

Be Specific: Determination of Site-Specific Engineering Parameters for Wind Turbine Foundations

Eric J. Soderlund, P.E.
Sargent & Lundy Consulting

BACKGROUND

There are an increasing number of situations under which it is necessary to know a wind turbine foundation's site-specific engineering parameters, including:

- Historical **fatigue damage assessments**,
- **Structural performance** determination, and
- **Partial repower** analyses

For most of these situations, wind turbine manufacturer foundation load specifications are not useful because they are typically developed in consideration of generic IEC parameters, and older load specifications don't always include fatigue loads.

Nonetheless, instrumentation can be installed on operational wind turbines to correlate measurements to foundation engineering parameters, such as:

- **Site-specific loads**,
- **Rotational stiffness**, and
- **Fundamental frequencies**

The foundation loads can also be factored into site-specific design loads for ultimate strength and fatigue as well as design loads for partial repowering.

OBJECTIVES

This presentation:

1. Discusses the instrumentation and data measurement campaign,
2. Lists determinable site-specific engineering parameters, and
3. Outlines the uses for those parameters

INSTRUMENTATION & DATA MEASUREMENT

Weldable Axial Foil Strain Gages: Attached to interior tower wall at four quadrants approximately two meters above base flange

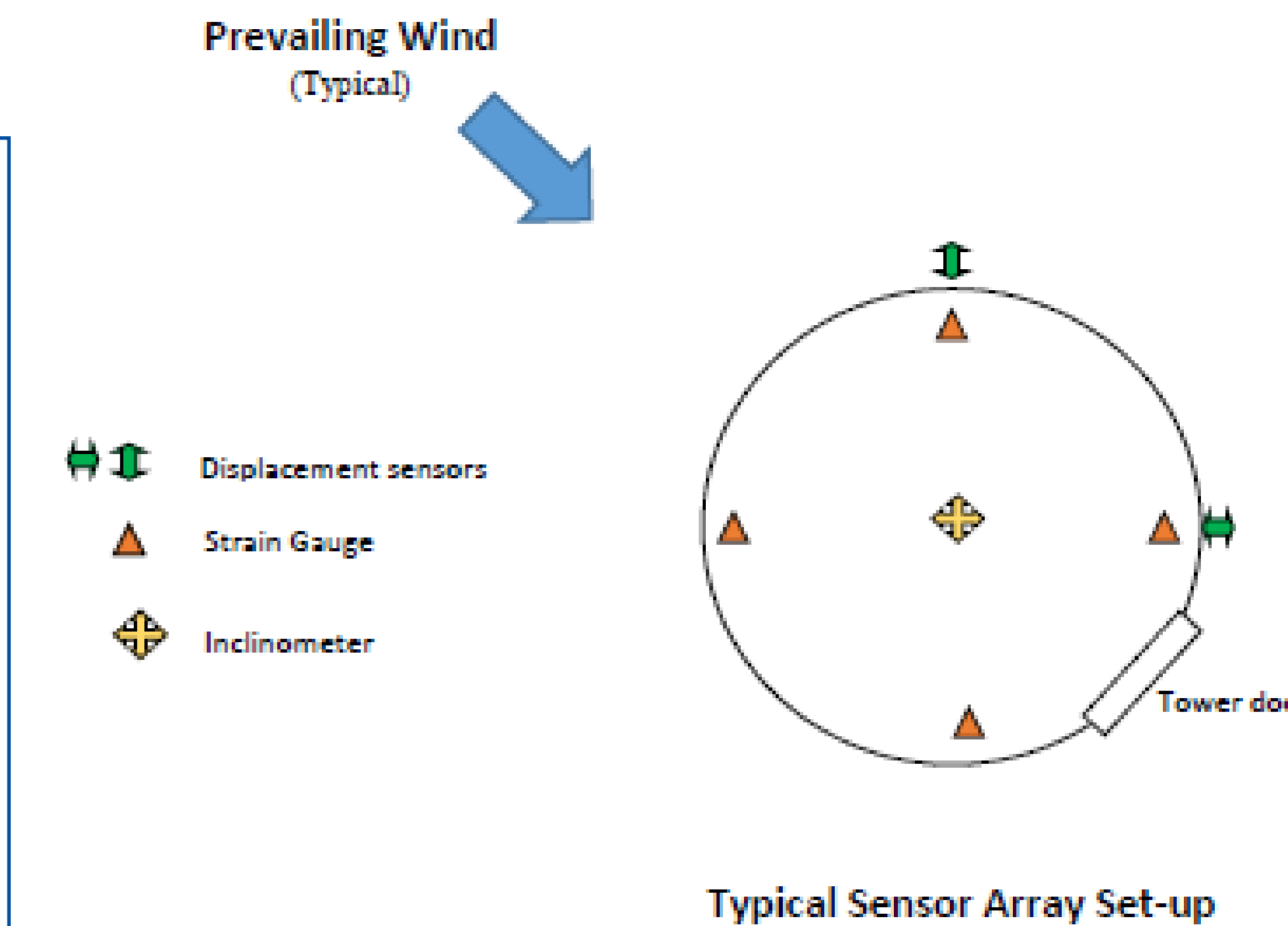
Linear Variable Displacement Transformers (LVDTs): Placed against outside of tower wall at two quadrants, and anchored 10 feet away

