Two concepts of oscillating-water-column wave energy converters: Halona and Malama

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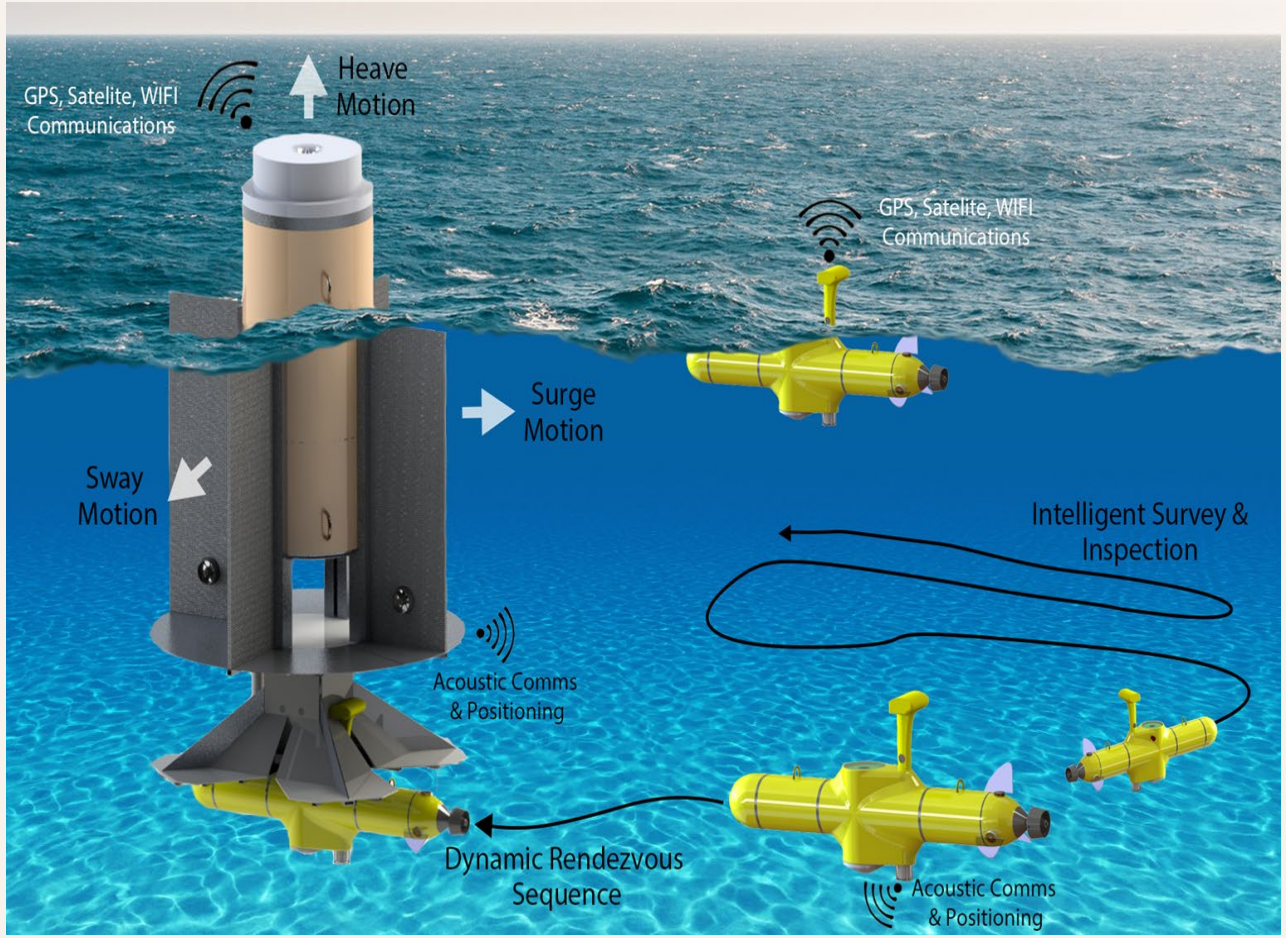
Research was supported by NSF, TEAMER and Naval Facilities Engineering and Expeditionary Warfare Center (NAVFAC EXWC)

Halona: A floating OWC for Underwater Vehicle Docking Station and Aquaculture Applications



Commercialization Effort:

HOPS
Hawaii Ocean Power Solutions

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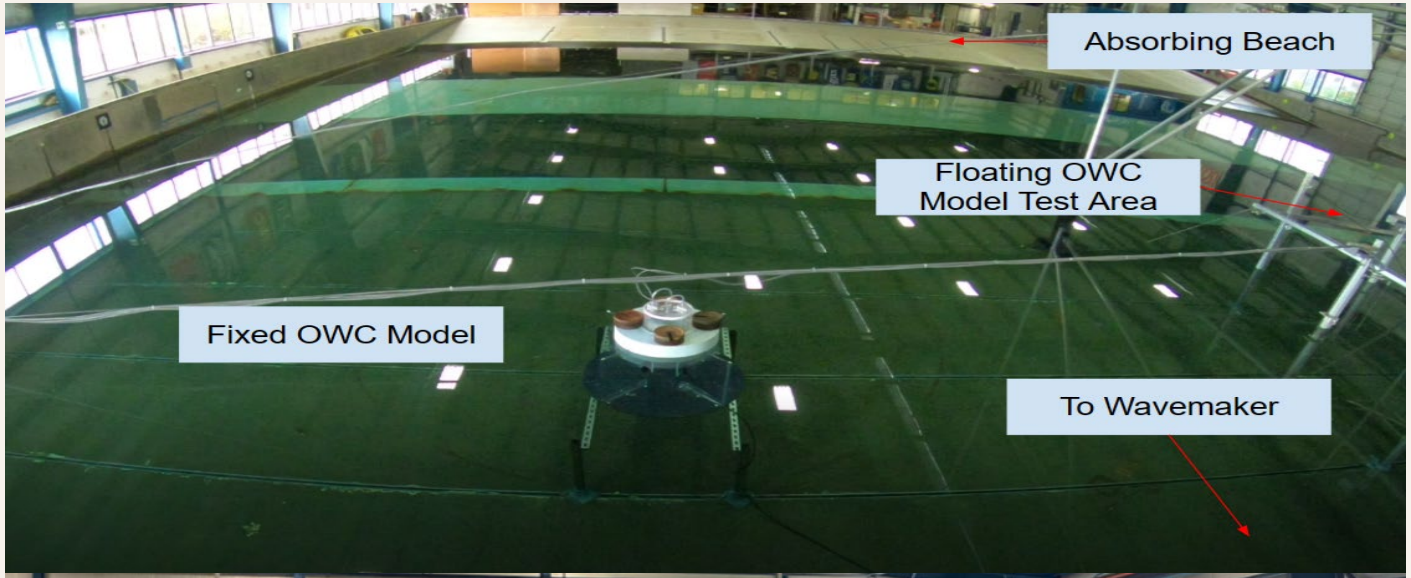
Halona: Wave Basin Testing At Oregon State



Regular Test Conditions

- +/- 0, 15, 25 degree incident waves
- 5 representative PTOs
- H = 5, 6.5, 8, 9.5, 11, 14 cm
- T = 1.25, 1.5, 1.75, 2, 2.25 2.5, 3, 4 s

Irregular Test Conditions

- 0 degree incident waves
- 4 representative PTOs
- Hrms = 7.7 cm
- Tp = 2 s
- Custom Spectrum based on site conditions

Fixed and Floating Models

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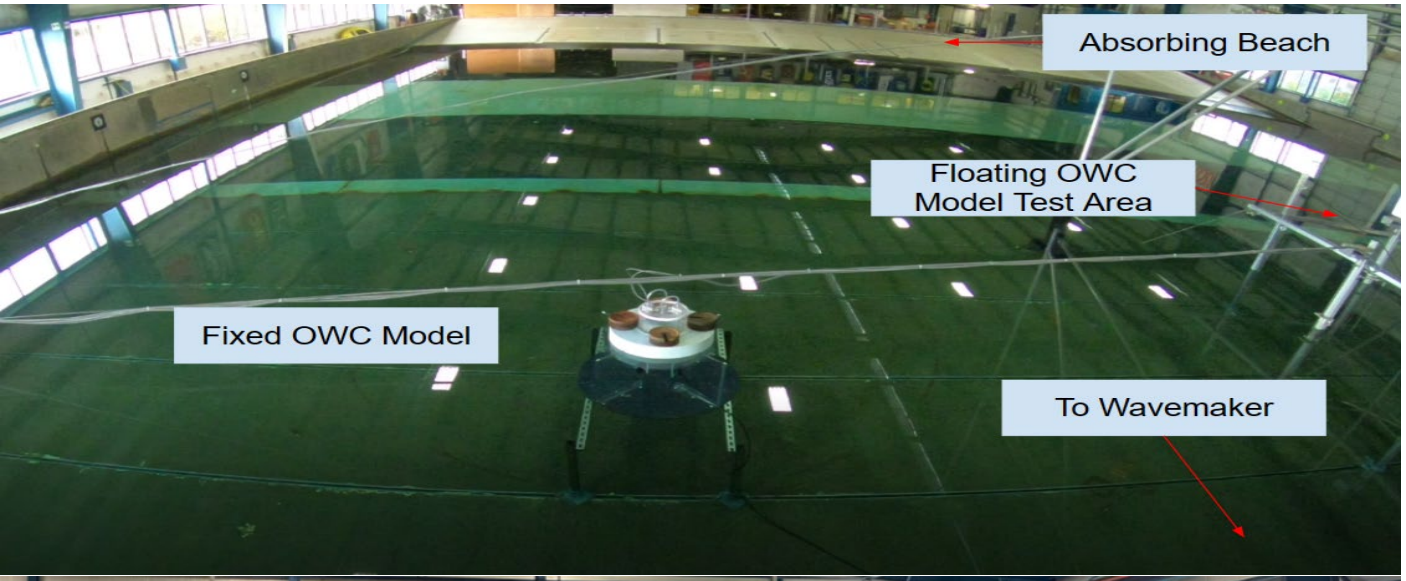
Wave Basin Testing At Oregon State



