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Quantification of geometrically non-linear cross-sectional deformations for wind turbine rotor blades

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Non-linear beam formulations are used in wind turbine simulations to model the behaviour of rotor blades. Deformations of the cross-sections are not taken into account in beam theory. Investigations of thin-walled beam-like structures, however, show cross-sectional deformations due to applied bending moments. This so-called Brazier effect (see [1]) can also be seen in very large and elastic rotor blades. So far, it is assumed that there is a coupling between the cross-sectional deformation and the aeroelastic behaviour of rotor blades. Particularly for very large and ultra-slender rotor blades, we expect considerable cross-sectional deformations parallel and perpendicular to the cross-section planes, especially in the inboard third of the blade span.
The goal of this work is to develop a methodology for the quantification of cross-sectional deformations. The basis for the investigations is a 3D finite element model of the rotor blade from the IEA wind task 37 (for details, see [2]). Combined extreme loads are applied to have a very conservative estimate of possible cross-sectional deformations. Two approaches are compared to describe the deformation of the cross-sections. The first is based on the projection of nodes onto the deformed cross-section plane, the second identifies the intersection geometry of the deformed 3D model with the deformed cross-sectional plane. Following a discussion on the accuracy of both approaches, the share of different load components, i. e., flapwise bending moments, edgewise bending moments, torsion, etc., on the overall cross-sectional deformation is analyzed. The results reveal implications on the structural design of large rotor blades, but the method itself can also be used for very large and highly loaded beam-like engineering structures as well.

REFERENCES

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