Wave Drifting Force Free Model 2015

- An application of WDPS for ocean structures -

Yutaka Terao
Tokai Univ.

Topics

- WDFFM
  - Wave Devouring Propulsion
  - 2 proposals of Wave Drifting Force Free Model
- New Idea and model experiments
  - 2D with fin
  - 3D with fin
  - Large Scale Model

Wave Free Form

First order wave force

- Theoretical Approach
  - Bessho
- Experimental Approach
  - Motora

Drifting force free form ＝Wave Devouring Propulsion

- Linden 1895

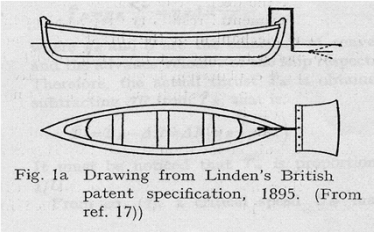


Fig. 1a Drawing from Linden's British patent specification, 1895. (From ref. 17))

WDP & DFFM

- Terao 1982 ***Model Test***
- WDP
  - Isshiki
  - Bessho
  - Naitou
  - Terao
- ***Drifting Force Free Floating Structure***
  - Terao 1984 (Experimental Approach)
  - S.Guha etc. 1995 (Theoretical Approach)

Theory of wave drifting force

- Maruo theory

2nd order wave force

$$\frac{\overline{F}_x}{\rho g \varsigma_a^2 L} = -\frac{KL}{8\pi}\int_0^{2\pi} |H(K,\theta)|^2 (\cos\beta + \cos\theta) d\theta$$

If the integrated value of this formula tends to 0, the drifting force will be zero!

These hull forms should be exist but we cannot imagine them.

Reverse wave drifting force theory

Longuett-higgins ?

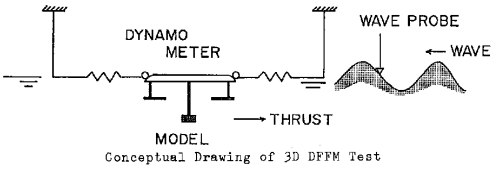
Momentum flux

Motion Free Form

- Heave & Roll-Free
  - Bessho
  - Motora
- Surge Free
  - Yamashita

Terao 3D DFFM Model Test

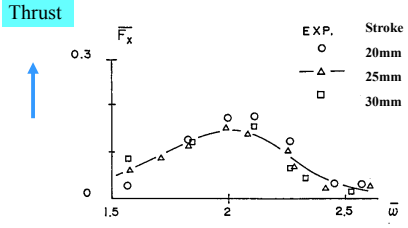
7th OCEAN ENGINEERING SYMPOSIUM June 13-14,1984,pp245-254



Conceptual Drawing of 3D DFFM Test

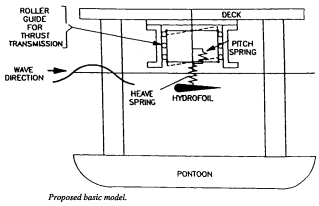
Maximum thrust force of 3D DFFM

Thrust



Thrust Generation of 3D DFFM.

Wave energy in drift control of offshore platform.
S.Guha and P.G.Sayer
Int. Ship build. Progr.,42,no432(1995)pp343-356



Proposed basic model.

Theoretical result of Guha,etc.

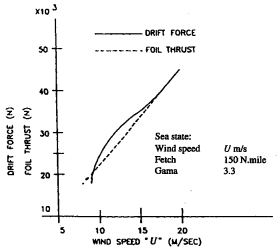


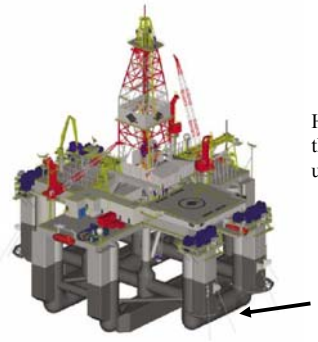
Figure 5. Performance of design hydrofoil.

