September 2018

Dear Colleagues,

Invitation to

CCP-WSI Blind Test Workshop – Series 3: Focused Wave Interactions with Floating Structures, ISOPE-2019 Honolulu, Hawaii, June 16-21, 2019

On behalf of ISOPE-2019 IHC, we invite you to participate in the 'CCP-WSI Blind Test Workshop – Series 3: Focused Wave Interactions with Floating Structures' organized by the International Hydrodynamics Committee (IHC) of ISOPE and the CCP-WSI (a Collaborative Computational Project in Wave Structure Interaction) Working Group, which includes the University of Plymouth, City, University of London, Manchester Metropolitan University, the University of Exeter, the University of Bath and the Science and Technology Facilities Council, UK.

Numerical modelling has become an important process in the design of offshore structures and a vast number of tools have been developed as a consequence. The complete range of model fidelity is now available with the common trade-off between computational efficiency and model complexity being the main driver in selecting a particular tool for a specific application. Despite this, as discovered in the 1st CCP-WSI Focus Group Workshop, there still remains considerable uncertainty in the required level of model fidelity to simulate the interaction of waves with offshore structures. The CCP-WSI Blind Test Workshops have been devised to provide a better understanding of this issue and inform the future development of numerical modelling standards. Details of the Series 3 Test Cases are attached.

***Participation form due*: November 9, 2018**		*Numerical results deadline*:	**February 8, 2018**
	or earlier	*Circulation of preliminary report*:	**March 8, 2018**
		Final report	**March 22, 2018**

How to join the CCP-WSI Blind Test Workshop – Series 3

(a) **E-mail** your participation form to s.yan@city.ac.uk & Edward.ransley@plymouth.ac.uk (if you'd like to submit a full paper to be included in the ISOPE-2019 Conference Proceedings, please attach an abstract when submitting the form).

(b) The CCP-WSI will provide a standard submission template (excel file) no later than end of December

(c) **Email** the completed submission template to s.yan@city.ac.uk & Edward.ransley@plymouth.ac.uk

For ***deadline extension***, do not hesitate to contact us

We look forward to seeing you next year in Honolulu.

Sincerely yours,

Prof. Qingwei Ma/Dr Shiqiang Yan (session organizer), ISOPE-2019 IHC Member, City, University of London
Prof. Deborah Greaves (CCP-WSI Chair)/*Dr Edward Ransley*, University of Plymouth, UK

Executive members of International Hydrodynamic Committee (IHC)

Prof. Decheng Wan (IHC Chair), Shanghai Jiao Tong University, China. dcwan@sjtu.edu.cn,
Prof. Yonghwan Kim, Seoul National University; yhwankim@snu.ac.kr
Dr. Shiqiang Yan, City Univ London, UK; shiqiang.yan@city.ac.uk ;
Prof. Q.W. Ma, City Univ London, UK; q.ma@city.ac.uk; Prof. Jin S Chung, ISOPE, jschung@isope.org

Encl. Call for papers

Application form for participation in the ISOPE-2019 IHC

CCP-WSI Blind Test Workshop – Series 3: Focused Wave Interactions with Floating Structures

Dear ISOPE-2019 IHC,

We are willing to participate in the CCP-WSI Blind Test Workshop - Series 3: Focused Wave Interactions with Floating FPSO-like Structures.

For all correspondence relating to the Blind Test please contact us via the following email address,

____.

Name of Institute:

Address:

Contact Person:

-Name:

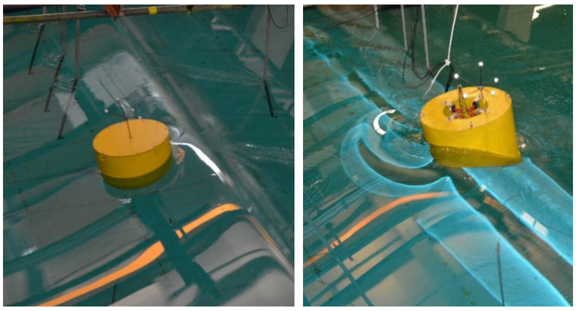
-Email:

CCP-WSI Blind Test Workshop - Series 3

in conjunction with the International Society of Offshore and Polar Engineering (ISOPE) conference

Numerical modelling has become an important process in the design of offshore structures and a vast number of tools have been developed as a consequence. The complete range of model fidelity is now available with the common trade-off between computational efficiency and model complexity (i.e. number of simplifications made to the physics being solved) being the main driver when selecting a particular tool for the scenario under investigation. Despite this, as discovered in the 1st CCP-WSI Focus Group Workshop, there still remains considerable uncertainty over the required level of model fidelity when using numerical methods to simulate the interaction of waves with offshore structures.

