Lag-Damping of the Nonlinear Blade-Wake Coupled System in Hover

The lead-lag mode is the most sensitive motion in a helicopter rotoraeroelastic analysis. The stability characteristics of a lag mode in arotor system can be observed through the eigenvalues. The resonancephenomenon can be predicted by eigen-analysis as well. This paper usesanalytic methods to integrate the wake dynamics, blade aerodynamics,and nonlinear composite rotor blade flap-lag-torsion structuraldynamics in the form of a coupled system. Only the homogeneousisotropic material blade will be studied in this paper in order tomake a preliminary investigation of a wake-rotor interaction and thecompatibility of the composite blade equation. The Galerkin's methodand the Duncan's polynomial are used to resolve the equations. Thecoupled nonlinear system is separated into equilibrium and disturbant(dynamic) states. The equilibrium state is solved by using nonlinearsolves. The system's flap-lag-torsion eigen-equations are formulatedby the combination of the equilibrium coefficients and the disturbantequations. The Floquet's theory is used to derive the systemeigenvalues. The nonlinear phenomenon will be investigated througheigen-analysis, especially for quasi-linear resonance. Various lagfrequencies (stiffness) of the isotropic rotor blades are studied inthis paper. The equilibrium results show that the wake has strongeffects in the blade tip displacements in higher blade pitch angles.The eigen-analysis of the lag damping shows the eigenvalue veeringphenomenon occurs when pitch angle is 8 degrees. All of these may bedue to the wake effects in the rotor-wake coupled system.