Experimental investigation on an OWC wave energy converter integrated into a floating offshore wind turbine

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Outline

1.1 Background

Energy crisis

Climate change

Pollutions

Renewable energy

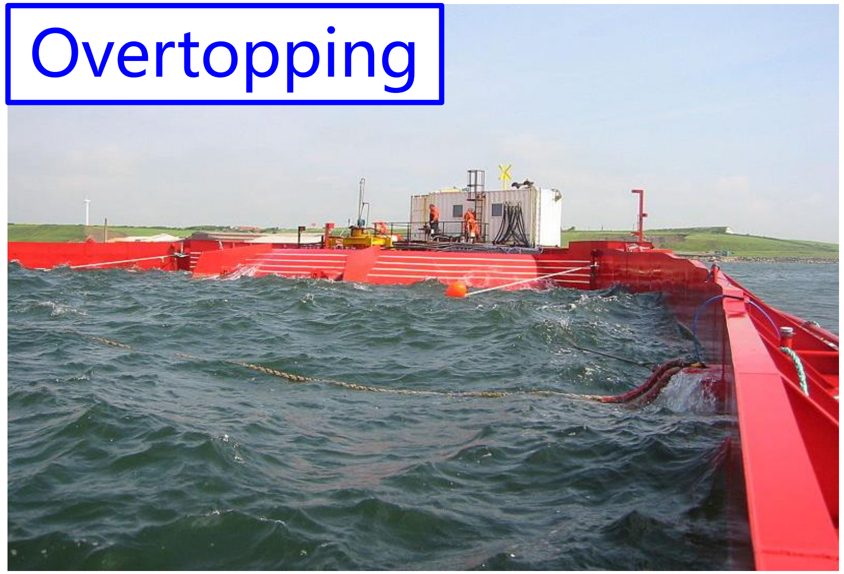
1.2 Development on wave energy devices

DEPARTMENT OF ENGINEERING SCIENCE
UNIVERSITY OF OXFORD

Oscillating Buoy

Pendulum

Overtopping



Oscillating Water Column

1.3 Multi-purpose platform

Offshore wind turbine

Wind+Wave

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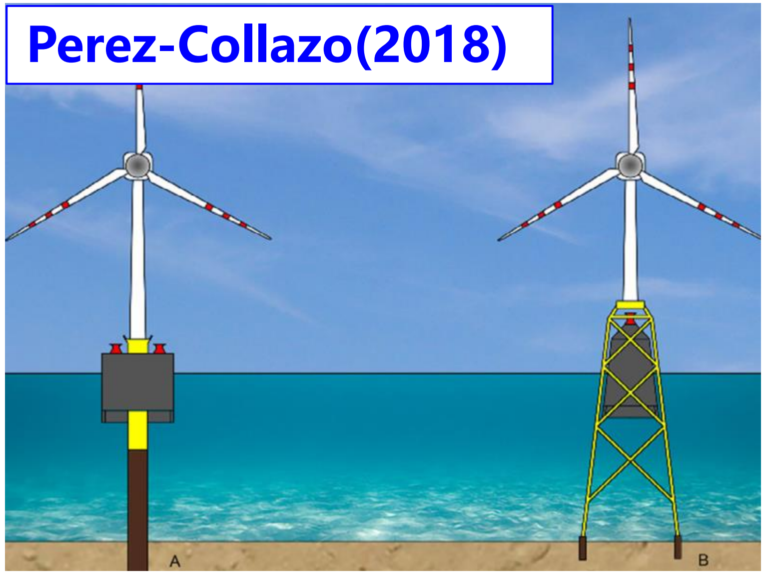
Cost reduction;