<u>Regular Test Conditions</u>

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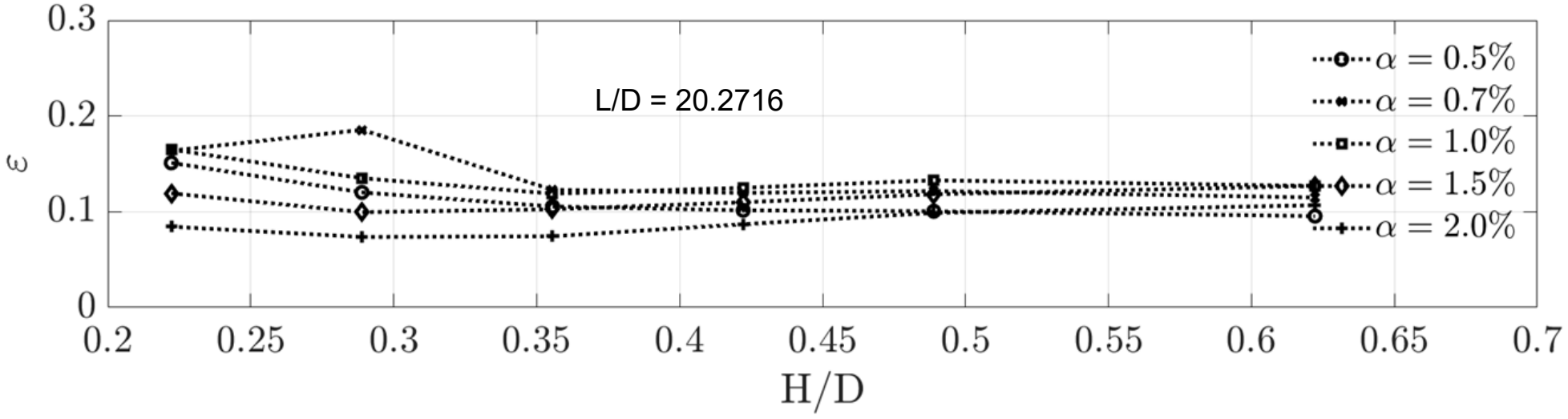
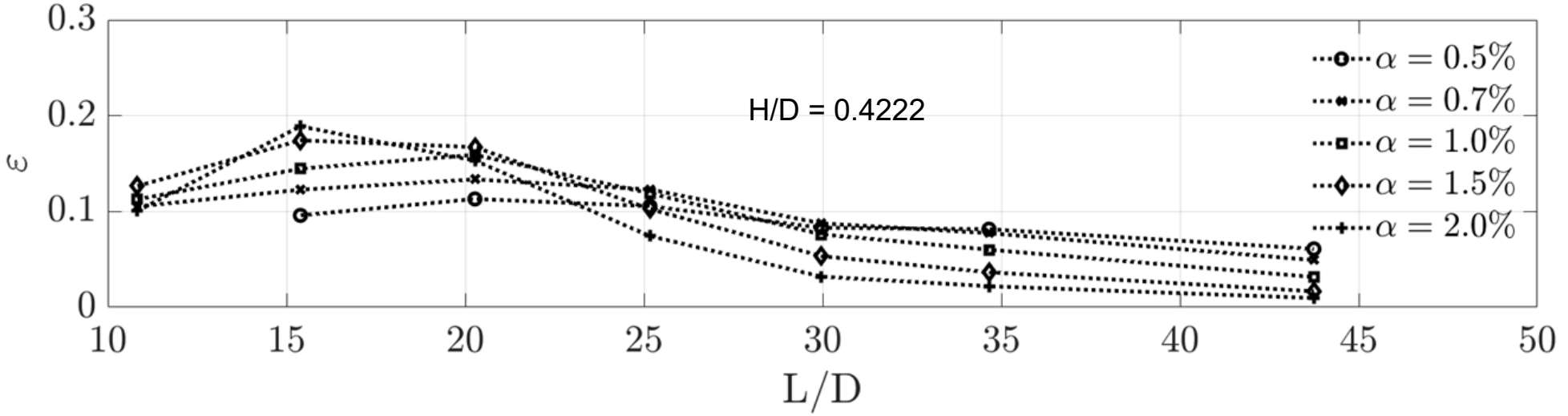
- Tp = 2 s
- Custom Spectrum based on site conditions

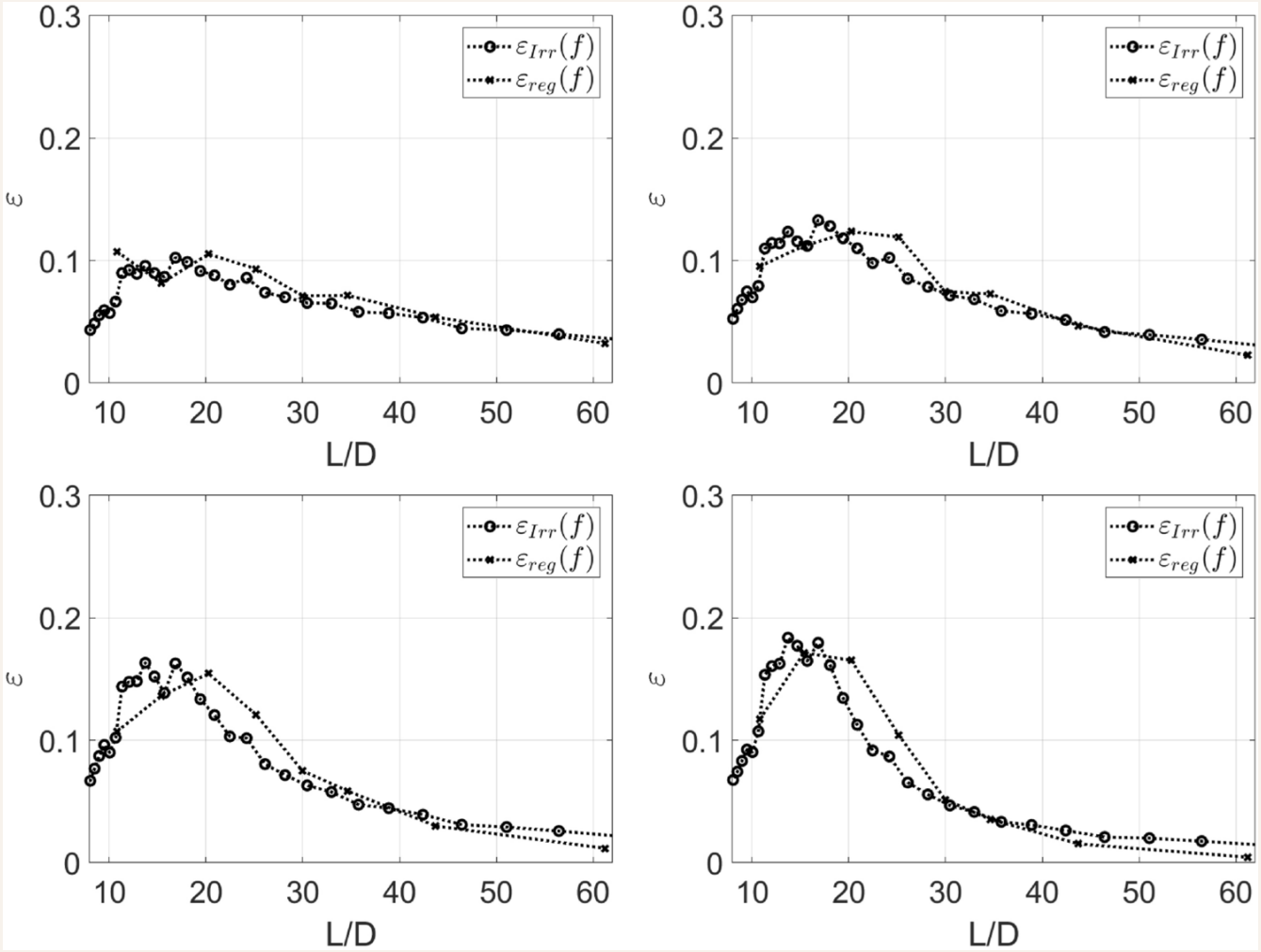
Fixed Halona: Wave Basin Testing At Oregon State-Regular waves





Ulm, N.; Huang, Z.; Cross, P. Experimental Study of a Fixed OWC-TypeWave Energy Converter with a Heave Plate and V-Shaped Channels for Intermediate-Water-Depth Applications. Energies 2023, 16, 5988.

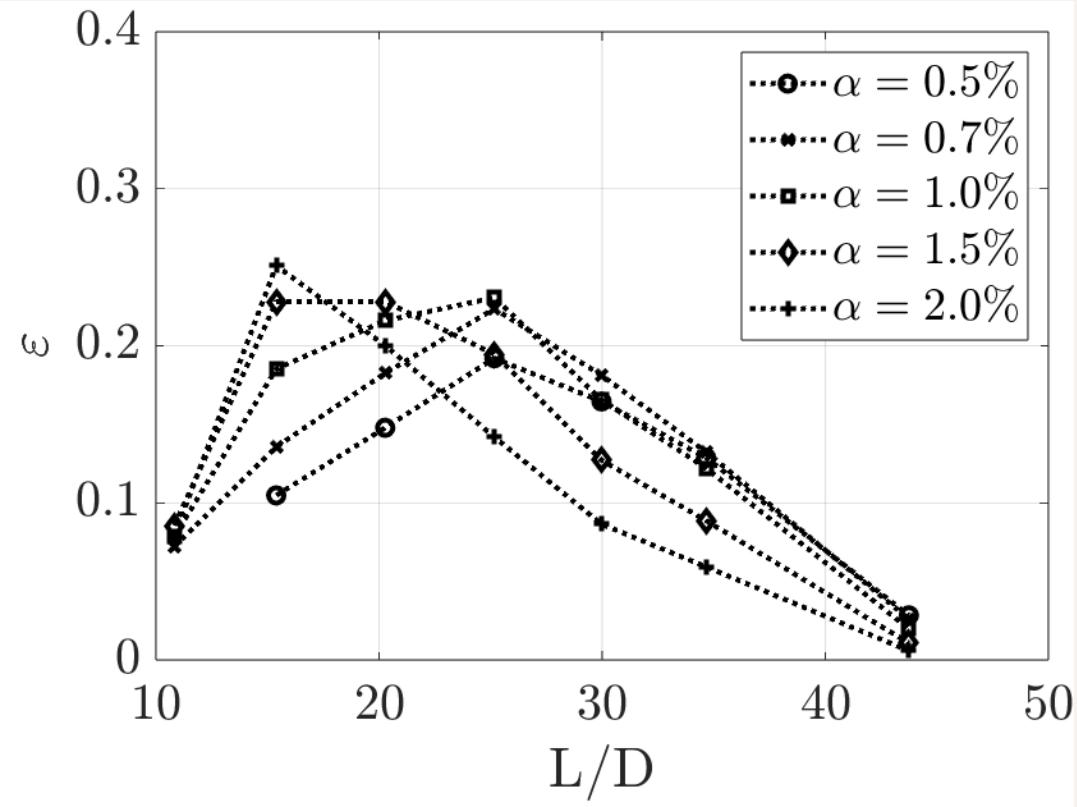
Fixed Halona: Wave Basin Testing At Oregon State-Irregular waves



