

Verification of wind turbine tower structural properties

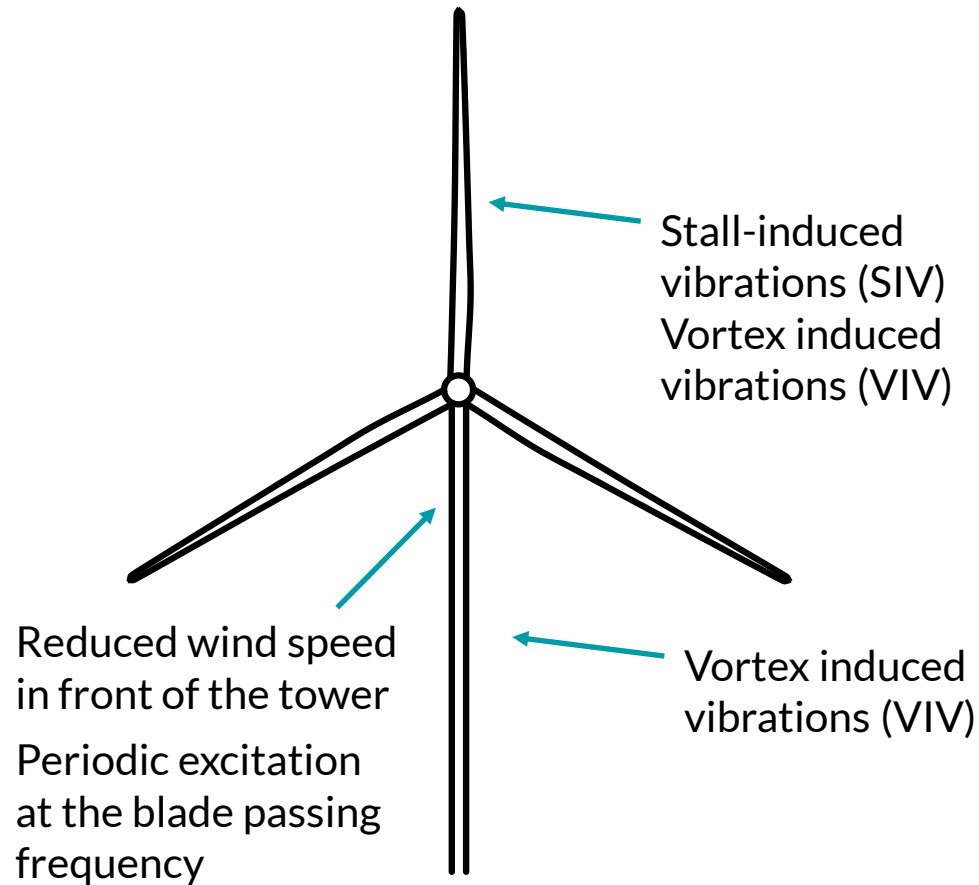
Rémi Corniglion, RISE

Monitoring of Modvion's wooden wind turbine tower



Modular wooden wind turbine towers with a net positive climate impact

Wind turbines are vibration machines



Structural modes of vibration and their damping are critical for aero-elastic stability of wind turbines

World's tallest wooden wind turbine tower

- Tower Height: 105 meters
- Turbine: V90-2.0MW
- Client: Varberg Energi
- Delivery Date: 2023

