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Wind power

Efficient wind turbines made of reinforced and prestressed concrete

Short title:

WinConFat

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Leibniz Universität Hannover, Institut für Massivbau

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[support structures of wind turbines](#)

[reinforced concrete](#)

[Material fatigue](#)

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 www.bgu.tum.de/cbm

 Technische Universität Dresden, Institut für Massivbau

 www.tu-dresden.de/bu/bauingenieurwesen/imb

DOWNLOADS FOR THE PROJECT

Literature list for the research project

 [Publikationsliste -WinConFat.pdf \(PDF, 164 KB\)](#)

QUINTESSENCE

- Wind turbines are exposed to cyclic and mechanical loads from wind and waves. This fatigues the material and in the worst case can destroy the entire turbine.
- New support structures made of reinforced and prestressed concrete offer technical and economic advantages.
- The material properties of concrete are investigated on new test stands. The aim is to obtain findings for load change numbers of two million and more.
- In the long term, the results are to be incorporated into reference documents and information sheets for concrete and structural engineering.

Nowadays, both tower and foundation, the support structures of wind turbines, are mainly manufactured in steel construction. Components made of reinforced or prestressed concrete would be a cost-effective alternative. High safety standards apply to materials and construction to ensure that wind turbines can safely withstand wind and waves. An important role is played here by the so-called fatigue behaviour, which is currently only insufficiently researched for concrete. Scientists within the research partnership "WinConFat" want to close this knowledge gap.

Wind and waves stress the tower and foundation

Continuous mechanical stress from wind and waves fatigues the individual components of a wind turbine. These load changes can, for example, result in cracks in the material and cause severe damage to the tower or foundation. The turbine has to be shut down and repaired. This is where the so-called design concept comes into play: This guarantees binding quality standards for individual components and the entire wind turbine. In concrete terms, this means a period of use of 20 years for wind turbines. There is currently insufficient knowledge on high load cycles for support structures made of reinforced and prestressed concrete. Additional safeguards are therefore required in the design concept. This means: more material for tower and foundation and consequently higher costs. This is where the research project WinConFat, short for "Material fatigue of on- and offshore wind powered plants out of reinforced concrete and prestressed concrete under high cyclic loading", comes in. The aim is to investigate and determine the material properties of concrete, reinforcing steel and their compounds. To this end, the project partners are for instance developing new test methods that can deliver the required results faster than conventional methods. In the medium term, the results of the research project are intended to be incorporated into German and European standards, so that in future wind turbines with towers and foundations made of reinforced or prestressed concrete can be erected economically and operated safely.



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The photo shows a multiple test stand for the cyclic loading of a total of three concrete cylinders.



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The photo shows the set-up of a fatigue test on a concrete cylinder under water.

New test stands and test methods for concrete and reinforcing steel

Wind turbines are operated on average for 20 years. During this time they undergo up to one billion load changes.

At present, the material properties of concrete have only been sufficiently investigated for load changes of up to two million. There has also been little research so far, as the experiments require a great deal of time. Scientists are therefore developing and using new test setups, some of which require less testing time. Despite these new tests, the material to be tested sometimes has to be processed for weeks or even months. Initial reliable findings with the newly developed methods will be available after about two to three years. The project partners then use the data obtained to determine, for example, the influence of environmental conditions (water saturation) and load frequencies. They also expect to learn to what extent laboratory tests can be transferred to real components.

Further investigations include tests on large-sized pre-stressed concrete beams. Concrete has a high compressive pressure resistance but only a low tensile strength. For this reason, concrete is pre-stressed with high-strength steel tendons in order to overcome tensile stresses. Initial results on corresponding prestressed concrete beams have shown that the stresses within the beams are redistributed from the damaged softer outer sides of the beams to their centre. In the case of wind turbines, this effect has a positive impact on the lifetime. The parts that were originally subject to the highest loads are relieved.



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The developed test stand can be used to generate high-frequency pressure threshold loads on concrete cylinder samples.



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A resonance test stand is used to investigate stress redistributions in concrete beams under fatigue loads.

