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Over the last decades, wind turbines have increased significantly in size. Optimisation of the turbine blades and towers has led to slender and therefore extremely flexible structures. Consequently, the first modes of resonance of the total structure are close to the excitation frequencies related to environmental loads from wind and waves. Hence, a modern wind turbine undergoes large deformations, not only during extreme weather conditions but also during power production.

Aeroelastic codes have been developed that may be employed for a lifetime analysis of the structural response. Existing codes, e.g. HAWC [1], have about 30 degrees of freedom for the entire structure. However, the current models do not account for dynamic soil-structure interaction (SSI) and, as a result of this, the forces on the structure may be over- or underestimated. In this paper, the SSI is introduced by fitting a lumped-parameter model [2] to the results of a rigorous model of a layered half-space, using the method proposed by Andersen and Clausen [3].

The influence of the subsoil on the response of a wind turbine is discussed with focus on horizontal excitation of the structure. Two different sites are considered--one with a loose top layer of sand and one with a soft clay deposit at intermediate depth. The emphasis is put on the geometrical damping in the soil, and a parameter study is performed with respect to the layer depths and the material properties of the soil. To ensure realistic results, the dynamic properties of the simple model are based on field measurements on a 3 MW wind turbine in Frederikshavn, Denmark [4].

The main conclusion is that the first mode of resonance, typically about 0.3 Hz, is not influenced by geometrical dissipation in the ground. On the other hand the geometrical damping may have a significant impact on vibrations at the second resonance frequency of the turbine tower, typically about 2 Hz. Here, it makes a great difference whether the soil is drained or undrained. However, the properties of the soil a depths greater than the characteristic length (e.g. diameter) of the foundation have almost no effect on the response.

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