Driven Piles Support **Wind Turbines in the U.K.**

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UK Foundation contractor Aarsleff Piling completed installing 700 precast concrete piles for three onshore wind farms in East Anglia, England, this winter.

Aarsleff drove different sizes and various lengths of piles to support the bases of 22 wind turbines at Deeping St. Nicholas at Spalding, Red House Farm near Holbeach, and Glass Moor near Whittlesey. A French renewable energy company, EdF Energies Nouvelles in association with U.K. wind energy developer, Wind Prospect, is developing the wind farms.

The contract to build the wind farm foundation and infrastructure was awarded to Anglo-German turbine manufacturer REpower Systems and U.K. engineering firm Peter Brotherhood.

Repower U.K. sublet the civil and electrical works to McNicholas Construction Services, which in turn sub-contracted the UK$400,000-piling contract to Aarsleff.

"The scheme was originally based on bored piling, but Aarsleff suggested the precast concrete driven pile alternative, which was accepted and incorporated into the design by our designer, Gifford," says McNicholas project manager, Tony Heaney.

The largest and longest piles were needed at the 12MW Red House Farm site, where Aarsleff used a Banut machine and a Junttan PM20 rig, both fitted with 6-ton hammers, to install 36 piles, equally spaced on a 13-meter-diameter area, for each of the six bases. The 350-millimeter-square-jointed piles were between 18 meters and 22 meters long.

Slightly smaller section and shorter piles were needed at the 16 MW Deeping St. Nicholas and 16 MW Glass Moor sites. Here Aarsleff installed 32 piles for each of the 16 bases. Piles were 300 millimeters square, with single section piles up to 15 meters long and jointed ones up to 17 meters long – all the piles found in clay.

Aarsleff carried out static and dynamic pile testing at each of the three sites. The piles have to cater for cyclical loading ranging from a maximum compressive working load of 630 kilonewtons to 160 kilonewtons in tension.

The piles contained extra steel reinforcement and earthing strips to maintain continuity across the mechanically interlocking full strength steel joints.

The wind turbines, which have a hub height of 59.5 meters, and 82-meter-diameter blades, were expected to be fully operational this spring. ▼

The Advantages **of Driven Piles**

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 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. ▼