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Comparison of Wake Oscillator Models to Predict Vortex-Induced Vibration of Tall Chimneys

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Abstract : The present study compares the semi-empirical wake-oscillator models that are used to predict vortex-induced vibration of structures. These models include those proposed by Facchinetti, Farshidian, and Dolatabadi, and Skop and Griffin. These models combine a wake oscillator model resembling the Van der Pol oscillator model and a single degree of freedom oscillation model. In order to use these models for estimating the top displacement of chimneys, the first mode vibration of the chimneys is only considered. The modal equation of the chimney constitutes the single degree of freedom model (SDOF). The equations of the wake oscillator model and the SDOF are simultaneously solved using an iterative procedure. The empirical parameters used in the wake-oscillator models are estimated using a newly developed approach, and response is compared with experimental data, which appeared comparable. For carrying out the iterative solution, the ode solver of MATLAB is used. To carry out the comparative study, a tall concrete chimney of height 210m has been chosen with the base diameter as 28m, top diameter as 20m, and thickness as 0.3m. The responses of the chimney are also determined using the linear model proposed by E. Simiu and the deterministic model given in Eurocode. It is observed from the comparative study that the responses predicted by the Facchinetti model and the model proposed by Skop and Griffin are nearly the same, while the model proposed by Fashidian and Dolatabadi predicts a higher response. The linear model without considering the aero-elastic phenomenon provides a less response as compared to the non-linear models. Further, for large damping, the prediction of the response by the Euro code is relatively well compared to those of non-linear models.

Keywords : chimney, deterministic model, van der pol, vortex-induced vibration
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