Foundation and Tower Condition Monitoring

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GEC
a DNV company

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Foundation and Tower Condition Monitoring

- Corrosion
- Bolt tension
- Fatigue
- Foundation stiffness

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Corrosion

- A visual inspection is the primary means of monitoring corrosion
- Anchor and flange bolts
  - Most susceptible to corrosion
  - Mitigate cause of corrosion
- Tower
  - Monitor performance of tower coating

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Anchor and Flange Bolt Tension

- Insufficient tension in the bolts will significantly increase their fatigue loading
- Bolt tension must be periodically checked
  - Relaxation of steel
  - Shrinkage and creep of concrete
  - Tower vibration
- Re-tension foundation and tower section bolts
  - Follow manufacture specifications
  - All anchor bolts should be re-tensioned after initial break-in period
  - A portion of anchor and flange bolts should be re-tensioned on regular basis

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Assessing Foundation and Tower Fatigue

- Inspection
  - Inspection of the foundation and tower can only reveal fatigue if cracking has occurred
  - Only a limited portion of the foundation is accessible for inspection
- Assess remaining life of the foundation and tower
  - Measure the loads at all turbines over entire life
  - Evaluate the operating history of the machine
    - Identify operating conditions and events of interest
    - Mine SCADA data to quantify time and cycles on a turbine by turbine basis
    - Calculate fatigue damage from operating history
  - Some combination of loads measurement and operating history

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Foundation Stiffness Monitoring

- The primary goals :
  - Compare foundation stiffness and movement to design specifications
  - Look for changes in foundation stiffness and movement over time
- Reasons for monitoring:
  - Cracking in soil around foundation
  - Unexplained softness in structure (high tower or nacelle acceleration)

Source: TreeHugger.com

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Foundation Stiffness

- Instrumentation
  - Foundation tilt
  - Tower bending
  - Foundation horizontal displacement
  - All measurements in two orthogonal directions
- Analysis
  - Rotational stiffness
  - Horizontal displacement
  - Natural frequency and damping
  - Frequency response during operation

