



LiftWEC

DEVELOPMENT OF A NEW CLASS OF WAVE ENERGY CONVERTER
BASED ON HYDRODYNAMIC LIFT FORCES

Deliverable D4.3

Open access experimental data from 2D scale model

Deliverable Lead	Ecole Centrale Nantes
Delivery Date	05/10/2021
Dissemination Level	Consortium Only
Status	Final
Version	1.0



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 851885. This output reflects the views only of the author(s), and the European Union cannot be held responsible for any use which may be made of the information contained therein.

Document Information

Project Acronym	LiftWEC
Project Title	DEVELOPMENT OF A NEW CLASS OF WAVE ENERGY CONVERTER BASED ON HYDRODYNAMIC LIFT FORCES
Grant Agreement Number	851885
Work Package	WP04
Related Task(s)	T4.2
Deliverable Number	D4.3
Deliverable Name	Open access experimental data from 2D scale model
Due Date	30 th February 2021
Date Delivered	5 th October 2021
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Document Number	LW-D04-03

Version Control

Revision	Date	Description	Prepared By	Checked By
0.1	30/09/2021	Draft for internal review	FT	GP
1.0	05/10/2021	Release to EU	MF	



EXECUTIVE SUMMARY

The experimental test campaign of a two-dimensional model of the LiftWEC concept was carried out in June and July 2021. The 2D model was designed, assembled and commissioned by Ecole Centrale de Nantes (ECN). The dataset associated with the experimental measurements was uploaded on Zenodo with DOI <https://doi.org/10.5281/zenodo.5534471>. The model tested is composed of one or two hydrofoils rotating around a horizontal axis, perpendicular to the wave direction. The model was tested in a range of regular and irregular seas. The data contains measurements of the model in the wave tank including; wave elevation measurements, rotor angular position, forces on the hydrofoils, and torque on the power take off. This data is the first of two sets of wave tank data generated for the LiftWEC H2020 research project. This first set consists of results for the device tested in 2D, while the second set will contain results for tests conducted in 3D. For a complete description of the dataset, readers are directed to "*LiftWEC Deliverable D4.4. Report on physical modelling of 2D LiftWEC concepts*" with DOI 10.5281/zenodo.5534520



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1 INTRODUCTION

This document attests of the publication of the experimental 2D model testing open source dataset on online repository Zenodo, with DOI: <https://doi.org/10.5281/zenodo.5534471>. This document provides essential information on the experimental testing carried out and the published data to facilitate the use of the data. The full description of the test campaign and data collected is available in "*LiftWEC Deliverable D4.4. Report on physical modelling of 2D LiftWEC concepts* " with DOI 10.5281/zenodo.5534520



2 MODEL TESTING SETUP

A close-up view of the sub-channel and of the model in the flume is shown in Figure 2-1. It includes the sub channel (made of concrete casting plates) and the central assembly with motor, rotor, foils and instrumentation. A schematic of the setup in the flume is shown in Figure 2-2.

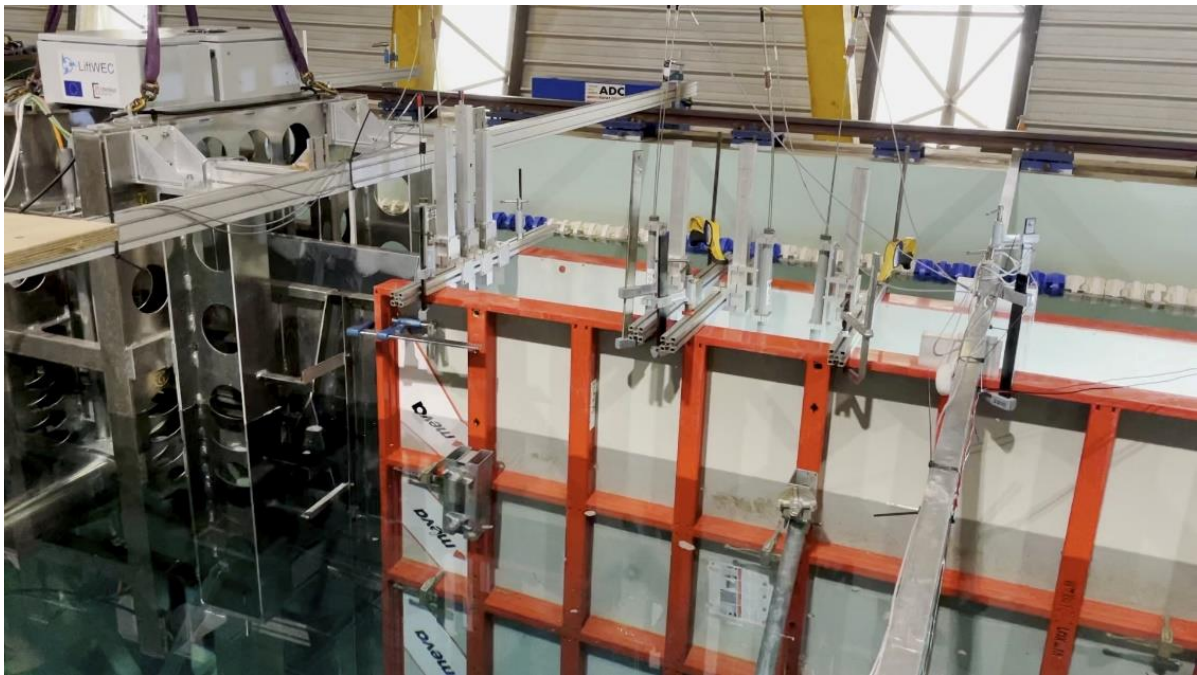


Figure 2-1: View of the sub-channel (right) and of the model (left)

