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Getting it right

Keller Canada worked on the foundations of a hydrogen plant in Fort Saskatchewan, Canada. Matthew Ramsden and John Wilson explain why continuous-flight auger piling saved the client time and money

Keller Canada used a Soilmec R625 drill rig to install two CFA test piles, proving that CFA piling could handle the difficult, sandy subsurface conditions

In many ways, hydrogen is the perfect fuel. It is the cleanest-burning and most efficient fuel used today. Unlike carbon-based fuels, it produces no harmful by-products upon combustion; just energy and water.

Hydrogen also easily combines with most elements, so it can be used as an industrial chemical in a range of applications. Hydrogen is most often used in petroleum refining to remove impurities found in crude oil so that cleaner-burning gasoline is produced. Hydrogen fuel also helps produce ammonia and other chemicals, metals and electronics. Overall, the hydrogen production market is worth over C$105 billion (US$84 billion).

Given this global demand, Air Products Canada recently built a large-scale hydrogen plant in Fort Saskatchewan, northeast of Edmonton. The plant produces hydrogen fuel by extracting it from methane gas using high-temperature steam. It can supply daily 153 million ft³ (standard) of hydrogen fuel to Air Products' customers via the Alberta Heartland Pipeline.

While designing the hydrogen plant, Air Products struggled with needing to install 925 deep piles in sandy soil on a tight schedule and budget. The Air Products design team turned to Keller ►

Meanwhile in the UK: Success in Chelsea

Engineering company Keltbray recently selected two new-generation Soilmec rigs, the SR-90 and the SR-75 Blue Series, to carry out piling at the urban regeneration project of the former Chelsea Barracks, London.

The barracks were originally built in the 1860s to house two battalions of troops of the British Army. The original Victorian buildings were then replaced by two 13-storey concrete tower blocks in the 1960s. The tower blocks were used to accommodate the Guards Regiments. The site was sold and vacated in 2008.

The project involves redeveloping the large 12.8-acre (51,800m²) site, located near the Thames, where new residential and commercial properties with underground parking over two levels will be built. When complete, there will be 448 residential units, local amenities and five acres of public gardens.

One section of the foundations, performed by Keltbray, consisted of a secant wall along the outer boundary of the site, a total length of 1,200m, constructed with bored secant piles.

Keltbray embraced the new Soilmec 'blue' concept rigs, designed for different drilling technologies using modern materials and high-strength steel to be lighter and offer higher performance. The concept design arose from the need to fit the rigs with Tier 4 emission standard diesel engines. Soilmec used this opportunity to completely revamp its product line.

The new SR-75 is a 70t-class rig mounted on a variable-gauge undercarriage with telescopic side frames. The base machine structure was overhauled to hold the CAT C13 diesel engine coupled with Bosch Rexroth hydraulic pumps and blocks that deliver more flexibility, efficiency and increase their output to 328kW.

The H-CAB has more space inside with greater visibility, a sliding door, air conditioning, air-suspended seat and adjustable DMS touch screen console. The four LCD cameras with multi-display monitor offer more visibility over a larger working area.

The catwalk, handrail and self-mounting counterweight system were redesigned for improved safety, and the new canopies are constructed with insulating materials for lower noise emissions.

The structure of the SR-75 includes: lightweight rotary heads with increased torque value; a simplified integrated structure for the mast (built-in high-strength steel); cathead and parallelogram system; and structural simplification to allow a fast transformation between CCS and WCS version. This lightweight construction optimises the forward weight balance of the machine, the mechanical performance of the 293kNm max rotary torque value and the higher pull-up force (up to 281kN for CCS and 408kN for WCS), resulting in enhanced stability, rig agility and pile capability.

Keltbray's SR-75s at work on the Chelsea Barracks in London

At Chelsea Barracks, the SR-75 performed 620mm-diameter piles to a depth of 20m, successfully completing five piles per day.

In addition, the Soilmec SR-90 installed 1,180mm-diameter piles to 25m depth, with the addition of over 20m casing depth, successfully completing four piles per day.

In all, 1,765 piles were installed to construct the secant wall, finishing on schedule in April 2015.

Keller Canada's load testing programme led to a significant revision of the foundation design, saving Air Products time and money

Canada for assistance given its expertise in building foundations in soft soils. The partnership with Keller Canada began during the early stage of the design, leading to a significant revision of the initial foundation design.

LOAD TESTING

Air Products' preliminary foundation design consisted of 925 belled cast-in-place (CIP) piles 15m deep. They faced a sub-surface top layer of weak material comprising mostly sand and an underlying layer of clay down to 19m interlayered with pockets of sand. These sand layers would have made belling difficult and time-consuming, because of the possibility for soil caving into the hole.

