

## EXAMPLES OF ISO 17025 ACCREDITED TESTING OFFERED

Accreditation through International Accreditation Services, Inc. allows manufacturers to contract with Advanced Structures and Composites Center to conduct third-party testing for product certification through agencies such as ICC-ES or GL. Field of testing related to wind blades includes plastic materials, composite materials, and adhesives.

Plastic Materials	ASTM D256	Determining the Izod Pendulum Impact Resistance of Plastics
	ASTM D635	Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position
	ASTM D638	Tensile Properties of Plastics
	ASTM D695	Compressive Properties of Rigid Plastics
	ASTM D696	Coefficient of Linear Thermal Expansion of Plastics Between -30 °C and 30 °C with a Vitreous Silica Dilatometer
	ASTM D790	Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
	ASTM D792	Density and Specific Gravity (Relative Density) of Plastics by Displacement
	ASTM D953	Bearing Strength of Plastics
	ASTM D2765	Standard Test Methods for Determination of Gel Content and Swell Ratio of Crosslinked Ethylene Plastics (Methods A and C)
	ASTM D3846	In-plane Shear Strength of Reinforced Plastics
	ASTM D4065	Standard Practice for Plastics: Dynamic Mechanical Properties: Determination and Report of Procedures
	ASTM D4812	Unnotched Cantilever Beam Impact Strength of Plastics
	ASTM D6109	Flexural Properties of Unreinforced and Reinforced Plastic Lumber
	ASTM D6110	Determining the Charpy Impact Resistance of Notched Specimens of Plastics
Composite Materials	ASTM C393	Flexural Properties of Sandwich Constructions
	ASTM D2344	Short-beam Strength of Polymer Matrix Composite Materials and Their Laminates
	ASTM D2584	Ignition Loss of Cured Reinforced Resins
	ASTM D3039	Tensile Properties of Polymer Matrix Composite Materials
	ASTM D3410	Compressive Properties of Polymer Matrix Composite Materials with Unsupported Gage Section by Shear Loading
	ASTM D3479	Tension-Tension Fatigue of Polymer Matrix Composite Materials
	ASTM D3518	In-plane Shear Response of Polymer Matrix Composite Materials by Tensile Test of a $\pm 45^\circ$ Laminate
	ASTM D4255	Standard Guide for Testing In-plane Shear Properties of Composite Laminates
	ASTM D5379	Shear Properties of Composite Materials by the V-Notched Beam Method
	ASTM D5528	Mode I Interlaminar Fracture Toughness of Unidirectional Fiber-Reinforced Polymer Matrix Composites
	ASTM D5766	Open Hole Tensile Strength of Polymer Matrix Composite Laminates
	ASTM D6115	Mode I Fatigue Delamination Growth Onset of Unidirectional Fiber-Reinforced Polymer Matrix Composites
	ASTM D6641	Standard Test Method for Determining the Compressive Properties of Polymer Matrix Composite Laminates Using a Combined Loading Compression (CLC) Test Fixture
	ASTM F1679	Using a Variable Incidence Tribometer (VIT)
Adhesives	ASTM D905	Strength Properties of Adhesive Bonds in Shear by Compression Loading
	ASTM D1101	Integrity of Adhesive Joints in Structural Laminated Wood Products for Exterior Use
	ASTM D2339	Strength Properties of Adhesives in Two-Ply Wood Construction in Shear by Tension Loading
	ASTM D2559	Standard Specification for Adhesives for Structural Laminated Wood Products for Use Under Exterior (Wet Use) Exposure Conditions
	ASTM D3165	Strength Properties of Adhesives in Shear by Tension Loading of Single-Lap-Joint Laminated Assemblies
	ASTM D5868	Lap Shear Adhesion for Fiber Reinforced Plastic (FRP) Bonding

Upon full commissioning of the Offshore Wind Laboratory expansion, the following ISO and IEC test standards will be added to Advanced Structures and Composites Center's accreditation scope:

IEC 61400-23 Full-scale Structural Testing of Rotor Blades  
 ISO 62 Determination of Water Absorption  
 ISO 178 Determination of Flexural Properties  
 ISO 527 Determination of Tensile Properties, Part 1 through Part 5  
 ISO 604 Determination of Compression Properties  
 ISO 844 Determination of Compression Properties  
 ISO 845 Determination of Apparent Density

ISO 1887 Determination of Combustible Matter Content  
 ISO 1889 Determination of Linear Density  
 ISO 2896 Determination of Water Absorption  
 ISO 3344 Determination of Moisture Content  
 ISO 3374 Determination of Mass per Unit Area  
 ISO 14130 Determination of Apparent Interlaminar Shear Strength by Short Beam Shear Method

WORLD LEADER IN COMPOSITE STRUCTURES

# ADVANCED STRUCTURES & COMPOSITES CENTER



DESIGN  
TESTING  
MANUFACTURING

NANO- TO FULL-SCALE  
UNDER ONE ROOF



ACCREDITED  
An ISO 17025  
accredited testing  
laboratory.

The 8,100 m<sup>2</sup> (87,000 ft<sup>2</sup>), \$100 million **Advanced Structures & Composites Center** has world-leading capabilities to **design, manufacture** and **test** large high-performance hybrid composite structures under one roof. Examples include up to 70 m (230 ft) wind blades, towers, airplane wings, bridge girders, ship hulls, offshore wind foundations, and tidal energy turbines. The laboratory employs 140 personnel.



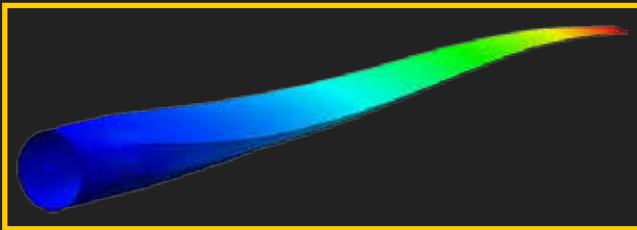
## ANALYSIS

Linear and nonlinear material modeling with elasticity, plasticity, brittle cracking, and damage initiation and evolution for material degradation.

Commercial modeling software including SIMULIA, NuMAD, ANSYS, WAMIT, MultiSurf, Abacus and LS-DYNA.

Customized numerical codes developed in-house and in cooperation with partners to satisfy unique analyses.

Composite material analysis using classical laminate theory and nonlinear progressive damage.



Finite element analysis (FEA) of a wind blade.

## DYNAMIC, FATIGUE AND IMPACT

Linear or nonlinear dynamic analysis of composite materials.

Linear perturbation analysis with natural frequency extraction, complex eigenvalue extraction, and steady state response to harmonic loading.

Direct cyclic and low-cycle fatigue analysis. Impact damage analysis.

## RELIABILITY-BASED ANALYSIS AND DESIGN

Probabilistic FEA.

Propagate material property uncertainties from coupon to structural level.

Reliability-based partial safety factors.



Automated composites manufacturing.

## ROBOTIC MANUFACTURING OF COMPOSITES

In-house manufacturing from coupon level to full-scale blades up to 70 m (230 ft).

Customized composites manufacturing processes include:

- VARTM
- SCRIMP
- Prepreg
- Hand lay-up
- Injection molding
- Compression molding
- Filament winding
- Tape and fiber lay-up
- Extrusion
- Nanomaterial enhancement



Gantry-crane Fiber Placement.

