
Project Acronym: VIHYDRO II

Project Reference Number: 1306

Infrastructure Accessed: CNR_Insean - Towing & Wave Tank
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 2\textsuperscript{nd} 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](http://www.marinet2.eu)
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1 Introduction & Background

1.1 Introduction

The present experimental campaign should be considered as a continuation of the previous FP7-MARINET project VIHDRO that concerned the violent impulsive slamming on jacket-type supports of offshore wind turbines. The VIHDRO tested a 5m jacket subjected to regular and focused waves. The physical model was already manufactured and available at INSEAN facilities. The VIHYDRO tests have been designed to access the violent loading on the structure (during a small-time interval after the impact of the wave). In VIHYDRO only the loading was measured without being able to measure motions (accelerations) and pressure distributions. In addition, in VIHYDRO the jacket structure was not supported at the bottom of the basin, but it was hanged by the carrier. VIHYDRO II goes a step beyond, proposing experimental study of jacket supports of offshore wind turbines, subjected to random, focused and regular waves. The jacket is elastically supported on the bottom of the basin, simulating that way the actual supports of real jackets on piles extending several meters in the soil beneath the sea bed. In fact, by using focused waves, the goal is to approximate the most severe mode of loading, that of steep waves. Therefore, the present project approaches the phenomena in their full complexity combining the effects of unsteady waves, wave-structure and soil-structure interactions. The project objectives are outlined in detail in the next sections. It should be noted that INSEAN performed the experiments associated with VIHYDRO with great success and hence it was ideal that the new set of experiments associated with the VIHYDRO II to be performed in the facilities of INSEAN. Indeed, the new set of experiments, which were very challenging, were conducted with great success.

1.2 Development So Far

1.2.1 Stage Gate Progress

<table>
<thead>
<tr>
<th>STAGE GATE CRITERIA</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stage 1 – Concept Validation</strong></td>
<td></td>
</tr>
<tr>
<td>• Linear monochromatic waves to validate or calibrate numerical models of the system (25 – 100 waves)</td>
<td>✓</td>
</tr>
<tr>
<td>• Finite monochromatic waves to include higher order effects (25 – 100 waves)</td>
<td>☹</td>
</tr>
<tr>
<td>• Hull(s) sea worthiness in real seas (scaled duration at 3 hours)</td>
<td>☹</td>
</tr>
<tr>
<td>• Restricted degrees of freedom (DoF) if required by the early mathematical models</td>
<td>☹</td>
</tr>
<tr>
<td>• Provide the empirical hydrodynamic co-efficient associated with the device (for mathematical modelling tuning)</td>
<td>☹</td>
</tr>
<tr>
<td>• Investigate physical process governing device response. May not be well defined theoretically or numerically solvable</td>
<td>☹</td>
</tr>
<tr>
<td>• Real seaway productivity (scaled duration at 20-30 minutes)</td>
<td>☹</td>
</tr>
<tr>
<td>• Initially 2-D (flume) test programme</td>
<td>☹</td>
</tr>
<tr>
<td>• Short crested seas need only be run at this early stage if the devices anticipated performance would be significantly affected by them</td>
<td>☹</td>
</tr>
<tr>
<td>• Evidence of the device seaworthiness</td>
<td>☹</td>
</tr>
<tr>
<td>• Initial indication of the full system load regimes</td>
<td>☹</td>
</tr>
</tbody>
</table>

| **Stage 2 – Design Validation** |        |
| • Accurately simulated PTO characteristics | ☹ |
| • Performance in real seaways (long and short crested) | ☹ |
| • Survival loading and extreme motion behaviour. | ☹ |
| • Active damping control (may be deferred to Stage 3) | ☹ |
### STAGE GATE CRITERIA

<table>
<thead>
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<tr>
<td></td>
<td>• Device design changes and modifications</td>
</tr>
<tr>
<td></td>
<td>• Mooring arrangements and effects on motion</td>
</tr>
<tr>
<td></td>
<td>• Data for proposed PTO design and bench testing (Stage 3)</td>
</tr>
<tr>
<td></td>
<td>• Engineering Design (Prototype), feasibility and costing</td>
</tr>
<tr>
<td></td>
<td>• Site Review for Stage 3 and Stage 4 deployments</td>
</tr>
<tr>
<td></td>
<td>• Over topping rates</td>
</tr>
</tbody>
</table>

#### Stage 3 – Sub-Systems Validation

- To investigate physical properties not well scaled & validate performance figures
- To employ a realistic/actual PTO and generating system & develop control strategies
- To qualify environmental factors (i.e. the device on the environment and vice versa) e.g. marine growth, corrosion, windage and current drag
- To validate electrical supply quality and power electronic requirements.
- To quantify survival conditions, mooring behaviour and hull seaworthiness
- Manufacturing, deployment, recovery and O&M (component reliability)
- Project planning and management, including licensing, certification, insurance etc.

