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Editorial

Editorial Note on Aero Elasticity

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EDITORIAL

Aero elasticity is a relatively new branch of applied mechanics that studies the interaction of fluids and flexible solid bodies. It is concerned with the interaction of aerodynamics, dynamics, and elasticity. Aerodynamic forces acting on the aircraft during flight cause deformations of the elastic structure, resulting in variations in aerodynamic forces. Aero elasticity is commonly used in the field of aircraft engineering. Aero elasticity can be broadly divided into two fields: static aero elasticity, which deals with an elastic body's static or steady-state response to a fluid flow, and dynamic aero elasticity, which engages with the body's dynamic (commonly vibrational) response. Static aero elastic phenomena that do not include inertial forces are distinguished by unidirectional structure deformation, whereas dynamic aero elastic phenomena that do include inertial forces are distinguished by the oscillatory property of structure deformation. Since aircraft must be lightweight and withstand high aerodynamic loads, they are susceptible to aero elastic effects. The following aeroelastic problems are avoided by aircraft:

1. Divergence occurs when aerodynamic forces increase the angle of attack of a wing, increasing the force.

2. Control reversal occurs when control activation produces a contrary aerodynamic moment, which minimizes or, in extreme cases, reverses control effectiveness; and

3. Flutter, which is an unacceptable vibration that can lead to an aircraft's destruction.

The first commercial wind turbine aero elastic problem involved a negatively damped edgewise mode. It is necessary to make sure that this mode shape has some out-of-plane deformation to avoid instability.

Aero elastic effects were blamed for the second failure of Samuel Langley's prototype plane on the Potomac (specifically, torsional divergence). George Bryan's Theory of the Stability of a Rigid Aeroplane, published in 1906, was an early scientific work on the subject. Classical flutter may become relevant for larger turbine blades with lower torsional stiffness and the possibility of higher tip speeds for offshore designs. When designing a wind turbine blade, it is critical to ensure that there is adequate damping for the various modes and that natural frequencies do not coincide with excitation frequencies (resonance). Aero elasticity encompasses not only the external aerodynamic loads and how they change, but also the aircraft's structural, damping, and mass characteristics. Prediction entails creating a mathematical model of the aircraft as a series of masses linked by springs and dampers tuned to represent the dynamic properties of the aircraft structure.

Aero elasticity issues have existed since the dawn of aviation. The crash of Langley's monoplane, which occurred only eight days before the Wright brothers' first successful flight, was the first famous event caused by an aero elastic phenomenon. As a result, the Wright brothers became famous as the first fliers, while Langley is only mentioned in aero elastic textbooks. As a result, the early stage of aviation is distinguished by biplanes, which enable the design of a torsionally stiffer structure. Torsional divergence was the dominant aero elastic phenomenon at the time. The various issues are identified, and the two-dimensional case of a wing's torsional divergence is studied. The theory is then extended to account for a finite wing's torsional divergence.

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