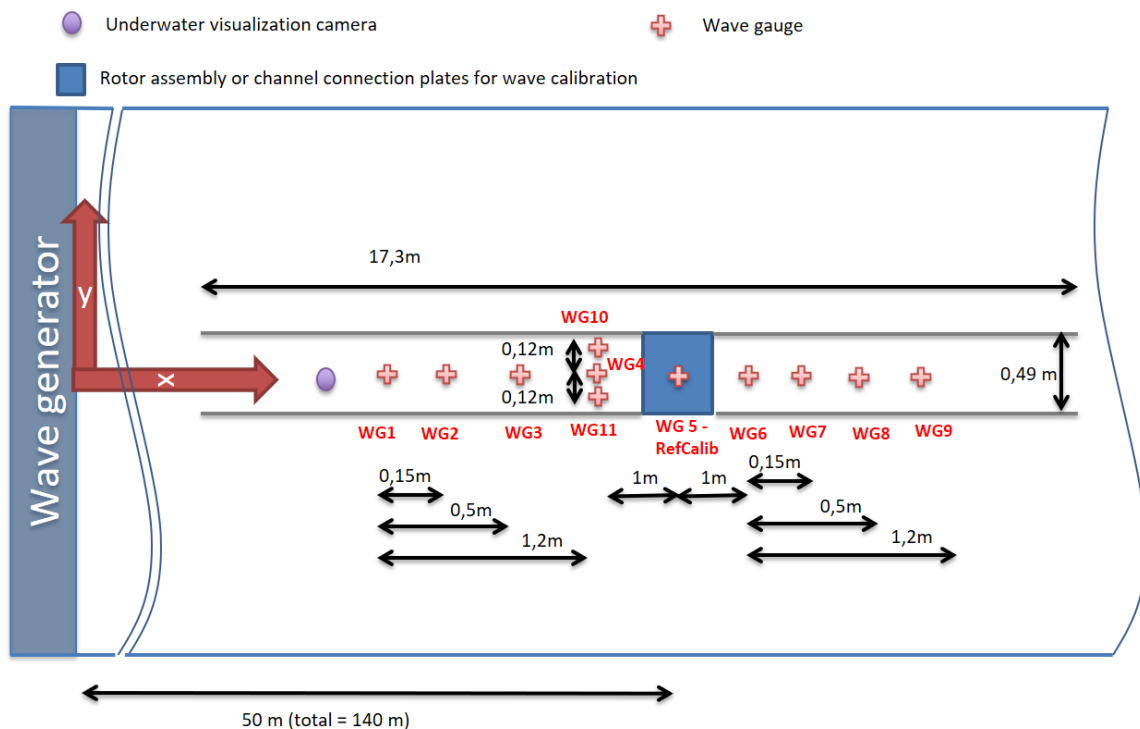


Figure 2-2: Schematic of the flume and model setup

3 TEST MATRIX

The test matrix provides the list of tests carried out during the test campaign. For each test, it gives the wave characteristics, model configuration and PTO control strategy. The parameters in the test matrix are:

- Test num: The unique test number, which is used in all the project reports, data files, etc.
- Date: Date of the test
- Wave type: type of wave generated during the test, it may be:
 - DRY: model test outside the tank
 - ZERO: no wave generated
 - RW = Regular waves
 - BiW = Bi-chromatic waves
 - IW = Irregular waves (Jonswap spectrum)
- T/Tp(s): wave period (regular) or Peak period (irregular) in s
- H/Hs(m): wave height (regular or Significant wave height (irregular) in m
- T2_s: second wave period in bi-chromatic waves only in s
- H2_m: second wave height in bi-chromatic waves only in m
- Gamma: Spreading factor for Jonswap wave spectrum (non dimensional parameter)
- Foil phase: Requested phase angle between wave peak and foil 1 position (or foil 2 when only foil 2 is in use) in degree

- Vrotor_Rad_sec: Rotor speed in motor constant speed mode in radian per s
- Added vel. Amp(deg/s): Rotor added velocity amplitude, motor control with velocity time series in degree per s
- Added vel. period (s) : period of the rotor added velocity amplitude in s
- Pitch1: Foil 1 angle, NA means this foil is not on the model in degrees
- Pitch2: Foil 2 angle, NA means this foil is not on the model in degrees
- Comments: Any comment or observation during the test

Note: The foils radius of rotation is 0.3m for all tests with the model.

The test matrix is shown in Table 3-1 to Table 3-6.

