WATERVIEW CONNECTION GROUND ANCHORS AND SOIL NAILS

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SUMMARY

GROUTING SERVICES played a significant role in providing specialist ground anchoring and soil nailing services as part of the retention works for the Waterview Connection Project. The $1.4b Waterview Connection Project was awarded in August 2011 to the Well-Connected Alliance (WCA). The Alliance comprises NZTA, Fletcher Construction, McConnell Dowell Constructors, Parsons Brinckerhoff, Beca Infrastructure, Tonkin and Taylor, and Japanese construction company Obayashi Corporation. Being the last segment of Auckland's south-western motorway, the Waterview Connection is the final key link for the 48km Western Ring Route which will provide an alternative to the Southern and Northern motorways (SH1), bypassing central transport corridors.

The Southern Approach Trench (SAT), the eastern approach to the tunnel and initial launch area of the 14.5m diameter tunnel boring machine (TBM) is approx. 45m wide and up to 30m deep near the front face. There is a great variance in the geology of the area, which dictated the construction methodology and the design of the trench retaining system.

DESIGN

The design approach adopted to anchoring the reinforced concrete bored pile walls was to install over 400No double corrosion protected multi-strand anchors through concrete waler beams. Anchor capacities ranged from 250T to 320T and lengths varied from 15m to 34m.

The specified working loads for each anchor type and anchor geometry requirements dictated minimum free and bonded lengths. Hole diameters were specified as 200mm and all anchors were inclined.

All anchors were designed as permanent Class 1 protection (commonly referred to as double-corrosion protection) and constructed in accordance with BS EN 1537:2000 with a minimum design life of 100years.

Double corrosion protection requires the full encapsulation of the anchor tendon (strand) strand within cement grout inside a single corrugated plastic duct. The corrugated ducting serves two purposes. Firstly, the duct allows transfer of the capacity of the multi-strand tendon from the inner grout to the outer grout without cracking, and secondly, the duct provides a continuous impermeable barrier to moisture for the lifetime of the anchor. The outer grout solely provides the bond mechanism for the anchor; it does not provide any corrosion protection.

Figure 1: Southern Approach Trench

CONSTRUCTION

Construction of the anchoring works proceeded in tandem with numerous other activities and this required a high level of co-ordination and project management of multi-disciplinary teams. This coupled with a demanding programme and restricted access

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associated with working in the trench dictated the use of multiple drilling rigs and crews to ensure target programmes were achieved.

Additionally, with space being a premium and anchors weighing in excess of 500kg (meaning manual lifting was not an option), alternative methods for lifting the anchors had to be considered in-lieu of traditional craneage techniques. Grouting Services (GSL) utilised in-house expertise to develop an anchor carousel frame and hydraulically-controlled rotational drive unit to allow the anchors to be safely installed without the use of a crane.

Figure 2: Anchor Installation Equipment

Drilling

Anchor holes for the SAT walls were drilled by conventional rotary wash drilling techniques through the weaker Tauranga Group (TG) into the underlying East Coast Bays Formation (ECBF). Drilling fluids comprised fresh water and all holes were flushed clean using compressed air and water.

The specification required the drill holes to be within 2-degrees of the theoretical centre-alignment over their full length and this was easily achieved.

In some locations, it was necessary to install temporary PVC casing to deal with low strength material encountered that was not self supporting.

At the front face (portal entry) strand anchors were required to be installed through the reinforced concrete bored pile wall, with a 7m wide stabilised block immediately behind and anchored into ECBF. An additional challenge was the need to ensure the installed path of the anchors in the upper section did not intersect the path of the TBM as it tunnelled the initial 30m section. Upon completion of the drilling a specialist gyroscopic device was lowered down the hole to take co-ordinate readings at 2m intervals. Readings were taken on the devices during its decent and ascent then averaged and compared to the future path of the TBM. Of the 10-No anchors analysed by this method the maximum deviation was 240mm, at a depth of 20m metres. The allowable tolerance was 700mm.

Overlying the TG and ECBF was a basalt layer of varying competency. To support the gantry crane used to re-build, and eventually dismantle the TBM within the SAT, 32-No double corrosion protected multi-strand anchors were installed at a 5^{o} inclination into the basalt layer. The anchor holes were drilled to 15m with a 200mm down-the-hole hammer.

Figure 3 shows the proprietary anchoring rig designed with a swing boom, super high pull back (15tons) and high-torque rotator (up to 4000kgm torque). The double rotation head facilitates continuous double drive drilling with casing and rods.

