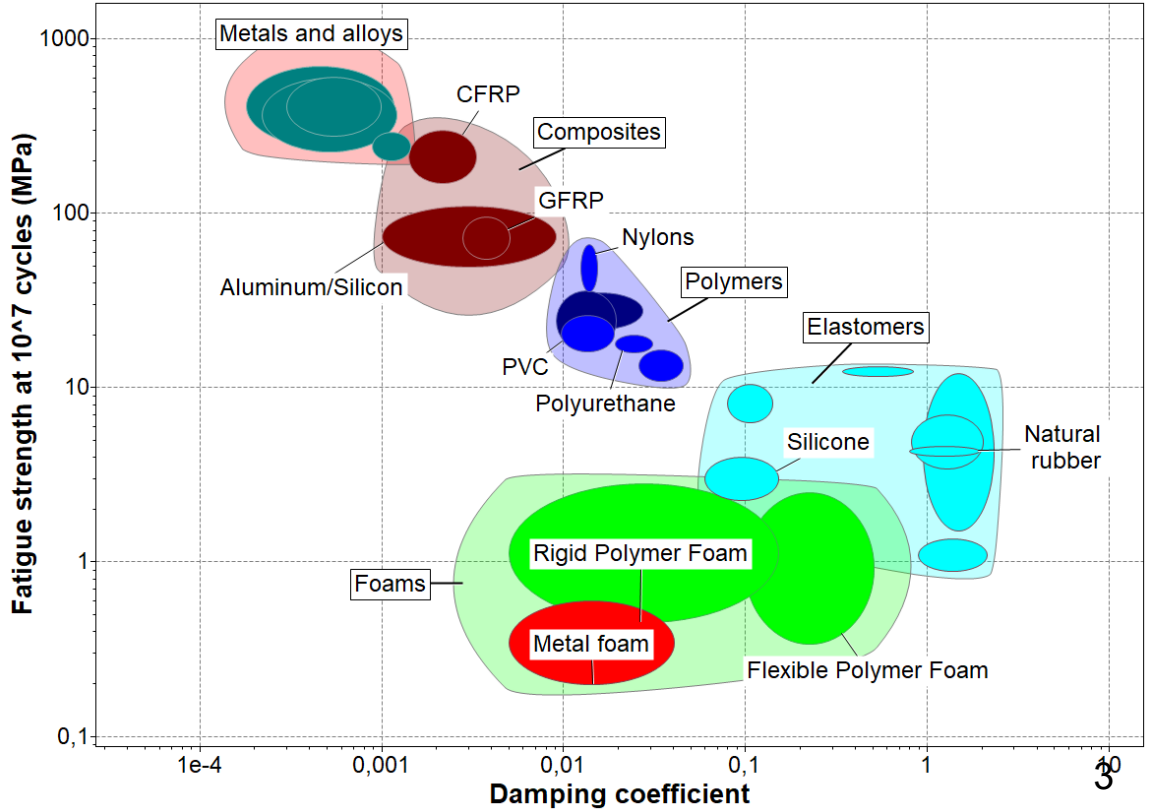
Complex shapes ↑: Polymers and Elastomers can be manufacturing in different shapes

Buoyancy ↑: Foam sandwich composites can be interpreted in the structure

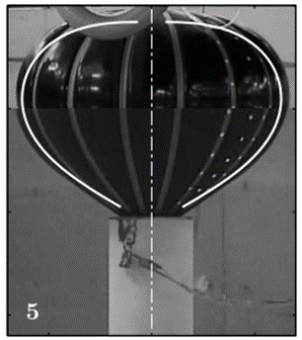
Flexible Materials in WECs

Marine environments are challenging and dynamic contexts for buildings. Structures should support hurricanes and high-energy storms with continual wetting and drying environment with salt-saturated water and intense solar radiation. Elastomers have different benefits including **high elongation**, **damping coefficient** and **fatigue life** which contribute to survivability. However, elastomers suffer from **reduced fatigue and tensile strength and low stiffness**. In BASM-WEC, selected materials will be fully characterised under dynamic and quasi-static loads considering environmental conditions.

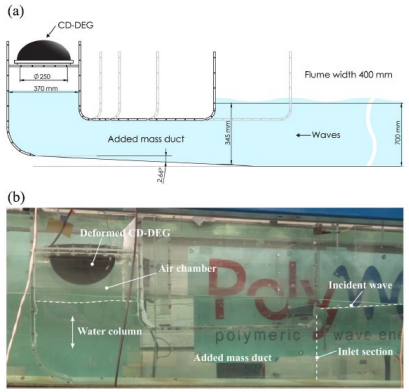




Membrane



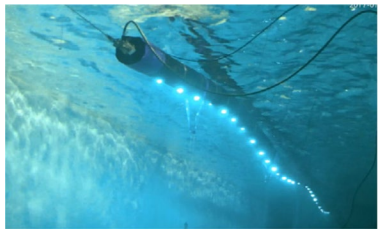
Air bag (A. Kurniawan et al., 2016)



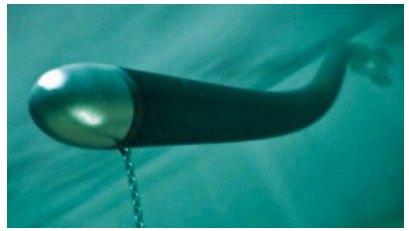
PolyWEC (G. Moretti et al. 2018)

