RUHR-UNIVERSITÄT BOCHUM

Windingenieurwesen und
Strömungsmechanik

RUB

Master's Thesis

On aerodynamic damping and lift spectral densities of aeroelastic cantilever cylinder under simulated transcritical flow in boundary layer wind tunnel

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Background:
Wind turbine tower as a large structure where in the field, it experiences transcritical range of Reynolds number with $Re > 2 \cdot 10^6$. To investigate the wind effects, which are important for the design and transportation phases of the wind turbine, scaled model experiments have mostly been conducted in the wind tunnel. Many techniques have been developed to recreate a simulated transcritical flow, such as using an additional roughness on the model surface. Although Reynolds number discrepancy still becomes an issue, wind tunnel experiments data are valuable to provide reference of measured response and force coefficient for the structure under wind.
A wind tunnel test campaign was conducted to analyze the vortex induced vibration (VIV) on slender scaled cantilever model of wind turbine tower. The model is measured by force balance at the bottom tested with different incoming wind speed. An in-depth spectral analysis, especially for the cross-wind response component, can be done to gain further insight into the global response of VIV experienced by the model. The disparity on aerodynamic coefficients due to Reynolds number difference is observed on drag coefficient, where lift coefficient and Strouhal number gives similar compared to full-scale measurement indicating the high Reynolds number. However, recent internal study shows the disparity was also observed in the estimated aerodynamic damping using spectral method [1], [2]. Several investigations are needed such as complete estimation of aerodynamic damping values for whole lock-in range and comparison of global spectral densities at the base of small scale models to the full-scale.

Tasks: Based on wind tunnel test data of a rough cantilever model as a scaled model of a wind turbine support structure, perform lateral (Lift/Cross-wind) response analysis and its spectral content analysis to gain further insight into VIV that occurred. Furthermore, estimate aerodynamic damping for the tested lock-in range.

- Perform post-processing and evaluation of wind tunnel data (force reaction at the base and flow condition)
- Calculate the lateral component of the model response (force reaction at the bottom and the bending moment at the bottom)
- Analyze the spectral content of the lateral component of the model response
- Perform analysis of global lift spectral density based on the model response
- Investigate the aeroelastic and vortex resonance parameters such as Strouhal number, Bandwidth parameters, variance, and the aerodynamic damping
- Using the standard deviation of displacement in lock-in range, estimate the global aerodynamic damping using spectral method and associated vortex shedding parameters, for each tested wind speed range.
- Formulate discussions on peak factor of the VIV response (e.g., the effect turbulence intensity, oscillation cycles and intermittency)

References:

[1] B. Vickery and R. Basu, “Across-wind vibrations of structures of circular cross-section. Part I. Development of a mathematical model for two-dimensional conditions,” *Journal of Wind Engineering and Industrial Aerodynamics*, vol. 12, no. 1, pp. 49–73, 1983.

[2] R. Basu and B. Vickery, “Across-wind vibrations of structure of circular cross-section. Part II. Development of a mathematical model for full-scale application,” *Journal of Wind Engineering and Industrial Aerodynamics*, vol. 12, no. 1, pp. 75–97, 1983.