2D-Model Theoretical Approach

Conclusion

- through predominantly numerical modelling, feasibilty of utilising wave energy to control the drifting of semi-submersible has been established.
- analytical prediction of foil thrust for short waves needs improvement which is expected to be achieved by the introduction of wave damping terms in the formulation.

Proposal of Simple Ideas



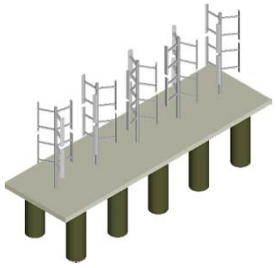
How to generate the thrust in the waves using the lower hulls.

Pontoon

An Illustration of Ocean Rover

Shallow water wind power plant

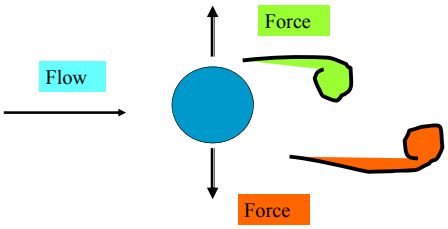
Deep Sea Wind Power Plant



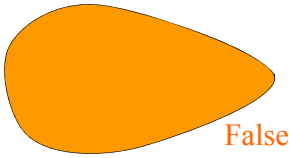
Yoshida Lab. Tokai Univ.

Shedding vortex effect

- Karmann Vortex



A cylinder + Flexible fin



False foil section

An ellipse + Flexible fin

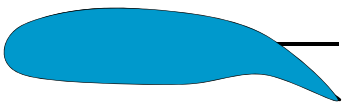
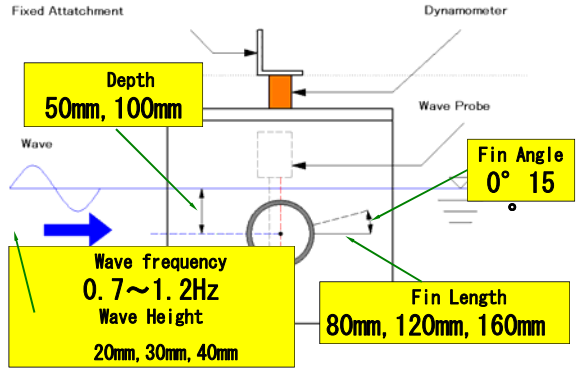
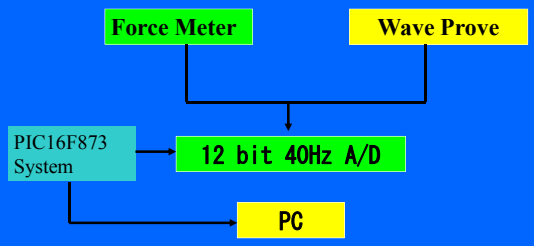


