Extreme Value Predictions using Monte Carlo Simulations with Artificially Increased Wave Height

It is well known from linear analyses in a stochastic seaway that the mean out-crossing rate $\nu(r)$ of a level $r$ is given by $\nu(0)\exp(-0.5\beta^2)$ where the reliability index $\beta=r/S_r$. Here $S_r$ is the standard deviation of the response and, hence, linearly dependent on the significant wave height $H_s$. For non-linear processes the reliability index depends non-linearly on the response level $r$, and a good estimate can be found using the First Order Reliability Method (FORM). The reliability index from the FORM analysis is still strictly inversely proportional to the severity of the sea state, i.e. $\beta=c(r)/H_s$. A more accurate result can be obtained by Monte Carlo simulations, but the necessary length of the time domain simulations for very low out-crossing rates might be prohibitively long. The present paper investigates whether the FORM property regarding the dependency of the reliability index on the significant wave height can be used in Monte Carlo simulations to increase the out-crossing rates and thus reduce the necessary length of the time domain simulations by applying a larger significant wave height than actually required for design. The mean out-crossing rate thus obtained can then afterwards be scaled down to the actual significant wave height using this property. Previous results have been presented by Tonguc and Söding (1986), albeit in a more empirical way, and by Jensen (2010), where, considering the overturning of a jack-up rig, a slightly more general relation of the type $\beta=a(r)+b(r)/H_s$ was found to be very accurate. In the present paper the generality of this relation is investigated, considering the probability that the design wave-induced hogging bending moment in a container ship is exceeded, accounting for both non-linear wave load effects (bow flare slamming) and hull flexibility (whipping vibrations).