Wynyard Quarter Innovation Precinct Stage 1 Building 5A Ground Anchors

David Sharp

David holds a Bachelor of Civil Engineering (Honours) and is a member of The Institution of Professional Engineers New Zealand. David has extensive experience in the local construction market having worked for companies that lead New Zealand in their specialist fields. David understands the construction implications of design well and has particular experience in post-tensioning, ground anchoring and soil nailing. He is regularly consulted for expertise in these fields having had substantial exposure to the full spectrum of design and construct. He is a solution-driven professional with more than 25 years of significant, progressive engineering experience. He has also co-authored several technical papers.

Figure 1: Sheet Pile and Anchor

SUMMARY

WYNYARD QUARTER is one of New Zealand's largest urban regeneration projects and has benefited from considerable public investment which is also set to continue. Its public spaces and level of amenity in Auckland is unrivalled. The planned Innovation Precinct consists of 48,000m· of high quality, sustainable office space across five buildings within the Wynyard Quarter block bounded by Halsey, Pakenham, Madden and Daldy Streets. Stage 1 included the development of a five storey Building 5A with a 2-basement structure located on Madden Street.

GROUTING SERVICES played a significant role in providing specialist ground anchoring services as part of the design and construction works for the Building 5A project. The basement required up to 7m high temporary retention and groundwater cut off for the formation of a permanent tanked basement.

INTRODUCTION

Grouting Services was engaged by Hawkins Construction to provide specialist design and construction services for the ground anchoring works required for the temporary perimeter retention. The design of the anchors was integrated with the design of the steel sheet pile system and an innovative concrete waling system developed that proved to be very cost effective when compared to a traditional steel waler system. The ground anchoring design works was consulted to CMW Geosciences.

Hawkins Construction engaged Contract Landscapes to design and construct the steel sheet pile works and the design was in turn consulted to CMW Geosciences. This collaboration ensured an optimum design would be achieved and a seamless transition between the contracting parties would result on site.

DESIGN

The site forms part of reclamation works that were undertaken in the period 1905-1917, which generally involved placement of hydraulic fill recovered by harbour dredging. However, the reclamation also included demolition debris, timbers, steel and other process related wastes.

The natural materials underlying the reclamation fill comprise clayey and sandy silts, then older and stiffer Tauranga Group Sediments (TGS). These materials infill the eroded surface of the East Coast Bays Formation (ECBF) bedrock.

The proposed retaining wall was to be positioned along the boundary of Site 5A and used to temporarily support the proposed two level basement excavation prior to permanent basement wall construction.

The retention system comprised steel sheet piles driven to the required depth, tied-back by inclined ground anchors (Figure 1). Continuity of restraint between the anchors was provided by a reinforced concrete waler.

With consideration to planned services developments in the adjoining road reserve, and the development of adjacent sites, the temporary retention anchors included an innovation promoted by Grouting Services in the form of removable (RCD) multi-strand ground anchors.

The RCD multi-strand anchors are load distributive compression type removable anchors that offer a complete solution where anchorage systems are required to be removed once they become redundant.

The removal process is generally done by hand. In addition, allowing the steel strand to penetrate through the inside and be secured to the end of the aluminium anchor body, distributes the jacking force along the length of the anchor body which maximizes the effective cross-sectional area of the grout body.

The design of the steel sheet pile and ground anchor wall system was analysed and optimised using the established and widely utilised proprietary software package WALLAP (Version 6.05). A key criterion for the design, and the objective of the optimisation exercise was to design a wall with the required factors of safety, with acceptable deflections.

The consent conditions estimated lateral deflections of up to 32mm and a limit of 30mm was subsequently recommended as an alarm level requiring bulk excavation to stop. The anchor levels, spacings and lock-off loads were optimized allowing estimates of between 16mm and 25mm.

SHEET PILES

The sheet pile wall comprised 12m long WRU17-600 sheet piles, tied-back with one level of ground anchors installed at RL 1.0m.

The sheet piles were required to be driven to full depth into the TGS, or where the ECBF rock level rises to within 12m of the ground surface the sheets should be driven to refusal.

GROUND ANCHORS

All anchors were designed as temporary in accordance with BS8081-1989 Ground Anchorages with a design life of less than 12-months.

Ground anchors were to be installed through the front face of the sheets and inclined at 45 degrees to the horizontal. The anchors were spaced at 3.6 m (nominally). Some reduced spacings were also included to mitigate risk of deflections where rock levels were low, and to avoid clashing with adjacent building piles.