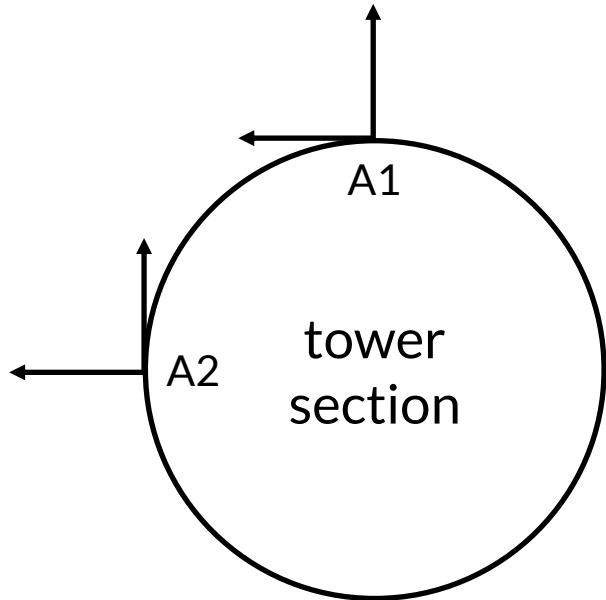
GOAL

Verify the modal properties of the wooden wind turbine tower



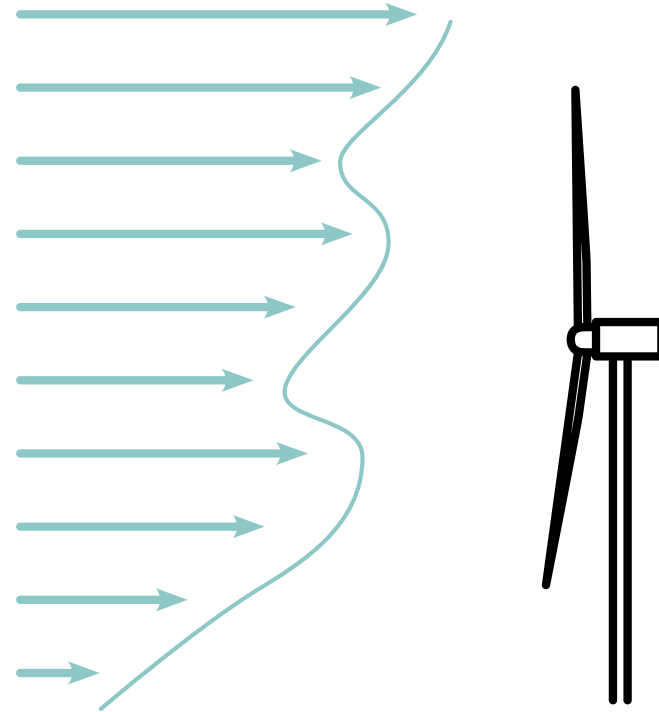
Monitoring system

Sets of accelerometers



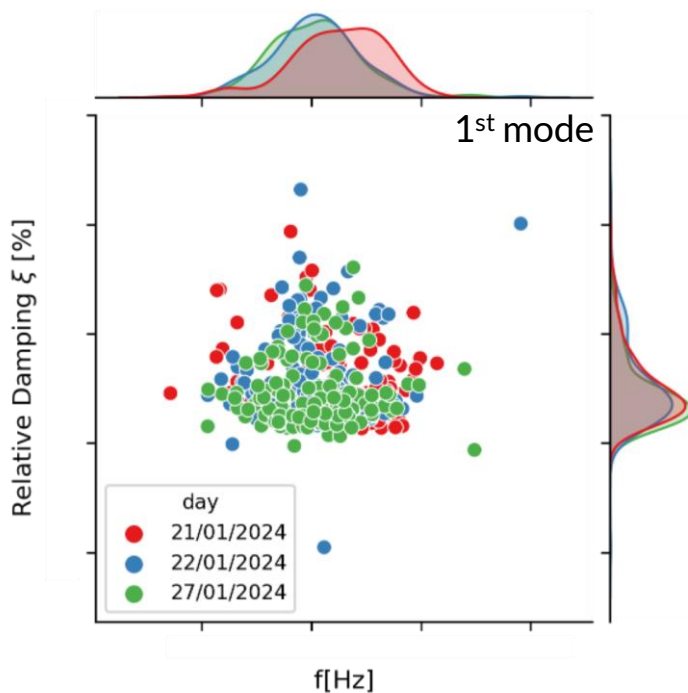
Operational Modal Analysis

- Goal: extract the structures modal frequencies and associated damping levels
- Natural wind excitation is causing structural vibrations
- 3 days of vibrational data from wind turbine in standstill



Operational Modal Analysis

Operational Modal Analysis (SSI-Cov) is used to extract the structures modes and damping levels from the vibration data



