

Maximizing long-term integrity of wind turbine foundation integrity requires considerable attention to fundamental aspects of construction and design.

THERE ARE FOUR MAJOR areas of wind project construction: civil (roads, wind turbine foundations, etc.); electrical collection system; wind turbine erection; and high voltage electrical work (substation/switchyard/transmission line). This column will examine some of the critical aspects of foundation design and construction. Quality foundations are one of the most important aspects of wind farm construction. Balance of plant contractors must exercise diligence throughout the wind turbine foundation design, procurement and installation process to insure that their foundations maintain their integrity for the full life of the wind project.

COMPATIBILITY WITH GEOTECHNICAL CHARACTERISTICS

Foundation designers choose the appropriate foundation type based upon the soil characteristics at each foundation location. Borings should be done at each turbine site to determine the suitable design. There are a number of commonly used foundation types: spread footing (or inverted "T"), tensionless pier, rock anchor, and soil anchor. The geotechnical investigation must include the appropriate geotechnical tests necessary to appropriately select and design the foundation. The geotechnical report results will be used not only for the foundation design, but also to determine the appropriate concrete mix, collection cable sizing and grounding grid design.

WIND FARM FOUNDATION DESIGNERS/ENGINEERS

Contractors that are engaging foundation design firms should consider several factors in making their selection. The design firm should have experience in designing foundations in the soil conditions similar to the specific project site, along with knowledge relative to the foundation's constructability and costs. The firm should understand the turbine's electrical interfaces (conduit) and be comfortable integrating them into their design. The firm should be accustomed to developing a design that meets all codes, standards, and turbine manufacturer requirements, and at the same time is cost efficient. Importantly, owners typically employ a third-party engineer to review the foundation design, often as a requirement of the

project lender. Foundation design reviews can be extremely rigorous and the design firm should be familiar with this process and capable of successfully shepherding their design through this review.

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CONSTRUCTION ISSUES

Foundation costs comprise a significant percentage of the overall construction costs, and are often on the project's critical path. In addition, foundation quality must be checked at multiple points on every foundation. Accordingly, each aspect of the wind turbine foundation design/construction must be planned carefully before construction begins:

- Weather conditions—Concrete placement in both hot and cold weather conditions requires the performance of specific tasks to ensure wind turbine foundation quality. Proper planning is essential to make sure that the proper options to deal with weather conditions are available before the project starts.
- Concrete sourcing—Wind projects located beyond the acceptable driving distance from a permanent ready mix plant, or in areas where permanent ready mix plants are not capable of meeting the quantity requirements, will typically use an onsite batch plant. Permitting the plant can be a schedule issue, and batch plant operational availability is critical. Accordingly, whenever a batch plant is used, permitting should be performed early in the preconstruction phase, and a secondary concrete source must be available as a contingency.



- **Material Procurement**—Foundations use large quantities of reinforcing steel. Rebar is a commodity and is subject to price and availability fluctuations. The contractor must ensure that the wind turbine foundation design is completed (and approved) in sufficient time to allow for timely site delivery. In recent years, large foreign purchases of rebar have created extremely long lead times and upward price pressure.
 - **Installation Expertise**—Wind farm foundation installation is essentially a manufacturing process that occurs in the field. Not all installation firms excel at relatively small, but repetitive, pours. Choosing the right installer is extremely important. Foundation quality depends upon attentiveness to detail in each installation phase: excavating, forming, rebar placement and tying, and concrete placement. Installation procedures are repeated for each foundation and it's important to get it right the first time. Successful foundation installers understand that crew efficiency increases with each foundation, and they count on this increased efficiency in pricing each project and in developing their quality procedures.
 - **Quality Assurance/Quality Control**—Contractors must have a stringent QA/QC process for wind turbine foundation installation. The QA/QC system should be designed to verify each aspect of foundation installation. Signal Energy's list of inspection and verification activities for foundation construction contains over eighty items and is too lengthy to repeat in this column. However, two practices are worthy of mention: (1) Requiring a qualified representative of the project geotechnical engineer to observe the foundation excavation to verify that the soil conditions are consistent with the report; and (2) Requiring a qualified representative of the foundation engineer to observe the foundation installation to confirm that it is installed in accordance with the foundation design.
- Wind farm foundation failures can have serious economic, safety and reputational implications for contractors, engineers, owners and turbine suppliers. Accordingly, contractors must exercise a high degree of diligence to ensure foundation integrity and reliability. ✨