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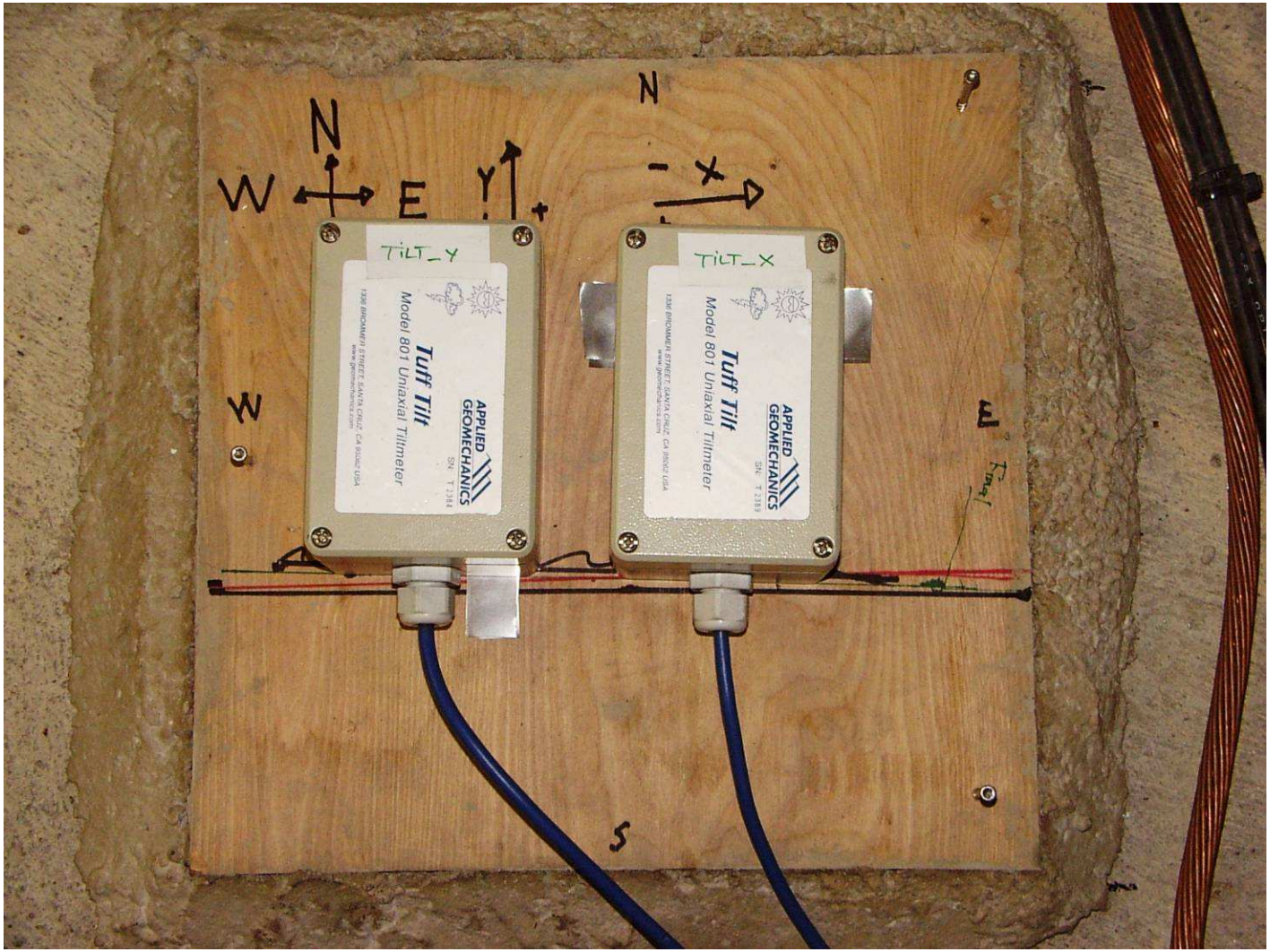
Foundation Tilt



