The Advantages of Driven Piles

This article is a companion piece to an article, "Driven Piles Support Wind Turbines in the U.K.", which originally was published in the Spring 2006 Issue of European Foundations Magazine. The article was about 3 wind farms in the U.K.: Deep St. Nicholas at Spalding, Red House Farm near Holdbeach, and Glass More near Whittlesey.

The foundations for the wind farm turbines were originally designed as bored piling. Aarsleff Piling suggested a change to precast concrete driven piles. We asked Aarsleff Piling why they suggested this change and what advantages driven piles offered over other deep foundation solutions for this application. Bob Handley, the company's engineer, provided the following information:

Driven precast concrete piles are well-established as the technique of choice in Northern Europe and Scandinavia where wind farms require piled foundations. Our Danish parent company, Per Aarsleff A/S, and our German sister company, Centrum Pfahle, have installed precast concrete piles to support thousands of wind turbine generators during recent years. Over the last 12 months, we have installed Centrum precast concrete piles for the foundations of 40 wind turbine generators here in England.

Since the piles must perform to strict specifications relating to the effects of cyclic dynamic loads from the wind turbine operation, integrity and quality of the reinforced concrete section is of paramount importance. With a factory produced precast concrete pile with a full audit trail, this is relatively straightforward, but not nearly so simple to satisfy with a reinforcing cage that is plunged into an uncased CFA pile after concreting.

Different sizes and lengths of piles were used to suit the ground conditions at each of the sites in East Anglia, with the larger 350-millimeter-square piles being employed on the site with the greater depth of weak alluvial soils. Typically, section sizes are 300/350/400 millimeters square and predominantly, the larger two sizes. Section size is mainly decided by the structural design to resist a combination of axial compression or tension loading and a coexistent bending moment. Horizontal loads are quite significant, but can be dealt with by using raking (inclined) piles (although this was not the case at the three sites mentioned in the European Foundations article).

Wind loadings and the resulting overturning moments, create the wide range of axial loads. The European standards require either an exhausting fatigue stress analysis of the forces in the pile reinforcement or compliance with a load case that does not allow any tensile forces in the pile (i.e., using more dead load in the form of a larger/deeper base). There is often a requirement to design for the buoyancy effects of a groundwater table at ground level. We generally design and install piles to a minimum length to resist the design tension load with an acceptable geo-technical factor of safety and then to a toe level/embedding or set to provide an acceptable geo-technical factor of safety on the design compression load. Load testing is carried out mainly using PDA measurements, but occasionally static load tests are specified. Where 100 percent reliance is placed on dynamic tests, the third parties involved in approvals (and there can be several layers of approval involving the developer, the turbine manufacturer and the bank) will expect to see the design ultimate resistances mobilized under the test blows and subsequent CAPWAP analyses. The other design consideration of particular relevance to these foundations is that shaft friction on piles degrades with reversible cyclic loads; European convention is to rely only on 80 percent of the ultimate/proven value. With this in mind, we now design to geo-technical factors of safety that give long term results, which accord with established European partial factor design – these global factors being 2.5 on compression and 3.0 on tension.

Please visit Aarsleff Piling's Web site www.aarsleff.co.uk for more information about their U.K. operations. Also visit www.aarsleff.com for information about their parent company and www.centrum.de for their German sibling. ▼