DYNAMIC SOIL-STRUCTURE INTERACTIONOF MODERN WIND TURBINES

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ABSTRACT

This paper assesses the way soil-structure interaction phenomena affect the seismic response of modern wind turbines. To this end, a novel element for three-dimensional finite element analysis of rigid rectangular foundations is proposed and implemented using the computational platform OpenSees. It is worthy of note that the proposed model is capable of capturing the effect of soil nonlinearity. Afterward, using the NREL 1.5-MW baseline turbine, some interaction models are introduced and the effects of three types of cohesionless soils, including soft, medium and stiff soils are investigated. Modal analyses show a decrease in natural frequencies when SSI is considered; and higher modes especially undergo bigger changes. The effect of viscous damping on the predicted turbine response is evaluated as well. Finally, several nonlinear dynamic time-history analyses are performed using three earthquakes with different peak ground accelerations to evaluate the effect of SSI on the maximum internal forces of the tower. Results reveal that SSI influence on the value and distribution of the maximum moment and shear demand will be significant. The alterations in the response of the tower are likely to require redesign of the turbine to account for SSI.

INTRODUCTION

Over the past decade wind energy and wind turbines have been becoming more important around the globe as a source for clean and renewable power. Globally, the long-term technical potential of wind energy is believed to be five times total current global energy production. This would require wind turbines to be installed over large areas. Earthquakes always pose a threat to these structures and their survival through earthquake events will mitigate financial loss due to disruption and theneed for replacement.

Existing studies include using simplified models with point masses for the nacelle and rotor at the top of the tower as a way to remove the complexity of modeling.The more precise and complicated models with more details of a real wind turbine have also been used.Haenler et al. (2006)investigated a turbine with an 80-m rotor diameter and 60-m hub height under both wind and seismic loadings and found that higher modes of the tower were more important for earthquake loadings than typical wind loadings.Zhao et al.(2007)presented a hybrid multi-body system for modeling turbine dynamics and concluded that a minor