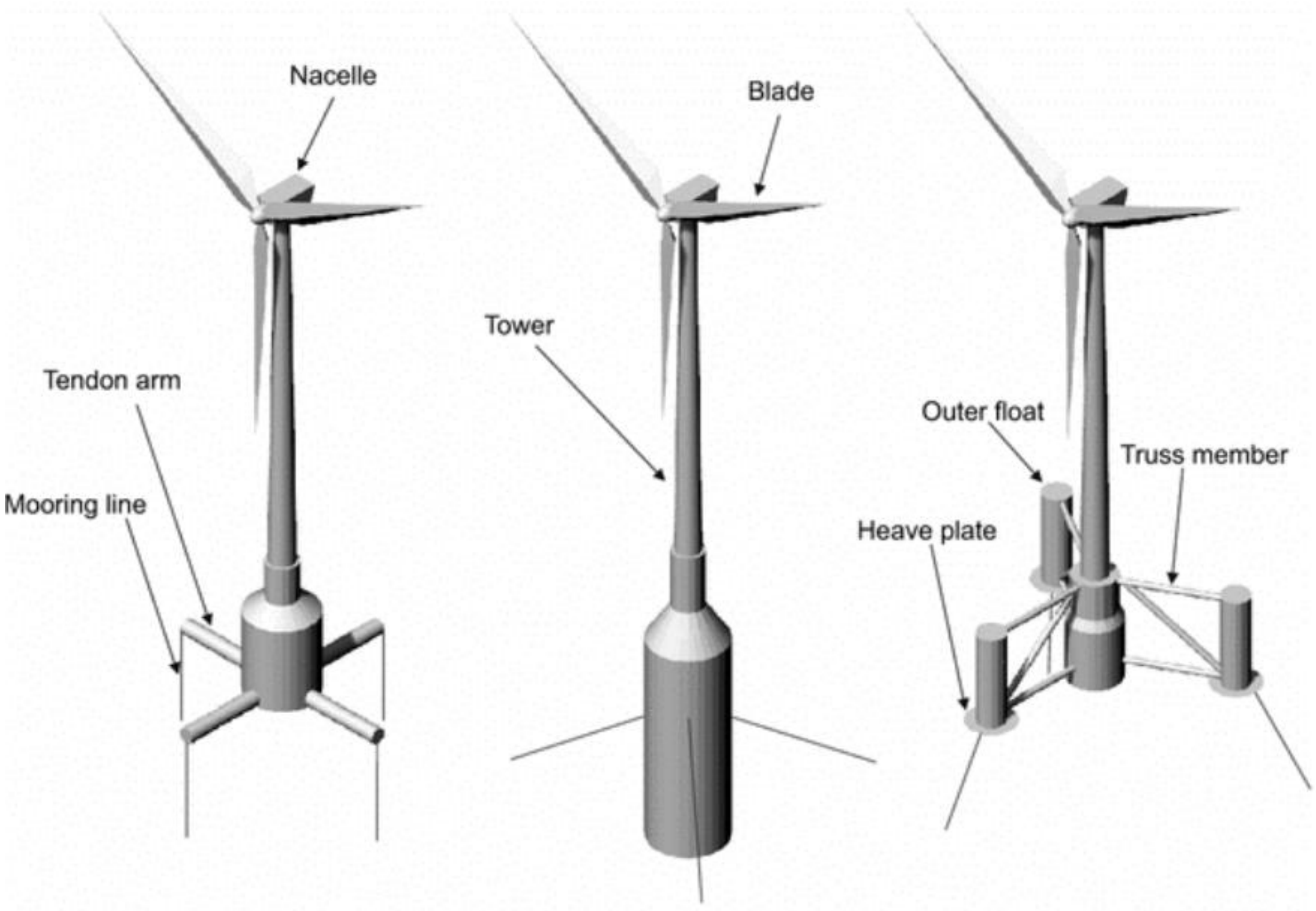
stability increase;



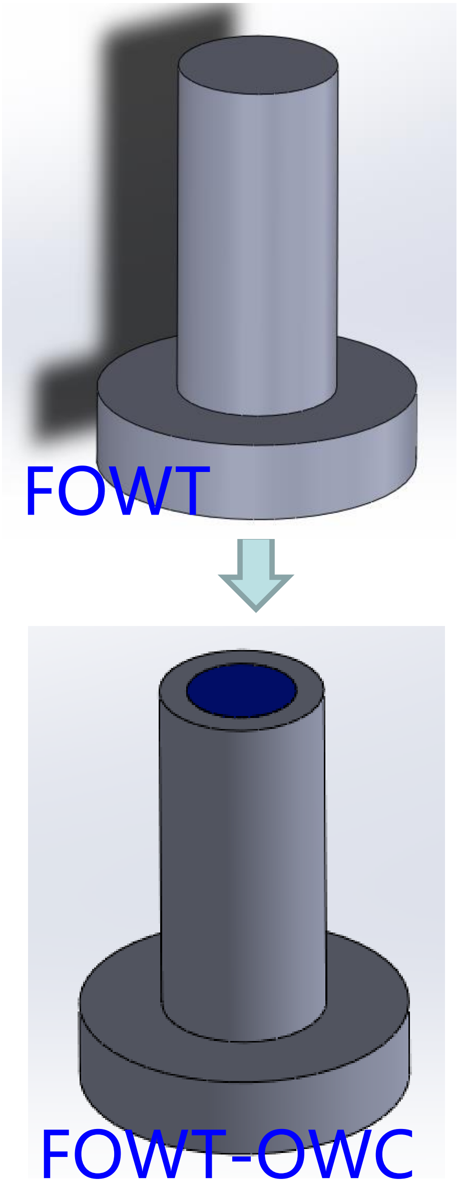
Perez-Collazo(2018)

Sarmiento(2019)

