Offshore & Dredging Engineering

Technische Universiteit Delft

Numerical study of VIV of a free-hanging slender structure with circular cross section using wake oscillator models

The aim of this work is to study the performance of the selected wake oscillator model in predicting the vortex-induced vibrations (VIV) response of a free-hanging vertical riser subjected to certain imposed harmonic oscillations at the top. This model is a simplification of the situations commonly found in offshore industries when a marine riser, subjected to current flows, is connected to a floating structure at the top which oscillates in any direction. The performance is assessed by comparing the results with recent measurements done in MARIN.

The wake oscillator model implementing the principle of van der Pol equation is coupled to the equation of motions of the structure using the acceleration coupling. A total of 24 cases with various combinations of flow velocity, pretension, frequency of imposed motions, as well as the amplitude of the imposed motions are applied to the structure. The combinations of frequency and amplitude applied represent some typical conditions, including the typical range of frequencies and amplitudes in vortex induced motions and in the range close to the Strouhal frequency and/or one of the natural frequencies.

Comparison with the measurements shows that, in the case with sway imposed motions, better predictions are observed when the Strouhal frequency is close to one of the natural frequencies, either when the frequency of imposed motions is close to or totally off from the Strouhal frequency. Despite the fact that some frequency components at the higher frequencies are not captured by the numerical model, the numerical model is, in general, able to predict the dominant frequency components in such cases.

On the other hand, less agreement is observed when the Strouhal frequency is not close to any of the natural frequencies of the structure. The same is also observed in the case with surge imposed motions. In these cases, the numerical model failed to predict the most dominant frequency components in the cross-flow directions. In the in-line direction, the numerical model only shows the frequency due to the imposed motions, but not the other frequency components observed at higher frequencies.
In terms of bending moment envelope, the numerical model in general underestimates the maximum bending moments in both directions, but overestimates the mean bending moment in the in-line direction.

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