Test num	Date	Wave type	T/Tp(s)	H/Hs(m)	Tz_s	H2_m	Gamma	Foil1 phase	Torque Max	Vrotor_Rad_sec	Added vel. Amp(deg/s)	Added vel. period (s)	Pitch1	Pitch2	Comments
2	30/06/2021	RW	1.00	0.048	0.000	0.000	0	0	0	0	0.000	0.000	NA	NA	
3	30/06/2021	RW	1.42	0.090	0.000	0.000	0	0	0	0	0.000	0.000	NA	NA	
4	30/06/2021	RW	1.21	0.070	0.000	0.000	0	0	0	0	0.000	0.000	NA	NA	
5	30/06/2021	RW	1.00	0.080	0.000	0.000	0	0	0	0	0.000	0.000	NA	NA	
6	30/06/2021	RW	1.83	0.150	0.000	0.000	0	0	0	0	0.000	0.000	NA	NA	
7	30/06/2021	RW	1.60	0.120	0.000	0.000	0	0	0	0	0.000	0.000	NA	NA	
8	30/06/2021	RW	1.42	0.153	0.000	0.000	0	0	0	0	0.000	0.000	NA	NA	
9	30/06/2021	RW	1.21	0.113	0.000	0.000	0	0	0	0	0.000	0.000	NA	NA	
10	30/06/2021	RW	2.46	0.186	0.000	0.000	0	0	0	0	0.000	0.000	NA	NA	
11	30/06/2021	RW	2.21	0.186	0.000	0.000	0	0	0	0	0.000	0.000	NA	NA	
12	30/06/2021	RW	2.00	0.186	0.000	0.000	0	0	0	0	0.000	0.000	NA	NA	
13	30/06/2021	RW	1.83	0.253	0.000	0.000	0	0	0	0	0.000	0.000	NA	NA	
14	30/06/2021	RW	1.60	0.200	0.000	0.000	0	0	0	0	0.000	0.000	NA	NA	
15	30/06/2021	RW	2.46	0.310	0.000	0.000	0	0	0	0	0.000	0.000	NA	NA	
16	30/06/2021	RW	2.21	0.310	0.000	0.000	0	0	0	0	0.000	0.000	NA	NA	
17	30/06/2021	RW	2.00	0.310	0.000	0.000	0	0	0	0	0.000	0.000	NA	NA	
26	02/07/2021	BiW	2.00	0.186	1.210	0.042	0	0	0	0	0.000	0.000	NA	NA	Not used in model testing
27	02/07/2021	BiW	2.00	0.186	1.420	0.054	0	0	0	0	0.000	0.000	NA	NA	Not used in model testing
28	02/07/2021	BiW	2	0.186	1.6	0.072	0	0	0	0	0.000	0.000	NA	NA	
29	02/07/2021	BiW	2	0.186	1.83	0.09	0	0	0	0	0.000	0.000	NA	NA	
30	02/07/2021	BiW	2	0.186	2.46	0.1116	0	0	0	0	0.000	0.000	NA	NA	
31	02/07/2021	BiW	1.21	0.0678	1.42	0.054	0	0	0	0	0.000	0.000	NA	NA	Not used in model testing
32	02/07/2021	BiW	1.21	0.0678	1.6	0.072	0	0	0	0	0.000	0.000	NA	NA	Not used in model testing
33	05/07/2021	BiW	1.21	0.0678	1.83	0.09	0	0	0	0	0.000	0.000	NA	NA	Not used in model testing
34	05/07/2021	BiW	1.21	0.0678	2	0.1116	0	0	0	0	0.000	0.000	NA	NA	Not used in model testing
35	05/07/2021	BiW	1.21	0.0678	2.46	0.1116	0	0	0	0	0.000	0.000	NA	NA	Not used in model testing
36	05/07/2021	BiW	1.6	0.12	1.21	0.042	0	0	0	0	0.000	0.000	NA	NA	Not used in model testing
37	05/07/2021	BiW	1.6	0.12	1.42	0.054	0	0	0	0	0.000	0.000	NA	NA	Not used in model testing
38	05/07/2021	BiW	1.6	0.12	1.83	0.09	0	0	0	0	0.000	0.000	NA	NA	
39	05/07/2021	BiW	1.6	0.12	2	0.1116	0	0	0	0	0.000	0.000	NA	NA	
40	05/07/2021	BiW	1.6	0.12	2.46	0.1116	0	0	0	0	0.000	0.000	NA	NA	
41	05/07/2021	IW	1.4	0.09	0	0	3.3	0	0	0	0.000	0.000	NA	NA	Not used in model testing
42	05/07/2021	IW	1.8	0.15	0	0	3.3	0	0	0	0.000	0.000	NA	NA	Not used in model testing
43	05/07/2021	IW	1.8	0.15	0	0	3.3	0	0	0	0.000	0.000	NA	NA	Not used in model testing
44	05/07/2021	IW	1.8	0.15	0	0	3.3	0	0	0	0.000	0.000	NA	NA	Not used in model testing
45	05/07/2021	IW	1.8	0.15	0	0	3.3	0	0	0	0.000	0.000	NA	NA	Not used in model testing
46	05/07/2021	IW	1.8	0.15	0	0	3.3	0	0	0	0.000	0.000	NA	NA	Not used in model testing
47	05/07/2021	IW	2.2	0.18	0	0	3.3	0	0	0	0.000	0.000	NA	NA	OK

Table 3-1: List of calibrated sea states, without the model rotor and an addition wave probe at its centre location

