PIPE JACKING CASE STUDY

Kakolanmäki Outlet Pipeline | Turku, Finland

PIPE JACKING ASSOCIATION

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PROJECT	**Kakolanmäki Outlet Pipeline, Turku, Finland**
CLIENT	**Turun seuden puhdistamo Oy (TSP)**
CONTRACTOR	**Ward & Burke**
PIPE SUPPLIER	**Tracey Concrete**
TUNNELLING MACHINE	**Herrenknecht AVN**
VALUE	**€19million**

PROJECT OVERVIEW

The city of Turku is situated on the Aura River at the mouth of the Baltic Sea. As part of an upgrade programme, the municipal authorities developed an ambitious scheme which will reduce discharges and environmental effects from the city's Kakolanmäki Wastewater Treatment Plant. The works involved the construction of a 2.5m diameter, 804m long tunnel, 2 x 10m deep caisson shafts and outfall structure into the harbour. The works will future proof the treatment plant against the effects of climate change, whilst reducing the wastewater load on the Baltic Sea.

DESCRIPTION OF WORKS

Launch Shaft

- The launch shaft was constructed within the Port of Turku, 25m from the Baltic Sea and 13m below sea level. The ground conditions consisted of 10m of Nordic fat clay overlying 7m of consolidated moraine onto granite bedrock. The highly sensitive fat clays encountered had an undisturbed shear strength of 7-20kPa with a disturbed strength of 1kPa.
- A perimeter wall of sheet piles around the shaft was first driven to minimise any risk of ground loss to the already diverted services, adjacent structures, and rail lines.
- The elliptical shaped shaft (11m ID / 13m OD) was sunk 15m below ground level with a 5m toe into the consolidated moraine. Large granite boulders (200+MPa) were encountered from 10m to 15m below ground level which required drill and blasting on two occasions.
- Upon reaching design depth a 5m thick concrete plug and 600mm thick reinforced concrete base was then completed.

Reception Shaft

- The shaft was situated in a small triangular parcel of land sandwiched between a busy dual carriageway to one side, private property (residential and commercial) and 10m away from the live electrified Helsinki to Turku Port rail line.
- The 9mID / 11mOD shaft was sunk through 7.5m of highly sensitive Nordic fat clay onto 0.5m of consolidated moraine overlying granite bedrock at 8m below ground level.
- In advance of shaft sinking a double perimeter wall of sheet piles were driven to mitigate the effects of any ground loss / settlement. The toes of the sheet piles were grouted in the moraine layer to control ground water loss. *Continued on page 2.*

DESCRIPTION OF WORKS

Reception Shaft *continued.*

- Ground water monitoring stations installed in the site vicinity recorded no interference with the existing ground water level in the area and inclinometers installed around the rail line recorded zero settlement during and after the sinking process.
- Once the shaft had come to rest on the highest point of bedrock a series of drill and blasts were undertaken to remove approx. 3m of the bedrock under the shaft. Once the rock was successfully removed and 3m high underpin pour to the shaft was completed.
- Once the underpin was completed, 90 rock anchors were drilled and grouted into the bedrock where a reinforced concrete base was then completed.
- Upon TBM breakthrough the reception shaft was connected to the drill and blast outfall tunnel from the Kakolanmaki Wastewater Works (15m beneath) via a 5m drop shaft wire sawed from the granite bedrock. Once connection was complete a reinforced hexagonal shaped liner wall to the sunk caisson was completed.

Tunnelling (804m of 2500 / 2980 pipe)

- The Herrenknecht AVND2500AB mixed head TBM with an OD of 3025mm was launched in late June 2020. The ground conditions between the two shafts consisted of Nordic fat clay (highly sensitive) and consolidated moraine with a high occurrence of large boulders.
- The triple curved route passed under 3 existing rail lines, close to commercial premises and up the central reservation of a busy dual carriageway. What made this drive unique was that the design demanded that the TBM must traverse under an existing City of Turku twin 1600mm concrete outfall lines with 1.7m of clearance for a distance of 65m (because of the skew alignment of the existing and curved line of the new pipeline). The existing pipeline was built in the highly consolidated, boulder laden moraine. W&B utilised an in-house developed combined air and slurry face stability system for this section. Zero settlement to the existing pipeline was recorded before, during and after tunnel completion.
- Given the sensitivities of the clays identified, floatation concerns were risk assessed at the detailed design phase and a bespoke pipe and TBM ballast weight system was developed and utilised. As a result, the VMT SLS Navigation System used for tunnel alignment recorded that the TBM broke through after 6 weeks of tunnelling within 10mm of target on both horizontal and vertical alignment.
- A best daily performance of 64m and a best weekly performance of 348m were recorded.
- All the 204 no. HDPE lined pipes were manufactured outside of Finland and transported by sea directly into the Port of Turku.

CO_2 SAVING

In all, the tunnel achieved an 80% reduction in CO_2 emissions over the more traditional open cut method.

HERRENKNECHT Tunnelling Systems

WARD & BURKE