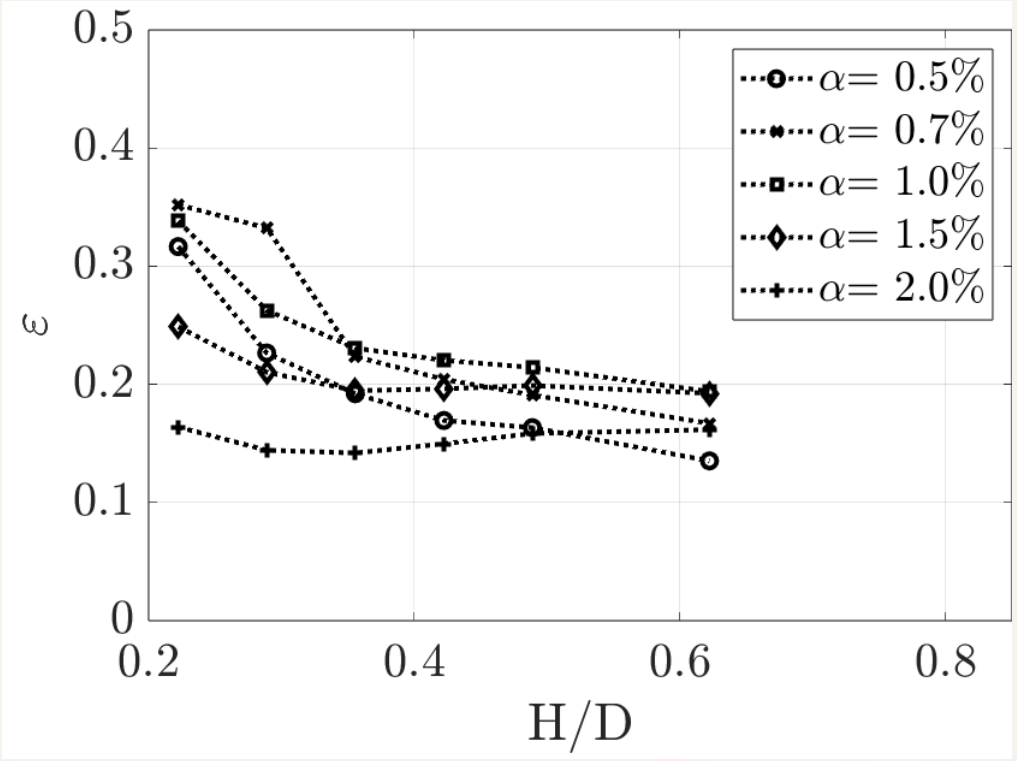
Opening ratio (%) α	$\tilde{\epsilon}_p$	ϵ_p	$[\tilde{\epsilon}_p - \epsilon_p] / \epsilon_p$
0.5	0.0345	0.0383	-0.0992
0.7	0.0362	0.0389	-0.0694
1.0	0.0340	0.0345	-0.0145
1.5	0.0284	0.0285	-0.0035

Ulm, N., Huang, Z. & Cross, P. Experimental study of a fixed OWC-type wave energy converter in irregular wave conditions. *Sci Rep* 15, 9420 (2025)

