Keywords: Femap, NX Nastran, wind turbine, wind tower, wind loading, static analysis, dynamic analysis, vibration analysis, natural frequency, normal modes, frequency response, fatigue analysis, steel structure, IEC 61400,

Main Graphic:

Caption: Erecting a 50 kW wind turbine tower.

Case Study Section: FEA | Linear Dynamics

Dynamic and Static Stress Analysis of a Hinged Wind Turbine Tower

Analysis Type: Linear, Dynamic, Vibration

A vibration study of a small wind turbine was conducted to determine the natural frequency of the tower. It was important to ensure that the rotating blades would not excite the normal modes of the structure. In addition to the analysis of the erect tower, it was important to analyze the bottom-out event the tower experiences as the hinged structure is lowered to the ground (see Figure 1).

A shell geometry model was constructed and meshed with 4-node plate elements. Bolted connections were modeled with a combination of beam elements for the bolts and rigid links to connect the beam elements onto the plate mesh (see Figure 2).

Once the normal modes of the tower were calculated, an excitation load was applied with at sine-sweep at the top of the tower. The goal was to idealize any rotor imbalance loads and apply them to the tower throughout the operating rotational-speed range of the turbine (see Figure 3)

Using the FE model to determine the stiffness of the tower in the lowered position, it was possible to calculate the deceleration of the tower as it experiences the bottom-out event. This load was applied to the FE model with a body-acceleration (see Figure 4).

The iterative design/analysis process with the efficient FE model allowed the client to make multiple changes to the geometry of the tower and analyze with quick turnaround. Once this process was complete, the client included the design changes and could move forward with confidence in their product.

Figure 1: The hinged tower rises and lowers with a hydraulic cylinder.