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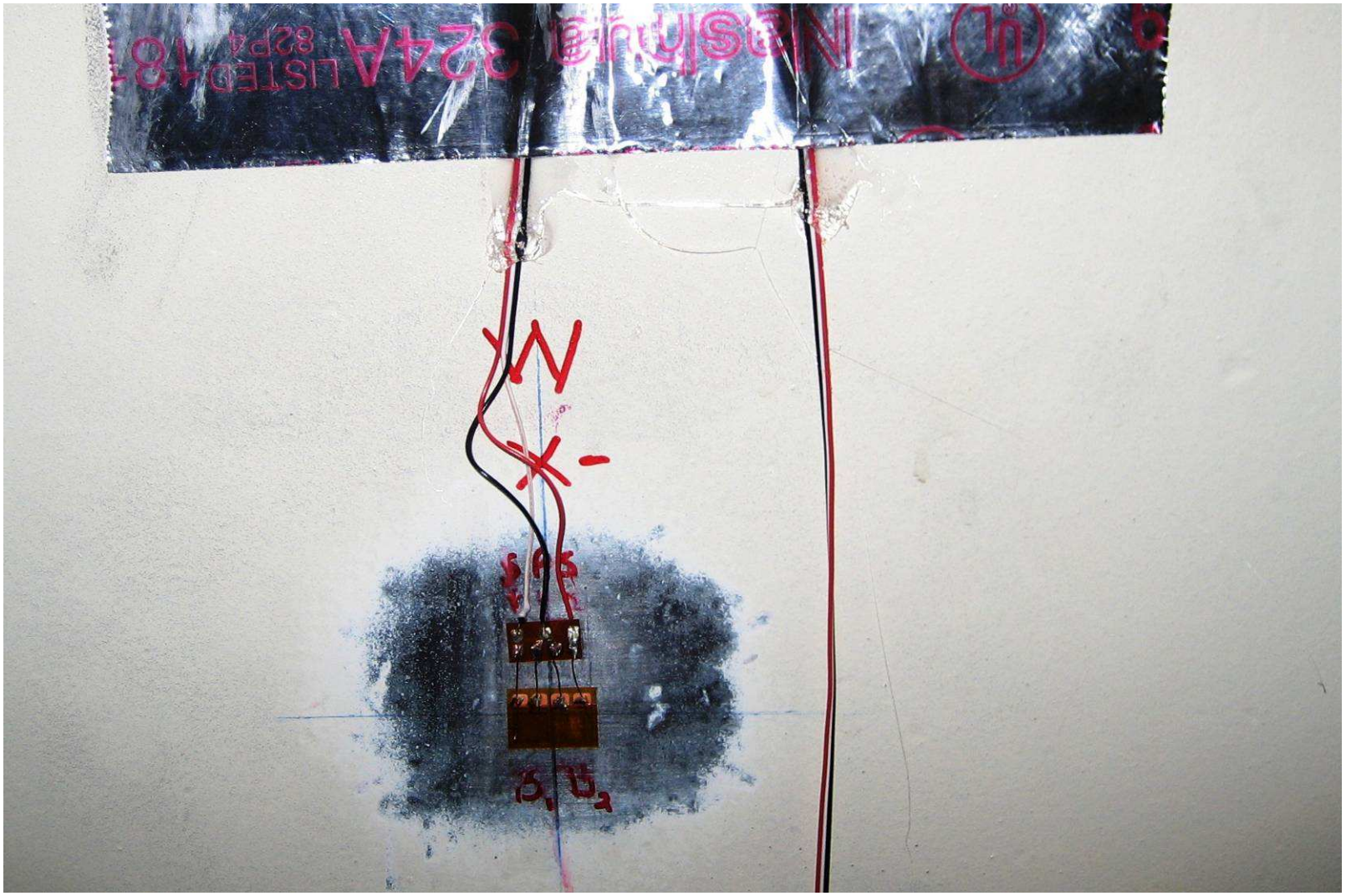
Tower Bending Measurement



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Foundation Horizontal Displacement

