EXploiting Tidal Renewable Energy and reducing MArine Litter by a FLOATing barriER

Project Acronym EXTREMAL-FLOATER

Project Reference Number 3222

Infrastructure Accessed CRIACIV_LABIMA - Wave Current Flume

Infrastructure Access Reports

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MaRINET2

ABOUT MARINET

The MaRINET2 project is the second iteration of the successful EU funded MaRINET Infrastructures Network, both of which are coordinated and managed by Irish research centre MaREI in University College Cork and avail of the Lir National Ocean Test Facilities.

MaRINET2 is a €10.5 million project which includes **39 organisations** representing some of the top offshore renewable energy testing facilities in Europe and globally. The project depends on strong international ties across Europe and draws on the expertise and participation of **13 countries**. Over 80 experts from these distinguished centres across Europe will be descending on Dublin for the launch and kick-off meeting on the 2nd of February.

The original MaRINET project has been described as a *"model of success that demonstrates what the EU can achieve in terms of collaboration and sharing knowledge transnationally".* Máire Geoghegan-Quinn, European Commissioner for Research, Innovation and Science, November 2013

MARINET2 expands on the success of its predecessor with an even greater number and variety of testing facilities across offshore wind, wave, tidal current, electrical and environmental/cross-cutting sectors. The project not only aims to provide greater access to testing infrastructures across Europe, but also is driven to improve the quality of testing internationally through standardisation of testing and staff exchange programmes.

The MaRINET2 project will run in parallel to the MaREI, UCC coordinated EU marinerg-i project which aims to develop a business plan to put this international network of infrastructures on the European Strategy Forum for Research Infrastructures (ESFRI) roadmap.

The project will include at least 5 trans-national access calls where applicants can submit proposals for testing in the online portal. Details of and links to the call submission system are available on the project website www.marinet2.eu

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1 Introduction & Background

1.1 Introduction

Tidal stream power is a highly dense renewable energy source, which has the favourable feature of being predictable. Its harvesting is the aim of many technological initiatives contributing to the development of renewable energy sector, one of the main societal challenges. A second major societal challenge is to cope with the marine litter, an issue that is presently growing to the attention of both the scientific research and the technological sector. EXTREMAL-FLOATER project deals with an innovative concept of hybrid structure, where the tidal turbine is integrated into floating barriers conceived to cope with marine litter.

Tidal turbines, installed in hostile oceanic environments, are subject to relevant hydrodynamic loads which contribute to fatigue and should be accurately quantified over the entire lifetime of the device. Such a quantification is crucial to the efficient and cost-effective design of tidal turbines [1,2]. Both the performance of a tidal turbine and the hydrodynamic loads acting on it are strongly design and installation site dependent (e.g. the support structure has been proven to have a relevant effect on both these aspects [3]). It is therefore essential to perform specific study for the foreseen design and met-ocean conditions of installation.

AM3 srl is studying the performance of different tidal stream turbines in the framework of a roadmap toward the development its own technology. SEADS ltd has proposed special floating barriers to prevent the dispersion into the sea of plastic debris coming from river mouths.

The integration of tidal turbines in such a system results in an innovative concept, allowing to jointly cope with the fundamental challenges: producing clean renewable energy and reducing plastics debris in the marine environment.

The synergic interaction between the floating barriers and the tidal turbine could concern, e.g., the following positive aspects:

(i) The floating barriers, blocking the propagation of plastic debris downstream, would create clean flow conditions, limiting the possibility of damage/obstruction of the turbine, hence increasing both structural safety and the electricity production;

(ii) The converted energy could be used directly onsite, e.g. to power conveyor belts or other electrical equipment needed for the plastic debris collection system;

(iii) The barriers shape could also be optimized in order to create favourable conditions for increasing the performance of the turbine and controlling the hydrodynamic loads.

SEADS ltd barriers concentrate the water stream toward a filtration system. The installation of the turbine after the filtration system might enhance the turbine performance. Moreover, the performance is also affected by the feature of the ambient flow turbulence [4,5]. In the system studied here, a relevant impact on the downstream turbulence is expected to be caused by the presence of the floating barriers, possibly improving turbulence conditions in favour of the turbine if adequate position will be studied.

The effect of the barriers on the hydrodynamic loadings acting on the turbine must also be carefully quantified prior to proceeding to the detailed design stage of such a system.

The proposed systems are tested in a small-scale model in a LABIMA wave-current flume, under the influence of a range of realistic met ocean conditions taken from hindcast data and representative of possible installation sites.