1.4 Present work



TLP Spar Semi



Buoy Volume

Construction Cost

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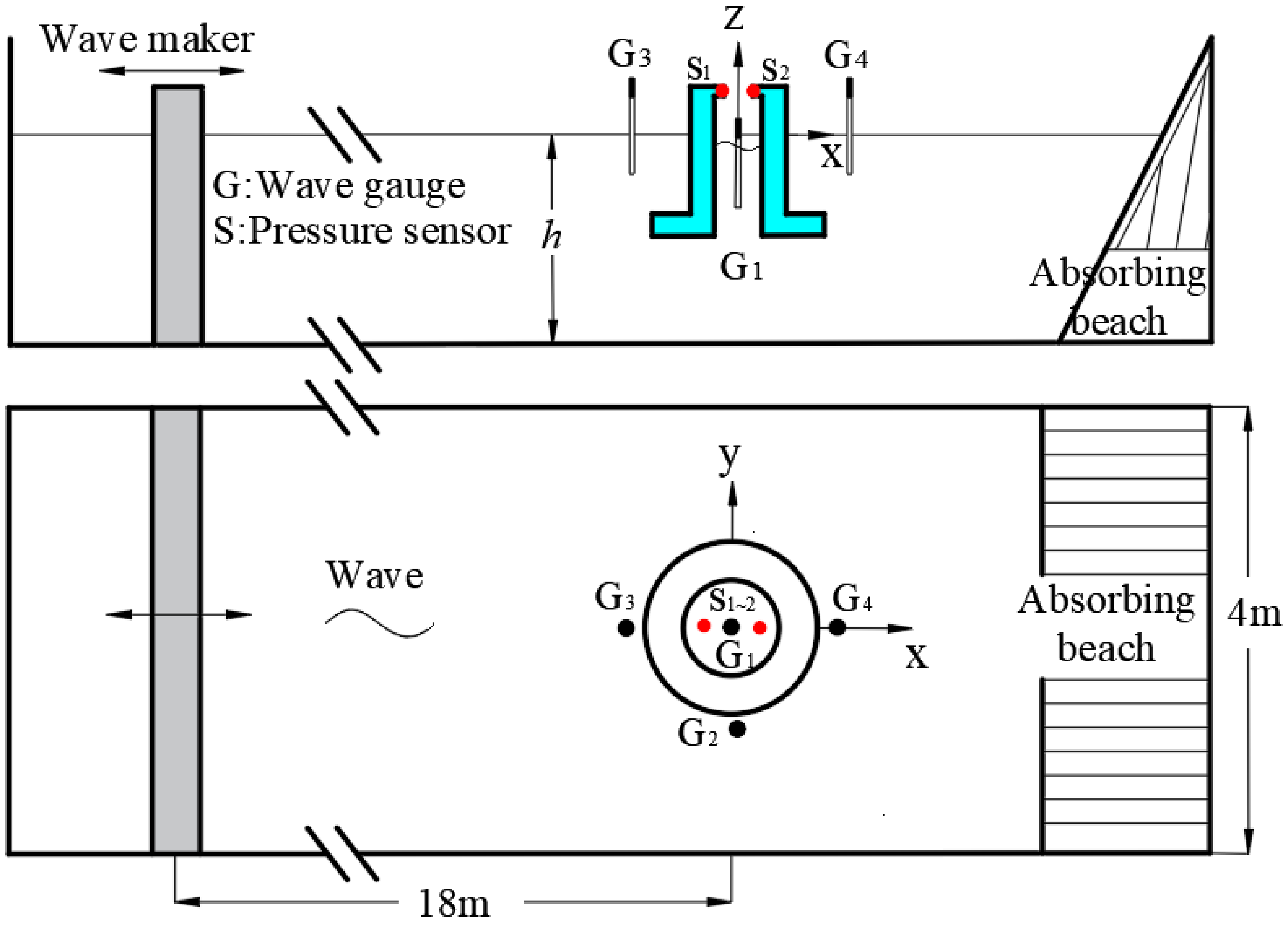
Experiment setup

2.1 Experiment setup



Wave tank with (69m, 4m, 2.5m)
Dalian University of Technology

One wave gauges were situated inside the OWC chamber

Two pressure sensers were installed on the chamber ceiling

2.2 Experimental models

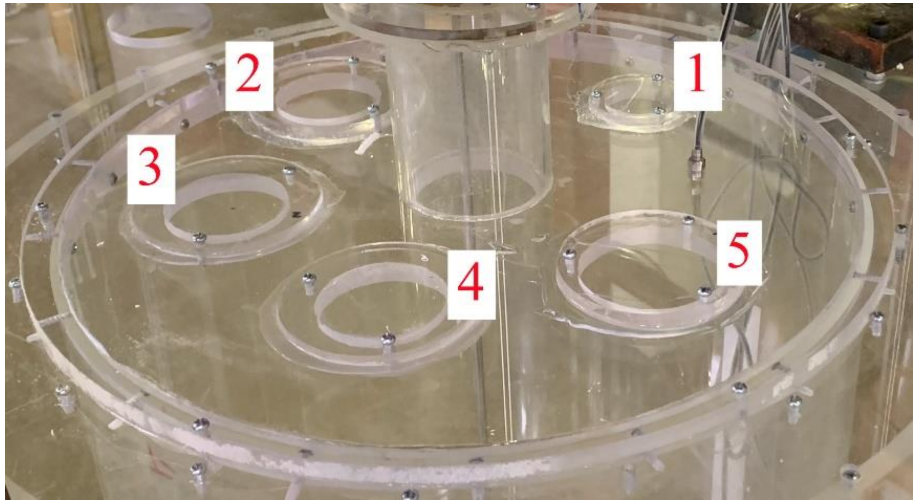
FOWT-OWC

Stationary model

Floating model

Opening ratios:

ε=1%, 2%, 3%, 5%, 9%



Heave motion;

