DOI：10.16285/j.rsm.2016.03.020

水动力质量实效施加方法及地基-筒型基础-塔筒体系的地震敏感性研究

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摘 要：针对海上风电结构在有限元计算中水动附加质量的施加问题，提出了一种在 ABAQUS 软件中简便有效易于实现的方法，可以提高有限元分析的前处理效率；建立有限元模型，分析有、无考虑水动附加质量和不同边界条件对海上风电结构自振特性的影响，并从力学角度进行分析；利用有限元模拟地震动作用下的海上风电结构塔筒响应，并对水动附加质量和边界条件进行敏感性分析。通过数值计算并结合理论分析表明：提出的水动附加质量施加方法是合理实用的；水动附加质量的施加使得结构固有频率减小，且随着阶数增大，固有频率减小的绝对值增大；边界条件对体系的模态参数影响比水动附加质量更显著，黏弹性透射边界条件下计算得到结构体系的各阶频率较固定边界均有比较明显的减小；黏弹性透射边界模型在地震动作用下的位移响应比固定边界模型大。分析结果对此类海上风电工程具有借鉴意义。

关 键 词：水动力附加质量；地基–筒型基础–塔筒体系；黏弹性透射边界；模态分析；地震荷载；位移响应

中图分类号：TU 435 **文献识别码：**A **文章编号：**1000－7598 (2016) 03－0767－09

A practical method for applying the hydrodynamically induced mass and the sensitivity analysis of the ground-bucket foundation-tower system

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Abstract: A simple and effective method is proposed to apply the hydrodynamically induced mass to the marine wind power structure in the finite element analysis. The proposed method can be readily implemented into the ABAQUS software, by which the preprocessing efficiency is improved in the finite element analysis. A finite element model is developed, and the influences of the hydrodynamically induced mass and different boundary conditions on the natural vibration of marine wind power structure are analyzed. Based on the finite element method, the sensitivity analysis is carried out for the hydrodynamically induced mass and various boundary conditions, through simulating the response of offshore wind power tower under the earthquake loading. The numerical simulation and theoretical analysis show that the proposed method yields good results. Applying the hydrodynamically induced mass decreases the natural frequency of the structure, and as the order number increases, the natural frequency and its absolute magnitude increase. The boundary conditions can influence the modal parameters more significantly than the hydrodynamically induced mass, and the natural frequencies of each order decrease significantly if the viscoelastic transmitting boundary condition is adopted. The model with a viscoelastic transmitting boundary yields a greater displacement response compared to the model with a fixed boundary.

Keywords: hydrodynamically induced mass; ground-bucket foundation-tower system; viscoelastic transmitting boundary; modal analysis; seismic loads; displacement response

收稿日期：2014-10-20
基金项目：国家自然科学基金创新研究群体科学基金（No.51021004）；国家自然科学基金（No.51408409）。
This work was supported by the Foundation for Innovative Research Groups of the National Natural Science Foundation of China (51021004) and National Natural Science Foundation of China (51408409).
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