Proceedings of the Eighth (2008) ISOPE Pacific/Asia Offshore Mechanics Symposium
Bangkok, Thailand, November 10-14, 2008

ISBN 978-1-880653-52-4

Hydrodynamic Analysis of Floating Piers in Waves

Zahra, Tajali
Deep Offshore Technology Corp.
Tehran, Iran
Mehdi, Shafieefar
Civil Engineering Department, Tarbiat Modares University
Tehran, Iran
Mahmood, Akhyani
Islamic Azad University, young researcher group
Ghaemshahr, Iran

ABSTRACT

In this paper, the characteristics of motion for floating pier under action of incident waves in frequency domain are studied. Floating pier made from two pontoons that pontoons are modeled as a rigid body and connected to each other by flexible and rigid connectors. Three-dimensional diffraction theory is used to predict the dynamic response of two modules in irregular waves and hydrodynamic behavior of the floating pier are investigated. The pier motions are mostly determined by the energy in short wind waves. This energy in irregular wind waves can be quantified by an incoming wave spectrum S_ζ . Jonswap wave spectrum methods can be used to determine the occurring wave spectrum. Response motions, wave and connection forces between the modules are determined with spectral analysis.
Influence of parameters such as the connector stiffness, dimension of the pontoon - length and beam - and the submerged depth on the pontoon on motion are also studied. Motion-amplitude transfer functions (RAO) of pontoon in marked point, connector forces for the wide range of wave frequency and heading angle are computed. Maximum response amplitude in meter, a maximum force of wave and connection are achieved. Finally we have show that the response of the floating pier motions is significantly dependant on the properties connector stiffness, wave conditions, wave frequency and interactions between the pontoons.

KEY WORDS: Floating structures; multi-body pontoon; hydrodynamic analysis.

INTRODUCTION

Floating piers have various advantages comparing to land based structures. They are minimally influenced by water level fluctuations due to tide and storm surge. These structures are not influenced by soil/seafloor condition, so they do not suffer from differential settlement and can easily be relocated. Recently, a large-volume floating concrete container pier (213m x 30.5m) has been installed in the Port of Valdez, Alaska. Floating piers should be stable and safe during handling, up and down loading of cargoes and the embarking and disembarking of passengers or vehicles. A multi-body floating pier has many advantages compared to a long single-body pier, e.g., flexibility for future extensions, mobility and relocation ability, lower weight and capability of quick transportation and installation.

Environmental loads on a floating pier include wind, waves, current and ice forces. Despite the usually well protected location of floating piers, waves with height up to 1.5m may occur causing major concern. When a pier is towed across the sea from construction yard to installation site, waves could be a major design load. In such cases, the distribution of wave heights and periods is very important.

A linear two-dimensional model describing the complete hydrodynamic problem (diffraction and radiation) of floating bodies has been developed by (Isaacson and Nwogu, 1987). They modified a two-dimensional hydrodynamic model in order to take into account the effect of finite floating body length. The hydrodynamic interactions between multiple bodies have been reported by many researchers, e.g. (Ohkushu, 1974; Kodan, 1984, Fang and Kim, 1986. Van Oortmerssen (1979) and Loken (1981) used the linear diffraction theory with constant panel method, while Choi and Hong (2002) employed an HOBEM (higher order boundary element method) to study three dimensional hydrodynamic interactions between two vessels. Williams and Abul- Azm (1997) and Williams et al. (2000) applied linear potential theory to calculate the hydrodynamic properties of floating breakwaters of rectangular section. They have reported that the wave reflection properties of the structure depends strongly on the width, draught and spacing of the pontoons and the mooring stiffness, while the excess buoyancy of the system is of lesser importance. Sannasiraj et al. (2000) studied the diffraction-radiation of multiple floating structures in directional waves using finite element method showing that interaction tends to become less in the higher frequency zone.

Fang and Kim, (1986) have shown that the hydrodynamic interactions between two bodies cannot be neglected for linked floating structures. The motion response of linked floating breakwaters moored to the ocean floor has been modeled mathematically by (Valioulis, 1989) to serve as an engineering tool in the design of breakwaters which involves the interaction of floating bodies.

Ran (2000) analyzed coupled dynamic analysis of floating structures in waves and currents. Kim (2003) carried dynamic analysis of multiple body floating platforms coupled with mooring lines and risers. Buchner et al. (2001) analyzed the interaction effects between a LNG Carrier in side-by-side mooring to a LNG FPSO. This analysis showed