Wave loadings acting on an innovative caisson breakwaters for energy production

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by

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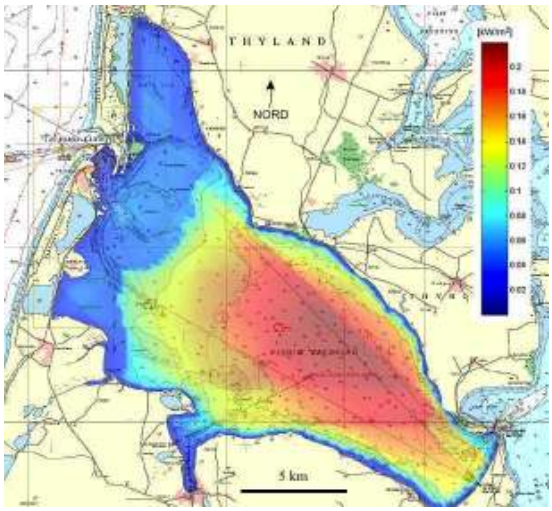
Introduction

The objective of this report is to provide guidelines for the instrumentation of a model in scale 1:10 to prototype of the AquaBuOY wave energy converter. The model will be located in Nissum Bredning area: this is an important waterway already used by Aalborg University for real sea tests of wave energy converters. In Nissum Bredning the wave climate goes from 0.04 to 0.4 kW/m2, therefore it is a convenient step after the laboratory experience in order to evaluate the performances of the device in real sea but still in a protected area. The AquaBuOY will be anchored to the bottom by a triple mooring system.

The present note will suggest different instrumentation option differing by cost and stored data.



Objectives

The purpose of the tests is to understand the possibilities of the energy converter in terms of power production. Prerequisite for this purpose is availability of the following data:

- Time series of the force on the pile-piston system,
- Time series of the relative displacement between the piston and the main floating body.
- Wave measurements

Product of the two first measurements will give time series of power production, and the wave measurements will make it possible to calculate efficiency of the device.

Other optional measurements that could give relevant information about the behaviour of the device are:

- Heave,
- Other movements of the main floating body.

In order to make in situ measurements, an autonomous unit for measuring the force on the piston and the relative displacement of the piston and the main floating body is proposed.

Set up of measuring system

The model of the wave energy converter will be tested during storm events. The model will be put in location right before the occurrence of the event that will be predicted by local forecast. The long experience of Aalborg University personal who spent years checking the weather in Nissum Bredning and the response of the wave energy converters prototypes already installed there, will guarantee the right testing conditions.

The components

To have accurate wave measurements, a wave rider buoy could be installed for the time during the test period. The buoy could send raw data (3D) by radio for wave statistics to be processed every 30 minutes. The importance of having real time data would be reflected also on the efficiency of the testing timing.

A less demanding solution would be to use a pressure transducer of the kind of A PSL 4.1.1 25m LI/30 from H. F. that could be installed at one of the mooring points. Data regarding pressures would be stored and time series of surface elevation extrapolated in second time.

In alternative, information on waves could be derived from wind measurements with a higher uncertainty.

The time series of the force on the connection pile to the piston will be given by a strain gage that will be installed on it.

Time series from the relative displacement will then be measured by ultrasonic remote sensing mounted on the upper part of the model; it is indeed scheduled that this part will be mounted at Aalborg University and designed in a way to allow the installation of this instrument. The preliminary work at Aalborg University will also include the tuning of the resistance that generates the force on the pile-piston system.

To measure the heave and the movements of the main floating body, an analog tri-axial accelerometer could be installed on the buoy.

The data will be logged in a data acquisition system for which the “stand alone” mode is suggested where the data are stored on a SD flash memory card. The assembled system, including batteries, will be located inside the main floating body.

The measuring system regarding the force and relative displacement could be self powered and forming an autonomous unit, easier to position and remove. The system could also be powered by cables from shore: accessibility to the grid is granted.

Costs

The final cost will include the instrumentation cost (comprehensive of installation), the man working hours to adapt the model at AAU and to position/ remove it from Nissum Bredning, the man working hours to perform the measurements and finally the man working hours to analyse and report the performance. The approximate individual costs are listed in Table 1.

Items	**Cost**
1 rent wave rider buoy	**60,000 DKR**
1 pressure transducer for wave measurements	**4,000 DKR**
wind measurements	**2,000 DKR**
1 strain gauge based force transducer	**8,000 DKR**
Ultrasonic sensor	**8,700 DKR**
1 analog tri-axial accelerometer (water insulation + rent)	**6,600 DKR**
Data logger	**3,000 DKR**
Cables and connections/batteries	**5,000 DKR**
Mooring system. Anchors + cables + floaters	**22,000 DKR**
Power take off + 37 man working hours to adapt the model	**18,000 DKR**
15 laboratory working hours for tuning the resistance to the pile-piston system	**4,800 DKR**
Installation on location. 20 man hours + transport + boat	**7,700 DKR**
Testing. 20 man hours + transport (land and sea)	**9,700 DKR**
Analysis and reporting	**6,500 DKR**

Table 1: Cost breakdown

The cost breakdown is show above, as it is our opinion that the total cost of the instrumentation is higher than the possibilities within the project. Therefore Aqua Energy is welcome to propose other solutions than the one described in the following.

Recommendations and conclusions

It is suggested that advantage is taken of the proximity either of the Wave Dragon or the Wave Star wave energy converters. This will be done by using their cabling, time series of surface elevation and nevertheless the offered accessibility.

We suggest the following instrumentation:

- Construction of 'power take off'
- Instruments: Force, displacement, data collection
- Installation: Anchor system + placing
- Access to other wave data
- Measurements: 2-4 'storm situations'.
- Analysis of performance + reporting

Total price will be: 80.000,- DKR + V.A.T.