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Finite Element Analysis and Failure Prediction of Adhesive Joints in Wind Turbine Rotor Blades

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Wind turbines have been growing in size significantly during the past years. As a consequence, the mechanical loads acting on the wind turbine components increase as well. This gives rise to the need to develop new or to enhance existing methodologies for failure analyses of wind turbine components in general, and for rotor blades in particular. This contribution focuses on the finite element analysis of adhesive joints in wind turbine rotor blades and addresses both ultimate and fatigue load analyses.

For ultimate loading, an equivalent stress approach according to Drucker-Prager [1] is utilized. In fatigue, wind turbines experience high amplitudes and very high cycle numbers of up to 10^8-10^9. Hence, an appropriate fatigue analysis framework is of utmost importance. Equivalent stress approaches cannot mimic the fatigue life of the adhesive joints due to a number of reasons. Therefore, we propose a critical plane approach [2]. Therein, the three-dimensional stress tensor is reduced to a two-dimensional traction vector on different material planes. On these planes, we calculate the fatigue damage. The material plane with the largest fatigue damage is interpreted as the critical plane on which crack formation will be observed. The model captures multiaxial stress states as required by current design guidelines [3] and takes into account nonproportional stress histories.

The presentation focuses on the trailing edge adhesive joints of wind turbine rotor blades, as they are highly stressed in longitudinal direction and shear. It will be shown by representative numerical examples that a multiaxial ultimate and fatigue load analysis approach is extraordinarily important to design reliable adhesive joints. The necessity to account for nonproportionality in the stress histories will further be demonstrated.

REFERENCES

[1] L. R. Alejano and A. Bobet, Drucker-Prager Criterion, *Rock Mechanics and Rock Engineering*, Vol. **45**, pp. 995–999, 2012.

[2] D. F. Socie and G. B. Talyor, *Multiaxial Fatigue*. Society of Automotive Engineers Inc., 2000.

[3] DNV GL AS, Design Guideline, *DNVGL-ST-0376: Rotor blades for wind turbines*, 2015.