Parametric Design of Wind Turbine Foundations- Enhancing Efficiency Through Automated Modeling

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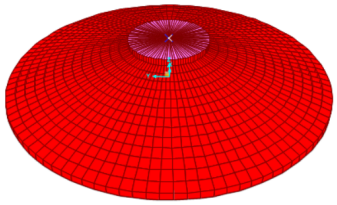
Climate change has heightened the focus on the renewable energy market. Initiatives aimed at reducing CO_2 emissions have made sustainable energy production one of today's greatest challenges. The question of how to generate electricity sustainably has become a prominent political debate. Among the various approaches, wind turbines stand out, having recently undergone significant technological advancements. Despite the improvements, the expansion of wind power lacks efficiency. Automating the modeling phase could be a key piece of the puzzle, enabling quicker production of drawings and dimensions for deployment.

It is widely known that digitization and efficiency in construction lag behind other industries. This, in turn, affects the time required for construction and approval. Today, many complex structures are modeled manually in advanced finite element programs. Testing various configurations can be very time-consuming and, therefore, expensive, which reduces incentives for building sustainable energy production. One solution to streamline this process is to automate modeling, thus achieving results faster. This not only makes modeling more efficient but also opens up opportunities for implementing advanced optimization algorithms with the goals of reducing material usage.

Within this area, this study focuses on the automation of modeling concrete foundations for wind turbines. By developing a script that communicates with a finite element program, it was feasible to produce results without manual modeling. The program models and sets up key components for a computational model on its own, then runs the simulation. The results are then used to calculate the required reinforcement for different sections of the foundation. Further, the program verifies the fatigue of the reinforcement, all with the push of a single button.

The studied gravity-foundation can be found on land in our daily life. The foundation is structured with an anchor cage in the center with pre-tensioned reinforcement to handle the heavy loads from the wind turbine. The anchor cage is anchored in heavily reinforced concrete to distribute the loads from the wind turbine while providing enough counterweight to prevent the turbine from overturning.



Modeled wind turbine foundation geometry from the script.

No detailed analysis on the anchor cage was conducted due to its complexity. However due to scripts' transformative nature it is easy to change and incorporate new features without starting from the beginning, which would not be the case for a manual modeling approach. Hence automation does not only provide effectiveness, but also gives the opportunity for flexible changes, which is becoming increasingly important in today's fast paced world.

To summarize, the research provides results for automation of wind turbine foundations, but also lays a foundation for future digitalization and automation efforts in a traditionally non-digitized industry.

Examensarbetet avslutat 2024: **Parametric Design of Wind Turbine Foundations- Enhancing Efficiency Through Automated Modeling**
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