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Impact of Stiffness on the Response of a Multimodule Mobile Offshore Base

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ABSTRACT

The linear, wave-induced response of a 5-module, 1500-m-long mobile offshore base (MOB) is investigated. Each module is a 2-pontoon, 8-column semisubmersible, and the MOB is represented by the lumped-parameter rigid module-flexible connector model. An extensive parametric study is carried out to determine the impact of the stiffness on the motions and connector loads. Results show that the hydrodynamic interaction between modules is relatively small. Although the response is a complicated function of the connector stiffness, the maximum extreme connector forces for hinged modules are often a result of horizontal bending induced by oblique waves. Also, it is shown that resonance can be a significant problem, especially for lower stiffnesses.

INTRODUCTION

There has been renewed interest in floating mobile offshore bases (MOBs) for military purposes. The general function of an MOB would be to provide logistical support where other appropriate facilities are not available. In this context, logistical support includes stationing of several thousand personnel and stockpiling supplies and materiel. Requirements dictate that an MOB would be at least 1500 m long to accommodate large cargo airplanes.

There are several conceptual designs of an MOB. Mobility requirements and the possible necessity to operate in deep, unprotected waters favor a multimodule design in which the modules are joined on-site. One such design consists of relatively conventional semisubmersible modules joined by mechanical connectors. Because semisubmersible design, analysis, and construction technologies have been well developed and proven in the oil industry, the principal technological questions for this class of MOB relate to the connectors, including their influence on the response and the forces they must withstand.

To better understand the wave-induced behavior of this class of MOB, a 5-module, 1500-m-structure has been analyzed. Each 2-pontoon, 8-column module is approximately 300 m × 152 m × 72 m with an operational draft of 39 m. The modules are arranged serially and are connected near the deck level to form the MOB. The primary focus of the investigation was a parametric study considering the influence of the connector stiffness and wave angle on the connector forces and MOB response. This paper describes the analysis procedure used and presents the results of the investigation.

A linear analysis procedure was used to determine the response. Although general 3-D linear hydroelasticity (Wu, 1984) could be used to determine the response of a multimodule MOB, simpler models are useful for preliminary design and parametric studies. The rigid module-flexible connector (RMFC) model assumes that the connectors are significantly more flexible than the modules themselves, hence all deformation occurs in the connectors (Wang et al., 1991, and Ertekin et al., 1993). This model has only 6 displacement degrees-of-freedom per module. Although the structural model is simplified, 3-D, linear potential theory can be used to represent the fluid forces. Specifically, the coupled structure-fluid-structure interaction problem can be considered. If the connectors are not significantly more flexible than the modules, the RMFC approach may still be used if equivalent connector stiffnesses, which include the module stiffness, are used. The RMFC approach then becomes a lumped parameter model.

Although the RMFC approach has limited applicability, it is particularly useful to study the motions and connector forces for this class of MOB for a wide range of stiffness. The method requires that the hydrodynamic calculations, which represent a significant effort for this size of structure, be carried out only once; the results can then be used for all stiffness cases. Hence, the RMFC model was used to represent the MOB for the analyses described herein. The connectors were modeled as linear, translational springs. The 3-D source distribution method was used to solve the coupled fluid-structure interaction problem. The frequency-dependent transfer functions for the desired response quantities were obtained in deep water and without any mooring lines attached. Extreme responses for unidirectional seastates were estimated from the transfer functions.

In the next section, the MOB design characteristics are described. The analysis procedure is then described in detail. This is followed by the results of the parametric study. The study resulted in voluminous numerical results, only a small subset of which can be presented here. However, the results illustrate fundamental issues that affect the connector loads.

MOB DESIGN CHARACTERISTICS

The MOB consists of 5 identical, doubly symmetric modules with a draft of 39 m. The plan dimensions of each module are 300 m × 152 m, and other principal characteristics are given in Table 1. The $\bar{x}_1 - \bar{x}_2 - \bar{x}_3$ coordinate system referred to in Table 1 is a module coordinate system, the origin of which is located at the

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KEY WORDS: Mobile offshore base, connector loads, fluid-structure interaction, hydroelasticity, very large floating structures.