Figure 3: Specialist Anchor Drilling Equipment HD180 Anchoring Rig

Anchor Manufacture

The anchors were specified as double corrosion protected and the tendon fabrication was conducted off site in a controlled

environment to minimise the risk of damage to the tendon and corrosion protection system.

Multi-strand tendons are greased and sheathed over the free length. Critical to the performance of a multi-strand anchor is the requirement of the strand to be fully greased within the lateral sheath. This is not only to allow the tendon to satisfactorily elongate during tensioning, but also to ensure no voids are present within the sheathing which would compromise the integrity of the anchor.

Each individual strand is run through a specialist greasing and sheathing machine that first opens the individual wires of the strands prior to immersion in a grease bath before completely encapsulating the strand in the outer sheathing thus ensuring no voids are present.

The individual greased and sheathed strands are configured into the design arrangement complete with plastic centralisers over the bare strand in the bond length to create a basket weave, and, internal grout hose and nose cone prior to insertion into the corrugated ducting.

The completed anchors were coiled onto a carousel ready for delivery to site for installation. The use of the carousel at this stage of the project added a further quality control step in the process and ensured all 431-No anchors were the correct length, contained the correct number of strands and were installed in the correct location.

Anchor Installation and Grouting

The use of the anchor carousel system developed specifically for this project eliminated the need for heavy straining and reduced the time taken to install anchors.

Anchors were installed to termination depth, and prior to any grouting taking place, all grout lines were checked to ensure they were clear. Grouting took place simultaneously internally and externally via grout lines that extend to the bottom of the anchor to maintain an equal pressure and minimise the risk of collapse to the corrugated duct.

Grouting comprised neat cement grout with a max water:cement ratio of 0.4. Grout bleed requirements were less than 2%.

Reconciliation of grout volumes in conjunction with visual checks on the level of the top of the grout was required to ensure adequate anchorage along the bonded length was maintained.

Grout samples were required to be taken and tested to validate the design strength of the grout.

Figure 4: Anchor Carousel

Anchor Stressing and Protection

The stressing operations included acceptance testing and residual load testing.

The testing criteria for the anchors saw every anchor receive an acceptance test equivalent to 150% of the working load over 2-loading cycles. An initial load equal to 10% of the working load was applied to bed in the anchor and testing system, and allow the jack to stabilise. The load was held steady at each increment (and decrement) and maintained to ensure a variation of no more than 2kN was observed from the specified load.

Displacements at each load increment was recorded using a dial gauge atop a remote tripod and at the end of the second load cycle, the anchors were locked off at the prescribed working load.

Five percent of the anchors installed were subjected to a residual load test to effectively prove that the anchor system met the specified criteria with respect to creep under constant load. This involved monitoring the load on the anchor and the deflections of the anchor head over a maximum 150minute period.

The maximum test load placed on a single anchor was 2600kN (260Tonne) on the 15m long anchors supporting the TBM gantry crane.

Long-term monitoring was incorporated into a number of anchors with the inclusion of strain gauge load cells.

Figure 5: Stressing Set Up

To meet the requirements for a 100year design life, all bearing plates were galvanised and included a trumpet that lapped with the corrugated ducting. The anchor heads were protected by a fibre reinforced polymer cap fixed to the bearing plate and filled with grout.

Soil Nails and Additional Works

The tendered programme was revised significantly as the project advanced and regular meetings were held between GSL and WCA to look for and realise risks and opportunities. Multiple drilling rigs and installation crews were required on the project as the anchoring works proceeded and the scope increased to include soil nails and bored drainage relief holes, not included in the initial competitive tender. High level co-ordination was required to work in tandem with the numerous additional activities being undertaken by many contractors within the confined space.

Summary

The Waterview Connection is the last segment of Auckland's south-western motorway and the final key link for the 48km Western Ring Route. The project is due for completion in early 2017 and it will unlock Auckland's potential to become a truly world class city, combatting regional congestion and creating a direct, time-saving link between the International Airport and CBD.

With an exemplary safety and quality record GSL was extremely pleased with the efforts made by their team and greatly appreciated the assistance provided by many members of the WCA team.

References

[1] www.nzta.govt.nz

[2] www.fletcherconstruction.co.nz

[3] www.groutingservices.co.nz

Acknowledgements

The authors wish to acknowledge the following organisations and personnel whose combined efforts helped to deliver the project works.

Fletcher Construction, John Burden, Louise Cooper, Adam Campbell
Grouting Services, Peter Ensor