The ground anchors were to be grouted 8.0 m into the ECBF bedrock providing the necessary bond strength to resist lateral loads. Adopting a conservative assumption of 0.75 MPa bond capacity results in a factor of safety of 3.8 against pull-out.

The anchors were to be proof-tested to 1080 kN (125% of working load) to confirm adequate capacity and then post-tensioned to 520 kN (60% of working load) to provide the desired level of lateral restraint.

CONCRETE WALER BEAM

Continuity between the anchors was to be provided by a reinforced concrete waler beam (Figure 2). The waler was designed to spread the maximum anticipated loads at the nominal spacing factored in accordance with NZS1170.

Figure 2: Concrete Waler Beam

Steel corbel brackets to support the waler were to be welded onto the sheets below the anchor penetrations. After the corbel installation, the waler was formed and cast against the wall. Proprietary anchorages complete with anti-burst reinforcing were cast into the waler to accept the ground anchor heads.

CONSTRUCTION

Construction of the anchoring works commenced as soon as the sheet pile installation was completed. The anchor installation works proceeded in tandem with excavation and concrete waler beam works which required a high level of co-ordination and project management of multi-disciplinary teams.

This, coupled with having to deal with site contaminants and manky ground in the form of rubble, gravels, timber and the like (Figure 3), meant the site team had to be meticulous in all aspects of construction to optimise efficiencies and meet target construction programmes.

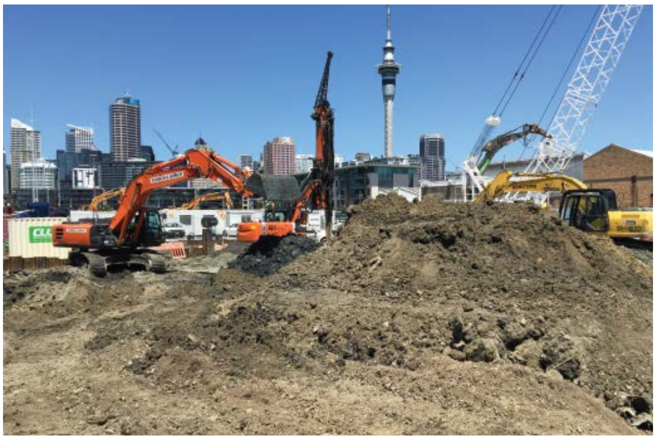

Figure 3: Site Pre-Excavation

DRILLING

The most significant component of risk in ground anchoring is the ground found to be present and of particular note on this project is the in-ground challenges presented by the site - a combination of reclaimed land, obstructions, a shallow water table and rock present at deep levels.

This required heavy duty drilling work which was managed using our HD180 proprietary anchoring rig designed with a swing boom, super high pull back (15 tons) and high-torque rotator (up to 4000 kgm torque). The double rotation head facilitates continuous double drive drilling with casing and rods.

All anchor holes were put down by conventional rotary wash drilling techniques advancing steel casing