## DYNAMIC MARINE SIMULATION BASIN

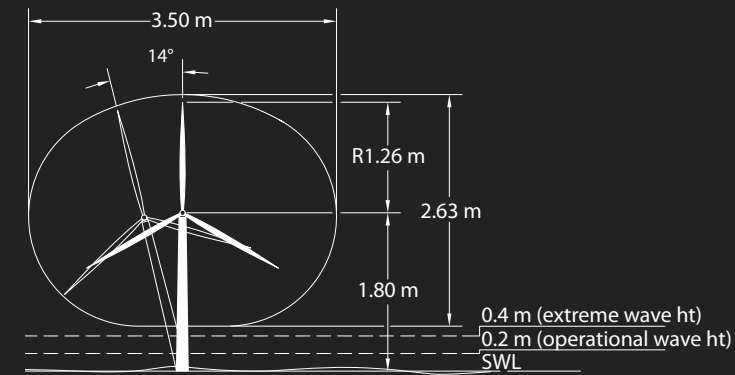
One of two facilities in the world with high quality conditioned wind and waves for scale model testing of fixed and floating offshore wind turbines and other marine structures.

Tank size: 9.7 m × 30.4 m × 4 m (32 ft × 100 ft × 12 ft).

Waves: 0.5 seconds to 4 seconds period and 0.5 m height.

Current generation.

Wind speed: up to 5 m/sec (16.4 ft/sec).



Sample 1:50 scale floating turbine test.

## COMPOSITES RELIABILITY

Health monitoring of composites using embedded fiber optic strain sensors.

Effects of processing parameters on reliability of FRP composites.

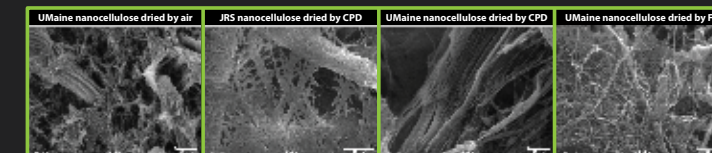
Range of NDE testing including:

- Ultrasonic (ASTM E2580)
- Radiography (ASTM E2662)
- Shearography (ASTM E2581)
- Thermography (ASTM E2582)
- NDT of Composites (ASTM E2533)

## MULTISCALE MATERIAL TESTING AND DEVELOPMENT

Material level testing to dozens of accredited ASTM standards or customized procedures.

Microscopy: AFM, microtomography, laser scanning confocal microscopy, SEM, ESEM, TEM.



Nanomaterial development.

## COUPLED ENVIRONMENTAL-MECHANICAL DURABILITY TESTING

- 7.3 m × 7.3 m × 6.1 m (24 ft × 24 ft × 20 ft) chamber.
- -40 °C to 50 °C (-40 °F to 122 °F).
- 10% to 100% relative humidity.
- Complete solar spectrum.
- 1,300 kN (300,000 lb) fatigue load.
- Programmable salt fog corrosion testing.
- Salt or fresh water immersion.
- UV testing.

TESTING

## LARGE-SCALE STRUCTURAL TESTING

Servo hydraulic static and dynamic tests.

73 m (240 ft) long reaction floor.

1,200 l/min (310 gpm) Hydraulic Power Unit.

Hydraulic actuators up to 4.45 million N (1,000,000 lb).

Examples of tests performed:

- Wind blades
- Bridge decks and beams.
- Building components.
- Earthquake simulations.
- Boat hulls
- Electric transmission structures

## BLADE TESTING

Up to 70 m (230 ft) blades, 68,000,000 N-m (50 million ft-lb).

Over 200 channels of data acquisition capacity.

Static, modal, and resonance fatigue testing following IEC 61400-23 structural testing guidelines.

Full-scale structural testing with the ability to apply multi-axis loads up to 4.45 million N (1,000,000 lb).

Root stud pull-out testing.



Wind Blade test.

## FRACTURE MECHANICS

Fracture mechanics analysis: mode I, mode II, mixed mode.

J-Integral method, strain energy release rate, EWF.

Fatigue fracture.

Crack propagation predictions using probabilistic finite element methods.

## NONCONTACT DISPLACEMENTS AND STRAINS

3D digital image correlation provides displacement during static and fatigue testing.

Full-field strain measurements for composites using 3D digital image correlation.



Integrated mechanical-environmental durability testing.

Noncontact displacement measurement for blades.

DESIGN

ADVANCED MANUFACTURING