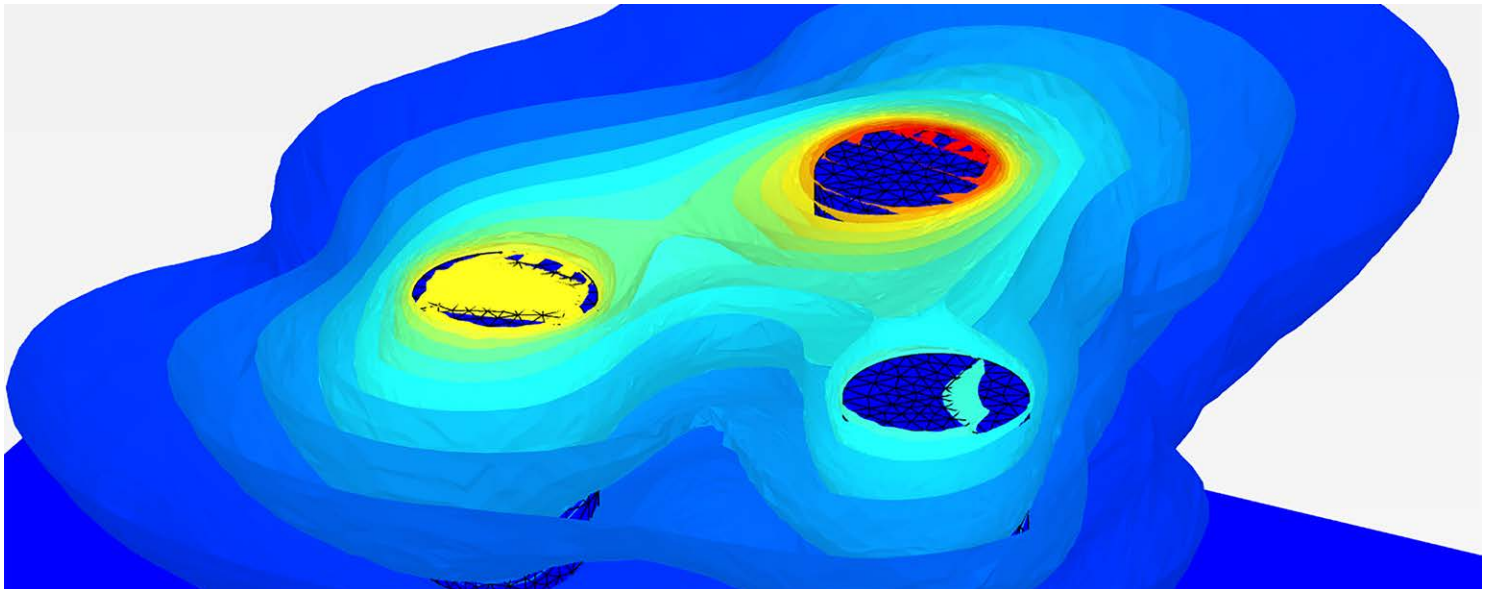
Bentley

Case study



Research project supports foundations for deep-water offshore wind farms

PLAXIS® and SACS™ reduced modeling time by 30% and construction costs by an estimated 15% to 30%

Evaluating jacket foundations for deep-sea wind power fields

As a clean and renewable energy source, offshore wind power has become one of the key solutions globally for reducing carbon emissions and addressing climate change. Over the past decade, the pace of China's offshore wind power development has significantly accelerated, with wind farms being constructed in deeper waters. Given the increase in water depth, common wind turbine foundation structures—such as single pile and gravity pile forms—are becoming less suitable both structurally and economically. A major player in the Chinese renewable energy sector is China Longyuan Power Group's research and development center, Longyuan New Energy Engineering Design and Research Institute (LDI). The team initiated a research project to evaluate and determine the structural feasibility of using multi-bucket jacket foundations.

"This project intends to break through the relevant technical difficulties [by researching] the complete set of technologies for suction jacket foundations for wind turbines in transitional water depths," explained Zhou Quanzhi, chief technology officer of Longyuan Group. The scope of the project included investigating the current application of suction bucket foundations in fixed offshore wind turbines, developing key technologies for design and construction of multi-bucket jacket foundations, and establishing control techniques for the sinking and leveling of jacket foundations. Upon completion of their feasibility study, LDI verified their capabilities for designing deep-water suction jackets to support affordable, safe, and sustainable power supply.

Complex environmental conditions and no existing design standards

Compared to onshore wind turbines, offshore wind turbines—more specifically, those located in deeper water bodies—face more severe natural and technical challenges, such as extreme weather conditions, giant waves, and strong winds. They also must accommodate complex marine, geological, and sediment environments.

Offshore foundations must be able to withstand these harsh sea conditions complicating installation and stability. "Offshore wind turbine foundations not only bear dynamic loads, such as wave load, but also bear great wind turbine load," said Quanzhi. "The soil conditions of offshore wind farms in China are complicated, and the surface soft, silty, sandy, and clay or layered soils are complex and diverse," he added. LDI's research needed to consider the influence of the bearing capacity of the bucket foundation during the application of the reciprocal loads, as well as control the verticality of the structure during the sinking process to prevent installation risks caused by soil clogging or avoid deformation of the bucket.

Furthermore, the lowering and leveling of the jacket structure also affect the safety of sinking.

Project summary

Organization

Longyuan (Beijing) New Energy Engineering Design and Research Institute Co., Ltd.

