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Model Testing of Tension Leg Platforms-Part II: Experimental Hardware and Data Analysis

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ABSTRACT

The purpose of this part (Part II) of the paper is to discuss different aspects involved in the design and fabrication of the experimental hardware, instrumentation and data acquisition procedures in hydrodynamic model testing. It reviews some of the design problems and innovations in model construction of TLPs. The use of different types of instrumentation is discussed. The data acquisition and experiment control hardware and software in use at the Hydraulics Laboratory of the National Research Council of Canada are also presented.

INTRODUCTION

In Part I of the paper, a general overview of the experimental test facility for the generation of the wind loading, currents, and wave conditions was presented. Techniques for the synthesis and calibration of regular and irregular long-crested waves, and short-crested waves were discussed. In this part, attention is focussed on the design and fabrication of the model, associated instrumentation, and data acquisition procedures.

The platform model has to be rigid and geometrically accurate. A critical component of the TLP is the tether system which needs to be modelled with care so that the platform response characteristics are reproduced faithfully, and the strength and fatigue life of the individual tethers are determined accurately. The necessity to simulate the various physical properties leads to complicated composite designs. The construction of typical model tendons and risers is discussed.

The model testing of an offshore structure with complex response characteristics like the TLP requires the use of a wide range of instrumentation. Some of the devices are readily available but certain instruments need to be developed and fabricated in the laboratory. A brief discussion of the different types of instrumentation is included.

The analysis and management of the laboratory data, including real-time experiment control and data acquisition, are important aspects of a test program. A general overview of the data acquisition and analysis techniques in use at the Hydraulics Laboratory of the National Research Council of Canada is presented.

CHOICE OF MODEL SCALE FACTOR

Ideally, the models should be as large as possible to keep the errors due to scaling effects to a minimum. But the model scale factor is always a compromise between several considerations: The dimensions of the model should be such that the prototype details are adequately represented, so that the environmental loading is simulated correctly. Also, the model scale should be large enough to permit accurate ballasting and installation of the onboard instrumentation packages. On the other hand, the available wave, wind and current simulators should be able to generate the extreme conditions at the required model scale. A further concern is the capability to assemble and service an extremely large and possibly heavy model structure in a laboratory environment.

Generally, another limiting factor is the size of the available test basin. Often, the most important factor is the depth of the basin itself, as the water depth affects the wave kinematics. A shallow basin will create harmonic distortions of low-frequency waves, which will cause crests to be steeper and higher than would be encountered in a deep-water situation. The model scale should be such that the basin floor effects are not felt even for the longest period waves, and the wave machine must be capable of generating the high-frequency waves satisfactorily. In the case of the multidirectional wave basin of the Hydraulics Laboratory, the depth of the pit (12m) is usually adequate.

A preliminary analysis must ensure a reasonable compromise between all these factors in the choice of an appropriate model scale.

DESCRIPTION OF MODEL AND ASSOCIATED HARDWARE

Model

The platform model is usually fabricated from aluminium sheeting which is formed in the required shape. The joints are welded, ground and filled with epoxy compounds to create a smooth finish. The aluminium construction provides a stiff and lightweight model. The deck is constructed in a manner to permit the installation of instrumentation and data transmission equipment within the deck area and to prevent the flooding of the platform due to wave overtopping. Provision is also made for adding lead ballast weights to obtain the correct mass distribution.

Tendons and Risers

Generally, TLPs are moored by a number of tendons at each column. The prototype tendons are made of hollow steel pipes terminating in flex-joints, which reduce the bending stresses at the top and bottom ends. Sometimes, multiple tendons can be modelled by one equivalent tendon in each corner. However, in that case, care has to taken in choosing an appropriate diameter of the equivalent single tendon, so that the fluid loading and the added mass effect are modelled correctly. If the model scale is such that

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