#### Stage 4 – Solo Device Validation

- Hull seaworthiness and survival strategies
- Mooring and cable connection issues, including failure modes
- PTO performance and reliability
- Component and assembly longevity
- Electricity supply quality (absorbed/pneumatic power-converted/electrical power)
- Application in local wave climate conditions
- Project management, manufacturing, deployment, recovery, etc
- Service, maintenance and operational experience [O&M]
- Accepted EIA

#### Stage 5 – Multi-Device Demonstration

- Economic Feasibility/Profitability
- Multiple units performance
- Device array interactions
- Power supply interaction & quality
- Environmental impact issues
- Full technical and economic due diligence
- Compliance of all operations with existing legal requirements

### 1.2.2 Plan For This Access

The objectives of the project were twofold: i) to continue and enrich the experiments from VIHYDRO using additional test cases and ii) to investigate experimentally the response analysis of jacket supports of offshore wind turbines subjected to steep (including breaking) wave conditions. The concept is unquestionably hot from every point of view: for academic (teaching) purposes, scientific research for validating theoretical models and for applied (commercially interesting) purposes as offshore wind turbines with jacket supports are expected to dominate in intermediate water depths (from shallow to deep). The worst case of hydrodynamic loading is steep (or breaking wave) impact. However, analogous configurations are not able to be easily produced in a controlled (and adjustable) facility. Steep or breaking waves exist but in trials numerous test cases must be performed. This is one of the reasons for asking more time for experiments. On the other hand, jacket supports do not remain completely fixed on the sea bed. Subjected to violent waves they vibrate due to the movement of their foundations into the soil. This second goal was proposed to be tackled by VIHYDRO II. The measurements will be used to validate advanced theoretical and numerical models for predicting the associated response of the
jacket structure; i.e. the hydrodynamic loading, the peak displacement, the occurrence of resonance and hence the dynamic amplification of the loading and peak displacement of the structure.

As described in the Stage Gate Criteria above, the jacket structure will be tested subject to regular (linear and nonlinear), random and irregular waves to investigate its response and the device seaworthiness. This will give an initial indication of the load regimes. Hence, the performance in long crested real sea states including extreme loading will be examined. Note that the infrastructure basin can only perform long crested steady and unsteady simulations. It is hence evident that the structure’s performance and reliability is also planned to be validated.

2 Outline of Work Carried Out

2.1 Setup

2.1.2 The model

The model was constructed by assembling (welding) tubular members (see photo in the executive summary). The model has a triangular shape with five pairs of X-braces on each side, which connect three main tubular chords. The scaling factor is not explicitly fixed as the specific structure (in full scale) can be installed in various water depths. A rational scaling factor can be assumed to 1:18. Each side of the equilateral triangle at the bottom part of the model is 1.75m which implies that in full scale the structure would occupy 430m$^2$ on the bottom. The diameter of the chords (the skeleton elements) is 21cm and the diameter of the bracings is around 12cm.
The model was oriented towards the wave maker as shown in the figure above. The orientation of the model ensured the worst case of loading.

### 2.1.3 The soil-structure interaction simulation

The model in VIHYDRO was hanged by the carrier. In VIHYDRO II the model is bottom seated and the soil is simulated by vertical and horizontal springs. Two sets of springs were constructed in Greece, with different stiffnesses to simulate different soil conditions as shown in Table 2.1. The spring were selected such as to represent a realistic scenario and allow the investigation of the dynamic behavior of the model. The first set of springs consisted of a horizontal and a vertical spring with stiffness of 7.65 kN/m and 370 kN/m, respectively. Following, a less stiff set of pads was selected which would allow the investigation of resonance phenomena and the corresponding stiffnesses were 3.20 kN/m for the lateral spring and 160 kN/m for the vertical one.