Solution

Structural Engineering

Location

Beijing, China

Project playbook

PLAXIS, SACS

Project overview

- LDI initiated a research project to determine the structural feasibility of using multi-bucket jacket foundations for deep-water offshore wind farms in China.
- The project required integrated structural and geotechnical design and analysis technology to accurately model and analyze pile-soil and superstructure loads.
- The team used SACS and PLAXIS to accurately simulate and verify the structural integrity of the jacket model under various environmental and geological conditions.

ROI

- Bentley applications reduce modeling time by 30% and increased design accuracy by 10%.
- LDI optimized structural steel consumption, estimated to save 15% to 30% in construction costs.

> “The integrated analysis function of SACS and PLAXIS provided by Bentley brings great convenience to improve the design analysis efficiency and calculation accuracy of offshore wind power suction jacket, and will greatly help the popularization and application of this new foundation type.”
>
> -Zhou Quanzhi, Chief Technology Officer of Longyuan Group

While the lateral constraint of the surrounding soil is beneficial to create more suction, the soil constraint affects the leveling degree and could potentially cause buckling of the bucket. “How to achieve the strict levelness requirement of the wind turbine foundation by sinking and leveling is also an urgent problem to be further studied,” said Quanzhi.

Compounding the above technical and environmental issues is the lack of domestic design specifications for these types of jacket structures for deep-water wind turbines. Meeting the structural strength requirements while minimizing the amount of steel presented an additional challenge. Previous manual design and analysis methods required separate software applications, proving time consuming and costly, and yielded inaccurate results. “Manual data transmission and interaction between two pieces of independent software not only consumes a lot of manual time, but also makes it difficult to obtain accurate simulation results,” emphasized Quanzhi. To effectively conduct their research and determine an affordable, efficient, and stable jacket foundation design and construction solution, LDI needed integrated geotechnical and structural modeling and analysis technology.

SACS and PLAXIS provide integrated geotechnical and structural solution

The research team selected Bentley SACS and PLAXIS to model the jacket foundations and perform the necessary pile-soil and superstructure load analyses. Bentley applications facilitated the integrated and optimal design of the wind turbine structures, enabling LDI to accurately simulate and verify the strength and deformation of the jacket model under various environmental conditions. “We combined [the] PLAXIS geological model with the SACS jacket foundation model [...] so as to optimize the pile foundation depth and improve the accuracy of pile length design,” said Quanzhi.

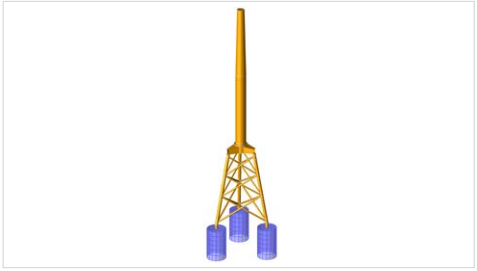
The embedded marine and steel codes, as well as advanced analysis and numerical simulation capabilities in SACS simplified post processing and provided accurate results, optimizing structural design. LDI was able to select specific conditions, such as water depth and the attachment of marine organisms, to digitally replicate the marine environment and load in the area where the jacket foundation model is located. The 3D interactive graphics modeler and intelligent features in both SACS and PLAXIS streamlined modeling, and their interoperability facilitated mutual conversion of models, allowing various environmental and geological conditions to be directly imported into the models. “Bentley’s SACS and PLAXIS contain full 3D graphical interactive interfaces and intelligent multi-document editing,” said Quanzhi. “They can be used in mutual conversion, and files such as models, sea conditions, piles, and soil can be directly imported into graphical models, and models containing sea conditions can be separated, which is convenient for subsequent processing of similar models,” he added.

Design optimization delivers savings and sustainability

Bentley’s applications provided a connected digital research platform for integrated jacket modeling, analysis, simulation, and design. “The establishment of a numerical model is more convenient, the details of offshore wind power design theory are more perfect, the numerical simulation analysis speed is faster, and the numerical analysis results are very accurate,” emphasized Quanzhi. Working in an integrated digital environment reduced modeling time by 30% and increased design accuracy by 10%, optimizing structural steel consumption, estimated to help save 15% to 30% in construction costs. “For a 1,000-megawatt wind farm, the cost that can be saved is CNY 468 million to 936 million, and the economic benefit is remarkable,” said Quanzhi.

Using Bentley’s application for structural and geotechnical design and analysis, LDI not only met their research goals, but exceeded task completion by 50% and improved data integration by 40%, simplifying post processing. They realized practical and optimal project design and application, and through digital, integrated comparative evaluation and verification, provided innovative solutions to the existing structural foundation issues facing the industry.

Adopting SACS and PLAXIS to perform their feasibility study, LDI delivered a safe and environmentally-friendly foundation solution, making it a sustainable choice for offshore wind farm construction. “Suction type multi-bucket foundations can effectively reduce risks and ensure the safety of offshore operators, machines, and equipment, cause little disturbance to the ecological environment, be recycled with zero residue after the expiration of service [...] and be extensively applied to offshore wind farm construction,” concluded Quanzhi.



LDI delivered a foundation that can be applied to offshore wind farm construction.

Bentley applications reduced modeling time by 30% and increased design accuracy by 10%.

Bentley

Find out more at **Bentley.com**
1.800.BENTLEY (1.800.236.8539)
Outside the U.S.: +1.610.458.5000
Global office listings: bentley.com/contact