The CCP-WSI Blind Test Workshops have been devised to provide a better understanding of the required level of model fidelity when simulating wave structure interaction (WSI) applications and provide information for future development of numerical modelling standards. Within these Workshops, numerical modellers within the WSI community are invited to use their numerical codes to simulate a series of specific WSI problems covering the full range of relevant complexities. The proposed test cases will be introduced at an Introductory Event providing a forum to discuss the blind test cases and the validation/comparative process. All the required information to reproduce a set of bespoke physical validation experiments will then be made available in a Release Event; the key outputs of the experiments will not be divulged until after the community have submitted their numerical results. A Showcase Event will then follow in which the results from the test and present recommendations will be shared with the community.



The CCP-WSI Blind Test Series 3 Test Cases

Focused wave interactions with floating structures
CCP-WSI Blind Test Series 3 (ISOPE)

1. Description

The CCP-WSI Blind Test Series 3 involves two different floating, surface-piercing structures (moored with a simple linear spring mooring) meant to represent simplified wave energy convertors (WECs). The two geometries are: 1) a hemispherical-bottomed cylinder, and; 2) a cylinder with a moon-pool, thus increasing the complexity in the latter case by introducing an ‘internal’ body of water. The Blind Test is, therefore, split into two parts:

- Part 1 - corresponding to the (more simple) hemispherical-bottom cylinder
- Part 2 - corresponding to the cylinder with moon-pool

Each structure is individually subjected to the same set of incident wave cases consisting of 3 focused wave events with a range of steepness, kA (0.129 – 0.206). The steepness of the waves is varied parametrically by increasing the crest height (keeping the same relative frequency contributions). The purpose of these experiments is to assess the effect of wave steepness and float geometry on the motion of the buoy and the load in the mooring line, as well as the accuracy of the numerical methods as a function of these parameters.

In each experiment, the 6DoF motion of the buoy is recorded as well as the load in the single point, linear mooring line. The free surface elevation in the vicinity of the buoy is also recorded by an array of resistive wave gauges.

2. Experimental Set-up

2.1 Basin geometry

The experiments were performed in the COAST Laboratory Ocean Basin (35m long X 15.5m width) at Plymouth University, UK. The basin has 24 flap-type, force feedback controlled wave makers with a hinge depth of 2m. The water depth at the wave makers is 4m and there is a linear slope to the working area where the water depth, *h*, was set to 3.0m. At the far end of the basin there is a parabolic absorbing beach (Figure 1).

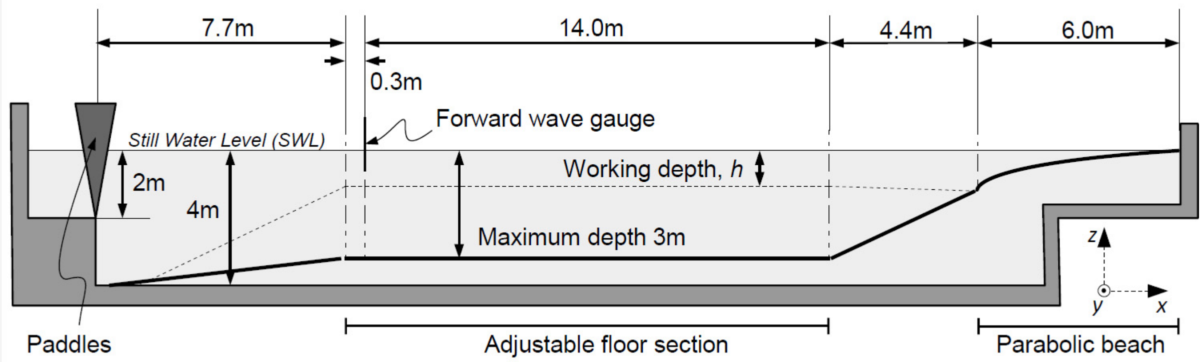


Figure 1: COAST Laboratory Ocean Basin dimensions.

