

Lessons learned from one of New Zealand's most challenging civil engineering projects: rebuilding the earthquake damaged pipes, roads, bridges and retaining walls in the city of Christchurch 2011 - 2016.

IPWEA Annual Excellence Awards 2016 award application

Story: Sumner Road Retaining Wall – Stage 4

Theme: Construction

An award application submitted for the IPWEA Annual Excellence Awards 2016, detailing Fulton Hogan's work repairing the repair methodology for the Sumner Road retaining wall – stage 4.

This document has been provided as an example of a tool that might be useful for other organisations undertaking complex disaster recovery or infrastructure rebuild programmes.

For more information about this document, visit www.scirtlearninglegacy.org.nz



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IPWEA Annual Excellence Awards 2016

SCIRT Delivery Team Fulton Hogan
Sumner Road Retaining Wall Stage 4

Best Public Works Project <\$5M

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Project Definition

The Stronger Christchurch Infrastructure Rebuild Team (SCIRT) was established in 2011 to repair Christchurch's severely earthquake damaged publicly-owned horizontal infrastructure (wastewater, fresh water, storm water, roads, retaining walls and bridges) within five years. SCIRT's programme is funded by the New Zealand Government and Christchurch City Council.

With more than 700 individual projects the \$2.2 billion, 5 year programme is New Zealand's most challenging civil engineering undertaking. As one of the delivery teams within the SCIRT alliance Fulton Hogan has worked collaboratively in Early Contractor Involvement (ECI) and construction on a diverse range of civil engineering works. The SCIRT programme is expected to be complete by the end of 2016.

Sumner Road is an arterial road that links Lyttelton to Sumner, partially closed due to rock fall risk as a result of the earthquakes. The road also provides access to a number of residential properties in the area. The retaining wall retains sections of fill which support the Sumner Road carriageway and services. The damage suffered to the retaining wall included failure of sections of the gravity stone facing and horizontal and vertical displacement of the footpath and roadway behind the retaining wall.

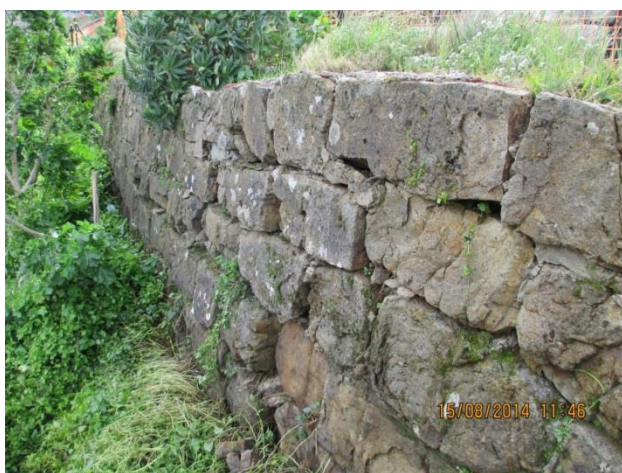


Figure 1: Pre-construction Sumner Road Stage 4

For the last three years SCIRT's Fulton Hogan delivery team has been repairing and strengthening the existing retaining walls along Sumner Road. Stages one and two are already complete. Sumner Road Stage 4 is the re-strengthening of an existing retaining wall that supports Sumner Road above the Holcim Cement site. The Sumner Road Retaining

Wall that required earthquake repair and strengthening consisted of three existing 100 year old stone walls up to 6 meters high. The design called for 180 new soil nails to be drilled through the existing block and grouted into place up to 8 meters long and 180mm in diameter. Once the soil nails were completed, drainage was installed, a footing was dug and poured and a reinforced shotcrete facing was applied in two layers of 150mm. A new handrail and repairs to damaged kerb and channel and footpath complete the project.

SCIRT's Fulton Hogan delivery team were involved from the design phase through to the delivery of the project. The project started 12th January 2015 and was completed 11th September 2015. The project cost was \$1.45M.