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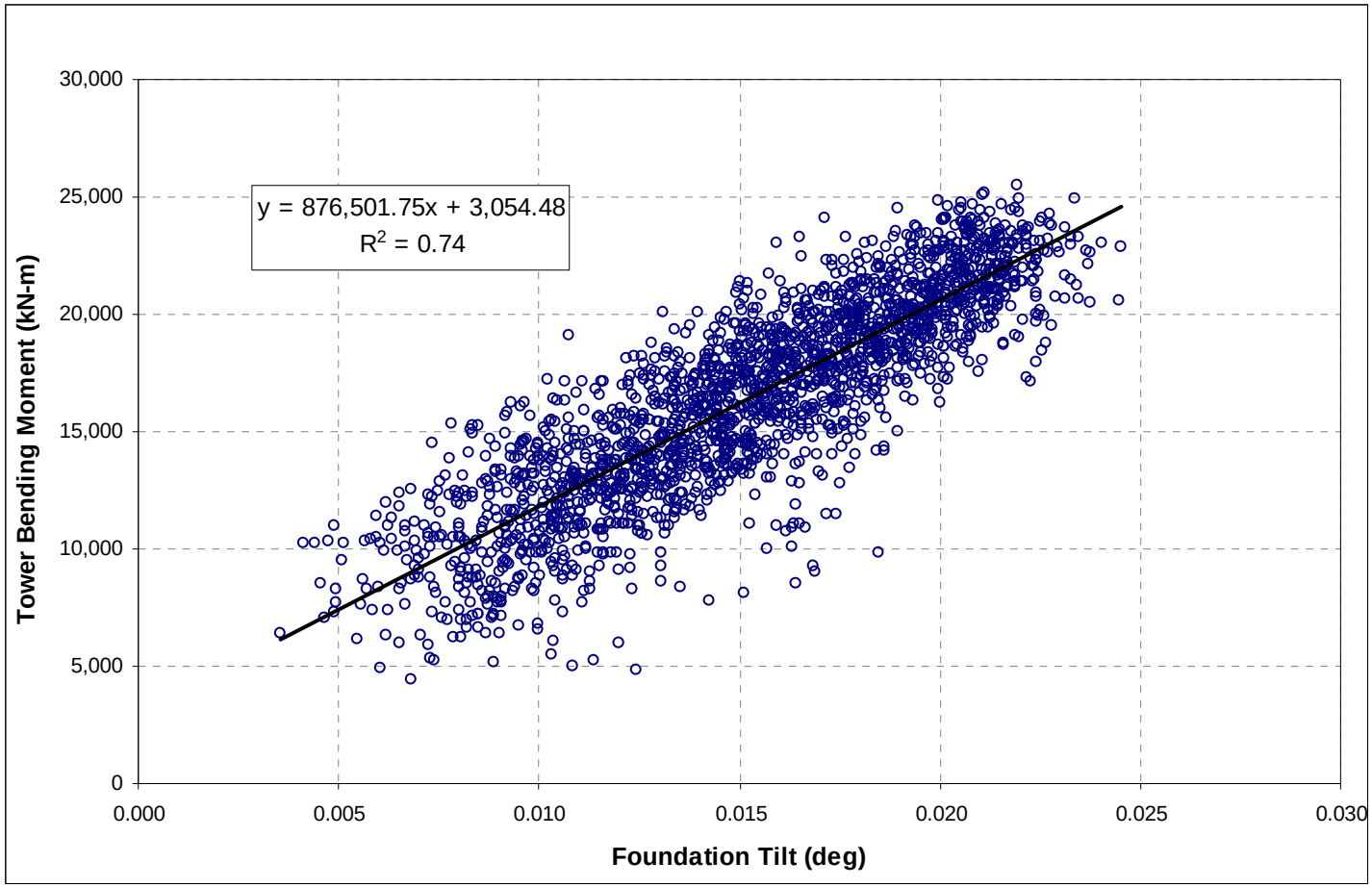
Rotational Stiffness



