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# Stochastic enhancements in wake oscillator models: experimental and modeling aspects

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**Abstract**

This paper reviews existing models for vortex-induced vibrations (VIV), and presents the author's contribution focusing on slow and random phase models. VIV is a critical phenomenon in the cross-wind behavior of structures and presents significant challenges for modeling, particularly due to the complexities of fluid-structure interactions. Although wake-oscillator models have historically been influential, their deterministic formulation limits their application in modern wind engineering. In contrast, stochastic models, such as the spectral model, better capture the randomness observed in real experimental settings. This work seeks to reconcile these two approaches by combining the stochastic spectral model with the deterministic wake-oscillator model.

Two primary sources of stochasticity in VIV are identified: turbulence in the oncoming wind and turbulence in the near wake. The first, arising from atmospheric turbulence, affects the vibration response of structures, while the second, linked to wake turbulence, governs vortex shedding dynamics. Starting from Tamura's wake oscillator model (because of its soundness and basement of first principles), incorporating these sources of randomness into the VIV models improves their realism and predictive accuracy, bridging the gap between the stochastic and deterministic frameworks.

Although numerical techniques can be used to simulate the problem, a key aspect to understanding is the application of multiple timescale analysis to the wake-oscillator model. By exploiting small parameter asymptotics, slow-varying solutions are derived, simplifying the numerical treatment by focusing on the slowly modulated amplitude and phase, rather than fast transient dynamics. The effect of turbulence intensity on the VIV response is also explored, revealing a complex interaction between turbulence and vortex shedding.

This work demonstrates how combining stochastic models, such as the spectral model, with deterministic approaches, like the wake-oscillator model, provides a flexible representation of VIV.