SCIRT Rebuilding Infrastructure

LEARNING LEGACY

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.

Protecting the past – Restoring heritage bridges

Story: Heritage Bridges

Theme: Construction

A document which describes the processes that SCIRT took when repairing some of Christchurch's heritage bridges.

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

Programme funded by

Christchurch City Council

New Zealand Government

city care

Downer

Fulton Hogan

McCONNELL DOWELL

Fletcher

Programme funded by
Christchurch City Council
New Zealand Government

Protecting the past – Restoring heritage bridges

With more than 250 heritage buildings in Christchurch and Banks Peninsula demolished after the 2010 and 2011 earthquakes, preserving and protecting those heritage structures that survived took on greater significance for the people of Christchurch.

Brick by brick: Work gets underway on the Armagh Street Bridge.

The Stronger Christchurch Infrastructure Rebuild Team (SCIRT) was tasked by the public entities funding its work programme with repairing 10 heritage bridges. Several were in the central city and all demanded painstaking care and attention to detail.

The rebuild work and repairs were collaborative projects between SCIRT, the Christchurch City Council's heritage team and advocate Heritage New Zealand.

Six of the heritage bridges cross the Avon River, which circles the city centre. Built between 1863 and 1902, they form a network of historic bridges of similar design.

They were built to upgrade transport infrastructure, but also to demonstrate progress and permanency in a young city.

The bridges' lace-like patterned railings and distinctive arches complemented the neo-Gothic style of public architecture in Christchurch at that time.

After February 22, 2011, SCIRT engineers and council heritage staff were greeted by twisted bridge decks, warped balustrades and cracked abutments.

How to restore and protect the bridges for future generations while making them safe and secure to carry people and vehicles was the task ahead for SCIRT.

Marrying old and new

Senior engineer Stuart Smith, a council representative, and a technical adviser - structures, to SCIRT, said the challenge for engineers was to achieve the engineering while minimising the impact on the integrity of the heritage fabric.

The restrictions of a heritage structure required creativity and problem solving from engineers. Not only were they dealing with a vulnerable asset, but they were working around a structure where damaged parts were not easy to access.

"Every heritage repair was different and to complete those in the short time frame of the SCIRT programme was an achievement," Smith said.

SCIRT senior structural engineer Steve Procter said the general approach to the bridge work when dealing with fragile assets "is slow and steady".

"But they are all different, that's the attraction of heritage structures," he said.

An experienced engineer who had worked on British heritage buildings, Procter said the aim of heritage authorities and engineers was to change as little as possible of the original structure as long as the structure remained safe for public use.

"I think the objectives of engineers when repairing heritage structures is to make the repairs as invisible as possible, and, ironically, probably the only area where heritage and engineering might differ is when heritage would like the repairs to be more visible," he said.

Where repairs were limited to elements of the structure, these were made quite obvious to acknowledge the history of the structure and to show the impact of the earthquake. However, when the structure had to be substantially dismantled and rebuilt, the aim was to rebuild as much as possible to the original.

"It's all about protecting the story the bridge is telling," Procter said.

An important part of the challenge was the imperfect nature of the original structure and the limitations of the technology used decades ago.

One example was the Gloucester Street Bridge.

The castings were not a perfect fit but they were not fixed because that was part of the "story" of the bridge, Procter explained.

Likewise, the Hamish Hay Bridge in Victoria Square underwent repairs to its beams in 1863 when it was built.

Procter said it was unclear how the damage happened.

SCIRT's repairs went alongside those changes.

"We could have mended it so you couldn't see it at all, but that would have deleted some of the history," Procter said.

On the same page

SCIRT designers were required to consult with council staff on a proposed repair strategy and the council to consult with Heritage New Zealand. As the asset owner, the council had to sign off on the repair strategy.

The SCIRT Heritage Guide for Delivery Teams set out procedures and the roles and responsibilities of the various parties in the heritage restoration projects.

Refer to the attached guide for more information on the step-by-step processes.

Gloucester Street Bridge

One of the most challenging projects was the rebuilding of the 130-year-old Gloucester Street Bridge crossing the Avon on the western flank of the central city, and part of a direct route to the new convention centre.