Floating Halona:Wave Basin Testing At Oregon State-Regular waves

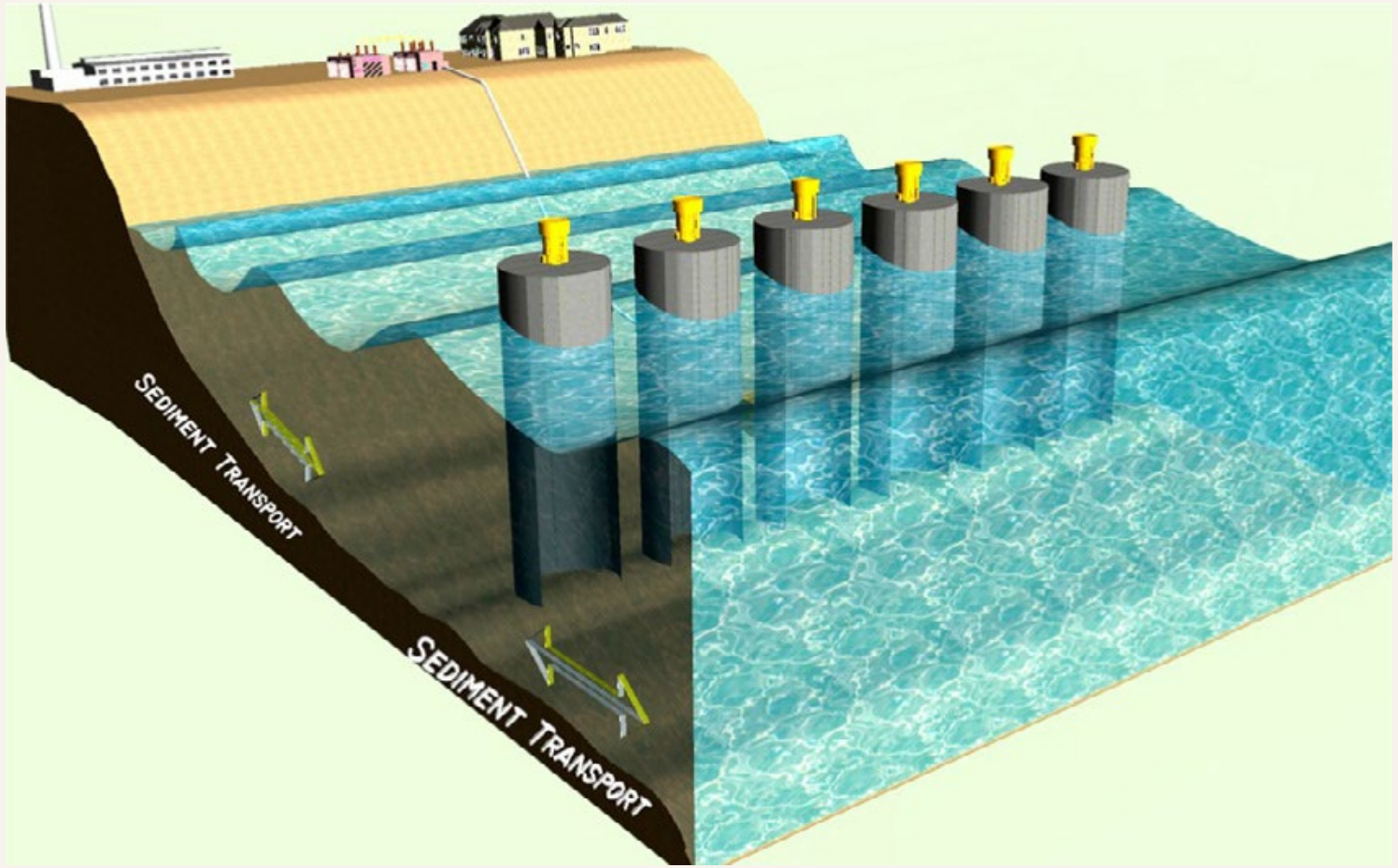


- Weak directional dependency
- Slightly higher efficiency than fixed model



Data analysis is currently underway in preparation for publication

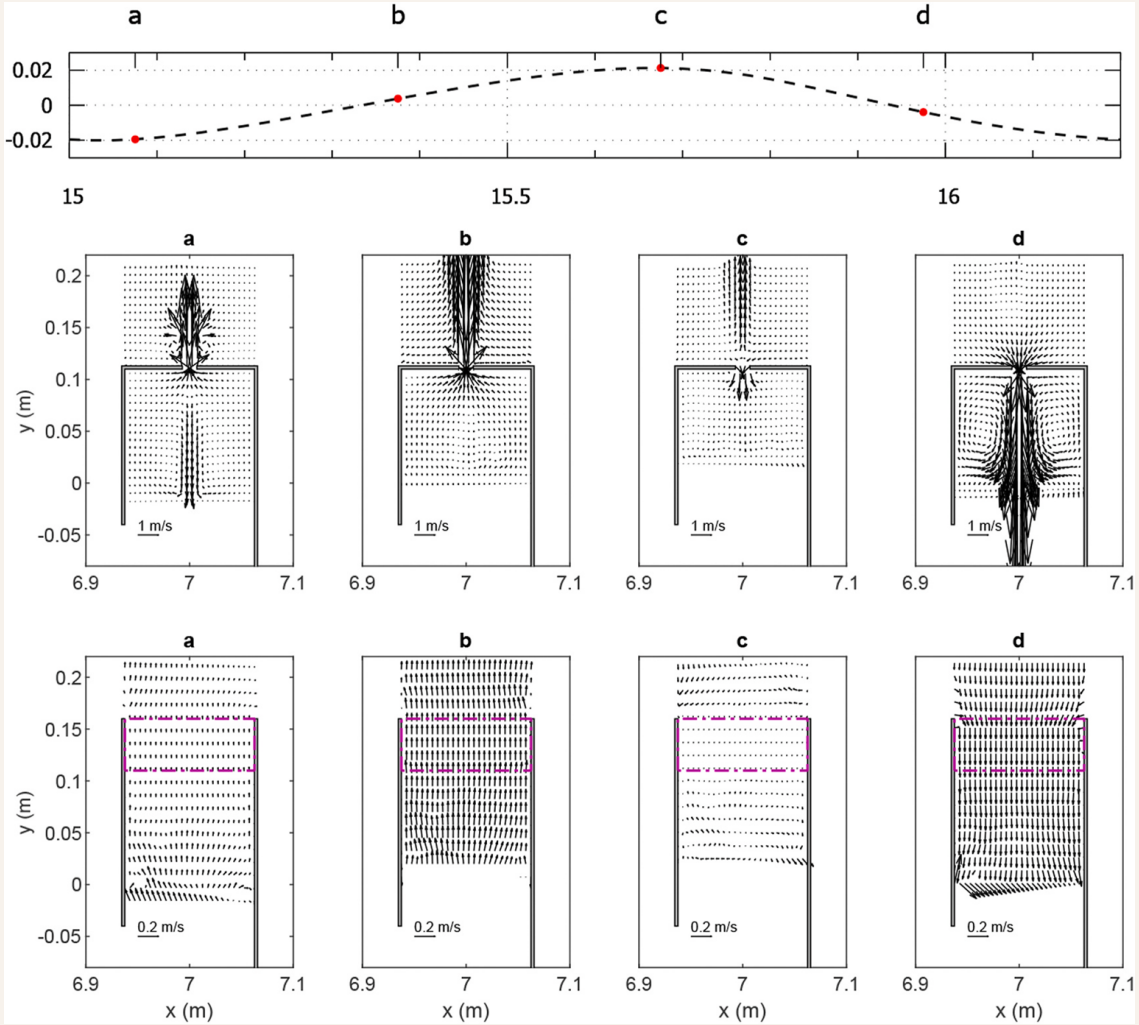
Malama: Basic Concept



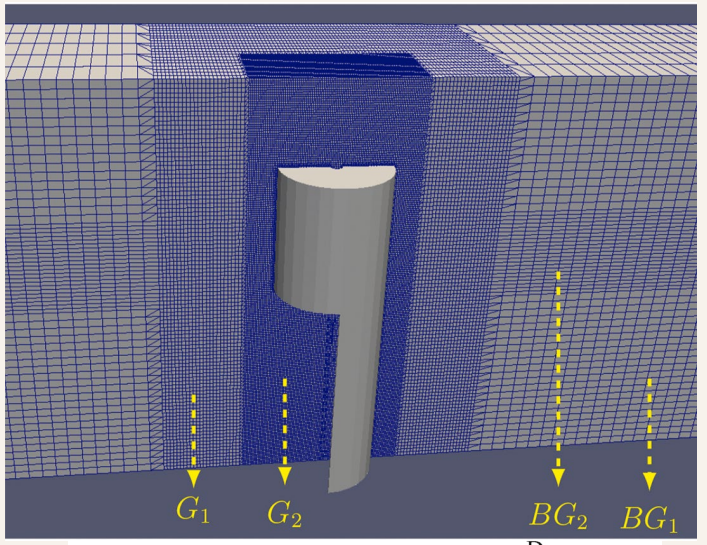
- Integrating OWCs into Slotted or Pile breakwaters
- Cost-sharing to make wave energy utilization economically feasible
- Stabilizing shoreline or reducing waves in a harbor
- Allowing water exchange between shoreside and seaside of the structure
- Supported by NSF

Xu, C., & Huang, Z. (2018). A dual-functional wave-power plant for wave-energy extraction and shore protection: A wave-flume study. *Applied Energy*, *229*, 963-976.

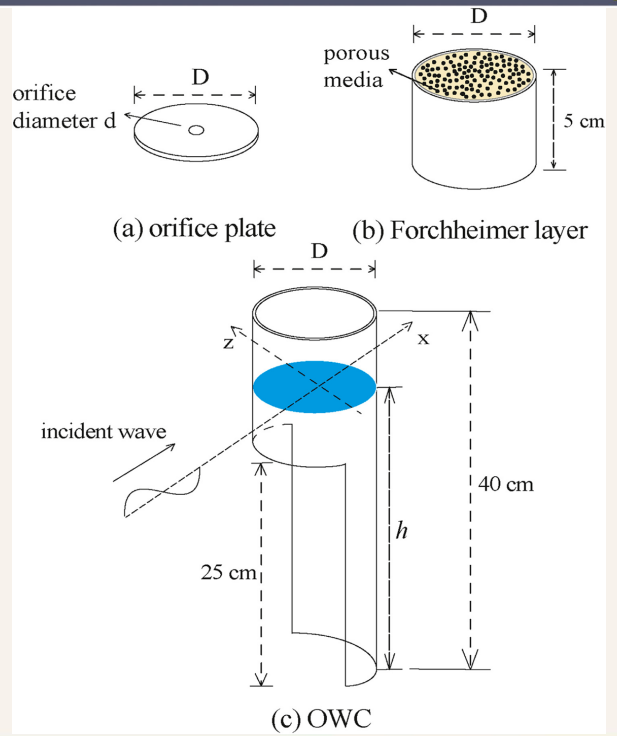
Malama: OpenFOAM Simulations



Orifice: Long simulation time

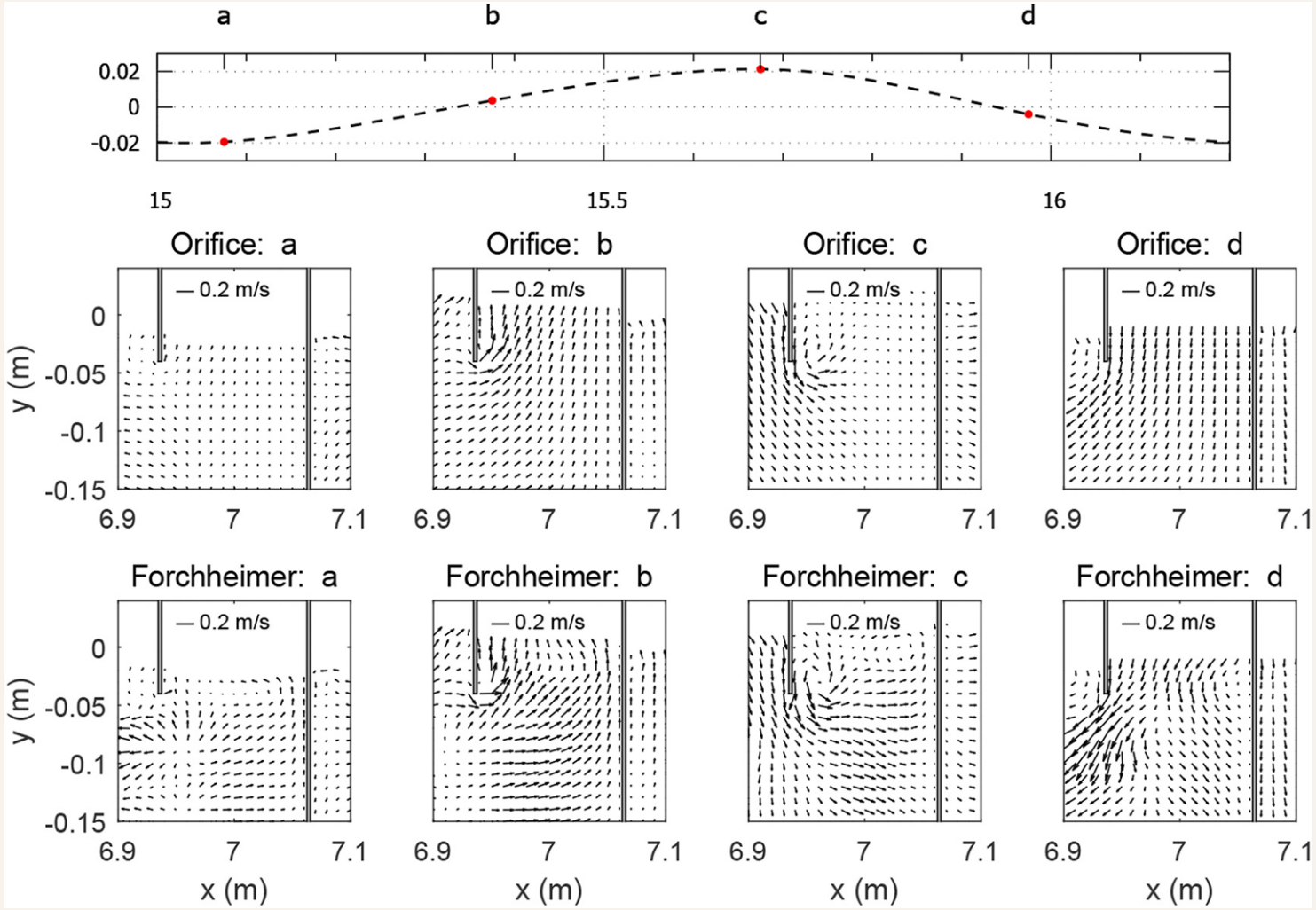


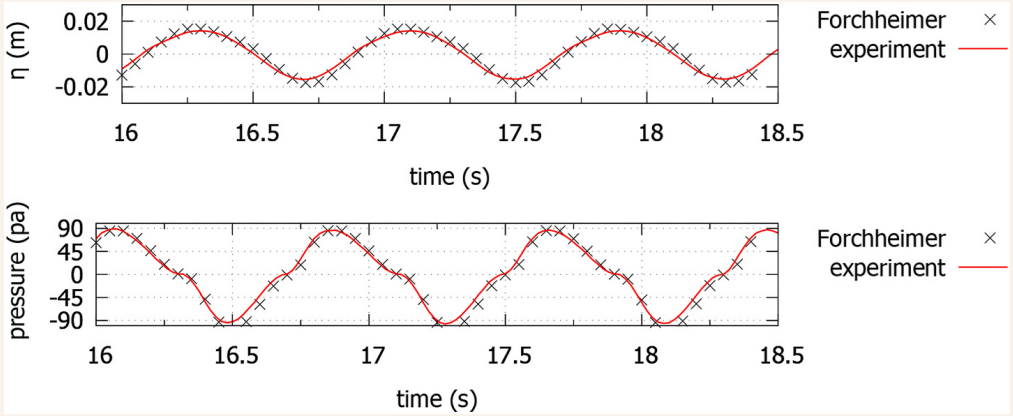
artificial Forchheimer layer approximation: Speed up the simulation by a factor of 20

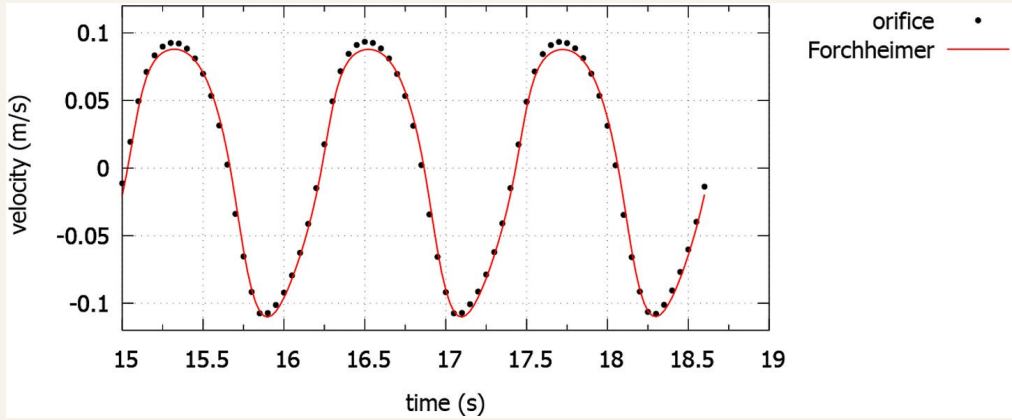


Huang, Z., & Huang, S. (2021). Two-phase flow simulations of fixed 3D oscillating water columns using OpenFOAM: A comparison of two methods for modeling quadratic power takeoff. *Ocean Engineering*, *232*, 108600.

