Multiple timescale spectral analysis of a floating bridge under wave excitation

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ABSTRACT

The E39 Coastal Highway Route in Norway, connecting Trondheim to Kristiansand via Bergen and Stavanger, is currently interrupted by seven major fjords. Over the past several years, the Norvegian Public Road Administration has worked on the development of bridge and tunnel technologies to address the challenge of crossing those wide and deep fjords without using ferries, in order to drastically reduce travel time between main norvegian cities. In this context, attention has been drawn to large wind- and wave-loaded structures like suspension bridges with pylons floating on tension-leg platforms and bridges supported by discrete floating pontoons (see figure). Considering such large slender structures, the Multiple Timescale Spectral Analysis (MTSA) is able to provide simple analytical approximations of their response statistics very rapidly compared to usual time and frequency domain analyses. The MTSA is actually a framework which relies on the existence of well separated timescales in the structural response to generalize the famous background/resonant decomposition, widely applied by the wind engineering community to compute the variance of the response of a single degree-of-freedom structure (or a modal response). For now, the MTSA concerns the analysis of structures subjected to buffeting wind loading, which is characterized by a rather low frequency content. It covers the evaluation of the covariances of modal responses and the calculation of the statistics of a single modal response up to fourth order, which are necessary to consider the influence of the non-Gaussianity of the loading or the non-linearity of the structural behavior. The purpose of this paper is to extend this approach to analyze structures subjected to wave loading, whose frequency content is much higher than buffeting wind loading, interchanging therefore the roles of the slow and fast timescales