1.2 Development So Far

1.2.1 Stage Gate Progress

Previously completed: ✓

Planned for this project: ➲

STAGE GATE CRITERIA	Status
Stage 1 – Preliminary studies	
• Numerical modelling of the SEADS Its Blue Barriers	✓
• Design and Test of a bottom-mounted tidal turbine	✓
• Selection of realistic met ocean conditions taken from hindcast data	✓
Stage 2 – Model design and construction	
• Select Blue Barriers (SEADS Its) model scale based on LABIMA flume size	✓
• Select turbine model scale based on LABIMA flume size	✓
• Produce the Blue Barriers small-scale model (SEADS Its)	✓
• Produce CAD model of turbine blades and manufacture by SLS	✓
• Install strain gauge array and generator to record deflection and turbine performance	➲
Stage 3 – Experimental Testing	
• Investigate the Blue Barriers (SEADS Its) efficiency for different configurations and flow conditions.	➲
• Investigate structural deflection and performance of the turbine integrated in a floating barrier under a range of wave and tidal flow conditions, to include: • Upstream-facing blades • Waves with tidal flow	➲
Stage 4 – Long-term development	
• Generate annual turbine performance forecasts for benign, moderate and extreme years	
• To quantify survival conditions and mooring behaviour	

1.2.2 Preparatory work and pervious tests

Relevant preparatory work for this project had been carried out before the EXTREMAL-FLOATER tests at the wave-current flume of Florence University, LABIMA-WCF, concerning both tidal turbine testing and SEADS barriers testing.

As far as the turbine model is concerned, a previous experimental campaign, funded by MaRINET2 through the SPECuWaTT trans-national access project [6] and [7] has been completed. Such previous tests were mainly aimed at expanding the knowledge base on the impact of concurrent wave and current on a tidal turbine (Fig. 1). Turbine performance and structural deflection data were collected and analysed.

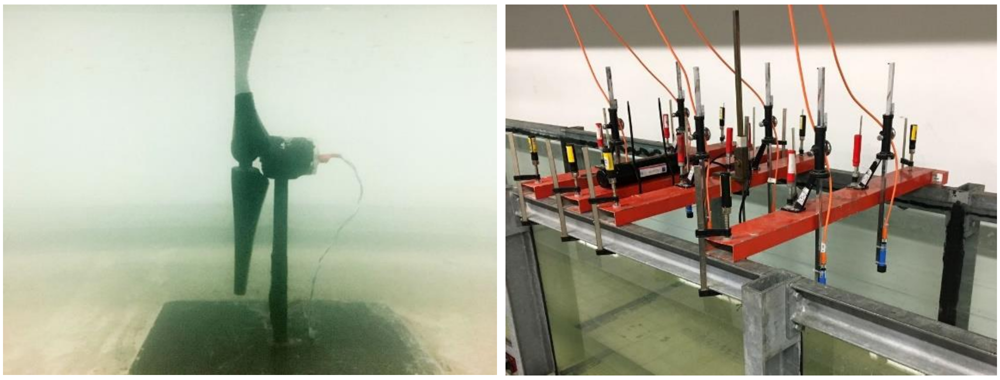

Figure 1: Bottom-fixed tidal turbine tested at LABIMA-WCF during the SPECuWaTT MaRINET2 project.

The Blue Barriers system proposed by SEADS ltd are composed of two floating barriers moored to the riverbed that serve to divert from the main stream the waste that floats on the water and trap it in a collection basin where it can be easily removed [8] (Fig. 2, left). As preparatory work carried out before this access, a numerical study commissioned by SEADS ltd [9] was performed at LABIMA to assess: i) the effectiveness of the device in holding floating waste for a set of design configurations, ii) the modifications induced on a water current in terms of elevations of the free surface and velocity field (Fig. 2, right). Numerical simulations had been implemented at the laboratory-scale model, in order to also aid in the develop the final design of the experimental activities to be conducted at LABIMA infrastructure in the framework of the EXTREMEAL-FLOATER project. Moreover, an experimental validation of the results obtained in such a preliminary study will be provided by the laboratory data collected in this access.

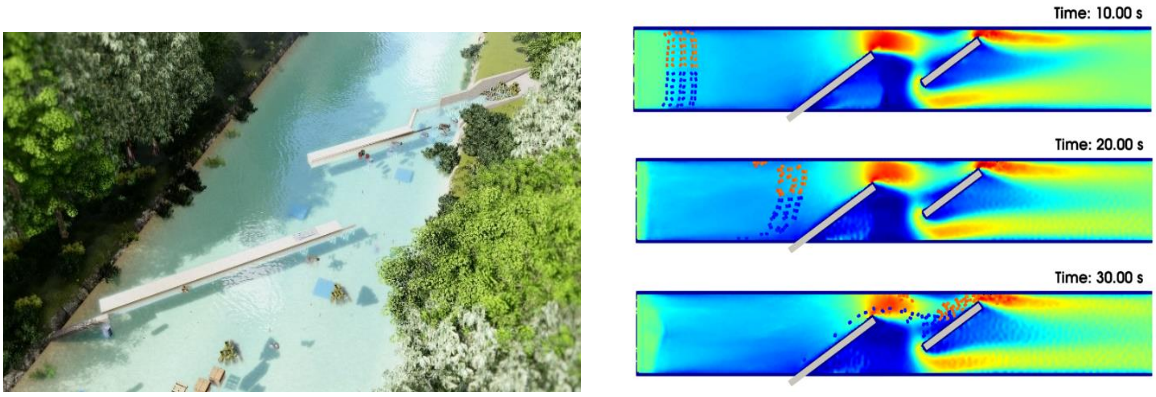

Figure 2: The Blue Barriers patented by SEADS [1] (left); Velocity fields at the free surface and floating objects position obtained in the numerical model for a specific barrier geometry and flow condition [9] (right).