Test num	Date	Wave type	T/Ip(s)	H/Hs(m)	TZ_s	H2_m	Gamma	Foil phase	Vrotor_Rad_sec	Added vel. Amp(deg/s)	Added vel. period (s)	Pitch1	Pitch2	Comments
0	test in air at 8deg													
48	06/07/2021	DRY	0	0	0	0	0	0	0.1	0.000	0.000	NA	8	OK
49	06/07/2021	DRY	0	0	0	0	0	0	1	0.000	0.000	NA	8	OK
50	06/07/2021	DRY	0	0	0	0	0	0	2	0.000	0.000	NA	8	OK
51	06/07/2021	DRY	0	0	0	0	0	0	5	0.000	0.000	NA	8	OK
52	06/07/2021	DRY	0	0	0	0	0	0	12	0.000	0.000	NA	8	OK
0	test in air at 0deg													
53	06/07/2021	DRY	0	0	0	0	0	0	0.1	0.000	0.000	NA	0	OK
54	06/07/2021	DRY	0	0	0	0	0	0	1	0.000	0.000	NA	0	OK
55	06/07/2021	DRY	0	0	0	0	0	0	2	0.000	0.000	NA	0	OK
56	06/07/2021	DRY	0	0	0	0	0	0	5	0.000	0.000	NA	0	OK
57	06/07/2021	DRY	0	0	0	0	0	0	12	0.000	0.000	NA	0	OK
0	No wave in water at 0deg													
58	07/07/2021	ZERO	0	0	0	0	0	0	0.1	0.000	0.000	NA	0	OK
59	07/07/2021	ZERO	0	0	0	0	0	0	1	0.000	0.000	NA	0	OK
60	07/07/2021	ZERO	0	0	0	0	0	0	2	0.000	0.000	NA	0	OK
61	07/07/2021	ZERO	0	0	0	0	0	0	5	0.000	0.000	NA	0	OK
62	07/07/2021	ZERO	0	0	0	0	0	0	12	0.000	0.000	NA	0	OK
0	No wave in water at 0deg to check acceleration times													
65	07/07/2021	ZERO	0	0	0	0	0	0	2.62	0.000	0.000	NA	0	OK
66	07/07/2021	ZERO	0	0	0	0	0	0	2.86	0.000	0.000	NA	0	OK
67	07/07/2021	ZERO	0	0	0	0	0	0	3.14	0.000	0.000	NA	0	OK
68	07/07/2021	ZERO	0	0	0	0	0	0	3.49	0.000	0.000	NA	0	OK
69	07/07/2021	ZERO	0	0	0	0	0	0	3.93	0.000	0.000	NA	0	OK
70	07/07/2021	ZERO	0	0	0	0	0	0	4.49	0.000	0.000	NA	0	OK
71	07/07/2021	ZERO	0	0	0	0	0	0	5.24	0.000	0.000	NA	0	OK
0	test with wave at expected 90 deg. Phase (rotor at 90 deg. At wave crest times)													
72	08/07/2021	RW	1.4	0.153	0	0	0	90	2.62	0.000	0.000	NA	0	Foil phase not exact
73	08/07/2021	RW	1.4	0.153	0	0	0	90	4.418	0.000	0.000	NA	0	Foil phase not exact
74	08/07/2021	RW	1.6	0.2	0	0	0	90	3.927	0.000	0.000	NA	0	Foil phase not exact
75	08/07/2021	RW	1.8	0.253	0	0	0	90	3.436	0.000	0.000	NA	0	waves didn't start
77	08/07/2021	RW	2	0.31	0	0	0	90	3.142	0.000	0.000	NA	0	Foil phase not exact
78	08/07/2021	RW	2.2	0.31	0	0	0	90	2.847	0.000	0.000	NA	0	Foil phase not exact
79	08/07/2021	RW	2.4	0.31	0	0	0	90	2.553	0.000	0.000	NA	0	Foil phase not exact
80	09/07/2021	RW	1.4	0.153	0	0	0	90	4.413	0.000	0.000	NA	0	test on RPM correction, noy used
0	Fairings removed to check the phase shifts on load cells													
83	12/07/2021	ZERO	0	0	0	0	0	0	1	0.000	0.000	NA	0	OK
84	12/07/2021	ZERO	0	0	0	0	0	0	0.1	0.000	0.000	NA	0	OK
85	12/07/2021	DRY	IN AIR	0	0	0	0	0	0.1	0.000	0.000	NA	0	OK
0	removed foil 2													
86	13/07/2021	0	0	0	0	0	0	0	0	0.000	0.000	0	NA	test foil1
0	foil change (removed 2 and placed 1) due to Load8 error, test with no fairings													
87	13/07/2021	DRY	IN AIR	0	0	0	0	0	0.1	0.000	0.000	0	NA	OK
88	13/07/2021	DRY	IN AIR	0	0	0	0	0	0.1	0.000	0.000	0	NA	repeat
89	13/07/2021	DRY	IN AIR	0	0	0	0	0	1	0.000	0.000	0	NA	OK
90	13/07/2021	DRY	IN AIR	0	0	0	0	0	2	0.000	0.000	0	NA	OK
91	13/07/2021	DRY	IN AIR	0	0	0	0	0	5	0.000	0.000	0	NA	OK
92	13/07/2021	DRY	IN AIR	0	0	0	0	0	12	0.000	0.000	0	NA	OK