<table>
<thead>
<tr>
<th>Spring Set</th>
<th>Horizontal (kN/m)</th>
<th>Vertical (kN/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7.65</td>
<td>370</td>
</tr>
<tr>
<td>2</td>
<td>3.20</td>
<td>160</td>
</tr>
</tbody>
</table>

The springs were assembled to form three pads, which were attached to the lower part of the jacket’s chords. The pads were designed by the group, constructed in Greece and shipped to INSEAN. The pad’s configuration and layout are shown in Figs. 2.2-2.5. The pads were...
Figure 2.3 Layout of pads

Figure 2.4 Soil-structure pad simulation; (a) View of the horizontal spring, (b) View of the vertical spring.
attached to the jacket by means of an appropriate assembly of plates that were constructed externally in Italy but there were also designed by the group. The configuration of the plates is shown in Fig. 2.5. Also, an installation sequence was suggested by the group and followed by INSEAN before the deployment of the structure. The jacket, together with the three pads and the springs weigh about 1.7t. The installation sequence is given in Appendix A. The pads were securely kept in the final position in the basin using a series of concrete blocks as shown in Figs. 2.2-2.3. Therefore, the pads were not moving relatively to the bottom of the basin, allowing the jacket to move in response to the wave loading. This way, a realistic simulation of the wave-soil-structure interaction could be achieved.

2.2 Deployment

The deployment of the jacket structure, with the pads attached to the legs, was a challenge on its own. The structure is 5.01m high and the attachment of the pads increased this height to 5.32m. It was the first time that the Italian institute dealt with such a large and heavy structure. Indeed, the deployment of the jacket during the previous project (MaRINET, VIHYDRO) was much easier as the structure was shorter and was hanged and moved in the desired position by the crane installed in the building. Such a solution was not possible in MaRINET-2 VIHYDRO II project because the structure was too high, and the pads should not be hanged freely as the springs might change stiffness due to the weight of the pads or the structure itself. In particular, the springs of one pad were attached after the deployment of the structure for the above reasons. Hence special care has been taken for the pads.

Overall the methodology followed for the deployment of the structure in the basin is very similar to the methodology that should be followed in full scale. The deployment followed the steps below. A series of photographs in the sequel visualize the described steps.

1. The jacket was laid down on the one side of the basin with one leg hanged from the crane (Fig. 2.6-1),
2. Buoyancy balloons were attached at the top and bottom side of the structure, so that the structure would be able to float and dragged by the crane at the desired location (Fig. 2.6-2),
3. Technicians on a boat removed the bottom buoyancy balloons in order to allow the bottom of the structure to sink smoothly (Fig. 2.6-3),
4. The jacket was lifted by the technicians to the upright position with a rope tied to the crane (Fig. 2.6-4),
5. Divers were involved to align the jacket at the desired position and to place concrete blocks on the pads (Figs. 2.6-5 -2.6-7).
Figure 2.6 Deployment of the jacket structure
2.3 Tests

2.3.1 Dry Tests

In order to test the structure under horizontal loads, the following protocol was followed:

a. The vertical springs were blocked to make the system as simple as possible
b. Forces were applied to achieve displacements of around 4 and 8cm respectively. The forces and the corresponding displacements were measured
c. The displacements and accelerations histories were recorded after a sudden removal of the applied force.

Application details:

- The vertical springs were blocked by appropriate assemblies of wooden blocks
- A steel pulling rope was used for the force introduction, with only a small fibre segment that was suddenly cut
- The pulling rope was perfectly horizontal in its first segment
- An ultrasound probe was installed for displacement measurements
- Video recordings are available

In order to test the structure under vertical loads, the following protocol was followed:

a. A vertical load of 3kN was applied
b. The vertical displacements and acceleration histories were recorded.

The horizontal displacement tests were made for 1kN (2 runs - Test 04 and Test 05) and 2 kN (1 run - Test 03). Some more preparatory runs were needed in order to optimize the procedure. In the sequence, resulting time histories for the 3 runs are shown. A similar sequence of measurements has been performed for the vertical displacements.