Photo of 2D Model

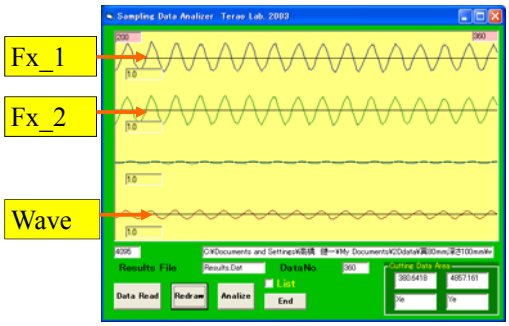
2D Model test



Measurement System

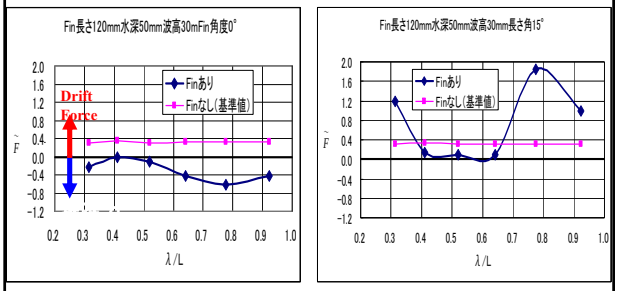


Measured Time history



Tested Results

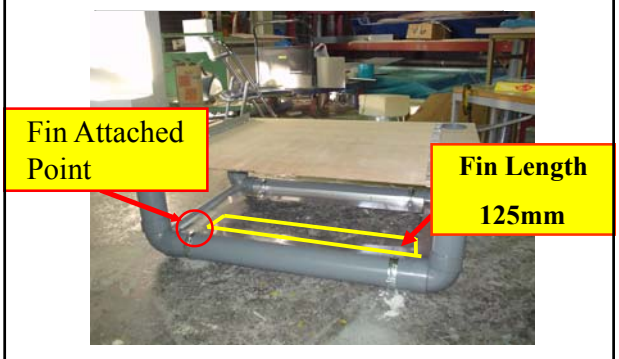
Fin angle and depth effects



2D Model Results

- (1)Fin angle 0° and fin length 120mm are assumed best combination within our tested wave and depth conditions. We can expect fairly constant thrust force.
- (2)Fin Angle 15° generates maximum thrust at the limited wave frequency.

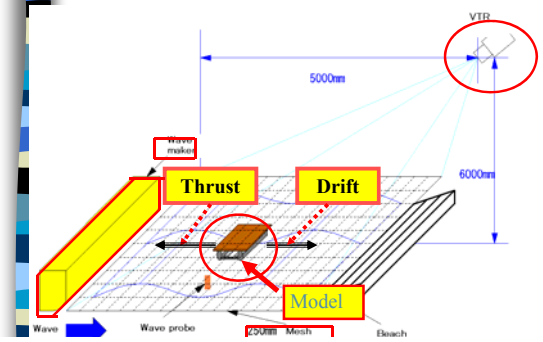
3D Model Photo

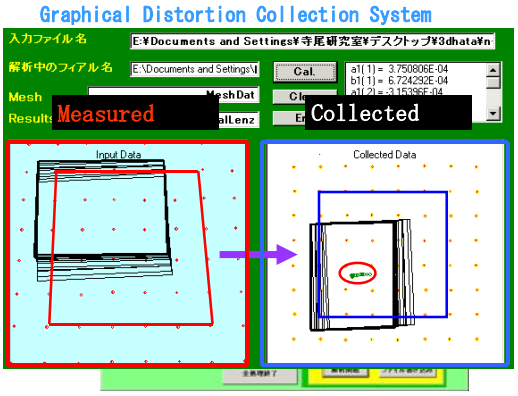


Tested wave conditions

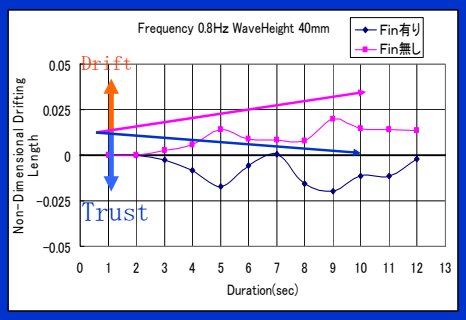
	Height(m)	Frequency(Hz)
With Fin	0.02～0.05	0.6～1.5
Without Fin	0.02～0.05	0.6～1.5

3D Model Test and Wave





3D WDFF Model tested results



The fin pitch motion is important in the oscillating hydrofoil.

=>

Apparent Hydrofoil Section

+

Apparent Pitch Motion

3D Model Results

With flexible fin, the wave drifting force is reduced.

This phenomena are independent on the incident wave frequency and wave height.

