Universität Rostock — Traditio et Innovatio

LWET Stiftungslehrstuhl Windenergietechnik | ESG

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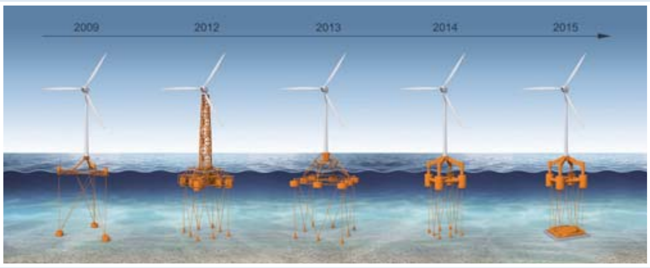
USE OF REINFORCED CONCRETE COMPOSITE MATERIAL

Development of a TLP substructure for a 6 MW wind turbine

PATH OF DEVELOPMENT – TLP SUBSTRUCTURE

The challenging work for the research project called 'Floating platform for offshore wind turbines' started in 2009. The GICON®-Group and their key partners, e.g. University of Rostock and fabrication partner ESG GmbH have been developing a TLP solution for offshore wind turbines with vertical and angled ten-sioned ropes. Based on the fundamental experience from experimental and numerical studies, the current design was established.



KEY PARAMETER COMPARISON OF THE STRUCTURE'S DESIGN PHASES:

Year / Parameter	2009	2012	2013	2014	**2016**
TLP Mass in t	≈ 2000	2214	1790	742	**1356**
Width in m	70	68	50	32	**32**
Height in m	25	24	39	28	**40**
Max. righting arm in m	N/A	5.30	7.60	2.50	**2.10**
CoG	N/A	8.90	10.50	10.91	**13.60**
# of anchor points	3	4	4	4	**4**
Wind turbine capacity	2.0 MW	2.0 MW	2.0 MW	2.3 MW	**6.0 MW**

ADVANTAGES:

- Deployable from 20 meters to 350 meters and more
- Portside assembly and transport of the entire structure to the deployme location
- Modular construction resulting in more flexibility in the supply chain
- Several anchoring technology options
- Reduced impact on site subsoil via gravity anchor plate foundation
- Ease of maintenance
- If needed, entire structure can be completely replaced

SCIENCE & RESEARCH

Currently ongoing research includes the comparison of calculated data with actual experimental data obtained through wind & wave tank experiments with the scaled models. These tests have provided insights regarding the dynamic characteristics of the GICON®-TLP by analyzing the measured time series RAO´s or decay test results.

Research insights from the various experiments have been published:

- The added mass coefficients belonging to the comparison of measured results compared with simulated ones yielded to C_{a_pipe} = 0.6 and C_{a_bb} = 0.2 > published by *Adam, F., Steinke, C., Dahlhaus, F. and Großmann, J.*, 2013. **„GICON-TLP for wind turbines – Validation of calculated results"**. Proc. ISOPE 2013 An chorage, vol. 1, pp. p: 421–427.
- Validation of the calculation model via decay test results and confirmation of the added mass coefficients > published by *Adam, F., Myland, T., Dahlhaus, F. and Großmann, J.*, 2014. **„Scale tests of the GICON®-TLP for wind turbines"**. Proc. OMAE 2014, Paper-No. 23216, San Francisco.
- Evaluation of internal force superposition on a TLP for wind turbines > published by *Adam, F., Myland, T., Schuldt, B., Großmann, J. and Dahlhaus, F.*, 2014. **„Evaluation of internal force superposition on a TLP for wind turbines"**. Renewable Energy
- Comparison of three different TLPs for wind turbines > published by *Adam, F., Myland, T., Dahlhaus, F. and Großmann, J.*, 2015. **„Comparison of three different TLPs for wind turbines by tank tests and calculated results"**. Proc. OMAE 2015, Paper-No. 41018, St. Johns.

DEVELOPMENT OF A TLP SUBSTRUCTURE FOR A 6 MW WIND TURBINE

The preliminary scaling up of the system will comprise initially a geometrical re-design, utilizing past experience to implement design improvements. Analysis will then be carried out re. three critical areas:

- Hydrodynamic stability, during both installation and operation
- Eigen Analysis
- Structural Resistance

Initially analyzing these areas will give a good overview of the feasibility of the system and highlight which areas of the design should be optimized for future development.

HYDRODYNAMIC STABILITY

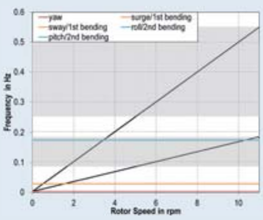
The hydrodynamic stability is an important part of the design as it is beneficial to keep the wind turbine at its optimal height and orientation. It is also vital to keep the movement and acceleration of the structure to a minimum in order to prevent damage to and potential failure of the components. Initially, the floating stability of the structure (Anchor + TLP + RNA + Tower) is analyzed to determine how the system would react independently.

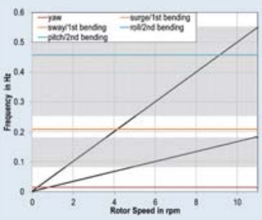
Angle of Attack in deg	Maximum Deviation				
	Acceleration in m/s²			Rotation in deg	
	x	y	z	rx	ry
180	0.616	0.155	3.014	0.058	0.716
135	0.385	0.495	2.799	0.078	0.854
90	0.017	0.661	2.716	0.164	7.970
45	0.384	0.496	2.801	0.040	0.736
0	0.617	0.155	3.017	0.100	0.735

EIGEN ANALYSIS

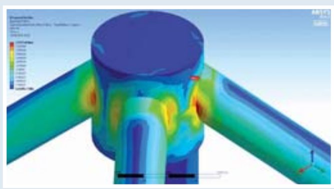
A modal analysis was then conducted on the entire TLP system, including: Mooring lines, Tower and SOF structure, with the RNA being modeled as a signal mass point. The results are presented for the following four systems:

- 50 meters water depth; 4 vertical mooring lines
- 50 meters water depth; 4 vertical mooring lines, 8 angled mooring lines





STRUCTURAL RESISTANCE



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