- ✓ Wide data available including numerical and analytical models and experimental results
- ✓ Less complex shape and phenomena involved
- ✓ Easy manufacture

Tube



SBM S3 WEC (Collins et al., 2021)



Anaconda (Collins et al., 2021)

- ✓ Modular configuration, easy to upscaling
- ✓ SBM Offshore S3 is using this configuration (our project partner)
- ✓ Higher absorbed power
- ✓ Easy manufacture, load out and installation
- ✓ Highly redundant both mechanically and electrically
- ✓ Distributed redundant PTO provides a step change improvement in the energy production potential

- ✓ Increasing the size of the device could produce other behaviours like buckling
- ✓ It is necessary to limit the strain to avoid reaching failure of the material
- ✓ Less absorbed power
- ✓ It is more difficult to upscaling (modular way)

- ✓ Less data available numerical, analytical and experimental results (more opportunities)
- ✓ More complex phenomena involved
- ✓ Larger loading may lead to more serious fatigue loading
- ✓ Power generation efficiency is affected by the wave direction

The most appropriate case for flexible WEC study ….

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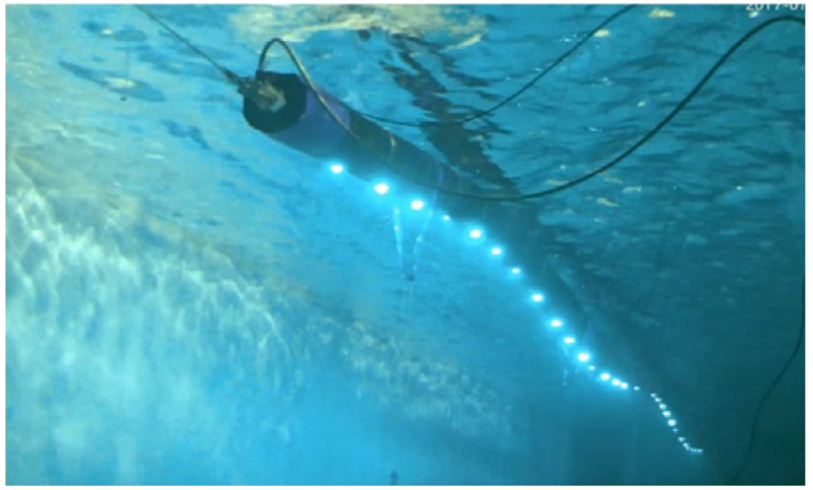
❑ Flexible tube WEC (SBM S3)

- ✓ SBM S3: merging the primary mover and the PTO function into the WEC structure.
- ✓ The flexible materials that make up the WEC hull have complex structural features, making the development of new materials of great significance.
- ✓ Most FSI problems experienced by flexible WECs can be found in SBM S3, i.e., two-phase flow, 6DoF motions, inner and outer flows, mooring dynamics, etc.



SBM S3 WEC (Collins et al., 2021)

❑ Fluid-structure interaction

- ✓ Inner and outer flows
- ✓ Two-phase flow
- ✓ Irregular wave conditions
- ✓ 6DoF motion
- ✓ Mooring system

Fluid part ⟺ **Structure part**

- ✓ Composite material
- ✓ Material flexibility
- ✓ Stress and strain
- ✓ Structural deformation

Collins I, Hossain M, Dettmer W, et al. Flexible membrane structures for wave energy harvesting: A review of the developments, materials and computational modelling approaches[J]. Renewable and Sustainable Energy Reviews, 2021, 151: 111478.

Next Plan – Material

❑ Material consideration

- ✓ Dynamic and quasi-static loads considering environmental conditions.
- ✓ Hurricanes and high-energy storms with continual wetting and drying environment with salt-saturated water and intense solar radiation.

WORKPLAN·2022												
	1	2	3	4	5	6	7	8	9	10	11	12
Literature·Review							D2					
Op.·Requirements		M1						M4				
Material·Assessment				D1					D3			
MWS·Modelling					M2							M5
MS·Integration							M3					
Material·Modelling										D4		
Standard·Tests												
Saltwater·Tests												D5

Notes:·1.·Material-Wave-Structure·(MWS),·2.·MS·(Material-Structure).

- ➢ **Milestone 1 (M1):** First Identification of operational conditions and mechanical and environmental requirements
- ➢ **Milestone 2 (M2):** Properties requirements and CFD model verification
- ➢ **Milestone 3 (M3):** First Material and structure performance analysis
- ➢ **Milestone 4 (M4):** Second Identification of operational conditions and mechanical and environmental requirements
- ➢ **Milestone 5 (M5):** CFD model verification

- ➢ **Deliverable 1 (D1):** Comprehensive datasheet for material selection
- ➢ **Deliverable 2 (D2):** Paper of material review in WECs
- ➢ **Deliverable 3 (D3):** Technical report including material assessment based on results and material selection
- ➢ **Deliverable 4 (D4):** First version of material model
- ➢ **Deliverable 5 (D5):** First Material characterisation report

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Thank You !

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