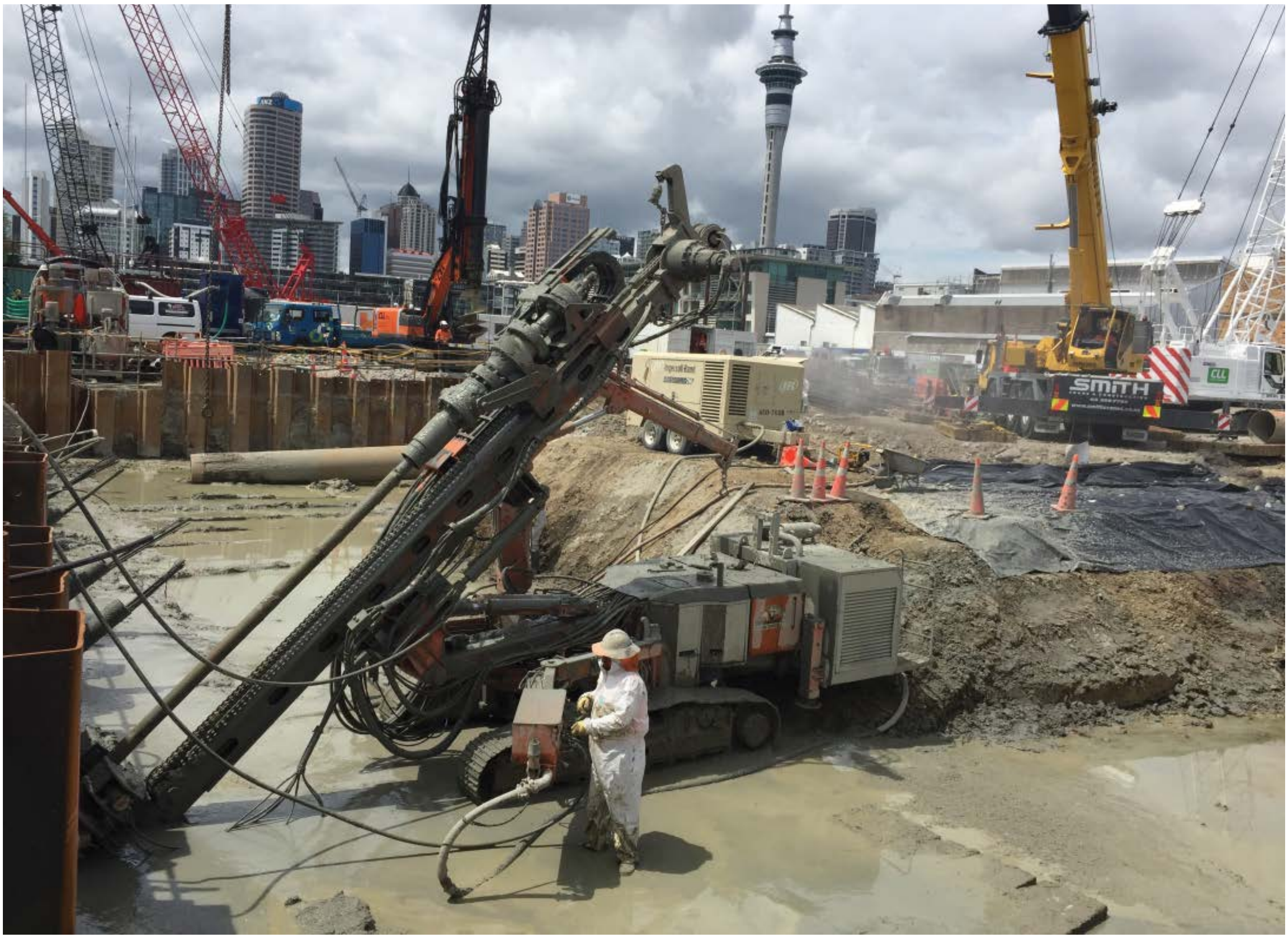

Figure 4: Specialist Anchor Drilling Equipment HD180 Anchoring Rig

through the overburden material into the underlying ECBF rock.

Drilling fluids comprised fresh water and all holes were flushed clean using compressed air and water.

Figure 4 shows the proprietary anchoring rig designed with a swing boom, super high pull back (15 tons) and high-torque rotator (up to 4000 kgm torque). The double rotation head facilitates continuous double drive drilling with casing and rods.

ANCHOR MANUFACTURE

The anchors were procured from Korea and manufactured in a world leading production facility (Figure 5). Contingencies were incorporated into the design length to ensure any variabilities in the ground found to be present could be easily dealt with.

For the temporary multi-strand anchors, the 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, a grout hose and nose cone added.

The RCD multi-strand anchors (Figure 6) incorporate discrete aluminium anchor bodies configured within the bonded length and greased and sheathed strand over the free length in the same manner as the temporary anchors.

Plastic centralisers are configured to ensure the tendon remains central in the drill hole.

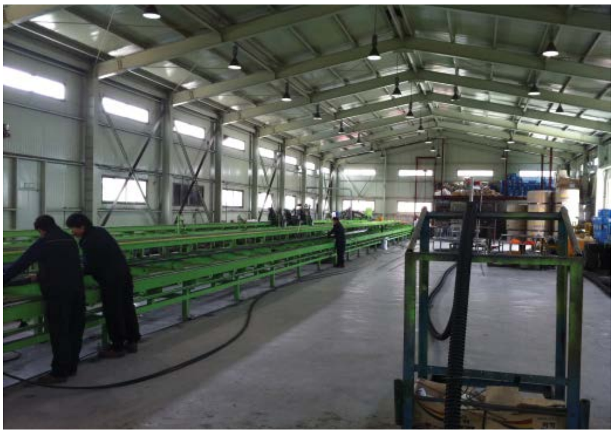

Figure 5: Anchor Production Facility

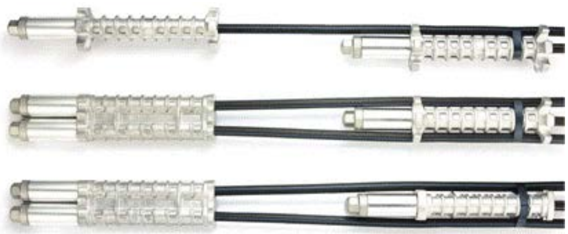

Figure 6: RCD Anchor Configuration – bond length

ANCHOR INSTALLATION AND GROUTING

Sloppy site conditions restricted access to the workface and prohibited the use of the innovative anchor carousel system. Rather, a crane was used to hoist the anchor and load into the drilled hole.