Beam up: A section of the Gloucester Street Bridge is hoisted into place

Lateral spread had twisted the bridge's abutments, wing walls had cracked and the failure of some splice bolts had resulted in the arches sagging.

Strengthening the structure to carry heavy vehicles, while retaining the heritage fabric, look and character, was a major assignment for SCIRT.

"Gloucester Street Bridge is essentially a modern bridge hidden inside a heritage bridge," Procter said.

However, only an expert would spot that fact.

The brittleness of the cast iron contributed to the difficulty of the repair work for the bridge built in 1886. The structure had little ductility and even small movements, like those caused by welding and drilling, threatened to crack it further.

SCIRT proposed – and heritage authorities agreed – that an "invisible" support structure be installed to strengthen the bridge. To do so, the bridge was partially deconstructed.

It was wrapped in plastic to prevent the dispersion of lead paint, which was removed; a corrosion protection system was applied and the girders were repainted. The "tent" was heated to help dry the paint during the 2016 winter.

The girders were retained as decorative historic elements, suspended underneath the bridge, and visible, but with no structural role.

Eight new steel beams, hidden from view, were installed between the old girders and connected to the new, reinforced concrete panel deck. Parts of the railings were broken and damaged, but these were carefully welded and repaired off-site.

Initially, traditional scaffolding was used for access. However, a risk assessment early in the project identified an increased risk of the Avon River flooding in this area because of water debris becoming trapped around the legs of the scaffolding deck. SCIRT's Fletcher Delivery Team decided to replace most of the scaffolding with four mobile platforms running on rails. They did not require supporting legs, so the river could flow more freely.

The 11-month restoration project was completed in December 2016.

Smith said it was a great example of clever engineering solutions marrying with heritage principles and objectives.

"For all intents and purposes, the bridge looks unaltered, with the same charm as it always had, but there's a lot of new, hidden structure underneath it to give it that longer life," he said.

Helmores Lane Bridge

Built in 1866 by a canny lawyer, Joseph Cornish Helmore, as a shortcut to his large Fendalton property, Millbrook, Helmores Lane Bridge was the oldest remaining timber bridge in Christchurch.

The repairs were complicated by the age of the bridge and more damage to the structure than expected. The challenge was to provide as much earthquake resilience as possible without destroying the heritage value.

"It's an artisan-built bridge with very crude construction," said Procter, who designed the repairs for the 150-year-old structure.

In consultation with the council heritage team, it was decided to build two five-metre-long "land spans", like ramps, at each end of the original 17-metre-long bridge for access. That allowed the soil under each end to be removed, reducing the load on the old timber frame.

Flock of onlookers: The Helmores Lane Bridge is reopened to pedestrian and animal traffic.

"My approach was to try and build the new land spans as a sympathetic modern version of the construction used for the old bridge," Procter said.

"The aim was to build the new land spans so had the original bridge been built now, it would have been constructed in the way the land spans were built."

The ramps were clearly a modern addition where timber with preservatives was used because it was just as durable as the original Australian hardwood, and stainless steel fixings were used instead of iron. The ramps and handrails were built to modern building codes, so the new handrails were a different height. The land spans move independently of the old bridge to protect it in any future earthquakes.

For the repair of the original bridge, recycled Australian hardwood timber was sourced from two dismantled bridges over the Waitaki River in North Otago, and the hardwood was made into new cross beams, handrails and posts, with the original mortise and tenon joints incorporated into the design. This was in keeping with the conservation practice of using material as close as possible to the original.

One of the tricky tasks was to cut out a rotten part of a beam. That required a careful jacking of the bridge and then cutting out half of the degraded beam at a time, and replacing it.

Prior to the earthquakes Helmores Lane Bridge carried vehicles. After a review of the bridge's status, the council's legal team found the approach to the bridge was part of Hagley Park and was not a legal road.

As a result, it was decided that the bridge would only be open to pedestrians and cyclists. The bridge reopened on September 5, 2016, after five months of repair work.