Table 3-2: Model testing with one foil only



Test num	Date	Wave type	T/Tp(s)	H/Hs(m)	TZ_s	H2_m	Gamma	Foil phase	Vrotor_Rad_sec	Added vel. Amp(deg/s)	Added vel. period (s)	Pitch1	Pitch2	Comments
0	FAIRINGS ADDED													
93	13/07/2021	DRY	IN AIR	0	0	0	0	0	0.1	0.000	0.000	0	NA	OK
94	13/07/2021	DRY	IN AIR	0	0	0	0	0	1	0.000	0.000	0	NA	OK
95	13/07/2021	DRY	IN AIR	0	0	0	0	0	2	0.000	0.000	0	NA	OK
96	13/07/2021	DRY	IN AIR	0	0	0	0	0	5	0.000	0.000	0	NA	OK
98	13/07/2021	DRY	IN AIR	0	0	0	0	0	12	0.000	0.000	0	NA	OK
0	model in water													
99	13/07/2021	ZERO	0	0	0	0	0	0	0.1	0.000	0.000	0	NA	OK
101	15/07/2021	ZERO	0	0	0	0	0	0	1	0.000	0.000	0	NA	OK
102	15/07/2021	ZERO	0	0	0	0	0	0	2	0.000	0.000	0	NA	OK
103	15/07/2021	ZERO	0	0	0	0	0	0	5	0.000	0.000	0	NA	OK
104	15/07/2021	ZERO	0	0	0	0	0	0	12	0.000	0.000	0	NA	OK
106	15/07/2021	ZERO	0	0	0	0	0	0	0.1	0.000	0.000	0	NA	OK
107	15/07/2021	RW	1.4	0.153	0	0	0	90	4.413	0.000	0.000	0	NA	test on RPM correction, noy used
108	15/07/2021	RW	1.4	0.153	0	0	0	90	4.418	0.000	0.000	0	NA	Foil phase improved
109	15/07/2021	RW	1.6	0.2	0	0	0	90	3.927	0.000	0.000	0	NA	Foil phase improved
110	15/07/2021	RW	1.8	0.253	0	0	0	90	3.436	0.000	0.000	0	NA	Foil phase improved
111	15/07/2021	RW	2	0.31	0	0	0	90	2.142	0.000	0.000	0	NA	Foil phase improved
112	15/07/2021	RW	2	0.31	0	0	0	90	3.142	0.000	0.000	0	NA	Foil phase improved
113	15/07/2021	RW	2.2	0.31	0	0	0	90	2.847	0.000	0.000	0	NA	Foil phase improved
114	15/07/2021	RW	2.4	0.31	0	0	0	90	2.553	0.000	0.000	0	NA	Foil phase improved
0	Foil 1 moved to 4 degree pitch													
118	16/07/2021	DRY	IN AIR	0	0	0	0	0	0.1	0.000	0.000	4	NA	OK
119	16/07/2021	DRY	IN AIR	0	0	0	0	0	1	0.000	0.000	4	NA	OK
120	16/07/2021	DRY	IN AIR	0	0	0	0	0	2	0.000	0.000	4	NA	OK
121	16/07/2021	DRY	IN AIR	0	0	0	0	0	5	0.000	0.000	4	NA	OK
122	16/07/2021	DRY	IN AIR	0	0	0	0	0	12	0.000	0.000	4	NA	OK
0	placing model in water													
123	16/07/2021	ZERO	0	0	0	0	0	0	0.1	0.000	0.000	4	NA	OK
124	16/07/2021	ZERO	0	0	0	0	0	0	1	0.000	0.000	4	NA	OK
125	16/07/2021	ZERO	0	0	0	0	0	0	2	0.000	0.000	4	NA	OK
126	16/07/2021	ZERO	0	0	0	0	0	0	5	0.000	0.000	4	NA	OK
127	16/07/2021	ZERO	0	0	0	0	0	0	12	0.000	0.000	4	NA	OK
128	16/07/2021	RW	1.4	0.153	0	0	0	90	4.418	0.000	0.000	4	NA	OK
129	16/07/2021	RW	1.6	0.2	0	0	0	90	3.927	0.000	0.000	4	NA	OK
130	16/07/2021	RW	1.8	0.253	0	0	0	90	3.436	0.000	0.000	4	NA	problem with friction

Table 3-3: Model testing with one foil only

Test num	Date	Wave type	T/Ip(s)	H/Hs(m)	TZ_s	HZ_m	Gamma	Foil phase	Vrotor_Rad_sec	Added vel. Amp(deg/s)	Added vel. period (s)	Pitch1	Pitch2	Comments
0	removed the model and tightened the fairings													
132	16/07/2021	ZERO	0	0	0	0	0	0	0.1	0.000	0.000	4	NA	OK
133	16/07/2021	ZERO	0	0	0	0	0	0	1	0.000	0.000	4	NA	OK
134	16/07/2021	ZERO	0	0	0	0	0	0	2	0.000	0.000	4	NA	OK
135	16/07/2021	ZERO	0	0	0	0	0	0	5	0.000	0.000	4	NA	OK
136	16/07/2021	ZERO	0	0	0	0	0	0	12	0.000	0.000	4	NA	OK
138	16/07/2021	RW	1.2	0.113	0	0	0	90	5.203	0.000	0.000	4	NA	phase shift is wrong
140	16/07/2021	RW	1.2	0.113	0	0	0	90	5.203	0.000	0.000	4	NA	OK
141	16/07/2021	RW	1.4	0.153	0	0	0	90	4.418	0.000	0.000	4	NA	OK
142	16/07/2021	RW	1.6	0.2	0	0	0	90	3.927	0.000	0.000	4	NA	OK
143	16/07/2021	RW	1.8	0.253	0	0	0	90	3.436	0.000	0.000	4	NA	OK
144	16/07/2021	RW	2	0.31	0	0	0	90	3.142	0.000	0.000	4	NA	video started too late
145	16/07/2021	RW	2.2	0.31	0	0	0	90	2.847	0.000	0.000	4	NA	OK
146	16/07/2021	RW	2.4	0.31	0	0	0	90	2.553	0.000	0.000	4	NA	OK
149	19/07/2021	ZERO	0	0	0	0	0	0	3.927	12.272	2.560	4	NA	OK
150	19/07/2021	ZERO	0	0	0	0	0	0	3.142	21.206	1.481	4	NA	OK
151	19/07/2021	ZERO	0	0	0	0	0	0	3.142	9.817	3.200	4	NA	OK
152	19/07/2021	ZERO	0	0	0	0	0	0	1.571	4.909	6.400	4	NA	OK
154	19/07/2021	RW	2	0.31	0	0	0	45	3.142	0.000	0.000	4	NA	OK
155	19/07/2021	RW	2	0.31	0	0	0	60	3.142	0.000	0.000	4	NA	OK
156	19/07/2021	RW	2	0.31	0	0	0	70	3.142	0.000	0.000	4	NA	OK
157	19/07/2021	RW	2	0.31	0	0	0	110	3.142	0.000	0.000	4	NA	Torque overload, test stopped
158	19/07/2021	RW	2	0.31	0	0	0	110	3.142	0.000	0.000	4	NA	OK
159	19/07/2021	RW	2	0.31	0	0	0	135	3.142	0.000	0.000	4	NA	Torque overload, test stopped
160	19/07/2021	RW	2	0.31	0	0	0	135	3.142	0.000	0.000	4	NA	OK
161	19/07/2021	ZERO	0	0	0	0	0	0	3.142	0.000	0.000	4	NA	OK
0	changed pitch to -4 deg													
162	19/07/2021	ZERO	0	0	0	0	0	0	0.1	0.000	0.000	-4	NA	OK
164	19/07/2021	ZERO	0	0	0	0	0	0	1	0.000	0.000	-4	NA	OK
165	19/07/2021	ZERO	0	0	0	0	0	0	2	0.000	0.000	-4	NA	OK
166	19/07/2021	ZERO	0	0	0	0	0	0	3.142	0.000	0.000	-4	NA	0
167	19/07/2021	ZERO	0	0	0	0	0	0	3.927	0.000	0.000	-4	NA	OK
169	19/07/2021	ZERO	0	0	0	0	0	0	12	0.000	0.000	-4	NA	OK
170	19/07/2021	ZERO	0	0	0	0	0	0	3.142	9.817	3.200	-4	NA	OK
171	19/07/2021	ZERO	0	0	0	0	0	0	2.553	0.000	0.000	-4	NA	OK
172	19/07/2021	RW	2	0.31	0	0	0	90	3.142	0.000	0.000	-4	NA	OK
0	changed pitch to -8 deg													
173	19/07/2021	ZERO	0	0	0	0	0	0	3.142	9.817	3.200	-8	NA	OK
174	19/07/2021	ZERO	0	0	0	0	0	0	3.142	0.000	0.000	-8	NA	OK
175	20/07/2021	RW	2	0.31	0	0	0	90	3.142	0.000	0.000	-8	NA	OK
0	changed pitch to -4 deg													
176	20/07/2021	ZERO	0	0	0	0	0	0	0.1	0.000	0.000	-4	NA	OK
177	20/07/2021	ZERO	0	0	0	0	0	0	3.142	0.000	0.000	-4	NA	OK
178	20/07/2021	ZERO	0	0	0	0	0	0	5	0.000	0.000	-4	NA	OK

