Sunderland Strategic Transport Corridor, Tyne and Wear

Geotechnical excellence delivered for major structure in the North East

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Aarsleff Ground Engineering were appointed in July 2019 by Principle Contractor Esh Civils to deliver a geotechnical works package as part of the Sunderland Strategic Transport Corridor project on behalf of Client Sunderland City Council. A significant number of retaining structures including 85m of contiguous bored pile retaining wall, 65lm retaining wall founded on CFA piles, a 250m long x 12m high Soil Nail wall and a large King Post Retaining wall encapsulating the existing 10m high retained wall pinned with ground anchors, were necessary to create space for the highway between the Pallion Shipyard and the upper existing highway and Tyne & Wear metro line; the latter borders the southern side of the land but at a much higher level. With existing land falling steeply across the site, and large industrial facilities to be negotiated, retaining structures and slope stabilisation works were key to making this possible along with an historic backfilled Quarry which the old shipyard have been constructed on.

Aarsleff's senior geotechnical consultant Dr. Dan Adams said: *"We were delighted to carry out these challenging geotechnical works. Delivering a contiguous bored pile wall combined with a large soil nailed retaining structure and the permanent anchors required close team work and good communication with our Client and Client's team".*

King Post Anchors

Investigation commenced in August 2019, with Aarsleff Ground Engineering installing and testing 3No. investigation trial anchors to confirm the ultimate bond stress at the rock/grout interface of the old Quarry. Anchor loads in excess of 4000 kN were successfully proven during these trials. The results were used to develop the permanent anchor design for the lower Pallion king post retaining wall. Aarsleff then undertook detailed design development with Category 3 checks carried out by Esh's independent design firm to demonstrate the achievable bond stresses. The proposed lower Pallion king post retaining wall required anchor working loads in excess of 2000kN; these comprised of large anchors up to 16 No. strands. The trials allowed Aarsleff to investigate the load transfer behaviour of the proposed anchors but also confirm the ultimate rock/grout bond stresses achievable in the underlying limestone.

In addition, Aarsleff found that the depth of the limestone, which their Ground Anchors were founded into, varied greatly over the site. The Ground Anchors needed to pass through at least 20m of granular material prior to encountering the limestone. Due to the varied ground conditions on the project, a variety of drilling systems were

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used on the project to ensure the integrity of the anchors. In addition, each anchor was designed checked by the on-site engineer during installation, to ensure the anchor was formed within competent limestone.

The kingpost retaining wall on the opposite side of the new highway was designed by the client's consultant Capita, with Esh then contracting Aarsleff to design and install more than 100No. high capacity ground anchors with up to 16 strands and working loads in excess of 2,000kN. The wall sits directly in front of one of the old retaining structures that has had to be incorporated into the scheme, but which is assumed to have no retaining capacity. The 10m-high kingpost wall was designed to be a freestanding structure, with up to 4No ground anchors where the new wall is highest that Aarsleff installed - pinning the old structure and mitigating any associated ground movements. The top anchors typically had three or four strands each, while those in the bottom rows were 16-strand anchors; Installed using a 220mm-diameter casing and 195mm-diameter open bore through the rock, they have a fixed length in the rock of up to 8m.

Installation of the ground anchors commenced in August 2020 with 84No ground anchors installed in the newly constructed kingpost wall (founded on rock) and a further 30No. anchors in the existing counterfort wall. This provided continuity for the ground anchor crew to be able to move directly across from installation on the kingpost wall to the counterfort wall to eliminate downtime.
The counterfort wall crosses the backfilled quarry, extending over an area of around two hectares and to a depth of at least 15m. It is an L-shaped section retaining wall of around 5m height built on CFA piles of 750mm diameter, up to 15m deep, and socketed 3m into the competent rock.

Ground anchors in the upstand provided additional restraining forces. These are only 10-strand anchors, but they had free lengths of up to 20m before they reach the competent rock. Because its predominantly going through granular material, a sacrificial steel casing was used with an overburden drilling system.