1st mode

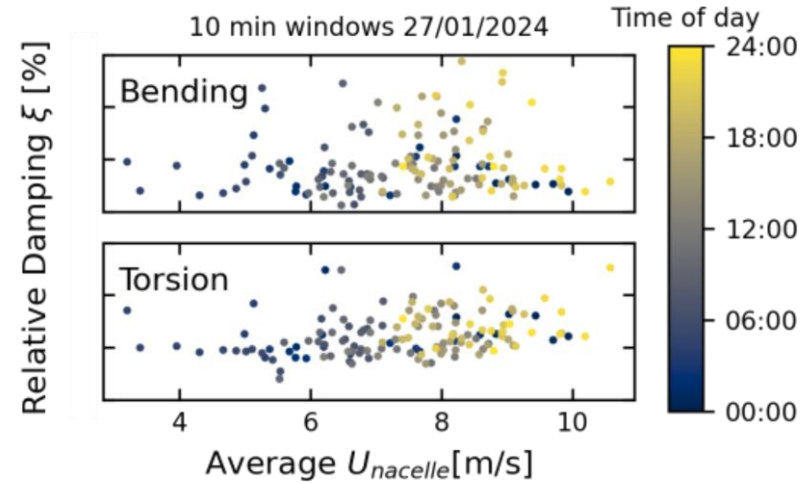
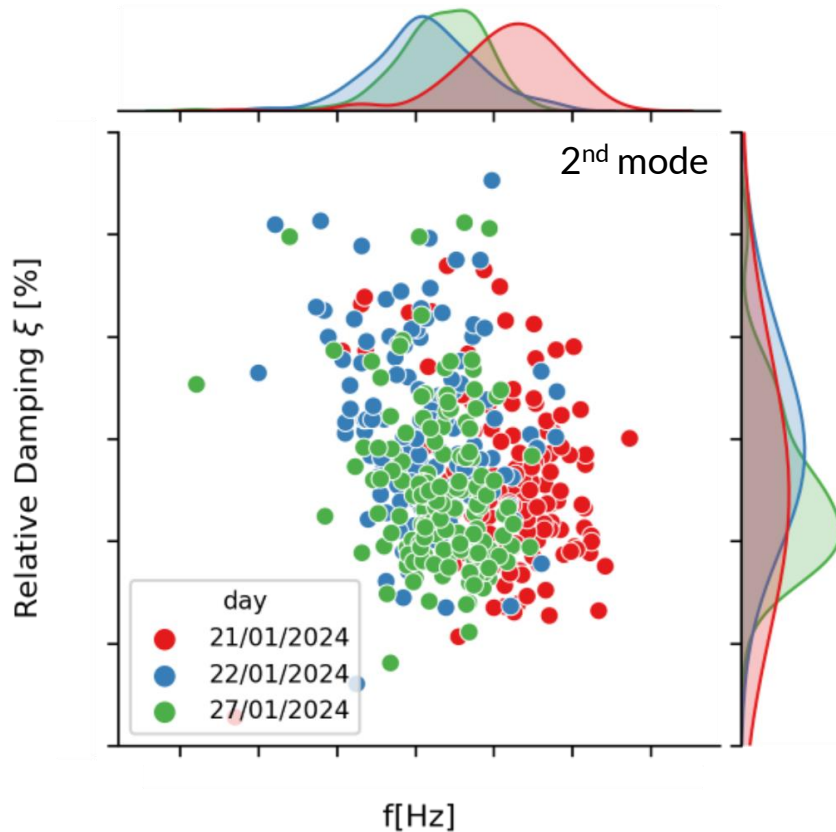


2nd mode



Regular Operational Modal Analysis can be performed to monitor the evolution of the structural modes of the wind turbine

Damping



Outcome

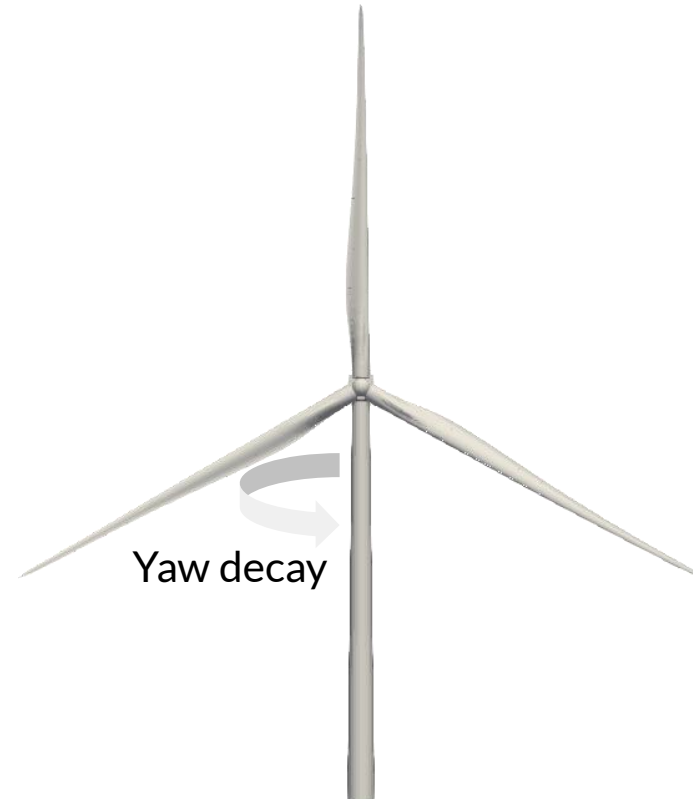
Verification of structural modes frequency compared to design values