Regular incident waves

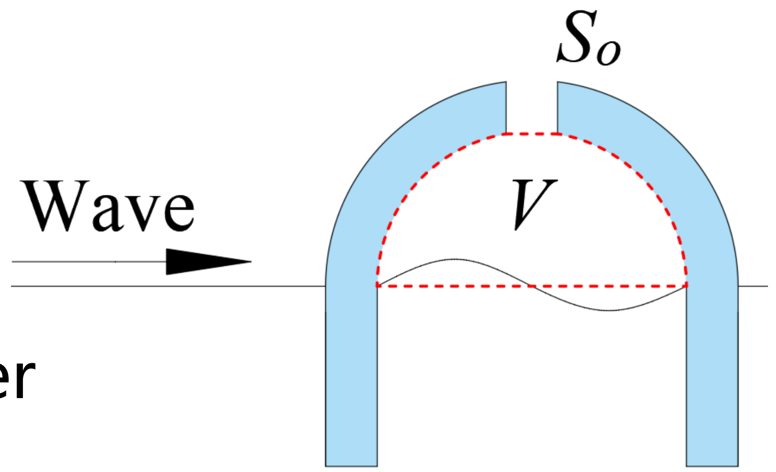
2.3 Power taken-off system

Incident wave energy: $P_{\mathrm{inc}} = 0.5\rho g A_{\mathrm{i}}^{2} c_{g}$ C_g: Group velocity

Captured wave energy: $P_{\mathrm{owc}} = \frac{1}{T}\int_{t}^{t+T} p_{\mathrm{a}}(t)\cdot Q(t)\mathrm{d}t$

$$Q_1(t) = \int_{S_{in}} \dot{\eta}_1(t)\mathrm{d}s - S_{\mathrm{in}}\left[\dot{\zeta}_3(t)\right]$$

Capturing efficiency: $\xi = \frac{P_{\mathrm{owc}}}{P_{\mathrm{inc}} D}$



D: Water column diameter

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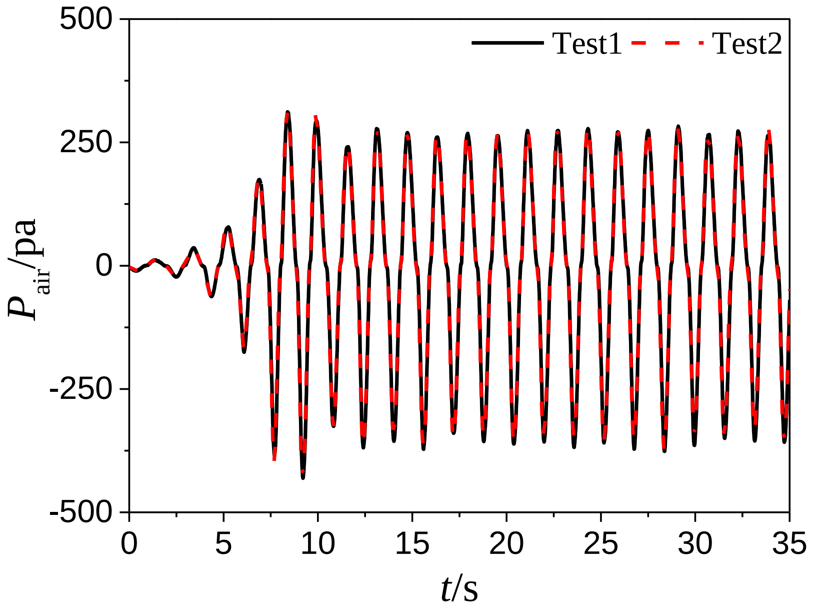
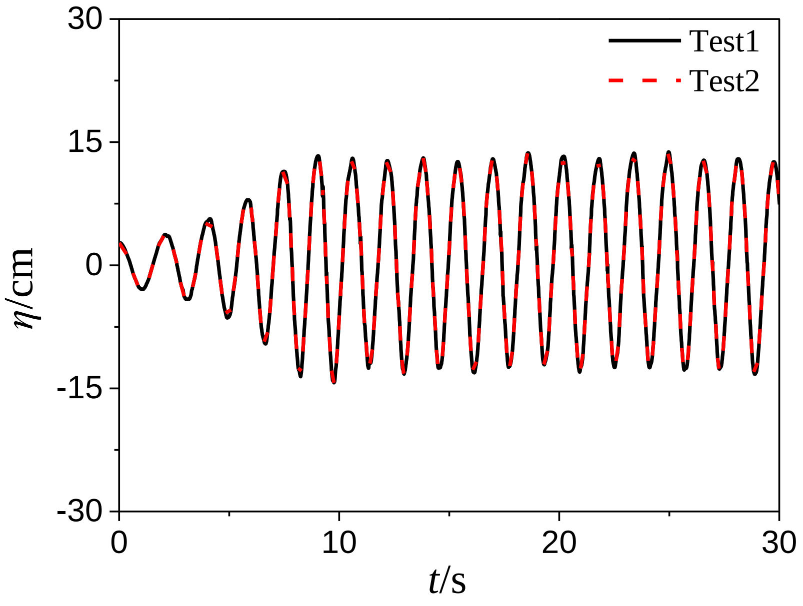
Model validations

