Structural Integrity Associates, Inc.®

WIND TURBINE COMPONENT
DAMAGE ASSESSMENT AND FAILURE ANALYSIS

STRUCTURAL INTEGRITY: UNDERSTANDING WIND TURBINE ISSUES

Wind turbines experience a number of degradation and damage mechanisms that can result in premature failure. We help our clients understand why and how damage (such as crack and delamination on blades, lightning damage, cracking on bolted connections, etc) occurs and to develop appropriate component maintenance plans.

Structural Integrity brings decades of success in condition assessment and life cycle management throughout the energy industry. This knowledge can ensure the life of your wind turbine is not cut short by component aging, design flaws and failures.

Damage and Failure Analyses Services

- Failure Mode & Origin Investigation
- Damage Evaluation
- Repair Evaluation
- Defect Assessments
- Stress Analysis
- Fatigue Analysis
- Custom Nondestructive Examination Solutions

OUR APPROACH

We use forensic engineering techniques and analyses to investigate component damage and/or failures, providing valuable information on how and why damage occurred and what can be done to mitigate future occurrences. Our analyses are based on a combination of inspection of physical evidence and detailed engineering damage assessment. If required, this can extend to a full root cause analysis. Some key questions guide our approach:

Where did the fracture originate?

Once a turbine failure or component damage has been identified, we use fractography — visual and macroscopic examination of the fracture features — to pinpoint specific areas of interest for detailed destructive and microscopic analysis.

What was the driving damage/failure mode?

Microscopic analysis sheds light on the mode of failure, such as tension, compression, torsion due to an overload or fatigue. This process can also reveal the presence of cracking, inclusions, voids, porosity, oxidation and other pre-existing material features. Our Materials Science Center can perform a wide range of evaluation including fractography, metallography and microscopic analyses.

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What was the component's operational loading and environment?

We peform component stress and fatigue analysis, factoring in loading conditions such as wind speeds, humidity, lightening, yaw and pitch angles, and rotational speed. We can then evaluate or compare results to the manufacturer's design allowable, as well as industry standards or guidelines.

What was the condition of the component before damage/failure?

A careful review of manufacturing procedures, inspection reports, SCADA data and BOP performance can identify component structural degradation, pre-existing damage or manufacturing defects. Our materials experts can also test mechanical properties and use advanced techniques such as metallography to evaluate material degradation.

What is the effect of pre-existing damage or manufacturing defects?

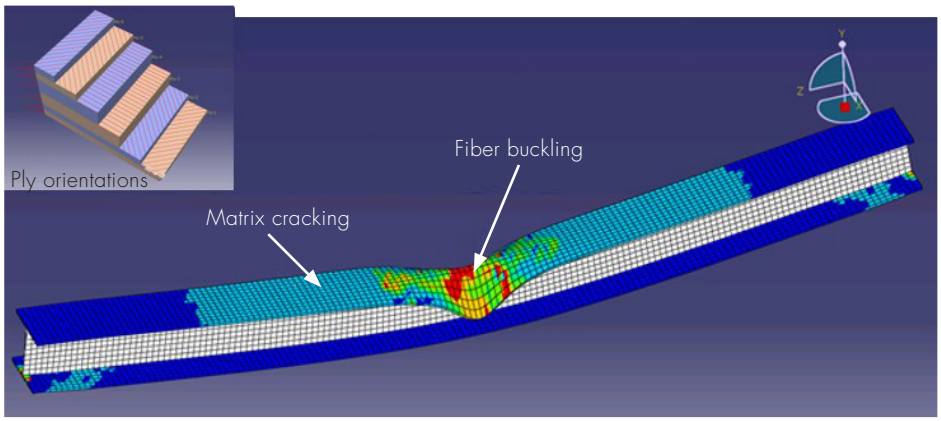
Using stress analysis and fracture mechanics simulations, we can determine if — and how — damage or defects will affect component performance. Fatigue analysis methods can then be used to calculate a more accurate component lifetime.

Is the damage/defect pervasive throughout the fleet?

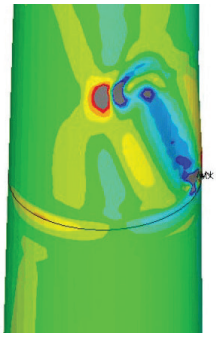
It can also be important to evaluate whether this is an isolated event or a widespread issue. Depending on the component, damage/defect type, area of interest and accessibility, our team may use different non-destructive inspection techniques, such as dye penetrant inspection or phased array ultrasonic, to identify damage in other components. This can include the development of custom NDE solutions for specific applications.

Catastrophic failure at main shaft

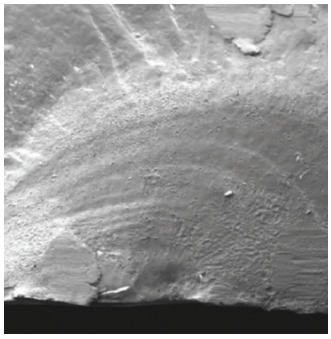
Fracture surface



Composite spar finite element analysis and damage modes



Tower impact damage finite element analysis



Fracture origin