Civil & Environmental Engineering Structures Seminar

Full-Scale Structural Testing of Wind Turbine Blades

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in collaboration with the Massachusetts Clean Energy Center – Wind Technology Testing Center
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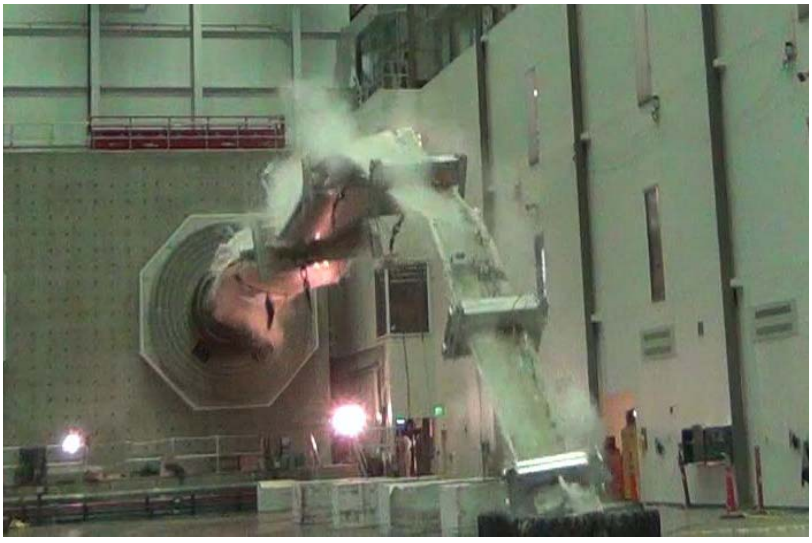
Modern wind turbines are large structures with moving parts weighing many tons subjected to highly dynamic loading. Durability and reliability of these structures is critical to ensuring safe cost effective renewable power generation over the lifetime of the machine. The blades of a wind turbine are a critical part and must not only perform aerodynamically but also be stiff enough and strong enough to withstand normal operation and extreme conditions on the turbine. Typically made entirely from glass and carbon fiber reinforced polymer composite materials, an individual wind turbine blade for a typical modern utility scale will be 45-55 m long and weigh 8 to 14 tons. In order to help ensure that new blade designs and manufacturing quality achieve the required mechanical behavior the industry has embraced full-scale testing of new blade designs as part of the requirement to achieve type certification for a turbine.

This presentation will discuss the motivation for testing blades, describe the required tests for certification of a wind turbine blade and present the capabilities of two US laboratories where this testing is performed – the National Wind Technology Center near Boulder CO and the Wind Technology Testing Center in Boston MA. Static testing and modal testing of wind turbine blades resembles testing techniques employed on other large structures such as aircraft or bridges although the large deflections require special considerations. Fatigue testing employs an entirely unique approach where the blade is excited at its resonance frequency. We will explore some of the details in designing these tests and the associated challenges, both for developing accurate predictive models and for developing the testing equipment required to achieve the necessary loading. Finally, we will take a look at the potential and pitfalls for biaxial resonance fatigue testing and some recent research in this area.



Test to failure of a wind turbine blade at the Wind Technology Testing Center

Bio for Dr. Nathan Post

Nathan Post grew up in Barnard, Vermont, and graduated from the Clarkson Honors Program in 2003 with a BS in Mechanical Engineering and minors in Applied Mathematics and Environmental Philosophy. Following graduation from Clarkson, Nathan continued his education in the Engineering Science and Mechanics

Department at Virginia Tech, receiving his MS in 2006 and Ph.D. in 2008 in Engineering Mechanics. Nathan's graduate research focused on the experimental fatigue of composite materials under variable amplitude loading and reliability based design methodologies for these materials.

In 2008, Nathan joined the Fraunhofer Institute for Wind Energy and Energy System Technology (IWES) in Bremerhaven, Germany, as a project engineer for composite structural testing. His work at IWES centered on conducting full-scale testing of wind turbine blades including assisting with the commissioning and subsequent commercial certification tests carried out at the new test facility for blades up to 70 m. In addition to developing methods and procedures for full scale structural blade testing, Nathan also participated in several research projects including a task under the EU funded Upwind project where laboratories and universities collaborated to develop advanced methods for characterization of materials used in wind turbine blades under complex fatigue stress conditions.

In 2010, Nathan was hired by the National Renewable Energy Laboratory (NREL) to be a Blade Test Engineer at the new Wind Technology Testing Center (WTTC) in Boston, Massachusetts. Since commissioning in 2011 the WTTC, which is owned and operated by the Mass Clean Energy Center, has performed structural testing on 17 multi-MW scale wind turbine blades as well as participating in related research projects with several regional universities and laboratories. NREL's mission at the WTTC has been to provide technical support and training at the new facility. Nathan has been an integral part of the WTTC team, managing and designed test programs, training new MassCEC engineers and technicians, and developing and implementing hardware, software and procedures to meet customer requirements and improve testing methods at the laboratory.