Community Outcomes

Lyttelton is built on sloping terrain, with its international seaport and associated trade located on reclaimed land. Due to the closure of Evans Pass, dangerous and large goods are transported out of the harbour via Gebbies Pass Road – an additional 36 kilometres each way. Lyttelton has a population of 2,859 with considerably fewer teens and young adults than Christchurch City and a greater percentage of those aged between 45 and 64 compared with Christchurch City. There are around 520 businesses employing 1,500 people.

The Christchurch City Council's Community Environment report states that community groups provide a range of activities and services for residents in the local area. In addition Project Lyttelton and the Lyttelton Harbour Information Centre provide leadership and mentoring to other community organisations with Christchurch, regionally and in some cases nationally. The Lyttelton harbour Information Centre provides weekly information to residents and includes a business directory, what's on guide and information about volunteers.

SCIRT's Fulton Hogan delivery team has already established strong relationships with key stakeholders when previously working in Lyttelton on other projects. We have set a high standard of communications by effectively informing the wider community by means of Community Board presentations, private property consultations, holding open-doors events, drop-in sessions, providing informative newsletters and work notices, and liaising with community magazines for free

publicity in the Lyttelton Review. Fulton Hogan also has a previously established relationship with the Lyttelton Port Company, which is vital as much of our work required us to check the shipping schedules. The Lyttelton community has high expectations of Fulton Hogan supporting businesses and schools in regards to providing as much information as possible to keep these organisations running at a high level.

Fulton Hogan did a kindergarten and a school visit. These educational programmes help build a rapport with the locals. Open Days were held on site in Lyttelton to allow the community to see the progress being made and get more of an understanding of the work involved in this project.

The project team have a site office based in Lyttelton, just down the road from where the work is taking place. They encouraged residents and the community to pop in if they had any questions or concerns about the work. A free 0800 number and email address was also available for project queries.

Maintaining access for residents and allowing room to work was a balance act and the team worked together to guarantee safety and progress. A good relationship was formed with many residents and the team really appreciated the local knowledge and the home baking.

“It was a challenging job, but a satisfying one. We managed to finish ahead of time because of the supportive residents. They really understood the site constraints and the difficult access. Because of their co-operation residents now have a number of freshly-repaired concrete retaining walls to help keep their roads in place and enable homes to be rebuilt” Project Manager David Oliver.



Figure 2: Talking to residents at the Sumner Road open day

Stakeholders

Prior to the earthquakes heavy trucks used Sumner Road to transport goods to and from the port of Lyttelton. The Canterbury earthquakes badly damaged the walls along Sumner Road leaving them bulging and cracked. Sumner Road has been closed since the February 22nd 2011 earthquake. It is the only suitable overland route for heavy vehicles if the Lyttelton tunnel was out of action.

There were a number of key stakeholders in the delivery of this project; they were as follows;

Christchurch City Council (Client)
Lyttelton Community
Lyttelton Port Company
Holcim Cement
Cera (Client)
Sumner Road Residents
Reserve Terrace (Detour Route)

Each had their individual requirements and interests in the success of the project.

This project has been very challenging for the client. Providing a timely solution to this section of the damaged wall has allowed SCIRT and its stakeholders to plan the further works on Sumner Road and look to complete the rebuild of this important piece of Christchurch infrastructure.

The project manager formed a good relationship with the asset owner (CCC) to not only ensure that Fulton Hogan delivered what they really wanted but also to work together to solve issues quickly. A ‘one team approach’ was established early on in the project. Through the open and honest working relationship a strong culture of collaboration continued to run from the early design stages through to the completion of the project.



Figure 3: Flooding on Sumner Road

The SCIRT design team deemed Sumner Road stage 4 a more critical project than stages 3 and 5 after the March 2014 floods. Geotech engineers warned that the bank was in further danger of collapsing following the floods. There was a high risk of loose rocks and tree material situated above the Holcim tanks and the road was also at risk of collapsing so repairing the wall was vital.

Regular collaboration was required with the designers. Fortnightly meetings were held to keep everyone up to date and discuss any design issues. If there were any inconsistencies with test results during construction monitoring, the feedback was passed onto the designers for their input. There was also regular communication to overcome the unforeseen ground conditions.

Communicating well with the residents of Lyttelton was fundamental to the success of the retaining wall repair programme. Residents are located in the midst of these retaining walls and have had to deal with over three years of road closures. Resident requirements were considered and where possible allowances for vehicle access and parking were made.