NOTE: The coordinate system used throughout this document has been defined with: the z axis running vertically (positive z upwards) with the z = 0 corresponding to the still water level, and; the x axis running in the direction from the wave makers to the beach. The y axis is then defined according to the right-hand-rule.

2.2 Wave probe layout

For all cases, 13 wave gauge positions were used according to Figure 2. Position 5 corresponds to the rest position of the buoy(s) (with the structure in place this wave gauge was removed but the same number system maintained).

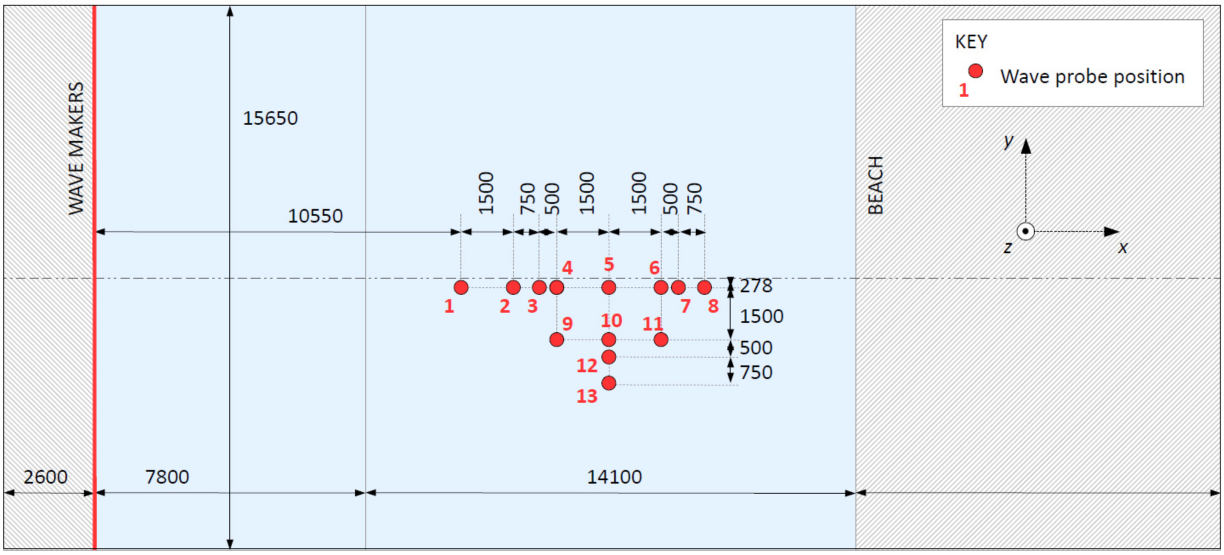


Figure 2: Wave probe layout (all dimensions in mm).

2.3 Buoy geometries and mass properties

As well as providing an increase in geometric complexity and a greater challenge due to the 'internal' fluid in the moon-pool, the two buoys have also been designed and ballasted to have similar drafts (it is hoped this will provide some information regarding the effect of the moon-pool on the dynamics of the system and that this can be related back to the predictive capability of the numerical models included in the tests).

2.3.1 Hemispherical-bottomed buoy (Geometry 1)

Geometry 1 is a hemispherical-bottomed buoy with both the radius of the hemisphere and the cylinder equal to 0.25m. The height of the cylindrical section is also 0.25m (see Figure 3). The mooring attachment is located at the bottom-most point of the hemisphere on the axial line.