3.1 Experimental repeatability

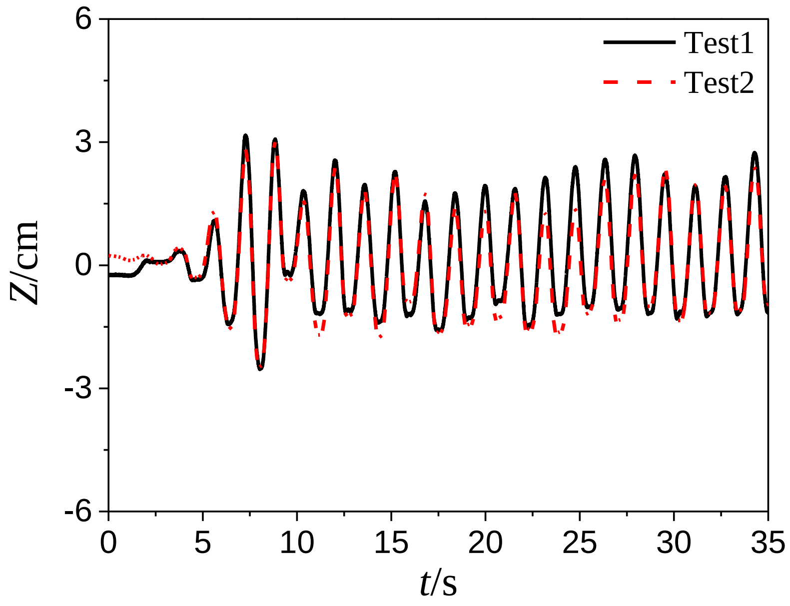
Air pressure



Chamber surface elevation



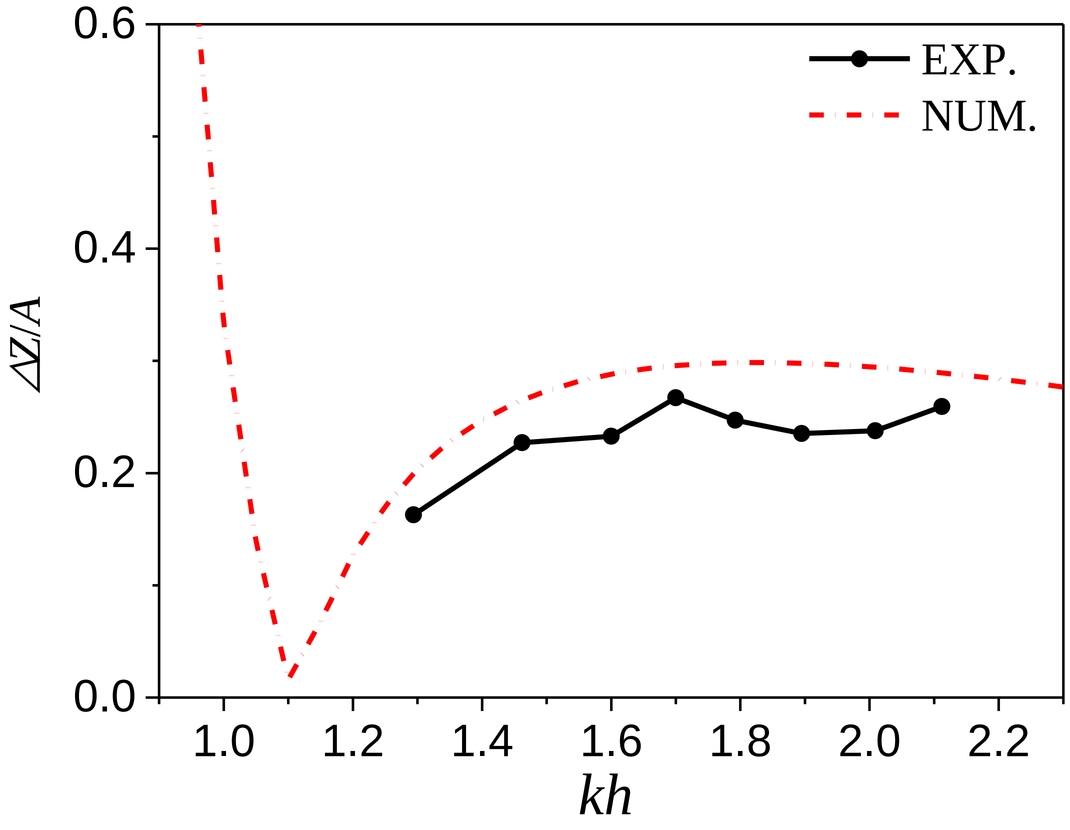
Heave motion

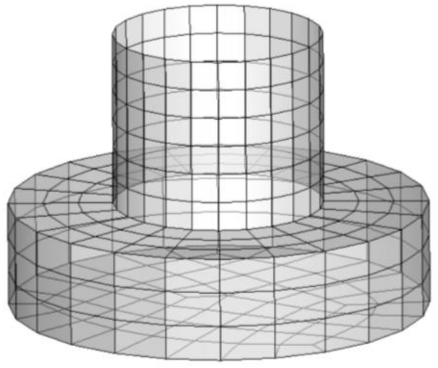


All the measured dates for repeated tests agree very well

3.2 Comparisons the numerical results

Heave motion amplitude





Meshes for BEM model