We also kept the residents and wider community informed on our works and the changes in traffic management. We received positive feedback from the locals on how we undertook the work and consider their access.

“We have been very impressed with the work SCIRT and Fulton Hogan have been doing. We have been watching the repair process over the last few years and see how incredibly hard the guys work. I’m also impressed the great relationship Fulton Hogan has with residents in the street. We

have been kept up to date throughout the work” Penny, Sumner Road resident

Holcim cement is positioned directly below the damaged retaining wall. The Holcim cement supply is critical to the Christchurch rebuild and was required to remain open during this project. Holcim were a key stakeholder so Fulton Hogan met with them prior to starting the project to explain the project and make any allowances that they would require concerning safety and no business interruptions. Regular meetings were also held during construction to make sure all parties were happy with the works and keeping everyone up to date with the progress. Collaboration was also done with the other delivery teams working in the area to ensure works didn’t clash and wouldn’t cause issues for the nearby local residents.

“Anybody would have concerns when you have a crane, a container and work being carried out directly above our operations. Those concerns were put to rest with the consultation between Fulton Hogan and Holcim coming to a happy result” Kerry Rosewarne, Holcim.



Innovation and Technical Difficulties

A critical factor in repairing the retaining walls has been to produce walls that are stronger and more resilient than the old ones in the event of future seismic activity.

The design was difficult due to access. Various options were considered including removing the wall and building a new one. However previous rain events on site had resulted in considerable storm water flow down Sumner Road. If the existing wall could not be stabilised it would have been extremely difficult to manage the storm water flow over the site

each end of the wall where the ground is close to the nail location.



Figure 6: Soil nail getting inserted into Sumner Road retaining wall

When opting for this container configuration a number of obstacles had to be overcome to allow the drill rig to be moved in the container. A gantry crane was designed to move the drill mast along the container; however when the drill mast is moved along the container when suspended, the containers balance moves and the drill mast could run downhill without a suitable control in place. A chain block was attached to the gantry crane, mounted at 90 degrees to allow for controlled movement of the gantry crane without the risk of the drill mast running downhill. Additionally a tior lever hoist was used at one end of the container to level the container due to the weight shift of the drill mast.

The requirement to have edge protection in place at all times was difficult to achieve and the use of expandable barriers were used to allow the rig to be moved and the barriers to always be in place. An access platform was also designed to allow a ladder to be set up to get on and off the platform without moving the platform.

Workshops

Due to the complexity of the build a number of workshops were held with the team to develop the methodology for construction. Once an understanding of the method was agreed a presentation was put together to circulate this information so all parties could understand the construction sequence, the reasons for each step and so they could provide input to ensure that all aspects of the build were considered.

WorkSafe

Due to the nature of the works and the unique site conditions the team invited WorkSafe to look over the site and procedures at the beginning of the project. This was a very useful process as WorkSafe helped identify a few additional hazards as well as give the team confidence that the procedures and methods being undertaken were safe. The work undertaken from the drilling rig had no safety incidents occurring.

“Although the ground conditions were extremely hard, drilling the nails was the easy part. Coming up with a way to do it safely was the trick”, David Oliver, Project Manager.



Figure 7: Engineer inspecting first layer of shotcrete

Archaeology

The Sumner Road retaining wall was deemed a high risk archaeological site. Prior to the work, the pre-1900 walls were recorded by archaeologists to capture information before the walls were deconstructed or covered in shotcrete.

The crew attended an archaeology site briefing prior to commencing works. They followed an Archaeological Accidental Discovery Protocol during the works and reported a number of interesting archaeological finds, including a glass bottle and a pick-axe head. When a discovery was made, the crew ceased all works immediately within a 20m radius and advised the site supervisor who then called the archaeologist and environmental advisor. Work only commenced again once the archaeologist had been to site and given the all clear.

The glass bottle was discovered during hand digging in front of the wall. Work was immediately stopped and the archaeologist was notified and came to site. The archaeologist was very

impressed with the crew's response and explained that the glass bottle was pre 1900. He removed the item from site and explained that if any further discoveries were made, the crew were to put the items aside and could continue on digging in front of the wall. The site engineer would take note when the discoveries were made and keep the archaeologist informed. This helped the crew stay on programme.