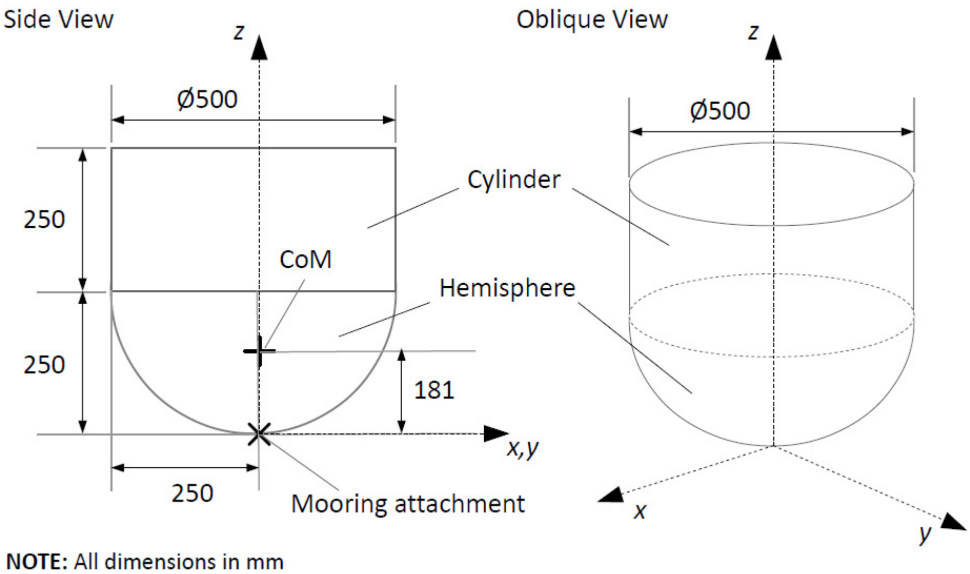


Figure 3: Geometry 1 (all dimensions in mm)

The mass of the hemispherical-bottomed buoy is 43.67 kg (including ballast). The mass properties of the buoy and the position of the centre of mass (CoM) can be found in Table 1 where $z_{Com,rel}$ is the axial (vertical) distance to the position of the CoM relative to the bottom of the buoy/mooring position and I_{zz} is the moment of inertia about the vertical (z) axis, i.e. yaw.

Table 1: Mass properties of Geometry 1

m	$z_{Com,rel}$	I_{xx}	I_{yy}	I_{zz}
(kg)	(m)	(kgm^2)	(kgm^2)	(kgm^2)
43.674	0.181	2.219	2.219	1.143

2.3.2 Cylinder with moon-pool (Geometry 2)

Geometry 2 is a cylinder with a cylindrical moon-pool running axially through the centre. The outer diameter is 0.577m and the inner diameter is 0.289m. The height of the cylinder is 0.5m (see Figure 4). An additional frame allows the mooring attachment to be located level with the bottom of the cylinder on the axial line.

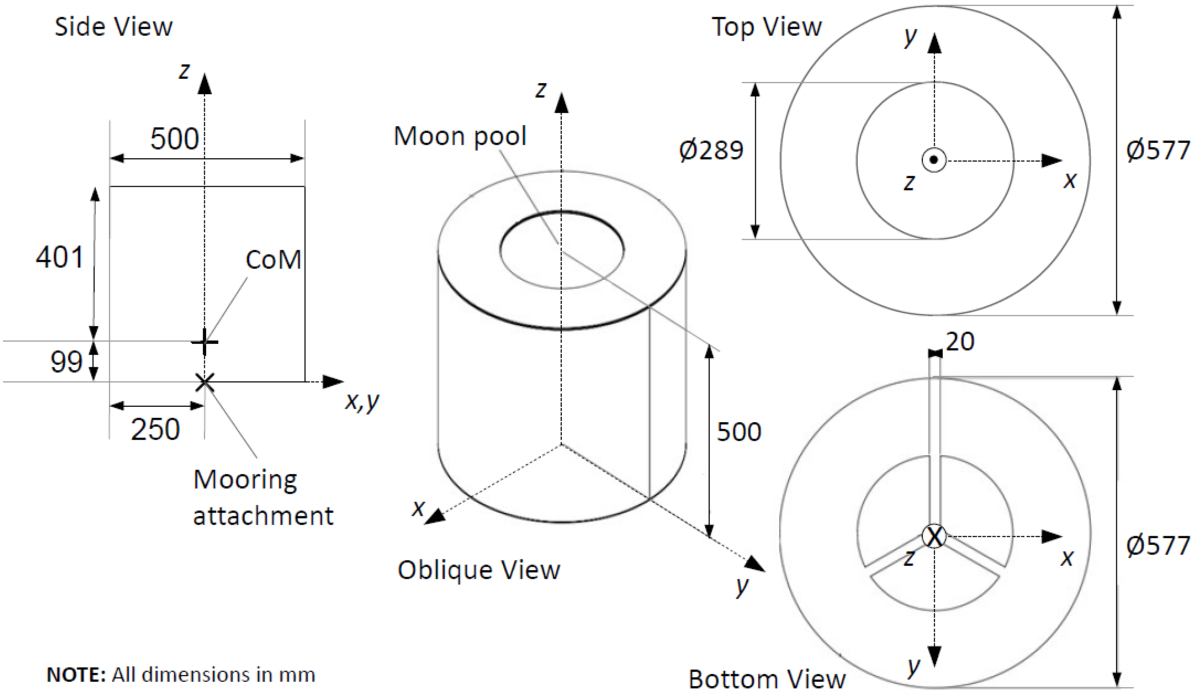


Figure 4: Geometry 2 (all dimensions in mm)