Further images



The photo shows the test setup for investigating fatigue behaviour in the VHCF range (very high cycle fatigue), fatigue at different load regimes and dynamic capacity (in air).

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The photo shows the test setup for quantifying the dynamic capacity (with combined corrosion attack).

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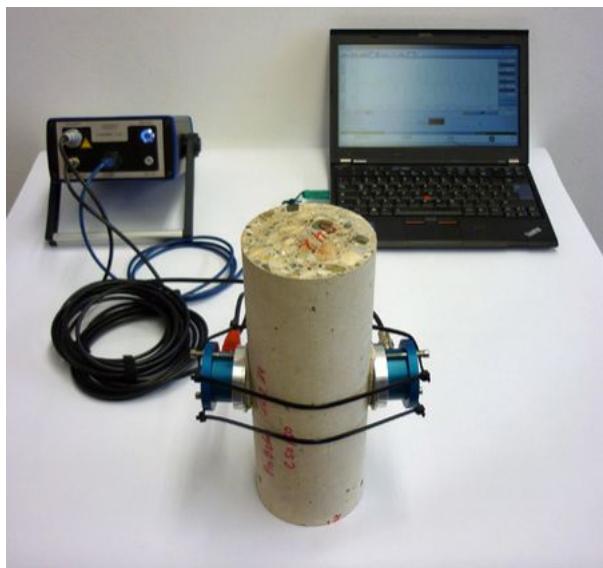
Fatigue test on a concrete cylinder

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Determining the remaining lifetime of wind turbines

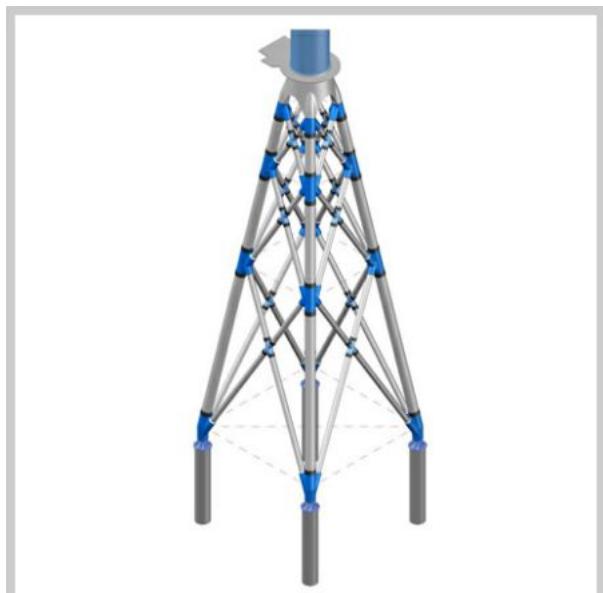
The scientific teams are also investigating how the degree of damage to concrete can be monitored most accurately using the ultrasonic measuring method and a suitable sensor application and data evaluation.

The aim is to develop recommendations for suitable monitoring methods in order to determine the condition of the tower and foundation of existing and new wind turbines. The data and recommendations obtained in this way can help operators to estimate the remaining useful life more accurately.



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Ultrasonic amplifier, sensors and measurement program



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In the "HyConCast" project, scientists investigated a jacket structure made of prestressed concrete pipes.

New concepts for support structures

The findings from the research partnership are also to be used to develop new concepts for support structures of concrete wind turbines. These could be, for example, dissolved foundation structures for offshore wind turbines. At present, these are based on the jacket or tripod foundations made of steel construction. It also enables more streamlined, lighter and taller tower structures. This will enable operators to make significant cost savings.

Adapting test methods and standards

Finally, the research results obtained are to be incorporated into guidelines and reference documents of the German Committee for Structural Concrete, DAFStb and the German Concrete and Construction Technology Association, DBV. It is also planned to include the findings in the applicable design standards. This process will take several more years.

Last updated: 20.07.2020



Among other things, EnArgus, the central information system for energy research funding, contains a database of all energy research projects - including this project.