1.2.3 Plan for this Access

The objective for this trans-national access were to study:

i) the plastic collection efficiency of the Blue Barriers patented by SEADS ltd for different geometry configurations (tests referred to, hereafter, as *FB tests*, i.e. *Floating Barrier tests*);

ii) the effect of floating barriers on the turbine performance and the hydraulic loads acting on the turbine connected to a floating barrier (tests referred to, hereafter, as *FBT tests*, i.e. *Floating Barrier + Turbine tests*).

Different flow conditions arrangements of the *FB* and of the *FBT* systems have been tested, in order to comparatively assess the effect of the investigated parameters on the plastic collection efficiency (*FB tests*) or on the turbine performance and hydrodynamic loads (*FBT tests*).

The effect of integrating the turbine in the barrier will be evaluated by means of a comparison with the performance and the hydraulic loads of the same turbine in isolated-bottom mounted conditions (i.e., not connected to a floating barrier), as previously tested during the *SPECuWaTT - Structural and Performance Effects of Current and Waves on Tidal Turbine* – project [6].

2 Outline of Work Carried Out

Laboratory tests were carried out on two different scale models:

(i) The Floating Barriers (*FB)* model, aimed to assess the plastic collection efficiency of the Blue Barriers. Such tests are described in *Section 2.1*.

(ii) The model of the turbine connected to a floating barrier (*FBT)*. Such tests are described in *Section 2.2*.

Both models were tested in LABIMA-WCF. LABIMA-WCF is a structure completely made of steel and glass side walls, with a total length of 3700 cm, and a width and height of 80 cm. The piston type wave generator is installed at one end of the wave flume and it has a stroke equal to 150 cm, driven by an electromechanical system with an absolute encoder of 0.01 cm accuracy in position. The WCF is equipped with a bi-directional recirculation system with maximum flow rate of 150 l/s.

2.1 The Floating Barrier tests (FB tests)

2.1.1 The FB model

The scale *FB model* was designed according to Froude similarity and the geometrical scale chosen is 1:20. The model of the barriers have been provided by SEADS ltd and is shown in Fig. 3. Each barrier model was composed by joining 6 barrier units (Fig. 3, right), made of polyvinyl chloride material.

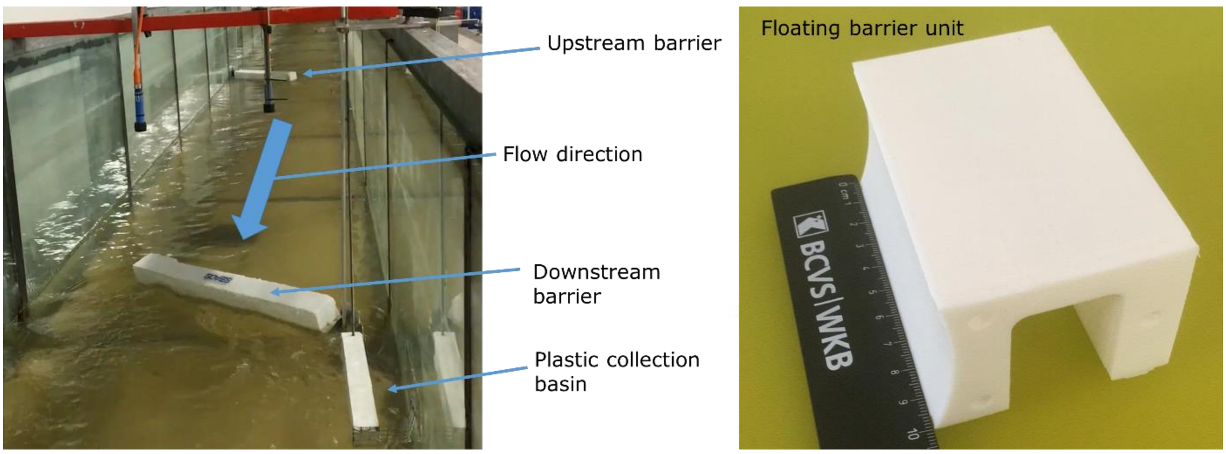

Figure 3: Layout at Laboratory scale.

The basic dimensions and characteristics of the barrier models were the following (symbols as in the definition sketch in Fig. 4):

- Barrier length, La=Lb=0.6 m;
- Barrier width, b=0.065 m;
- Barrier height, g=0.05 m;
- Width of collection basin, c=0.07 m;
- Distance between upstream and downstream barrier, D=5, 15, 12 m;
- Barrier inclination, α=30-45°;
- Water level in the WCF, h=0.2 m.