Decay tests of torsion oscillations

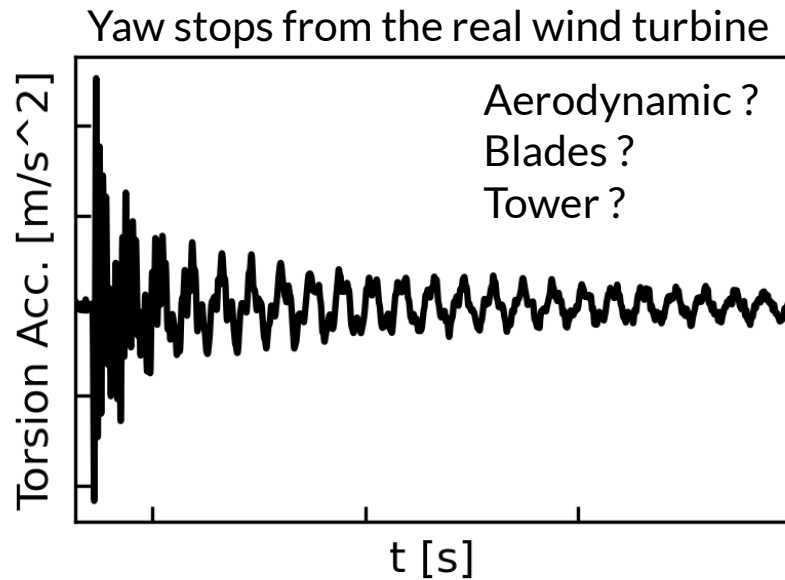
Real wind turbine



Numerical model



Identifying damping contributions

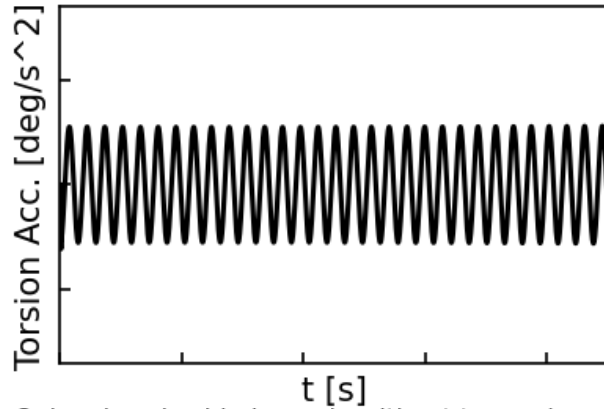


Isolating damping contributions with the numerical model

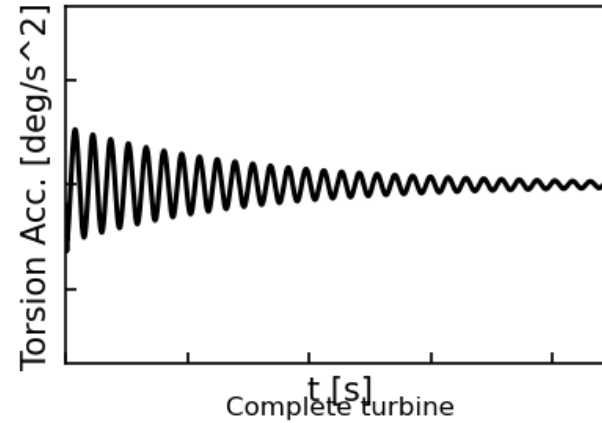
Case	Purpose	Aerodynamics	Blade and tower bending	Torsional damping
1	Identify aerodynamic damping	ON	OFF	OFF
2	Identify torsional damping in a simple case	ON	OFF	ON
3	Identify contribution of blade and tower bending	OFF	ON	OFF
4	Identify interaction between blade/tower bending and aerodynamics	ON	ON	OFF
5	Identify interaction between blade edgewise bending and torsional damping	On	Only blade edge mode	OFF
6	Complete turbine, identify tower structural torsion damping from full system response	ON	ON	ON