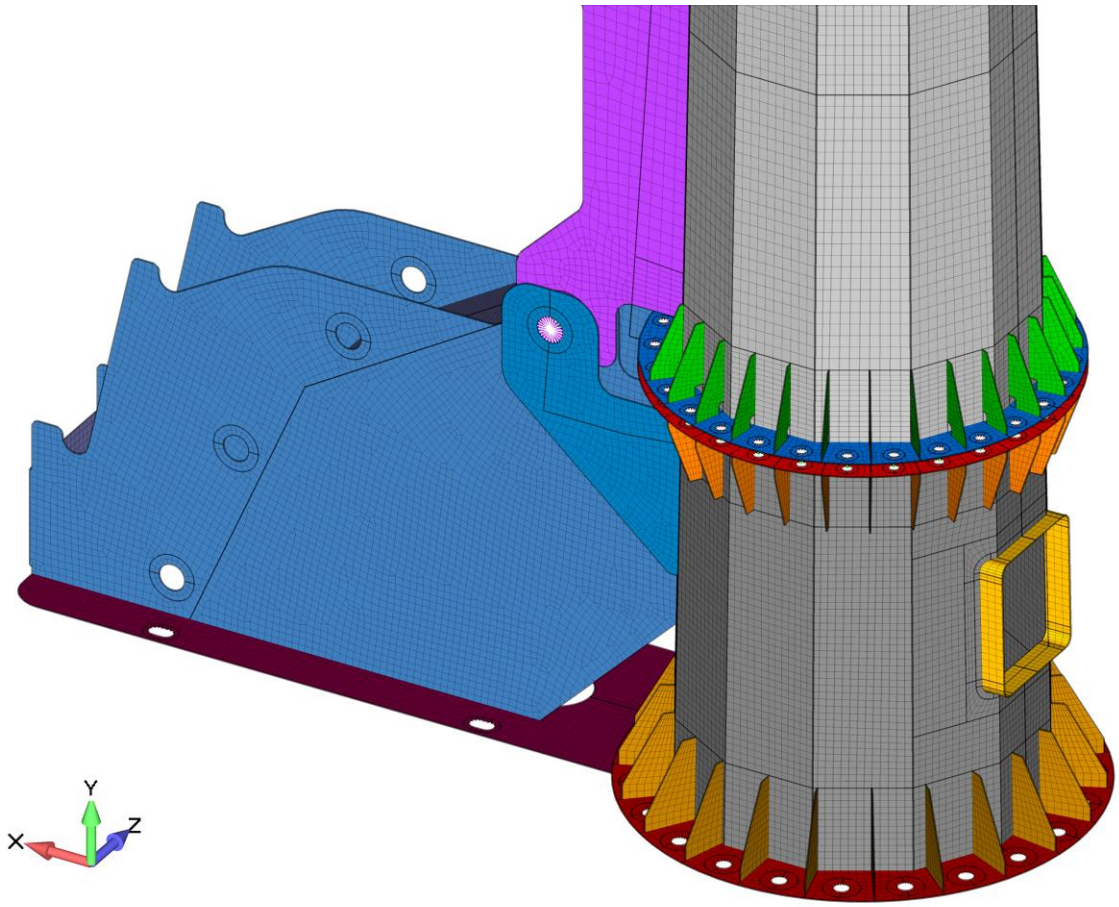

Figure 2: Finite element model of the hinged tower in the erect position.

