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Interactive comment on "Modal Properties and Stability of Bend-Twist Coupled Wind Turbine Blades" *by* Alexander R. Stäblein et al.

Anonymous Referee #2

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In the paper, the authors study the impact of structural bend-twist coupling (flap-twist to feather, flap-twist to stall, edge-twist to feather, and edge-twist to stall) on the natural frequencies and damping characteristics of wind turbine rotor blades, and the aeroelastic stability of said rotor blades. The aeroelastic stability is also studied on turbine level in order to account for the dynamic interaction between the turbine components. The authors assume the bend-twist coupling to be triggered by the anisotropic nature of fiber composite material usually used for wind turbine rotor blades. For the description of the structural dynamics, a finite beam element formulation based on generalized degrees of freedom allowing for full coupling between the degrees of freedom is utilized. The aerodynamics is accounted for by means of unsteady blade element momentum theory. The models have been implemented in the HAWCStab2 code, which is a turbine simulation tool in the frequency domain, allowing for the calculation of the rotation

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Discussion paper

speed dependent frequency and damping characteristics. The structural model is thoroughly validated against several numerical examples from literature. For the studies, the DTU 10 MW reference turbine was chosen as a baseline, and the blades were modified to include the bend-twist coupling characteristics. The couple blades are compared to the baseline configuration.

The topic of aeroelastic stability and the proper calculation of frequency and damping characteristics is highly relevant for the wind energy science community, especially for very large rotor blades such as those of the DTU 10 MW reference wind turbine. Due to the very high impact of aeroelastic stability on the structural health of wind turbines, the topic is highly important and of broad international interest.

The paper presents results achieved by simulations with a commercially available tool which was extended by a finite beam element formulation that was previously published. The simulation results as such are novel, interesting, not obvious in all concerns, important, and highly relevant. It is not clear if the results are generally valid, or turbine specific, but that is a general issue in wind energy research.

The objectives are clearly formulated and addressed continuously throughout the paper. The paper is generally very well written, well structured, and clearly formulated to the point. The language is fluent, precise, and grammatically correct.

The scientific methods are valid, state of the art, and well chosen. They are clearly described and reproducible. The discussion of analysis results seems valid and detailed. The presented results form the basis for discussions at a later stage of the manuscript, and support the interpretations without exceptions. The discussion is relevant and backed up by own results and investigations done by other authors. The conclusions reached are accurate and base on the presented results. The authors also give proper credit to related and relevant work from other authors, and clearly indicate their own contributions and also construct the context to other works properly.

The title is chosen to the point. It reflects the content of the paper, is informative, and gives the reader the chance to find the paper when searching for respective content. The abstract provides a concise and complete summary, and includes qualitative results (which makes sense in the context of shortness). Quantitative results are presented at a later stage of the manuscript.

Figures and tables are useful and all necessary. However, some of them could be positioned closer to where they are discussed in the text. Mathematical formulae, symbols, abbreviations, and units are mainly correctly defined and used according to the author guidelines. The number and quality of references is appropriate.

Some exceptions from the aforementioned comments are present in the paper. The following minor changes should be implemented in the manuscript:

- Section 2.5.4: The parameter γy is introduced in section 3, but is utilized here already. Please introduce symbols where first used.
- Table 3: It would be nice not only to see the difference in numbers, but to know about the principle differences in beam element formulation without reviewing the entire references. Some basic remarks will be welcome.
- In order to save space, the authors should place figures 3 and 4 side by side, as well as figures 5 and 6.
- The authors should make sure that the figures are included in the text close to where referenced. Sometimes, the reader has to turn several pages, which is no fun at
- Figures 5 and 6, and partly Figures 12-14: The slope change at the tip looks erroneous (as it was hinged). Could the authors explain the reason?

To wrap up: The paper is definitely worth publishing. A proper implementation of the preceding comments will be appreciated. There is no need to re-review the manuscript.

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