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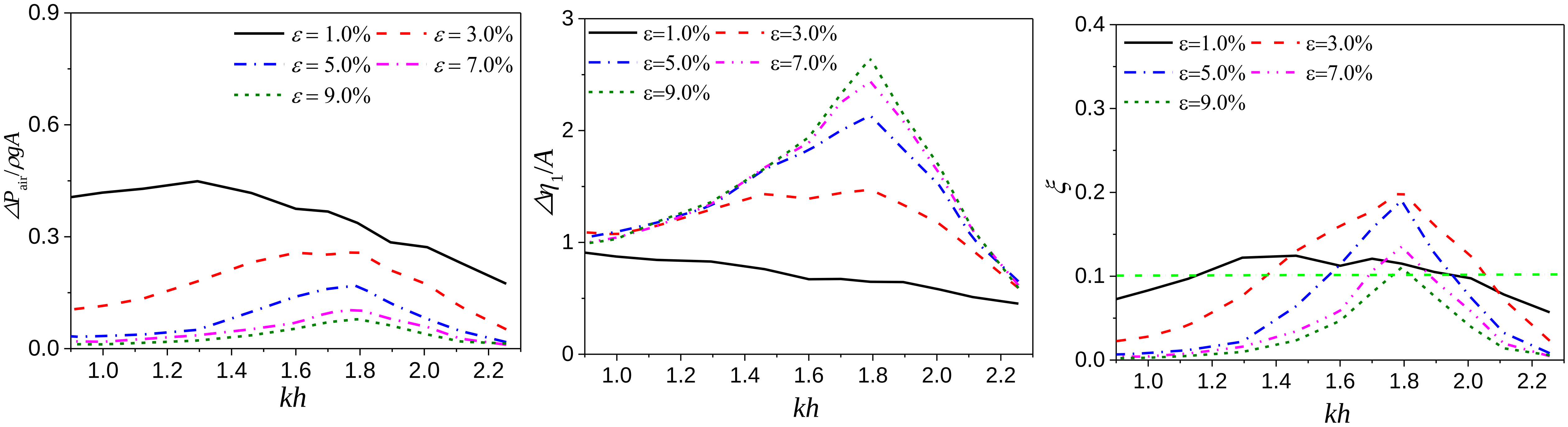
Results and Discussions

4.1 Effects of the opening ratios



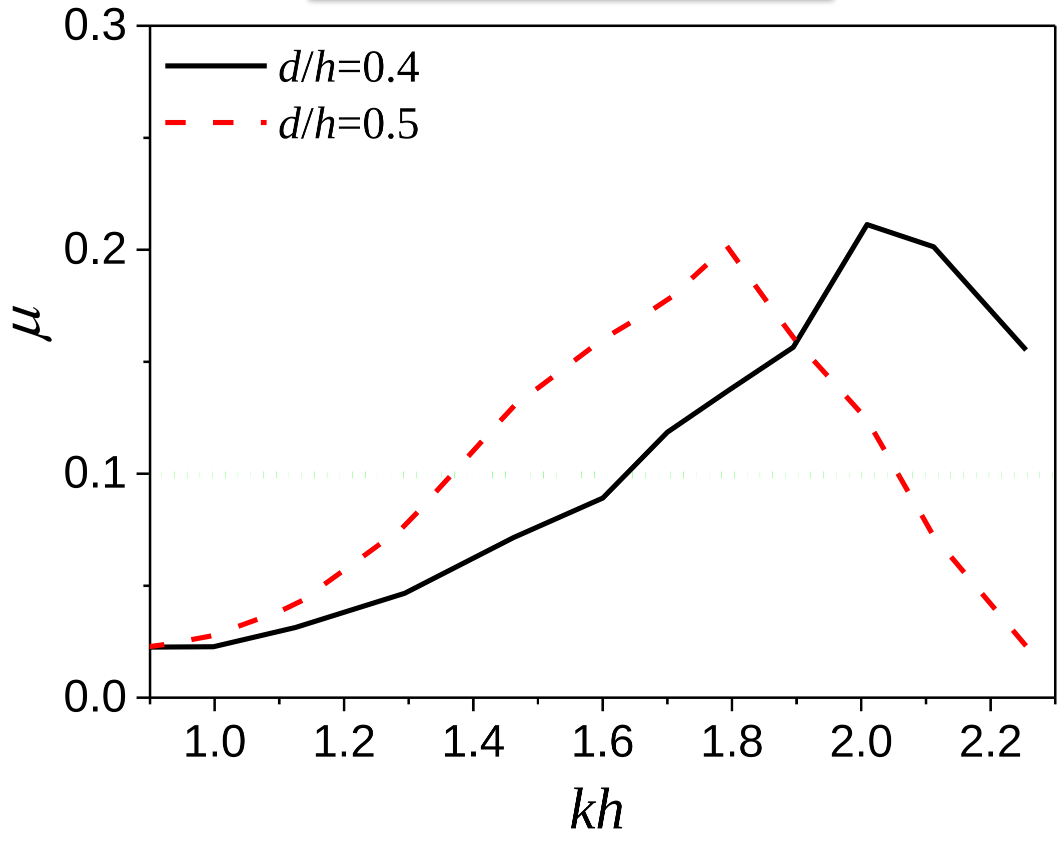
(a) Chamber air pressure (b) Chamber surface elevation (c) Capturing efficiency

The optimal opening ratio is 3.0% which produces a maximum efficiency.