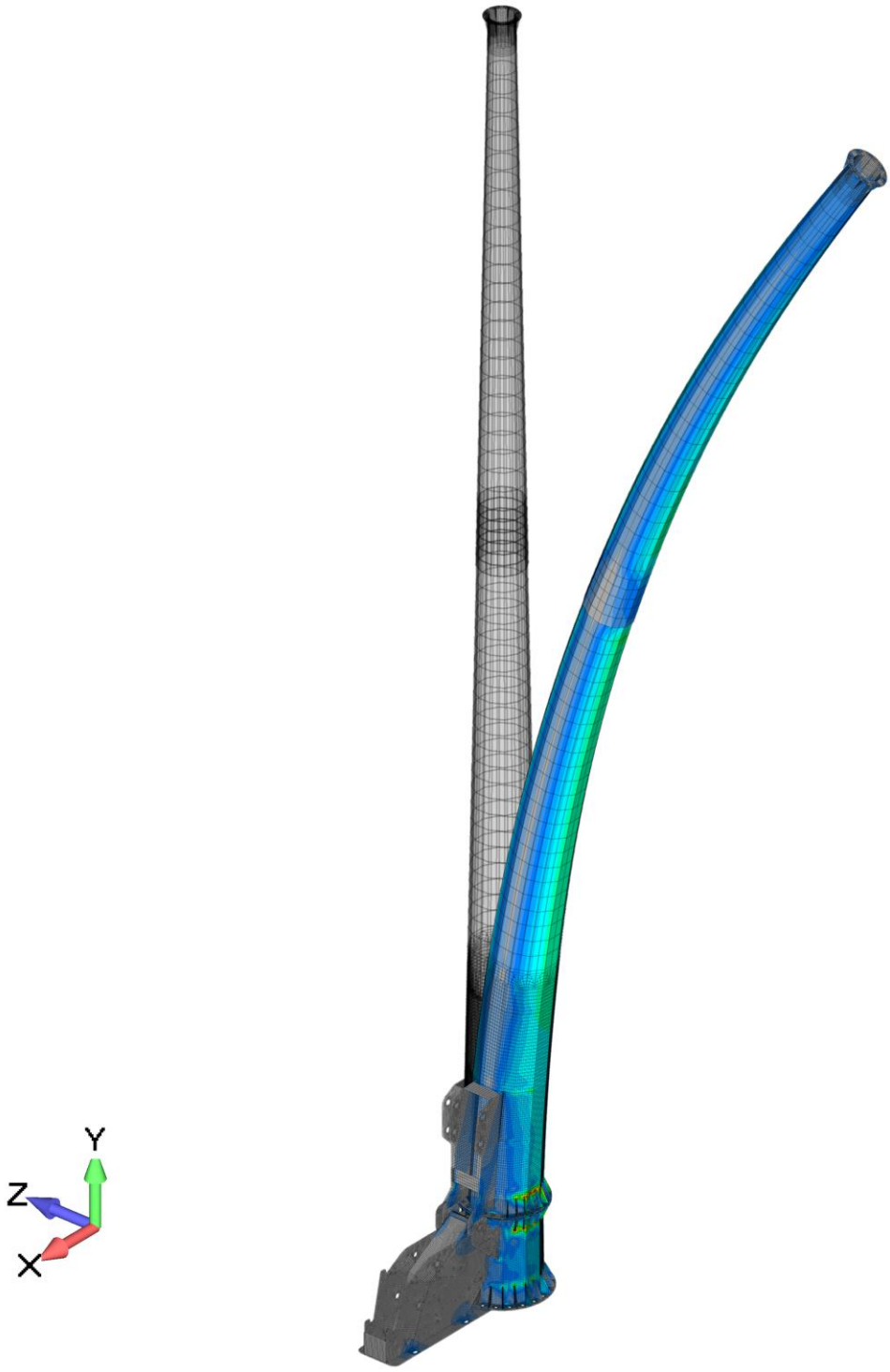

Figure 3: The full tower with exaggerated deformation to illustrate the first normal mode.

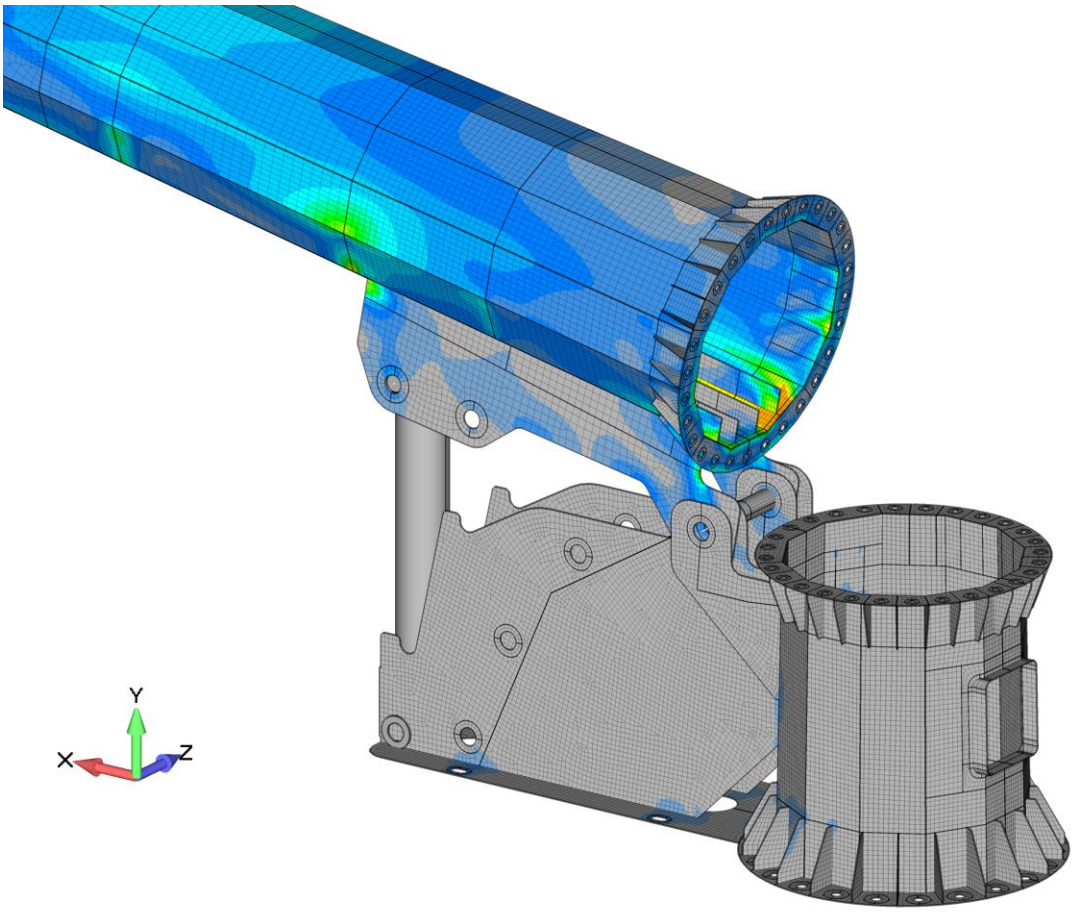

Figure 4: The bottom-out event occurs when the prop rod hits the concrete foundation as the tower is being lowered. With the tower in this orientation, the turbine is accessible for service.