Figure 8: Archaeology discovery

Native Fauna

This project prompted the development of a new Accidental Discovery Protocol for lizards and skinks across the SCIRT program. The crew found ten Canterbury Geckos living in the wall during deconstruction, and immediately stopped work and called the Fulton Hogan Environmental team for advice. A herpetologist (lizard expert) was contacted and the crew were instructed to carefully capture the geckos for collection. The geckos were then handed over to the Department of Conservation and released to a new home in a nearby rock outcrop.

Herpetologist and ecologist Marieke Lettink said the retaining wall was pre-1900 so the species could have been living behind the concrete blocks for decades.

"They've managed to survive by finding a really nice deep, narrow crack to live and breed."

<http://www.stuff.co.nz/the-press/news/70818059/Colony-of-geckos-rescued-from-Lyttelton-retaining-wall>



Figure 9: The Press article on Geckos recovered from the project

Completion

The project was completed ahead of schedule, under budget and achieved zero harm on 99.32% of the construction days.

Financial

To ensure best value for the client, 'best for project' solutions were continually discussed and tested by the project team, and when beneficial, implemented. The success of this approach was evident with Fulton Hogan completing the project below the client's budget. This considerable saving was achieved without compromising quality or safety.

The daily costs of drilling and the daily productivity were used to track the financial progress of this aspect of the job. This was by far the most important financial element of the project and by achieving a good unit rate the projects financial security was ensured. The increased production reduced the full length of the programme and resulted in significant savings in P&G and overhead costs.

A cost control programme of Candy Construction Software (CCS) was used to set the job budget and calculate an earned value and track actual costs each month. The report highlighted areas where cost savings could be realised and were productions were not as per the estimate. This allowed early identification of areas to reassess to see if costs could be reduced.

Sumner Road retaining wall stage 4 was led by a Project Manager who oversaw the project from design through to delivery. A site engineer and site foreman managed the project on site daily. Four week look-ahead and last planner were tools used on day to day site management.

Staff were encouraged to identify any potential issues before they arose. Even though the project manager pushed the team to deliver the project ahead of schedule safety and quality stayed priority focus.

Safety

Daily pre-starts were held discussing what work was planned for the day. Job Safety and Environmental Assessments (JSEA's) were reviewed on a daily basis to identify any hazards and to make sure the team knew the work they would be carrying out.

Weekly tool box talks were used to get the team together and go over any internal and external company messages and talk about upcoming works. The team were also aware of the target productivities and this was discussed at the weekly meetings. This worked well as a lot of production improvements came from the team understanding the targets and providing improvements.

Quality

The project had monthly audits. These covered traffic management, Safety, Environmental and Quality. The audits were undertaken by the site engineer in conjunction with the foreman. They ensured that all of the quality procedures that were in place were followed by the team.

On this project a collaborative approach was taken towards quality to make it everyone's responsibility. The energy put into enforcing attention to detail was equal with that put into safety.

Inspection Test Plan (ITP's) were used and on significant hold points, they had to have a designer sign off. In addition, each soil nail when each soil nail was installed bore logs were taken of each nail and recorded to identify the ground conditions. These results were reviewed by the designer. Additionally 25% of the nails were load tested up to 150% of the design load. The movement of the nail was measured and graphed to enable the engineers to confirm the nails obtained the strength assumed in design. All grout mixes had compression testing

complete to ensure the required strength had been achieved.

The final walkover with the asset owner to hand over the project identified no significant issues and the client provided positive feedback on the quality of the work, and excellent engagement with the local community. Stakeholders were also pleased to have had regular contact and update throughout the project; positive feedback was received from the community throughout the construction.



Figure 10: Retaining wall on Sumner Road complete

References

One of SCIRT's biggest projects has been the retaining wall repairs on Sumner Road which links the port suburb of Lyttelton with the seaside suburb of Sumner, and provides an alternative route to the port from Christchurch.