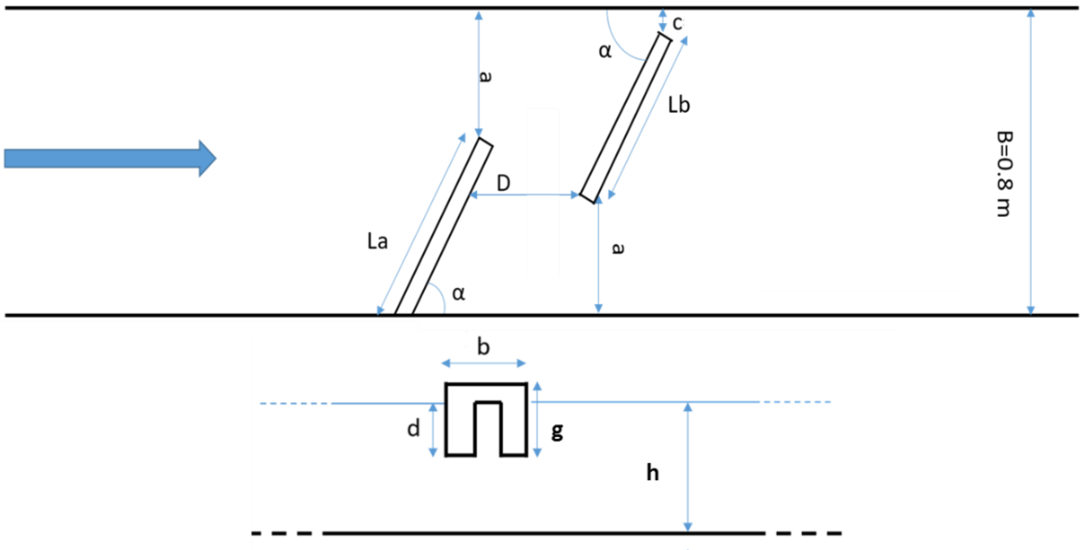

Figure 4: Definition sketch of the *FB model*: plain view (top) and cross section view (bottom).

The barriers were moored by using vertical stainless-steel bars, connected to the WCF bottom by means of metal plates.

In order to assess the plastic collection capability of the barriers, laboratory-scaled floating objects were released in the WCF. As floating objects, plastic floaters with characteristic size between 1 and 2 cm have been used. The plastic floaters were specifically selected to be representative of HDPE (high-density polyethylene) and LDPE (low-density polyethylene).

To calculate the effectiveness of the *FB model*, the number of floating objects collected in the collection basin have been counted. The effectiveness, expressed by Φ [%], can be computed as the ratio of the retained objects over the total.

2.1.2 Wave-Current flume set-up & Instrumentation

The sketch of the FB model position in the WCF is reported in Fig. 5. The WCF was instrumented with 5 ultrasonic Wave Gauges (WGs), to measure the effect of the barriers on the water surface level. The details of the locations from the paddle is given in Fig. 5. The employed WGs measure the free surface displacement with an accuracy of 1 mm at a distance from the sensor in the range 60-500 mm and belong to Series 943-M18-F4V-2D-1C0-330E by HONEYWELL (Fig. 6).

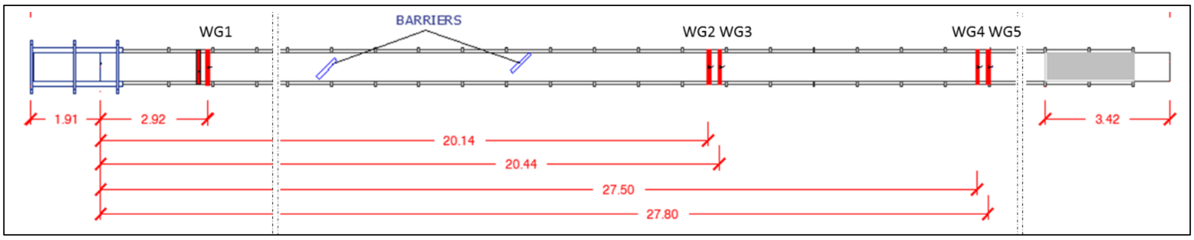

Figure 5: Experimental set-up of the WCF for the FB model tests, plan view.

Max. sensing distance:	500 mm
Min. sensing distance:	60 mm
Switching frequency:	100 ms
Repeatability:	0,2 % or ±1 mm

OUTPUT	TERMINATION	REFERENCE
0-10 V	Connector	943-F4V-2D-1C0-330E
0-10 V	Cable	943-F4Y-2D-1C0-330E
4-10 mA	Connector	943-F4V-2D-1D0-330E
4-20 mA	Cable	943-F4Y-2D-1D0-330E

Figure 6: Ultrasonic wave gauges HONEYWELL Series 943-M18-F4V-2D-1C0-330E (left) and technical data sheet (right).

2.1.3 Test Matrix

The performance of the *FB model* was tested under 5 different flow rate conditions (codes V1-V5 in Table 1. The test matrix, with the definition of the barriers' geometry configurations tested, is reported in Table 2.

Table 1: Flow conditions tested for the FB model.

Flow code	Velocity (prototype scale) [m/s]	Velocity (model scale) [m/s]	Flow rate [l/s]
V1	1.0	0.23	36.2
V2	1.5	0.34	54.4
V3	2.0	0.45	72.4
V4	2.5	0.57	90.5
V5	3.0	0.68	108.6

Table 2: Test matrix showing naming of the tests, flow condition and FB configuration tested. Symbols as in Fig. 4.