Keller Canada believed there was an easier way – continuous-flight auger (CFA) piling. Working with Air Products' geotechnical engineers, Keller performed a test pile programme to gain valuable insight into the geotechnical conditions and to prove that CFA piling could handle the soil profile more effectively.

The load-testing programme consisted of two 610mm-diameter CFA piles fully instrumented with strain gauges for performance analysis. These were installed using a Soilmec R625 rig and Soilmec S6.90 concrete pump, then tested a week later.

The first CFA test pile had a depth of 19.2m and design load of 850kN. During the test, Keller Canada added loads in increments of 100kN until ultimately a load of 2,500kN was reached, at which time only 13mm of pile head movement was observed. Next, they removed the load in four decrements to measure the rebound curve. The pile head rebounded by 10mm. Finally, the pile was reloaded in four increments to 2,500kN, then extra loading was applied in 125kN increments until geotechnical failure was reached. Failure occurred at a load of 3,500kN, resulting in pile head displacement of 46mm.

A second CFA pile (design load of 292kN) was installed down to 10m then load-tested. Geotechnical failure occurred at a load of 1,080kN and pile head displacement of only 25mm.

Through its load testing programme, Keller Canada showed that CFA piling could

handle the sandy subsurface conditions. It also showed that the pile depth could be significantly reduced using CFA piling with end bearing, as compared to Air Products' revised proposal to use 34m-deep CFA piles. As a result, Air Products changed the drilling technology from belled CIP piling to CFA piling with an average depth of 19m.

REDESIGNING THE PROJECT

The process of load testing and revising the foundation design delayed the schedule. Keller Canada was awarded the foundation project on the date originally designated to begin construction, so the CFA piles needed to be installed quickly to make up time in the overall schedule.

As well as saving time by using shorter CFA piles, Keller Canada provided other engineering solutions to ensure that the foundation work could be delivered as safely and rapidly as possible. Working with the geotechnical engineers, Keller demonstrated that the reinforcement cages could be shortened from 14m to 9m, so they could be installed easily without a crane. Keller also determined that not all the piles were working in tension, so they added Dywidag central bars to those piles acting in tension to handle uplift loads.

Keller Canada managed the congested job site using two Soilmec P6.90 concrete pumps

"Through its load testing programme, Keller Canada demonstrated that CFA piling could handle the sandy subsurface conditions"

Once the redesign was complete, Keller Canada mobilised one Soilmec R625 rig, one Soilmec SR-90 rig and two Soilmec P6.90 concrete pumps.

In just over eight weeks, they installed 925 CFA piles to complete the hydrogen plant foundation, including 294 piles with a diameter of 762mm (depth: 19-21m), and 631 piles with a diameter of 610mm ►

Soilmec SR-90 and R625 CFA rigs faced off, while installing piles for one of the larger foundation pads for the hydrogen plant

(depth: 16-21m). Keller Canada used its R625 rig to install almost all of the 610mm-diameter piles, and its SR-90 rig to install the 50 remaining 610mm-diameter piles and all 762mm-diameter piles.

OVERCOMING CHALLENGES

Keller Canada faced the additional challenge of having to rapidly install this number of CFA piles in multiple phases. Rather than building a single foundation pad for the hydrogen plant, they had to build 23 foundation pads in separate areas specified by the foundation design. And many of these foundation pads were small. This meant Keller Canada continually used its two Soilmec drill rigs close together within a tight space, rather than spread out across the job site.

Using Soilmec P6.90 concrete pumps enabled Keller Canada to manage this congested site. These Soilmec self-propelled and crawler-mounted pumping stations were able to work adjacent to the drill rigs, as well as manoeuvre easily around the other equipment, extended rebar cages and excavations.

Their diesel engines also pumped the concrete faster than traditional pump systems, allowing improved installation efficiency.

Above right: Soilmec drill rigs and concrete pumps were used to install 925 CFA piles to complete the hydrogen plant foundation in Fort Saskatchewan

SAVINGS PILING UP

Keller Canada executed the Fort Saskatchewan hydrogen plant foundation smoothly from design to construction.

The revamped CFA foundation work required only two Soilmec drill rigs and two Soilmec concrete pumps: a reduction in equipment compared to the 14 rigs needed to perform the proposed belled CIP piles. By using shorter CFA piles, Keller Canada was able to almost halve the compared to the original plan.

As winter was fast approaching, Keller Canada also rearranged the phasing of the individual pad construction to complete the larger areas first. This ultimately saved the client a further $3 million in heating and hoarding costs.

Overall, the foundation project entailed 5,650 work hours, 480t of installed rebar, 8,000m³ of poured concrete and the installation of 17.9km of CFA piles. Keller Canada executed all of this foundation work without any safety incidents, and it finished almost two weeks ahead of schedule. ▼

"Air Products Canada needed to install 925 deep piles in sandy soil on a tight schedule and budget"

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