Biaxial Tiltmeter: Mounted on the center of the foundation to capture inclination in same two directions as LVDTs

Data Acquisition System: 4-channel intelligent wireless node placed within tower

General Instrumentation & Data Recommendations:

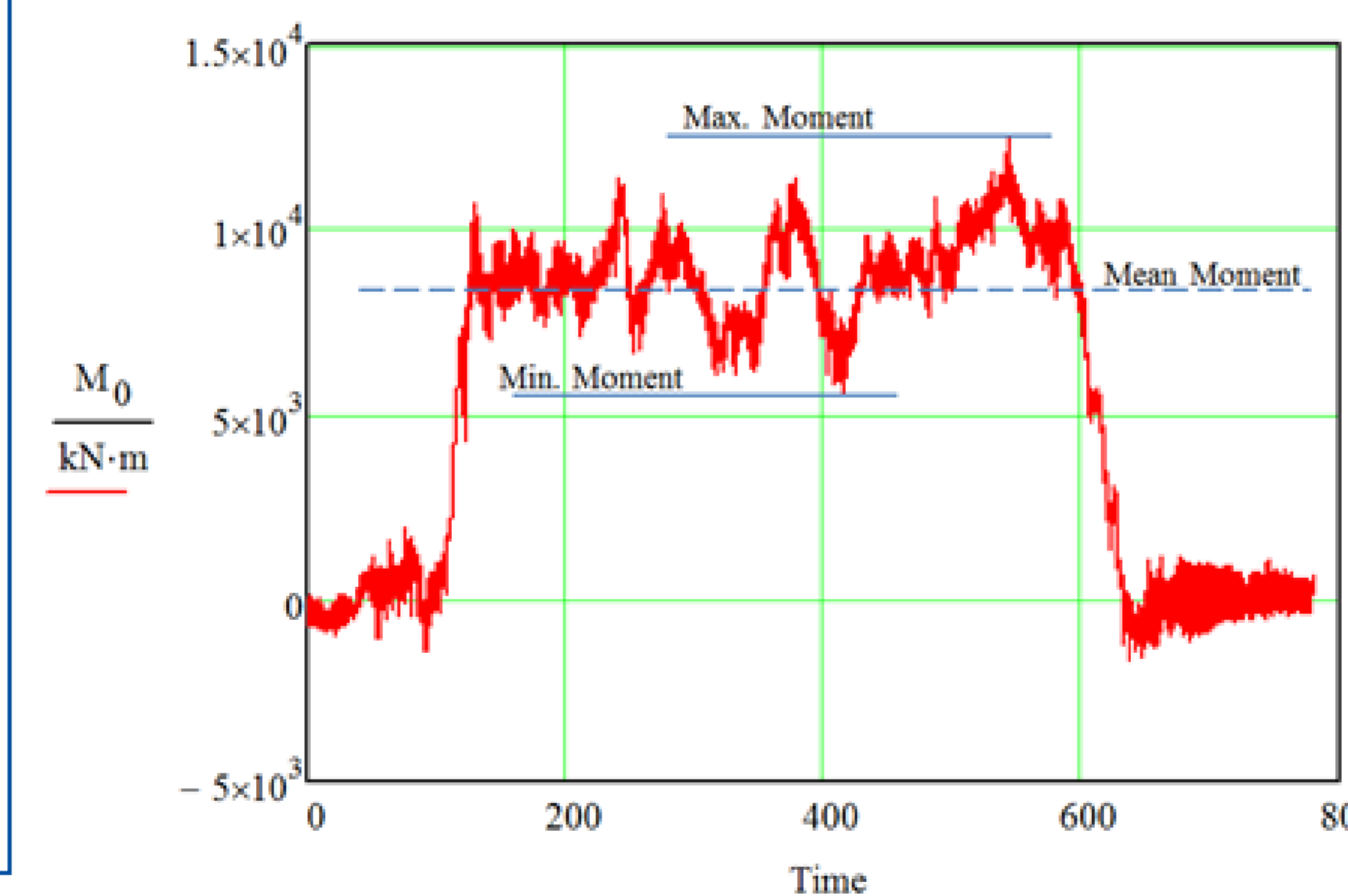
- Equipment should have adjustable capture rate from 1 Hz to 1 kHz (recommend recording at 50 Hz)
- Data must be time-stamped for importation into LabVIEW or MATLAB computer software