Test code	Flow condition	D [m]	α	h [m]
C2V1A3050PZ	V1	5	30	0.2
C2V2A3050PZ	V2	5	30	0.2
C2V3A3050PZ	V3	5	30	0.2
C2V4A3050PZ	V4	5	30	0.2
C2V5A3050PZ	V5	5	30	0.2
C2V1A4550PZ	V1	5	45	0.2
C2V2A4550PZ	V2	5	45	0.2
C2V3A4550PZ	V3	5	45	0.2
C2V4A4550PZ*	V4	5	45	0.2
C2V5A4550PZ*	V5	5	45	0.2
C3V1A3050PZ	V1	15	30	0.2
C3V2A3050PZ	V2	15	30	0.2
C3V3A3050PZ	V3	15	30	0.2
C3V4A3050PZ	V4	15	30	0.2
C3V5A3050PZ*	V5	15	30	0.2
C4V4A3050PZ	V4	12	30	0.2
C4V5A3050PZ	V4	12	30	0.2

2.2 The Floating Barrier + Turbine tests (FBT tests)

2.2.1 The FBT model

The scale *FBT model* was designed according to Froude similarity and the geometrical scale chosen is 1:81. In this set of tests, a turbine model is connected to a floating barrier model (Fig. 7).

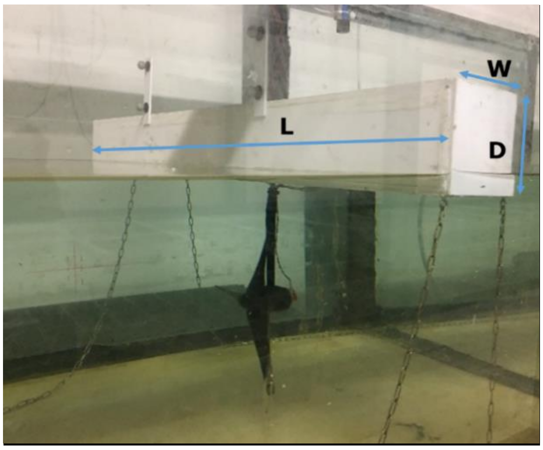

Figure 7: Turbine model on fixed base as in SPECuWaTT tests (l), and fixed to floating barrier as in FBT tests (r).

The floating barrier model has a parallelepiped shape and is made of made of polyvinyl chloride. The barrier model has the following basic dimensions and characteristics:

- Barrier dimensions (symbols as in Fig. 7, right): L x W x D=0.79 x 0.097 x 0.09 m;
- Barrier freeboard, Fb=0.072 m;
- Barrier weight: 1.169 kg;
- Water level in the WCF, h=0.3 m;

Four markers (Fig. 7, right) are attached to the floating barrier, to be used by the motion tracking system used to track the motion of the floater (described in *Section 2.2.2*). The total weight of the four ball markers is 6 g. A mooring system connected the scale barrier model to the wave flume bottom through four chains with a length of 1.115 m each. Each chain was connected to steel base, to hold the structure in position. The steel bases are located 0.9 m away from the barrier model (2 upstream and 2 downstream, as in Fig. 9, left).

The 1:81 scale turbine model used in this study was a three-blade horizontal axis turbine. The blade profile was based on that of a commercial design and was manufactured in polyacrylate at the University Of Sheffield Department Of Applied Inkjet Printing. As aforementioned, a similar turbine was previously tested in LABIMA-WCF in a bottom mounted configuration [6]. The turbine blades were each 100 mm from root to tip, with a 12° degree root-tip twist, a tip chord of 8 mm and a root chord of 26 mm. The blades were mounted on a nacelle, which was itself fixed to the turbine generator. No gearbox or other power transfer mechanisms were used. The support structure of the turbine was a simple 8 mm diameter cylindrical bar, connected to the floating barrier. The total weight of the turbine (including its support structure) is 0.142 kg.

2.2.2 Wave-Current flume set-up & Instrumentation

CAD schematics of the LABIMA Wave-current flume set-up for the *FBT model* tests during the EXTREMAL-FLOATER project are shown in Fig. 8 and Fig. 10. The *FBT model* is located 21.83 m away from the wavemaker and 12.6 m from the channel end.

An absorbing structure (wave dissipation ramp) was added to the channel to diffuse wave power and reduce reflection from the end of the channel. This perforated steel structure was 2.4 m in length and reached across the channel, angled upwards from the base to above the height of the highest waves to be tested. The absorbing structure used is shown in Fig. 8 (bottom) and Fig. 9 (right).

Turbulence is critical in water channel tests. Water flume turbulence characteristics must match those of real tidal installation cases, in order to ensure accurate replication of reality. Prior to testing, turbulence intensity and flow profiles in the WCF had been characterized, as documented in [6-7]. Turbulence-generating structures were installed in the flume in order to obtain turbulence intensities in the empty WCF comparable to those expected in a real tidal installation site. Turbulence-generating structures were installed both upstream and downstream of the turbine. A combination of blocks and mesh (denoted as "turbulence promote nets" in Fig. 8) were used. Cubic stone blocks of 120 mm width were installed with a cross-channel separation distance of 150 mm and a streamwise separation distance of 200 mm between rows (Fig. 9, left). Alternating rows of two and three blocks were used, covering a total distance of 2.4 m. The first and the second array of bricks were placed 11.5 m and 29.53 m away from the wave-maker, respectively (Fig. 8). Two turbulence promote nets, made of stainless steel and with a 12 mm grid size, ware installed across the channel and over its full depth, at a distance of 15.1 m and 28.33 m from the wave maker, respectively.