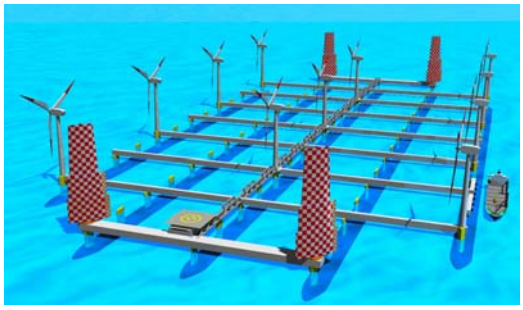
2004 WDPS Model Test

- Applied Flexible Mobile Mega Float
- Fixed type WDPS
- Large scale model test

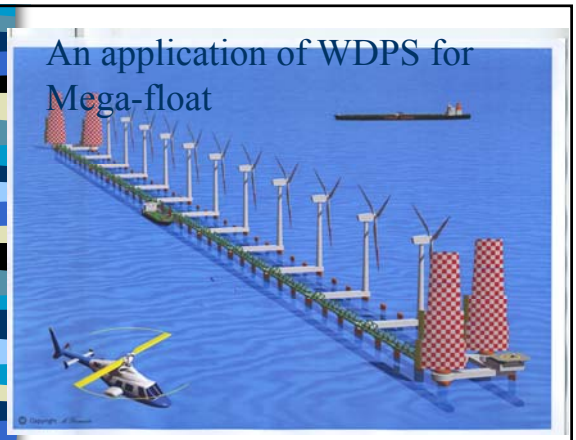
Requirements of WDPS

- Free energy thruster
- Anti-drifting device
- Motion stabilizer

Deep Sea Wind Power Plant

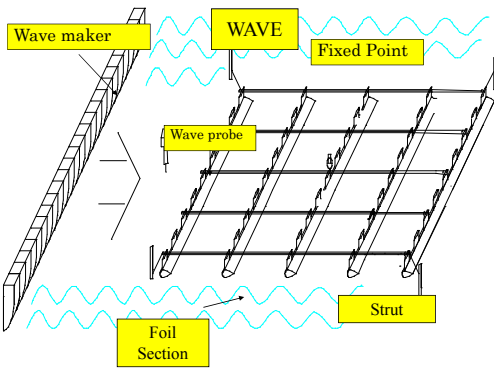


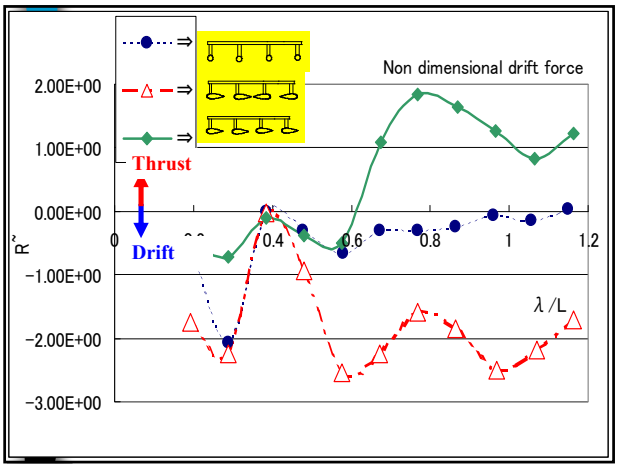
An application of WDPS for Mega-float



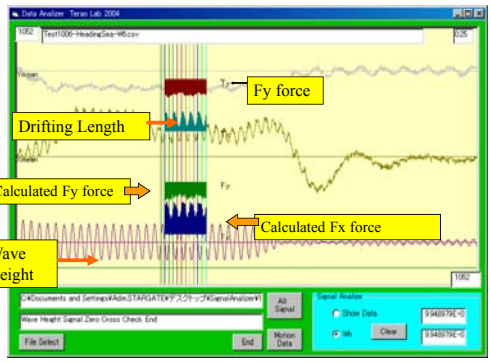
Model experiments in the large wave tank