Table 3-4: Model testing with one foil only



Test num	Date	Wave type	T/Tp(s)	H/Hs(m)	TZ_s	H2_m	Gamma	Foil phase	Vrotor_Rad_sec	Added vel. Amp(deg/s)	Added vel. period (s)	Pitch1	Pitch2	Comments
0	ADDING foil 2 @ 0deg pitch													
180	20/07/2021	ZERO	0	0	0	0	0	0	0.1	0.000	0.000	0	0	touching fairing
181	20/07/2021	ZERO	0	0	0	0	0	0	0.1	0.000	0.000	0	0	OK
182	20/07/2021	ZERO	0	0	0	0	0	0	1	0.000	0.000	0	0	OK
183	20/07/2021	ZERO	0	0	0	0	0	0	3.142	0.000	0.000	0	0	OK
185	20/07/2021	ZERO	0	0	0	0	0	0	5	0.000	0.000	0	0	OK
186	20/07/2021	ZERO	0	0	0	0	0	0	12	0.000	0.000	0	0	OK
187	20/07/2021	RW	1.8	0.253	0	0	0	90	3.436	0.000	0.000	0	0	OK
188	20/07/2021	RW	2	0.31	0	0	0	90	3.142	0.000	0.000	0	0	OK
189	20/07/2021	RW	2.2	0.31	0	0	0	90	2.847	0.000	0.000	0	0	Rotor did not engage
190	20/07/2021	RW	2.2	0.31	0	0	0	90	2.847	0.000	0.000	0	0	OK
191	20/07/2021	RW	2.4	0.31	0	0	0	90	2.553	0.000	0.000	0	0	OK
192	20/07/2021	RW	2.4	0.31	0	0	0	NA	free	0.000	0.000	0	0	Free wheeling for zero speed then motored to constant speed followed by free wheeling
193	21/07/2021	ZERO	0	0	0	0	0	90	1.047	0.000	0.000	0	0	OK
195	21/07/2021	ZERO	0	0	0	0	0	90	1.571	0.000	0.000	0	0	OK
196	21/07/2021	ZERO	0	0	0	0	0	90	2.095	0.000	0.000	0	0	OK
197	21/07/2021	ZERO	0	0	0	0	0	90	4.189	0.000	0.000	0	0	OK
198	21/07/2021	ZERO	0	0	0	0	0	90	4.713	0.000	0.000	0	0	OK
199	21/07/2021	ZERO	0	0	0	0	0	90	6.284	0.000	0.000	0	0	OK
201	21/07/2021	RW	2	0.31	0	0	0	90	1.047	0.000	0.000	0	0	OK
203	21/07/2021	RW	2	0.31	0	0	0	90	1.571	0.000	0.000	0	0	OK
204	21/07/2021	RW	2	0.31	0	0	0	90	2.095	0.000	0.000	0	0	Wavemaker error
205	21/07/2021	RW	2	0.31	0	0	0	90	2.095	0.000	0.000	0	0	error in phase angle
206	21/07/2021	RW	2	0.31	0	0	0	90	2.095	0.000	0.000	0	0	OK
208	21/07/2021	RW	2	0.31	0	0	0	90	4.189	0.000	0.000	0	0	OK
209	21/07/2021	RW	2	0.31	0	0	0	90	4.713	0.000	0.000	0	0	OK
210	21/07/2021	RW	2	0.31	0	0	0	90	6.284	0.000	0.000	0	0	OK
211	21/07/2021	IW	2.2	0.18	0	0	0	0	4.418	0.000	0.000	0	0	OK
212	21/07/2021	IW	2.2	0.18	0	0	0	0	4.418	0.000	0.000	0	0	OK
213	21/07/2021	IW	2.2	0.18	0	0	0	0	4.418	0.000	0.000	0	0	OK
214	21/07/2021	IW	2.2	0.18	0	0	0	0	4.418	0.000	0.000	0	0	Rotor interrupted during run probable overspeed error
215	21/07/2021	IW	2.2	0.18	0	0	0	0	4.418	0.000	0.000	0	0	OK
216	21/07/2021	RW	2	0.31	0	0	0	90	3.142	0.000	0.000	0	0	repeat test

