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# Determination of Roll Damping Coefficients for an FPSO Through Model Tests and CFD Analysis

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**The purpose of this study is to provide a guideline to estimate the damping coefficient for a box-shaped Floating Production Storage and Offloading (FPSO) under various loading conditions and bilge keel heights through model tests and Computational Fluid Dynamics (CFD) analysis. A series of free roll decay model tests is carried out under various conditions for parameters such as the draft, metacentric height (GM), radius of gyration, and bilge keel height. 3D CFD simulations are carried out and 6DOF motion of the FPSO is realized through the employment of the overset mesh technique. The effects of the loading condition and bilge keel height on the roll damping performance of a box-shaped FPSO and a prediction method of roll damping through the use of CFD simulations are discussed in detail.**

## INTRODUCTION

As FPSOs are operated under various loading conditions, the motion responses for each loading condition should be investigated. The roll damping is essential for the accurate prediction of the motions at initial and detailed design phases. Ikeda (1976) and Himeno (1981) extensively investigated the empirical roll damping prediction method. Prediction based on a database from previous projects may be a practical solution, but the available database for box-shaped FPSOs is quite limited. Recently, Computational Fluid Dynamics (CFD) solvers have been applied to investigate the roll damping. Atluri (2009) computed hydrodynamic coefficients of oscillating bodies by CFD and validated the method on a flat plate. The roll damping for sharp and rounded bilges of a 2D rolling hull section was studied by Jaouen (2011). Veer and Fathi (2011) investigated the roll damping of a converted FPSO with riser balcony and bilge keels through CFD analysis. Additionally, Veer et al. (2012) investigated a validated methodology to calculate the oscillatory loads on bilge keels of ships operating in irregular sea states through the numerical and experimental studies. Yan (2013) studied the effect of bilge keel tip configuration on the normal force acting on the bilge keel through CFD. Thilleul (2013) investigated the turbulence model effect on the drag force acting on a circular cylinder in oscillatory flow.

In the present study, a series of free roll decay tests of a box-shaped FPSO is carried out under various conditions for the parameters that may have a significant impact on the roll damping coefficient, such as the bilge keel height, draft, metacentric height (GM), and mass moment of inertia. The radius of gyration and GM are varied for ballast and fully loaded conditions. The decay tests are repeated more than five times with different maximum roll amplitudes. A series of comparative CFD roll decay simulations is carried out for the corresponding experimental cases. The free surface is taken into account and 6DOF motion is realized through the employment of the overset mesh technique. The sensitivity studies are performed for the mesh size, time step, and number of inner iterations. The roll decay time traces and damping coefficients obtained from CFD simulations are compared with the experimental results.

## EXPERIMENTAL STUDIES

A box-shaped FPSO with the dimensions of 300 m in length and 64 m in beam is selected for this study. Figures 1 and 2

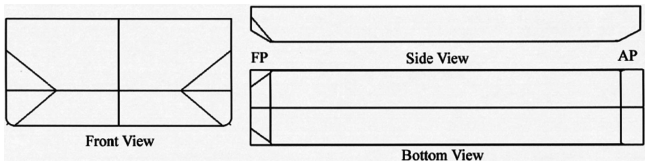


Fig. 1 A box-shaped FPSO hull

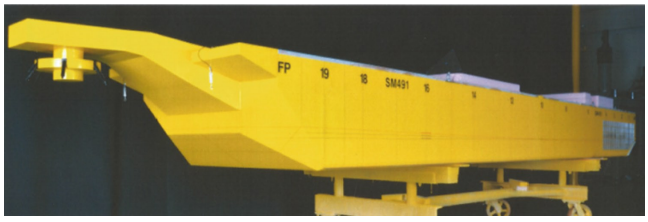


Fig. 2 FPSO model (1/60 scale)

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KEY WORDS: Roll damping, free decay, GM, radius of gyration, bilge keel height, CFD, FPSO.