Anisotropic beam model for analysis and design of passive controlled wind turbine blades

The main objective of the project was, through theoretical and experimental research, to develop and validate a fully coupled, general beam element that can be used for advanced and rapid analysis of wind turbine blades. This is fully achieved in the project and the beam element has even been implemented in the aeroelastic code HAWC2. It has also been demonstrated through a parametric study in the project that a promising possibility with the tool is to reduce fatigue loads through structural couplings. More work is needed before these possibilities are fully explored and blades with structural couplings can be put into production.

A cross section analysis tool BECAS (BEam Cross section Analysis Software) has been developed and validated in the project. BECAS is able to predict all geometrical and material induced couplings. This tool has obtained great interest from both industry and academia.

The developed fully coupled beam element and cross section analysis tool has been validated against both numerical calculations and experimental measurements. Numerical validation has been performed against beam type calculations including Variational Asymptotical Beam Section Analysis (VABS) and detailed shell and solid finite element analyses. Experimental validation included specially designed beams with built-in couplings, a full-scale blade section originally without couplings, which subsequently was modified with extra composite layers in order to obtain measurable couplings. Both static testing and dynamic modal analysis tests have been performed.

The results from the project now make it possible to use structural couplings in an intelligent manner for the design of future wind turbine blades. The developed beam element is especially developed for wind turbine blades and can be used for modeling blades with initial curvature (pre-bending), initial twist and taper. Finally, it has been studied what size of structural couplings can be obtained in current and future blade designs.

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