Sumner Road retaining wall stage 4 has been a challenging project for all involved. Finding an innovative but safe way to repair the retaining wall, keeping residents satisfied when they have already had three years of work on their road and collaborating with Holcim to make sure their business remained open and was safe during construction. The project was a success by finishing ahead of schedule, under budget and stakeholders were satisfied with the finished project and how everything ran during construction.

"The project had challenges with tough ground conditions, access and all the planning involved in the construction methodology. The team excelled, despite these challenges and delivered a quality project to the client ahead of schedule. SCIRT were also impressed with the positive feedback received from the locals and that the community were satisfied with the construction", Tim Mason, SCIRT Delivery Manager.

During construction drone footage was taken and shows the extensive repairs on the Sumner Road Stage 4 retaining wall. The footage was produced by SCIRT's Fulton Hogan delivery team revealing the innovative repair method used to rebuild a retaining wall on the road above Holcim Cement in Lyttelton.

The footage was shared by *The Press* and has also been uploaded to youtube with over 2000 views. Below is the link to both the youtube footage and the press article.

<http://tinyurl.com/jbkwrqo>

<http://www.stuff.co.nz/the-press/christchurch-life/75900011/Drone-footage-shows-repairs-to-retaining-wall-on-Christchurchs-Sumner-Rd>

Sumner Road Retaining Wall Stage 4 won the Canterbury Contractors Federation Award 2015 for category C projects \$1 million to \$3 million. The team also won the SCIRT Outstanding Performer in March 2015 for the innovations they engineered on a challenging job.



Figure 11: Canterbury Contractors Federation Award

An article 'Overcoming Sumner Road's retaining wall challenges' was written for the NZ Construction News April/May edition regarding the project and work in Lyttelton. Please see next page for a copy of the article.



Figure 12: Articles written on the Sumner Road retaining wall stage 4 project

Road residents:

"They've been pleasant, and what more can you ask for. They've worked incredibly hard." Sumner Road resident

"We had residents in the first one that were taking them down morning tea, you know once a week a big bake up. Now the relationship has got to be pretty good if that's going on." Sumner Road resident



Figure 13: Sumner Road residents being updated on the project

Overcoming Sumner Road's retaining wall challenges



Lyttelton's narrow and steep streets have drawn several innovative solutions from the SCIRT teams for the repair of the retaining walls

For the past four years, the Stronger Christchurch Infrastructure Rebuild Team (SCIRT) and Fulton Hogan have been working in Lyttelton's steep streets, repairing several earthquake-damaged retaining walls. Now, the end is in sight.

One of SCIRT's biggest projects has been the retaining wall repairs on Sumner Road which links the port suburb of Lyttelton with the seaside suburb of Sumner, and provides an alternative route to the port from Christchurch.

The major retaining wall on Sumner Road has consisted of five separate projects, each with different design needs and requiring a specific repair methodology. Stages one and two were ground anchor and precast block walls, with stage one completed in 2013 and stage two in 2014.

But the March floods in 2014 changed everything as Sumner Road sustained heavy damage. "The design team deemed Sumner Road stage four a more critical project that needed to be completed as soon as possible," says project manager David Oliver.

MINIMISING RISK

Stage four started at the end of 2014 and consisted of three retaining walls above the yard of Christchurch's main cement supplier, Holcim. The wall design was for 170 soil nails to be installed with structural foundations and shotcrete. To install these soil nails, either the drilling rig had to be mounted on scaffolding, or a rope-mounted rig was needed with an abseil team.

The site was steep, narrow, unstable and difficult to access. SCIRT has a strong safety culture so a way had to be found to minimise risks. In the end, the solution was to use a crane-suspended drilling platform.

"This method was chosen because the crane would sit back from the edge of the existing wall without placing any additional weight on the damaged retaining wall that could cause it to fail," Mr Oliver says. "The platform gave the guys an area to work and safely operate the drilling machinery. As some of the soil nails took up to nine hours to drill and install, it was important that the guys had an adequate working environment."

Stage four of the Sumner Road retaining wall repairs was completed at the end of 2015 and won the NZ Contractors' Federation award for the best project in the \$1 million to \$3 million category.

WALLS AND WORKS

Work is currently underway on Sumner Road stages three and five, and these should be finished by September this year. Sumner Road stage three consists of three separate walls and new underground services works.

