Experimental Investigation on Lift Coefficient for a Truss SPAR Subjected to Vortex Induced Motions

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ABSTRACT

The prediction of lift coefficient of Truss Spars is the base for investigating added mass coefficient and damping coefficient, which are important in the estimation of fatigue damage rates. The 1:60 scale Truss Spar model tests have been conducted in towing tank at Zhejiang Ocean University (ZOU). The Truss Spar model consists of a hard tank with removable helical strakes, a truss section and a square soft tank. Model tests were carried out with simplified mooring system.

In this study, results from the experiment subjected to uniform current were reported. The Reynolds numbers varied from 8E04 to 2E05. The lift coefficient, lift coefficient components in phase with velocity and acceleration, and the phase angle were calculated. The results showed that the symbol of the lift coefficient in phase with velocity varied with the reduced velocity, while the lift coefficient in phase with acceleration was negative at the investigated range of reduced velocity. The magnitude of lift coefficient in phase with acceleration decided the magnitude of the lift coefficient. The symbol of phase angle varied with the reduced velocity, which was in agreement with the symbol of the lift coefficient in phase with velocity.

KEY WORDS: Truss Spar; vortex-induced motions; lift coefficient; phase angle.

INTRODUCTION

Vortex-induced motions (VIMs) of the Truss Spar would cause considerable fatigue damage level, which is a significant consideration in the structure design (Blevins, 1990; Sarpkaya, 2004; Gabbai & Benaroya, 2005; Williamson & Govardhan, 2008). The vortex-induced motions depend on many dimensionless parameters. The prediction of the vortex-induced motions requires not only the investigation of the parameters, but also the relationships between the parameters (Vandiver, 1993).

Lift coefficient is a critical parameter in the prediction of the Truss Spar VIM behaviour. The prediction of lift coefficient of Truss Spars is the base for investigating of added mass coefficient and damping coefficient, which influence the response frequency.

Lift force can be split into two components; one is in phase with the acceleration of the Truss Spar and the other with the velocity of the Truss Spar. The phase angle is the angle by which the oscillating lift force leads the imposed oscillating motion (Gopalkrishnan, 1993). Estimation of the lift coefficient components are reported by numerous papers (Vikestad et al., 2000; Wu et al, 2007).

Two significant dimensionless parameters are given in Equation (1) and Equation (2). The strouhal frequency as an approximately estimation of the vortex-shedding frequency, is estimated by the strouhal number \((St)\), as shown in Equation (1).

\[
St = \frac{U}{f_{st}}
\]

where, \(U\) is the current velocity and \(D\) is the diameter of the Truss Spar.

The relationship between these parameters is reflected by a dimensionless parameter, reduced velocity \((U_r)\), as shown in Equation (2).

\[
U_r = \frac{U}{f_s D}
\]