Hydrostatic and Hydrodynamic Analysis of TLP Supported 5MW Wind Turbine based on Malabar Costal Climate

NithinRaj. M.R.[1]

[1]*M.Tech Student, Department of Civil Engineering, SIMAT, APJ Abdul Kalam Technological University, Kerala, India*

---***---

Abstract - *The demand of electrical energy is getting higher around the world every other passing day and India is no such exception. With limited non-renewable resources of energy to generate electricity, over the recent years, India is slowly shifting its focus towards renewable resources of energy like solar and wind to produce electricity. Here comes the relevance of the offshore wind turbine platforms the biggest advantage is being uninterrupted and constant high efficiency of tapping wind energy as compared to onshore. Hydrostatic and Hydrodynamic analysis of the mini TLP prototype is done according to Malabar costal wind, wave and ocean currents by considering a specific region of average constant sea floor depth 2250 meter which lies between 10 degrees and 11 degrees north latitude and 74 degrees and 75 degrees east longitude using ANSYS AQWA and their motion characteristics are discussed in this paper.*

Key Words: (Mini TLP, Hydrostatic analysis, Hydrodynamic Analysis, Latitude, Longitude

1. INTRODUCTION

Wind energy is one of the most renowned source of renewable energy, with steep hikes in fuel prices, wind energy poses to be an attractive and environment friendly source of power generation. Most of world's metropolises are near shore and offshore wind energy offers the obvious advantage of no land usage and probably more reliable wind resource. Thus the project aims to study the tension leg platform feasibility and response in Indian Malabar coastal region according to the wind, Wave and Currents of the region between 10 degrees and 11 degrees north latitude and 74 degrees and 75 degrees east longitude Mini tension leg platform is modeled in ANSYS AQWA design modeler and hydrostatic and hydrodynamic analysis are carried out.

2. METHADOLOGY

Cylindrical solid bodies are generated and surfaces are generated from existing solid bodies and separate surface bodies together form the entire TLP since the ANSYS AQWA will only support the surface bodies.

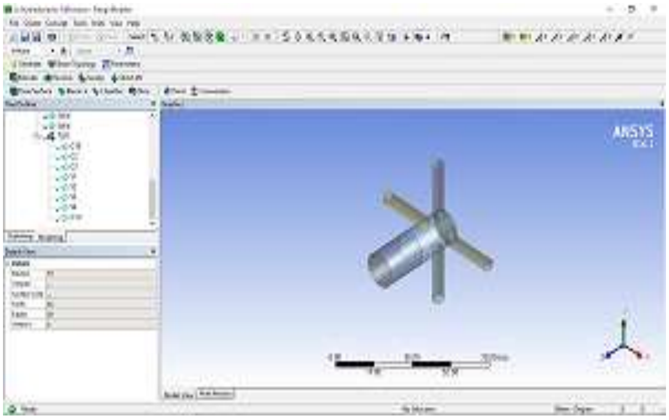

Fig -1: Modeled Mini TLP with draft and spokes

The generated surface body from solid is imported in AQWA and Hydrostatic analysis is carried out .Wind, Current and wave characteristics are purely based on data from Malabar coastal climatic conditions

Offshore structures should be able to stand up to the dynamic effects of environmental loads throughout their lifespan. These loads vary from temporary/transient loads induced by earthquakes and ocean storms to continuous loads due to wind, waves, and ocean currents. Since floating offshore structures aren't supported directly by the ground, however, effects of earthquakes on floating structures have received less attention compared with those on fixed Structures.

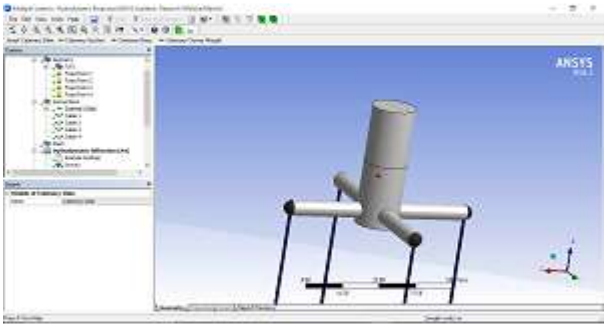

Fig -2: Imported Mini TLP with draft and spokes Moored to the sea bed using tendons

Table -1: Properties of TLP prototype

Property	Draft	Spokes
Diameter	15m	5.5m
Length	40m	4
Number of entity	25	4
Total Surface area	2235.95m2	460.08m2

Table -2: Mass of 5MW wind turbine prototype

Part of turbine	Mass in kg
Rotor	111,000 kg
Nacelle	240,000 kg
Tower	250,000 kg
Weight of hull above still water level	240,000 kg

Bathymetric data provided by national center for Environmental information gives the exact picture of ocean depth. Ocean floor which lacks undulations is selected.

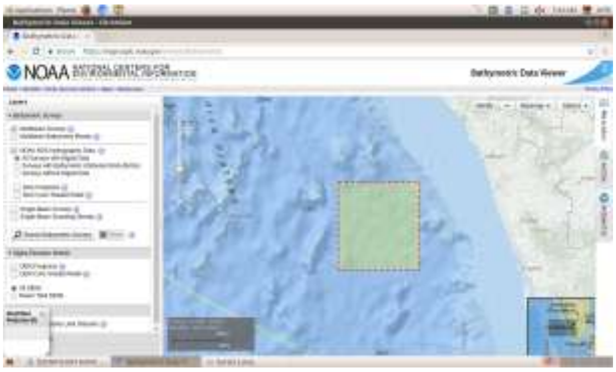

Fig -3: location selected with ocean depth 2250m

Forecasted wave wind and ocean current data are obtained from INCOIS web portal the data is inputted in ANSYS AQWA for obtaining further results.