Figure 2.7 Dry Tests, Horizontal Displacements. Left Column: Displacement Measurements, Right Column: Acceleration Measurements
### 2.3.2 Wet Tests

The trials concerned regular, irregular focused and randomly phased waves. All the wave cases are shown in the tables below. The underlying spectrum employed for the irregular sea-states was a JONSWAP spectrum. The wave cases that were chosen and implemented cover a variety of sea-states. In particular, the water depth conditions include a range of intermediate to deep water conditions ($1.19 < k_d < 9$), where $k$ is the wavenumber and $d$ the water depth; the former varying and the latter remaining at $d = 3.5m$. For regular waves, the wave steepness is expressed as $kH_i/2$, where $H_i$ is the generated wave height. The regular wave measurements vary with respect to wave steepness from weakly nonlinear to highly nonlinear ($0.051 < kH_i/2 < 0.340$). In the irregular wave measurements, associated with focused events, the wave steepness is expressed as $kA_i$, where $A_i$ is the summation of the amplitudes of the underlying spectrum's frequency components. The focused wave measurements also vary with respect to wave steepness from weakly nonlinear to highly nonlinear ($0.058 < kA_i < 0.198$). The effect of the broadness of the spectrum has been also examined, with the variation of the peak enhancement factor ($1.0 \leq \gamma \leq 5.5$). Finally, the response of the spectrum under random waves has been also measured by introducing sea-states of varying steepness ($0.060 < kA_i < 0.111$).

In the following, we provide separately the test matrices for the regular waves, the irregular focused events and the irregular random waves are provided separately.

#### Table 2.2 Suggested test matrix for regular waves

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<tr>
<th>$H_i$ (m)</th>
<th>0.25</th>
<th>0.40</th>
<th>0.25</th>
<th>0.40</th>
<th>0.25</th>
<th>0.40</th>
<th>0.25</th>
<th>0.40</th>
<th>0.25</th>
<th>0.40</th>
</tr>
</thead>
<tbody>
<tr>
<td>$f$ (Hz)</td>
<td>0.30</td>
<td>0.35</td>
<td>0.40</td>
<td>0.50</td>
<td>0.55</td>
<td>0.60</td>
<td>0.65</td>
<td>0.70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$T$ (s)</td>
<td>3.33</td>
<td>2.86</td>
<td>2.50</td>
<td>2.00</td>
<td>1.82</td>
<td>1.67</td>
<td>1.54</td>
<td>1.43</td>
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</tr>
<tr>
<td>$kd$</td>
<td>1.42</td>
<td>1.82</td>
<td>2.23</td>
<td>3.53</td>
<td>4.24</td>
<td>5.07</td>
<td>5.96</td>
<td>6.90</td>
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<tr>
<td>$kH_i/2$</td>
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<td>0.06</td>
<td>0.08</td>
<td>0.13</td>
<td>0.20</td>
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<td>0.29</td>
<td>0.34</td>
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<td>0.39</td>
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#### Table 2.3 Implemented test matrix for regular waves

<table>
<thead>
<tr>
<th>Wave Case</th>
<th>$f$ (Hz)</th>
<th>$T$ (s)</th>
<th>$H_i$ (m)</th>
<th>$kd$</th>
<th>$\tanh(kd)$</th>
<th>$kH_i/2$</th>
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<tr>
<td>1 R10 R14 R40</td>
<td>0.3</td>
<td>3.33</td>
<td>0.25</td>
<td>1.42</td>
<td>0.890</td>
<td>0.051</td>
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<tr>
<td>2 R15</td>
<td>0.35</td>
<td>2.86</td>
<td>0.25</td>
<td>1.82</td>
<td>0.949</td>
<td>0.065</td>
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<tr>
<td>3 R31</td>
<td>0.35</td>
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<tr>
<td>4 R16</td>
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<td>5 R32</td>
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<tr>
<td>6 R17 R18</td>
<td>0.45</td>
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<tr>
<td>7 R25</td>
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2.4 Results

In the following, figures for selected cases of the measurements in accordance to the previous Tables are provided. The figures include the time series of the surface elevations along with the accelerations and displacement. The measurements will be subjected to exhaustive processing to yield reliable conclusions.
### R11:

<table>
<thead>
<tr>
<th>Wave Case</th>
<th>$f$ (Hz)</th>
<th>$T$ (s)</th>
<th>$H_i$ (m)</th>
<th>$kd$</th>
<th>$\tanh(kd)$</th>
<th>$kH/2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>R11 R19</td>
<td>0.5</td>
<td>2.00</td>
<td>0.25</td>
<td>3.53</td>
<td>0.998</td>
<td>0.126</td>
</tr>
</tbody>
</table>

**Figure 2.8** Regular wave Test R11. Time Series of Surface elevations in Gauges 1:7

**Figure 2.9** Regular wave Test R11. Left Column: Displacement Measurements, Right Column: Acceleration Measurements
### Table 2.1

