Turbulent wind field representation and conditional mean-field simulation

The covariance structure of a homogeneous isotropic turbulent wind velocity field is derived in terms of modified Bessel functions for an extended form of the Kármán velocity spectrum, including explicit expressions for the transverse coherence functions. A concept of transformed isotropic turbulence is introduced to account for differences in the axial, transverse and vertical fluctuating wind velocities and length scales in natural wind. A special form of the auto-regressive simulation format is developed for convected turbulence with exponentially increasing intervals to the regression planes. In each step, the wind velocity field in a transverse plane is represented by a conditional mean field and a stochastic contribution determined explicitly by the time-space covariances. Simulation results are presented for a square area of dimension less than the integral length scale, representative of buildings and wind turbines, and a horizontal line of length six times the length scale, representative of a long-span bridge. The simulations demonstrate high accuracy of simulated spectral densities, covariance functions and transverse coherence functions. The simulated results do not show visible dependence on the specific points used for the simulated records. The efficiency and the free simulation point configuration suggest high competitiveness compared to fast Fourier transform-based spectral methods.

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