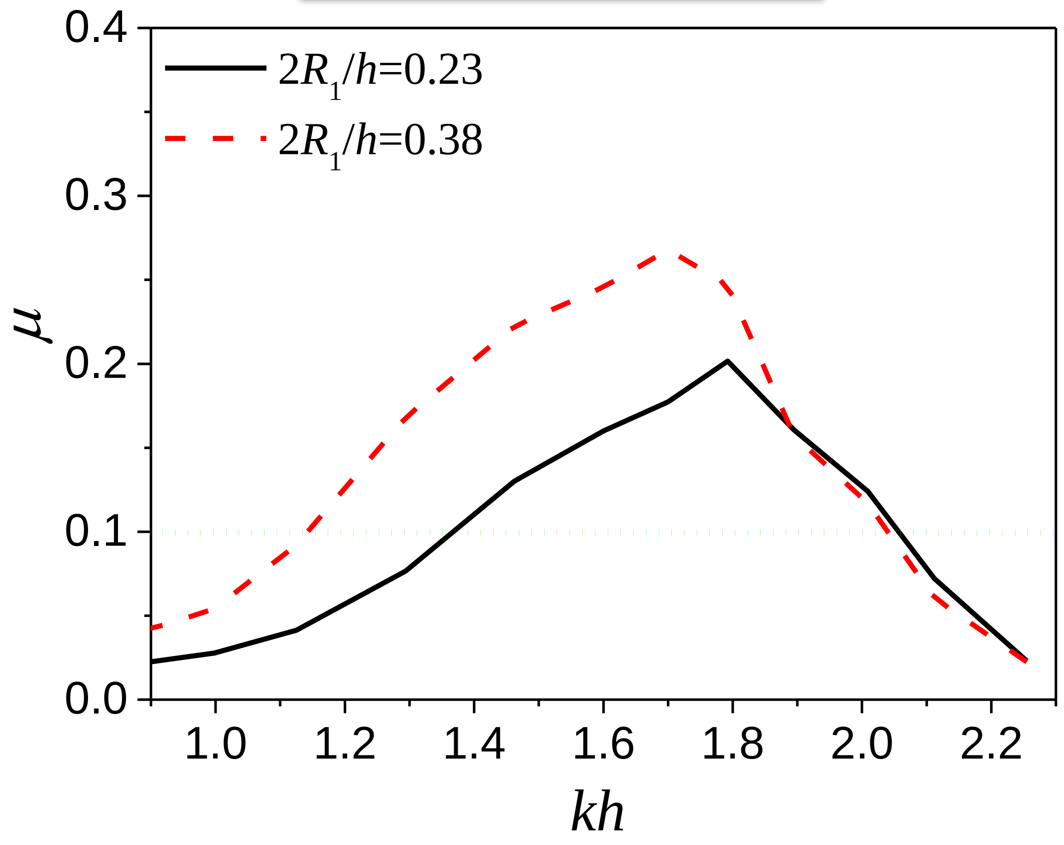
The free surface elevation and air pressure have an opposite variation as the opening ratios.