Armagh Street Bridge

Like the Gloucester Street Bridge, the Armagh Street Bridge was designed by city surveyor Charles Walkden who, in the 1880s, designed several heritage bridges across the Avon, giving the area a distinctive character.

Like its sister structure, the 1883 bridge was no match for the ground forces unleashed in the February earthquake and suffered significant damage.

The main repairs to the arched bridge, which was built with six layers of bricks, focused on a 20-millimetre-wide and 14-metre-long crack through the brick barrel – penetrating all six layers – and five others cracks.

The SCIRT engineer supervising the project, Tom Harding-Ilott, said it was essential to find the right balance between retaining the original materials and replacement and repair, so that the finished work was inconspicuous and the bridge would last another 150 years.

The damaged outer layer of bricks was removed. Recycled bricks of the same type and size were sourced from a demolished building and used as replacements. The cracks were injected with grout, and holes were drilled for fine-threaded stainless steel rods to be grouted into the bricks in a “cross-stitch” pattern to repair the cracks. A crack in the unreinforced concrete foundation was tackled in a similar way but employing bigger steel reinforcing bars.

SCIRT’s Downer Delivery Team developed a propping structure to support the bricks and help protect team members from any falling debris.

The bridge’s balustrades – comprising more than 150 panels – were dismantled for repair off-site. Each panel was numbered and labelled so it could be returned to the same position.

Harding-Ilott said communication was essential to the success of the project as close contact was maintained with council heritage advisers, archaeologists and key

Brick up: A worker fills the gaps under the Armagh Street Bridge

stakeholders.

The bridge was opened ahead of schedule, enabling the reopening of the central city tram loop before the peak season.

“Working on a heritage structure was an amazing experience,” he said. “To see how things were built back in the 1880s and to tie our repairs into this was a great challenge.

“We had to make our mortar work look ‘messy’ and dismantling the balustrade puzzle was both an exciting and frustrating process. Work could not be rushed, everything needed to be planned well to avoid any unnecessary disruption to the heritage fabric of the bridge.”

The meticulous restoration work was recognised at the 2016 Canterbury Heritage Awards. The SCIRT project was highly commended in the Public Realm, Saved and Restored category. The Armagh Street Bridge project also won the Civil Contractors NZ, Category B Award, for contracts valued between $250,000 and $1 million.

Side warp: A warped girder on the Colombo Street Bridge.

Colombo Street Bridge

Next to the Christchurch Town Hall, the Colombo Street Bridge, which was built in 1902, was the last of the city's cast-iron Gothic bridges to be constructed.

Seismic forces buckled its arched girders and twisted the abutments about 30 degrees, causing the handrails to bend and pull out of the pilasters.

At the request of the council, SCIRT designed the bridge repairs to keep the buckled arch-edge girders as a visual reminder of the February 2011 earthquake.

The nine-month restoration project in 2013 and 2014 was extensive, requiring the replacement of the abutments, the repair of the girders and the removal, repair and reinstatement of the cast-iron ornamental balustrades, along with improvements to the bridge's seismic resilience.

The work involved the excavation of the old abutments and the hydro-demolition of concrete. Plastering was done with lime-based mortar, as used on the original bridge. Milk was even sprayed on the structure to encourage gradual mould growth.

As with other heritage projects, everything had to be photographed before sections were removed. The cast-iron balustrades were dismantled and repaired off-site and each piece tagged and returned to its original position.

One of the major repairs was the strengthening of the ground around the bridge's abutments. Drilling created long, narrow vertical columns which were pumped with concrete. Then 9.5-metre soil anchors were drilled horizontally through the abutments and into the stabilised ground, tying it to the abutments to stop rotation in further earthquakes.

Lessons learnt:

Good communication: Regular communication between the heritage authorities, the repair designers and the construction contractors proved essential for a restoration project.

Clear comprehensive guidelines: SCIRT established a set of clear and comprehensive guidelines for Delivery Teams to follow to ensure the heritage assets were protected and not damaged.

Roles and responsibilities: The respective roles and and responsibilities of the heritage authorities and construction teams was explicit to ensure no unauthorised work was carried out.