Computational Aeroelasticity Study of Horizontal Axis Wind Turbines with Coupled Bending – Torsion Blade Dynamics

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With the increasing size of wind turbines and the use of flexible and light materials in aerodynamic applications, aeroelastic tailoring for power generation and blade stability has become an important subject in the study of wind turbine dynamics. To this day, coupling of bending and torsion in wind turbine rotor blades has been considered primarily as an elastic mechanism due to a coupling laminate construction. In this report, inertial coupling of bending and torsion, due to offset of axis of elasticity and axis of center of mass, is investigated and numerical simulations are performed to test the validity of the constructed model using an, in-house developed, aeroelastic numerical tool.

A computationally efficient aeroelastic numerical tool, based on Goldstein’s helicoidal vortex model with a prescribed wake model and modal coupling of bending and torsion in the blades, is developed for 2-bladed horizontal axis wind turbines and a conceptual study is performed in order to argue the validity of the proposed formulation and numerical construction. The aeroelastic numerical tool, without bending-torsion coupling, was validated (Chattot 2007) using NREL Phase VI wind turbine data, which has become the baseline model in the wind turbine community. Due to novelty of the proposed inertial bending-torsion coupling in the aeroelastic model of the rotor and lack of field data, as well as, other numerical tools available for code to code comparison studies, a thorough numerical investigation of the proposed formulation is performed in order to validate the aeroelastic numerical tool.

Finally, formulations of geometrically nonlinear beams, elastically nonlinear plates and shells, and a piecewise linear, two degree of freedom, quasi steady, aerodynamic model are presented as an extension for nonlinear wind turbine aeroelastic simulations. Preliminary results of nonlinear beams under sinusoidal and Heaviside forcing functions, plates, shells, and 2 DOF NACA0012 aeroelastic model are presented.