Malama: OpenFOAM Simulations







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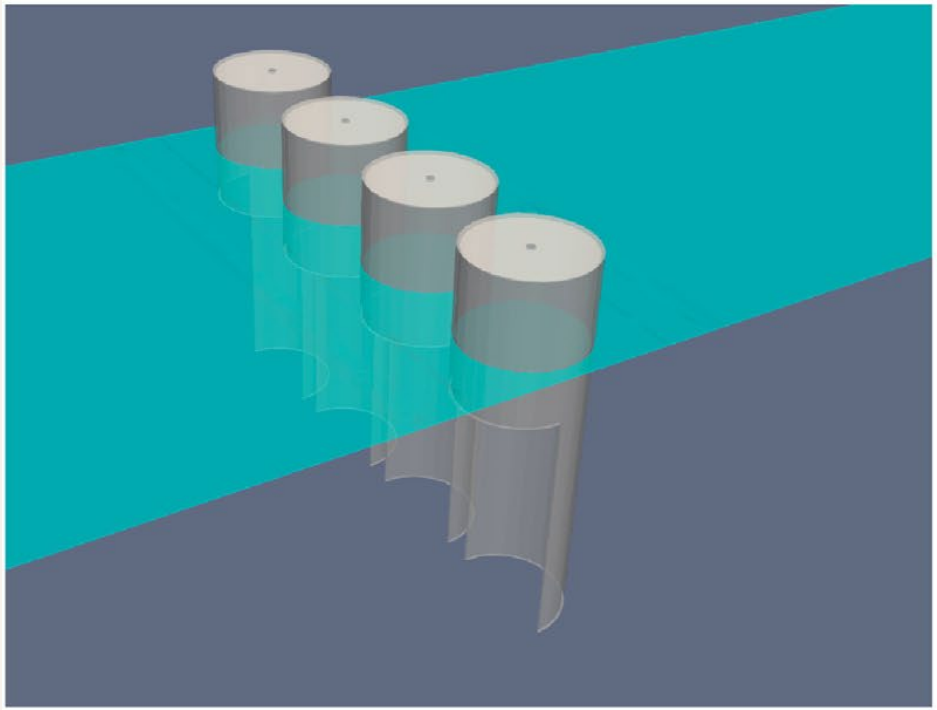
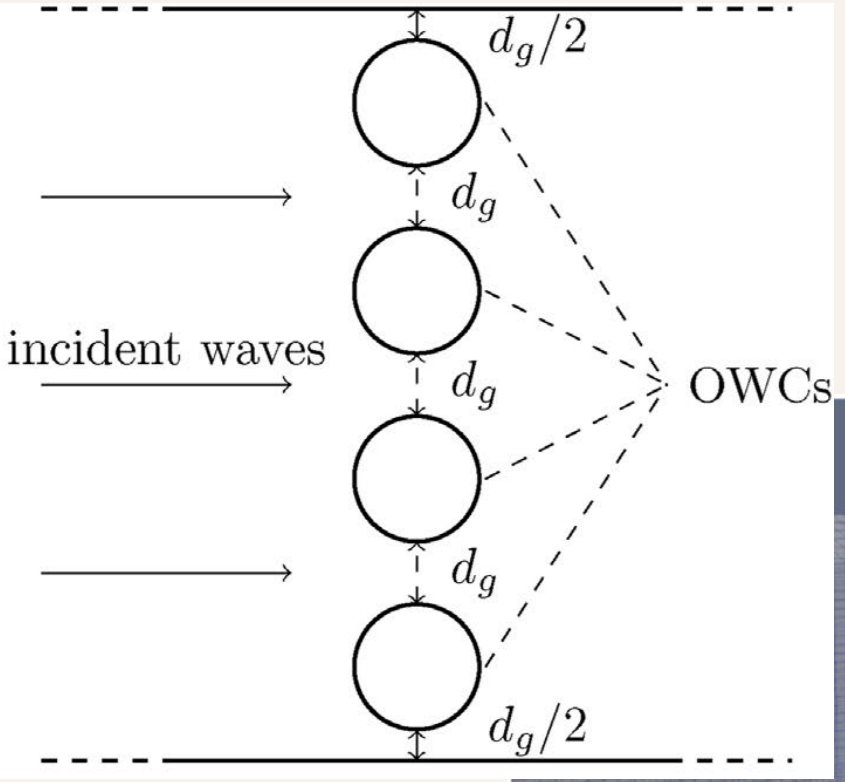
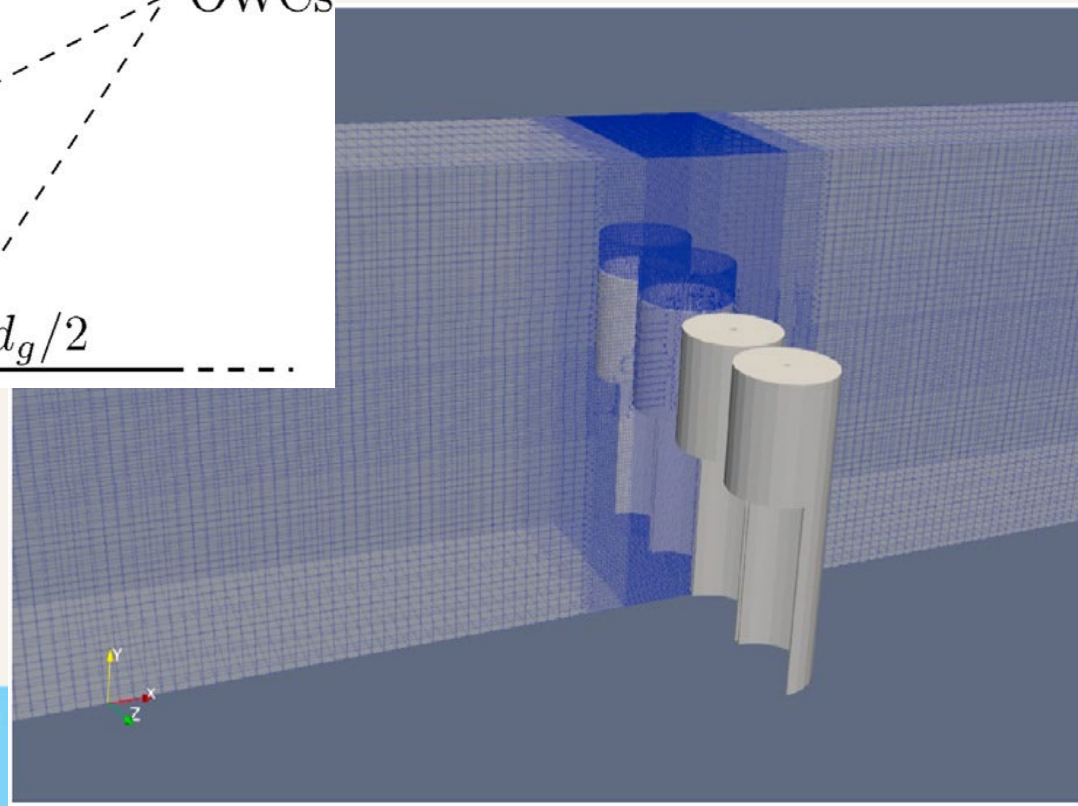
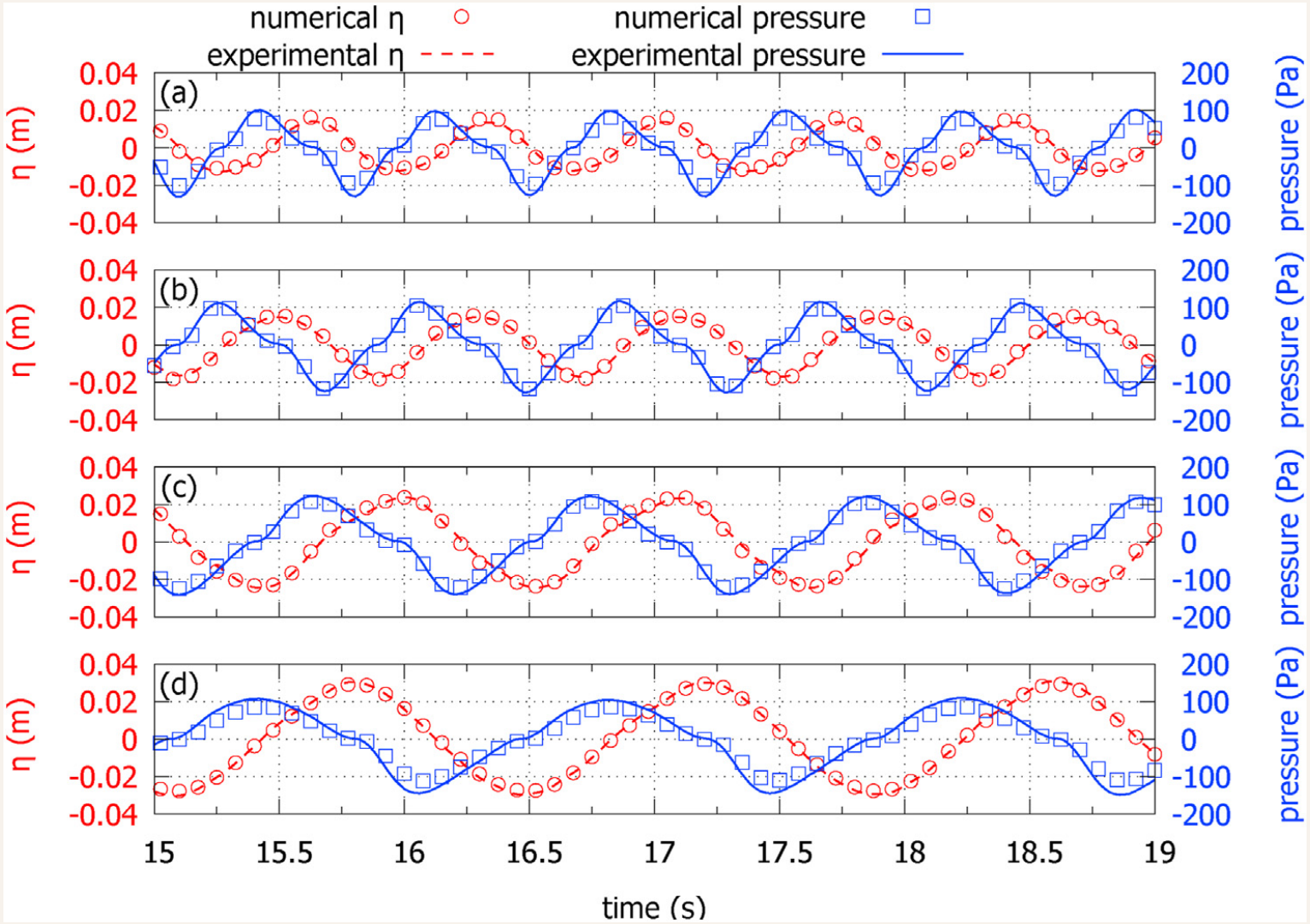