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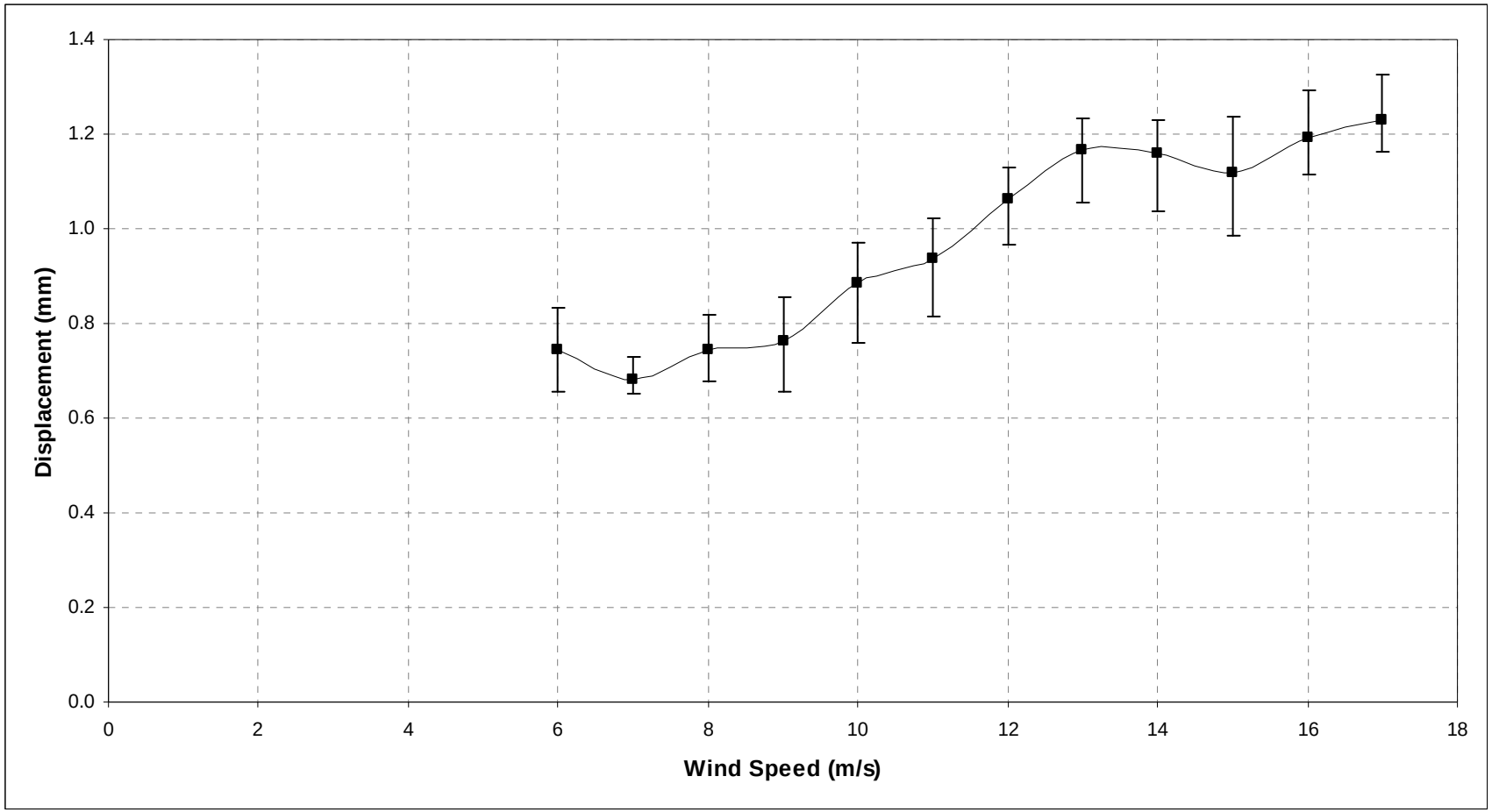
Horizontal Displacement



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Natural Frequency and Damping

- Provide impulse to turbine and observe response
  - Accomplished by performing a “hard” shutdown during operation
  - The natural frequency is determined by the frequency of oscillation after the stop
  - The damping is determined by the decay of the oscillation after the stop
- Natural frequency
  - Change in natural frequency implies change in stiffness of structure
  - The natural frequency is more sensitive to the tower stiffness than foundation stiffness

