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Time-domain analysis of a floating bridge subjected to wind and wave loads based on state space models

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ABSTRACT

To cross deep-water areas, floating bridges are receiving increasing attention. Due to the low lateral bending frequency of floating bridges, the impact of second-order nonlinear wave forces cannot be ignored. Therefore, this paper conducts a time-domain analysis of the dynamic response of floating bridges under the combined action of turbulent wind and irregular waves. The quadratic transfer function (QTF) of the second-order wave force is calculated by potential wave theory (Fig.1). Additionally, the added mass and damping coefficients for the pontoons in six degrees of freedom are computed, and the transfer function of radiation wave force is established. The state-space method (SSM) is applied to calculate the radiation force in the time domain. A simplified finite element model of the Bjørnafjord straight floating conceptual bridge is established to calculate the dynamic response of the floating bridge under the combined action of turbulent wind and nonlinear irregular waves. The spatial effects of waves are investigated by comparing the difference responses induced by two-dimensional long-crested waves and three-dimensional short-crested waves.

The analysis results reveal that the second-order waves induce the lateral static displacement and the low-frequency response of the floating bridge., while the first-order waves elicit higher-mode responses, and the low-frequency response induced by turbulent wind is more significant. For the same return period, wind loads cause greater lateral displacement of the floating bridge (Fig.2) compared to wave forces, but smaller displacement in the vertical direction. Interestingly, the bending moments exhibit an opposite phenomenon, namely, the long-crested waves generate much larger lateral bending moments near the quarter span (Fig.3), but smaller bending moments in vertical dimension than those caused by the turbulent wind. It is observed that the lateral and vertical displacement induced by long-crested waves are both larger but the vertical bending moments are smaller than that caused by short-crested waves.

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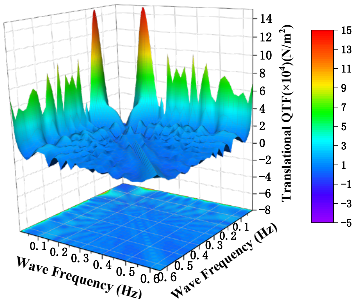

Fig.1: QTF of the second order wave forces

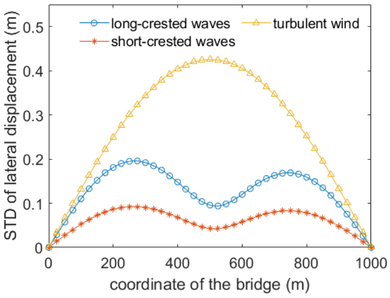

Fig.2: STD of the lateral displacement

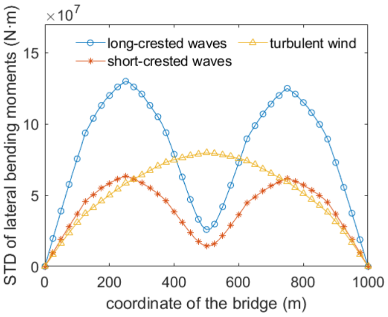

Fig.3: STD of the lateral bending moment