A comprehensive investigation of trailing edge damage in a wind turbine rotor blade

Wind turbine rotor blades are sophisticated, multipart, lightweight structures whose aeroelasticity-driven geometrical complexity and high strength-to-mass utilization lend themselves to the application of glass-fibre or carbon-fibre composite materials. Most manufacturing techniques involve separate production of the multi-material subcomponents of which a blade is comprised and which are commonly joined through adhesives. Adhesive joints are known to represent a weak link in the structural integrity of blades, where particularly, the trailing-edge joint is notorious for its susceptibility to damage. Empiricism tells that adhesive joints in blades often do not fulfil their expected lifetime, leading to considerable expenses because of repair or blade replacement. Owing to the complicated structural behaviour—in conjunction with the complex loading situation—literature about the root causes for adhesive joint failure in blades is scarce. This paper presents a comprehensive numerical investigation of energy release rates at the tip of a transversely oriented crack in the trailing edge of a 34m long blade for a 1.5MW wind turbine. First, results of a non-linear finite element analysis of a 3D blade model, compared with experimental data of a blade test conducted at Danmarks Tekniske Universitet (DTU) Wind Energy (Department of Wind Energy, Technical University of Denmark), showed to be in good agreement. Subsequently, the effects of geometrical non-linear cross-section deformation and trailing-edge wave formation on the energy release rates were investigated based on realistic aeroelastic load simulations. The paper concludes with a discussion about critical loading directions that trigger two different non-linear deformation mechanisms and their potential impact on adhesive trailing-edge joint failure. Copyright © 2016 John Wiley & Sons, Ltd.

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