The mass of the moon-pool buoy is 61.46 kg (including ballast). The mass properties of the buoy and the position of the centre of mass (CoM) can be found in Table 2 where, again, $z_{Com,rel}$ is the axial (vertical) distance to the position of the CoM from the bottom of the buoy/mooring position and I_{zz} is the moment of inertia about the vertical (z) axis.

Table 2: Mass properties of Geometry 2

m	$z_{Com,rel}$	I_{xx}	I_{yy}	I_{zz}
(kg)	(m)	(kgm^2)	(kgm^2)	(kgm^2)
61.459	0.099	1.790	1.790	3.298

2.4 Mooring and rest positions of buoys

In both cases, the mooring used is a linear spring with a stiffness of 67 N/m and a rest length of 2.224m (Figure 5). Table 3 gives some key parameters with the buoy at rest (where z = 0 is assumed to be the still water level).

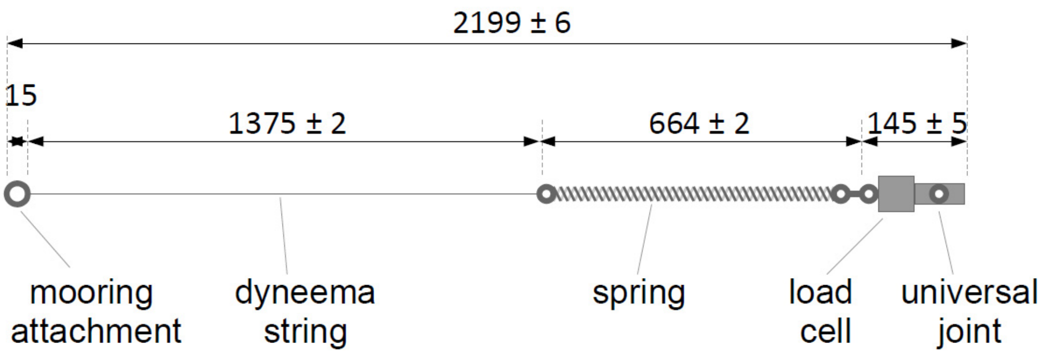


Figure 5: Details of the mooring (all dimensions in mm)

Table 3: Key values when buoys are at rest

Geometry	draft	Pretension in mooring	Z position of CoM
	(m)	(N)	(m)
1	0.322	32.07	-0.141
2	0.330	31.55	-0.231

3. Test Program

The incident waves were generated in the COAST Laboratory Ocean Basin (Figure 1) using the EDL paddle control software. The software is designed to reproduce the desired free-surface elevation by applying various corrections to account for the change in water depth in front of the wave paddles and the nonlinear propagation of the wave fronts. In this case, each wave was create using linear superposition of 244 wave fronts with frequencies evenly spaced between 0.101563Hz and 2Hz and a theoretical focus location, x_0. Each wave front is then transformed back to the position of the wave paddles by the control software. In each case, the theoretical focus location, x_0, was calibrated to produce the desired wave shape (symmetric troughs either side of the main crest) at the rest position of the buoy(s), i.e. the position of wave probe 5. The amplitudes of the frequency components were derived by applying the NewWave theory to a JONSWAP spectrum with the parameters in the Table 3. All waves in this Blind Test Series are crest focused waves, i.e. have zero phase angle at the focus location (Figure 6).