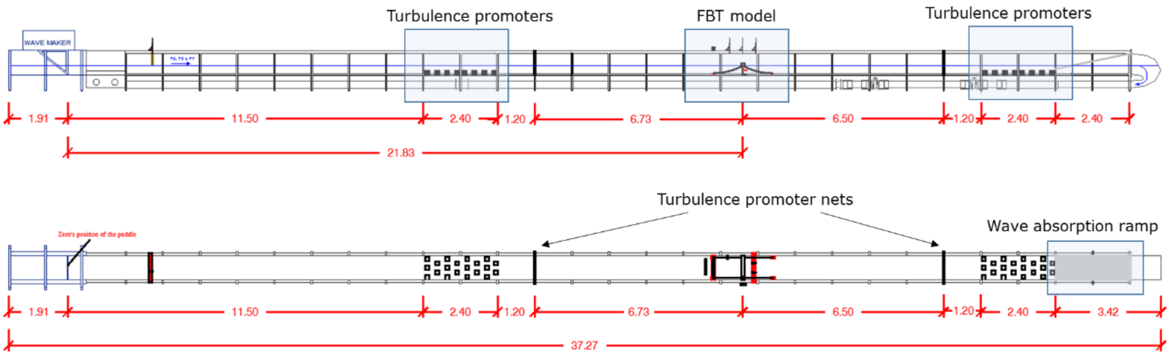

Figure 8: FBT model layout at Laboratory scale.

Figure 9: Turbulence-generating blocks (left) and wave absorbing structure (right).

The FBT model was equipped with the following instrumentation, described below (Fig. 10):

- Ultrasonic Wave Gauges (WGs);
- Optitrack Video motion Tracking system (VT);
- Strain Gauges (SGs).

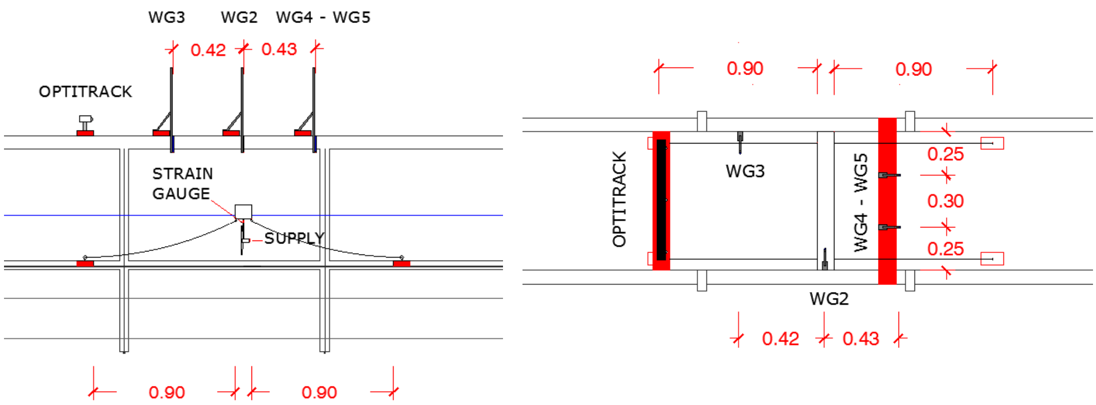

Figure 10: Position of the sensors and of the mooring system for the *FTB model*.

Ultrasonic Wave Gauges (WGs):

5 WGs have been used (Fig. 10). The employed WGs are of the Series 943-M18-F4V-2D-1C0-330E by HONEYWELL (described in Section 2.1.2 and Fig. 6). Location of the WGs is summarized in Table 3.

Table 3: Position of the WGs in the WCF for *FBT tests*.

Sensor Name	Distance from the wave-maker [m]	Sensor type
WG1	2.92	Ultrasonic Wave Gauges
WG2	21.83 right side of the WCF (on the floater)	Ultrasonic Wave Gauges
WG3	21.41 left side of the WCF	Ultrasonic Wave Gauges
WG4	22.26 right side of the WCF	Ultrasonic Wave Gauges
WG5	22.26 left side of the WCF	Ultrasonic Wave Gauges

Optitrack Video motion Tracking system (VT):

The VT system, used for tracking the movement of the floating barrier with six degrees of freedom (6DOF), was located perpendicular to the LABIMA-WCF axis, at a distance of 20.95 m from the wave paddle (see Fig. 10 and Fig. 11). A sketch of the coordinate system used for the obtained 6-DoF data is shown in Fig. 11-b. The calibration of the VT system was checked comparing the measurements with that of an ultrasonic wave gauge used to measure the motion of the barrier model.

