Structural Validation at the NWTC Helps Improve Component Design and Increase System Reliability

Since 1990, the National Wind Technology Center (NWTC) at the National Renewable Energy Laboratory (NREL) has validated more than 150 wind turbine blades, as well as blades and components for marine energy devices. Researchers at the NWTC can experimentally validate full-scale and subcomponent articles, conduct data analyses, and provide engineering expertise to optimize design practices. Structural evaluation of turbine blades enables designers, manufacturers, and owner operators to assess designs and structural performance under specific extreme loading and dynamic conditions. Rigorous structural validation can reveal design and manufacturing problems at an early state of development that lead to improvements in component design and increase system reliability.

Structural validation of full-scale wind turbine blades is performed to the International Electrotechnical Commission 61400-23 Standard through implementation of an International Organization for Standardization 17025-compliant quality management. NREL is accredited by the American Association of Laboratory Accreditation. Structural validation laboratories perform property, static, and fatigue assessments required by blade manufacturers to certify blade and wind turbine designs. In addition to full-scale validation, NWTC facilities have extensive capabilities to perform small- to large-scale subcomponent evaluations.

The NWTC develops static and fatigue systems that enable the latest advancements of blades and components to be evaluated with a high degree of confidence. Resonant excitation systems developed at NREL decrease the time and cost of applying millions of fatigue cycles while at the same time applying loads that are more characteristic of in-field loading. Recent advancements in validation methods developed and used at the NWTC include high-speed, multiblade evaluation of small turbine rotors, biaxial fatigue validation methods to coherently examine flapwise and lead-lag load conditions for utility-scale turbines. Validation facilities and equipment are ideally suited for the application of complex three-dimensional loading, which is important for blade designs that include material bend-twist coupling and geometric sweep or precone.

Component and complete-blade validation performed at the NWTC include:

- **Inertial and Modal Characterization** methods are used to evaluate inherent structural properties, including mass-balance, natural frequencies, and mode shapes

- **Static Strength Loading** is used to validate design values and demonstrate the ability of a component or system to handle extreme loads
- **Cyclic Fatigue Loading** demonstrates the durability of a component or system.

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

Technical Characteristics

Infrastructure and Hardware

- Three facilities capable of validating kilowatt- to multimegawatt-scale components and blades; component and blades length capacity of over 50 meters
- Combined 1,800 square meters of laboratory space for test mobilization, instrumentation, and validation
- Five reaction stands with overturning moment capacities from 100 kilonewton-meters to 16.7 meganewton-meters
- Modular servo-hydraulic test systems, hydraulic flow capacity of 680 liters per minute
- Servo-hydraulic actuators with force capacities from 5 to 500 kilonewtons, actuator stroke capacities to 1.5 meters
- 100 and 500 kilonewton structural load frames
- Servo-electric winches for quasi-static load application.

Instrumentation and Data Acquisition

- National Instrument's Ethercat data acquisition system capable of recording hundreds of data channels
- Custom data acquisition software tailored for static strength and fatigue validation
- Multi-channel modal test systems
- A 48-channel Physical Acoustics acoustic emission system
- API laser tracker for surface characterization and three-dimensional displacement measurements
- Micron Optics Fiber Bragg Grating fiber-optic interrogator
- Flir thermal cameras for active and passive thermography
- Extensive inventory of load, displacement, and strain sensors
- Digital Image Correlation for full-field strain and displacement measurements

Partner With Us

The NWTC's expertise helps industry partners verify and improve new component designs, analyze structural properties, and improve manufacturing processes. By partnering with us, you can take advantage of our engineering and design experience that spans more than 30 years of wind energy and water power technology evolution.

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

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Low-pressure surface view of structural validation of the Verdant 56-kW Composite KHPS Blade at NREL. Photo by Mike Desmond, NREL 21715

Cover photo by Scott Hughes, NREL14708

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