Fujian Yongfu Power Engineering Saves CNY 400 Million Using Integrated Geotechnical and Structural Offshore Design Technology

Integrated Digital Solution Helps Pioneers a New Wind Turbine Foundation Structure in the Global Offshore Wind Industry

- *The Changle offshore wind farm consists of 62 wind turbines located in open sea, 45 kilometers from the coast of the Fujian province in water depths up to 50 meters.*
- *The deep-sea wind farm project is the first in the global offshore wind industry to adopt the new suction pile jacket foundation.*
- *Fujian Yongfu conducted a feasibility study evaluating the structural integrity and cost-effectiveness of the innovative wind turbine foundation structure.*
- *Their success was predicated on having an integrated digital solution for geotechnical analysis and offshore structural design using PLAXIS and SACS to build a composite 3D model that resolved a series of technical and engineering issues.*
- *The wind farm fosters energy savings and ecological protection, modernizes Fujian's energy infrastructure, and promotes smart offshore wind power in China and the global industry.*

Proposing an Innovative Wind Turbine Foundation Structure

Located in open sea off the coast of the Changle shoreline, Area C of the Changle Offshore Wind Farm spans a planned area of 58.6 square kilometers and consists of 62 wind turbines with stand-alone capacity of 8 megawatts, and a total installed capacity of 500 megawatts. The wind farm adopts a new type of wind turbine foundation structure—the suction pile jacket foundation—that is designed to withstand various environmental loads. Upon completion, the project will be the world's largest wind farm using the suction pile foundation. It will provide energy savings, using natural renewable energy resources, and reduce pollution to the surrounding environment, promoting ecological protection and sustainable development of the local Fujian economy.

Fujian Yongfu Power Engineering (Yongfu) provides integrated solutions for power and energy systems and was tasked with designing and installing the foundations, performing a feasibility study during the design phase to determine the viability of their proposed new wind turbine foundation structures. While the innovative suction pile jacket offers the same advantages as a conventional steel pipe jacket, it is also characterized by low steel consumption, low costs, simpler construction equipment, fast installation, and a shorter construction process. The project is the first application of suction pile jacket structures for offshore deep-sea wind farms in China.

Location, Environmental, and Geological Challenges

Given that the wind farm is about 45 kilometers offshore amid water depths up to 50 meters causing extreme hydrometeorological conditions, the project presented structural integrity and construction management challenges, compounded by a complicated geological engineering environment. "The project is located in the coastal area of Fujian, China, which is one of the three major air vents in the world, and is seriously threatened by storm surge. It has one of the

deepest water depths for offshore wind power construction in China, with water depths of the site area reaching 45 to 50 meters," stated Xialing Fan, engineer at Yongfu. Faced with these difficulties, Yongfu needed a structural design solution that not only could accommodate the instability and settlement of the soil, and withstand the environmental loads, but that also could streamline the construction schedule, shortening the construction period and minimizing costs.

To overcome these challenges, Yongfu sought to implement the global offshore wind industry's first application of a suction pile conduit frame foundation. They conducted a feasibility study evaluating the structural integrity and cost-effectiveness of this proposed solution. During the design phase, they needed to accurately simulate the interaction between the lower suction pile and soil, and simultaneously consider the design of the upper conduit frame structure. "We tried to simulate the interaction between the suction tube and soil using the traditional p-y method but found this method was not applicable to the large diameter suction pile structure, and would result in a significant increase in overall project cost," said Fan. Recognizing that their traditional soil simulation and strength assessment methods were insufficient, they subsequently tried using separate, disparate software programs for geotechnical analysis and structural design, only to determine that the analysis results could not be properly integrated into the design of the frame structure.

Leveraging Integrated Geotechnical Applications

Yongfu realized that they needed an integrated digital offshore structural and geotechnical design solution and selected Bentley's SACS and PLAXIS applications. "Bentley offers a unique integrated design process based on SACS and PLAXIS that allows users to create an overall model of suction pile conduit frames in SACS, and to extract the suction tube mesh model and key loads of the upper conduit frame to PLAXIS to facilitate the analysis of barrel-soil interaction," commented Fan. Using Bentley technology completely resolved the difficulties that came with designing the large suction pile foundations. They facilitated pile-soil interaction simulation and structural geotechnical design integration, validating the industry's first application of a suction-type conduit frame foundation.

Working in an integrated structural design and geotechnical analysis environment, users can obtain a composite model of the conduit frame and pile body, complete with the soil-to-pile support units. Leveraging the interoperability and automated features of SACS and PLAXIS, the team seamlessly applied the design loads related to the wind turbine foundation and then performed the necessary static and dynamic response analysis of the suction pile structure. "The calculation results in SACS and the results of the PLAXIS 3D finite element analysis and calculations meet the design requirements perfectly," added Fan. Yongfu achieved coupling analysis and calculation of the upper foundation simultaneously with geotechnical engineering, which had not been done in the industry.

Digitalization Promotes Smart Offshore Wind Power

Using Bentley technology solved a series of technical difficulties related to the new suction type conduit frame foundation, including resolving the problem of soil failure around the suction pile body due to excessive load application, which is characteristic of traditional technology. The integrated SACS and PLAXIS digital solution supports the implementation of the new type of three-pile conduit frame foundation. The design that they achieved appropriately reduces the weight of the tower and the amount of steel used, which reduced overall costs by 30% compared to conventional foundation structures and led to a savings of approximately CNY 400 million. According to Fan, "The new type of wind turbine foundation structure adopted in this project has important promotion value in today's high-speed development of offshore wind power because of its wide application range, short construction cycle, large equipment savings, and its positive impact on the marine ecological environment and sustainable development."

The foundation type used for the Changle Offshore Wind Farm has won the utility model patent in the field of offshore wind power foundation design. Being the first application in China's deep ocean offshore wind farms, the project offers engineering experience and technical support and provides a reference for constructing these deep-sea facilities in the future. Moreover, developing an integrated digital strategy supporting innovative solutions for construction of deep-sea offshore wind farms demonstrates Yongfu's commitment to clean, smart energy, and to modernizing the energy infrastructure in Fujian province. The team continues to promote research of offshore wind power suction pile technology and the design of smart offshore wind power. They also plan to integrate Bentley iTwin technology to build a digital twin that will facilitate intelligent processes within the industry. "We have actively participated in the planning and construction of Fujian Yongfu Smart Offshore Wind Farm Operation and Maintenance Platform to build an integrated intelligent system to serve the offshore wind power industry," concluded Fan.

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Image 1:

Caption: The deep-sea wind farm project is the first in the global offshore wind industry to adopt the new suction pile jacket foundation.

Image 2:

Caption: Fujian Yongfu conducted a feasibility study evaluating the structural integrity and cost-effectiveness of the innovative wind turbine foundation structure.

Image 3:

Caption: The wind farm fosters energy savings and ecological protection, modernizes Fujian’s energy infrastructure, and promotes smart offshore wind power in China and the global industry.