Table 3-5: Model testing with two foils



Test num	Date	Wave type	T/Tp(s)	H/Hs(m)	TZ_s	HZ_m	Gamma	Foil phase	Vrotor_Rad_sec	Added vel. Amp(deg/s)	Added vel. period (s)	Pitch1	Pitch2	Comments
0	changed pitch to 1 @ -4deg and 2 @ 4deg													
219	21/07/2021	ZERO	0	0	0	0	0	0	0.1	0.000	0.000	-4	4	OK
220	21/07/2021	ZERO	0	0	0	0	0	0	0.1	0.000	0.000	-4	4	OK
221	21/07/2021	ZERO	0	0	0	0	0	0	1	0.000	0.000	-4	4	OK
222	21/07/2021	ZERO	0	0	0	0	0	0	2	0.000	0.000	-4	4	OK
223	21/07/2021	ZERO	0	0	0	0	0	0	5	0.000	0.000	-4	4	OK
225	21/07/2021	RW	1.4	0.153	0	0	0	90	4.418	0.000	0.000	-4	4	OK
226	21/07/2021	RW	1.6	0.2	0	0	0	90	3.927	0.000	0.000	-4	4	OK
227	21/07/2021	RW	1.8	0.253	0	0	0	90	3.436	0.000	0.000	-4	4	OK
228	21/07/2021	RW	2	0.31	0	0	0	90	3.142	0.000	0.000	-4	4	video started too late
229	21/07/2021	RW	2.2	0.31	0	0	0	90	2.847	0.000	0.000	-4	4	OK
230	22/07/2021	RW	2.4	0.31	0	0	0	90	2.553	0.000	0.000	-4	4	OK
231	22/07/2021	BiW	2	0.186	1.6	0.072	1.6	90	3.142	0.000	0.000	-4	4	OK
232	22/07/2021	BiW	2	0.186	1.8	0.09	1.6	90	3.142	0.000	0.000	-4	4	OK
234	22/07/2021	BiW	2	0.186	2.4	0.1116	1.6	90	3.142	0.000	0.000	-4	4	OK
235	22/07/2021	RW	1.8	0.253	0	0	0	45	3.436	0.000	0.000	-4	4	touching fairing
236	22/07/2021	RW	1.8	0.253	0	0	0	45	3.436	0.000	0.000	-4	4	OK
237	22/07/2021	RW	1.8	0.253	0	0	0	70	3.436	0.000	0.000	-4	4	OK
238	22/07/2021	RW	1.8	0.253	0	0	0	90	3.436	0.000	0.000	-4	4	OK
239	22/07/2021	RW	1.8	0.253	0	0	0	110	3.436	0.000	0.000	-4	4	OK
240	22/07/2021	RW	1.8	0.253	0	0	0	135	3.436	0.000	0.000	-4	4	OK
241	22/07/2021	RW	2	0.31	0	0	0	90	3.142	0.000	0.000	-4	4	OK
242	22/07/2021	RW	2	0.31	0	0	0	90	3.142	0.000	0.000	-4	4	Constant speed then switch to free wheeling to see if the system can be driven by waves.
0	changed pitch to 1 @ 4deg and 2 @ -4deg													
243	22/07/2021	ZERO	0	0	0	0	0	0	0.1	0.000	0.000	4	-4	OK
244	22/07/2021	BiW	1.6	0.12	1.8	0.09	0	90	3.927	0.000	0.000	4	-4	OK
245	22/07/2021	BiW	1.6	0.12	2	0.1116	0	90	3.927	0.000	0.000	4	-4	OK
246	22/07/2021	BiW	1.6	0.12	2.4	0.1116	0	90	3.927	0.000	0.000	4	-4	OK
0	00/01/1900	0	0	0	0	0	0	0	0	0.000	0.000	0	0	0
247	22/07/2021	RW	2.4	0.31	0	0	0	90	2.553	0.000	0.000	4	-4	Constant speed then switch to free wheeling to see if the system can be driven by waves.
0	changed pitch to 1 @ -8deg and 2 @ 8deg													
248	23/07/2021	RW	1.8	0.253	0	0	0	90	3.436	0.000	0.000	-8	8	OK
249	23/07/2021	ZERO	0	0	0	0	0	0	0.1	0.000	0.000	-8	8	OK
250	23/07/2021	RW	2	0.31	0	0	0	90	3.142	0.000	0.000	-8	8	OK
251	23/07/2021	RW	2.2	0.31	0	0	0	90	2.847	0.000	0.000	-8	8	OK
252	23/07/2021	RW	2.4	0.31	0	0	0	90	2.553	0.000	0.000	-8	8	OK
253	23/07/2021	RW	2.2	0.31	0	0	0	90	2.847	0.000	0.000	-8	8	OK
254	23/07/2021	RW	2.2	0.31	0	0	0	90	2.847	0.000	0.000	-8	8	OK
255	23/07/2021	RW	2.4	0.31	0	0	0	90	2.553	0.000	0.000	-8	8	OK
256	23/07/2021	RW	2.4	0.31	0	0	0	90	2.553	0.000	0.000	-8	8	OK
0	changed pitch to 1 @ -4deg and 2 @ 4deg													
257	23/07/2021	ZERO	0	0	0	0	0	0	0.1	0.000	0.000	-4	4	OK
258	23/07/2021	BiW	2	0.186	1.8	0.09	1.6	90	3.142	0.000	0.000	-4	4	OK
259	23/07/2021	BiW	2	0.186	1.8	0.09	1.6	90	3.142	0.000	0.000	-4	4	OK
260	23/07/2021	RW	2	0.31	0	0	0	90	3.142	0.000	0.000	-4	4	OK
261	23/07/2021	RW	2.4	0.31	0	0	0	90	2.553	0.000	0.000	4	-4	OK
262	23/07/2021	RW	2.4	0.31	0	0	0	90	2.553	0.000	0.000	4	-4	OK