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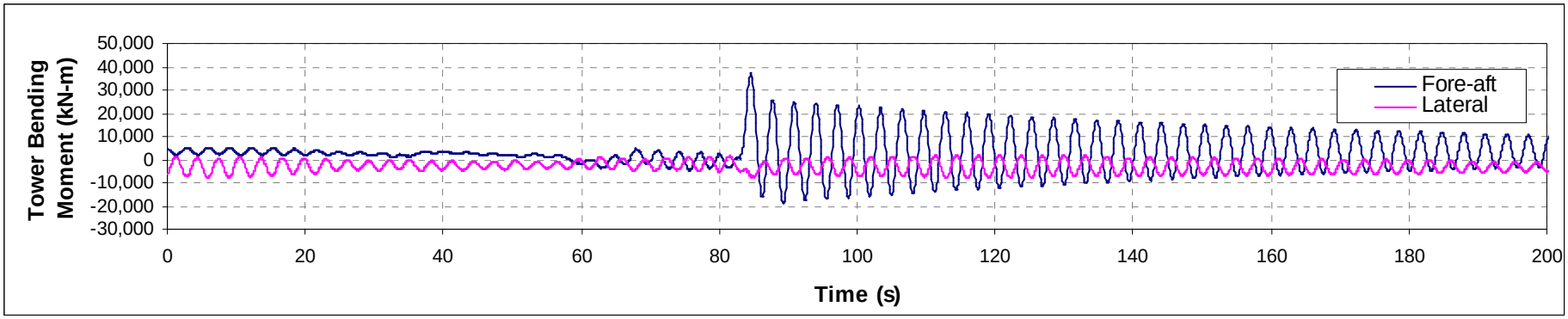
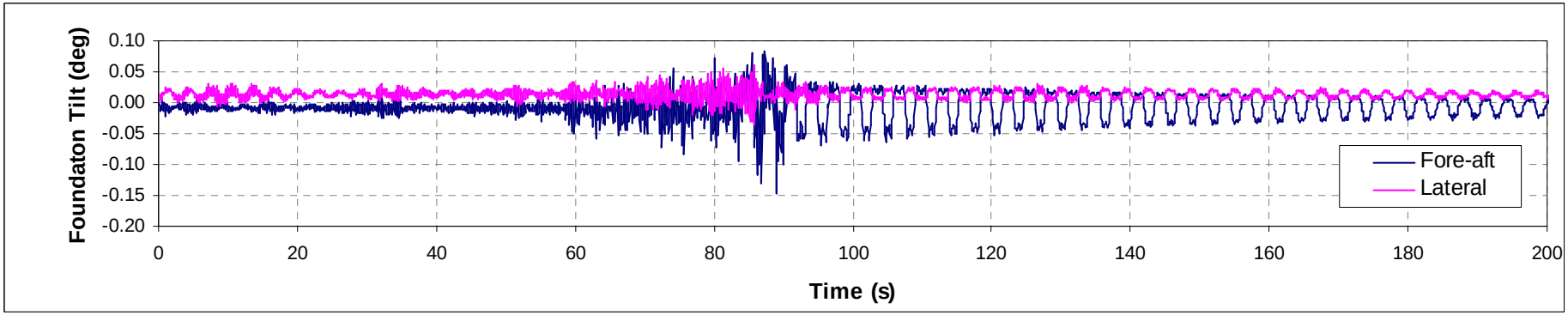
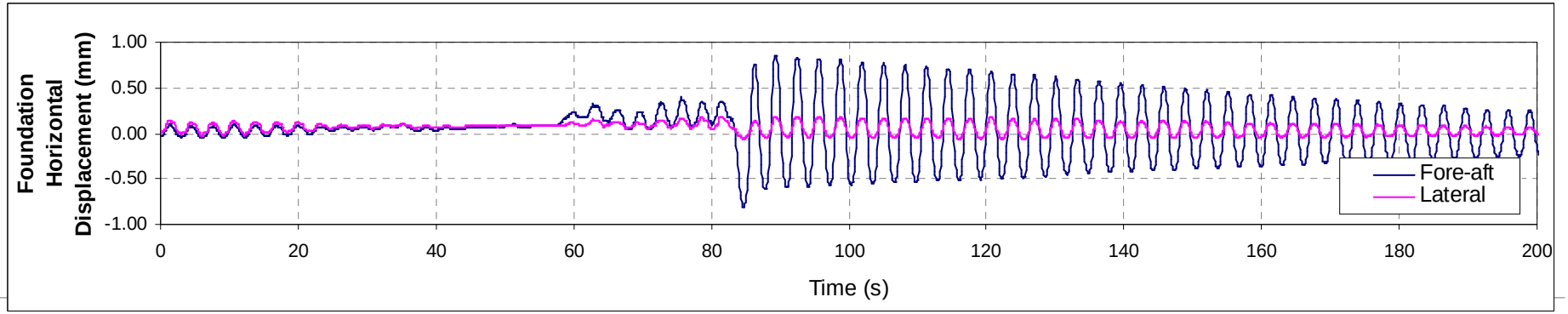
Natural Frequency and Damping







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Evaluating Frequency Response

- Typically the tower natural frequency is slightly higher than the rotational frequency of the rotor
- Low foundation stiffness will cause the natural frequency of the tower and foundation approach the rotor frequency causing unwanted excitation
- The magnitude of measurements at the rotational frequency of the rotor can be monitored over time to assess changes

