An Integrated Tool for Aerodynamic and Structural Load Calculations

Background

The trend in wind energy is to increase the size of wind turbines for producing more electricity power over the last 30 years. But further increases in size of wind turbines are not easily achievable. In fact, designers are expected to face more unknown technical problems such as aero-elastic stability problems. Therefore, it is important that the tools to determine dynamic loads are improved in accuracy and are capable of predicting well the time dependent loads in yaw, wind shear and dynamic inflow.

Objectives

The objectives are to develop a combined aerodynamic and structural load calculation tool based on an unsteady panel code for the aerodynamics and a structural model using fully nonlinear beam models. The tool is expected to be able to predict the unsteady loads and blade deflections of wind turbine rotor blades effectively and sufficiently accurate in conditions of axial flow, wind shear, yawed flow, dynamic inflow, active pitch control and its combinations.

Methodology

1. Panel code adaptation.

The vortex panel code currently in operation within the group needs further verification and validation. Both stall delay as well as dynamic stall models are implemented. The latter are adaptations of the Beddoes-Leishman model as well as approaches formulated on the basis of fundamental unsteady lifting line theory.

Optimisation of the free vortex panel model in the near wake, as well as a more generic vortex representation in the intermediate and the far wake are part of the improvements in order to obtain better efficiency in the numerical calculation time.

2. Nonlinear beam model implementation.

The first step is the adaptation of existing fully nonlinear beam models for enabling the implementation into the integrated tool. At present a joint research activity is taking place between the structures group of Aerospace Engineering and the wind energy research group.

The current project extends the aerodynamic model to a vortex panel code enabling more detailed external load distribution determination as well as strong interaction between structural modeling and aerodynamic modeling at an equal level of fidelity.

References