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WIND ENERGY SCIENCE DISCUSSIONS

Interactive comment on "Determination of Natural Frequencies and Mode Shapes of a Wind Turbine Rotor Blades using Timoshenko Beam Elements" *by* Evgueni Stanoev and Sudhanva Kusuma Chandrashekhara

Anonymous Referee #1

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The article by Stanoev and Chandrashekhara provides a valuable analysis of the determination of the free vibration properties of wind turbine blades.

The dynamic models considered, contains shear flexibility within the framework of Timoshenko beam theory. This is a suitable compromise for wind turbine blades, due to the large changes in cross section shape along the beam axis and the large cylindrical parts at the root. Thus, the model is appropriate for the analysis of modern wind turbine blades. A key feature of the numerical approach in the article, is the formulation of the beam stiffness via the static formulation using classic virtual work. The

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formulation of the evolution format, integrated by a RK procedure, corresponds to the use of complementary virtual work, in which the static field comprise the virtual fields. Hereby, shear flexibility is included for free and variations in cross sectional properties are directly represented by the corresponding parameters appearing in the denominators of (13) or (14). The mathematic formulation appears to be elegant, although it is difficult to assess and verify all details in the formulation. The final results provide good agreement with the numerical results obtained by dedicated numerical packages. The paper is well suited for WES and should be accepted once the authors have addressed or commented on the following issues:

1. The analysis assumes an arbitrary location of the reference axis. This is very fine, as many simplified codes assumed decoupled kinematic effects. The authors still provide relations for a coinciding axis with the elastic center (see equations (11) and (14)). The paper would me more compact if the general case without the simplification by coinciding axes. Please consider whether it is necessary to include this particular case.

2. In (9)-(10) there is no coupling between torsion and shear. This implies that the chosen reference axis coincides with the shear center. Although this is done regularly in beam modelling, it is based on an assumption where coupling terms are neglected. The authors may note this in conjunction with equations (9)-(10).

3. In (13) and (14) many rows in the system matrices are zero rows, whereby the evolution of the section forces (strangely enough referred to as cutting forces in the paper) is explicitly attainable from the loading. Would it be possible to use the explicit relation to simply reduce the "redundant" section forces and thereby minimize the size of the system?

4. In the mass matrix (18) the structure is difficult to verify because zeros have not been included. Please consider to explicitly add the zero entries, as in (13)-(14).

5. It is stated that Hermitian interpolation is of 4th and 2nd order. As the polynomial

order is cubic I would think it would be interpolation of order 3 and 1. Consider to change the naming of order or be more specific of what you mean about e.g. 4th order interpolation.

6. The use of Runge-Kutta integration is elegant. Gauss integration is commonly used, as it is exact for polynomials, although the possess discontinuities at the element boundaries. For beam elements this is not required, whereby the alternative integration schemes is feasible. (This is just a comment.)

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