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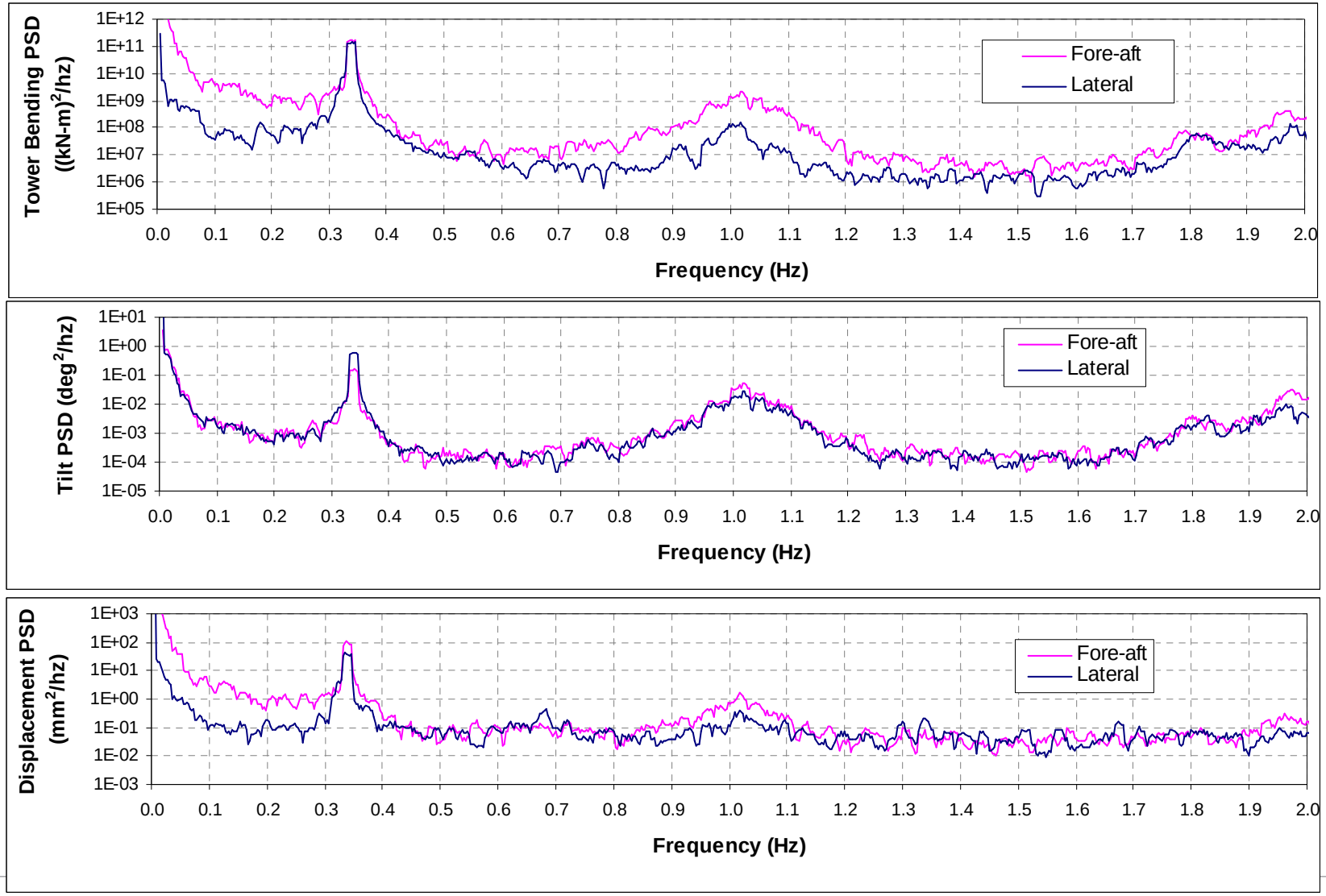
Evaluating Frequency Response



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