<table>
<thead>
<tr>
<th>Wave Case</th>
<th>$f$ (Hz)</th>
<th>$T$ (s)</th>
<th>$H_i$ (m)</th>
<th>$kd$</th>
<th>tanh($kd$)</th>
<th>$kH_i/2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 R22 R39</td>
<td>0.65</td>
<td>1.54</td>
<td>0.25</td>
<td>5.95</td>
<td>1</td>
<td>0.213</td>
</tr>
</tbody>
</table>

**Figure 2.10** Regular wave Test R39. Time Series of Surface elevations in Gauges 1:8

**Figure 2.11** Regular wave Test R39. Left Column: Displacement Measurements, Right Column: Acceleration Measurements
**F7-R70**

<table>
<thead>
<tr>
<th>Wave Case</th>
<th>$f_p$ (Hz)</th>
<th>$T_p$ (s)</th>
<th>$\gamma$</th>
<th>$A_1$ (m)</th>
<th>$k_p d$</th>
<th>tanh($k_p d$)</th>
<th>$A_1 k_p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>F7: R56 R70</td>
<td>0.353</td>
<td>2.83</td>
<td>3.3</td>
<td>0.11</td>
<td>1.85</td>
<td>0.951</td>
<td>0.058</td>
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</tbody>
</table>

Figure 2.11 Focused Wave Test F7:R70. Time Series of Surface elevations in Gauges 1:8

Figure 2.12 Focused Wave Test F7:R70. Left Column: Displacement Measurements, Right Column: Acceleration Measurements
### F3-3-R63

<table>
<thead>
<tr>
<th>Wave Case</th>
<th>$f_p$ (Hz)</th>
<th>$T_p$ (s)</th>
<th>$\gamma$</th>
<th>$A_i$ (m)</th>
<th>$k_p d$</th>
<th>$\tanh(k_p d)$</th>
<th>$A k_p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>F3-3: R52 R63</td>
<td>0.472</td>
<td>2.12</td>
<td>5.5</td>
<td>0.22</td>
<td>3.15</td>
<td>0.996</td>
</tr>
</tbody>
</table>

**Figure 2.13** Focused Wave Test F3-3:R63. Time Series of Surface elevations in Gauges 1:8

**Figure 2.14** Focused Wave Test F3-3:R63. Left Column: Displacement Measurements, Right Column: Acceleration Measurements
R73

<table>
<thead>
<tr>
<th>Wave Case</th>
<th>$f_p$ (Hz)</th>
<th>$T_p$ (s)</th>
<th>$\gamma$</th>
<th>$A_i$ (m)</th>
<th>$k_p d$</th>
<th>$\tanh(k_p d)$</th>
<th>$A k_p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 R73</td>
<td>0.386</td>
<td>2.59</td>
<td>5.5</td>
<td>0.18</td>
<td>2.16</td>
<td>0.974</td>
<td>0.111</td>
</tr>
</tbody>
</table>

Figure 2.15 Random Wave Test R73. Time Series of Surface elevations in Gauges 1:8

Figure 2.16 Focused Wave Test R73. Left Column: Displacement Measurements, Right Column: Acceleration Measurements
2.5 Analysis & Conclusions

From the preliminary investigation of the measurements it is shown:

- The structure moves in surge and less in sway and heave direction. Surge and heave was expected with the latter being much smaller since the vertical springs are stiffer than the horizontal ones (See Table 1). The sway motion is larger than expected. The group allowed some sway movement to avoid excessive friction to surge and heave motion. However, since the waves are long-crested, the expected sway motion was expected to be smaller. The group will take the above into account during the analysis of the results.
- The above discussion also stands for the roll, pitch and yaw motions with only the pitch motion being expected. However, fortunately the roll and yaw motions are more than an order of magnitude smaller than the pitch, hence the analysis can progress further.
- The displacements are analogous to the wave steepness. Indeed, for regular waves, when the wave steepness is doubled, so is the surge and pitch motions. Similar behaviour is shown for focused events.
- The focused events provoke larger displacements than regular waves. Although it has to be examined whether the eigen-period of the structure is hit, this is a first indication that such structures must be examined under realistic sea-states.
- Nonlinear effects are present in the focused events leading to surface elevations larger than the amplitude sum $A_i$. It is important to discuss the response of the structure taking the latter into account.

It is obvious that the process of the data will lead to more robust conclusions. These will be presented in literature as discussed in Section 4.

