NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Structural Testing at the NWTC Helps Improve Blade Design and Increase System Reliability

Biaxial fatigue test of an MHI Wind Power Americas, Inc. turbine blade at the NWTC.
Photo by David Snowberg, NREL 28797

Since 1990, the National Renewable Energy Laboratory's (NREL's) National Wind Technology Center (NWTC) has tested more than 150 wind turbine blades. NWTC researchers can test full-scale and subcomponent articles, conduct data analyses, and provide engineering expertise on best design practices. Structural testing of wind turbine blades enables designers, manufacturers, and owners to validate designs and assess structural performance to specific load conditions. Rigorous structural testing can reveal design and manufacturing problems at an early stage of development that can lead to overall improvements in design and increase system reliability.

Structural blade tests are performed to the IEC 61400-23 standard through implementation of an ISO 17025-compliant quality management system accredited by the American Association of Laboratory Accreditation (A2LA). The structural testing laboratories perform property, static, and fatigue tests required by blade manufacturers to certify blade and wind turbine designs. In addition to full-scale blade testing, NWTC facilities have extensive capabilities to perform small- to large-scale subcomponent tests.

The NWTC develops blade test systems that enable the latest advancements of wind turbine blades and components to be tested with a high degree of confidence in the results. Resonant test systems developed at NREL decrease the time and cost of applying millions of fatigue test cycles while at the same time applying test loads that are more characteristic of in-field loading. Recent advancements in test methods developed and used at the NWTC include high-speed, multi-blade testing of small wind turbine rotors, biaxial fatigue test methods to coherently test flapwise and lead-lag load conditions for utility-scale turbines, and the ability to tailor bending and torsional loading important for blade designs that include material bend-twist coupling and geometric sweep and pre-cone.

General types of rotor blade testing performed at the NWTC include:

- **Property testing**—to evaluate inherent structural properties, including mass and inertial properties of the test article.
- **Static strength testing**—to validate design parameters and demonstrate the ability of a component or system to handle extreme design load cases.
- **Fatigue testing**—to demonstrate the durability of a component or system.

Acoustic emission sensors are mounted to the low-pressure surface of a blade for testing.
Photo by Scott Hughes, NREL 32520

Technical Characteristics

Infrastructure and Test Hardware

- Three test facilities capable of testing kilowatt- to multimegawatt-scale blades (>50 m) and components
- 70-m test preparation facility for instrumentation and inspection of test articles
- Combined 1,800 m^2 of laboratory space for instrumentation and testing
- Five test stands with overturning moment capacities from 100 kN m to 16.7 MN m
- Modular servo-hydraulic test systems, unit flow capacity of 680 lpm and 200 bar
- Individual hydraulic actuator force capacities from 5 kN to 500 kN, actuator stroke capacities to 1.5 m
- 100 kN and 500 kN load frames
- Servo-electric multipart winches for quasi-static load application

Instrumentation and Data Acquisition

- NI Ethercat data acquisition system capable of recording hundreds of data channels
- Custom data acquisition software tailored for static and fatigue testing
- 64-channel VXI modal system for dynamic characterization testing
- 48-channel PAC acoustic emission system
- API laser tracker for surface characterization and 3D displacement measurements
- Micron Optics FBG fiber optic interrogator
- Flir SC640 thermal camera for active and passive thermography
- Extensive inventory of load, displacement, and strain sensing instrumentation

Partner With Us

The NWTC's expertise helps industry partners verify and improve new blade designs, analyze blade structural properties, and improve manufacturing processes. By partnering with us, you can take advantage of our engineering and design evaluation experience that spans 25 years of wind technology evolution.

In addition, the NWTC's structural testing facilities include office space for industry researchers, experimental laboratories, computer facilities for analytical work, tools and machine shops, and space for assembling components and turbines.

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