Table 3-6: Model testing with two foils



4 TEST FILE

Each test files contains a time series of all parameters measured during testing. The name of the file for each test is “LIFTWEC_XXX.mat”, with XXX the test number described in the test matrix section.

The list of channels is different for the wave calibration series in Table 3-1 and all other tests for model testing. During wave calibration, the list of channels in the data elements are:

- 1 column with time in second. Zero value corresponds to the time when the wave generation system starts.
- 2 columns with wavemaker trigger in binary format and in Volts. This does not need to be used for analysis, all channels are synchronised in time.
- 11 columns with Wave gauges 1 to 11 measurement in meter.

During model testing, the list of channels in the data elements are:

- 1 column with time in second. Zero value corresponds to the time when the wave generation system starts.
- 2 columns with wavemaker trigger in binary format and in Volts. This does not need to be used for analysis, all channels are synchronised in time.
- 11 columns with Wave gauges (WG) 1 to 11 measurement in meter (WG5 was removed and the WG5 data should not be used).
- 8 columns with force measurement (F) from the 8 load cells on the model.
- The rotor speed in radian/s
- The motor estimated torque in Nm
- The torque measured at the torque meter in Nm
- The rotor absolute position in degrees

5 DESCRIPTION OF SENSORS AND MEASURED PARAMETERS

5.1 WAVE GAUGES

During wave calibration, without model in the basin, eleven wave gauges, 0.6m long, were measuring water surface elevation. The list of wave gauges and locations are in Table 5-1 and Figure 2-2. This setup allows measurement of the reflected waves in front and behind the model with four wave gauges aligned at the centre of the sub-channel either side of the model. In addition, two wave gauges placed either side of WG4 in the direction perpendicular to the wave propagation direction gives an estimate of the radial waves in the sub-channel.

During model testing, the wave gauge number 5 was removed to give place to the model rotor and foils.



Wave gauge ID	Wave gauge length (m)	Position X (m) (distance to paddles)	Position Y (m) (Relative to basin centre)	Comments
1	0.6	47.8	0	
2	0.6	47.95	0	
3	0.6	48.3	0	
4	0.6	49	0	
5	0.6	50	0	Only during calibration
6	0.6	51	0	
7	0.6	51.15	0	
8	0.6	51.5	0	
9	0.6	52.2	0	
10	0.6	49	0.12	
11	0.6	49	-0.12	

Table 5-1: Position of wave gauges in the basin (model scale)



5.2 LOAD CELLS

Eight load cells measured the load applied from the two foils on the rotor arms. Two are located on either side of each foil and measure the load in radial and tangential directions. The radial direction is parallel to the line passing through the centre of the rotor and the centre of the foil (half of the cord length). The tangential direction is perpendicular to the radial direction. The list of load cells and their location is in Table 5-2

Sensor	Direction	Side	Foil
F1	Radial	Motor	1
F2	Tangential	Motor	1
F3	Radial	Motor	2
F4	Tangential	Motor	2
F5	Radial	Collector	1
F6	Tangential	Collector	1
F7	Radial	Collector	2
F8	Tangential	Collector	2

Table 5-2: List of load cells and location

The radial force is positive when the force applied by the foil on the rotor is directed away from the centre of rotation. The tangential force is positive when the force applied by the foil on the rotor is directed towards the leading edge, in this direction the foil is accelerating the rotor or generating power.

5.3 PTO TORQUE

A torque transducer, DRBK II 100 A produced by the German company ETH-messtechnik, with a torque rating of 100Nm, measured the torque on the motor shaft. It is located in the motor dry enclosure in series between the motor shaft and the main rotor shaft, arms and foils.

5.4 ANGULAR POSITION

A magnetic encoder measures the rotor angular position, it is placed in the dry enclosure on the slip ring side of the model, opposite to the motor side. The moving part is attached to the shaft in line with the motor and torque meter and it has a resolution of 4096 pulses per turn corresponding to an angle of 0.09 degree. The encoder is produced by the German company Automation Sensorik Messtechnik



(ASM). The magnetic disk model is PMIR5-50-64-M-83-AB and that of the reader head is PMIS4-50-64-20KHZ-TTL-Z3-3M-S

The angle value is zero when the line passing through the centre of the rotor and the centre of the foil (half of the cord length) is vertical and the foil 1 is at its highest position. The recorded value is wrapped between 0 and 360 degrees.