Table 3: Wave parameters for each of the test cases

CCP-WSI ID	Original ID	An	fp	h	Hs	kA
		(m)	(Hz)	(m)	(m)	-
1BT3	Test1	0.2	0.4	3.0	0.274	0.128778
2BT3	Test3	0.3	0.4	3.0	0.274	0.193167
3BT3	Test4	0.32	0.4	3.0	0.274	0.206044

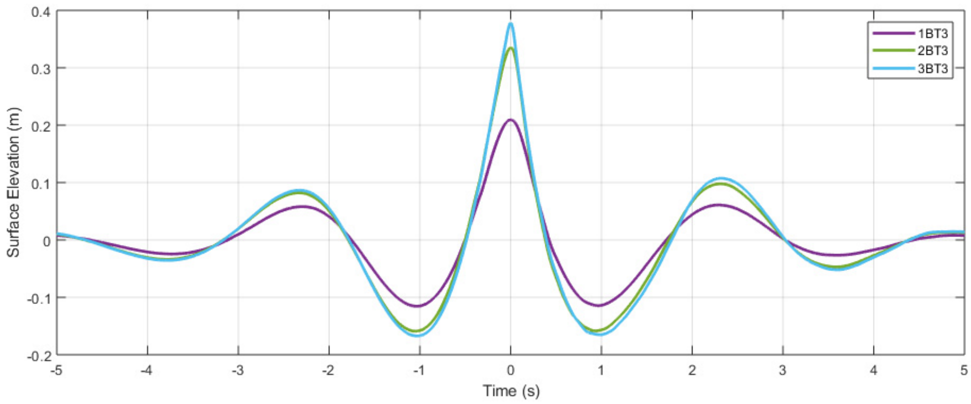


Figure 6: Surface elevation measurements from the empty tank tests, at wave gauge 5 (buoy position), for each of test cases (NOTE: peaks artificially aligned at time = 0s).

4. Physical Measurement Data

The CCP-WSI Blind Test Series 3 is a 'blind' validation of numerical WSI codes. Consequently the only physical measurement data released at this time is the surface elevation data from the wave gauges in the empty tank tests (see Figure 2 for the wave gauge positions). This data should be sufficient to reproduce the incident waves in each of the cases which are the same as those used in the cases with the structure(s) in place. The surface elevation data from the empty tank tests are supplied in the supporting set of text documents (one for each wave case), e.g. 1BT3.txt corresponds to the empty tank tests for the 1BT3 wave case. The remaining physical measurements will be released shortly after completion of the CCP-WSI Blind Test Series 3 through the CCP-WSI Website (http://www.ccp-wsi.ac.uk/).

5. Assessment Criteria

For each case, the CCP-WSI requests time series data from simulations during the period of time between 35.3s and 50.3s (relative to the empty tank data released). We do not wish to restrict participants to this window of time but request that the submitted data and execution times correspond to this period only. In addition to time series data from the simulations, a set of assessment criteria, requiring some basic analysis from participants, have been selected and correspond to the submission data requested for participation in the CCP-WSI Blind Test Workshop – Series 2. The validity assessment criteria, for all cases, are as follows:

- Maximums (see Figure 7) in:
    - Surface elevation at wave gauge 5, η_{max} (m) (empty tank tests)
    - Heave displacement, z_{max} (m)
    - Surge displacement, x_{max} (m)
    - Pitch angle, ϑ_{max} (degrees)
    - Mooring load, F_{max} (N)
- Preceding trough depth (see Figure 7) in:
    - Surface elevation at wave gauge 5, η_{trough} (m) (empty tank tests)
    - Heave displacement, z_{trough} (m)
    - Surge displacement, x_{trough} (m)
    - Pitch angle, ϑ_{trough} (degrees)
    - Mooring load, F_{tough} (N)
- Rising time (see Figure 7) in:
    - Surface elevation at wave gauge 5, τ_{η} (m) (empty tank tests)
    - Heave displacement, τ_z (s)
    - Surge displacement, τ_x (s)
    - Pitch angle, τ_{ϑ} (s)
    - Mooring load, τ_F (s)
- Peak frequency, f_p (variance density, see Figure 8) of:
    - Surface elevation at wave gauge 5, $f_{p,\,\eta}$ (Hz) (empty tank tests)
    - Heave displacement, $f_{p,\,z}$ (Hz)
    - Surge displacement, $f_{p,\,x}$ (Hz)
    - Pitch angle, $f_{p,\,\vartheta}$ (Hz)
    - Mooring load, $f_{p,\,F}$ (Hz)
- Variance density at f_p (see Figure 8) of:
    - Surface elevation at wave gauge 5, Ψ_{η} (m^2/Hz) (empty tank tests)
    - Heave displacement, $\Psi_z(f_p)$ (m^2/Hz)
    - Surge displacement, $\Psi_x(f_p)$ (m^2/Hz)
    - Pitch angle, $\Psi_{\vartheta}(f_p)$ (degrees^2/Hz)
    - Mooring load, $\Psi_F(f_p)$ (N^2/Hz)
- Spectral bandwidth, b (variance density, see Figure 8) of:
    - Surface elevation at wave gauge 5, b_{η} (Hz) (empty tank tests)
    - Heave displacement, b_z (Hz)
    - Surge displacement, b_x (Hz)
    - Pitch angle, b_{ϑ} (Hz)
    - Mooring load, b_F (Hz)
- Execution time of simulation between 35.3s and 50.3s (relative to empty tank data) (s)

