Abstract:

The aerodynamics and dynamics of a sub-scale coaxial rotor model designed for high-advance-ratio forward flight were investigated by means of a comprehensive analysis. Hover measurements were used to calibrate and validate the numerical predictions. The dynamics of the rotor system were analyzed with a focus on the interactional aerodynamics responsible for increased hub loads, blade loads, and blade deflections. A numerical aeromechanics model with reduced-order aerodynamics modeling using a free vortex wake method was used to ensure computational efficiency. Performance predictions as well as predicted blade flap deflections showed good correlation with the measurements. Predicted hub loads correlated well with the measurements in terms of the average loads. Vibratory loads showed similar trends compared to the measurements, although the peak loads were underpredicted. The effects of varying lift offset on the harmonic hub loads were different depending on the specific harmonics and advance ratios. Furthermore, strong rotor–rotor interactions were seen, and local excursions in the flap bending moments could be correlated to blade–vortex interactions on the
advancing side of the rotors even at relatively high advance ratios, and to the unsteady aerodynamic effects of the reverse flow regions on the respective retreating sides of the rotor disks. The improved comprehensive analysis modeling capabilities will be helpful to quickly assess the dynamics and their aerodynamic sources, including the effects of lift offset and rotor–rotor interactions, and so they will prove instrumental in the understanding of the investigated test rig as well as future coaxial rotor designs.