Simplified Bottom Fixed Offshore Wind Turbine in Extreme Sea States

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ABSTRACT
The study investigates hydrodynamic design loads on column type of a bottom fixed offshore wind turbine foundation in intermediate water depths. An experiment with a simplified one degree of freedom cylinder was carried out at the small wave flume of the Norwegian University of Science and Technology in April and May 2015. A stiff cylinder mounted onto a rotational spring was exposed to extreme storms and the response bending moment was measured at the mudline. Significant first mode motion of the cylinder was observed during the experiment, often corresponding to the passage of a steep breaking or near breaking wave. Studies of slamming dominating events indicate that they occur too fast to trigger first mode motion of the system. It was shown in a previous paper (Suja-Thauvin, Krokstad, and Frimann-Dahl 2016) that for a selected event, high order hydrodynamic loads could trigger it. In this paper, the continuous wavelet transform and a reconstructed linear wave from the measured wave are used to carry out a statistical analysis of about 1000 events where large responses of the structure were recorded. The results are consistent with what was concluded in the previous paper, i.e. that the 1st mode motion correlates well with the 2nd and 3rd order hydrodynamic loads calculated from the FNV method.

KEY WORDS: ringing, extreme waves, extreme response, nonlinear loads, wave linearization

NOMENCLATURE
\( c \) wave celerity
\( C \) damping ratio
\( g \) gravitational acceleration
\( h \) water depth
\( H_S \) significant wave height
\( I_A \) moment of inertia due to added mass
\( K \) rotational stiffness of the spring
\( k \) wave number
\( l \) wavelength
\( M_{\text{hydro}} \) hydrodynamic excitation moment
\( R \) cylinder radius
\( t_D \) slam load duration
\( T_p \) spectral peak period
\( T_W \) wave period
\( u \) water particle horizontal velocity
\( w \) water particle vertical velocity
\( z \) vertical coordinate
\( \beta \) order of the Butterworth filter
\( \zeta^{(1)} \) linear wave elevation
\( \zeta^{(2)} \) second order wave elevation
\( \theta \) angular position of the cylinder
\( \lambda \) cut-off frequency factor
\( \rho \) water density