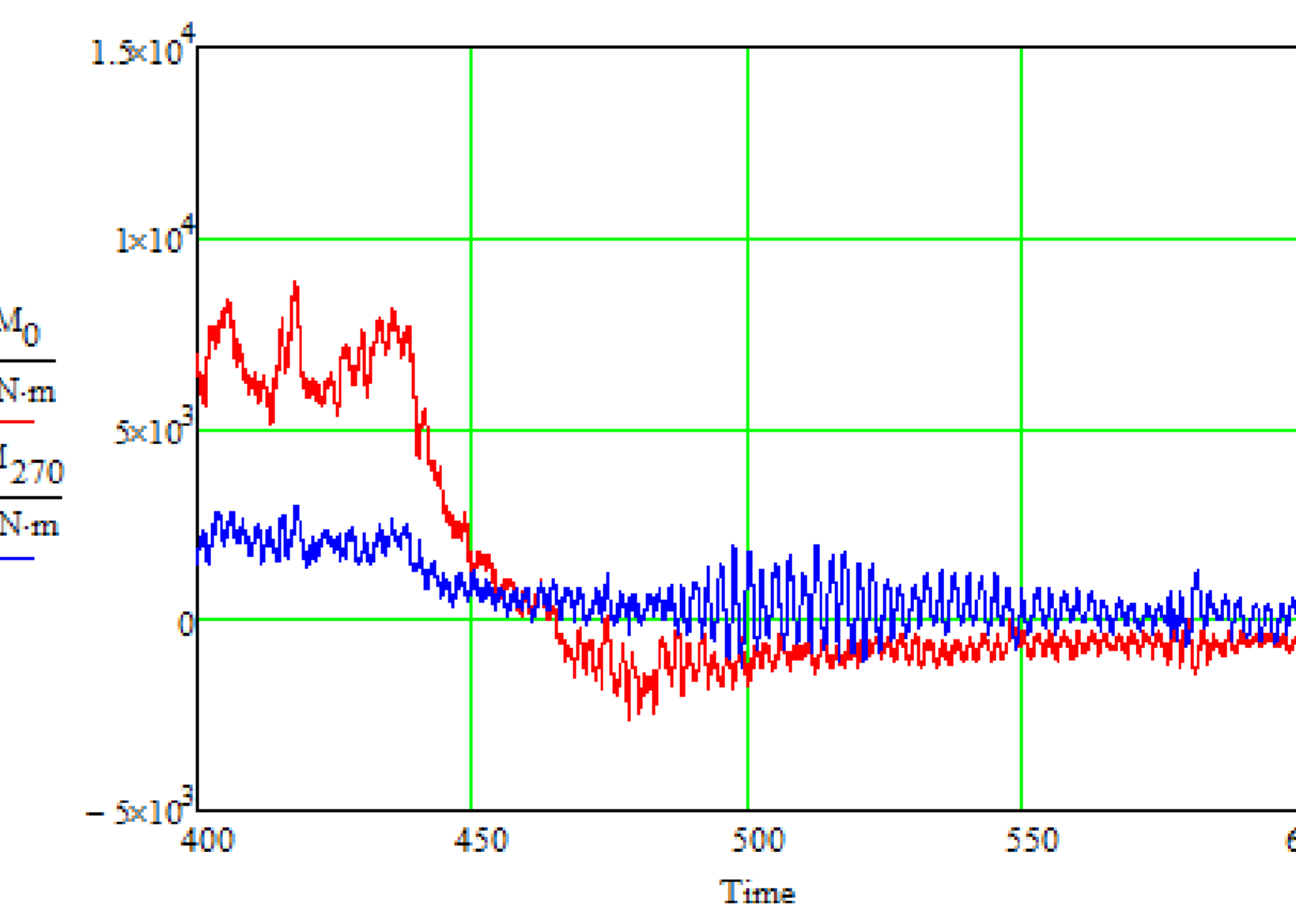
ENGINEERING PARAMETERS

- Site-specific **foundation loads**
- Tower **inclinations**
- Foundation **rotational stiffness**
- Foundation **fundamental frequencies**
- Foundation response to **startup and stop events**
- Foundation **overturning moment time series**
- Foundation **displacement time series**
- Foundation **fast-stop response**