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 with the extraction of the temporary steel casing and continued until cement rich grout exited the drill home.

Grouting (Figure 7) 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.

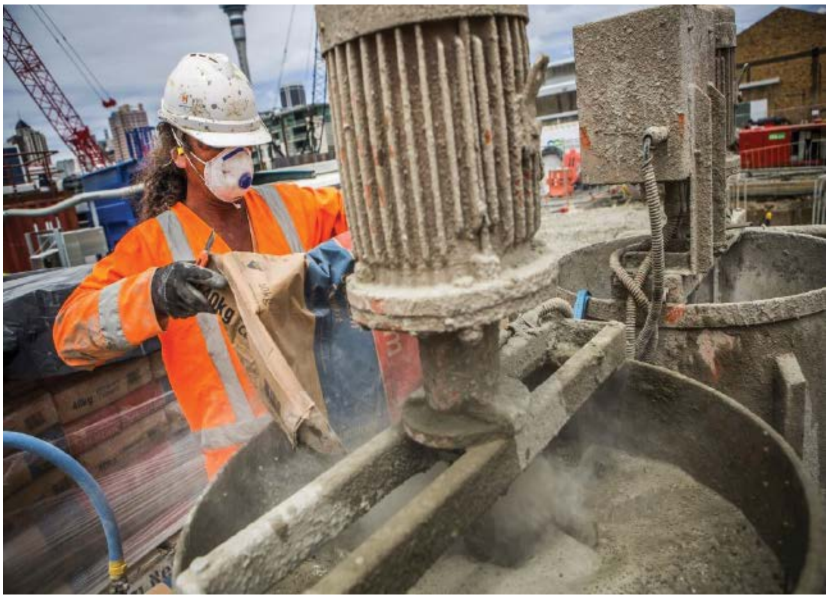

Figure 7: Grouting Station

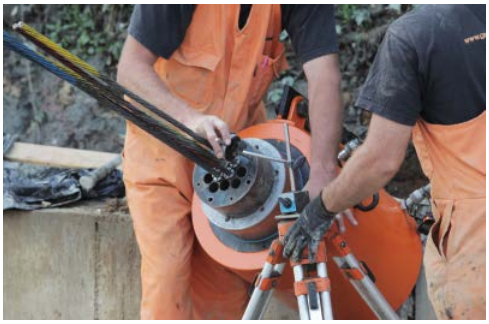

Figure 8: Typical Stressing Set Up

ANCHOR STRESSING AND PROTECTION

The stressing operations included proof testing (Figure 8).

The anchors were proof-tested to 1080 kN (125% of working load) to confirm adequate capacity and then post-tensioned to 520 kN (60% of working load) to provide the desired level of lateral restraint.

Displacements at each load increment was recorded using a dial gauge atop a remote tripod and at the end of the peak load cycle, creep monitoring was recorded over a 15 minute hold period.

Anchor heads were wrapped with denso tape to provide the necessary temporary protection.

ANCHOR DE-STRESSING AND REMOVAL

Anchor de-stressing and removal is schedule to be undertaken during the 3rd quarter of 2016. For the temporary anchors, this will involve yielding the strands at the anchors head with a blow torch followed by cutting back the strands to the structural element.

The innovation with RCD anchors means that the entire steel strand can be quickly and easily removed with limited site access. The strand is simply rotated to release the wedges which are fixed in the end of the aluminium anchor body and the entire steel strand is easily withdrawn through the sheath leaving the small aluminium anchor body in the grouted hole.

SUMMARY

The Building 5A project is an integral part of the transformation of the Wynyard Quarter Innovation Precinct and Grouting Services not only effectively led a design team, it provided world leading construction expertise to get the job done on time and on budget.

With an exemplary safety and quality record Grouting Services extremely pleased with the efforts made by its internal team and greatly appreciated the assistance provided by project team led by Hawkins Construction.

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