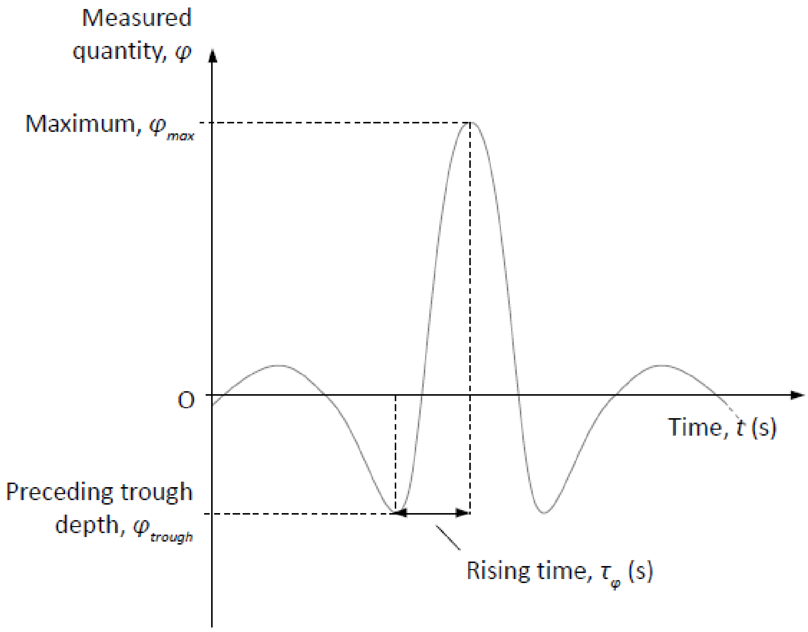


Figure 7: Explanation of validity assessment criteria.

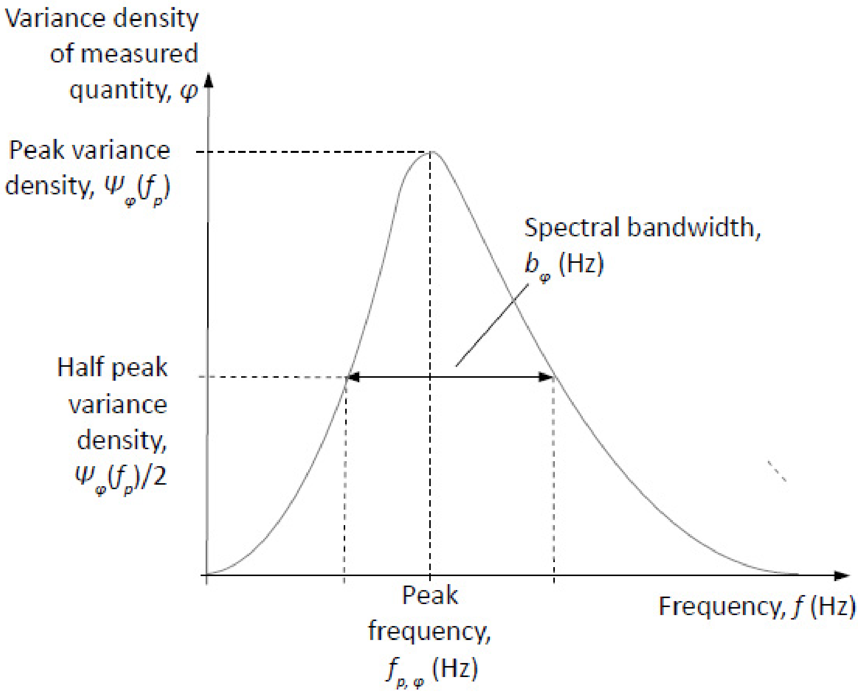


Figure 8: Explanation of validity assessment criteria.

