

Estimation of Current Loads on Side-by-Side Moored Two Vessels

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ABSTRACT

Environmental loads acting on offshore structures, particularly side-by-side moored vessels such as LNGC (Shuttle)-FPSO, are important for analyzing the behavior of the vessels in order to examine the possibility of a safe LNG transfer between two vessels. Among various environmental loads, current loads are normally estimated by using empirical load coefficients. However, standardized load coefficients for offshore vessels are available to a limited extent and it is not easy to apply for vessels with arbitrary shape. Particularly it is the case for multiple vessels. In order to estimate current loads on offshore structures accurately, towing and wind tunnel tests are carried out.

In this study, current loads on side-by-side moored two vessels are estimated by towing tests. First, we considered two shuttles of the same kind set in parallel with varying the separation distances. A moored FPSO-Shuttle system is also considered with different ballast conditions. Experimental results clearly show the interaction between two floaters in terms of the magnitude and direction of the load. It implies that the current loads must be correctly treated in the motion analysis of multiple offshore floaters.

KEY WORDS: Current force coefficient; Offshore vessels; FPSO; VLCC (Shuttle); Side-by-side mooring system

INTRODUCTION

Environmental loads due to current, wave and wind must be considered in analyzing the motion behavior of offshore vessels to examine the watch circle and ensure its operability. Among various environmental load types, current and wind loads are important for assessing the static offset which are, in general, estimated empirically because these are caused by fluid viscosity and it is difficult to estimate them theoretically. Moreover, there are only a few standardized load data that can be applied to offshore vessels. In practice, wind and current loads on offshore vessels are usually estimated with the help of experimental data published by OCIMF (Oil Companies International Marine Forum) in 1977 and revised in 1994. The OCIMF performed towing tests extensively for VLCCs and experimental data were converted into the

current load coefficient. However, it is not clear whether the OCIMF data can be applied to arbitrary hull shapes. Furthermore, there are few data of currents loads acting on multi structures such as side-by-side moored vessels. In this study, current loads on side-by-side moored two vessels are measured by towing tests.

The hydrodynamic analysis of multi vessels was performed by several researchers. Buchner et al. (2001) presented the result of simple diffraction analysis for FPSO-shuttle tanker moored system with different ballast conditions. Choi & Hong (2002) applied HOBEM to FPSO-shuttle system in tandem and in side-by-side arrangement. However, these studies did not include current forces. Yuck et al (2005) calculated current loads acting on single vessels (Shuttle & FPSO) with arbitrary current directions using experiments and calculations. Various numerical methods of calculating the drag of KVLCC2M in head current were proposed at the CFD Workshop Tokyo (2005).

In this paper, we present the current loads acting on FPSO-shuttle system and shuttle-shuttle system in side-by-side arrangement. Several experimental cases are considered depending on the ballast condition, the distance between two vessels and the current angle of attack.

EXPERIMENTS

Method

Tests are carried out at the towing tank in SNU (Seoul National University). The tank dimension is $100m \times 8m \times 3.5m$. Experimental models are towed at a constant speed which is to be equivalent to the constant current inflow. The entire model tests are conducted according to the Froude law, which implies that the Reynolds number of the model test is different from that of prototype. The current load acting on floaters is dominated by the viscous effect. But the effect of different Reynolds numbers will be limited to the small current angles (ICIMF, 1994).

The towing speed is as slow as 0.3 m/s ($Re=10^5$) so that waves do not be generated. For the prototype, the current speed will be about 3m/s. The current angle of attack is varied from 0° to 180° at constant interval, 10° . The sign convention and coordinate system adopted for this paper are illustrated in Fig 1. All tests are made under the deepwater condition ($WD/T \geq 6$)