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Ultimate strength of wind turbine blade structures under multi axial loading

Wind turbines must endure a variety of weather conditions including uncontrollable, extreme winds without developing damage and fracture during a lifetime of minimum 20 years. The variety of loading leads to multi axial loading resulting in complex states of stress. The prediction of the effects of the complex states of stress with existing failure criteria can be uncertain and damages and failures often occur earlier than expected. In order to increase reliably and robustly operating wind turbine systems it is of great importance to predict damage initiation and growth accurately. Therefore a profound understanding of the mechanical behaviour of composite materials and structures for wind turbine blades is necessary.

The purpose of this PhD project is to investigate how multi axial loading effects influence the ultimate strength of typical composite structures in wind turbine blades and to develop methods to perform reliable prediction of failure. The complex loading of wind turbine blade structures subjected to different realistic load case will be investigated in order to determine most critical multi axial loading spots in the structure. Damage detection, modelling and prediction of damage evolution under multi axial loading will be carried out based on accurate physics-based failure criteria that have been developed and are preferred to curve-fitting-based criteria. The main limitation associated with latter criteria is that their applicability is restricted to load combinations corresponding to those from which the fitted curves originate. The ability of different criteria to predict failure under multi axial loading conditions will be investigated and methods to account for imperfections will be developed.