Fatigue of concrete under cyclic loading from wind turbine generators

Wind turbine generators are exposed to a very high number of load cycles in the range of $\Sigma N = 10^9$. High cycle fatigue controls the design of modern wind turbine generators. Open questions and deficits in the design of structural members under cyclic loading initiated the report „Ermüdungsverhalten von Beton unter zyklischer Beanspruchung aus dem Betrieb von Windkraftanalgen“ (“Fatigue of concrete under cyclic loading from wind turbine generators”).

The design models in several concrete standards (DIN1045-1, DIN EN1992, CEB fib Model Code 1990 und 2010) do not represent the fatigue behaviour of concrete appropriately. In the first line the consideration of the fatigue loads shall prevent a premature failure. The commonly applied PALMGREN-MINER-rule, however, may lead to both conservative and non-conservative design results depending on the given impacts. For the heterogeneous composite material concrete the two basic assumptions of this rule (a) linear accumulation of the material degradation and (b) independence of the impact order do not apply. Furthermore, the design results are very sensitive to variations of several influence parameters.

The aim of the investigations was to create the basis for an evaluation of the existing design procedures for structural members under fatigue loads from wind turbine generators. Theoretical and experimental investigations, which are the basis for the existing design models, have been summarised and evaluated. Furthermore, advanced design approaches from literature have been described and compared. This is followed by comparative calculations of the fatigue resistance in typical sections of wind turbine generators. Based on these investigations the need for further research activities under consideration of the characteristic impacts from wind turbine generators is given.

First, a thorough literature research in combination with the generation and evaluation of a test data base is recommended. Second, appropriate experimental investigations under consideration of the occurring fatigue loads and typical concrete properties are needed. Furthermore, numerical analyses with advanced material models for the concrete should be performed. The numerical analyses can be used to investigate the proceeding material degradation and the resulting stress redistributions. A combination of the described investigations is expected to yield sufficient information on the fatigue behaviour and design of structural concrete in modern wind turbine generators.