Schematic view of model testing



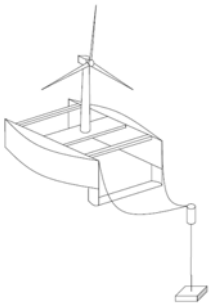


Time history of model test

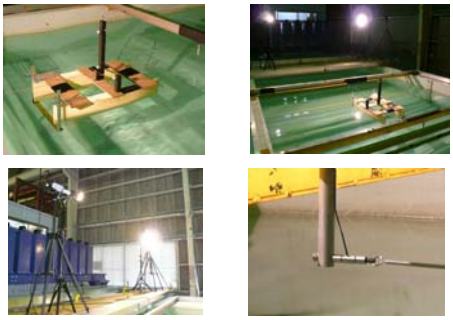


New Approach after Mermaid 2

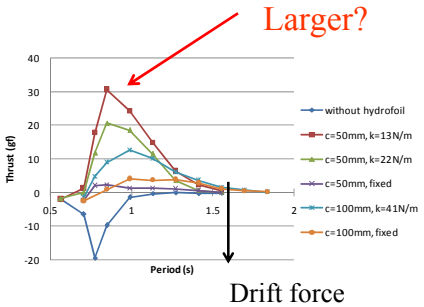
An image of the single mooring system



Experimental apparatus

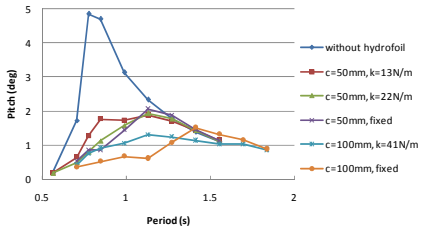


WDPS thrust force

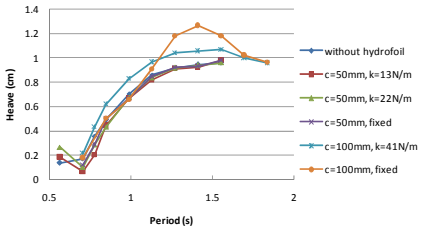


Drift force

WDPS pitch amplitude



WDPS heave amplitude



Newly developed hydrofoil forced oscillator

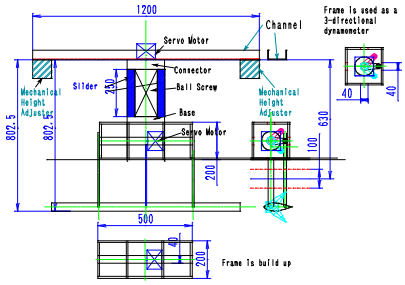
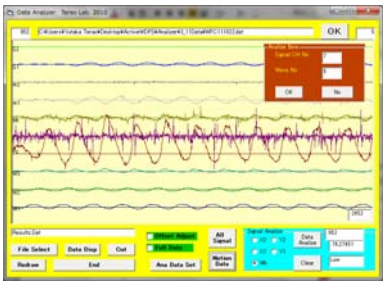
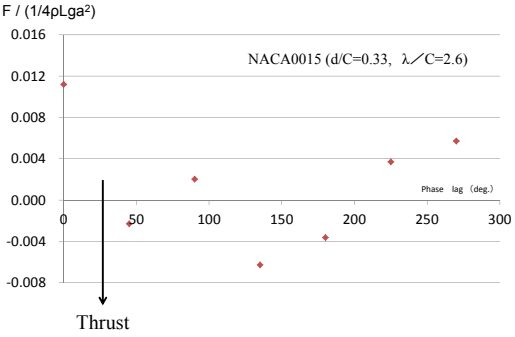


Photo of the forced oscillator system

Forced 2-dimensional hydrofoil test



Non-dimensionalized steady surge force on the hydrofoil for combined motion



Wave drifting free forms

- Future problems
  - Zero speed theory
  - Three bonus point
    - Thrust
    - Motion damping
    - Energy absorber