Fatigue-Driven Wind Farm Towers:
A Practical Introduction to Fatigue Calculations

by

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ABSTRACT

This paper discusses the fatigue design of steel tubular towers serving as the support structures for large power-generating wind turbines. Unlike wind and earthquake analysis for most routine structures, fatigue analysis is not a mainstream concern for structural engineers. However, wind farm tower structures are subject to high-cycle fatigue on the order of several hundred million cycles over a typical 20-year design lifetime. In fact, fatigue loading often governs tower design.

This paper focuses on the *S-N* curve approach using the Miner's Rule damage summation method as implemented in the Eurocode. European fatigue guidelines serve as the current standard of the wind industry worldwide and even in the US market. This paper will discuss and illustrate fatigue concepts such as the following:

- Fatigue loading basics including the popular "Rainflow" cycle counting method
- The fatigue load spectrum extracted from the Markov matrix
- The fatigue damage-equivalent load and its calculation from the fatigue load range spectrum
- Construction details and fatigue Detail Categories
- The "hot spot" stress approach in accordance with International Institute of Welding (IIW) guidelines that provide methods to calculate stress concentration factors from finite element analysis models.
- Fatigue calculations using a load-to-stress transfer function that is nonlinear

Where possible, the attempt is made to describe these unfamiliar sounding concepts in more familiar and routine terms. Further, design examples will clearly illustrate these fatigue concepts and design requirements.

Finally, this paper discusses experiences from past wind farm tower projects in reconciling US Code requirements with European standards and guidelines.