AIAA Reno Jan 2003, #0870

Modeling of blades as equivalent beams for aeroelastic analysis

by

David J. Malcolm
Global Energy Concepts, LLC

and

Daniel L. Laird
Sandia National Laboratories

Abstract

Introduction

The blades of a modern wind turbine are key components, central to all aspects of the system from energy capture to system dynamics to tower clearance. They are also complex structural items, typically comprising many layers of fiber reinforced material with necessary shear webs, root fixtures, and tapering cross sections. Special codes have been developed to construct 3-dimensional finite element models of such blades [Laird, 2001] typically using thousands of composite shell elements. These models are of value in examining the internal stress distribution within the blade but are too detailed for use in a system aeroelastic analysis which normally represents the blades as a series of 1-dimensional beam elements.

The 1-dimensional beam element must accurately represent all of the mechanical properties of the full 3-dimensional blade including shear deformation, coupling between the various forces and moments and the offsets of the elastic and shear centers. Attempts at capturing all of this information by examining the sections alone have been prone to approximations and omission of important aspects. To accomplish this task in a comprehensive manner, Sandia National Laboratories have funded a program of code development which is now near completion. There are three basic steps in the process established:

1. Create an ANSYS® [ANSYS Inc] finite element model through the NuMAD interface [Laird, 2001].
2. Apply a suite of unit tip loads and transfer the displacement results to a series of MATLAB® routines which extract the stiffness matrices for the equivalent beam elements.
3. Incorporate the stiffness matrices into a preprocessor and generate the complete aeroelastic model for the ADAMS® code [Mechanical Dynamics, 1994].

Global Energy Concepts LLC (GEC) has worked under contract to Sandia National Laboratories to develop the basic algorithms for this task and have carried out validation of the preliminary steps. This has been reported in detail in [GEC,2001] and [GEC,2002]. The purpose of this paper is to present an overview of the method and to report on the application of the procedure to complete blades and to wind turbine models.