4.2 Effects of the chamber draft and breadth

Chamber draft



Chamber breadth

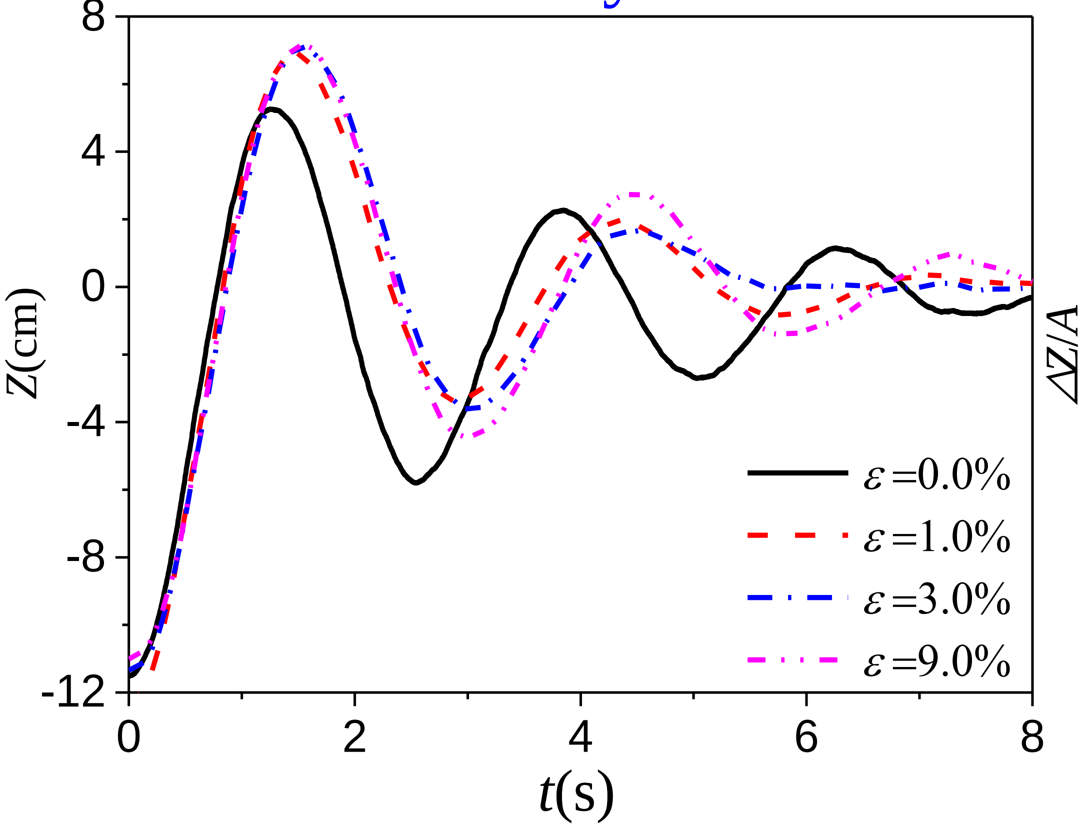


The resonance frequencies shifts to the low-frequency domain as chamber draft and breadth become larger.

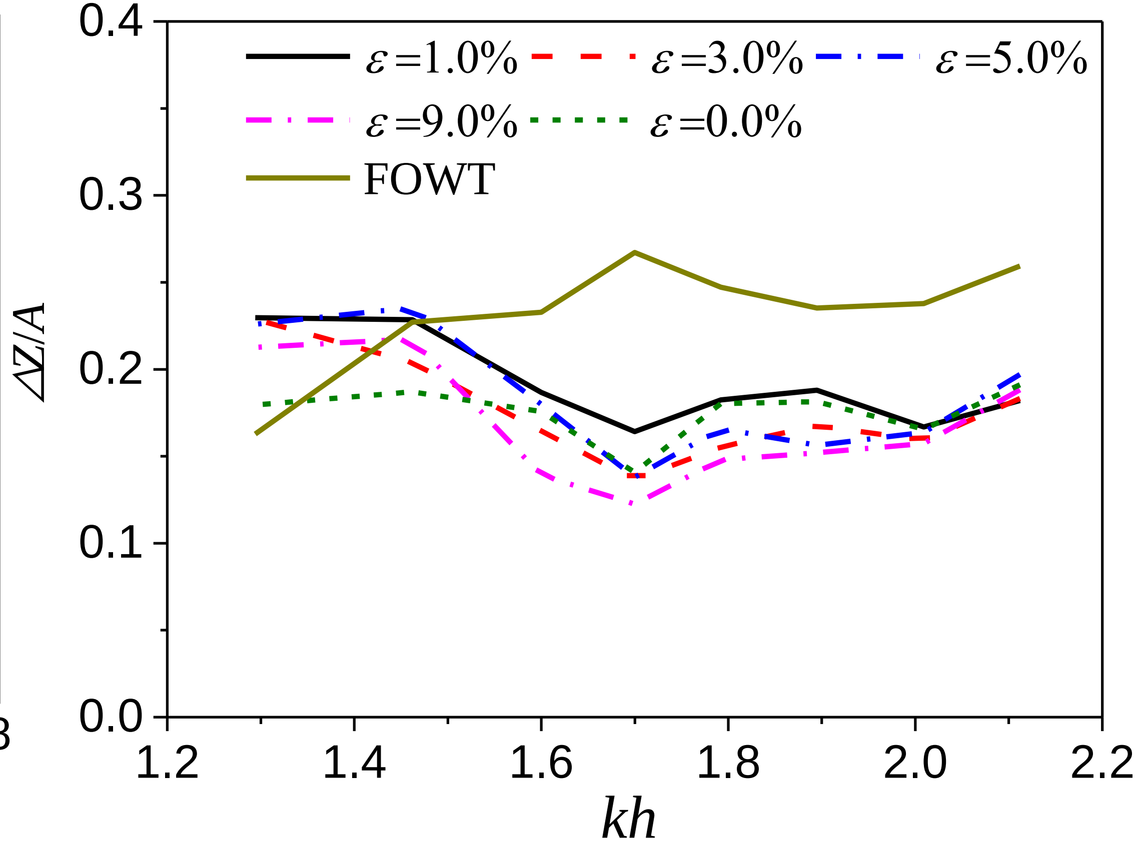
A shorter chamber draft can enhance the wave energy capability for high frequency waves.

4.3 Hydrodynamics of heave-motion model

Free decay test



Heave motion



Heave natural period increases as the increase of the opening ratio ε.

The introduction of the OWC can not only capture wave energy, but also decreases the heave-motion of the foundation. The maximum reduction rate is κ = 54%

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Conclusions

5. Conclusions

1. The optimal opening ratio is 3%, which produces a maximum efficiency near the resonant frequency.

2. The chamber draft and breadth can be designed and optimized for the maximum efficiency.

3. The introduction of the OWC can not only capture wave energy, but also decreases the heave-motion of the foundation.

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