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Impact of Connector Stiffness on the Response of a Multi-Module Mobile Offshore Base

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ABSTRACT

The linear, wave-induced response of a 5-module, 1500 m long MOB is determined. Each module is a 2 pontoon, 8 column semisubmersible, and the MOB is represented by a rigid module-flexible connector model. A parametric study is carried out to determine the impact of the connector 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 loads for a number of stiffness cases are a result of horizontal bending induced by oblique waves. Also, it is shown that resonance can be a significant problem, especially for softer connectors.

Key Words: Mobile Offshore Base, Connector Loads, Hydroelasticity, Fluid-structure Interaction

INTRODUCTION

There has been renewed interest in floating mobile offshore bases (MOBs) for military purposes. The general function of a 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. Transport to and from the MOB would be via sea and air. Air support would require a MOB that is at least 1500 m long to accommodate the landing and take-off of large cargo airplanes.

There are several conceptual designs of a MOB. Mobility requirements and the possible necessity to operate in deep, unprotected waters favor a multi-module design in which the modules are joined on-site. One such design consists of relatively conventional semisubmersible modules which are joined by mechanical connectors. Because semisubmersible design, analysis, and construction technologies have been well-developed and proven in the oil industry, the principle 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 two-pontoon, eight-column module is approximately 300 m x 152 m x 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 connector stiffness and wave heading 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 multi-module MOB, simpler models are useful for preliminary design and for parametric studies involving connector stiffnesses. One approach is to assume that the connectors are significantly more flexible than the modules themselves, and hence all deformation occurs in the connectors. This assumption results in the rigid module-flexible connector (RMFC) model, in which there are only 6 displacement degrees-of-freedom per module (Wang et al., 1991; Ertekin et al., 1993). Although the structural model is simplified, full three-dimensional, linear potential theory can be used to represent the fluid forces. Specifically, the coupled structure-fluid-structure interaction problem can be considered.

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 connector 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 connector 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. Then, the analysis procedure is 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 the fundamental issues which control the connector design, insofar as how their linear stiffness affects the MOB response and the connector loads.