Keywords: Risk Assessment, Wind turbine, Strong wind, Reliability.

Risk assessment of adverse events for wind turbines caused by strong winds

S. Rastayesh[a], G. Zorzi[b], S. Miraglia[a], J. D. Sørensen[a]

Nowadays, renewable energies are becoming more popular; one of them is wind turbines. Wind turbines are continuously exposed to changing environmental loads, including wind, waves, and currents for offshore turbines. These cyclic loads may cause fatigue damage leading to a decreased of the structural performance and thus results in an increased risk of failure. These effects of environmental loads can be due to fatigue of steel components (e.g., monopole, bolts and stud anchor bolts) and concrete components in the foundation structure. There are lots of failures recorded for wind turbines caused by strong winds that exceed design loads. By looking at the literature review on the effect of strong winds on wind turbines, it has been concluded that better design standard is needed especially for offshore wind turbines since wave effects can worsen the situation [1], [2]. The strong wind, drastic turbulence and unexpected change of wind direction are the main factors of wind turbine failures in case of strong wind, exposing the design defects of operating wind turbine. We can divide these failures into three different categories: Wind turbine tower and foundation collapse, Blade crack and break, Pitch control system and yaw system.

Extreme events like typhoons and extreme winds can induce plastic deformations on the load bearing structures, thus causing a high risk of collapse of the wind turbine. This paper aims to investigate risk assessment of adverse events caused by strong wind leading to wind turbine collapse. A typical wind turbine is considered to model load effects on wind turbine caused by strong wind such as typhoons and extreme wind gusts. Different failure modes and collapse mechanisms of the wind turbine are considered: such as excessive- rotation-tilting. An ultimate limit state equation is formulated including a stochastic model especially focusing on the extreme loads when there is a collapse; additionally, a serviceability limit state is presented when there is an excessive tilting. By having environmental data of typhoons considering their uncertainty, a one-dimensional model is used to transfer the external load down to the foundation. The behavior of the foundation (rotation-tilting) by simulating the change in soil structure interaction under cyclic loading conditions is studied in this paper. A reliability analysis is presented and next a risk-based decision-making process is proposed and illustrated to minimize the economical costs over the life-time upon choice of design parameters.

Figure 1: strong wind in an offshore wind turbine

---

[a] Dep. Civil Engineering, Aalborg University, Thomas Manns Vej 23, Aalborg, Denmark
[b] GuD Geotechnik und Dynamik Consult GmbH, Berlin, Germany

[1] Graf et al., *IDRC International Disaster and Risk Conference* (2018).
[2] Li et al., *J. Engineering Failure Analysis.* **165**, 27 (2013).