Project Report

Introduction to the 180-Meter UHPC Mixed Tower Structure Wind Power Project in Lianshui, Jiangsu

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Abstract: Large-scale wind turbines are one of the development trends of the wind power industry. This article provides an engineering overview and highlights the innovation of the world's first 180 m ultrahigh mixed tower commercial application project and explains the technical advantages of the wind power mixed tower.

Keywords: mixed tower; wind turbine; Ultra High Performance Concrete

1 Project Overview

Large-scale wind turbines are the most important trend in the wind power industry. Large megawatts, long blades, and ultrahigh towers have become one of the important breakthroughs of wind power in the parity market. Large units can reduce the amount of raw materials per unit power in the manufacturing process of wind turbines, reduce the non-equipment costs, and increase the number of power generation hours, thereby promoting a decrease in supporting facilities and the operation and maintenance costs of wind farms and effectively reducing the cost per kilowatt-hour. Currently, the largest wind turbine impeller diameter in China has reached 230 m, the tallest wind turbine mixed tower has reached 180 m, and the largest wind turbine single-unit capacity has reached 7.25 MW.

The wind turbine tower is the most important supporting structure of the wind turbine, usually including steel structure towers, concrete towers, and concrete-steel mixed towers (hereinafter referred to as the mixed towers). Among them, the mixed tower, as a relatively new structural form, has many advantages and has a large number of engineering cases at home and abroad.

On April 30, 2024, the world's first 180 m Ultra High Performance Concrete (UHPC) mixed tower wind power batch commercialization project was officially connected to the grid and generated electricity in Lianshui, Jiangsu Province. The success of the project marked a huge leap in the Chinese wind power industry, breaking through the boundaries of technology and engineering, and laying a solid foundation for the future development of wind resources in the 200-500 m space.

2 Engineering Characteristics and Innovations

2.1 Wind Turbine with a Height of Up to 180 m

In this project, the height of the wind turbine tower is 180 m, and the height of the mixed tower section is 157.4 m. Compared with the low towers, high towers will greatly break through the limitations of natural conditions, capture more abundant

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wind resources in the environment of low wind speeds and high shears, and improve the overall power generation efficiency.

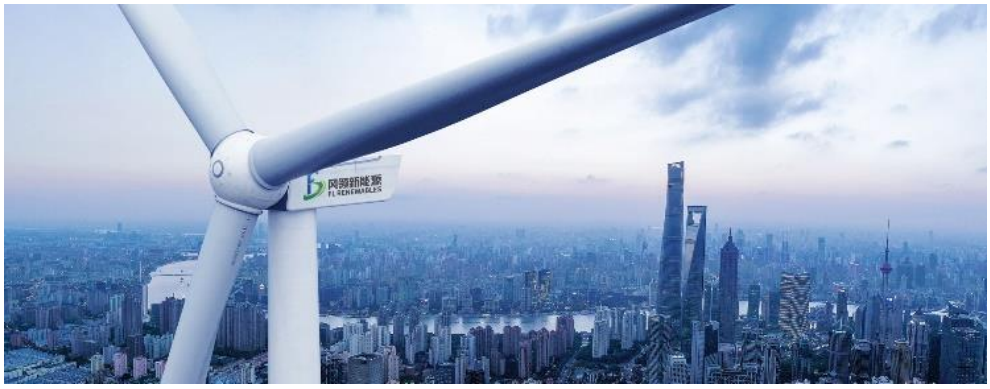

Figure 1 Wind turbine concept map

2.2 *Standard Modular Tube Section Design*

The mixed tower section adopts a standard modular tube section design. Through the flexible combination of 9 standard tube section modules, it can adapt to different tower schemes with different main wind turbines and different heights from 120 m to 300 m.

Figure 2 Transportation of 180 m wind turbine mixed tower components in Lianshui, Jiangsu

2.3 *The World's First UHPC150 Tower Tube*

This project is the world's first tower tube that adopts UHPC150 ultra-high strength concrete, and it is also the tower tube with the highest concrete strength grade in the global mixed tower structure. UHPC is a new type of building material, which is composed of well-graded cement, quartz sand, active admixtures, high-efficiency water reducing agents, steel fibers, and water, and then formed by hot and humid curing of a new type of ultra-high performance cement-based composite material. Compared with ordinary concrete, the compressive strength of UHPC can reach more than 150 MPa, which is 4 to 6 times that of ordinary concrete. Because steel fibers and other metal materials are added to the main components of UHPC, the combination between the cement matrix and the steel fibers is very tight, so it can greatly improve the density and tensile strength of UHPC, reducing the risk of block falling and cracking of the mixed tower.

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Figure 3 Prefabricated segment of the concrete tower

2.4 Segmented Internal Bonded Prestressed System

The project adopts an internal prestressed system. Through grouting material, the steel strand is integrated with the tower tube, separating the steel strand from the corrosive environment outside, so that it can still maintain good performance in harsh natural environments and improve the durability of the steel strand. In addition, the bonded prestress can enhance the integrity of the prestressed tendon and the structure, ensure that the prestress loss is controllable, and greatly improve the safety of the tower tube.

Figure 4 Prefabrication yard of the concrete tower tube

2.5 Installation Method

In order to ensure the flexibility and safety of the hoisting process, the project adopts a tower crane, which has the ability of self-supporting and buttressing. This

hoisting method is not only safer, but also can be raised simultaneously with the tower tube without being limited by the hoisting height and weight.

Figure 5 Installation of wind turbine mixed tower in Lianshui, Jiangsu

3 Mixed Tower Advantages

3.1 Good Stability

The first-order frequency of the structure is located between 1P and 3P, without problems such as resonance or frequency crossing, simplifying the control system logic and improving safety. Due to the high stiffness of the concrete tower tube, through optimized design, the first-order frequency of the structure can be made to fall within the allowable range. Since the first-order frequency is higher than the 1P frequency corresponding to the minimum rotational speed of the wind turbine impeller, the control system does not require a complex frequency crossing algorithm, which can greatly reduce the top swing amplitude and extend the fatigue life of the unit.

3.2 Small Deformation Range

With high structural stiffness, the deformation amount is small under the action of wind load, improving stability, safety, and comfort, and reducing power generation loss. Due to the characteristics of concrete materials, it can better meet the requirements for the stability of the tower frame of large megawatt and long blade wind turbines.

3.3 Small Power Generation Loss

The wind speed corresponds to the rotational speed and frequency of the wind turbine during operation. When the operating frequency of the wind turbine is within the resonance frequency range of the flexible tower, in order to avoid resonance pitch change, it will lead to a decrease in the power coefficient C_p of the wind turbine, thereby affecting the power generation efficiency. By adopting a mixed tower structure, the power coefficient of the wind turbine is improved and the power generation loss is reduced.

3.4 Reduced Costs

The concrete tower tube requires less usage of components such as connecting flanges and anchor bolts compared to the steel tower tube. The mixed tower section is maintenance-free for life, and each set of tower tubes can save considerable

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maintenance costs every year. Large units can reduce the amount of raw materials per unit power in the manufacturing process of wind turbines, reduce the non-equipment costs, increase the number of power generation hours, thereby promoting a decrease in supporting facilities and operation and maintenance costs of wind farms, and effectively reducing the cost per kilowatt-hour.

Conflict of Interest: All authors disclosed no relevant relationships.

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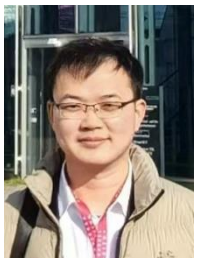
AUTHOR BIOGRAPHIES



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