Huang, S., & Huang, Z. (2022). Hydrodynamic performance of a row of closely-spaced bottom-sitting oscillating water columns. *Renewable Energy*, *195*, 344-356.

Malama: OpenFOAM Simulations



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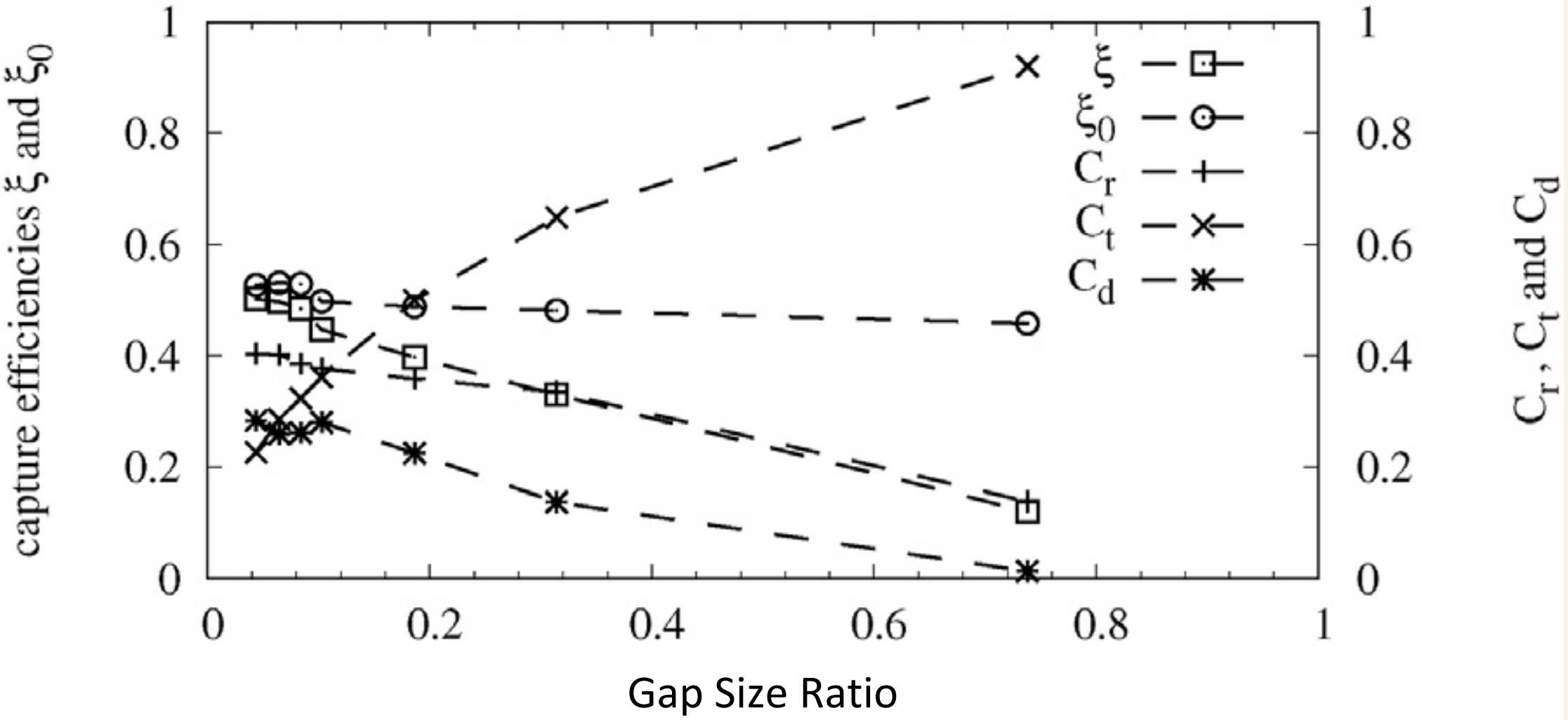
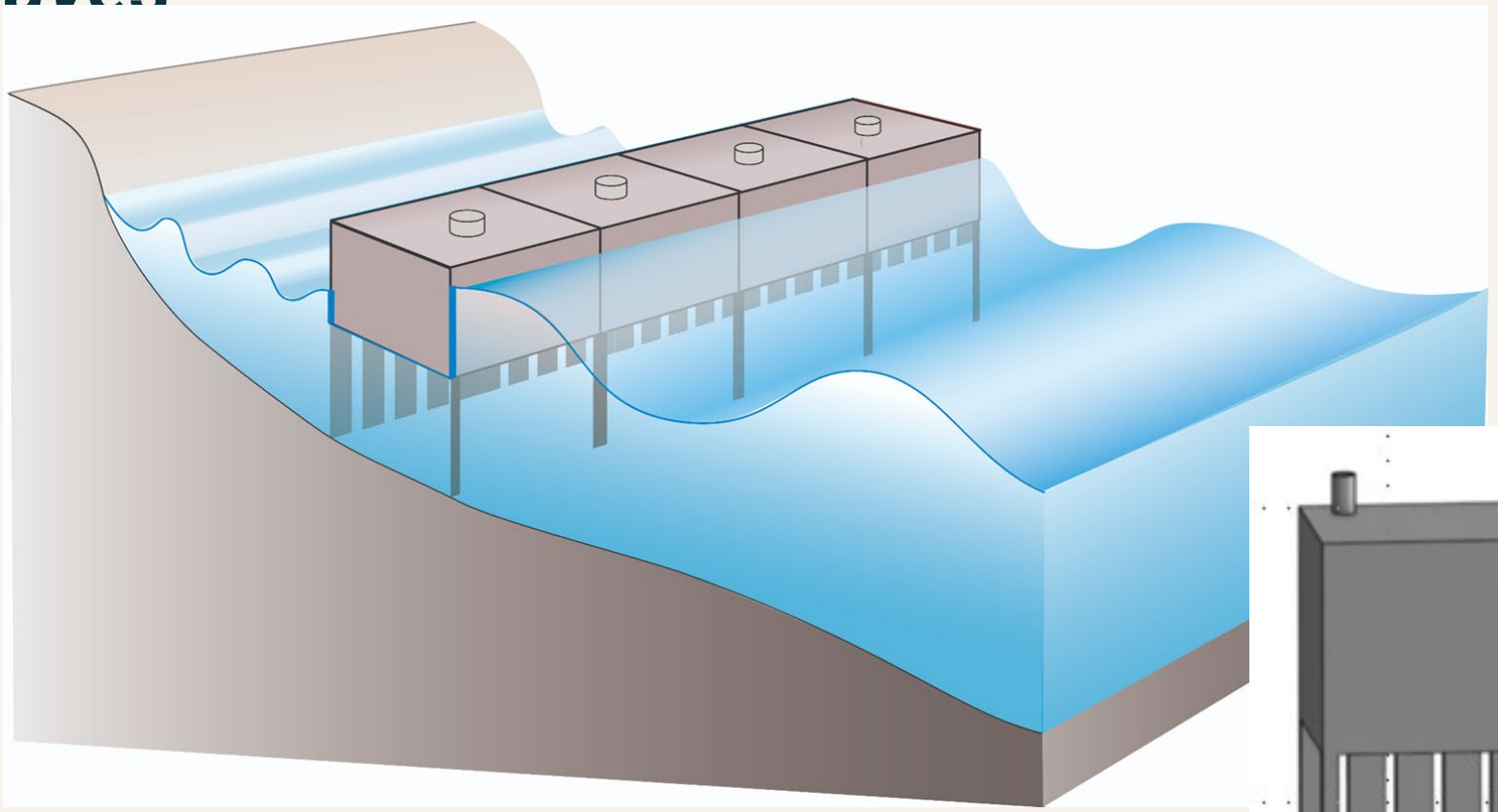
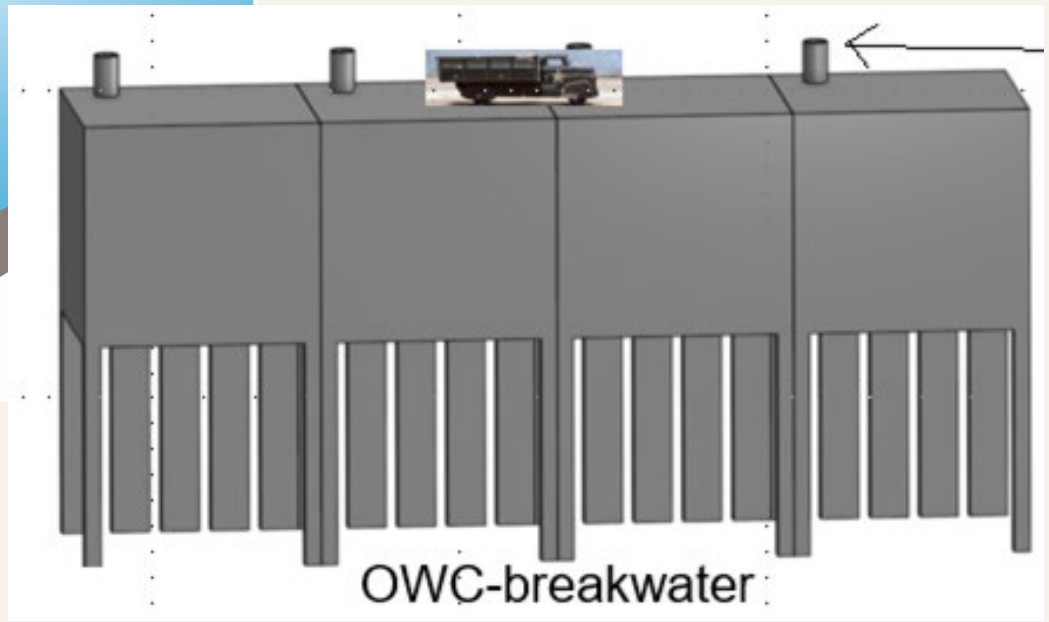