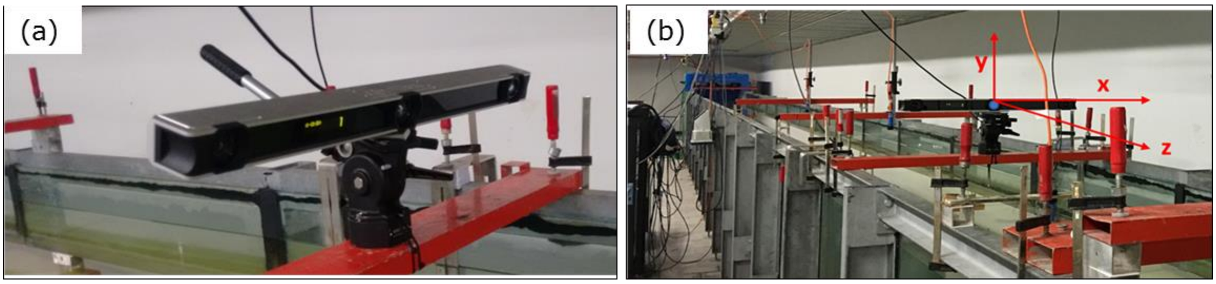

Figure 11: The VT OptiTrack video motion tracking system: the three cameras of the VT attached on a single axis (a); sketch of the coordinate system used for the VT system (b).

Strain gauges (SGs)

In order to measure performance and structural deflection, the turbine model was equipped with a generator and strain gauges (SGs). A small DC motor (model MFA RE-385) was used as a generator. The voltage produced by the generator was measured using the LABIMA Data Acquisition system. Since the key performance output of the turbine in this study is the relative power generation, generator output was not scaled or calibrated to rotational speed. Instead, generator voltage was used to give a direct comparison between cases.

The copper foil SGs (model BF350, 350Ω with sensitivity coefficient 2.1) were installed on the turbine support structure at a distance of 58.5 mm below the lower surface of the floating barrier. One gauge was installed on the upstream-facing portion of the support structure, and another perpendicular to this on the side of the support structure. Gauges were installed in a half-bridge configuration, and were supplied with 5V via the LABIMA data acquisition system and deflection recorded using the same system.

In order to correlate support structure deflection and strain gauge voltage output, the gauges were calibrated using a load cell. A rigid steel bar was fixed between the load cell and the centre of the nacelle, and the turbine was incrementally moved towards the load cell whilst recording both strain gauge and load cell outputs. Testing was repeated multiple times and were found to be unaffected by the direction of movement of the structure (i.e. whether the turbine was moving towards or away from the load cell). A linear relationship was found between the deflection of the structure and the load applied, as illustrated Fig. 12.

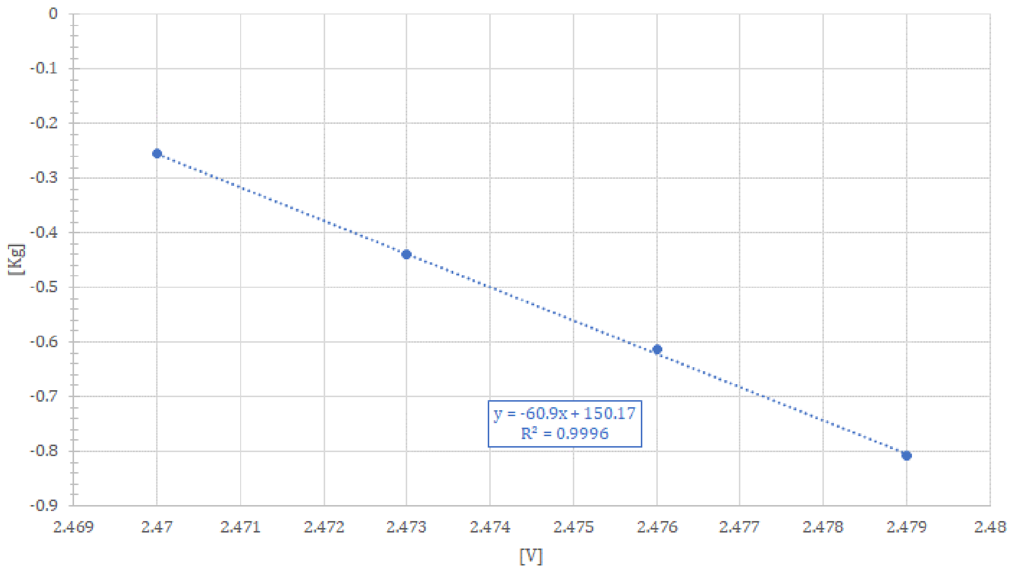

Figure 12: Strain gauge / load cell calibration.

2.2.3 Test Matrix

The *FBT model* was tested under different combinations of wave and flow rate conditions. Waves and flow conditions were chosen to be comparable with that used for the SPECuWaT project [6], where the turbine model fixed to the WCF bottom was tested. Regular waves only are tested.

The following combination were considered:

- *FBT model* under waves only (wave characteristics and codes as in Tab. 4);
- *FBT model* under current only (flow condition as in Tab. 5);
- *FBT model* under waves + current, with current and waves coming from the same direction;

The full matrix of tests carried out and the naming convention used is shown in Tab. 6. Each test with waves took the following form: first, a 10 second period without waves, and then a period of wave generation as in Tab. 4, followed by a 30 second period without wave generation.

