Foundation on micropiles of SCR-installation at Siekierki Power Plant in Warsaw

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Introduction
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- Coal combustion power plants are the main (over 90%) source of energy and heat in Poland.
- Most of them were built more than 30 years ago, utilizing old exhaust gas treatment standards.
- Currently, as the regulations become more strict and demand for clean air increases, the process of retrofitting plants with more sophisticated installations is on-going.
- This includes NOx (nitric oxide and dioxide) treatment
Problem

- The four power units of the Siekierki power plant, built in late 70’s were equipped with electrofilters and desulphurization systems that have recently been modernized.
- Selective Catalytic Reduction installation (SCR) was not considered in the original design, so no room was left next to existing structures.
- The only possibility was to expand upward, and place the catalytic reactors above the electrofilter ducts, 35 meters above ground level. This solution introduced the new challenge of having to fit pylons and footings between existing ducts.
Problem
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The General Contractor (GC), required a design-build foundation solution giving supporting structure with fixed load transfer points. Multiple factors had to be taken into account, such as:

- Power units constantly running during work hours
- A number of elements crucial to power plant operations, such as cable ducts, dredging and sewer, were located underground and could not be shut off or relocated
- Limitation of available space, with overhead clearance of only 4 meters and narrow access to drilling points
Problem

- Multiple load cases: vertical forces up to 6000 kilonewtons, horizontal up to 650 kilonewtons per footing, and maximum allowable settlement difference of only 5 millimetres between the footings
- High possibility of subsurface obstacles (construction leftovers, old concrete structures not shown on plans, etc.)
- Necessity to keep vibration to minimum so as not to trigger vibration sensors that would result in disconnecting the turbines.
Possible Solutions

Two potential solutions became clear: micropile installation or reinforced jet grouting block.

Although jet grouting solution was considered easier to design, micropiles became the technology of choice. The main reasons for this were:

- Risk of grout penetration to the existing underground structures during high pressure grouting was deemed unacceptable
- Wide Jet-Grouting body would interfere with some of the installations
- Micropiles would provide better load transfer due to ability to be installed at various angles
- Micropiles provided for easy spacing of individual elements to avoid underground structures
Design

- Regarding various design, equipment and economic issues, the 51N (51/33) Gonar self-drilling rods were chosen, with drilling bits modified to larger (200 milimeters) diameter.

- In addition, to increase system rigidity the Ø159/4mm 3m steel pipes were added to the elements with highest horizontal loads.
Micropile bearing capacity was determined based on CPT test investigation using GGU-AXPILE from GGU Software.

The power plant is located next to a river, on alluvial sand layer, so the majority of the micropiles were installed in sand with a minority drilled into underlying clay.
To check forces in each element and foundation displacements, the Autodesk Robot Structural Analysis v.2011 was incorporated using 3D modeling. The soil-micropiles interaction was considered by adding flexible horizontal supports (Kosecki method).
Finding the optimal micropile layout was challenging and time consuming, as every option had to be run through multiple load cases, resulting from climate induced (wind, snow) changeable loads.
Despite multiple optimizations of layout, calculated settlement differences between some footings reached 7 millimeters, exceeding the predefined limit of 5 millimeters. These values were accepted by the Structure Designer.
Execution

- Batch plant installation
The work scope included foundation of two separate catalytic reactor installations. 380 micropiles of 12 meters in length each were installed, totaling 4560 linear meters. 49 work days were required.
Execution

A Keller KB-0 Jet-Grouting rig was used, as it provided access to narrow locations and could be fitted with a 4-meter mast to enable the use of 3-meter 51N rods. Another advantage is that it could be fitted with 88.9-millimeter JG rods without a need to change adapters, so DHH conversion could be done instantly.
Execution
Execution
Five static load tests were carried out. The loadings were done in two cycles with forces 100%Qr = 336 kN and 125%Qr = 420 kN accordingly, where Qr is the factored maximal design load.

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<th>Qr [%]</th>
<th>Settlement [mm] *</th>
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Problems encountered

- Existing infrastructure installations and associated as-built information
Problems encountered

- **The shortcomings of hollow bar system**: bar type was chosen as compromise between the micropile performance (from this point of view solid bar would be better) and rigs drilling system capabilities (favoring the medium range hollow bars).

- Working in the area with full of construction leftovers, it was sometimes hard to determine if the rig operator should stop the drilling with bar and retool for JG rods and hammer, when hitting an obstacle.

- Attempts to drill threw obstacle without retooling, often led to damaging the bars or making them very hard to unscrew.

- This caused loses in both material and time
SCR instalation
Thank you for your attention!

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