3 Main Learning Outcomes

3.1 Progress Made

This project is one important step towards the investigation of the reliable performance of jacket foundations for offshore wind turbines. These types of supports are expected to dominate in mid-deep waters where the wind potential is higher.

3.1.1 Progress Made: For This User-Group or Technology

This user group has now available experimental measurements for further elaboration and post-processing. The user group has now the ability to validate theoretical and numerical models. The experiments and the detailed analysis of the videos taken will allow better understanding of the phenomenon of slamming in truss-type structures. It is noted that the implementation of such type of experiments and in particular in such large scaling is not feasible in Greece. It should be noted that VIHYDRO II is complementary to VIHYDRO, a previous project materialized in INSEAN through MaRINET. With the present project, the users are able to analyse the response of the structure, taking into account the wave-soil-structure interaction and hence an integral set of experimental measurements are now available. Furthermore, the wave tests applied vary with steepness and effective depth and they include regular, focused and random wave tests. Hence the measurements include a full set of test cases and can be used to validate numerical and analytical methods for designing such structures.

3.1.1.1 Next Steps for Research or Staged Development Plan – Exit/Change & Retest/Proceed?

It is the intention of the group to continue the tests. Given the development of the Offshore Wind Industry in general, the research group would like to propose different soil-structure interaction conditions. Indeed, a different set of springs is already manufactured and can be tested in a future project. The latter should be enhanced with a larger number of very steep waves, such as breaking waves, in order to investigate the response of the structure subject to impact loading. Force and load measurements are also important and should be included in a future project.
3.1.2 Progress Made: For Marine Renewable Energy Industry

The structure constructed in the content of this campaign resembles the usual type of jacket supports for offshore wind turbines. The dimensions used are the typical dimensions for this type of structures. It has already been agreed within the research and industry community that triangular truss structures perform equally well with square ones and they have the leading advantage of being cost effective to build. To the group’s knowledge, combined measurements of fluid-structure and soil-structure interactions of truss-type structures subject to large waves have not been performed in the past. In our opinion, this experimental project can work as a benchmark for such studies and comparisons with standard design methodologies.

3.2 Key Lessons Learned

The full process of the data is yet to be accomplished. However, important lessons have been learnt concerning the implementation of the experimental project. For example,

- the deployment of a structure of such a large scale is complicated and requires very careful and time-consuming tests as explained in this report,
- five full working days are required only for the deployment of the jacket,
- it would be useful to have measured the focused waves in the basin with no structure to be able to consider the wave transformation due to its presence. Indeed, the wave-structure interaction may lead to wave conditions much more severe than the ones predicted with the generated incident waves according to standard design methodologies,
- nevertheless, the first conclusion that could be drawn, even in this preliminary stage of the analysis of the results is that the loading exerted on the structure can be tolerated by it.

4 Further Information

4.1 Scientific Publications

The intention of the group is to publish the results of the experimental campaign as soon as possible. The first publication shall include only the experimental results. Other conference and journal publications will follow showing comparisons with numerical models.

4.2 Website & Social Media

Website: 
YouTube Link(s):
LinkedIn/Twitter/Facebook Links:
Online Photographs Link:

4.3 Acknowledgments

Special thanks should be addressed to the following, without which the implementation of the project would have not been possible.
5 Appendices

5.1 Device installation sequence

1. Prior to the operations in the water basin, specially designed steel plates should be welded on the steel jacket.

The correct alignment of the vertical plates perpendicularly to the waves direction is very important for the functioning of the system.

The horizontal plate has slotted holes to facilitate minor misalignments in the connection of the vertical springs.
2. Installation of the steel bases in the water basin. Special attentions should be given so that the bases are appropriately aligned and in the configuration shown in the figure.
3. Installation of the jacket and connection to the steel bases through bolting with the vertical spring. Notice that the horizontal springs are not yet connected. In this stage, it should be checked that the jacket can move freely on the steel bases. The whole range of expected horizontal displacements should be ensured (±150mm). In case of limited horizontal displacements, the steel bases should be re-aligned.
4. After the alignment of the bases, it should be checked that the vertical springs are centered within the slotted hole of the steel base.

5. Installation of the horizontal springs through bolting. Attention should be given to connect the springs horizontally. In this respect, slotted holes have been placed in the vertical plate, to facilitate the alignment.
6. Installation of the ballast (concrete blocks)