Malama: Wave Basin Testing At Oregon State-Irregular waves





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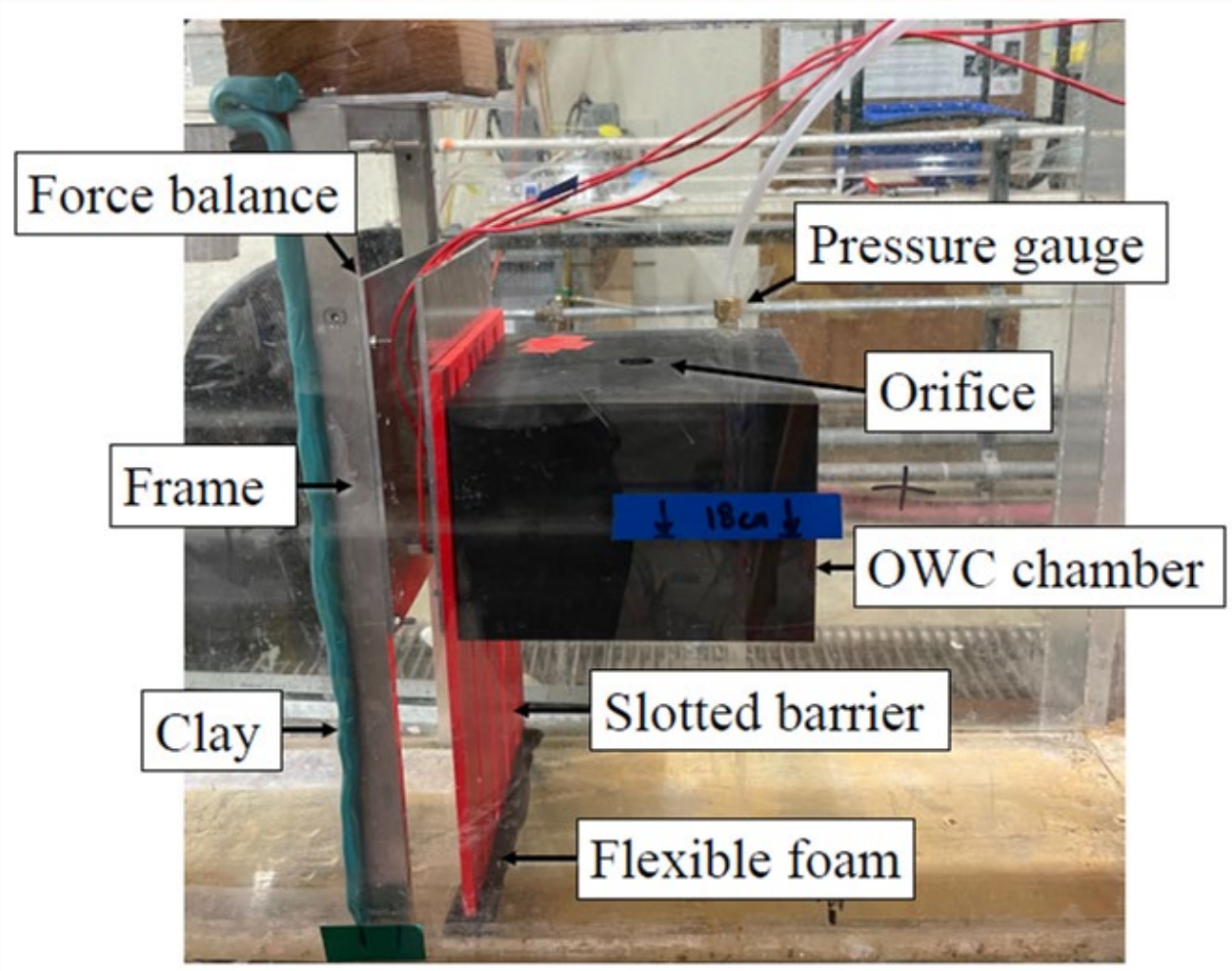
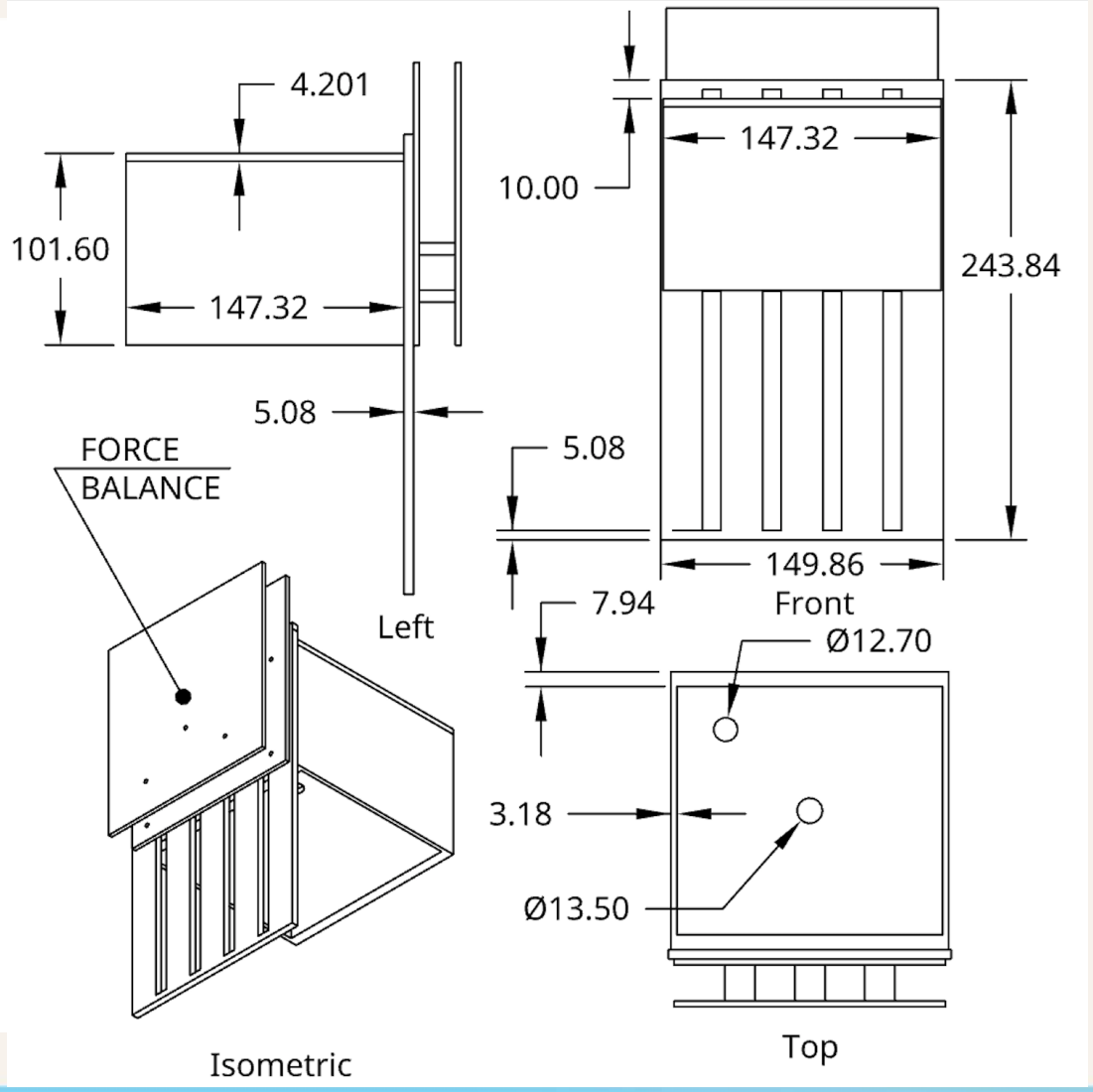
Malama: Wave Flume Testing At UH Manoa





