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Wind energy generation systems - Design specification for integrated support structures of offshore wind turbines

风能发电系统 海上风力发电机组支撑结构一体化设计规范

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5 General Principles

5.1 The integrated design process should include the following steps.

a) External condition assessment. Conduct a comprehensive assessment of external conditions and obtain the necessary environmental parameters and design input data.

b) Integrated Modeling. Establishing an integrated model that includes offshore wind turbine generators, support structures (including fixed and floating types), control systems, etc. Numerical analysis models should be developed to accurately reflect the structural dynamics and the influence of all external environmental factors.

c) Integrated load analysis. Clearly define the design conditions, determine the load combinations and design requirements, covering start-up and shutdown, normal operation, survival, and failure. Special operating conditions; load simulation is performed using time-history load analysis, comprehensively considering wind, waves, ocean currents, water level, sea ice, and earthquakes. The coupling effect of various environmental loads with the whole system is used to evaluate the load response of the structure.

d) Integrated support structure design. Based on the integrated load analysis results, the support structure is designed, and its strength, stability, and fatigue strength are evaluated. Service life, optimize structural parameters, and ensure safety and economy.

e) Iterative optimization. Perform iterative design based on simulation or experimental results to ensure that all design parameters meet the requirements.

5.2 Integrated design should adopt the limit state design method expressed with partial factors, and the ultimate limit state of bearing capacity should be determined according to different working conditions. And normal use limit state analysis and verification. Specifically, it includes the following.

a) Determining partial factors. Various uncertainties are analyzed by introducing partial safety factors. In limit state design, partial factors... Used to evaluate the safety and reliability of a structure under different design conditions.

b) Design value calculation. The design value of the action is obtained by multiplying the representative value of the action by the partial factor of the action. The representative value of the resistance is multiplied by the partial factor of the resistance. The resistance design value is obtained by dividing the two values, and is used to calculate the design values of the structural action side and the resistance side, respectively.

5.3 Integrated design should include overall dynamic time-history load analysis and support structure design and optimization, encompassing the wind turbine-nacelle components and supporting structure. The transformation is as follows:

a) Overall dynamic time-history load analysis. The time-history load analysis method is used to evaluate the offshore wind turbine generator and its supporting structure under different working conditions. The dynamic response under various environmental loads, including the coupled effects of wind load, wave load, and current load, is considered.

b) Support structure design. Design of fixed or floating support structures based on integrated loads, and assessment of the ultimate bearing capacity of the structure. Conditions and normal use limit states;

c) Iterative optimization. Multiple rounds of iterative optimization are performed during the design process, continuously improving the design based on simulation or experimental results to ensure compliance. It meets all design requirements and standards.

6.1 General Rules

6.1.1 External conditions should include wind conditions, ocean conditions, geological conditions, and earthquakes, etc.

6.1.2 Integrated design should take into account the impact of environmental and power grid conditions on the construction and operation of offshore wind farms.

6.1.3 Integrated design should take into account normal external conditions during operation as well as extreme external conditions with different return periods.

6.1.4 The area for offshore wind farm projects should ideally include at least one year of measured wind data. The measurement method should comply with the provisions of GB/T 18709. The data should include measured time-series data such as wind speed, wind direction, temperature, and air pressure. The review, interpolation, and correction of wind measurement data should be carried out in accordance with... The provisions of GB/T 37523.

6.1.5 The completeness of valid wind measurement data for offshore wind farms shall not be less than 90%, and the calculation method shall comply with the provisions of GB/T 18710.

6.1.6 The offshore wind farm project area should include at least one year of measured hourly water level, wave, and ocean current data, as well as measured seabed topography and historical data. Historical charts. Related data should comply with GB/T 51308 and should be prepared in accordance with GB/T 31517.1-2022 for marine hydrological and environmental data collection. Environmental condition assessment.

6.1.7 In the absence of long-term measured data for the engineering area, numerical simulations of the marine hydrological conditions in the engineering area should be conducted, based on the simulations. The results were statistically analyzed to determine the marine conditions such as waves, currents, water levels, and sea ice at any location in the project area.

6.1.8 The environmental condition parameters and their joint probability distribution should include the following.

a) Wind conditions. Wind speed, wind direction distribution, and turbulence intensity are obtained through long-term measured data or high-precision wind resource assessment models;

b) Waves. Wave height, wave period, and wave direction are obtained through wave observation data or high-precision wave numerical models;

c) Ocean currents. Obtain current velocity and direction through ocean current observation data or high-precision ocean current numerical models;

d) Water level. Water level changes are obtained through methods such as water level observation or high-precision numerical simulation;

e) Sea ice. Obtain ice thickness, ice velocity, ice orientation, and sea ice data through field observations, field sampling experiments, satellite remote sensing, or high-precision numerical models. Strength, etc.;

f) Geology. Obtain soil layer distribution, physical and mechanical parameters through geophysical, geotechnical engineering investigation and indoor geotechnical tests.

6.2 Wind conditions

6.2.1 The wind condition model used for integrated load analysis shall meet the requirements of GB/T 18451.1-2022.

6.2.2 The wind speed probability distribution model should be determined based on the wind measurement results of the engineering site, and the calculation method in GB/T 18451.1-2022 can be adopted.

6.2.3 The turbulence values at different wind speeds for offshore wind farm sites should be determined based on measured wind resource data, and the wake of the offshore wind farm should be taken into account. Influence.

6.2.4 The 10-minute average wind speed Vhub, which occurs once every 50 years, should be evaluated using extended data from nearby reference meteorological stations or numerical models. Estimate. In tropical and subtropical regions, when tropical and temperate cyclones dominate, Monte Carlo simulation methods can be used to assess the extreme winds of tropical cyclones. For specific methods, please refer to Appendix J of GB/T 18451.1-2022.

6.2.5 The calculation of air density at offshore wind farm sites shall be in accordance with the provisions of GB/T 18710.

6.2.6 If the project site is located in a typhoon-prone area, the integrated load analysis should consider the impact of typhoons, and the typhoon wind conditions should comply with GB/T 31519. According to the regulations.

6.3 Waves

6.3.1 The wave characteristic parameter values used in the integrated design meet the requirements.

a) The NSS condition should obtain the long-term joint probability distribution of Vhub, Hs, and Tp for hub height, as well as the joint probability of wind direction and wave direction.