6. Submission Procedure

6.1 Empty tank simulations

It is requested that, for each test case performed, a corresponding empty tank simulation is also conducted and data from this submitted as part of the Blind Test.

6.2 Test case priority list

The CCP-WSI Working Group realises that participation in the Blind Test Series 2 is wholly voluntary and that completing all of the test cases may not be possible for all participants. All contributions are welcomed but it is requested that the test cases are performed in priority order to ensure a meaningful comparison can be drawn between all of the submissions. The requested order is as follows:

12BT3, 11BT3, 13BT3, 22BT3, 21BT3, 23BT3

where 12BT3 corresponds to Geometry 1 (hemispherical-bottomed buoy) with incident wave 2BT3 and 22BT3 corresponds to Geometry 2 with the same incident wave.

6.3 Submission format

The assessment criteria listed in Section 5 should be inputted into the spreadsheet template (template_BT3_submission) supplied in the accompanying documents below. The spreadsheet should then be completed and renamed according to the convention <institution>_BT3_submission (e.g. Plymouth_BT3_submission). Please fill out the individual columns for each of the test cases **[NOTE: For items where the details are the same across all six cases you need only complete the first column and we will assume this is the same for all cases].**

For the empty tank submissions it is requested that time series data be submitted for surface elevation recorded at wave gauges 1, 3, 5 and 8. For each empty tank case please submit:

- A single, tab-delimited text file:
  - **filename**: <institution>_<caseID>_empty (e.g. Plymouth_11BT3_empty)
  - **column 1**: Time (in secs relative to beginning of empty tank data, i.e. 35.3 – 50.3s)
  - **columns 2-5**: Surface elevation measurements (in metres)
    - WG 1, 3, 5, 8

For the cases with structures it is requested that time series data be submitted as follows:

- A single, tab-delimited text file:
  - **filename**: <institution>_<caseID> (e.g. Plymouth_11BT3)
  - **column 1**: Time (in secs relative to beginning of empty tank data, i.e. 35.3 – 50.3s)
  - **column 2**: Heave displacement of CoM (in metres)
  - **column 3**: Surge displacement of CoM (in metres)
  - **column 4**: Pitch angle of buoy relative to the vertical (in degrees)
  - **column 5**: Mooring load (in Newtons)

[NOTE: please retain the order of the requested data as above and please do not submit addition data in these files]

7. Relevant References

Ransley, E., Greaves, D., Raby, A., Simmonds, D., Hann, M., Survivability of Wave Energy Converters using CFD, *Renewable Energy*, 109 (2017): 235-247, doi: http://dx.doi.org/10.1016/j.renene.2017.03.003

Hann, H., Greaves, D., Raby, A., Snatch loading of a single taut moored floating wave energy converter due to focussed wave groups, Ocean Engineering, 96 (2015): 258-271, doi: https://doi.org/10.1016/j.oceaneng.2014.11.011

8. Resources

The accompanying documents (detailed in the Table below) are available on the CCP-WSI Website (https://www.ccp-wsi.ac.uk/blind_test_series_3). ***For each case, the corresponding case without structures (empty tank) has been run. Surface elevation data recorded by all wave gauges in the empty-tank tests are released in the following documents.***

filename	Description
template_BT3_submission	Spreadsheet template for recording submission details and assessment criteria.
1BT3.txt	Empty tank test surface elevation data for 1BT3 wave case; tab-delimited text file (line 1 - header; column 1 – Time (s); columns 2-14 – surface elevation at wave gauges WG1-WG13 (m))
2BT3.txt	Empty tank test surface elevation data for 2BT3 wave case; tab-delimited text file (line 1 - header; column 1 – Time (s); columns 2-14 – surface elevation at wave gauges WG1-WG13 (m))
3BT3.txt	Empty tank test surface elevation data for 3BT3 wave case; tab-delimited text file (line 1 - header; column 1 – Time (s); columns 2-14 – surface elevation at wave gauges WG1-WG13 (m))

CCP-WSI
a Collaborative Computational Project in Wave Structure Interaction

UNIVERSITY OF PLYMOUTH
CITY UNIVERSITY OF LONDON EST 1894
Science & Technology Facilities Council
UNIVERSITY OF EXETER
Manchester Metropolitan University
UNIVERSITY OF BATH