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Dynamic Behavior of Wind Turbines under Downbursts

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ABSTRACT

Wind turbines are considered to be key sources of wind energy, one of the fastest-growing technologies for clean and renewable power. Although wind turbine towers are widely studied using static, quasi-static and dynamic analyses under synoptic and extreme wind loading, dynamic behavior of wind turbines under downbursts is not known. To the best of the authors' knowledge, this study is the first to assess the dynamic behavior of wind turbines under downbursts. The downburst wind field consists of a moving mean component with a superimposed turbulence component. In this study, the mean component is generated using previously conducted Computational Fluid Dynamic (CFD) simulations based on the RANS method. The turbulence is simulated using Consistent Discrete Random Flow Generation (CDRFG) as a stochastic process using turbulence power spectral density and coherence functions pertaining downbursts. The study considers the downburst parameters that affect the turbine response such as the jet velocity, the jet diameter and the downburst location relative to the tower center. The analysis is conducted using the commercial code FAST coupled with a user-compiled module. The moments at the tower base and at the blades roots are determined under different downburst configurations. Comparison between quasi-static and dynamic analyses is conducted and the dynamic amplification factor is determined for different downburst configurations. The aerodynamic damping of the blades is also estimated and compared with previous analytical closed form solution.

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