

Modeling and Simulation of a Tension Leg Platform

*Marco Masciola¹, Meyer Nahon
McGill University, Centre for Intelligent Machines
Montreal, QC, Canada*

ABSTRACT

In this paper, we present a non-linear 6 degree-of-freedom dynamics model for a tension leg platform type structure. The dynamics model and simulation presented here is different from other models in its derivation approach. Existing models are usually based on deriving stiffness coefficients from an analysis of single-degree-of-freedom perturbations of the platform. By contrast, we analyze the generalized platform motion, based on fundamental kinematic principles, and calculate the forces and moments resulting from this motion. Also included in this analysis are the effects of random wave forces and a method to calculate the buoyant righting moment.

KEY WORDS: Tension Leg Platform; Offshore Structure; Simulation.

INTRODUCTION

A tension leg platform, or TLP, can be described as a multi-tethered buoyant marine platform, and consists of a floating platform on the water surface tethered to the sea floor by a series of cables. These cables are usually under high tension, causing a portion of the platform to submerge below the waterline. These ocean structures are commonly used for extracting oil in deep water. With current forecasts predicting higher oil prices, there is currently an effort to push oil exploration into deeper waters, since it is now an economically feasible journey. Therefore, we can expect semi-submersible technology to remain relevant for many years to come.

With this expectation, more precise simulation tools must be introduced to accurately simulate TLP-type structures. One of the aims of a simulation package is to forecast unidentified issues before they reveal themselves in the model testing phase. Since model testing is a costly, time consuming process, reducing the amount of time needed at a testing facility would also reduce development costs. Additionally, a more accurate dynamics model has other uses than for the designing semi-submersibles; it can also be used for designing and evaluating controllers for a dynamic positioning system.

Several previous works have developed a deterministic TLP dynamics model. Malaeb and Wilson (1983) have introduced one method to derive the equations of motion for a TLP. In their model, linear wave theory is used to formulate a closed form solution to the forces on the columns and pontoons. They developed the tendon stiffness

coefficients by assuming that each cable behaves as a linear spring, then displaced the platform in each degree-of-freedom, and solved for the resulting restoring force. Mekha, et al. (1994) produced a study on how the response of a TLP varies based on different wave theory assumptions. In that paper, the tendons were treated as linear springs. More recently, Chandrasekaran and Jain (2003) applied the approach of Malaeb and Wilson to illustrate how the response of a triangular TLP is different from that of a square TLP.

The approach presented in this paper is different from the previous approaches, in that we do not solve for tendon stiffness coefficients for each degree-of-freedom. Instead, the restoring force is solved by defining a set of vectors that describes the tendon position and orientation, from which the corresponding forces and moments can be obtained. Included in this simulation is a comprehensive wave force model that considers the position of the platform components (columns, pontoons) relative to a wave train, while also accounting for the changes in this position due to the motion of the platform. The effects of drift forces are also considered. Finally, to estimate the buoyancy force and righting moment, we consider the geometry of the submerged components and present a simple method to perform the calculation. For a given wave spectrum, we illustrate how the behavior of the platform can be estimated. At the conclusion of this paper, we report graphical results from a simulation using the theory introduced in this paper.

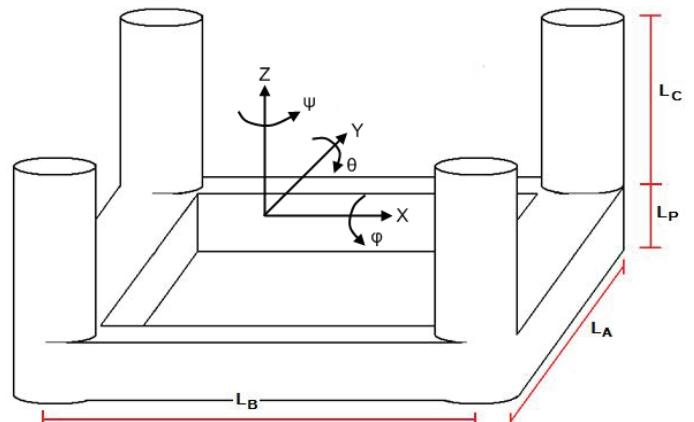


Fig. 1, Sub-sea TLP geometry.

¹ mmasciol@cim.mcgill.ca