"Wall 1 for stage three will be repaired with 78 anchors each 13–15 m long and 40 temporary soil nails and precast concrete blocks," Mr Oliver explains. "Half of the ground anchors and all of the temporary soil nails have been installed. The bottom half of the wall will then need to be excavated and the rest of the anchors installed."

"From there we will construct the foundation and then install the blocks. The blocks are tied into the anchors and then filled with concrete," Mr Oliver explains.

"Wall 2 will be repaired with 38 vertical ground anchors, 50 temporary soil nails and 35 precast concrete panels. Work has only just begun," he notes. "The wall will be excavated, and then vertical anchors installed. Precast concrete panels will be placed followed by pouring a concrete foundation."

Wall 3 has been completed, Mr Oliver adds. "Some 62 soil nails and concrete blocks were



Testing the soil nails on stage four of the Sumner Road retaining wall repairs – a crane-suspended drilling platform was used to provide a safe working area

used to repair it. The wall was first excavated, followed by the installation of the soil nails. The foundation was then poured, and the concrete blocks installed and tied in to the foundation."

RESIDENT COMMUNICATIONS

This year is SCIRT's final year in a five-year programme of repairs to Christchurch's roads, bridges, retaining walls and underground pipe networks. SCIRT work is funded by the New Zealand government and the Christchurch City Council, and is on target to be complete by December.

A critical factor in repairing the retaining walls has been to produce walls that are stronger and more resilient than the old ones in the event of future seismic activity. In addition, communicating well with the residents of Lyttelton has been central to the success of the retaining wall repair programme.

"Residents are located in the midst of these retaining walls and have had to deal with over three years of road closures. We have considered resident requirements and where possible have made allowances for vehicle access and parking," Mr Oliver says.

"We also keep the residents and wider community informed on our works and the changes in traffic management. And we do receive positive feedback from the locals on how we undertake the work and consider their access," he adds.

RE-FACING WITH RED ROCK

The most prominent retaining walls in Lyttelton are the historic red rock walls, some of which

were built between the late 19th century and the start of World War I by hard labour gangs from the Lyttelton gaol. Red volcanic scoria rock was quarried, cut and fitted by hand along embankments and walls up to 8 m tall.

SCIRT has designed all of its repairs to red rock walls so they can be re-faced with the red rock in the future under a Christchurch City Council works programme. Chris Gregory, head of transport, says the council's intention is to restore the walls to give the appearance they are still completely made of red rock.

"Each wall will need its own design to match what the wall looked like before the earthquakes, as well as meeting the building code so the re-facing does not collapse in the event of another earthquake," he explains.

"The walls have a tie-in design similar to a lot of veneer walls. The tie length is modified to give just the correct amount of grip into the rock so that the dowel that is drilled into the rock won't crack the already brittle material."

The construction of the re-facing was set to start early in April this year.

INNOVATIVE SOLUTIONS

Besides Sumner Road, the Fulton Hogan team have been busy with several other retaining wall repairs in the port suburb, and its narrow and steep streets have drawn several innovative solutions from the SCIRT teams.

For example, to reach the wall at Seaview Terrace, a helicopter was at one stage considered to bring in material. In the end, a temporary access way was built to get the machinery up to the worksite. The Seaview Terrace retaining wall has been replaced with a structurally reinforced concrete cantilever wall and was completed in July 2015.

The need to install soil nails in the wall under the Sutton Quay bridge presented a technical challenge because right behind the wall was a stormwater pipe on an angle. SCIRT used a laser scan to pinpoint the position of the large pipe, and soil nails were installed on angles to avoid hitting the pipe.

"Working so close to people's houses, sometimes in their front yards, creates a real challenge for the workers and the residents. Maintaining access for residents and allowing room to work is a balancing act: we have had to work together to guarantee safety and progress," Mr Oliver says.

"A good relationship has been formed with many residents, and the team have really appreciated the local knowledge – and the home baking! It has been a long road for many people in Lyttelton, and it will be a great thing when we can celebrate completing all the retaining wall works on Sumner Road in September this year – an accomplishment worth celebrating with the community."



SCIRT Fulton Hogan project manager David Oliver