Up to three rigs were used for the ground anchor installation including two excavator-mounted rigs, one of which sits on top of the wall and installs the top row of anchors and some of the second row down. The second rig, which is capable of installing anchors to a height of about 8.5m, worked from ground level. The anchors have

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up to 16 strands and are up to 30m in length, so they are quite significant elements. They are factory-manufactured and supplied with a pre-grouted fixed length ready for installation. The first four permanent anchors were subjected to on-site acceptance tests, and each and every production anchor was tested to 1.5 times the working load.

Soil Nails

Value-engineering resulted in the introduction of the soil-nailed wall face with Gabion stone which is the largest of the structures under Aarsleff's scope of works - extending across 1,995m^2 of wall face between the new highway alignment and the metro line, rising up to 12m high and some 250m long. This structure was originally designed by Capita as a anchored combi-wall made up of drilled steel tubes with sheet piles which required a large embedment depth and extensive temporary works. By redesigning it as a soil nailed wall solution Aarsleff were able to provide project savings shared across all parties and more importantly de-risked the construction and created something that was more aesthetically pleasing.

Andrew Georgeson, the Operations Director at Esh Civils said: "Early engagement with our partners Aarsleff allowed the team to gain key information to progress the detailed design development with our 3rd party design firm Byland and provide a value engineered solution to the Soil Nail wall, passing savings to our Client in the process."

Constructing the wall required excavation from the top down in 1.5m-high benches, with the slope first being trimmed and cut to the correct profile before the soil nails up to 15m long were installed along with the structural facing of galvanised steel mesh, which restrains the face of the slope against any movement. It is a passive system, and it relies on movement to mobilise the bond stresses. Because of the top-down nature of the construction, all the settlements and movements occur during the construction process.

'Self-drilling' soil nails are essentially hollow-stem galvanised steel bars with sacrificial drilling bits and bar diameters from 38mm to 51mm. As the bar is drilled into the ground, grout is pumped down the central annulus and into the drilling bit, then it flows back up the drill hole to keep the bore open while the nail is installed. The grout hardens and creates the bond between the nail and the ground. Once soil nails and mesh were installed over the full height of the wall, the non-structural facing of 300mm-thick gabion mattresses working from the bottom up was installed.

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The ground conditions were challenging in a number of aspects. Owing to the sites previous use as a Shipyard, numerous unchartered structures, buried asbestos and existing deep drainage culverts the ground conditions encountered on the Soil Nail Wall were very mixed. This caused challenges with the design of the geotechnical works, as we needed to assume a worst-case scenario to manage the ground risk on the site. The aggressive nature of the ground meant that differential movement and associated settlement needed to be considered and dealt with to provide the clients required 120-year design life. Aarsleff developed a ground model and then validated assumptions with sacrificial test nails early on and throughout the works.

Steve Garrigan, Project Directo at Esh Civils said: "*The size of the scheme and logistics needed to accommodate construction through extensive temporary works along, coupled with maintaining access and assets for numerous stakeholders was a tremendous achievement for all involved. Challenging Schemes of this nature and magnitude don't come along often. The collaboration and efforts by all involved is testimony to its successful completion safely, on time and within budget.*"

This iconic project is becoming the benchmark in soil nail design and execution standards. Working closely with our partners Esh and Sunderland City Council, Aarsleff are changing the landscape forever and demonstrating along the way how total partnership between client, contractor and specialist can truly work to deliver highly engineered and quality structures. Through a collaborative preconstruction design process with Esh and design firm Byland Engineering coupled with agile reactions on site to overcome changes to the ground conditions on all stages of the SSTC3 project, Aarsleff were able to install quality ground engineering products safely.

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Data
- 1600No. Soil Nails
- 3No Trial Anchors
- 114No Ground Anchors
- 85m contiguous bored pile retaining wall
- 651m retaining wall founded on 750mm diameter CFA piles

Client
Sunderland City Council

Main Contractor
Esh Civils

Type of contract
Subcontract

Construction period
August 2019-January 2021

Equipment
X2 Excavator mounted rigs
(24T and 35T
Casagrande C6 XP-2

Aarsleff Ground Engineering is one of Europe's leading piling contractors, and we undertake a wide variety of piling, drilling and foundation projects in the UK, and abroad. We have offices in Denmark, Poland, Czech Republic, Sweden, Germany and Norway. Our fleet covers hydraulic piling and drilling rig as well as cranes and vibrators.

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