Table 4: Wave parameters for FBT tests (values at model scale 1:81 / values at prototype scale).

code	Wave height, H [m]	Wave period, T [s]	Wave length, L [m]	Test duration [s] lab. scale
H2	0.05 / 4.05	1 / 7.2	1.37 / 111	44
H4	0.05 / 4.05	0.8 / 9.0	0.96 / 79.4	51
H5	0.05 / 4.05	1.2 / 10.8	1.77 / 143.4	41

Table 5: Flow parameters for FBT tests (values at model scale 1:81 / values at prototype scale).

Code	Flow direction	Flow rate [m/s]
F2	same as the waves	0.16 / 1.3
F3	same as the waves	0.21 / 1.7
F7	same as the waves	0.26 / 2.1

Table 6: Test matrix showing naming of the tests, flow condition and FB configuration tested. Symbols as in Fig. 4.

Test code	Flow Condition	Wave condition	Test duration [s] lab scale	Turbine blades angle	Water depth h [m]
F2angle2	F2	no waves	60	30	0.3
F3angle2	F3	no waves	60	30	0.3
F7angle2	F7	no waves	60	30	0.3
H2F2angle2	F2	H2	44	30	0.3
H4F2angle2	F2	H4	51	30	0.3
H5F2angle2	F2	H5	41	30	0.3
H5F3angle2	F3	H5	41	30	0.3
H4F3angle2	F3	H4	51	30	0.3
H2F3angle2	F3	H2	44	30	0.3
H2F7angle2	F7	H2	44	30	0.3
H4F7angle2	F7	H4	51	30	0.3
H5F7angle2	F7	H5	41	30	0.3
H5 angle2	no current	H5	41	30	0.3
H4 angle2	no current	H5	51	30	0.3
H2 angle2	no current	H2	41	30	0.3
NoWaveNoCurrent**	no current	no waves	60	30	0.3

** test performed to obtain the reference acquisition values at rest for the different instruments

3 Results and Database

The EXTREMAL-FLOATER project had the main outcome to produce a database containing all significant variables related to the tested models, the *FB model* and the *FBT model* (i.e. free-surface elevation for both models, plastic collection efficiency of the *FB model*, motion of the floater in its 6-DoF, turbine strain gauge and generator output for the *FBT model*).

The data acquired during the EXTREMAL-FLOATER project are stored in an online archive accessible (password protected) via the link:

https://www.labima.unifi.it/vp-185-extremal-floater.html

3.1 Structure of the database

The data resulting from the EXTREMAL-FLOATER project has been stored in the LABIMA online archive. The database has the following basic structure:

EXTREMAL-FLOATER Project Folder

- FB tests → Results following codes in Tab. 2, with flow condition in Tab. 1
- FBT tests → Results following codes in Tab. 6, with flow and wave conditions in Tab. 4 and Tab. 6

3.2 Data Analysis

Analysis of the data collected is ongoing, and it is intended that a journal publication and conference presentation will result from such analysis.

4 Main Learning Outcomes

4.1 Progress Made

The tests on the FB tests (SEADS barriers) performed during the EXTREMAL-FLOATER projects allowed to understand how the barriers behave under high speed water flow conditions (corresponding to flooding conditions). The results allowed to improve the barrier stability in order to optimize their effectiveness and the possibility of more easily being integrated effectively with the tidal turbine.

As for the *FBT tests*, the major progress made during the EXTREMAL-FLOATER project is the expansion of the knowledge base on the impact of concurrent wave and current on a tidal turbine connected to a floating barrier, which can be compared to previously performed test on a similar turbine fixed to the bottom. This knowledge base has been added to with both turbine performance and structural deflection data.

The knowledge globally arising from this project, besides the aforementioned progress made for the two tested models (and the related technologies) individually, could constitute a base for the future development of the synergic interaction between the floating barriers and the tidal turbine.

4.2 Key Lessons Learned

A small number of lessons learned have been identified at this stage. It is anticipated that more specific points will arise during data analysis.

Key lesson learned from the *FB tests* (SEADS barriers):

- The optimal angle of the barriers that allows to maximize their stability, especially for the one downstream, is 30°, differently from what considered previously.
- Increasing the speed of the water the barriers sink not homogeneously along their lengths, the end of the barrier sinks much more than the rest of the structure.
- The sinking was not due in majority to the forces applied by the anchorage (as previously expected), but from the turbulence created behind the barriers. This is confirmed by the sudden sinking ones the water overcome the border of the barriers.
- In order to allow the barriers to float with sufficient stability and improve the value of the synergy with the tidal turbine in high speed condition of the river flow the design needs to be slightly modified in accordance to the results of the tests.

Key lesson learned from the *FBT tests*:

- Visually, the turbine performance in the FBT cases did not appear significantly different to the performance recorded during the SPECuWaTT project tests with a fixed turbine. Full analysis of the data will confirm whether this is the case.
- In some wave cases, the motion of the floater was sufficient to drive the turbine and generate power, despite there being no flow rate.

5 Further Information

5.1 Website & Social Media

Website:

- The project post access report, database and picture and video are available at: https://www.labima.unifi.it/vp-185-extremal-floater.html

LinkedIn/Twitter/Facebook Links:

- Some updates have been published on Twitter at www.twitter.com/mrstuartwalker and www.twitter.com/LABIMA_UNIFI

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