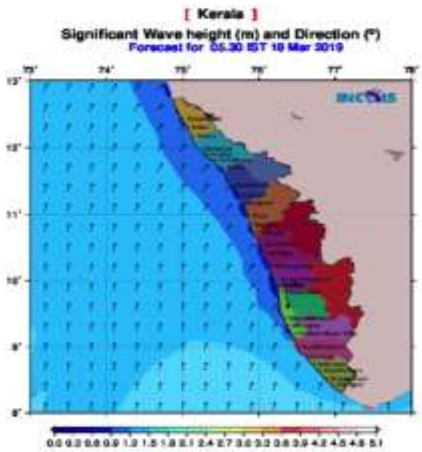

Fig -4: Wave height and direction from INCOIS

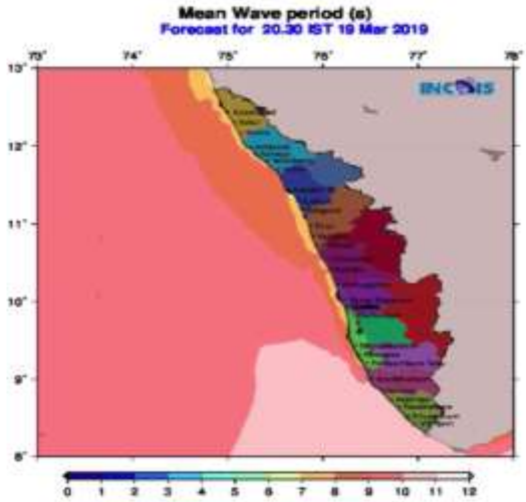

Fig -5: Wave period range from INCOIS

3. RESULT AND DISCUSSION

Results of hydrostatic analysis obtained from ANSYS AQWA are provided below.

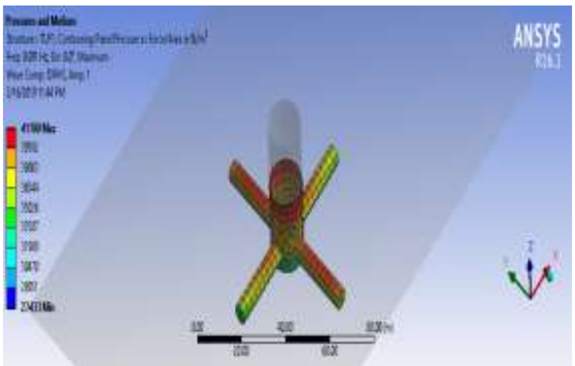

Fig -5: Pressures and motions from ANSYS AQWA

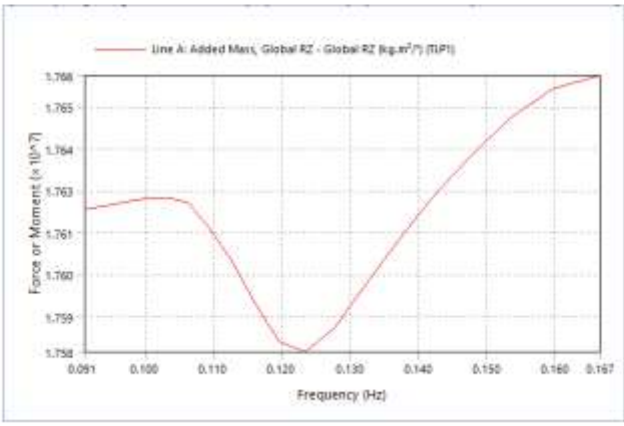

Chart -1: Added Mass (Force/Moment vs Frequency)plot

Hydrostatic Stiffness

	X	Y	Z
Centre of Gravity (CoG) Position:	0. m	0. m	-32.987999 m

	Z	R X	RY
Heave (Z):	1730998.9 N/m	6.5251e-3 N/°	8.0309e-3 N/°
Roll (RX):	.3738602 N.m/m	20925216 N.m/°	5.6216e-2 N.m/°
Pitch (RY):	.4601356 N.m/m	5.6216e-2 N.m/°	20925214 N.m/°

Hydrostatic Displacement Properties

Actual Volumetric Displacement:	5936.606 m³
Equivalent Volumetric Displacement:	1432.8118 m³

Centre of Buoyancy (CoB) Position:	X:	1.2605e-2 m	Y:	-1.4131e-2 m	Z:	-13.294188 m
Out of Balance Forces/Weight:	FX:	-2.2132e-7	FY:	3.0377e-8	FZ:	3.143326
Out of Balance Moments/Weight:	MX:	-5.8559e-2 m	MY:	-5.222e-2 m	MZ:	1.3123e-5 m

REFERENCES

[1] A. Athanasia and A. B. Genachte, "Deep offshore and new foundationconcepts,"EnergyProcedia,vol.35,no.41,pp.198–209,2013M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.

[2] E. E. Bachynski and T. Moan, "Design considerations for tensionlegplatformwindturbines,"MarineStructures,vol.29, no.1,pp.89–114,2012.

[3] E. N. Wayman, P. D. Sclavounos, S. Butterfield, J. Jonkman, and W. Musial, "Coupled dynamic modeling of floating wind turbinesystems,"Wear,vol.302,pp.1583–1591,2006.

[4] S. Butterfield, W. Musial, J. Jonkman, P. Sclavounos, and L. Wayman, "Engineering challenges for floating offshore wind turbines," in Proceedings of the Copenhagen Offshore Wind Conference & Expedition, vol. 13, pp. 25–28, Copenhagen, Denmark,2005.