A Modelica Library of Anisotropic Flexible Beam Structures for the Simulation of Composite Rotor Blades

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The non-linear static and dynamic analysis of bent and twisted beams is of major importance for many engineering disciplines. Especially for helicopter rotor applications beam models are used to simulate its dynamic behavior. Due to the predominant deployment of composite materials in rotor blade development the long and slender beam structure is subject to non-classical effects such as transverse shear deformation, geometrical nonlinearities, cross-sectional warping, and elastic coupling. Thus a sophisticated beam theory has been implemented to Modelica which is capable of simulating extensional, torsional and flexural deformation and the couplings between those degrees of freedom. The theory used has extensively been tested in practical applications such as the CAMRAD II rotorcraft analysis code and been proven to provide satisfactory results [2, 1]. It is based on cross-sectional modeling and thus allows the user to provide varying material parameters at any number of points along the beam principal axis. Hence the influence of anisotropy and inhomogeneity can be taken into account.

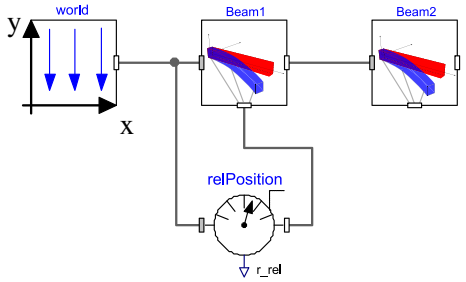

Figure 1: example beam setup

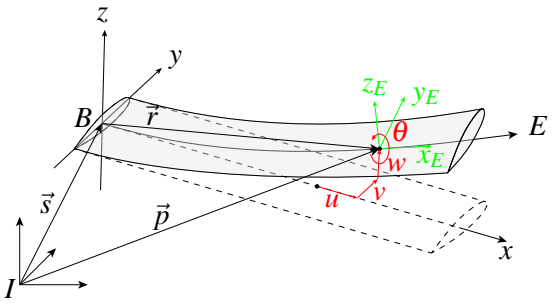

Figure 2: motion of the beam

The library presented describes the motion of the beam element by the rigid motion of a reference frame at one end of the beam and an elastic motion relative to this frame. The element can be attached to the standard Modelica multi-body environment using frame connectors. In addition to the connectors at each end of the beam an arbitrary number of frames can be defined to connect to other components such as joints, sensors, or force elements. Figure 1 shows an exemplary setup with two beam segments connected in series and Figure 2 depicts the reference frame and its elastic degrees of freedom.

References

[1] HODGES, D. H.: *Nonlinear composite beam theory*. American Institute of Aeronautics and Astronautics, 2006.

[2] JOHNSON, W.: *Rotorcraft dynamics models for a comprehensive analysis*. 1998.