Site-Specific Foundation
Overturning Moments

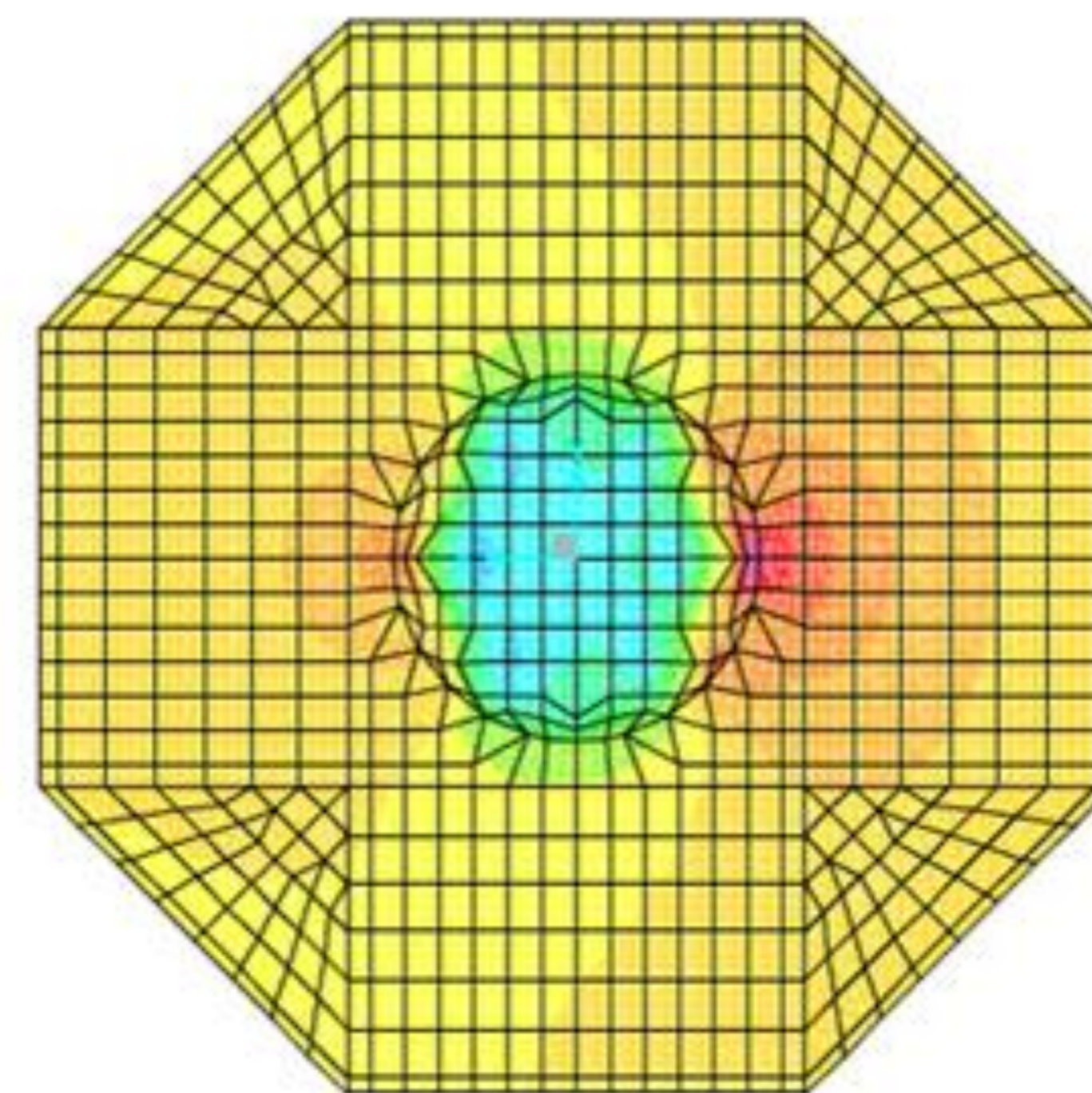


Overturning Moments
During Fast-Stop



NEEDS FOR SITE-SPECIFIC PARAMETERS

- **Fatigue damage assessments**
- **Remaining useful life calculations**
- **Structural health monitoring**
- **Structural performance determination**
- **Partial repower analyses**
- **Power uprate analyses**



CONCLUSIONS

- There are many needs for site-specific wind turbine foundation engineering parameters not provided in load specifications.
- Instrumentation can be installed on operational wind turbines for data collection.
- Post-processing of the instrument data allows determination of site-specific engineering parameters.

METHODOLOGY

As part of our more than 125 years of electric power industry experience, Sargent & Lundy has significant wind energy experience. We provide a full range of services to the wind industry, including site screenings, project feasibility studies, wind resource assessments, independent engineering, interconnection planning, conceptual engineering, contract development, detailed engineering, design reviews, construction monitoring, commissioning services, and O&M support. We have been involved with the analyses of over 250 wind turbine foundations in the last 10 years. In fact, Sargent & Lundy was actively involved in the ASCE/AWEA committee that prepared the first U.S. guideline for the design of wind turbine foundations. Our experience with wind turbine foundations provides the basis for the content of this presentation.

BIOGRAPHY

Mr. Eric J. Soderlund is a Senior Project Manager with Sargent & Lundy Consulting. His experience in the wind industry includes engineering design modifications, conceptual studies, due diligence, construction monitoring, operations monitoring, project management, and other analyses for a multitude of domestic and international projects. He holds a B.S. in Civil Engineering from the University of Illinois at Urbana-Champaign, an M.S. in Civil Engineering from the University of Illinois at Chicago, and an M.B.A. from DePaul University. He is a licensed Professional Engineer in Illinois.

CONTACT INFORMATION

Eric J. Soderlund, P.E.
55 East Monroe Street
Chicago, Illinois, 60603-5780
+1-312-269-6596
esoderlund@sargentlundy.com