CASE STUDY
Blade Test 2, NaREC, Blyth

Project: One of three new testing facilities being developed at the National Renewable Energy Centre's existing site in Blyth.
Van Elle Involvement: New bearing pile foundation design and installation for the new 'Blade Test Facility 2' (BTF2).
Location: Blyth, Northumberland
Client: National Renewable Energy Centre (NaREC)
Principal Contractor: Shepherd Construction Limited
Engineer: Arup

Van Elle Project Team:
Operations Director – Steve Morton
Contracts Director – Ian Jones
Lead Design Engineer – Darren Milo
Contract Manager – Ed Brown

Scope of Work:
- Probing through existing Dry Dock floor prior to the mobilisation of the Soilmec CM70 CFA Piling Rig.
- 66No 450mm dia. CFA piles to 14m (max) deep.
- 397No 600mm dia. CFA piles to 18m (max) deep.
- 84No 750mm dia. CFA piles designed by Arup to depths of 15m using C60 DC-3 concrete.
- Proof load testing of 5No. working piles.
- Integrity testing 25% of all working piles.

Pile locations were situated on the site of the existing test centre business units and car parking facilities to the southern end of the site. At the north end of the site there were 2 existing filled dry docks with concrete bases.

Prior to mobilisation of the piling rig, the client carried out demolition works to the existing structures, removed and/or relocated existing services including a water main that bisected the site and removed contaminated materials, including asbestos, from site.

Our tender, design and construction risk assessments highlighted a number of concerns which may have been detrimental to the successful completion of the works:

Geotechnical:
To meet the tight performance requirements, our project design required 600mm diameter piles, the majority of which would have to penetrate relatively weak coal measures to stronger underlying sandstone where we found a substantial rock socket. This created specific constructability concerns. Whilst the sandstone was to provide the majority of the bearing capacity, the mudstone was to provide essential additional skin friction to help meet the tight settlement criteria, whilst the actual level and strength of the Sandstone were variable across the site. It was essential that a piling rig, not only capable of boring the sandstone, but capable of boring it without polishing the coal measures above through over rotation of the auger, was used. This was achieved through the use of our high powered Soilmec CM70 piling rig with a 1 tonne pull down winch and 156 kNm meters of torque.

Confirmation of the sandstone depth was accomplished through a number of trial bores across the site, which were carried out early in the project. These were correlated to the piling rig's computer instrumentation records for those trial bores, and the sandstone level by identifying the small increases in torque, penetration rate and rotational energy which indicated the point at which we entered the harder material. This provided construction confidence, enabling us to indicate to the rig operator what he should expect to see when boring.

For the 83 piles installed in the former dry dock area of the site, these were bored through approximately 10m of soft/loose fill, the concrete base and into the mudstone and sandstone directly below. In this area, reliance upon attaining a good socket into the stronger material was heightened as a result of the removal of all material to 10m during the prior construction of the docks. It was also essential that we surpassed the concrete base of this dock. To assure this we mobilised a smaller drilling and probing rig to site from our restricted access fleet. This was used to carry out open hole probes to the dock floor which was then cored through using rock roller and down the hole hammer (DTH) techniques. These were subsequently backfilled leaving the area substantially clear of obstructions for the Large CFA rig.

The Soilmec CM70 CFA rig drilling at NaREC

Concrete:

The calculated stresses on a large proportion of the piles resultant from the relationship between load vs cross sectional area meant that we initially envisaged using high strength C35/45 and C60 concrete mixes having DC-3 design classifications across the board. The CFA system requires concrete to be pumped from a holding drum on site, through up to 100lm of reinforced rubber concrete hose to the rig and from there it travels through the fixed pipes to the top of the rig's mast and down through the rotary table before being discharged into the void from the bottom of the hollow stem of the drilling auger. The pile is then concreted from the bottom up as the auger is withdrawn from the bore. The reinforcing cage is subsequently lowered into the wet concrete, once the pile head is cleared of any loose spoil, to form the pile. For this construction method to be achievable, it is essential that the concrete maintains a high workability, normally having an S4 slump of around 180mm. Maintaining this slump until after placement of the steel reinforcing cage is crucial to the successful completion of the pile. Unfortunately, by it's very nature, high strength concrete has a high cement content, the properties of which are opposite to the characteristics desired for CFA piling where workability over an extended period of time is of great importance.

The concrete strength and durability requirements at NaREC necessitated an extremely high cement content in the mix designs; up to 480kg/m^3. This would reduce the workability lifespan of the concrete and any delay to pumping it would present a high risk of blockages in the pipelines and create difficulty when placing the 13 – 15m long reinforcing cages. We designed our methods around these risks and working closely with a supplier who could provide a mix designed to meet our specific requirements of both high strength and extended workability and deliver to site at the time required was of primary importance. Trial mixes were carried out prior to our mobilisation to site to ensure that the high workability mixes, designed by Tarmac, could achieve their specified strengths. It is a notable achievement, that through working closely with our client and the supply chain, despite the unusual concrete mix, we suffered very few hose blockages and we had great success in installing the long reinforcing cages into the high strength concrete.

Our in-house design team also contributed to the success experienced on site through designing-out the higher risk concrete grades wherever possible. A value engineering and risk management exercise highlighted approximately 265 piles which could be installed using a lower specification C28/35 strength concrete.

Site Control & Management:
In summary, the project consisted of 547 piles of varying diameters, lengths, 17 load characteristics, 17 different cage configurations and lengths, a range of cut-off levels, diverse soil conditions and 3 different concrete mix designs across the site.

This required a high level of control with our site teams taking total ownership of the project whilst Van Elle had a site presence. Things to be considered included:

- Management of the piling programme and individual daily pile sequence
- Ordering of the correct concrete at the correct time and ensuring deliveries arrive when required
- Organising steel bar deliveries and on site fabrication of the cages to minimise the site stock whilst also maximising flexibility of sequence
- Through working closely with the client and other sub-contractors, helping to maintain the overall project programme

This project presented an array of potential simultaneous problems throughout the works and each pile brought its own specific difficulties, however, through careful planning and good communication and interaction between the main contractor, the engineers and both our on-site project team and our design team, we successfully completed the works with a very happy client.

The site team forged extremely close relationships with Shepherd Construction based both on trust and an understanding of each others requirements and objectives. This was fundamental to the success of the project.

Results:
We successfully designed, installed and tested all the foundation piles using three varying concrete mix specifications and reinforcing cages of up to 15m long to cater for both onerous loading conditions in both compression, horizontal and tension cases. The performance of the piles under loading was tested in both compression and tension and was proven in all cases to be more than satisfactory.

The results for test piles carried out on site were all beyond the expectations of the Client and the Engineer. In fact, the results indicated that the performance of the piles and the soil parameters performed substantially better than could have been reasonably considered likely from the information provided.

Van Elle's Project Value: £1,050,000.00