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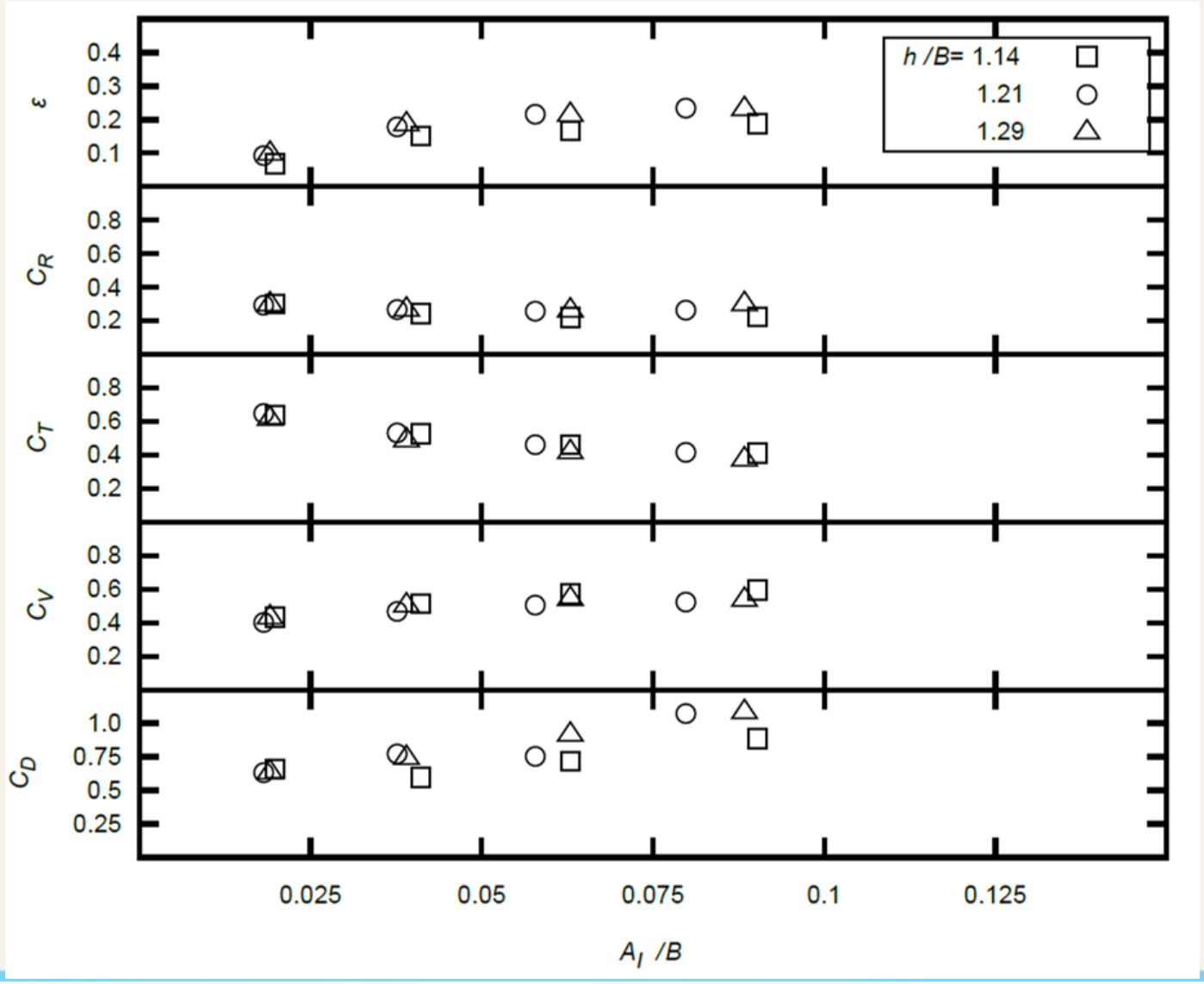

Reyes, C. C., Walker, M., Huang, Z., & Cross, P. (2024). A dual-function design of an oscillating water column integrated with a slotted breakwater: A wave flume study. *Energies*, *17*(15), 3848.

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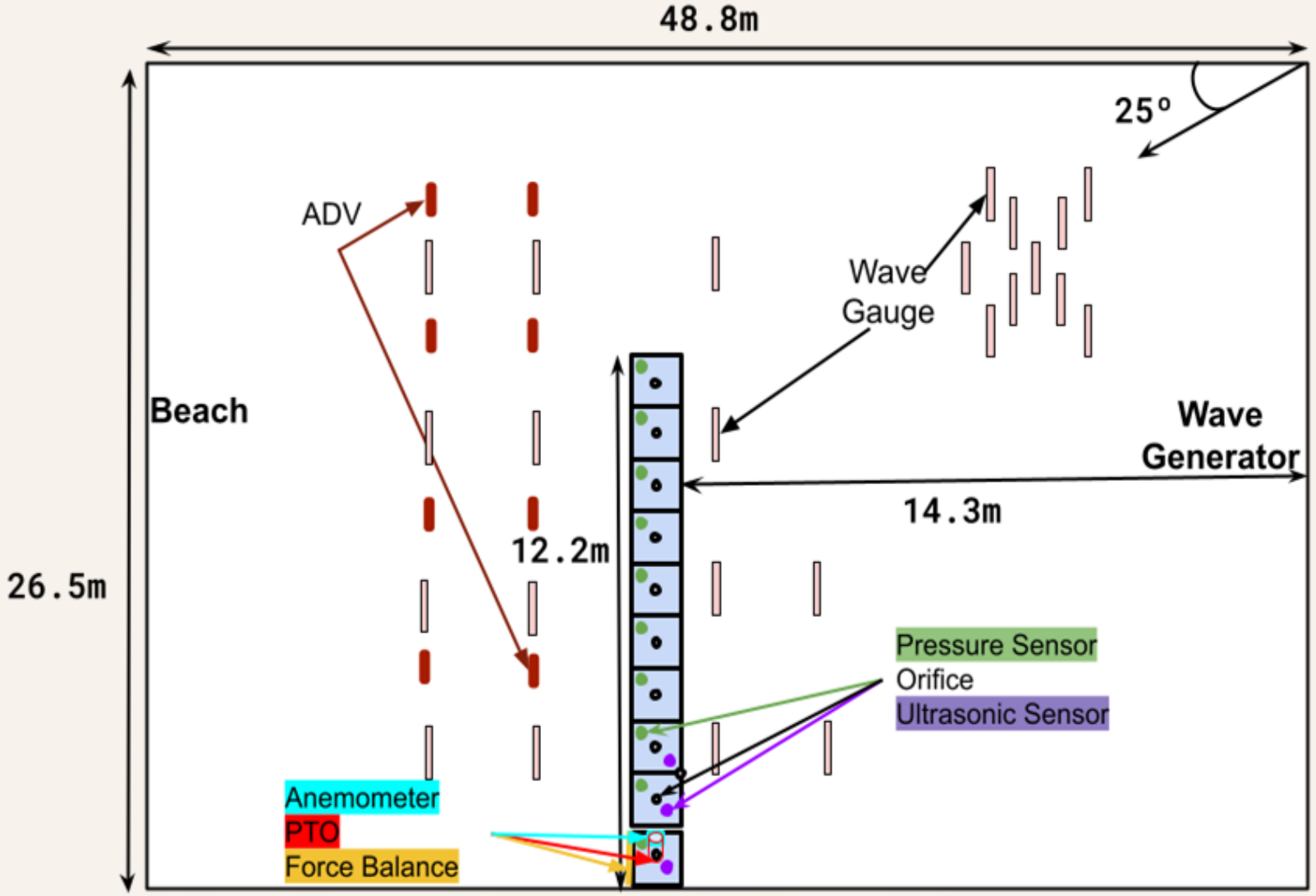

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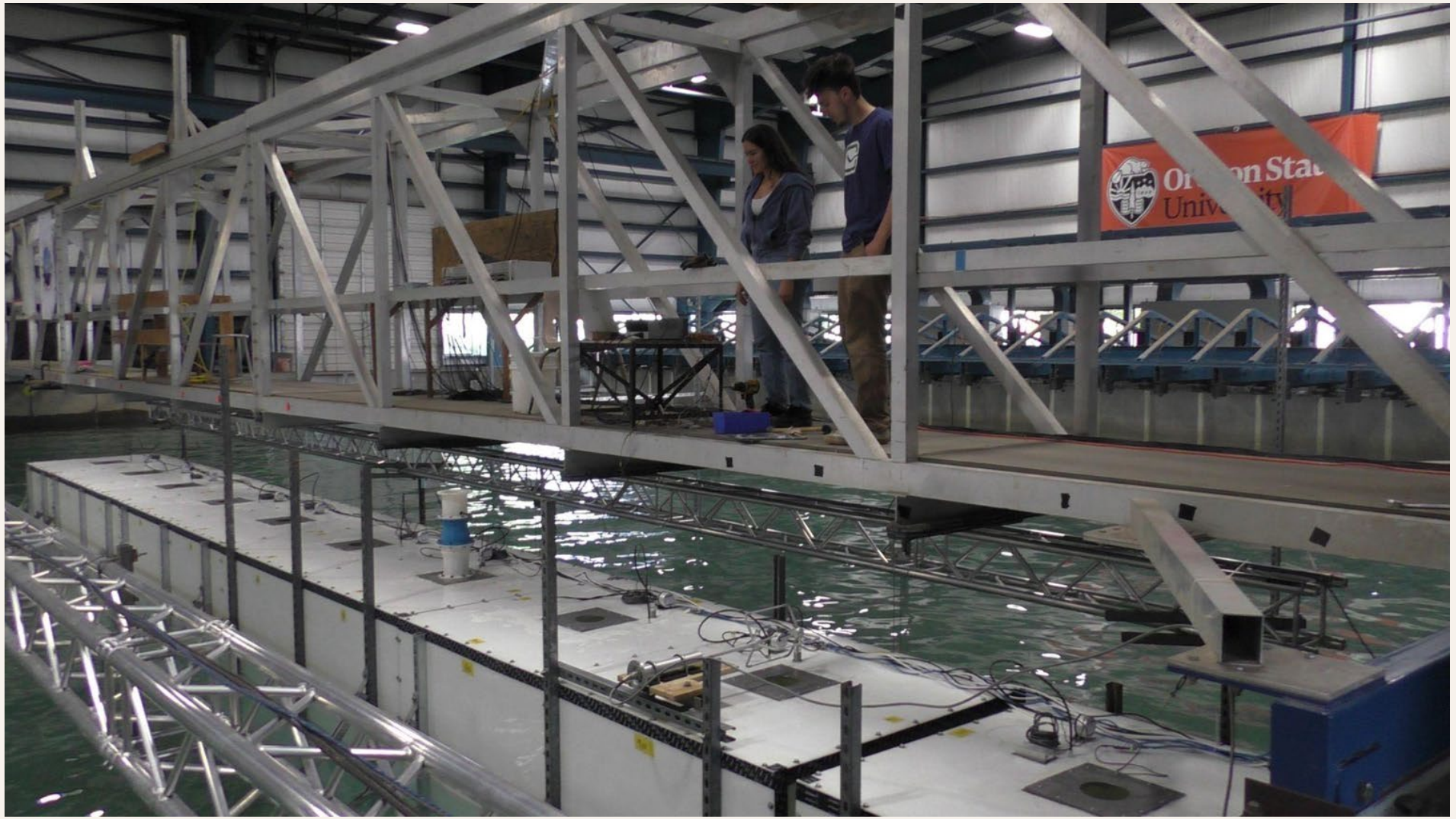

Data analysis is ongoing.

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Q&A