RUHR-UNIVERSITÄT BOCHUM

Windingenieurwesen und
Strömungsmechanik

RUB

# Master's Thesis

*Estimation and classification of wind profile for Vortex-Induced Vibration (VIV) prediction on wind turbine tower*

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**Background:**
In the neutral state of the atmosphere, the wind comes to the Earth's surface can be simplified as the boundary layer flow depending on the terrain roughness. This is known as the "wind model", an area that is still under investigation to account for the complexity of atmospheric flow. Standards such as DIN EN-1991-1-4:2010 NA [1] suggest a power law function to estimate the wind profile in the assumed neutral atmospheric condition. A logarithmic law may also be suggested, as noted in EN 1991-1-4:2005 [2]. In the new draft Eurocode (prEN 1991-1-4:2024) [3], the wind profile suggested by Deaves and Harris is now included [4], [5].

Willecke et al. [6] investigated long-term measurement data of wind condition from 344 m of met mast in Gartow, where six different wind profile types are observed and classified. This is particularly important to be considered when one deals with slender structure and tower such as wind turbine, and generally for Vortex-Induced Vibration (VIV) phenomenon caused by vortex shedding in the wake of the structure. Furthermore, combination of varying diameter of the tower and the local mean wind speed can give different sectional spectral densities of vortex shedding load. Field measurements is currently conducted in Østerild, Denmark [7], where both tower response and simultaneous wind condition at met mast are being continuously measured, including at the time of VIV occurrence. The evaluation and analysis of simultaneous wind profile with the measured cross-wind (lateral) response of the tower under VIV based on the full-scale data can give realistic evaluation on sectional approach of vortex resonance.

**Tasks:** Based on full-scale measurement data from met masts and wind turbine tower, classify the measured wind profile and map the measured response of wind turbine tower under VIV based on the respective wind profile.

- Perform post-processing and evaluation of full-scale measurement data
- Observe the shape of wind profile measured in met masts, and classify different state of wind profile due to varying thermal stratification of the atmosphere
- Compile the simultaneous measured response of wind turbine tower for respective wind conditions and wind profile
- Compile a VIV data set for validation of calculation methods
- Perform VIV calculation with the help of pre-defined calculation script

**Reference:**


[1] “DIN EN 1991-1-4/NA Nationaler Anhang – Eurocode 1: Einwirkungen auf Tragwerke – Teil 1-4: Allgemeine Einwirkungen - Windlasten (in German).” Dezember 2010.

[2] EN 1991-1-4:2005, “Eurocode 1: Actions on structures – Part 1-4: General actions – Wind actions.” CEN, Brussels, 2005. doi: ICS 91.010.30; 93.040.

[3] “prEN 1991-1-4:2024. Eurocode 1: Actions on structures: Part 1-4: General Actions - Wind Actions.,” prEN 1991-1-4:2024, Mar. 2023.

[4] D. M. Deaves, R. I. Harris, and Construction Industry Research and Information Association, *A mathematical model of the structure of strong winds*. London: CIRIA London, 1978.

[5] S. O. Hansen, R. Höffer, J. Rees, F. Ricciardelli, and P. Spehl, “Towards the Second Generation Eurocodes: Evolution of EN 1991-1-4 Wind Actions,” in *Proceedings of the XV Conference of the Italian Association for Wind Engineering*, F. Ricciardelli and A. M. Avossa, Eds., Cham: Springer International Publishing, 2019, pp. 350–364.

[6] M. Clobes, A. Willecke, and U. Peil, “Shape-dependent characteristics of full-scale wind profiles,” *Journal of Wind Engineering and Industrial Aerodynamics*, vol. 99, no. 9, pp. 919–930, 2011, doi: https://doi.org/10.1016/j.jweia.2011.05.005.

[7] R. Höffer, I. Kurniawati, F. Lupi, M. Seidel, and H.-J. Niemann, “Full-scale tests on wind turbine towers: towards a realistic prediction of vortex-induced vibrations,” in *CICIND Report 97th Conference in Paphos*, 2022.