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Estimation of Wave Drift Damping for a TLP

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ABSTRACT

A simplified ARG procedure, involving only the zero forward speed Green's function, is used to calculate the low-frequency damping of an arbitrary three-dimensional floating structure in waves. In addition, an approximate approach, which involves calculating the mean longitudinal drift force at zero forward speed at a Doppler-shifted wave frequency, is investigated. It is found that for the ISSC TLP, wave drift damping coefficients calculated using both approaches are in good agreement and so the approximate technique may offer a computationally attractive alternative for estimating the low-frequency hydrodynamic damping of a TLP.

INTRODUCTION

Large amplitude responses may be induced in the surge, sway and yaw modes of oscillation of a TLP by second-order, low-frequency wave components causing resonant excitation of the structure. At or near resonance, the response of the system is limited only by the damping. Since at low frequencies first-order radiation damping is vanishingly small, damping due to viscous or higher order effects must be introduced to correctly model the low-frequency response. The low-frequency surge experiments of Wichers and Sluijs(1979) on a moored tanker in waves indicated that the hydrodynamic damping was linearly dependent on the structure's low frequency motions. Also, the damping was larger in waves than in still water. The additional wave-borne damping was dependent on the incident wave frequency but not on the motion frequency, and was proportional to the incident wave-amplitude squared. Incorporating this additional damping component into the numerical model for the low-frequency surge response gave much better agreement with experiments (Wichers, 1982). Wichers and Huijsmans(1984) demonstrated theoretically, and verify experimentally, that the (dominant) potential component of the low-frequency surge damping due to the waves was related to the mean longitudinal wave drift force (added resistance) derivative with respect to the body velocity at zero mean forward speed.

Based on the findings of Wichers and Huijsmans(1984), Hearn and Tong(1986) developed and applied a theoretical added resistance gradient (ARG) method of predicting the wave damping coefficients using an enhanced strip theory procedure. Hearn *et al.* (1988a) extended this two-dimensional analysis to three dimensions and presented a comparison of low-frequency surge damping coefficients from the two- and three-dimensional theories and experimental measurements for ship forms. Also discussed was a simplified analysis procedure in which the zero forward speed Green's function was used to calculate low-frequency damping, in this approach each forward speed is used to define an encounter frequency for the problem. Standing *et al.* (1987), presented a further simplified procedure in which the wave drift damping was taken to be proportional to the product of the mean longitudinal drift force at zero forward speed and the wavenumber associated with the incident wave frequency. This simplification was investigated in detail for both a tanker and a barge by Hearn *et al.* (1988b). It was concluded that for these particular geometries not only were the amplitudes of the wave drift damping coefficients obtained by the two methods quite different, but that their respective peaks occurred at different frequencies. In the present paper the analysis procedure of Hearn *et al.* (1988a) involving the zero forward speed Green's function is used to calculate the low-frequency damping of the ISSC TLP. Also, a simplified approach equivalent to that of Standing *et al.* (1987), which involves calculating the mean longitudinal drift force at zero forward speed at a Doppler-shifted wave frequency, is investigated. It is found that for the TLP considered herein, wave drift damping coefficients calculated using the two approaches are in good agreement. Therefore, the approximate method may offer a computationally attractive alternative for the estimation of the low-frequency damping of a TLP.

THEORETICAL DEVELOPMENT

A structure advancing at a steady forward speed in waves experiences a resistive force additional to that in still water, the so-called added resistance in waves, R_{2w}. The added resistance can also be viewed as the mean second-order longitudinal drift force, F_{2mx}, induced by the incident wave field on an advancing structure. At low frequencies the hydrodynamic damping in surge can be written as

$$b = b_o + b_1 x + b_2 \tag{1}$$

in which b_o is the still-water low-frequency damping, b_1 is the quadratic viscous damping and b_2 is the low frequency damping in waves. The (dominant) potential component of low frequency surge damping may be determined from (Wichers and Huijsmans, 1984)

$$b_2 = -\frac{\partial F_{2mx}}{\partial \dot{x}_{2-}}\left(x_{1w}, x_{2-}, \dot{x}_{2-}, t\right)\Big|_{\substack{\dot{x}_{2-}=0 \\ x_{2-}=0}} \tag{2}$$

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