Identifying damping contributions

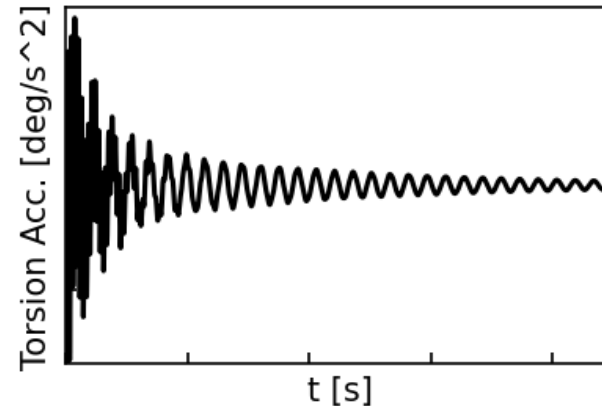
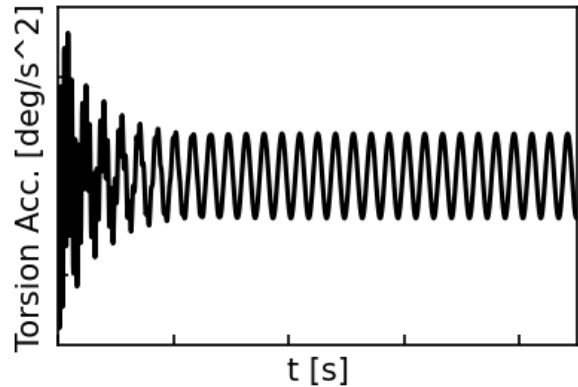
No bending and no torsion damping (pure aero)



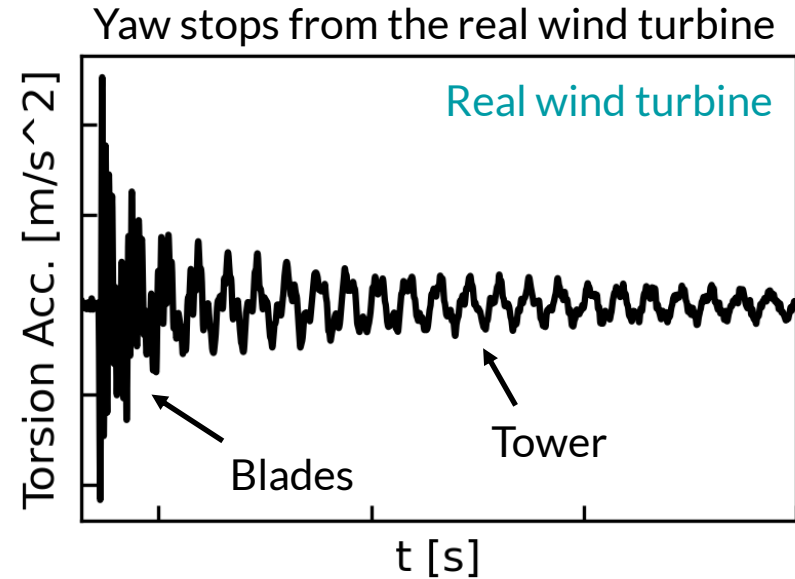
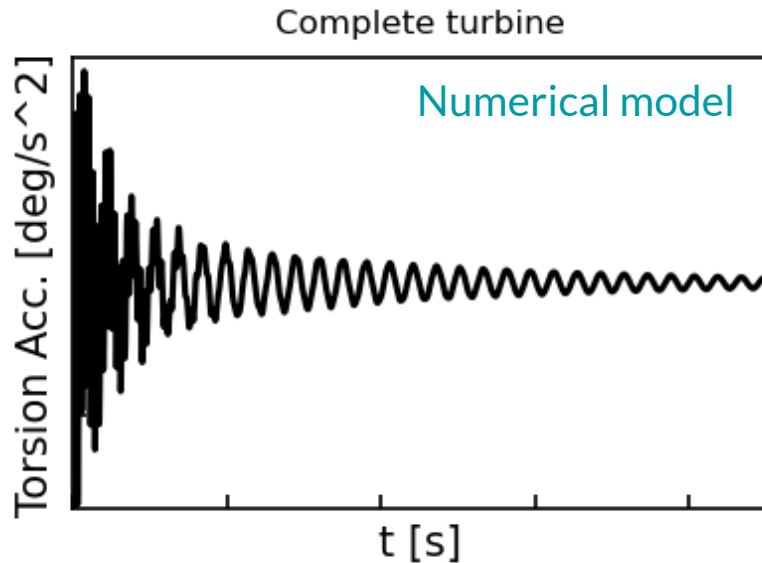
Stiff blades with aero and tower damping



Only edgewise blade mode without tower damping



Identifying damping contributions



Conclusion

- Operational Modal Analysis of a real wind turbine enables to verify modal properties of a novel modular wooden tower
- Comparison of a numerical model to fields tests to further test the damping properties of the real wooden wind turbine tower

QUESTIONS ?